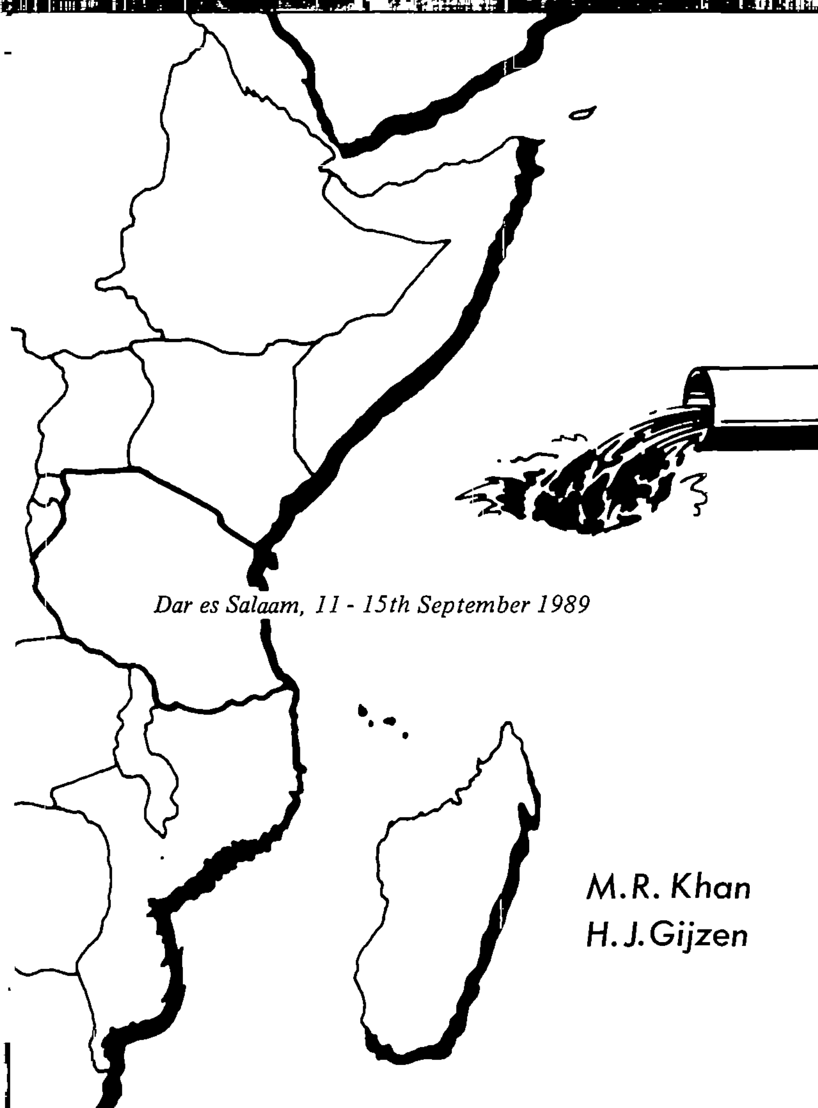
ENVIRONMENTAL POLLUTION AND ITS MANAGEMENT IN EASTERN AFRICA



Dar es Salaam, 11 - 15th September 1989

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ENVIRONMENTAL POLLUTION AND ITS MANAGEMENT IN EASTERN AFRICA

EDITORS

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CONTENTS

SECTION 3: AGROCHEMICALS

SECTION 4: HEAVY METALS

SECTION 5: MONITORING METHODS, MODELLING AND MANAGEMENT

Preface

During recent years, environmental awareness has increased enormously, both in developed and in developing countries. Environmental issues currently rank high on both the political and the academic agendas and numerous scientific and policy meetings about the state of the environment have been held. Environmental issues of major concern include deforestation, global warming, protection of ozone layer, water pollution, solid waste management and hazardous waste.

Although environmental awareness is generally on the increase, there is still a lack of responsibility mainly from the side of the producers of pollutants. The unauthorised dumping of toxic waste from the developed countries in the coastal seas of developing nations, like the recent incident on the West African coast, should be considered as a crime. The indiscriminate export of agrochemicals, substandard and expired pharmaceuticals and other chemicals which are banned in the developed countries on the other hand are clear examples of lack of responsibility. In some cases even false declarations are used to promote the sale of harmful and banned products, such as the wide spread sale of the Lion Brand Chinese made mosquito repellent coils, which are labelled " Harmless to Human", when they contain 17% DDT.

The general reluctance, inability and lack of proper legislation on part of the governments of developing nations to protect the environment, together with the lack of education and awareness of the consequences of pollution add on to the destruction of the environments beyond recovery. A realization of the close link between poverty, environmental degradation and sustainable development is of crucial importance to developing countries. Unplanned rapid industrialization and urbanization causes uncontrolled pollution. "Prevention is better than cure" therefore should be the motive before new developments are introduced.

Experiences in other countries could be very useful in the control and management of the menace of pollution. Since the situation in most East African countries is similar, it will be absolutely necessary to have good communication, coordination and collaboration on the control of pollution in the region.

Keeping the above in mind, the Dean, Faculty of Science, University of Dar es Salaam, on the 25th of October, 1988, called a meeting to discuss openly the past, the present and the future state of pollution in Tanzania. Another point of discussion was on the role the Faculty can play in shouldering the responsibility in protecting the environment in the country and the region. It was decide at that time that the Faculty should organised a regional symposium on environmental pollution which will be the first of its kind in Tanzania. The major objective of the symposium would be to evaluate the present and future state of the environment in the East African region.

As you are aware, the symposium did take place from September 11th to 15th, 1989 in Dar es Salaam. A large number of participants from Tanzania and from other countries in the region contributed papers, indicating the seriousness of the topic. During the symposium, Dr. M.G. Bilal, the Dean, Faculty of Science, announced the intention of the faculty to start a Master's programme in Environmental Sciences from 1991 as a first step towards the control of pollution in the region.

It is needless to say that the generous and timely support of all the donors was highly appreciated. Without their support the symposium could not have materialised. On behalf of the organizing committee and the Faculty of Science we thank all the participants for their time and effort to participate in this symposium and making it a success. The press coverage and the public concern as evident from the reports in local newspapers during and shortly after the symposium, indicate that we did succeed at least to some extent in putting our concern across to the public. This is a first step towards a controlled and healthy environment.

Because of the success of the first regional symposium on Environmental Pollution, it was agreed to organize such meetings on bi-annual basis in future. We sincerely hope that future meetings will consolidate whatever we have achieved so far.

We are convinced that concerted, determined and coordinated efforts on a regional basis will go a long way in protecting the region from the menace of pollution. "Where there is a will there is a way" can not be said better anywhere else.

M.R. Khan
H. Gijzen

OPENING ADDRESS

OFFICIAL OPENING OF THE SYMPOSIUM ON ENVIRONMENTAL POLLUTION AND ITS MANAGEMENT IN EAST AFRICA: MONDAY 11TH SEPTEMBER, 1989

The Faculty Dean, The Symposium Chairman, Symposium Participants, Ladies and Gentlemen.

It gives me great pleasure to be able to officially open this symposium this morning. I therefore wish to welcome all participants to this symposium, to Dar es Salaam and wish them a happy and memorable stay here. As you may already know, Dar es Salaam means Heaven of Peace. We hope you will have the peace of mind necessary to carry out successfully the goals of such a symposium.

This symposium, I am told, will address itself to all aspects of pollution in the East African region and to Tanzania in particular. Pollution is a household word throughout the world in that it is something that is constantly threatening to destroy us and the world we are living in. The continuous release of fluorinated hydrocarbons to the atmosphere has resulted in the depletion of the protective ozone layer around the planet while the indiscriminate dumping of industrial wastes into the environment has resulted into a decrease in the amounts of clean air and water on earth, both very vital to our continued existence. We, in East Africa, must become specially aware of our increasing tendencies towards polluting our environment because we are pushing towards greater industrialization. Our industries must refrain from dumping harmful wastes into our rivers, lakes, seas and air. The public in the region must learn to refrain from activities that pollute our environment. The old saying that "we are what we make of ourselves" is very true, the cleaner the environment we live in the healthier people we shall be.

Although pollution is not a very serious threat to Tanzania and East Africa at present, prevention is better than cure should be the watch word in order to keep the region free of pollution in the future. There are several clear examples of unchecked pollution taking place and it is my hope that the symposium organizers will take the participants around Dar es Salaam for some evidence of atmospheric, aquatic and terrestrial pollution so as to stimulate a stronger discussion into different aspects of pollution. I hope that simple and cheap methods of identifying, monitoring and checking pollution and the conversion of existing polluted areas into pollution free areas will be some of your main concerns during this symposium.

Ladies and gentlemen, this symposium, I am informed, is the first of its kind being undertaken in the country and therefore I wish to commend you Mr. Faculty Dean, and the staff in the Faculty of Science, for coming out to the forefront in this area. We, in the region, are very dependent on you scientists to help in identifying cases of pollution and propose solutions to curb such practice. Please allow and encourage the continuous monitoring of all pollution and the research into ways of stopping any existing sources of pollution. I would also like to add a word of thanks to all the donors whose generous contributions lead to the successful hosting of this symposium.

The government of Tanzania recognizes that environmental protection is essential in obtaining meaningful development and in this connection a National Environmental Management Council has been formed. We all look forward to guidance from the Council as well as from Government Ministries responsible for the environment either directly or indirectly.

It is my sincere hope that participants will feel free to express and discuss pollution problems of the region and come up with recommendations that governments may use in the formation of legislation to stamp out practices that lead to pollution. It is also my hope that this symposium will not be the only one but that it will be followed by annual or at least biannual similar symposia in the future.

Mr. Faculty Dean, Symposium Chairman, distinguished guests, ladies and gentlemen, it is now my pleasant duty to declare this symposium officially open and wish you every success.

Prof. P. Msuya
Acting Vice Chancelor,
University of Dar es Salaam.

PLENARY LECTURES

DEVELOPMENT OF POLLUTION CONTROL MANAGEMENT IN TANZANIA

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ABSTRACT

A review is made of current pollution issues/problems in Tanzania. Major causes of problems are identified and analyzed. Measures being taken to mitigate pollution are described, and in particular the role and function of the National Environment Management Council (NEMC), the enacted national body for environmental issues.

INTRODUCTION

Tanzania is a country just south of the Equator covering an area of 945,000 sq.km. of which 885,000 is land and 59,000 sq.km. inland lakes. Officially known as the United Republic of Tanzania the country consists of Mainland Tanzania and the Islands of Zanzibar and Pemba.

The country has a population of 23.2 million. The annual average growth rate (1978-1988) was 2.8 per cent. The mainland population density is 25 persons/sq.km. These figures were observed in the 1988 census. Actual data on the urban population remain to be published, but the 1978 census observed that the proportion of urban population in Mainland was 14 percent with a growth rate of 9 percent.

The per capita income in Tanzania averages Tshs. 2,400 (1988).

The agricultural sector dominates the economy. It contributes more than 50 percent to the GNP, 75 percent to the total export earning and is employer of 80 percent of the national population. The main export products are coffee, cotton and sisal. Agriculture had a growth rate (1978-1986) of 1.4 percent. The industry sector contributes about 5 percent to the GNP. The last decade has been a period of decreasing industrial production which is a consequence of the worsening economical conditions during this period.

Tanzania is rich in minerals, such as coal, iron, apatite, gold and gas. However, the mining sector is yet not much developed. The country has also good exploitable resources for hydroelectric energy production.

Tanzania suffers a full share of the problem of degradation of the environment. The country has problems of desertification and soil erosion, depletion of aquatic and marine resources, of agrochemical pollution, urban pollution and industrial pollution. Soil erosion and related degradation of the rural land resources through irrational agriculture and forestry are the environmental problems affecting the greatest number of people in present Tanzania.

Pollution adversely affects the quality of life of people both in rural and urban ares through contamination of drinking water, food and the living natural resources upon which man is ultimately depending for his survival.

MAJOR POLLUTION PROBLEMS

The pollution of the environment that can be observed in Tanzania is not different from that of other tropical developing countries. The most obvious and serious pollution is the urban pollution, i.e. water pollution, air pollution and solid waste emanating from densely populated areas as a result of poor, if at all existing, waste water and solid waste management. Industrial pollution is another distinguishable type of pollution, though not (yet) as pronounced as in developed countries. But the problem of industrial waste will grow with improved economical conditions and consequent expansion of the industrial sector, though possible to control to a insignificant extent if preventive and protective measures are taken in time. The third pollution problem which will be discussed in this overview as a matter of concern to Tanzania is pollution through the use and handling of chemicals in agriculture, notably pesticides.

Urban pollution

Tanzanian towns are small in international comparison, but they grow fast. Faster than the population growth in the country as a whole. Only six towns have so far reached a population exceeding 100,000. Together they account for about 2 million of which Dar es Salaam alone has 1.4 million inhabitants. There are communal sewer systems in five towns, though serving only minor parts of their respective populations. The rest of these towns and all other towns in the country are not sewered at all. People in these areas rely on soak-aways and septic tanks, built individually for each house/plot. The sewer systems and connected treatment facilities, where existing, are of old age and in need of rehabilitation. Such renovation has in recent years been undertaken only in Dar es Salaam. Drainage systems for surface run-off are likewise found only in limited areas.

In Dar es Salaam all the sewage from the city centre is discharged into the sea untreated. The other sewered areas in the capital are located in separate areas and connected to respective stabilization ponds before discharge into the nearest local water course. Only one town has a functioning treatment plant for its municipal waste water. The other sewered towns have no treatment at all or treatment facilities which are not operating.

Due to the generally poor sanitary standard in urban areas the local receiving water bodies, including adjacent coastal waters of sea-located towns, are heavily polluted. Where investigations have been made, for instance in Msimbazi river in Dar es Salaam, by NEMC in 1984-1986 and the Ministry of Water (Haskoning & M-Konsult Ltd.) in 1988, they show presence of substantial amounts of organic matter and nutrients due to influence by waste water. Bacteriological investigations revealed human induced bacteria in concentrations making the river unsuitable for domestic use, swimming or for irrigation of vegetables. If similar investigations were carried out in surface waters of other towns they would show the same results. Preliminary measurements undertaken by NEMC in Arusha and Moshi indicate this.

The pollution described emanates from discharges of untreated sewage from sewered areas, and also, to a greater extent, from the overflow from septic tanks and soak-aways which are filled up or having bad infiltration capacity. In combination with poor drainage systems, the insufficient waste water handling result in the building-up of pools of sewage and contaminated run-off in streets and yards, which especially during wet seasons is severely hampering the life quality of town dwellers. Outbreaks of fecal-oral water-borne diseases are frequent and malaria mosquitoes have good breeding grounds.

Another serious urban pollution is municipal waste. A quick tour through a local area of any town in the country should give the visitor a clear picture of the magnitude of the problem. Systems for collecting and disposal of the wastes are existing in most towns, but are working at low level of efficiency, if functioning at all, because of financial and transport constraints. The result is that the waste piles up or is being burnt outside the houses or in the streets.

The third, and last, type of urban pollution which should be mentioned is air pollution. Bad air quality in town is generally not yet recognized as a pollution problem of importance in developing countries. True it is not as damaging as water pollution in these parts of the world, as far as we know, but urban air pollution is nevertheless a problem worth mentioning in this context also with respect to Tanzania. The major source is vehicle exhausts. Traffic density in peak hours in central Dar es Salaam is as high as in cities in developed countries; at least this is the impression when observing the standing queues of cars in the city quarters; and the vehicles are generally far from the level of trim of cars in rich countries. The problem remains to be addressed in Tanzania. The country has no legislation or control systems for this kind of pollution.

Another noticeable air pollution in Tanzanian towns is smoke and smell from garbage in streets and dumps. This problem is much observed in Dar es Salaam these days where the city landfill has been closed by court decision upon complaints by people suffering from uncontrolled burning at the dump.

Industrial pollution

The Tanzanian industrial sector is small. Industry has been much affected by the harsh economical conditions during the last 10 to 15 years, a problem which the country shares with so many other developing countries. In the earlier days the industrial development focused on investments in new industry. Now priority is given to rehabilitation of existing, as a whole, worn-out and under-utilized industries. A major constraint for industrial production is the great dependance on foreign currency demanding imports of spares, tools, starting materials, etc.

The majority of Tanzanian industries are located in the bigger towns. Therefore industrial waste discharges can be seen as part of the urban pollution. What distinguishes the industrial pollution from the rest is the composition of wastes and ways and means to control them. Few existing industries in the country have taken any environmental protective measures; a situation which significantly contributes to the urban water pollution as exemplified in the Dar es Salaam water quality investigations. In addition there are rural based industries which at places have a serious impact on the local environment. Bigger industries in the leading towns are connected to municipal sewage systems, where existing. The majority of these produce waste waters with a quality similar to sanitary waste water. In some stabilization ponds studied this industrial input contributes to a serious overloading.

The water pollution investigations so far made show little, if any, impact of metals and other specific industrial pollutants. However, this should not be seen as evidence of that no such pollution exist. It is known that several town based industries are located in areas without sewers or drainage. As a result their waste waters are discharged via the factory's soak-away or just poured onto the ground. This contributes to the building-up of a soil and ground water pollution which cannot easily be traced. Worse still is that such hazardous effluent may be used by nearby settlers for watering of their gardens or even in the households for cooking, etc. Such cases have been observed both in Dar es Salaam and other towns.

There are industries with acceptable effluent treatment, even if they are very few. One example is Southern Paper Mill in Iringa Region, in South-West Tanzania. The mill is fairly new and environmental considerations were included in the planning. Another example is the textile and leather industries in Morogoro, located within the Morogoro industrial estate. They are connected to a joint stabilization pond system. Also these industries are rather new.

An obvious pollution in Tanzania is oil pollution. Where-ever oil is used and handled, the ground at the site and nearby trenches/ditches are impregnated by oil through discharges of oily wastes or accidental spills. Measures to control oil waste are practically non-existent. This is a serious pollution problem both with respect to the local water and soil environments and the health of the people exposed to these substances.

Air pollution from industrial sources are of less importance in an overall assessment compared to pollution by waste water and solid waste. The major air pollution one would say is vehicle exhausts, dusting and smoke from burning of garbage and litter in urban areas.

Pollution by agrochemicals

Fertilizers and pesticides are the main causes of agricultural pollution if one excludes the impact by agriculture and animal husbandry practices as such. There are reports of detrimental effects on soil quality from countries with intensive mechanized agriculture, notably acidification, through use of synthetic fertilizers. There is, however, no reason to believe that the use of such chemicals is a pollution problem in Tanzania.

The situation is different with respect to pesticides. Such chemicals are widely recognized as a serious threat to health and the environment in the third world. These countries are highly depending on pest control, especially in tropical countries where pests are plentiful, in order to get good and reliable yields. The use of pesticides is the most widely spread method to control the pests.

Tanzania so far uses relatively small quantities of pesticides in international comparison. However, the use has increased rapidly during the last two decades. Most of the chemicals are imported. In coming years an increased share will be made or formulated within the country. The pesticides are used for cash crops, mainly coffee and cotton, and some subsistence crops, e.g. wheat and maize. Their use in small scale farming is negligible. In addition pesticides play an important role in disease vector control. Malaria vector control consumes the biggest share of DDT used in the country.

A number of pesticides currently used in Tanzania have been banned or are heavily restricted in developed countries. One of the reasons why they are still allowed in Tanzania, though with restrictions, is that they are less expensive than modern, less environmentally hazardous alternatives. The two main types of pollution in connection with pesticides use are the general contamination of exposed living organisms, soil and water and, secondly, spills and leakages in connection with their handling and storing.

The first is a globally recognized problem of concern to all countries which use these chemicals regardless of if they are poor or rich. The build-up of stable pesticide residues in the environment implies also a risk to Tanzania and should require a close monitoring. The second type of pesticide pollution can be expected to be more pronounced in the developing countries as a consequence of their more lax control and lack of awareness among people handling and using the chemicals. It is known that pesticide products in Tanzania are stored under poor conditions at several depots. The result is spills and leakages from damaged packing and products turned into waste. Some recently revealed cases in the country indicate that this pollution is a serious threat to the people and environment around these storages.

CAUSES OF POLLUTION

The underlying causes of pollution and other environmental degradation are to be found in the historical background - the country became independent in 1961 - and the socio-economic problems of a developing country with a small economy and fast population growth.

Historical

Earlier development was aimed at exploitation while conservation and protection of the environment was neglected. As a consequence no measures were taken to control environmental degradation. Exceptions were the establishing of forest reserves and the regulating of the mode of agriculture. But those measures were primarily aimed at securing the interests of the exploiters. The people were not involved and, consequently, the control systems fell apart at the time of independence.

Lack of awareness/knowledge

Developers and authorities, as well as the public at large, were unaware of the importance of protecting the environment and of the benefits of such measures. In the last few years, however, environmental issues have got much attention within leading strata of society. But it remains to bring out this awareness to the general public.

Financial constraints

Shortage of funds is, i.e., the underlying cause of poor maintenance in industry, lack of spare parts, etc. The consequence is worn-out process equipment, low runability and losses of materials and energy.
Other problems having their roots in lack of money are the urban pollution through failure to develop and maintain waste control infrastructure and the continuing use of cheap, but hazardous, pesticides instead of less hazardous, but more expensive alternatives.

Lack of proper planning

Generally, environmental protection was not included, or not given the required attention, in urban planning, industrial planning, etc. For instance, settlement areas or industrial areas may be planned, and plots demarcated and allocated, without provisions for waste water disposal, drainage etc.

Lack of adequate legislation

The country has several legislations within different sectors, all having a bearing on the environment. The general characteristic is that this legislation is unsupported by overall coherent environmental policy. The legislations are out of date and non-comprehensive. This is a major reason why existing environmental legislations are difficult to enforce. Tanzania lacks comprehensive legislation (umbrella legislations) on conservation of natural resources and environment protection.

Administrative/institutional shortcomings

Maybe the most obvious problem has been lack of coordination/cooperation between concerned sector bodies. An example of this is the independent and parallel planning and implementation of municipal sewerage and industrial waste management as observed in one of the major towns. The result is a big, under-utilized effluent treatment facility for the industries concerned and the simultaneous discharge of raw sewage from the town. Meanwhile the authorities concerned with urban water and waste water development are looking for funds to complete the unfinished municipal stabilization ponds next door to the existing industrial ponds.

MEASURES AGAINST POLLUTION

Important measures to combat pollution and other forms of environmental degradation through man's activities are:

Environmental considerations must be incorporated in development projects. One way of doing this is to establish legal systems of mandatory approval or licencing of activities having an impact on the environment before their implementation. This is particularly important with respect to industrial development. Preventive action is a prerequisite of effective industrial pollution control. Measures in after hand can never fully compensate lack of preventive action.

There are legal provisions for such prior examining of development projects in existing Tanzanian legislation, notably the Water Utilization Act and the Industries Licencing and Registration Act. However, these legislations have so far not been used for this purpose. The major reason for this is that the two legislations primarily had other objectives when drafted than to protect the environment. Moreover, the legislations do not provide for an integrated multisectoral approach when examining projects.

The awareness of environmental issues must be promoted. Needless to say this is a fundamental prerequisite to obtain any sustained progress in environmental conservation. All strata of society must be made aware. Measures need to be designed and implemented with respect to respective target groups. Environmental research must be promoted and its results disseminated in appropriate ways. Major channels would be information and education.

The Government must put more priority (funds) to environmental issues. Such support would be needed i.e. to authorities/institutions engaged in environment management and research, to industry in order to encourage preventive maintenance, for stimulating self-reliance to neutralize the foreign currency bottleneck in industry and for helping local governments to build and maintain local sanitary infrastructure.

Planning procedures must be improved. This concerns for example town planning. Industries must be properly separated from settlements. Necessary water and sanitary infrastructure must be secured before plot allocation.

Legislation must be harmonized and updated.

Administration/management of environmental issues must be improved. For this reason the Government has established the National Environment Management Council as the national body with special responsibility for the environment.

The measures as have been described are not only required in Tanzania but are necessary wherever effective management of the environment is required. Tanzania is in the beginning of this work. There are other countries which started earlier and have reached further.

THE ROLE AND FUNCTION OF THE NATIONAL ENVIRONMENT MANAGEMENT COUNCIL

The 1972 UN Conference on the Human Environment was the starting point for the discussion of environmental issues on the global arena. One result of the conference was the acceptance of the need for different sectors of society to work harmoniously and in multisectoral cooperation in order to combat environmental problems. To this end in 1977 the Government designated the then Ministry of Lands, Housing and Urban Development as a focal point and coordinator of environmental issues. In 1981 the Ministry formed an Inter-ministerial Committee on the Environment in order to facilitate intersectoral cooperation. The Committee emphasized the need to form a strong national organization with legal mandate to deal with environmental issues. This culminated in 1983 in the enactment of an Act of Parliament which provide for the formation of the National Environment Management Council (NEMC). The Council was duly inaugurated in November 1986.

Functions of the Council.

NEMC is responsible for the implementation of the National Environment Management Council Act (1983). The Council's parent Ministry is the Ministry of Lands, Natural Resources and Tourism. The Act specifies the tasks and related regulations for the Council. It makes provisions in the broadest sense possible for the coordination and stimulation of national environment management and the prevention of pollution.

The functions of the Council are outlined in paragraph 4 of the Act. It shall advise the Government on all matters relating to the environment. Thirteen tasks are mentioned specifically. These include the coordination and communication of bodies with respect to the environment (4.b); the evaluation of existing and proposed policies and activities of the Government with respect to environmental management and control of pollution (4.c); the fostering of cooperation between the Government, local authorities and other bodies engaged in environmental work (4.e); the advancing of knowledge and technology with respect to changes in the environment and minimizing pollution (4.g); the operation of a system of documentation (4.i); the maintaining of relations with other national and international bodies (4.k); the performing of other functions assigned by the Minister (4.m). For the better performance of its functions the Council shall be in collaboration, cooperation and consultation with any person or body established by law having function or relevance to the environment (4.3). Very general powers are given to the Council to act alone, in collaboration with, or on behalf of other organizations to properly perform its functions (paragraph 5).

The strength of the National Environment Management Council is its right of representation in relevant bodies, its coordinating and stimulating powers for the interpretation and implementation of legislation, its general powers to disseminate relevant information and its power to act upon such information. Transferring executive powers presently vested in ministries and national institutions to the Council would weaken both the stimulating and coordinating powers of these bodies. It was therefore recommended that the Council with its present functions is represented in sectoral boards, committees etc. of importance with respect to the environment.

Organizational structure of the Council

NEMC is headed by a Board of Directors with the Chairman appointed by the President. Its fifteen members are appointed by the Minister for Lands, Natural Resources and Tourism from ministries and other organizations dealing with matters affecting the environment. Three other members can be appointed by the Minister from amongst knowledgeable persons in the field of environment.

The Council's office is headed by a Director General appointed by the President. The approved units of the Council are the following: An audit and legal division is the central staff unit. There are four directorates under the Director General, Natural Resources; Research, Education and Documentation; Pollution Prevention and Control; Finance and Administration.

The staff of the Council is being recruited gradually. By the end of 1989 the Council should have 20 professionals.

Activities of the Council

The current major programmes are nature conservation and marine conservation, pollution prevention and control, and beach erosion control. Partly this work is being undertaken within intersectoral projects coordinated by NEMC, namely the project of formulating a national conservation strategy, the project of preparing a plan of action to combat desertification and the project of formulating an integrated national marine policy.

A more detailed description of the pollution prevention and control programme is given below:

The Pollution Prevention and Control Programme

The pollution control work of NEMC and its forerunner, the Environment Protection Section of the then Ministry of Lands, Housing and Urban Development, started in a more organized form in 1984. It focused on urban and industrial pollution. An inventory has been made of major industries. Industries and bigger towns have been regularly visited. Environmental monitoring programmes have been established at some industries in cooperation with respective companies. The Council organized a workshop in 1988 on appropriate technology to reduce wastes in industry.

The purpose of the programme is to assess pollution emanating from industries, urban areas and other sources, such as the handling and disposal of hazardous waste, and to determine appropriate recommendation for abating pollution. Included in the program is also the monitoring of chemical uses for the purpose of controlling of pollution through the use and handling of hazardous products.

It should be observed that the Council does not have legal powers to impose mandatory requirements on the polluters. The approach is to seek the cooperation of the industry in question in order to reduce the environmental disturbances. The means are advice and recommendations. The work includes a big educational component.

There are four sub-programmes:

- surveys/studies of polluting activities, mainly industries
- assessments of environmental impacts of developing projects
- monitoring of hazardous wastes
- monitoring of chemical uses

The pollution prevention and control work is partly a current work of an environmental authority, such as assessments of development projects, supervision of polluters and advice etc. to polluters and regional/local authorities. Projects on selected problem areas are also part of the work, such as mapping inventories of polluting activities not studied before or the production of information material on hazardous chemicals.

So far the work has concentrated on collecting information and data and on the consolidating of the role of the Council as the national competence centre for pollution control management. An important element in this work has been the development of the Council's staff involved in the pollution control work.

Recent reinforcement of the Council with personnel and equipment will increase its capacity and efficiency in dealing with the pollution issues in the coming years. One consequence of this should be increased attention to important development needs, such as the preparing of an Environment Protection Act which makes it mandatory for developers to acquire an environmental protection licence for industries and such like projects, likely to have an impact on the environment prior to such undertakings. There is also a need to develop guidelines and information to industrialists and concerned authorities, at different levels, on environment protection and supervision issues. The country also needs to establish a system of monitoring effluent and the quality of the environment. This will also be an important task for NEMC in the coming years.

THE ROLE OF THE TANZANIA COMMISSION FOR SCIENCE AND TECHNOLOGY IN COORDINATING AND PROMOTING RESEARCH ON ENVIRONMENT

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INTRODUCTION

Much has been written about air and water pollution, chemicals in food, noise levels, pesticides, waste disposal, flood control, over population, the concertizing of our countryside and man's other alterations of his environment. Little however has been said about the fact that the health and welfare of man - both as an individual and in society - are rooted not in air, water, food and so on, but in a complex system made up of all facets of his habitat, including man himself, interacting with and on each other. Study of our environment makes no sense if it focuses on one aspect without the others.

The many stresses created by our industries impinge upon all of us. The most important question to ask ourselves however is whether they are or should be harmful or not. Most writers have made us believe that these stresses are indeed harmful and have brought much of the population, to the brink of illness or death. No one would argue of course that air pollution, radioactive fallout or chemical insecticides washed into a water supply, to take a few examples, are beneficial, but we would like to suggest that before physiological effects of these environmental pollutants are well understood or established, the surveyors of gloom and doom should refrain from writing about them as though they were.

Such statements like: "Man is exposing himself to hundreds of new chemicals in the air he breathes, the food he eats, and the water he drinks. As chronic bronchitis, lung cancer, and emphysema grow more prevalent, man seems to be choking to death on his own technology". Such statements abound in pitfalls for the unwary; they do little to help us understand the very dangers they seek to expose. They are as oversimple as the statement that since the life expectancy is rising steadily and the world population is "exploding", environmental pollution obviously is beneficial to health.

The failure of both approaches is the failure to realize that our environment is a vast complex system that cannot be understood in terms of any of its parts. It is impossible to understand and deal with air pollution, for example, without considering its relationship to waste disposal, electric power generation, public transportation, human and animal health, or the chemistry of agriculture, to name just a few parts of an intricate interrelationship.

An excellent description of the unit of our habitat that has lessons for us today is the statement by Hippocrates on "Airs, Waters and Places" written some three thousand years ago. He said:

> "Whoever wishes to investigate medicine properly should proceed thus: in the first place to consider the seasons of the year and what effects each of them produces. Then the winds, the hot and the cold, especially such as are common to all countries, and then such as are peculiar to each locality. In the same manner, when one comes into a city to which he is a stranger, he should consider the situation, how it lies as to the winds and the rising of the sun; for its influence is not the same whether it lies to the north or the south, to the rising or the setting sun. One should consider most attentively the waters which the inhabitant use, whether they are marshy or soft, or hard and running from elevated and rocky situations, and then if saltish and unfit for cooking; and the ground whether it be naked and deficient in water, or wooden and well watered, and whether it lies in a hollow, confined situation or is elevated and cold; and the mode in which the inhabitants live and what are their pursuits, whether they are fond of drinking and eating to excess, and given to indolence or are fond of exercise and labour, and not given to excess in eating and drinking. If one knows all these things, or at least the greater part of them, he cannot miss knowing when he comes into a strange city, either the disease is peculiar to the place, or the particular nature common diseases, or commit mistakes as is likely to be the case provided one had not previously considered these matters".

Hippocrates did not know all the answers, but surely he pointed to the questions. The deeper the analysis of the well of life is pushed, the more meaningless becomes the word <u>independence</u>. In other ways it is not possible to talk of independent variables when one is referring to the complexity of life in a particular environment.

The study of the environment as a system lends itself to the methods developed by systems analysts. One of the difficulties involved in this, however, is that it is not possible to deal with the total system because of its bewildering complexity. A common conceptual framework and methodology enabling scientists from different disciplines to work together is wholly lacking. They don't even speak the same language. Ecologists, demographers, chemists, engineers and physiologists not only have no common language, they often refuse to talk to each other. This is understandable of-course because each feels insecure in the presence of the others. Unfortunately, understanding this failing does not help in our predicament.

The Tanzania Commission for Science and Technology realizing that the study of environment was of multidisciplinary and inter-disciplinary nature established a broad-based advisory committee with experts from the various relevant disciplines and sectors. This committee enables a mix of ideas to be filtered through and coordinated programmes.

In this paper a brief description of the structure and functions of the Commission will be given. Details of some of priority programmes will be given in the subsequent pages to illustrate the efforts being made by the Commission in coordinating and promoting research on environment.

STRUCTURE AND FUNCTIONS OF THE TANZANIA COMMISSION FOR SCIENCE AND TECHNOLOGY (TCST)

The Tanzania Commission for Science and Technology was established by the Act of Parliament No. 7 of 1986. This Act also repealed and replaced the Tanzania National Scientific Research Council Act No. 51 of 1968. The main purpose of the new Act was to establish a government organ which could effectively and efficiently coordinate and promote scientific research and technology development in the country and also act as the principal advisory organ to government on science and technology policy and all matters pertaining to the development of science and technology and its application to socio-economic development in the country. The functions of both the TCST and its predecessor the Tanzania National Scientific Research Council though seem to be identical, there are indeed very significant differences between them.
Thus whereas the Tanzania National Scientific Research Council Act No. 51 of 1968 merely stipulated the functions and responsibilities of the Council, without providing it with means whereby such functions and

responsibilities could be executed, the Tanzania Commission for Science and Technology Act No. 7 of 1986 goes a step further by providing the Commission with the means by which it could effectively and efficiently perform its functions. That was the main weakness which hampered the efficiency and the effectiveness of the Tanzania National Scientific Research Council. There was, therefore, no way in which the Council could coordinate the research activities of the national institutions or advise on research priorities without being seen as interfering with the affairs of those institutions.

The main objective of the TCST Act No. 7 of 1986 was therefore to establish a national organ for the coordination and promotion of the application of science and technology which would be free from the weakness inherent in the Tanzania National Scientific Research Council Act of 1968.

(a) THE STRUCTURE OF THE TANZANIA COMMISSION FOR SCIENCE AND TECHNOLOGY (TCST)

The TCST Act No. 7 of 1986 provided for a structure framework of the Commission which would bring together, under one forum, the top leadership of the scientific and technological community in the country to work jointly through cooperation and bring science and technology to bear on the socio-economic development problems of the country. The structural framework of the Commission has been designed and formulated in such a way that all national scientists and technologists under its umbrella work in cooperation. Furthermore all the major national research institutes are, through the Act, affiliated to the Commission.

The Commission performs its functions through 9 statutory committees established by the Act and one non-statutory committee as shown below:-

1. The Executive Committee

2. Seven Research and Development (R&D) Advisory Committees: These are Sectoral Committees of experts set up to advise the Commission on how to carry out its mission in various sectors of the national economy:-

   (i) R&D Advisory Committee on Agriculture and Livestock
   (ii) R&D Advisory Committee on Natural Resources
   (iii) R&D Advisory Committee on Industry and Energy

(iv) R&D Advisory Committee on Medicine and Public Health
(v) R&D Advisory Committee on Environment
(vi) R&D Advisory Committee on Basic Sciences
(vii) R&D Advisory Committee on Social Sciences

3. The Tanzania Award for Scientific and Technological Achievement (TASTA) committee.

4. The Research Clearance Committee which is non-statutory.

(b) THE FUNCTIONS OF THE COMMISSION

According to the TCST Act No. 7 of 1986 the functions of the Commission can be summarized as:

(i) To act as the principal advisory organ of government on all matters relating to scientific research and technology development.

(ii) To formulate a national policy on the development of science and technology in the country.

(iii) To monitor and coordinate all scientific research and technology development activities in the country.

(iv) To acquire, store and disseminate scientific and technological information through conferences, symposia, workshops, seminars and through publications.

(v) To advise government on priorities in scientific research, allocation of research funds, regional and international cooperation in Scientific research and technology development, training and recruitment of scientific personnel, scientific education and establishment and maintenance of scientific standards.

(vi) To popularize science and technology at all levels including the general public.

The Commission executes these functions through its R&D Advisory Committees which are the main advisory organs of the Commission in so far as these functions are concerned.

THE ROLE OF THE TCST IN COORDINATION AND PROMOTION OF SCIENTIFIC RESEARCH IN ENVIRONMENT

In order for the nation to derive maximum benefit from the scientific research being carried out by different institutions in the field of environment it is necessary to have their activities coordinated. Such coordination is the best way of guarding against unnecessary duplication of effort and of ensuring optimum use of human and material resources including scientific facilities and equipment. There are several ways in which coordination is carried out by the Commission. These include:-

(i) Regular meetings of the R&D advisory committee on Environment.

(ii) Regular periodic visits by members of the R&D advisory committee to research institutes and other R&D institutions within the sector of environment.

(iii) Annual seminars/workshops for all research scientists involved in conducting research in environment management.

(iv) Regular publication of research results in environment.

The main role of the R&D advisory committee as already mentioned is that of being the principle organ of the Commission responsible for coordination of all scientific and technological research carried out in the country in its field or sectoral area of responsibility and shall, in that respect, be responsible for advising in relation to, among others, research policy and priorities.

The R&D Advisory Committee on Environment met for the first time in November 1988 to discuss and chart out priority areas of research programmes in the field of Environment. The rationale was that efficient and carefully planned exploitation of our natural resources should ensure a sustainable availability of the natural resources for the livelihood of the present and future generations and also alleviate nutritional, wood fuel and other problems. Further, the recent industrial development and other physical urban development in the country have progressed without due regard to the negative environmental impacts leading to environmental pollution in the atmosphere, rivers, lakes, ocean and the soil. It should be realized and emphasized that the plans and tools which are designed for socio-economic development must also contribute to sound management so that the resources and ecological systems and the environment in which they exist are not damaged. This therefore calls for the need to institute and/or strengthen the mechanisms for monitoring and controlling environmental hazards and degradation due to pollution and uncontrolled utilization of natural resources.

PRIORITY AREAS AND RESEARCH PROGRAMMES ON ENVIRONMENT

The following are priority areas of research programmes in the field of Environment:

(1) Research into water-borne diseases and waste control which include research and development of appropriate methods for waste disposal including sewage methods.

Domestic effluent are sometimes discharged into waterbodies untreated. For example, in Dar es Salaam City fresh human faeces is dumped in the Indian Ocean without proper treatment. Most urban centers which have sewerage treatment system carried out in stabilization ponds and collection pumping stations face problems associated with these disposal systems including failure to produce an acceptable effluent. The consequence of such system is creating an environment suitable for the multiplication of disease - causing microorganisms and other organisms. This will greatly increase the incidence of water-borne disease notably malaria, schistosomiasis and cholera.

(2) Development of pollution and waste control systems through designing of improved garbage and refuse disposal systems as well as sewerage and drainage systems.

The main emphasis here is placed on the solid domestic waste disposal. It is well known that there is an acute shortage of refuse and garbage collection trucks and this makes the organic domestic garbage to be left to decompose on the streets of most urban centers. This situation is a health hazard to residents of especially those in low-income housing and squatter areas where people are most congested. There are a number of alternatives which could be looked into in the development of technologies for waste disposal and these include:

- Land filling
- Thermal treatment
- Incineration
- Chemical, physical and biological treatment
- Neutralization
- Underground injection
- Land forming
- Solidification

Each of these waste disposal and treatment systems has certain technical and economic advantages and disadvantages which depend on the quantity and type of waste. A careful assessment is therefore a prerequisite before adopting any particular system and this is, therefore, an important area for research.

(3) Conduct studies on radioactive wastes which are damped in open and deep seas.

One of the problems of radioactivity is its persistence, resulting in continuous ionization. The injuries we are mostly concerned with are those resulting from intense, acute doses of gamma radiation received in less than a minute and those delayed effects of fallouts.

The recent practices by foreign ships and vessels dumping wastes of radioactive nature are hazardous to our environment and should be monitored and studied to establish their lethal doze. Monitoring the atmospheric environment of the presence of pollutants, microorganisms, gaseous polluting substances and other pollutants.

In urban areas where there is a large concentration of industries and factories, air pollution can be a serious environmental problem. The major source of air pollution is the gaseous emissions resulting from combustion of oil and coal and other industrial processes. These gaseous emissions include sulphur dioxide, sulphur oxide, acid vapours, ammonia and other nitrogenous oxides, dust particles of vanadium pentoxide, rock phosphate and metallic particles of lead and possibly other heavy metals.

All these atmospheric pollutants are dangerous to the well being of humans and other living organisms. For example in human exposure to excessive concentration of these gaseous and other atmospheric pollutants can cause respiratory diseases such as asthma, tuberculosis, pneumoniasis and even lung cancer in the long run.

Atmospheric pollution is not only restricted to urban areas, people living in rural areas who make about 87% of the Tanzania population are also exposed to air pollution. This is particularly true of the women in the rural areas who spent hours cooking using fuelwood and charcoal in poorly ventilated kitchens. The smoke they inhale in those kitchens contain high dosage of carbon dioxide and carbon monoxide which may be detrimental to human health. This obviously calls for investigation into the presence of various atmospheric pollutants and assessing their effects on humans and other living organisms. There may be problems of instrumentation for such kind of projects.

(4) Studying the effects of VIP latrines on ground water especially in those areas with a high water table.

(5) Assessing pollution in industries with a view of determining practical recommendations for abating pollution in respective types of industries.

In this country practically all industries are emitting industrial wastes and byproducts to the surroundings (mainly streams, rivers, lakes and ocean) without proper treatment. The highly polluted Msimbazi Creek of Dar es Salaam is a typical example into which the industrial effluent from textile mills at Ubungo and the beer factory at Ilala are discharged. These effluents contain chemicals which are harmful to marine and other aquatic life. In Mwanza, the soap factories and the edible oil refineries discharge their untreated industrial effluent in Lake Victoria, whereas in Arusha, Mbeya and Moshi the untreated industrial effluents are discharged into Rivers Themi, Sisimba and Rau, respectively.

It is thus obvious that there should be programmes of inventorying all polluting industries and factories and assessing the extent of their pollution and the effects of such pollution to life. Such information is of paramount importance in determining and setting guidelines which will help in abating pollution in various types of factories. This programme could be carried out by the National Environment Management Council in collaboration with all interested parties. Further to setting of the guidelines there should be a mechanism of monitoring so as to safeguard the environment.

(6) Assessing and evaluating processes leading to land degradation and establishing measures to arrest it.

Land degradation refers to processes which lead ultimately to the impoverishment or diminution of the production potential of land, as can be deduced from reduced productivity of desirable plants and livestock, alterations in the biomass and the diversity of the fauna and flora, accelerated soil deterioration and increased hazards for human occupancy. Further, land degradation processes are a consequence of the combined pressures of adverse and fluctuating climate and excessive exploitation by man.

There have been a few programmes being carried out by government and other institutions in the area of land degradation. HADO of Kondoa and Dodoma, and HASHI of Shinyanga are good examples by government in attempting to arrest land degradation in the country. Several studies have highlighted the existence of increasingly serious land degradation in Sukumaland, Dodoma, Kondoa and Singida. None of these studies have provided a clear understanding of the nature and magnitude of the problem, as such it is difficult to prescribe and execute appropriate rehabilitation measures. The programme of work which the Institute of Resource Assessment would like to undertake includes an attempt to trace and establish the development of land degradation processes through the pre- and post-independence periods. This approach will help to identify the periods in the history of Tanzania which have experienced the most severe and intensive land degradation. This will further help to identify the major factors which are associated with the land degradation in the Sukumaland.

The objectives of the study will be as follows:

(a) To examine and map out the various kinds of land degradation processes, their intensity and extent at various time periods.

(b) To establish and rank the major factors of land degradation in Sukumaland.

(c) To review and assess the impact of past and present land conservation and rehabilitation attempts in Sukumaland.

Land degradation is not limited to Sukumaland only. Most semi arid regions of Tanzania such as Dodoma, Singida, Tabora, Shinyanga, and Arusha experience various forms of land degradation which have been aggravated by overgrazing, deforestation for crop cultivation and firewood and soil erosion.

(7) Studying fire ecology; its prevention, management and control in different ecosystems. In recent years the occurrences of forest fires in Tanzania have been increasing. The areas which have been most affected are the national parks, forest plantations, forest and game reserves, and catchment forest areas. Most forest fire outbreaks occur in the dry season. Uncontrolled forest fires can be one major cause of environmental degradation. Therefore there is a need to institute a study programme aimed at assessing the occurrence and frequency of forest fires, their effects on forest plantation and other plant species in the affected areas, the response of forest tree species to the effect of fires and management of forest fires in general.

(8) Promoting the protection and conservation of coral reefs along the coastline in order to sustain their high biological productivity and also other natural areas of scientific interest.

(9) Assessing the extent and consequences of unplanned physical development in urban areas.

(10) Studying the water quality in Tanzania inland waters with respect to pollution and other impacts of human activity.

The R&D Advisory Committee will from time to time review these programmes in the view of modifying some of them or adding more programmes as the need arises. Furthermore the committee will have an annual seminar or workshop where participants from institutions and other individual scientists carrying research in the field of environment will be invited to discuss their research programmes and other issues of relevance to environment management.

CONCLUSION

It is clear that environmental studies including pollution control and management calls for multi-disciplinary approach which must be properly coordinated at various levels. The Commission's R&D Advisory Committee on Environment has just begun its work of drawing up research areas and laying out strategies for implementing the various programmes. As has clearly been demonstrated in this symposium the work on environment is not a one-man job. All disciplines and sectors should be involved in order to ensure that we live in a safe, productive and self-sustaining environment. Clearly this is the message begun by the symposium and therefore all parties concerned should have an open-minded approach and attitudes. The industrialists should appreciate the remarks made by the experts; on the possible hazards of industrial effluent; agriculturist should also exercise good agricultural practices so that the land can continue flowing with milk and honey; various people exploiting forests and their forest products should be aware that it is easier to destroy than to build and hence a tree cut today may need another thirty years to be replaced; domestic waste disposal methods should be improved so that we do not end up distributing diseases through the water supply and finally we should be alert on the possibilities of being used as dumping grounds of abnoxious waste from industrial countries which would have far reaching deleterious effects on the flora and fauna of our countries as well as being health hazards to human beings.

MARINE POLLUTION MONITORING, ASSESSMENT AND CONTROL IN THE FRAMEWORK OF UNEP'S REGIONAL SEAS PROGRAMME: A COMPREHENSIVE APPROACH

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INTRODUCTION

The United Nations Conference on the Human Environment (Stockholm, 5-16 June 1972) defined Earthwatch (the global environmental assessment programme) as one of the three basic components of the Action Plan for the Human Environment. The Governing Council of UNEP subsequently defined Earthwatch as a "dynamic process of integrated environmental assessment by which relevant environmental issues are identified and necessary data are gathered and evaluated to provide a basis of information and understanding for effective environmental management". The Global Environmental Monitoring System (GEMS) is one of the four components of Earthwatch and the "assessment of the state of ocean pollution and its impact on marine ecosystems" was adopted as GEMS' task by the Governing Council of UNEP.

Following the recommendations of the Stockholm Conference, and in particular the numerous decisions of the UNEP Governing Council, the monitoring of the quality of the marine environment has been organized and the Regional Seas Programme was initiated by UNEP in 1974 as a global programme implemented through regional components. Since then the Governing Council of UNEP has repeatedly endorsed a regional approach to the control of marine pollution and the management of marine and coastal resources and has requested the development of regional action plans.

All action plans are structured in a similar way. An action plan usually includes the following components: Environmental assessment, environmental management, environmental legislation, institutional arrangements and financial arrangement.

The "Environmental Assessment" is thus one of the basic components of the Regional Seas action plans. It concerns assessing and evaluating the causes of environmental problems as well as their magnitude and impact on the region. Emphasis is given to such activities as: baseline studies; research and monitoring of the sources, levels and effects of marine pollutants; ecosystem studies of coastal and marine activities and social and economic factors that may influence, or may be influenced by, environmental degradation; and the survey of national environment legislation. Environmental assessment is undertaken to assist national policy makers to improve the management of their natural resources in a more effective and sustainable manner and to provide information on the effectiveness of legal/administrative measures taken to improve the quality of the environment.

It is essential to bear in mind that all components of a regional programme are interdependent. Assessment activities identify the problems that need priority attention in the region. Legal agreements are negotiated to strengthen co-operation among States in managing the identified problems. They also provide an important tool for national policy-makers to implement national control activities. Management activities, aimed at controlling existing environmental problems and preventing the development of new ones, are one of the means by which States fulfil their treaty obligations. Co-ordinated assessment activities then continue to assist Governments by providing scientific information by which to judge whether the legal agreements and management policies are effective.

The present paper briefly describes UNEP's Regional Seas Programmes and outlines UNEP's present strategy and approach to regionally coordinated comprehensive programmes for marine pollution assessment and control under the above mentioned action plans.

UNEP REGIONAL SEAS ACTION PLANS

The Regional Seas Programme at present includes ten regions (Annex 1) and has over 130 coastal States participating in it. It is conceived as an action-oriented programme having concern not only for consequences but also for the causes of environmental degradation and encompassing a comprehensive approach to combating environmental problems through the management of marine and coastal areas. Each regional action plan is formulated according to the needs of the region as perceived by the Governments concerned. It is designed to link assessment of the quality of the marine environment and the causes of its deterioration with activities for the management and development of the marine and coastal environment. The programme is under the overall co-ordination of the Oceans and Coastal Areas Programme Activity Centre

(OCA/PAC) of UNEP but its success critically depends on the work of specialized organizations and centers dealing either with specific regions covered by the programme or with specific subjects common to most or all of the regions.

The substantive aspect of any regional programme is outlined in an "action plan" which is formally adopted by an intergovernmental meeting of the Governments of a particular region before the programme enters an operational phase. In the preparatory phase leading to the adoption of the action plan, Governments are consulted through a series of meetings and missions about the scope and substance of an action plan suitable for their region. In addition, with the co-operation of appropriate global and regional organizations, reviews on the specific environmental problems of the region are prepared in order to assist the Governments in identifying the most urgent problems in the region and in corresponding priorities to be assigned to the various activities outlined in the action plan. UNEP co-ordinates directly, or in some regions indirectly through existing regional organization, the preparations leading to the adoption of the action plan.

OBJECTIVES OF A COMPREHENSIVE MARINE POLLUTION ASSESSMENT AND CONTROL PROGRAMME

1. The overall objective of the programme is to establish a regionally co-ordinated comprehensive Marine Pollution Assessment and Control Programme catering for the immediate and long-term requirements of the Regional Seas Conventions and their Protocols (including those that are in the process of development), as well as for the requirements of the Member States of the respective regions.

2. Specific objectives of the programme are:

   (a) To organize and carry out regionally co-ordinated marine pollution monitoring and research programme concentrating on contaminants and pollutants affecting the quality of the marine and coastal environment, as well as the human health and to interpret/assess the results of the programme as part of the scientific basis for the region;

   (b) To generate information on the sources, levels, amounts, trends and effects of marine pollution within the region as an additional component of the scientific basis upon which the formulation of proposals for preventive and remedial actions can be based;

(c) To formulate proposals for technical, administrative and legal pollution control and abatement measures and to assist the Governments in the region in implementing and evaluating their effectiveness; and

(d) To strengthen the capabilities of national institutions to carry out marine pollution monitoring and research, as well as to formulate and apply pollution control and abatement measures.

PRINCIPLES

1. The main principles on which the programme is to be based are:

(a) Monitoring of pollutants focussed on pollutants and sites identified as requiring urgent attention. An assessment of the state of pollution will be prepared for each of the monitored sites together with a concentrate proposal for remedial action which may eliminate or mitigate the negative impact of pollution for that site;

(b) Research focussed on topics deemed necessary for a better understanding of problems identified as requiring urgent attention or clarification. Concrete proposals for pollution control or abatement measures should be the desirable end-product of such research;

(c) National, sub-regional and regional baseline studies on the sources, amounts, levels and effects of contaminants and pollutants focussed on compounds justifiably suspected as being significant for the quality of the marine environment and human health. Such baseline studies should be carried out within a defined time frame, and after the evaluation of the results obtained, will be either terminated or will lead to the establishment of monitoring programmes in the appropriate areas;

(d) Representative reference sites considered as being outside the direct influence of an identifiable source of pollution to be monitored for selected contaminants in order to establish the variations and long-term trends (if any), in the levels of these contaminants;

(e) The pollution monitoring and research activities envisaged to be carried out in the framework of the programme will be built, as much as feasible, on the relevant past and on-going activities in the region and elsewhere;

(f) In order to ensure the adequate quality and comparability of data generated through the programme, use of common sampling strategies and methods, analytical techniques based on reference methods, data quality control programmes and data processing are to be carried out as mandatory for all participants;

(g) The results obtained through the programme will be subject to careful and critical scientific evaluation before their release to the Governments of the region; and

(h) The implementation of the programme to be achieved through activities carried out by national institutions of the region under formal contracts with the specialized agency taking care of the day-to-day coordination of the programme or a specific component of it.

ELEMENTS OF THE PROGRAMME

1. The programme consists of interlinked components of research, monitoring, baseline studies, preparation of assessment, identification of priorities, formulation of proposals for pollution control and abatement measures and assistance to governments in the implementation of these measures, and in the evaluation of their effectiveness.

<u>Monitoring</u>

2. Based on the priorities indicated by Government nominated experts from the region, as well as on the principles adopted for the programme (see paragraph 1), the sites, matrices and parameters agreed to be monitored are determined (see Annex II). Within two years from the initiation of the monitoring an assessment of the state of pollution will be prepared for each of the monitored sites together with a concrete proposal

for remedial action which may eliminate or mitigate the negative impact of pollution for that site.

3. The sites decided to be monitored as "reference sites" [see principles 1(d)], including details relevant to their monitoring are also described as per Annex II.

Baseline studies

4. A regional baseline study on the sources and amounts of contaminants reaching the coastal waters of the region from land-based sources is undertaken. This is in order to provide the background information needed for eventual negotiations of regional protocol concerning the control of pollution from land-based sources by the Parties to the Regional Convention.

5. Further baseline studies to be carried out during a one year period at sites which are considered as being under the influence of pollutants. At the end of the study period, an assessment of the environmental problems of the studied areas will be prepared, including recommendations on the eventual follow-up which may be required [see principles 1(c)].

6. These further baseline studies to be undertaken should cover the assessment of pollution levels, by the measurement of selected marine contaminants in various matrices.

Research

7. Only research and studies directly relevant to the achievement of the objectives of the programme are to be carried out [see principles 1(b) above].

8. The results of the research component should provide clear advice on the effectiveness of proposed control measures, and quantification of the biological and ecological effects of contamination.

Formulation of proposals for pollution control measures

9. Taking into account the state of knowledge about the sources, levels, fate and effects of the major pollutants of the region, the following general guidelines for the formulation of proposals aimed at pollution control and abatement will be recommended to the States of

the region at intergovernmental meeting:

(a) To control oil pollution, waste receiving facilities and disposal sites should be established by the participating States, oil spill contingency plans should be finalized and related international and national legislation enacted;

(b) Sewage treatment combined with appropriate disposal facilities and sites are required for controlling sewage pollution;

(c) To control industrial pollution, environmental impact assessment studies should be introduced and effectively implemented and legislation requiring environmental impact assessments should be enacted and effectively enforced. Proper waste treatment facilities or waste disposal alternatives need to be established to eliminate or recycle contaminants at their source;

(d) To control pollution from agricultural activities, legislation restricting the use of persistent pesticides and inorganic fertilizers needs to be enacted and enforced;

10. More specific proposals for pollution control measures are expected to result from activities described in paragraphs 2, 4 to 8.

<u>Assistance to the States in the implementation of pollution control measures</u>

11. The technical, administrative and legal measures which may be adopted as a result of recommendations emanating from the programme will need two types of follow-up which are expected to be provided through the programme. These include:

(a) Monitoring of the changes in the levels and effects of pollutants, as an indication of the effectiveness and adequacy of the adopted measures; and

(b) Re-assessment of the situation created by the application of the adopted measures and, if necessary, the formulation of proposals for new or supplementary measures which may be needed for further improvement of the situation.

ORGANIZATION OF THE PROGRAMME

1. A comprehensive programme, for monitoring, assessment and control of marine pollution, obviously requires clear and well-defined management and organizational structures and mechanisms as the basic prerequisite for the achievement of its objectives. In defining these structures and mechanisms, the following should specifically be kept in mind:

   (a) The programme is part of: (i) the relevant Regional Seas action plan, as implemented under the authority of the Contracting Parties to the regional Convention; and (ii) the programme of the IOC's subsidiary body relevant to the region as implemented under the authority of Member States of that region;

   (b) The programme activities relevant to the assessment of the quality of the marine environment are considered as the regional components of UNEP's Global Environment Monitoring System (GEMS) and of IOC's GIPME-MARPOLMON;

   (c) Any on-going related activities and programmes supported by UNEP, IOC, FAO, WHO and other organizations globally and in the concerned region in particular, should be associated with, and as far as appropriate, incorporate in the programme; and

   (d) The existing structures established by UNEP, IOC, FAO, WHO and other organizations will be used to the maximum benefit of the programme.

<u>Participants</u>

2. The programme is to be implemented by a network of national institutions of the States from the region, selected by the coordinating structures of the programme, in consultation with the relevant national focal points.

DEVELOPMENT OF A REGIONAL MARINE POLLUTION MONITORING, RESEARCH AND CONTROL PROGRAMME FOR EASTERN AFRICA

1. Background

The Conference of Plenipotentiaries on the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region convened in Nairobi, 17-21 June, 1985 adopted the final Act of the Conference.

By the Resolution on Programme Implementation the Conference decided on the elements of the Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region, which should be implemented as priorities, subject to the availability of resources. One of the programme's priorities was defined as "monitoring and research related to the sources, levels and effects of pollutants.

A joint UNEP/UN/UNIDO/FAO/UNESCO/WHO/IMO.IUCN exploratory mission visited eight states (Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia and the United Republic of Tanzania) of the region in October and November 1981. The findings of the mission were used to prepare six sectoral reports. Those having specific relevance to this project are:

- FAO/UNEP, Marine pollution in the East African Region; UNEP Regional Seas Reports and Studies No. 8. UNEP 1982.
- UNIDO/UNEP, Industrial sources of marine and coastal pollution in the East African Region; UNEP Regional Seas Reports and Studies No. 7. UNEP 1982.
- WHO/UNEP, Public health problems in the coastal zone of the East African Region. UNEP Regional Seas Reports and Studies No. 9. UNEP 1982.

The reports of the mission were used as the basic working documents of the Workshop on the protection and development of the marine and coastal environment of the East African Region (Mahe, Seychelles 27-30 September, 1982) which drafted the Action Plan and defined the priority activities to be implemented within its framework.

The Conference of Plenipotentiaries of Eastern African States (Nairobi 17-21 June, 1985), referred to above, considered the recommendations of the workshop, adopted the Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region, and accorded highest priority to those activities that concern protection, management and conservation of coastal and marine areas.

2. EAF/6 PROJECT

Taking into consideration the marine environmental problems of the Eastern African Region identified in the above documents, a regional project on Monitoring and Research Related to the Sources, Levels and Effects of Pollutants in the Eastern African Region (EAF/6) was prepared in close co-operation with the Food and Agriculture Organization of the United Nations (FAO) and the Intergovernmental Oceanographic Commission (IOC).

The following are the specific objectives of the project.

(a) Short-Term objectives:

- To formulate and carry out a co-ordinated pollution monitoring and research programme concentrating on contaminants and pollutants affecting the quality of marine life and the coastal environment as well as human health in the Eastern African Region;

- To assist national institutions in developing their capabilities to participate in the programme;

- To analyze the source, amounts, levels, pathways, trends and effects of contaminants relevant to the Eastern African Region as part of the scientific basis for the formulation of proposals for preventive and remedial actions; and

- To formulate proposals for technical, administrative and legal pollution control and abatement measures.

(b) Long-term Objectives:

- To assist the Governments, Contracting Parties to the Nairobi Convention to prevent, abate and combat marine pollution and to protect and enhance the quality of the marine and the coastal environment of the Eastern African Region.

3. Status of the Project Development

In order to assist in the establishment of the network of national institutions, and in initiating the work on the project, a UNEP/FAO mission was undertaken in 1988 to the Eastern African countries party to the Action Plan. The purpose of the mission was to identify, in co-operation with National Focal Points for the Eastern African Action Plan, the national laboratories which may participate in a regionally co-ordinated project on monitoring and research related to sources, levels and effects of pollutants (EAF/6). Specifically, the mission was to look at various aspects of the project in general framework of the comprehensive approach described above, and to determine the assistance they may need (equipment, training) for effective participation in the project. The mission visited the following countries: Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia and Tanzania.

The preparatory phase of the project would concentrate on the establishment of the network of existing national laboratories which would participate in the implementation of the project and on strengthening monitoring capabilities. The established network would then initiate monitoring activities at the selected sites in a consolidated manner covering at each site all aspects of monitoring and research, namely: (i) monitoring and research into trace metals and pesticides residues in marine biota and sediments, including data quality control and assurance; (ii) monitoring of deposition of tar balls on beaches and research into factors influencing it and measurements of basic oceanographic factors affecting its deposition; and (iii) monitoring of bacteriological contamination of recreational waters and shellfish.

4. Potential participants in the Project

Based on the findings of the 1988 UNEP/FAO mission a list of national institutions and laboratories that could participate in the EAF/6 project was compiled (Annex III).

ANNEX I

UNEP REGIONAL SEAS ACTION PLANS

Mediterranean Action Plan

Geographic coverage: Seventeen States participating in the Action Plan (Algeria, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Morocco, Spain, Syria, Tunisia, Turkey and Yugoslavia). Action plan adopted in 1975. Convention signed in 1976; entered into force in 1978. EEC is one of the participants in the Action Plan and is Party to the Convention. Secretariat: UNEP.

Kuwait Action Plan

Geographic coverage: Eight States participating in the Action Plan (Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates). Action Plan adopted in 1978. Convention signed in 1978; entered into force in 1979. Secretariat: Regional Organization for the Protection of the Marine Environment (ROPME).

West and Central African Plan

Geographic coverage: Twenty-one countries participating in the Action Plan (Angola, Benin, Cameroon, Cape-Verde, Congo, Cote d'Ivoire, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mauritania, Namibia, Nigeria, Sao Tome and Principe, Senegal, Sierra Leone, Togo and Zaire). Action plan adopted in 1981. Convention signed in 1981; entered into force in 1984. Secretariat: UNEP.

Carribean Action Plan

Geographic coverage: Twenty-five States participating in the Action Plan (Antigua and Barmuda, Bahamas, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, St. Christopher and Neves, St. Lucia, St. Vincent and Grenadines, Suriname, Trinidad and Tobago, United States of America and Venezuela) and the Carribean territories of France, Netherlands and the United Kingdom. Action plan adopted in 1981. Convention signed in 1983; entered into force in 1986. EEC is one of the participants in the Action Plan and signed the Convention. Secretariat: UNEP.

East Asian Seas Action Plan

Geographic coverage: Five States participating in the Action Plan (Indonesia, Malaysia, Philippines, Singapore and Thailand). Action plan adopted in 1981. Convention expected to be negotiated during 1989/1990. Secretariat: UNEP.

South-East Pacific Plan

Geographic coverage: Five States participating in the Action Plan (Chile, Ecuador, Panama and Peru). Action plan adopted in 1981. Convention signed in 1981; entered into force in 1986. Secretariat: CPPS.

Red Sea and Gulf of Aden Action Plan

Geographic coverage: Seven States participating in the Action Plan (Democratic Yemen, Jordan, Palestine, Saudi Arabia, Sudan and Yemen Arab Republic). Recently (August 1989) Egypt joined the Action Plan and signed the relevant agreement. Action plan adopted in 1982. Convention signed in 1982; entered into force in 1985. Secretariat: Arab League Educational, Cultural and Scientific Organization (ALECSO).

South Pacific Action Plan

Geographic coverage: Sixteen States participating in the Action Plan (Australia, Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Solomon Islands, Tonga, Tuvalu, Vanuatu and Western Samoa) and the South Pacific territories of France, United Kingdom and the United States of America. Action plan adopted in 1982. Convention signed in 1986. Secretariat: SPC.

Eastern African Action Plan

Geographic coverage: Eight States participating in the Action Plan (Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia and United Republic of Tanzania) and the Eastern African territories of France. Action plan adopted in 1985. Convention signed in 1985. EEC is one of the participants in the Action Plan and signed the Convention. Secretariat: UNEP.

South Asian Seas Action Plan

Geographic coverage: Five States participating in the Action Plan (Bangladesh, India, Maldives, Pakistan and Sri Lanka). Action plan and convention expected to be adopted in 1990. Secretariat: UNEP.

ANNEX II

MONITORING OF REFERENCE SITES

BASELINE STUDIES OF SITES CONSIDERED AS BEING UNDER THE INFLUENCE OF POLLUTANTS

RESEARCH AND STUDIES

The following information should be made available for each of the above project elements:

(a) Name, location and size of the area (or area of research);

(b) Matrices, parameters or effects proposed to be monitored;

(c) Sampling methodology, including observation frequency;

(d) Justification for the proposed monitoring programme;

(e) Expected outputs and their use;

(f) Workplan and timetable;

(g) Estimated budget (amounts and purpose to be specified);

(h) National institution(s) responsible for the proposed programme; and

(i) Estimated value of the national institution(s) contribution to the proposed programme (in cash and in kind).

Taking into account principles 1(a) and 2, (elements of programme) the above information is expected to be provided by and based on inputs from scientists from the region who will participate in an expert meeting of potential principal investigators of the project during the preparatory phase of the project.

ANNEX III

NATIONAL INSTITUTES AND LABORATORIES IDENTIFIED AS POTENTIAL PARTICIPANTS IN THE RESEARCH AND MONITORING COMPONENT OF EAF/6

Countries visited	Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia and Tanzania.
Comoros	Laboratoire de Biologie (El Maront Hospital) (Could participate in component D: microbiology)
Kenya	Government Chemists Department (could participate in components A: hydrocarbons, heavy metals, PCBs and B: intercalibration and data quality assurance)
	Kenya Marine Fisheries Research Institute (KMFRI) (could participate in components C: oil/tarbal monitoring and D: microbiology)
Madagascar	Station Marine Tulear (SMT) (could participate in component C: oil/tarball monitoring and D: microbiology)
Mauritius	Government Analytical Laboratory (at Labourdonnais Street) (could participate in components A: hydrocarbons, heavy metals, PCBs and B: intercalibration and data quality assurance)
	Albion Fisheries Research Station (could participate in components C: oil/tarball monitoring and D: microbiology)
	Agricultural Chemistry Division (MANR) (could participate in components A: hydrocarbons, heavy metals, PCBs and B: intercalibration and data quality assurance)
Mozambique	Laboratorio Nacional de Hygiene de Alimentos Agnas (LNHAA) (could participate in components A: hydrocarbons, heavy metals,

	PCBs; B: intercalibration and data quality assurance and C: oil/tarball monitoring)
	Instituto Nacional de Investigacao Verenaria (INIV) (could participate in component D: microbiology)
	Institute of Fisheries Research (IFR) (could participate in component C: oil/tarball monitoring)
Seychelles	Technological Support Services (Ministry of National Development) (could participate in components A: hydrocarbons, heavy metals, PCBs; B: intercalibration and data quality assurance and D: microbiology)
	Public Health Laboratory (could participate in component D: microbiology)
Somalia	Department of Chemistry (National University of Somalia) (could participate in components A: hydrocarbons, heavy metals, PCBs and B: intercalibration and data quality assurance)
	Fisheries Research Department (could participate in component C: oil/tarball monitoring)
	Department of Veterinary Medicine and Animal Production (in collaboration with Department of Fisheries Research) (could participate in component D: microbiology)
Tanzania	Department of Chemistry (University of Dar es Salaam) (could participate in components A: hydrocarbons, heavy metals, PCBs and B: intercalibration and data quality assurance)
	Government Chemical Laboratory (could participate in components A: hydrocarbons, heavy metals, PCBs and B: intercalibration and data quality assurance)

Kunduchi Marine Biology Station (could participate in components C: oil/tarball monitoring and D: microbiology)

Institute of Marine Sciences, Zanzibar
(could participate in components A: hydrocarbon, heavy metals, PCBs; B: intercalibration and data quality assurance and D: microbiology).

Question by Prof. Aswathanarayana

Recent developments in remote sensing e.g. use of Synthetic Aperture Radar has been shown to be a good method (reliable) when used in combination with laboratory tests for monitoring marine pollution. Has this technique been adopted by UNEP for the East African Region.

Answer

Remote sensing is widely used for monitoring of pollution in marine environments. However, it cannot be solely relied upon. Moreover, it is expensive and requires complementary results obtained by other methods.

Question by Prof. Tole

Are there any programmes on the safety of the high seas by UNEP. We hear of the Green Peace Movements but it appears that the activities of the movement are only temporary and not very effective as far as pollution of the respective waters is concerned.

Answer

The high seas waters are out of control of UNEP. However, there are protected areas where no ship is allowed to dump any waste. The enforcement of the laws of the agreement is difficult, and maintenance of pollution-free zones depends on how the respective states respect the agreement.

ORGANIC WASTES/INDUSTRIAL WASTES

CONTRIBUTION OF BREWING AND MALTINGS TO ENVIRONMENTAL POLLUTION CONTROL AND MANAGEMENT

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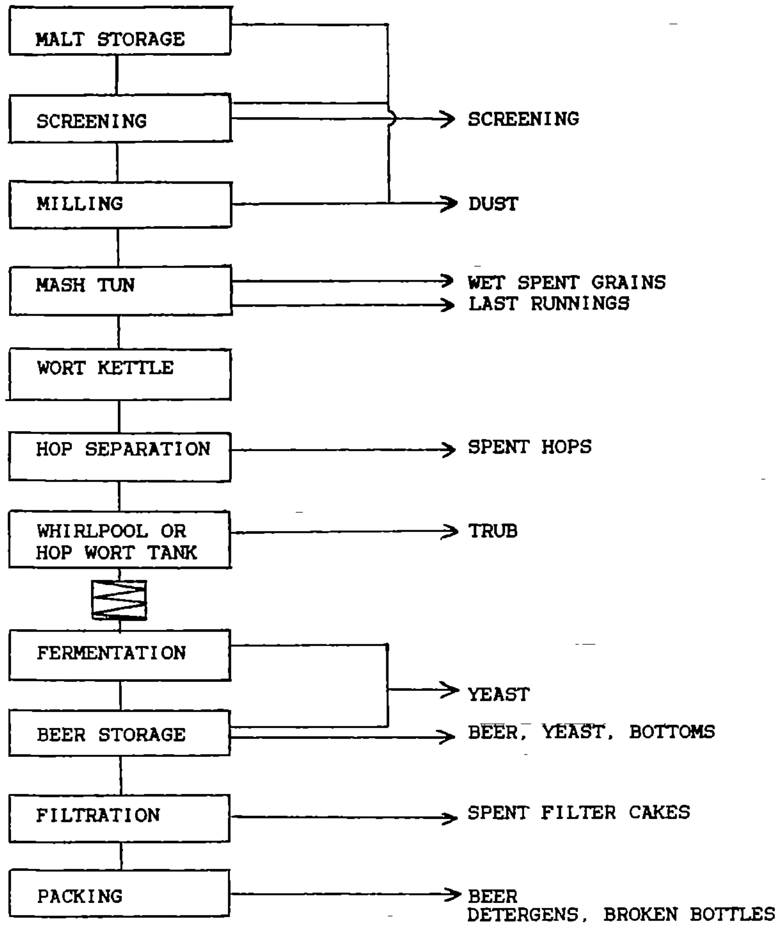
INTRODUCTION

Malting and brewing industries generate a lot of organic waste loads and suspended solids (SS). The organic waste loads primarily originate from steep liquor, excess yeast and tank bottoms, spent hops, trub, last running, spent grain press liquid, spent detergents and beer. Suspended solids are generated from spent grains, yeast, kieselguhr, filter sheets, bottles labels, broken bottles and defective cans.

This paper addresses the overview of organic wastes and SS, their contribution to environmental pollution, control and management. However, very little reference is made on Eastern Africa. The figure overleaf is the process flow of brewing operations showing major waste discharges.

BREWERY WASTES

Essentially there are two stages of operation in a brewery; brewing and fermentation; bottle filling (in Tanzania) in other countries cask, kegging and canning. Each stage produces waste varying in strength both in Biological Oxygen Demand (B.O.D.) and SS. Wastewater of one brewery may be different from the other because of the type of beer produced, e.g. in our brewery the production of Safari generates waste water with high B.O.D. as compared to Pilsner, because of the amount of materials used. Similarly those breweries producing strong ale and stout have even higher B.O.D. than those producing pale ales.



Process flow diagram of beer brewing, showing major waste discharges

In one study, it was estimated that production of one pint of beer imposes a pollution load similar to the sewage discharged by one person each day. In the U.K. for example waste waters coming from the brewing industry are equivalent in organic terms to the domestic sewage produced from a population of about 1 million, not considering the seasonal peaks. In Tanzania, because nobody had any interest on this, the amount of waste water generated could not be estimated. These could very well be associated with the situation at Msimbazi River and its tributaries, let alone the entrance to the ocean at Selender Bridge. Possibly our colleagues from other parts of E. Africa could tell us what is happening in their Breweries.

In terms of wastewater volumes there is a wide variation; in general the waste water could be six to eleven times to the volume of beer produced depending on the brewing practices and the type of beer. Above eleven times then there must be something wrong.

MALTINGS WASTES

Large volumes of water are used in maltings for steeping. Submerging barley requires 9-11 hl/tonne, but several changes of steep water may give rise to lesser volumes. The first steep liquor normally has a higher B.O.D. than the second. Materials contributing to the B.O.D. are soluble components including amino, organic and phosphoric acids, simple sugars, peptides and polyphenols. The pH values of steep liquor vary from 5 to 8 depending on aeration of the steep than the alkalinity of the water used.

EFFECTS OF ORGANIC WASTES AND SUSPENDED SOLIDS ON RECEIVING WATERS

Brewery and malting wastes are almost non-toxic but their polluting effects are essentially restricted to the oxygen - depleting effect they have on receiving waters, although other polluting effects cannot be disregarded. When the wastes are discharged to the environment, they are broken down by bacteria and other micro-organisms. This normally takes place aerobically. This demands a supply of oxygen sufficient to meet the needs of the micro-organisms and the normal fauna and flora. If there is insufficient oxygen much of the normal fauna and flora is poisoned or deprived of oxygen, its natural life is extinguished and the waterway becomes an offensively smelling open sewer.

Strict controls on the levels of suspended solids and materials capable of taking up oxygen reduces pollution of the rivers. Crude wastes may be discharged into rivers when it is not toxic, where the volumes involved are relatively small, not exceeding the "self-purifying capacity" of the receiving waters and when the legislation does not preclude it.

In Tanzania breweries, all the wastes are discharged to the environment and to one of the Msimbazi river tributaries. Similarly, in Arusha the wastes are discharged into the river. The Arusha municipality has started warning the brewery authority to reduce their waste loads. In Dar es Salaam the situation is still calm, possibly due to the high dilution at the ocean and not much of the Msimbazi water is used by the community, unlike in Arusha. The pollution load the brewery has effected at Msimbazi river is tremendous that there is hardly any life in it because there is very little oxygen or none at all.

CONTROL AND MANAGEMENT

Traditionally the brewing industry did not treat their effluent even in the developed world. The breweries were at that time small and constructed in areas which are highly populated to take the advantage of the local authority sewer treatment works. However with the increase in brewing capacity, effluent treatment costs and pressures from the environmentalists, the industry has involved itself in serious controls and management of effluent.

The maltings on the other hand has been practising waste treatment for quite sometimes because of the volume and locations of the malting plants. To discharge steep liquor to rivers directly in some countries, particularly the developed world, has a stringent legislation. The B.O.D. of steep liquor varies from 1,500-3,000 mg/l and SS of above 350 mg/l. In Britain or America for examples the limits are 20 mg/l for B.O.D. and 30 mg/l SS. In Tanzania the malting plant in Moshi include an effluent treatment plant which has never functioned properly since the commissioning of the plant in 1982. The steep liquor is therefore crudely discharged to the environment or rivers.

Thanks to the economic hardships and poor rains that the malting plant has never attained its capacity utilization. There are various methods of reducing waste load and minimizing water usage in malting and brewing. These include preventing product or by-product from entering the sewer, recover as much by-product as possible for inclusion in the animal feed and feed supplements, re-cycling by-product, effluent treatment and good house-keeping.

In maltings, because of the high B.O.D. of the waste water, it is customary to treat this water to reduce the B.O.D. to about 20 mg/l and 30 mg/l SS. Discharge on to the fields at a rate of 15 cm of water per hactre per week also reduces the amount to be discharged to the sewer. Dry cleaning of barley and spray steeping instead of submersion reduces the volume of effluent. Similarly cooling and humidifying water could be recirculated.

It is claimed that the steep liquor soluble components are stimulatory to yeast growth during fermentation; however, very few maltings supply this to breweries unless the malting and the brewery are in one premise. Breweries on the other hand produce more wastes than maltings but these could be minimized and at the end of the day only beer and spent grain exit from the process. The spent grain, press liquor and the last running could be recycled and used in mashing in-operation instead of discharging to the river. This contributes a lot to the reduction in B.O.D., process economy and energy saving. The spent grains could be mixed with trubs excess yeasts from fermentation, and tank bottoms and could be sold as is or dried and pelletized into animal feed and feed supplements. Single cell protein has also been produced from excess yeast.

Spent filter sheets could be washed to remove the kieselguhr, dried and reprocessed into new filter sheets. This stage generate waste water with very high B.O.D. so special treatment is required. Waste beer is normally recovered and reprocessed. However, the spillage goes to the drain. Beer is a strong pollutant, therefore full or partial treatment is of paramount importance. The broken bottles and defective cans are sent to dumping sites. However the large broken bottles are re-processed into new bottles.

Many breweries and malting carry out partial treatment of their effluent, these include trickling-filter systems and activated sludge systems. The techniques involve settling, screening, and aerobic digestion. The aerobic digestion may involve mechanical aeration of the effluent to encourage growth of the aerobic bacteria. Aerobic digestion are usually suitable for effluent with less dissolved organic materials and suspended solids. The plants are multi-stage, therefore more engineering work is required.

The anaerobic system on the other hand require less engineering works, it consists of only two major stages. The biomas digester and the settling tank. It also handles effluents which are rich in dissolved materials and suspended solids. The anaerobic digester generates electricity (from biogas) to power the factory or may be sold to the national grid. Most of the breweries use the cleaning-in-place (CIP) system as its major water conservation programme. Water energy and efficiency in cleaning is effected because it allows the re-use of water and cleaning solutions. Similarly the effluent is highly reduced.

Practising good house-keeping in the brewery has been claimed to reduce effluent up to about 25%. In Tanzania breweries there is no control and management of waste loads or effluent treatments. All the effluent irrespective of the B.O.D. and SS are directly discharged into the river. It was understood when the breweries were established that there was no danger to the environment because the capacities and the city and towns population were low. Similarly there was no legislation which precluded the discharge of crude wastes to the sewer, river or environment. However with the increase in production and the continued expansion programmes and possibly the imposition of environmental legislation, the management has to seriously think on how to reduce waste loads and effluent treatments. In other countries the reduction of waste loads and water usage is an integral part of all new designs and process revision and is considered during design review meetings.

CONCLUSION AND RECOMMENDATIONS

1. It is true that breweries and maltings are not the major pollution offenders as compared to pulp and paper, or textiles and chemical industries. However, they contribute to the industrial effluent loads, therefore have a role to play. Waste water treatment, whether in plant or at a local authority, is an expensive operation. Carrying out an appropriate in-plant investigation and good planning minimizes these costs and reduces environmental pollution.

2. Most of the people do not understand the meaning and ways of enhancing environmental protections therefore a strong national environmental policy followed by campaigns to educate the public on the significance of environment to lives and a need to protect and preserve the environment. The Policy should be followed by a strong legislation which will punish the environmental offenders.

3. The Industries should start research and development units which would research on water conservation, type of plant which would be suitable and skills needed to manage the plants economically and efficiently, because to run a waste treatment plant is very costly.

4. New expansions and process designs of the industries should include a waste treatment plant. The anaerobic treatment plants would be more suitable because it handles wastes which are rich in B.O.D. and SS. It is also cheaper than aerobic plants.

5. Linkage between policy and decision makers and scientists.

Question by Mrs. A.K. Kivaisi

Since Tanzania Breweries did not plan for its waste treatment initially, why isn't it advised to make modifications in order to at least direct its waste-waters to the municipal sewage system rather than to continue dumping everything into Msimbazi creek.

Answer

It is very difficult for scienctists to advise decision makers without involving highly place politicians. The lack of co-ordination between scientists and decision makers is a very big draw-back in attempts to control pollution.

Question by Dr. H. Gijzen

Tanzania Breweries is planning to increase its production. Since there are no plans to treat its waste, no doubt pollution will also increase. There is, therefore need for an immediate action to minimize the pollution by recycling and re-utilization. The used grains could be used as animal feed while excess yeast could be re-used instead of dumping.

Answer

Only a small fraction of spent grain is used as animal feed and the rest is dumped. Excess yeast is re-used. It is only the bad yeast which is discharged together with waste water.

RIVER POLLUTION IN DEVELOPING COUNTRIES A CASE STUDY: EFFECT OF WASTE DISCHARGES ON QUALITY OF RUIRUAKA RIVER WATERS IN KENYA

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ABSTRACT

The effect of various effluent on the quality of Ruiruaka river waters was studied over a period of about one year, water samples were collected at five chosen points along the stream at regular intervals over a period of nine months. Ten quality parameters, namely temperature, pH, conductance, biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved solids (DS), suspended solids (SS), levels of chloride, nitrate and total phosphate were monitored at each point. In addition water samples were also analyzed for profiles of both the dissolved and suspended forms of elements with special attention to the presence of toxic metals such as mercury, lead, cadmium, copper and zinc. The quality parameters of waters at selected sites were also monitored at different times of the day. The study revealed that levels of pollutants varied considerably at all the sites depending on the time of the day and also had seasonal variations. Inferences were drawn based on the analytical data.

INTRODUCTION

Pollution of Water Systems is one of the major problems faced by most of the industrialized countries. This has lead to increased awareness to minimize water pollution in developing countries. The root cause of river pollution is man's tendency to dilute and dispose wastes instead of removing them at the source. With the ever increasing population levels, migration to urban centers and industrialization, the environment, in particular the water systems, are considerably polluted even in the developing world. As a result many streams and rivers which are sources of life and other activities have been converted into polluted drains. The wastes discharged into waterways can be classified into three general types - domestic, industrial and agricultural. Industrial pollution, particularly due to the presence of organic or inorganic substances, is the commonest type of pollution which is the most intractable.

In the Kenyan context, analysis of waters, sediments and plants for heavy metals in various lakes in Kenya, such as Lake Victoria, has been reported[1] . Nitrite concentration in surface and ground waters in various parts of Kenya has also been studied. No systematic work has been done to evaluate the quality of river waters on any of the rivers in Kenya, except on Nairobi and Ngong rivers. In the present communication the results of the detailed studies conducted on Ruiruaka river water of about nine months from November 1985 to July 1986 are reported.

Ruiruaka river originates in the Kikuyu escarpments of Kenya and descends through coffee plantations and Karur forest land in the Kiambu district which neighbours Nairobi city. For about 10 km stretch the river runs within the Greater Nairobi city limits, flowing through large coffee plantations, agricultural farms, forest and residential areas before it enters Ruiruaka estate which is a region slowly developing as the second industrial area of Nairobi. Further down, the stream passes through sparsely populated region with minimal or marginal industrial and farming activities and finally joins the Nairobi river (Figure 1). The river has flow throughout the year although the flow is lean in the summer months. The rainy season was in the months of April and May in 1986. Ruiruaka river has an approximated flow of 94 ± 25^3 per minute in the lean months at the first sampling point (RUA I) and the volume of flow at last sampling point (RUA V) was about 250 ± 65 m^3 per minute. During the rainy seasons the flow rates were about 6-8 times and 4-5 times higher than in the lean periods at RUA I and RUA V respectively.

EXPERIMENTAL

I. Sampling sites:

In this study of the effect of various effluent on the quality of the waters five sampling points were identified as follows:-

RUA I - (Limuru road bridge) At this point, the river carries water from its upper tributaries and also run-off waters from coffee plantations and forest lands.
RUA II - A location within Karura forest with little human activity and about 2.5 km from RUA I.

RUA III - Prior to the point the river emerges from a swamp carrying partly treated domestic sewage and waters from small tributary from farm lands. About 1.5 km from RUA II.

RUA IV - A location about 500 m down stream from discharge of brewery effluent and about 1 km from RUA III.RUA V - Downstream location with no industrial activity and located about 3 km from RUA IV.

II. Sampling:

Water samples were collected at the identified sampling points about the midstream of the river, avoiding air bubbles. All the sample bottles (polyethylene containers) were thoroughly washed with water, then soaked in nitric acid and washed with distilled water before sampling. Samples were collected in 1000 cm^3 containers and the pH of the sample was adjusted to about pH 2 with nitric acid to prevent metabolic processes which cause changes in samples and to reduce the absorption of metal compounds on the surface of the container. The samples were stored in a refrigerator.

Methodology:

Temperature was measured immediately after the sample was collected. pH and conductivity values were determined in the laboratory in the quickest possible time. BOD_5, 20°C, COD, DS and SS were determined employing standard procedures[2-4]. Chloride was determined by Volhard's method[4] and nitrate was determined by the Brucinemethod[4]. Total phosphate was determined calorimetrically after persulphate digestion as ortho phosphate[4]. X-Ray Fluorescence technique was used for the analysis and complete profile of various metals both in suspended particulate form and in soluble form in the water samples[5-6]. The X-Ray Fluorescence spectrometer comprised of an Ortec SILi detector (HWFW-200 ev at 5.9 K.ev) and a Canberra multi-channel analyzer (MCA-40) linked to a professional 350 computer. The excitation source was ^{109}Cd of energy 22.1 EV and of half life 453 days.

RESULTS

Water samples were collected at monthly intervals over a period of nine months (Nov.'85-July'86) at all the five sampling points identified. Samples were analysed for different parameters to characterize the quality of the waters. The analytical data obtained for a typical batch of sample from five sites (19th Nov.'85) are tabulated in Tables 1 and 2. The levels of various parameters over 9 months at each sampling point, i.e. the variation of temperature, hydrogen ion concentration and conductivity, the levels of BOD, COD, DS, SS, chlorides, nitrates and phosphates are illustrated in figures 2-5. The levels of selected heavy metals as they exist in the aquatic samples were analysed separately, as soluble and suspended species and are shown in figures 6-9. The analytical data presented for metals is restricted to only the levels of zinc, copper, manganese, lead and titanium while other toxic metals were below the detectable limits.

Data analysis and discussion:

A perusal of figures 2-9 indicate that in general throughout the study period the quality parameters of water samples at RUA I, RUA II and RUA III were fairly the same except for the occasional variations observed at RUA III which are possibly due to the inflow of domestic or farm effluent prior to the point. The characteristics of the waters at RUA IV changed significantly due to influx of brewery effluent.

(a) Temperature

The temperature of Ruiruaka river waters at RUA I varied between 17.1 and 20.1°C, touching the lower in the rainy season (Fig. 2). Slight decrease in temperature (about 0.5°C) was recorded at RUA II, possibly due to slow flow through thick forest covered with trees. A relative increase was observed at RUA II in all samples. A significant increase of 1 to 2°C was observed at RUA IV, due to the influx of warm brewery effluent. At RUA V, relative to RUA IV, a lower temperature was recorded possibly due to thermal exchange with surroundings.

(b) pH

A perusal of the data presented show that the pH of waters between RUA I and III varied between 7.0 and 7.5 during most of the study period. Exception was the rainy season, during which the pH was about 6.5. At RUA IV the pH dropped to 5.5 in some samples indicating acidic nature of the brewery effluent. The pH difference between RUA III and IV samples were less pronounced in the rainy months when the river carried a high volume of water. At RUA V the pH raised to some extent in all the samples.

(c) Conductance (Specific conductivity)

The conductance value at RUA I, II and III varied between 98 and 215 $\mu s\ cm^{-1}$. The lower values were observed during the rainy season. High values

(450 $\mu s\ cm^{-1}$) were recorded at RUA IV due to inflow of brewery effluent. Relative to RUA IV lower values were observed at RUA V.

(d) BOD

The biochemical oxygen demand determined after 5 days incubation at 20°C were found to be quite low in all the aquatic samples at RUA I, II and III ranging mostly between 6 to 16 mg/l during the study period (Fig. 4). Fairly low BOD values all the way down to RUA III indicate the good state of the waters upstream. Higher BOD levels maximum reaching up to 2700 mg/l were noticed at RUA IV. But even at RUA IV values of BOD reduced to 34 mg/l during rainy season due to high dilution of effluent by rain waters. The levels of BOD at RUA V were found to be significantly low compared to values at IV pointing towards the rapid self-purification process, which could be due to the quality of waters prior to RUA IV and due to the efficiency of natural cleaning processes[7]

(e) COD

The chemical oxygen demand values at RUA 1 to III were not affected much by seasonal changes remaining fairly in the same range 34 to 84 mg/l over the study period (Fig. 3). Low COD Values observed indicate that the waters were fairly clean up to this point. COD levels at RUA IV were considerably high and in dry season, Jan. '86 as high as 6,520 mg^{-1}, but fairly low values were observed in rainy months of April and May '86 due to the high volume of water in the river (Fig. 4). Relative to RUA IV, about a 10% reduced COD levels were observed at RUA V.

(f) DS

The dissolved solids at RUA I varied widely ranging from 104 to 550 mg/l during the duration of study, lower values being in rainy season. Similar levels were noticed at RUA II and III. At RUA IV the maximum and minimum values were 1690 mg/l (in dry season) and 180 mg/l (in rainy season) respectively. AT RUA V DS values reduced significantly relative to RUA IV (Fig. 5) DS levels at RUA IV much above the acceptable levels for drinking water consideration according to WHO standards.

(g) SS

The suspended solids at RUA I to RUA III ranged from 30 to 70 mg/l (Fig. 5). The values of SS were higher in the rainy months than in the dry season which could be due to run-off of different suspended solids with rain waters. In all seasons relatively high values of

SS were observed at RUA IV. At RUA IV the seasonal influences were the reverse of what was observed at the other points, recording lower SS levels in the rainy months (80 mg/l) and higher levels in the dry months (2760 mg/l). This was possibly due to dilution of brewery effluent by high volume of rain waters. Significantly lower values were observed at RUA V, showing a good recovery of the stream from the pollution in a distance of only 3 km.

(h) Chloride

During the investigation period, chloride concentrations in the river water between RUA I and III was in the range of 10 to 20 mg/l. About a five fold increase was observed at RUA IV which is possibly due to brewery discharges.

(i) Nitrates

Nitrate concentrations estimated as $N\text{-}NO_3$ between RUA I and III were in the range of 0.26 to 1.96 mg/l (Fig. 3). The higher values were observed during the rainy season which could be the result of the washing off of the nitrate fertilizers from the farms. No appreciable increases in nitrate levels were observed at RUA IV. This suggests that the brewery discharges also contain approximately similar concentrations of nitrate as in the receiving waters. Nitrate concentrations tended to be lower at RUA V.

(j) Phosphates

The total phosphate concentrations estimated as $P\text{-}PO_4$ were found to be in the range of 0.01 to 0.28 mg/l higher being in rainy season at RUA I, II and III. Marked increases were recorded at RUA IV reaching as high as 2.90 mg/l (June 1986) which is far above the WHO acceptable standards (0.2 mg/l)[8]. This was due to brewery effluent which contained high concentrations of phosphate. Phosphate levels at RUA V varied in the range of 0.31 to 1.57 mg/l. These levels are considerably higher compared to corresponding levels at RUA I.

(k) Soluble elemental concentrations

Soluble copper concentrations at RUA I to III were below the detectable limit and in the dry seasons maximum detected was about 28 ppb. An increase in concentration was recorded at RUA IV where the concentration ranged between 28 ppb (rainy season) and 15 ppb (dry season). Relatively lower values were observed at RUA V (Fig. 7). Zinc concentrations at RUA I, II and III varied in the range of 31-110 ppb lower being in the rainy season, except for occasional increase observed at RUA III (154 ppb). At RUA IV values ranged between 55 ppb (rainy season) and 530 ppb (dry season) which indicates that the brewery effluent carry high concentrations of zinc. Relatively lower values were recorded at RUA V (Fig. 6).

Soluble form of manganese at RUA I varied between 80 to 4800 ppb, higher being in April '85 during rainy months. In the same batch of samples the concentration of Mn at RUA II further increased reaching a value of 6360 ppb. Relatively lower values were observed at RUA III. No significant increase in Mn levels were observed at RUA IV. Substantial increase in soluble form of Mn at RUA I and II suggest run-off waters from Mn rich soils (Fig. 8).

During the study period, quite low levels of soluble form of lead were observed at RUA I to III. Occasionally in some samples 110 ppb Pb was detected. No noticeable increase was detected at RUA IV due to influx of effluent (Fig. 9).

Suspended elemental concentrations

Concentration of suspended form of titanium was generally high even at RUA I, and in the range of 170 to 970 ppb, the higher being in the rainy season. This could be due to Ti rich soils in the catchment area of the river. Increase in suspended titanium levels at RUA IV were only marginal and relatively lower values were observed at RUA V. Suspended zinc levels at RUA I to III were in the range 15 to 32 ppb. Maximum suspended zinc observed was about 75 ppb and at RUA IV in the months of Jan., Feb., and March '86 and fairly same levels were maintained at RUA V (Fig. 6).

Suspended form of copper at RUA I to III was either below the detection limit or low in the range of 10 to 20 ppb. At RUA IV, while it was below detection limit in rainy season, maximum recorded in the dry season was about 160 ppb (Fig. 7).

Suspended form of Mn was generally low in dry seasons at RUA I to III and higher values observed in rainy season suggest that the source of both the suspended and soluble form of manganese is prior to the first sampling point. Influx of brewery effluent had no marked effect on the suspended Mn levels as evident from the data obtained at RUA IV (Fig. 8).

Suspended lead concentrations in water samples at RUA I to III were below the detection limit except in few samples at RUA II. Data obtained at RUA IV suggests that from breweries occasional washing of trace concentration of suspended form of lead occurs (200 ppb) (Fig. 9).

CONCLUSIONS

Analysis of the data, figures and results indicate that the quality of the Ruiruaka river waters can be classified as good between RUA I and II, fair at RUA III. In the downstream the quality of water deteriorated due to the influx of the brewery effluent. This is evident from the pH values of the receiving waters reaching as low as 5.5 and BOD and COD values reaching very high values such as 2700 mg/l and 6520 mg/l respectively in some aquatic samples at RUA IV. The peak DS and SS values recorded at RUA IV were about 1690 mg/l and 2760 mg/l respectively explicitly indicate the heavy burden carried by the river in the summer months. The waters at RUA IV were also enriched with substantial concentrations of phosphate which facilitate the growth of biota which further depletes dissolved oxygen in waters. A sign of recovery of the stream was observable in 2-3 km stretch from RUA IV to V self purification process but slow. In the rainy months the quality parameters at RUA IV and V clearly show that the river effectively dilutes the pollutants entering in and quickly recovers to a class of moderately polluted river.

Both the soluble and suspended forms of elements observed were well within the acceptable levels, and the brewery effluent contributed to only marginal increase in elemental concentrations. Overall the analytical data clearly pinpoint the brewery discharges as the main source of pollution of the river. This drastically impairs the quality of the waters in the dry seasons. This could be quite effectively controlled by retaining the effluent in oxidation ponds over a period of few days to let the suspended and dissolved solids to settle down. The retention in oxidation ponds and primary treatment would also bring down the BOD and COD levels of effluents before they are discharged into the river[9]. Although at this stage (1986) the river appeared not to be heavily polluted, considering the fast growth of industrial activity and increase in settlements in the rain catchment areas, Ruiruaka river has the potential of turning into a heavily polluted drain in the near future if proper controls are not implemented. This would lead to a variety of hygienic problems.

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Question by Mr. Paulsson

For what purpose were you conducting this study?

Answer

This study was carried out for purely scientific purposes in collaboration with the city council of Nairobi.

Question by Mr. Paulsson

Were the results communicated to the City Council of Nairobi?

Answer

The City Council of Nairobi is informed of the results but unofficially.

FIG I MAP OF NAIROBI AREA SHOWING SAMPLING POINTS ON RUIRUAKA RIVER

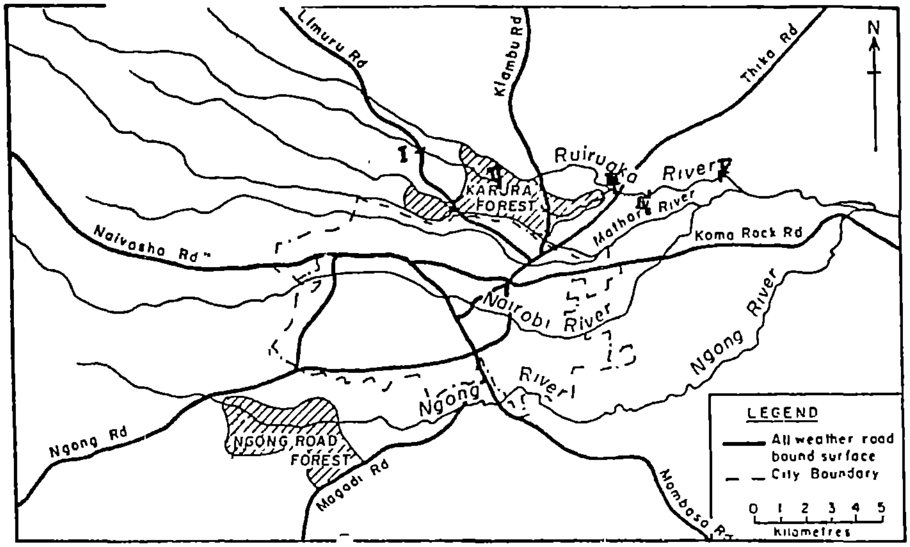


FIG 2 TEMPERATURE AND pH PROFILE OF RUIRUAKA RIVER WATERS

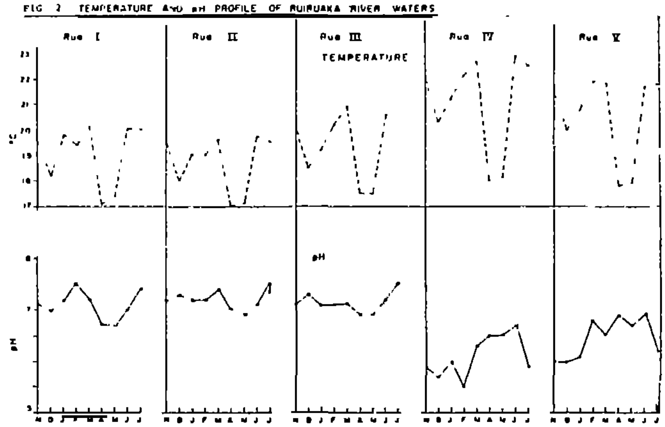
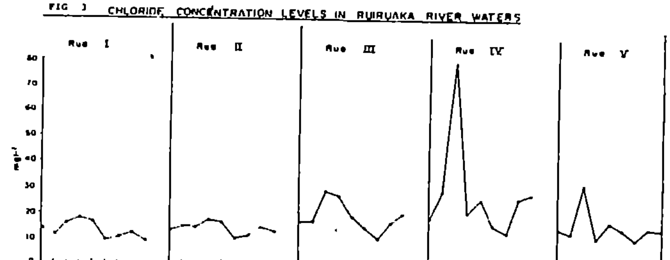


FIG 3 CHLORIDE CONCENTRATION LEVELS IN RUIRUAKA RIVER WATERS



NITRATE AND TOTAL PHOSPHATE LEVELS IN RUIRUAKA RIVER WATERS

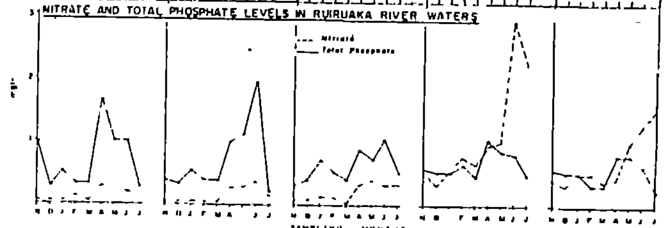


FIG. 4 BIOCHEMICAL AND CHEMICAL OXYGEN DEMAND OF RUIRUAKA RIVER WATERS

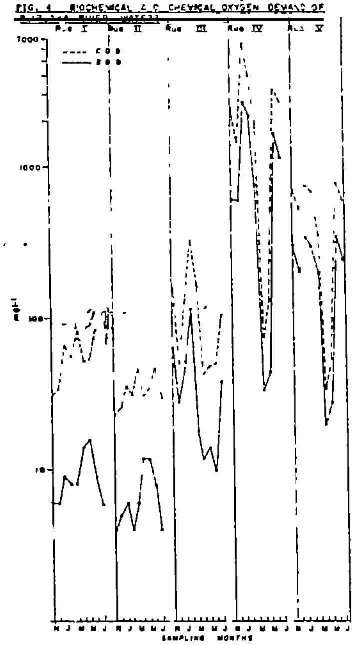


FIG 5 DISSOLVED AND SUSPENDED SOLID LEVELS OF RUIRUAKA RIVER WATERS

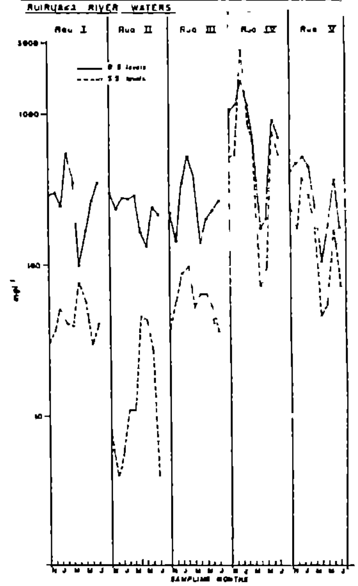


TABLE 1

QUALITY PARAMETERS OF RUIRUAKA WATERS SAMPLED ON 19th NOVEMBER, 1985

PARAMETERS	SAMPLING POINTS I	II	III	IV	V
Temperature (°C)	19 6	19 4	20 1	22 1	21 5
pH	7 1	7 2	7 1	5 9	6 0
Conductivity (mcm^{-1})	155	157	146	321	241
BOD (mg l^{-1})	6	4	64	610	300
COD (mg l^{-1})	31	23	156	2 450	705
D S. (mg l^{-1})	289	294	220	1 050	424
S S (mg l^{-1})	31	8	38	516	252
Chloride (mg l^{-1})	14	14	17	19	15
Nitrate (N-NO_3) (mg l^{-1})	1 00	0 40	0 30	0 60	0 54
Total Phosphates (P-PO_4) (mg l^{-1})	0 05	0 05	0 06	0 50	0 40

TABLE 2

QUALITY PARAMETERS OF RUIRUAKA WATERS (19th Nov' 85)-SOLUBLE AND SUSPENDED ELEMENTAL CONCENTRATION

(a) Soluble elemental concentration

ELEMENTS	LLD/ppb	Precision %	SAMPLING POINTS I	II	III	IV	V
Mn (ppb)	4	11	*	50	57	78	55
Cu (ppb)	5	14	10	*	17	74	40
Zn (ppb)	8	13	40	26	100	73	40
Pb (ppb)	10	35	38	115	25	20	*

(b) Suspended matter elemental concentration

ELEMENTS	LLD/ppb	Precision %	I	II	III	IV	V
Ti (ppb)			243	274	188	341	98
Cu (ppb)			*	*	*	76 0	55
Zn (ppb)			15	17	17	25	18

* - below the minimum detectable limit

FIG. 6 ZINC LEVELS IN RUIRUAKA RIVER WATERS

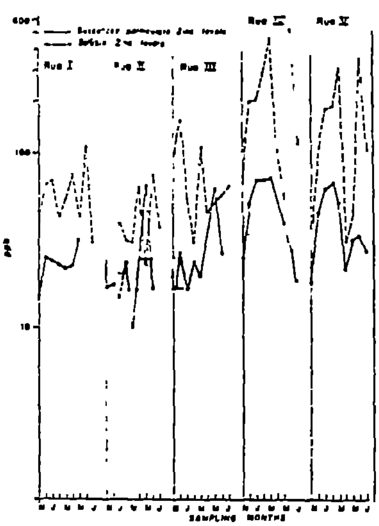


FIG. 7 COPPER LEVELS IN RUIRUAKA RIVER WATERS

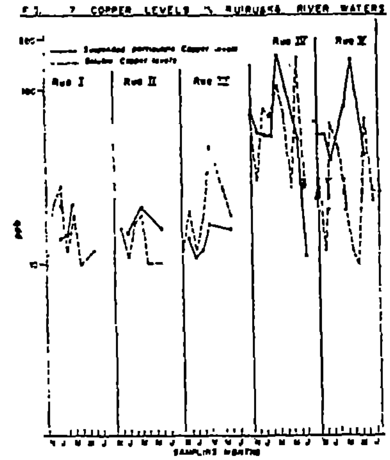


FIG. 8 MANGANESE LEVELS IN RUIRUAKA RIVER WATERS

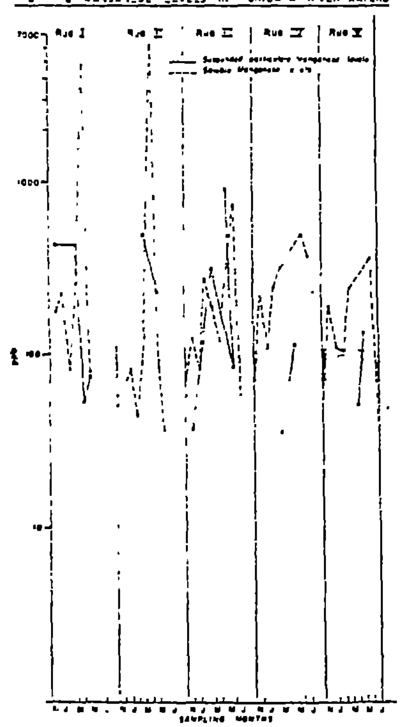
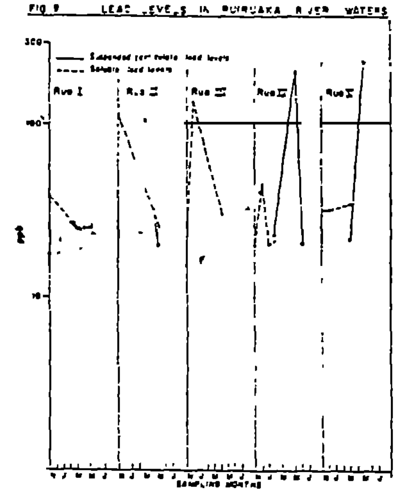


FIG. 9 LEAD LEVELS IN RUIRUAKA RIVER WATERS



IMPACT ASSESSMENT OF FERTILIZER PLANT DISCHARGES ON THE QUALITY OF MUKUVISI RIVER

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INTRODUCTION

The city of Harare, the capital city of Zimbabwe, covers an area of 559 sq. km and is situated at a height of 1492 m above sea level. Its current population is estimated at about 1 million. The major water source for this population is lake Mcllwaine, which is situated 30 km South-West of the city. It is a fairly big dam, 13.6 km long and an average width of about 2 km. It is supplied by three major rivers which together make up the drainage system of the city. Marimba river drains the Northern suburban area and the main industrial areas; Mukuvisi river originates in the North-East and runs through the center of the city; and Manyame river to the South of the city runs through Chitungwiza which has a population of about 100,000.

The city is therefore the catchment area for its own water source. This is an unusual and potentially hazardous situation. A thorough study of the impact of this unfortunate geographical arrangement on the current quality of the river waters and the drinking water of the city, and a thorough impact assessment of any future developmental projects are crucial to maintain the quality of the water at acceptable international standards.

One of the current problems is excessive eutrophication of the lake by the water-hyacinth and the water lettuce. Some of the suspected causes of this overgrowth of weeds is nourishment from the effluent from the sewage treatment plants, domestic waste and industrial waste. One major industry suspected of being a main source of these nutrients is ZIMPHOS - a fertilizer manufacturing company situated adjacent to the Mukuvisi River. ZIMPHOS discharges its partially treated and untreated waste into the river. The major constituents of these discharges are expected to be phosphates, nitrates, chlorides, calcium and potassium.

The aim of this study is to evaluate the impact of the fertilizer effluent on the quality of the Mukuvisi waters.

METHODOLOGY

Water quality parameters like temperature, pH, conductivity, DS, SS and the concentration levels of inorganic phosphate, nitrate, chloride, potassium and calcium were monitored at 3 points along the river. Sampling point No. 1 was just above the bridge where Mutare Road crosses the Mkuvisi River; No. 2 was just after the fertilizer plant; No. 3 was 3 km downstream from the fertilizer plant.

Water samples were collected using two liter polythene bottles. Bottles were pre-washed with nitric acid and thoroughly rinsed with distilled water. At each sampling point, three samples were collected within a radius of 10 meters. One of the bottles, for metal analysis, was acidified with nitric acid in order to keep metals in solution. All the bottles were tightly sealed and immediately taken to the lab for analysis. The water temperature was recorded on site. All the other parameters were analysed in the laboratory.

pH:

The pH was measured at 25°C using an ORION pH meter and glass electrode.

Suspended solids (SS):

500 ml of water were filtered through coarse filter paper which had been pre-dried to constant weight and the filter paper and residue were dried to constant weight. The difference in weight corresponded to the weight of the suspended particles.

Dissolved solids (DS):

20 ml of filtered water were dried in a crucible. The change in weight corresponded to the weight of the dissolved solids.

Conductivity:

Conductivities were measured at 25°C directly in Siemens using a conductivity meter (WPA scientific instruments).

Chloride:

Chloride was measured volumetrically by titrating 100 ml portions of water samples with a standard solution of silver nitrate in the presence of potassium chromate as an indicator.

Nitrates:

Nitrates were measured colorimetrically using a UV-spectrometer (SPEKOL 11). Concentrations were estimated by measuring the intensity of the yellow colour developed by the reaction of Brucine with nitrates.

Phosphates:

Inorganic phosphates were measured calorimetrically using the phosphomolybdenum method. Ammonium Molybdate reacts with orthophosphate to produce phosphomolybdenum, which is a deep-blue complex. Phosphates in water were converted to orthophosphate by digestion with persulphate.

Potassium and Calcium

These were measured using Atomic Absorption spectroscopy. Strontium chloride was added to Ca^{++} samples to minimize spectral interference.

Data from 1973 to 1988 was obtained from city of Harare Water Works Department.

RESULTS

There are two kinds of results presented in this paper:

1. Annual averages (1973 to 1988) obtained from the city of Harare Water Works Department and our data (1989), and
2. Data obtained recently from an intensive monitoring exercise for one week (Aug. 28th to 31st, 1989).

Temperature:

During the intensive monitoring exercise for one week, the temperature ranged from 14°C in the mornings to 22°C in the afternoons. At points 1 and 2 temperatures were the same but point 3 temperatures were about two degrees lower, mainly because point 2 was located at a densely wooded area.

pH:

The pH ranged from 6.7 to 7.6 at POINT 1, 3.2 to 5.7 at POINT 2 and from 5 to 6.4 at POINT 3 for the annual averages from 1973 to 1988. The pH at POINT 2 was two units lower than at POINT 1. The same pH pattern was noticed in the weeks monitoring from 28th to 31st August. There is some improvement at POINT 3 to pH values around 6.0. The pH of the discharges was very low (3.5) showing that the plant was responsible for the acidity at POINT 2.

Dissolved Solids:

The concentration patterns of dissolved solids were very clear. At POINTS 1, 2 and 3 the averages were 64, 1143 and 310 ppm respectively. Point 2 always showed considerably higher levels than POINT 1 showing that the excessive levels of dissolved solids were introduced by the discharges from the plant. This was confirmed by results of measurements of dissolved solids in the discharges (1888 ppm).

Conductivity:

Conductivities averaged 190 μmhos at POINT 1, 1550 at POINT 2. At POINT 3 went down to 325 μmhos due to some dilution, and 2137 μmhos in effluents. The patterns observed for conductivities are identical to those for dissolved solids, as expected.

Potassium and Calcium:

Both K and Ca showed very high levels at POINT 2 compared to POINT 1, and at POINT 3 levels were still high, even though there were signs of recovery (See Table 5).

Phosphates:

The averages were 4.30, 10.96 and 9.24 ppm at P1, P2 and P3 respectively. The concentrations in the discharges were 16.17 ppm showing that the fertilizer plant was the source of the pollutant.

Chloride:

Chloride concentrations averaged 17.78, 37.90 and 20.60 ppm at P1, P2 and P3 respectively. The discharges contained 45.20 ppm Cl which again confirms that the plant was the source of these unacceptably high levels of salts.

Nitrates:

Nitrate concentrations showed the same pattern as chloride, i.e. 3.96, 30.09 and 16.21 at P1, P2 and P3 respectively.

Data from the city of Harare Water Work Department also show the same picture over many years. The fertilizer plant is obviously discharging waste-water carrying unacceptably high levels of salts. pHs are too low (<4) for virtually the whole dry season (April to October). During the rainy season there is some improvement (pH 5.5) due to dilution.

These results indicate that the fertilizer plant is contributing significantly to the nutrients causing excessive growth of weeds, in particular the water-hyacinth, in lake McIlwaine. Estimates based on the total volume of water carried by the three rivers to the lake and the average concentration of phosphates, nitrates and ammonia in their waters, show that Mukuvisi river waters contribute 63.7% of the phosphates, 76.7% of the nitrates, and 88.1% of ammonia going into the lake. Compared to the other two rivers (Manyame and Marimba rivers) Mukuvisi carries 23% of the water flowing into the dam, but 75% of the key nutrients needed by the weeds. Phosphate is a critical factor in plant biomass accumulation and its removal from the fertilizer plant discharges could help to reduce the rate of growth of the weeds.

CONCLUSION

The fertilizer company could reduce the salt load in the waste-water discharges by efficient utilization of sedimentation ponds and secondary treatment to enhance precipitation of dissolved salts. The pH of the waste waters could be easily raised to between 7 and 8 by neutralization with base, before it is discharged into the river. The accumulated solid waste could be taken to carefully selected dump sites far away from sensitive areas. A more drastic solution could be to actually relocate the plant. This might seem to be too expensive initially, but could prove to be a more economic solution in the long run.

Table 1: Quality parameters of samples collected on Monday, August 28th, 1989.

	POINT 1	POINT 2	POINT 3	Effluent
PARAMETERS:				
Temperature (°C)	14	18	16	17
Dissolved Solids (ppm)	75	1026	207	1200
Conductivity (micromhos/cm)	273	1590	160	1750
pH	7.1	3.55	6.94	3.91
Nitrates (ppm)	1.44	62.24	28.06	3.96
Phosphates (ppm)	2.30	10.95	8.15	15.21
Chloride (ppm)	7.5	32.1	22.2	-
Potassium (ppm)	31.16	36.8	7.45	-
Calcium (ppm)	66.3	120.9	159.0	

Table 2: Quality parameters of samples collected on Tuesday August 29th, 1989.

	POINT 1	POINT 2	POINT 3	Effluent
PARAMETERS:				
Temperature (°C)	22	19	16	20
Dissolved Solids (ppm)	80	120	190	1490
Conductivity (micromhos/cm)	180	1545	385	1630
pH	6.55	4.44	7.36	3.79
Nitrates (ppm)	-	15.3	.27	44.3
Phosphates (ppm)	4.19	8.79	-	20.84
Chloride (ppm)	15.9	21.3	4.08	45.2
K (ppm)	14.88	34.54	26.8	-
Ca (ppm)	70.9	123.6	64.7	153.9

Table 3: Quality parameters for samples collected on Wednesday, August 28th, 1986.

	POINT 1	POINT 2	POINT 3	Effluent
PARAMETERS:				
Temperature (°C)	21	19	15	20
Dissolved Solids (ppm)	70	1247	460	3755
Conductivity (micromhos/cm)	158	1695	372	3730
pH	6.98	3.76	7.27	3.44
Nitrates (ppm)	3.24	60.5	9.72	4.32
Phosphates (ppm)	3.55	7.62	8.70	27.18
Chloride (ppm)	24.7	41.5	33.2	-
Potassium (ppm)	4.53	47.76	4.65	-
Calcium (ppm)	36.2	141.8	114.6	178.7

Table 4: Quality parameters of samples collected on Thursday, August 31st 1989.

	POINT 1	POINT 2	POINT 3	Effluent
PARAMETERS:				
Temperature (°C)	19	19	15	21
Dissolved Solids (ppm)	30	1155	280	1105
Conductivity (micromhos/cm)	150	1370	386	1440
pH	6.98	3.76	7.27	3.44
Nitrates (ppm)	-	-	-	-
Phosphates (ppm)	7.21	16.48	10.86	1.44
Chloride (ppm)	23.04	56.7	22.9	-
K (ppm)	8.22	28.3	7.45	-
Ca (ppm)	65.3	103.3	105.3	-

Table 5: Mean values for quality parameters measured daily from August 28th to 31st August, 1989.

	POINT 1	POINT 2	POINT 3	Effluent
PARAMETERS:				
Temperature (°C)	19	19	15.5	20
Dissolved Solids (ppm)	64	1143	310	1888
Conductivity (micromhos/cm)	190	1550	325	2137
pH	6.83	3.85	7.21	3.72
Nitrates (ppm)	3.96	30.09	16.21	17.44
Phosphates (ppm)	4.30	10.96	9.24	16.20
Chloride (ppm)	17.78	37.90	20.60	45.20
Potassium (ppm)	14.70	36.85	2.08	-
Calcium (ppm)	59.68	122.45	110.9	165.3

Table 6: Annual averages of quality parameters for data from the years 1973 to 1988 at sampling points 1, 2 and 3 (obtained from city of Harare - Water Works Department).

Parameter / Year	Cl (ppm)	Amonia (ppm)	Nitrates (ppm)	pH	Total Hardness	Phos. (ppm)	Conductivity (μMhos/cm)
1973:							
P1	20	0.09	-	7.9	62	0.11	-
P2	136	22.8	-	3.25	1100	1.6	-
P3	68	1.6	0.4	5.5	484	0.9	-
1977:							
P1	4.0	0.1	-	6.6	28	0.027	-
P2	-	2.68	0.4	3.3	1200	7.70	-
P3	24	0.22	0.07	4.7	188	1.70	-
1978:							
P1	7	0.13	0.1	7.17	30	0.30	-
P2	17	3.24	0.45	3.34	181	0.667	-
P3	16.5	-	-	4.88	128	0.278	-
1982:							
P1	6.3	0.103	0.22	6.44	27.3	0.039	-
P2	17.7	3.81	0.18	5.43	109.3	1.31	-
P3	17.0	0.91	0.38	5.847	126.7	0.94	-
1984:							
P1	13.7	0.25	0.032	6.12	122.0	0.15	300
P2	41.7	5.20	0.461	5.99	183.3	2.10	410
P3	39.0	3.21	0.278	6.22	191.7	1.0	410
1986:							
P1	2.33	0.21	0.122	6.48	43.3	0.3	79.3
P2	32.0	8.43	2.02	3.29	460.0	5.2	963.3
P3	17.0	9.15	1.09	4.96	274.0	0.5	753.3
1988:							
P1	2.0	0.20	-	6.78	30	0.40	70
P2	16.0	2.25	0.185	5.33	190	9.40	450
P3	16.0	0.57	0.162	6.40	145	1.62	330

HIGH RATE ANAEROBIC DIGESTION OF SOLID ORGANIC WASTES BY A RUMEN DERIVED PROCESS

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ABSTRACT

An excess of organic wastes containing large amounts of cellulose are produced worldwide mainly by agricultural, industrial and domestic activities. Anaerobic digestion of cellulosic residues could provide an attractive means of waste reduction and waste stabilization with simultaneous recovery of methane as an energy source.

The degradation of cellulose to biogas proceeds by the combined action of hydrolytic, fermentative and methanogenic species. Hydrolysis of cellulose has been demonstrated to be the rate-limiting step in the overall degradation of cellulosic wastes.

Anaerobic digesters are usually inoculated with an undefined mixed bacterial population from animal manure, sewage or other sources. In contrast to the inefficient degradation of solid waste materials in current digesters, the anaerobic digestion of cellulosic materials in certain natural microbial ecosystems is known to proceed at high rates. The forestomach of ruminants may be considered as a high-rate natural digester for cellulose degradation. Ruminants have evolved a symbiotic interrelationship with microorganisms which enables them to convert huge amounts of structural plant polymers.

Because of their high cellulase activity and relatively short generation times, rumen microorganisms possess an enormous biotechnological potential in the application to the anaerobic digestion of cellulosic wastes. Loading rates applied to a Rumen Derived Anaerobic Digester appeared to be about 10 to 50 times as high as those reported for conventional biogas reactors. The results obtained for various (ligno-) cellulosic waste materials will be presented.

INTRODUCTION

Large quantities of solid organic waste materials (lignocellulose) are produced worldwide mainly by agricultural, municipal and food processing activities. This production often results into a deterioration of the environment. The costs of current disposal through methods like dumping and burying are increasing. Especially for waste materials with a high moisture content, anaerobic digestion could provide means of reducing disposal costs, providing biogas for energy, and controlling pollution. Anaerobic digestion of cellulosic wastes in conventional digesters is a slow process and hydrolysis of cellulose in this case, is the rate-limiting step (Noike et al, 1985). The rate of hydrolysis is primarily dependent on the crystallinity of cellulose, the degree of association with lignin (Ladish et al, 1983) and the cellulase activity of the microbial process applied.

Unlike the artificial digester, anaerobic degradation of lignocellulosic materials is efficient in some natural ecosystems e.g. rumens of ruminants and hindguts of termites (Table 1). The efficiency is due to high cellulolytic activity and relatively short generation times of the microorganisms involved. Loading rates applied to a Rumen Derived Anaerobic Digestion (RUDAD-) process are about 10 to 50 times as high as those reported for conventional digesters.

This study was undertaken to examine the capability of rumen microorganisms to degrade various organic waste materials, and in combination with a methane reactor to convert pure cellulose (model substrate) into methane.

ANAEROBIC DIGESTION

Anaerobic digestion of complex organic biopolymers to methane and carbon dioxide is brought about by the combined action of a wide range of microorganisms in the absence of oxygen or other strong oxidizing chemicals (sulphate, nitrate). Overall anaerobic digestion is considered to proceed according to the reaction scheme depicted in Fig. 1. The degradation pattern in this figure is simplified in order to emphasize the major metabolic routes.

Table 1: Efficiency of some artificial and natural digesters for cellulose

Type of Digester	Substrate	Loading rate (KG VS[a] $L^{-1}D^{-1}$)	Retention (days)	Conversion (%)
Indian/ Chinese	Manure	0.5-1.5	30-100	15-40
Mixed reactor	Manure	1-3	20-40	30-50
Termite hindgut	ligno-cellulose	35-70	0.5-1	60
Rumen	grass	50-100	1-2	50-70
Rumen reactor	ligno-cellulose	25-35	2-3	60-80

VS[a] = Volatile solids.

The flow of carbon from cellulosic biomass to methane proceeds in several successive stages. Hydrolysis of cellulose is brought about by cellulase producing microorganisms. The soluble products of hydrolysis are metabolized intracellularly by both hydrolytic and non-hydrolytic microorganisms. The major products of the acidogenic stage are acetic acid, propionate, butyrate and H_2/CO_2. Hydrogen producing acetogenic bacteria are responsible for the anaerobic oxidation of VFA produced in the acidogenic stage to substrates suitable for methanogenesis (Acetate and H_2/CO_2). The reaction involved in the production of acetate from VFA are thermodynamically unfavourable and will only proceed under low partial pressure of H_2. In this respect methanogens are very important since they catalyse the conversion of H_2/CO_2 and acetate into CH_4/CO_2 in the last stage of the overall digestion process.

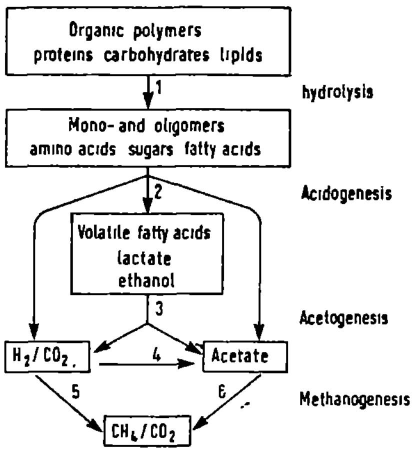

Fig. 1: Anaerobic degradation of polymeric biomass to methane and the microbial groups involved.

1,2: Hydrolytic and fermentative bacteria.
3: Hydrogen-producing acetogenic bacteria.
4: Hydrogen-consuming acetogenic bacteria.
5: Hydrogenotrophic methanogens.
6: Acetoclastic methanogens.

THE RUDAD-PROCESS

The RUDAD- process consists of two reactors which are connected in series (Gijzen et al, 1988). In the first reactor organic matter is fermented to mainly volatile fatty acids (VFA), CH_4 and CO_2 by a mixed population or rumen microorganisms under conditions similar to those of the rumen (T = 39°C, hydraulic retention time is shorter than solid retention time, high load of lignocellulose, pH 6-7).

In order to prevent acidification, the fermentation liquid containing the produced VFA are continuously removed through a filter unit and subsequently fed to an Upflow Anaerobic Sludge Blanket methanogenic reactor. After conversion of VFA into biogas, the effluent of the methanogenic reactor is either discharged or recirculated. A schematic diagram of the two-phase process is shown in Fig. 2.

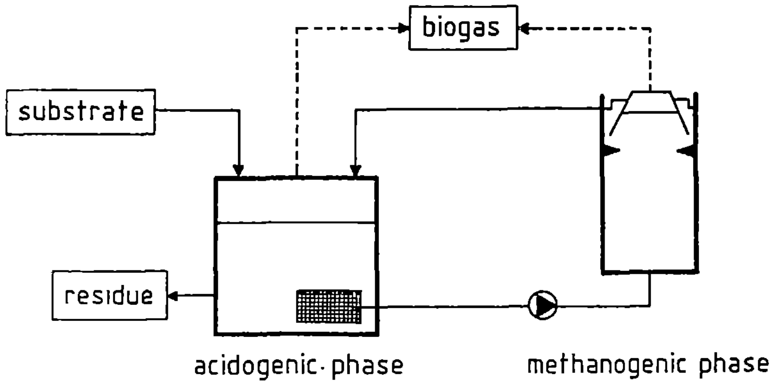

Fig. 2: A schematic representation of the RUDAD - process.

ANAEROBIC DEGRADATION OF VARIOUS ORGANIC WASTE MATERIALS BY RUMEN MICROORGANISMS

Various organic waste materials were screened for anaerobic digestion by a mixed population of rumen microorganisms. The extent of their total fibre degradation is shown in Table 2. High loading rates could be applied at a retention time of only 60 h, and degradation efficiencies obtained for most of the materials were in the range of 60-70%, irrespective of the composition.

When pure cellulose was fed to the acidogenic reactor of the two-phase RUDAD- process, a complete conversion of substrate could be obtained. In this case a complete recycling of the fermentation medium could be applied. At loading rates up to 26.g.1-1d^{-1}, a total methane production yield of 0.438 1 CH_4.g^{-1} ^{1}VS substrate was observed, which is 98% of the theoretical value.

Table 2: Steady state degradation of various types of digester feed.

Type of degradation waste material	Loading rate $gVS.l^{-1}.d^{-1}$	(h)	SRT[a] %
MSW - OF[b]	30	60	68
MSW - PF[c]	23	90	70
Grass	29	60	63
Horticultural waste	24	60	72
Papermill sludge	32	40	61
Bagasse	18	60	64
Barley straw	18	60	68
Coffee pulp	17	60	72

[a] SRT = Solid retention time.
[b] MSW - OF = Municipal solid waste - organic fraction.
[c] MSW - PF = Municipal solid waste - paper fraction.

CONCLUSIONS

1. The application of rumen microorganisms in combination with a high rate methane reactor appears to be an efficient means of anaerobic degradation of cellulosic residues to methane. Conversion efficiencies obtained with this newly developed reactor type are 10-50 times as high as those reported for conventional reactors.

2. Large volumes of solid organic waste materials could be greatly reduced by employing rumen microorganisms for anaerobic degradation. The RUDAD-process is, hence of enormous potential to reduce environmental pollution and produce a cheap source of energy.

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ENVIRONMENTAL EFFECTS OF ENERGY GENERATION AND UTILIZATION - GEOTHERMAL POWER

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ABSTRACT

The Eastern Africa region has high potential for development of geothermal power for electricity generation. The costs of geothermal energy are, for this region, usually lower than for hydropower. However, geothermal energy exploitation results in enhanced emissions of noise-, heat-, visual-, physical earth-, and chemical- pollution to the environment over and above those which would be naturally emitted. Of these, the potentially most adverse is chemical pollution, which may release CO^2 H^2S, B and NH^3 into the air, and H^2S, Hg, As, B, F, Pb, Zu, Cu, Se into the water systems. This paper discusses the minimisation of pollution from geothermal power plants, and cites the Olkaria geothermal power station, the only one in Africa, as an example.

INTRODUCTION

The world is currently at a crossroads in the thinking on energy policy. Recent awareness of the dangers posed by the greenhouse effect caused by gases arising from combination of fossil fuels (mostly CO^2) has resulted in a search for alternative fuels that are less damaging to the environment.

Proponents of nuclear, energy have proposed that this is one of the viable safe energy sources (see for example Blix, 1989). Public opinion, however has been weighed heavily against nuclear energy since the March 1979 Three Mile Island nuclear accident in the USA. In the thinking of some people, the April 1986 Chernobyl nuclear accident in the USSR may have sealed the fate of nuclear energy. However, of late, even Sweden which was committed to dismantling of all of its nuclear power plants by early next century is looking at the issue again.

Hydropower has been cited as a clean energy source. However, the dams associated with hydropower have been said to be ecological disasters. In the East Africa region, siltation of the dams makes hydropower an expensive energy source.

Geothermal energy is found in great abundance in plate boundary areas of the earth (Figure 1). In these areas, instabilities in the earth's crust lead either to circulation to great depths of surface-derived waters which are heated and come back to the surface as hot springs, or to the occurrence of hot rocks at fairly shallow depths within the crust and which heat ground waters.

Rift valleys are one type of such plate boundaries, and hence the countries of Eastern Africa, especially those through which the Rift passes, have good prospects for the development of geothermal energy. The geothermal energy can be put to various uses (Table 1), but in the tropical countries by far the most significant use of geothermal energy has been on electricity generation (Table 2). Kenya, for example, currently generates 45MW of electricity from the Olkaria geothermal power plant near Naivasha, and exploration has been underway to increase the amount of geothermal energy - derived electricity in the country, since the cost of electricity generated from geothermal in cheaper than that generated from hydropower.

This paper outlines the environmental effects of generating electricity from geothermal energy, and discusses the minimisation of pollution from geothermal power plants, using the example of the Olkaria geothermal power plant.

SOURCES OF CHEMICAL POLLUTANTS

During circulation, geothermal waters interact with the rocks through which they pass, a process which is enhanced by factors such as the high temperatures of the water and the prolonged period of contact between rocks and water, among others. The geothermal waters therefore acquire a chemical composition which is initially determined by rates of dissolution reactions dependent on the compositions of the rocks through which they pass, but, upon prolonged contact, by subsequent precipitation reactions of secondary hydrothermal minerals from the geothermal waters.

Table 3 shows the chemical composition of a typical geothermal fluid. the most abundant constituents in solution are Na, Cl, HCO^3 and SiO^2 and in some cases, K, Ca and SO^4. The concentration of total dissolved solids can range from less than 1,000mg/kg in rapidly circulating rainwater - derived geothermal fluids, to more than 350,000mg/kg in slowly circulating seawater derived geothermal fluids. In addition to the major dissolved constituents, however, there are minor and trace elements such as B, F, Hg, As, Pb, Zn, and Se dissolved in the water. Some of these elements are toxic when ingested by flora or fauna. Dissolved gases are predominantly CO^2 and H^2S, but H^2, N^2, NH^3 and H^3BO^3 may also be present. These usually occur in the steam phase, and of these H^2S and H^3BO^3 can induce toxic reactions and/or cause damage to construction works.

Exploitation of geothermal energy usually entails drilling for the geothermal fluids and tapping them at depth, thereby enhancing the volumes discharged over and above those which would obtain under natural discharge conditions. For the 45 MW power plant at Olkaria, typical flows of geothermal fluids (water and steam) are about 570 tonnes/hr of which 120 tonnes/hr constitute water with the composition shown in Table 3. The remaining 450 tonnes/hr constitutes steam with the gases shown in Table 3. For environmentally sound exploitation of geothermal energy, therefore, disposal of these fluids must be properly planned for before any geothermal energy project starts.

DISPOSAL STRATEGIES

The ultimate solution is to reinject the geothermal fluids into the rocks upon extraction of the energy-take it back to where it came from. However, this solution is economically undesirable due to the extra energy required to pump the fluid back, and not always technically feasible since the wells may become clogged with precipitates.

The next best solution is to dispose of the water in a pond, so that it naturally seeps back into the ground where suitable conditions exist. This may lead to contamination of shallow natural fresh ground water aquifers in the vicinity of the infiltration ponds. However, if these ponds can be located in depressions, then the possibility of fresh ground water contamination is minimised. This is the strategy that has been adopted for the Olkaria geothermal field. It has been estimated that the geothermal fluids constitutes 0.01% of the reginal groundwater flow.
Another strategy involves the evaporation of the geothermal fluids, and possible recovery of salts contained in the waters. This is a particularly viable option for highly saline fluids, where salt manufacture may be a secondary operation to generation of geothermal power.

Where the waters are dilute, or where the power plant is sited near the sea, the geothermal fluids can be discharged at the surface. This has, however been the most environmentally undesirable option, where the trace elements in the geothermal fluids have interfered with plant life (Boron in El Salvador affected the Coffee crops) or with aquatic life, the heat from the geothermal fluids can also raise the temperature of the water body into which the geothermal fluid is discharged.

These strategies do not take care of the gaseous emissions. These usually eascape into the atmosphere, unless special equipment is added on, specifically to get rid of the gases. Such equipment (e.g. to get rid of H^2S) can be very expensive. Usually, the amount of H^2S and CO^2 released into the atmosphere are less than those released by fuel-fired plants of equivalent capacity.

For example, approximately 22,000 tonnes of CO^2 and about 890 tonnes of H^2S are released into the atmosphere annually from the Olkaria geothermal power plant; a coal-fired power plant of the same rating (45MW) would release 140,200 tonnes of CO^2 per annum and more than 900 tonnes SO^2 per annum. An oil fired power plant of the same rating would produce 109,050 tonnes of CO^2 and 1120 tonnes of SO^2 per annum. (Fossil fuel figures are calculated from WECO, 1988).

At the Olkaria geothermal power station, the gases are discharged into the atmosphere, where volume dilution decreases the concentrations to harmless levels. This is possible because the plant is located far from settled areas. However, there is evident of an increase in corrosion of metals (fence wires etc) in the plant area, ostensibly due to reactions between the metals and oxidised, humidified H^2S (sulfuric acid). The CO^2 retained in the water has encouraged prolific algal growth in the conditioning and infiltration ponds. Table 3 shows the estimated discharges per annum from the Olkaria geothermal power plant. The Olkaria geothermal plant is located in a semi-arid part of the country. Lush vegetation, uncharacteristic of the area, thrives in the vicinity of the geothermal waste-water disposal sites. However, no studies have yet been done on the content and distribution of trace elements in this vegetation, nor on the suitability or otherwise of the waste water for irrigation purposes.

OTHER POLLUTANTS

Noise pollution is another undesirable effect of exploitation of geothermal energy. The use of ear-muffers are encouraged in the early stages of drilling of borehole but later, silencers are used to reduce the pitch and intensity of the noise. Again the location of the power plant will determine the degree to which noise must be reduced. Machinery noise is reduced by sound-proofing control rooms and offices.

Other forms of pollution include airborne sprays (e.g. of silica), fog, seismic disturbances, visual aesthetic effects, and possible modificaiton of the local ecology. These effects are usually minimal since most geothermal plants tend to be located in remote areas. The electric cables may also be sources of electromagnetic pollution, but again this can be minimised by discouraging the location of dwellings close to these cables.

SUMMARY

Exploitation of geothermal energy can induce the release of enchanced levels of chemicals pollutant into the atmosphere and into water systems. Usually, the remote locations of geothermal power plants render these pollutants harmless, but environmental impact assessment studies should be carried out to determine the best methods of disposal of chemical wastes for a particular geothermal power station.

Notwithstanding the above, the emissions from geothermal power stations are usually lower than those from fossil-fuel plants. This, coupled with the low cost of geothermal energy compared to hydropower, makes it a very attractive form of energy to exploit in the Eastern African region.

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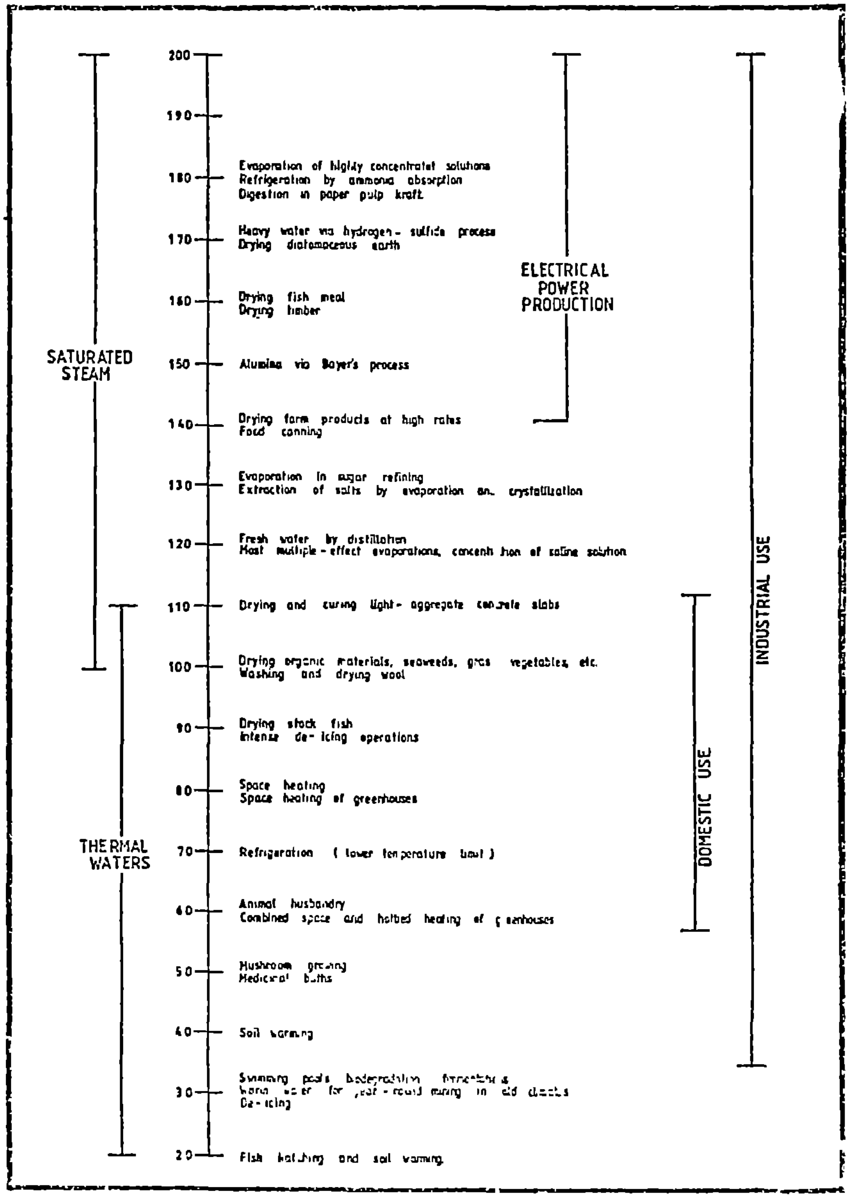
Table 1: Some uses of geothermal systems at various temperatures.



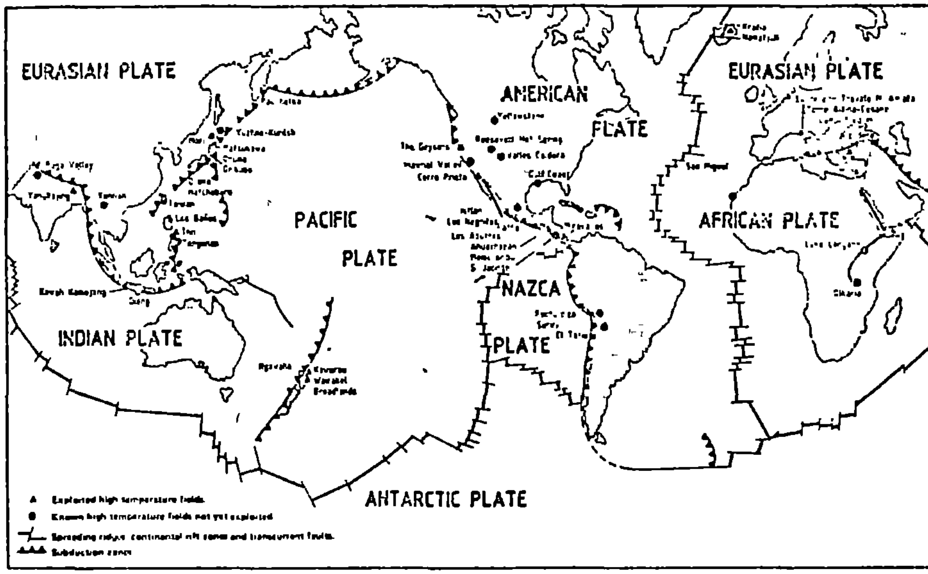


Fig. 1 Locations of the major geothermal areas in the world
(After Barbier, Fanelli and Gonfiantini, 1983)

Table 2: Geothermal Power Plants in the World in 1987 (after Di Pippo, 1988)

Country	Installed capacity (Mw)
United States	2211.9
Phillippines	894.0
Mexico	655.0
Italy	504.2
Japan	215.1
New Zealand	167.2
El Salvador	95.0
Indonesia	87.3
Kenya	45.0
Iceland	39.0
Nicaragua	35.0
Turkey	20.6
China	14.6
USSR	11.0
France (Guadalupe)	4.2
Portugal (Azores)	3.0
Greece	2.0
World Total	5004.1

Table 3: Typical Chemical Composition of Geothermal fluid from Olkaria and estimated annual output of chemicals (45MW Plant) (510 tonnes of steam/hr and 83.4 tonnes of water/hour) (Partly after Muna, 1982).

Water		Tonnes/annum
pH at 20°C	8.30	
SiO_2	589 mg/l	430
B	6.5	5
Na	671	490
K	97.6	70
Ca	0.87	0.6
Mg	0.30	0.2
Li	1.04	0.8
CO_2	44.0	32
SO_4	72.0	52
H_2S	2.0	1.4
Cl	826	602
F	71.0	52
NH_3	0.7	0.5
Fe	4.8	3.5
Mn	1.6	1.2
Mo	Nil	-
Br	2.5	1.8
I	0.05	0.04
P	0.1	0.07
Hg	Nil	-
Pb	Nil	-
Cr	Nil	-
Cu	Nil	-
Zu	0.4	0.3
TDS	2418	1,760
<u>Steam</u> (wt % gases)		
CO_2	0.49	21,850
H_2S	0.02	890
H_2	0.001	45
CH_4	0.0009	40
N_2	0.0003	13
NH_3	0.0003	13

Question by Mr. M. Meghji, M. Konsult

What is the cost of K.W.H. of geothermal energy production compared to hydropower?

Answer

Geothermal energy production is about 30 cents per k.w.h. whereas hydropower costs about 1.00 Kenyan shilling per k.w.h.

Question by Dr. D.A. Mashauri

Methane is one of the many products of geothermal power stations. How is it used?

Answer

Since it is expensive to recover the products, most of them including methane are just discharged.

THE ENVIRONMENTAL IMPACT OF INDUSTRIAL AND DOMESTIC WASTE WATER IN DAR ES SALAAM, TANZANIA

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ABSTRACT

In Tanzania the pollution of natural water bodies (streams, oceans, lakes etc.), which are used to receive liquid or solid waste from domestic and or industries, is often not considered when a project is proposed. This negative planning has a serious impact on the environment be it air, water or the soil. It is high time the project proponents thought about and planned for natural or the existing environmental set up so as not to damage it beyond its own "carrying" capacity. In this paper the potential danger of discharging raw sewage into the Indian ocean through a sea outfall will be discussed. Some indications of the levels of pollution from both industrial and domestic sources to the Msimbazi stream - by the large and main collector of wastes in Dar es Salaam will be given and finally the possible environmental impacts of this pollution will be discussed.

INTRODUCTION

1. General

Tanzania, though mainly an agricultural country, has a few industries which have a polluting effect on the waste receiving bodies (lakes, rivers and oceans). This is not to belittle the entrophicating effects of the agrochemicals (pesticides, fertilizers and herbicides etc.) used in the agricultural activities. Most of the Tanzanian industries are concentrated in the urban centers which is natural as in these places are also most of the needed services e.g. roads, power, water and waste-water systems. Dar es Salaam city is no exception to this trend.

2. Industries in Dar es Salaam

Dar es Salaam City (the commercial and industrial center as well as the defacto capital of the country) is heavily "industrialized" by Tanzania standards. The industries in Dar es Salaam can be subdivided into the following main groups:

(1) Food Processing

- Vingunguti Abattoir.
- Ubungo Dairies Ltd.
- Darbrew Ltd.
- Tanganyika Meat Packers Ltd.
- NMC - Animal, chicken feed complex and fruit and juice canning.
- Breweries.
- Soft drink factories etc.

(2) Textile Industries

- Tasini Textiles.
- Sungura Textiles.
- Urafiki Textiles.
- Ubungo Spinning Industries.

(3) Power Generating

- Ubungo TANESCO thermal generators (standby).
- Individual power generators at hospitals and various other locations.

(4) Metal Industries

- Ubungo Farm Implements.
- NECO.
- Metal Products.
- Aluminium Africa
- Bicycle Company.

(5) Petroleum Industries

- Kigamboni oil refineries.
- Simba Plastics.
- Fuel Stations.
- Tegry Plastics.
- Kurasini oil dump.
- Various garages within the city boundaries.
- Fuel filling Stations.

Since all these industries discharge their wastes, rather raw, into some streams leading into the Indian ocean one is bound to question if any Environmental Impact Assessment (E.I.A.) studies were done prior to the decisions to realize them. From the quality and quantity of waste discharges emanating from these industries it is not difficult to judge the damaging effect on the marine life in the receiving waters.

The potential polluting effect on the flora and fauna along these very streams cannot be underestimated. It is due to this reason that we find this symposium both timely and appropriate to address this very critical issue of environmental pollution.

POLLUTION SOURCES

1. Domestic Wastes

The main pollution sources are the non-point, e.g. septic tanks/soakpits which leach into the ground water and quite often overflow to the nearby streams eventually to the sea and the point loading from the industries. The domestic wastes are mainly responsible for the deficiency in dissolved oxygen of the receiving waters due to oxygen depletion as a result of decomposition of the organic load in the water. The direct discharge of raw sewage into the streams e.g. Msimbazi is not rampant as most of the sewage either is disposed through the central sewerage system or is pumped from septic tanks by mobile emptiers to be discharged into the main duct leading to the sea outfall.

Nevertheless a few pit latrines etc. which may leak into the ground water may find their way into the drinking water system. This is fairly true when shallow wells are dug close to pit larines and especially where the soil is sandy. And in Dar es Salaam most of the subsoil is sandy making it very permeable to both water and the pollutants carried in it. this problem may be solved by providing potable and pipeborne water supply reliably throughout the year. By doing this the shallow wells would be abondoned for the cleaner and dependable water supply. Secondly, most, if not all, sewage must be disposed safely through a pipe or duct network to avoid polluting the ground-water supply especially on the fringes of the urban centers. This will reduce the non-point pollution to minimum and whatever remains will be taken care of by the natural carrying capacity of the receiving body. The Tabata sanitary fill (Tabata dump could be the more appropriate name) is a special domestic and industrial point-load on the Msimbazi stream. The composite polluter is a time bomb as far as environmental pollution is concerned.

2. Industrial Pollution

The industries pollute the streams and the ocean at a higher level than the domestic sources. While the domestic wastes are easily handled/treated by septic cum/soak pits or through oxidation pond systems the industrial wastes are more difficult to treat and dispose.

The industrial wastes demand more elaborate treatment methods which may entail standard (e.g. activated sludge) treatment or may demand tertiary treatment depending on the type of the polluting industry. The selection criterion on the treatment to be used will also depend on the allowable pollutin levels at the effluent of the individual constituents. The specific effluent standards would have to apply in this regard. These wastes are in some cases infested with non-biodegradable materials e.g. metals, plastics, oils, glasses, ashes, industrial smoke/dust and heavy metals. While some of these wastes can be recycled e.g. glass, plastics and metals the rest are permanent residues. The heavy metals (mercury, lead, arsenic and chromium) are bound to be transported into the food chain to man in the long run. It is these materials that we have to dislodge from the waste-waters before discharging into the receiving waters least they enter our food chain.

LEVELS OF INDUSTRIAL POLLUTION

1. The Food Processing Industries

Other than the chemical preservatives used in the canning industries the wastes are of the biodegradable type. This implies that standard oxidation ponds could be used to treat the resulting waste-waters. There are usually large amounts of water used for rinsing, washing and processing. This water could be recycled (at a small cost) to serve the environment from deterioration and at the same time cut down on cost of buying water.

It should be underlined that dairies produce very high BOD values of as high as 1800 mg/l (Project 17-83-40) which are very entrophicating; as such the population equivalents must be calculated before discharging into the receiving bodies, to assess the potential damaging effect. In any case a proper planned waste treatment and disposal system must be worked out in each case.

2. The Textile Mills

These produce intermittently, dyes, bleaching agents, alkalis, starch, colours and large amounts of washing and rinsing waters. If the effluent water is not regulated through retention tanks, "shock loads" may result in the receiving waters. This is true at the large textile mills such as Tasini and Urafiki which produce considerable amounts of waste-waters daily.

The textile mills also produce cotton wastes, threads and riprap textile pieces as part of their wastes. Part of these solids are flushed into the waste-water system. These wastes are partly biodegradable but the rest will remain in the waste water body for a considerable time. Hence their treatment and final disposal must be planned for at the very beginning of the projects. The dyes and colours are more difficult to handle as some of them contain trace elements which cannot be easily degraded to simpler compounds. Special treatment must be instituted to take care of the wastes.

3. The Power Generating Sector

The power generating industry in Dar es Salaam is solely owned by TANESCO. All the generators are thermal type using heavy industrial oils as fuel. The main pollutant here is the oils, grease and industrial smoke/dust. The quantities are small but very localized where the industry is situated. This has the inevitable effect of "overkill" in the immediate environmental set-up, e.g. flora and fauna in the waste receiving Msimbazi stream. The effect of pollution in the stream further downstream is likely to be attenuated by the natural dispersion capacity of the stream and due to the dilution factor inherent of the increased flow in the stream.

4. Metal Industries

These are the most troublesome of all as they produce paints, mercury, lead, copper and hot waters as their wastes. While hot water could be recycled for cooling purposes and for some other industrial processes, the paints and heavy metals are difficult to treat. As a result the heavy metals in solution end up in the nearby streams such as Msimbazi stream and finally the Indian Ocean. These metals accumulate in the marine life (e.g. fish and crustaceans) which is then consumed by man. These metals can also enter the man's body through taking water containing them or food (e.g. vegetables, fruits) from contaminated soils. If animals (livestock etc.) are fed with hay grown on contaminated soil or irrigated by contaminated water the heavy metal will be concentrated in the final point of the food chain.

5. Petroleum Industries

The oil refineries at Kigamboni are bound to discharge some residues in the process of producing petroleum products (petrol, diesel, paraffin etc.). These residues are then disposed off into the Indian ocean which has a certain environmental situation e.g. marine micro- and macro-life. By virtue of this introduction of foreign matter into the existing set up, a damaging process is initiated. It is only through proper mitigation methods and enforceable laws can the situation be contained. The refineries also release gasses/smoke into the atmosphere which contributes to the "green-house' effect on the earth.

The plastics industries produce a number of multi-chlorinated compounds which are difficult to treat or handle. Since no waste treatment is practiced at these industries the receiving bodies are bound to be damaged. The fuel stations and garages discharge oils, greases and fuel into the receiving waters. Their polluting effect on the environment must be assessed in view of the above explanation.

ENVIRONMENTAL POLLUTION OF THE MSIMBAZI STREAM

1. Effects on the Msimbazi stream

Since the Msimbazi basin has been earmarked to become a "food basket" in Dar es Salaam (Daily News, May 1989) it will serve as good example of environmental pollution of marine and fresh waters. The Msimbazi river, (refer Figure 1) is the main collector of most of the industrial waste in Dar es Salaam city. The stream flows into the Indian ocean after traversing a long distance all the way from near the Pugu hills. Its tributaries form the main waste receiving channels for some industries.

The basin is to have among others a hatcher, dairy farm, poultry farm, paddy farm, vegetable garden and a fruit orchard. All these ventures will depend, to a large extent, on the water from the Msimbazi stream. The dairy cattle will get their drinking water from the stream while grass for the cattle will be irrigated by the water from the river. Since the water is polluted by both industrial and domestic wastes, then the dairy products (milk, butter and meat) are bound to have some pollutants which are bound to be concentrated in the highest level of the food chain. Likewise the produce from the orchard and the vegetable garden is equally polluted. The situation here is even worse as fruits and salads are often eaten raw making them very vulnerable to the transmission of pathogens from the waste water to the consumers. Needless to say the poultry products (eggs, meat etc.) would naturally be contaminated. Untreated industrial wastes from textiles mills, metal-plating industries (heavy metals) and plastics industries are led into the stream upstream of the "food basket" - Msimbazi basin. As some of these wastes are not biodegradable it is to be expected that trace elements will end up in the produce of the farms. The damaging effect to human beings and animals is yet to be known. It is imperative then to call for a thorough Environmental Impact Assessment (EIA) study to be done on the project.

While we are aspiring for a sustainable development we should not over emphasize our present needs over the needs of the future generation. By doing so we close the options for the future generatins to meet their own aspirations.

2. Effects on the marine life

Eventually the Msimbazi leads to the Indian ocean discharging under the Salender Bridge. The wastes contained in its waters end up in the marine fauna and flora. Table 1 shows typical concentrations of heavy metal in some fishes in the vicinity of this discharge.

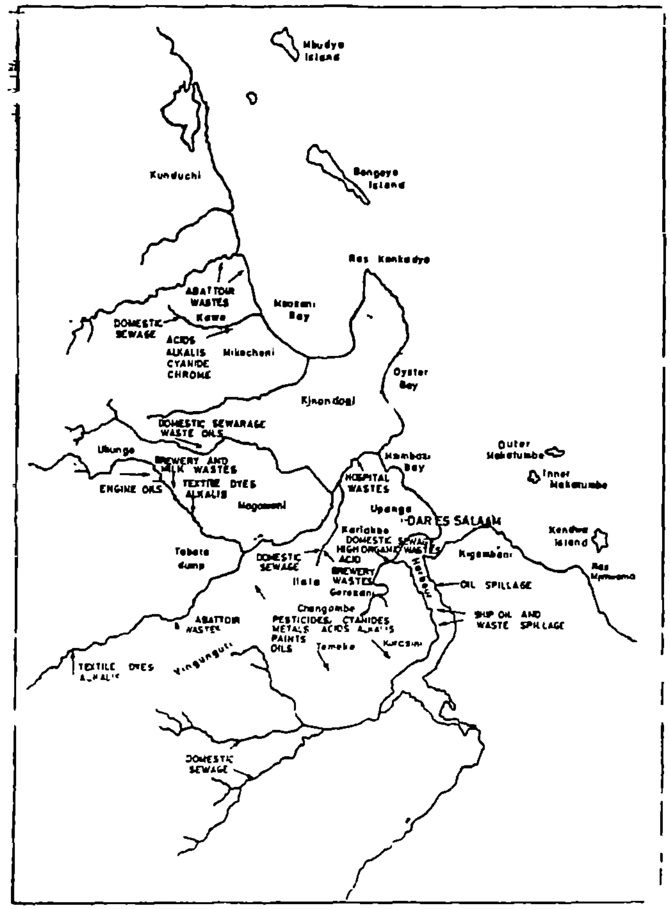

FIG.1

Table 1: Heavy Metal Concentration in Fish (Anon, 1987)

Heavy metal	Marine	Fish
	Cockle (mg/kg)	cyters (mg/kg)
Lead	2.8	7.7
Cadmium	0.2	0.5
Chromium	5.9	7.7
Copper	5.4	23.6

It could be concluded, without deviating too much from the truth that these metals emanated from the industrial waste-water coming from the Msimbazi. As fish is a common relish around Dar es Salaam, these metals are accumulating in the human body. The adverse results of this contamination will be known at a much later date making it difficult to trace back to its origin.

ENVIRONMENTAL POLLUTION AND DEVELOPMENT

1. Effects of Environmental Pollution on Development

When the environment gets degraded through pollution by one way or another then it is to be expected that:

(1) A small number of people may benefit but only in the short run. The example of the Msimbazi basin is valid here where the developers using polluted water will gain some revenue in a short time after their investment. We believe that this is not the only example in the country.

(2) The majority will not gain in the long run - contaminated foodstuffs, fish etc. will lead to a morbid population to say the least. The morbidity is aggravated further by the synergetic effect of other ambient diseases.

(3) The degradation may even contribute to the poverty and thus under development of the population.

(4) The degradation will eventaully close options for the local fisherman from getting fresh and safe catch in the vicinity of Dar es Salaam city. This will lead to reduction in the ability to achieve their objectives - to fish for food and for the generation of some funds.

(5) The degradation of the environment (eg. Msimbazi and the Indian Ocean) may reduce the ability of the present population to adapt and deal with uncertainty. This is especially so as the population is more or less static on its daily endeavors (eg. small holder farming, fishing etc.) and suddenly this opportunity is removed.

(6) Since Environment and Development are inseparable entities, then in order to have development (sustainable) we need to take care of the environment, which in turn will propel the development of the country.

(7) Environmental degradation in the rural areas may lead to problems of development in the urban areas due to the fact that:

(a) Degradation will inevitably invite poverty which in turn attenuates rural development and this can also degrade further the environment.

(b) The chain of downward spiral fall is set in motion by the poverty which propels migration - rural to urban.

(c) The migration obviously creates more degradation of the urban development as the environmental set-up is likely to be over crowded beyond its carrying capacity (water supply, sewerage, health care, educational facilities, solid waste disposal sites and waste receiving capabilities). Figure 2 summarizes this point

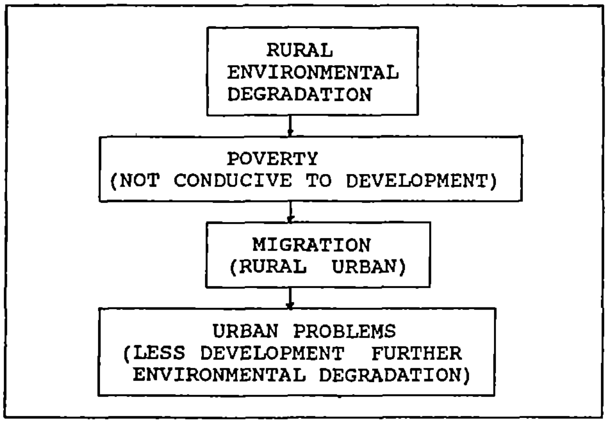

Figure 2 : Urban/Rural Development versus Environmental Degradation.

2. Some Suggested Solutions

In view of the afore discussion the human nature is to utilize its intelligence to create new solutions to the pertaining problems - pollution of the environment. the solutions could take the form of for an example:

(1) To design a sustainable development without compromising the future needs of coming generations.

(2) To produce proactive EIA of policies, projects and physical plans. This is to take care of the industrial wastes prior to agriculturise the Msimbazi basin.

(3) To programme ways and means to utilize wastes from industries. Here we advocate waste recycling and or treatment before disposal.

(4) To cooperate with international community on matters which are of multinational nature or are too difficult/expensive to be handled by one country alone.

CONCLUSIONS

(1) Untreated sewage from both domestic and industrial sources is environmentally polluting the potential fresh water (e.g. shallow wells) and the Indian Ocean in Dar es Salaam. This restricts the full use of the ground water potential and the marine produce (fish etc.).

(2) The pollutants are bound to enter the food chain and thereby are potential health hazards. Especially now that the Msimbazi basin is to be turned into a grain basket of the city, a serious assessment of the possible implication should have been carried out.

(3) There are no EIA procedure in the country to check the possible effects of planned projects on the environment. This should be instituted especially when dealing with major hydraulic projects, irrigation schemes and any other which interfer with the natural habitat such, as rare animals or the rain forests. By doing EIA after a project is implemented is synonymous to shooting first and aiming later.

(4) The legalistic system is "loose" or silent on the environmental issues making it difficult to take

any legal action against offenders. This state of affairs must be addressed sooner than later.

(5) In order to effectively manage the environment it might be necessary to:

(a) Maintain essential ecological processes while man-made development takes place.

(b) Preserve genetic diversity, that is to say that no development should be allowed to eliminate some genes for that sake.

(c) Ensure sustainable utilization of species or ecosystems so that the future generations can have meaningful options in their endeavours to develop.

(d) Maintain as well as enhance environmental qualities so as to pave the way for sustainable development.

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<u>Comment by Mr. Paulsson</u>

I am glad your study has revealed the extent of pollution in the Msimbazi river. I am sure we need studies of a similar nature on other rivers in Tanzania.

<u>Answer</u>

The pollution of River Msimbazi is of concern to the people of Dar es Salaam because the Msimbazi Valley will be or is actually being used in some parts to produce food for the residents of this city and the polluted water of that river will be used to irrigate the crops.

<u>Question by Dr. Chale</u>

What are your findings with regard to the state of pollution in river Msimbazi?

Answer:

We have analysed the tissues of fish caught in the Msimbazi river and the results showed 23mg. Kg dry weight for copper, 7.7 mg Kg dry weight for lead and 0.5 mg Kg dry weight for cadmium.

WATER BASED POLLUTION IN DAR ES SALAAM

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ABSTRACT

This study covered Solid Waste, Pollution Management and Drainage of Dar es Salaam. It is essentially a summary of main findings of the above study and covers various aspects of pollution generation, disposal and mitigative actions for "LIQUID BASED POLLUTION" in Dar es Salaam city. In this paper the following sources of pollution were considered (a) Existing sewer systems (b) major industries (c) pit and septic tank emptying services (d) storm water discharge (e) other point sources (f) other diffusive sources

METHODOLOGY

The situation was studied using field and desk research. The sampling programme, the biomarine survey and the inspection of pumping stations were executed during the dry season (July to September, 1988). The inspection of the waste-water stabilization ponds, tank emptying services and major industries was completed during November. In this period only few showers occurred. In December some storm water discharge was observed after local showers ("short rains"). Most of the information on the present system was drawn from the available studies, Dar es Salaam Sewerage and Sanitation Study (1980) and (1982). Cross checks were made and additional information was acquired during meeting with competent authorities in Dar es Salaam.

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1 This paper is based on results of study undertaken by Haskoning/M-Konsult for the Department of Sewerage and Drainage of the Ministry of Water between June 1988 - March 1989

POLLUTION SOURCES

1. Introduction

Domestic, industrial and institutional pollution sources contribute to the pollution of surface and groundwater of Dar es Salaam. The pollution sources can be distinguished into point sources and non-point or diffusive sources. Point sources are sources like the sea outfall, the effluents from waste stabilization ponds, the dumping stations for disposal of sludge from pit emptying services, effluents from major industries and institutions and storm water outfalls. Rivers dishcarging polluted water to the sea can also be regarded as point sources. No-point sources are scattered emissions from individual people, houses, small industries and institutions, not connected to the public sewer system. Primarily the non-point sources directly contribute to the groundwater pollution.

2. Point - Sources

The nature and extent of point sources and their effects has been studied by means of emission calculations, a water-quality survey and a bio-marine survey. for some issues, like the waste-water stabilization ponds, pit latrine, emptying the sewage pumping stations, and the pumping stations, Tabata dumpsite and the major industries, special audits have been made. The results of these investigations can be comprised as follows:

2.1 Sea Outfall

According to emission calculations 8,957 kg BOD, 9,455 kg COD, 14,929 kg SS, 26,540 kg DS, 1,310 kg N-tot and 249 kg P-tot are daily disposed of into the sea by the sea outfall. During the water quality survey little pollution was found in the sampling stations around the shore line of the sea outfall location, apparently foul sewage water released from the outfall does not affect the local shoreline. The biomarine survey especially the aerial survey, has confirmed that the effluent of the outfall is well absorbed and diluted by the tidal currents.

The observatins confirm previous studies. Analysis of oysters taken from the breakpoint of the pipeline suggest the presence of relatively larger amounts of heavy metal in the effluent, compared with heavy metal levels in oysters taken from the shoreline. This suggests that some of the sludges from unknown origin which are dumped via Gerezani Streat Station may contain industrial waste. Heavy metals like cadmium, chromium and copper are bio-accumulating in oysters at the break of the sewage outfall pipe. This accumulation is not found in oysters at the shoreline or at the regular mouth of the outfall. The dispersion at the mouth is large and the impact of the outfall is limited to the proximity of the emission source.

The Total Coliform analysis during the water quality survey has confirmed that pollution at the shoreline of the sea outfall has not been caused by the outfall. Very likely high Total Coli concentrations at the swimming club, are caused by fresh human excrets from the fish market or the swimming club itself.

2.2 Sludge Dumping from Pit Emptying Service

If sludges from pit-lartines, septic tanks or soakaways were properly disposed of by emptying the non-site facilities adequately once a year this would result in 83 kg BOD, 824 kg. COD, 82,438 kg SS, 1,630 kg DS, 803 kg N-tot and 153 kg P-tot per day. This would be dumped in selected locations upstream of the sea outfall (Gerezani Street) or selected stabilization ponds (Regent Estate).

Presently only a minority of the septic tanks and pit latrines are being emptied by vacuum trucks. A substantial number of the pits are not emptied by vacuum trucks when full.

The present function of pit emptying services is to mitigate the nuisance of liquid overloaded pits. Especially they occur in impermeable or low-lying areas with high groundwater table. The need to do so is emphasized by the Total Coliform counts made during the survey. Pit-latrine water has Total Coliform counts of 11,000,000 MPN per 100 ml and soakaway water counts some 250,000 MNP per 100ml. Such counts indicate the seriousness of the problem with respect to health.

2.3 Sewage System

The sewage systems receiving effluents from connected houses, industries and institutions and emptying of vacuum trucks either dispose of their effluents to the sea outfall (Central Urban Section of Dar es Salaam), or at the waste water stabilization ponds in the Northern or the Southern section of the city.

The emission calculations have accounted for the total flow of sewage water and its foul water strength. Since the sewer system, is essentially a dry weather system overflows due to storm water will occur. Mechanical or electrical malfunctions result in temporary overflows next to the pumping houses.

2.4 Waste Water Stabilization Ponds

The location of sewer systems, dumping sites of cesspit trucks, oxidation ponds and main sea outfall are indicated on figure 2.1. The pollution caused by effluents from waste water stabilization ponds has been assessed by the emission calculations, water quality surveys and inspection of ponds. Since August 1987 the waste water stabilization ponds have been under the management of DSSD.

Where ponds are operated correctly they generally perform in accordance with design values for treatment efficiency. Operational constraints are felt in a number of ponds.

These are:

- Shortage of water in dry season, (University).
- No effluent due to lack of electric power for pumping station, (Airport - Airwing).
- Shortage of funds for rehabilitation (Buguruni), blocking of inlets due to clogging (Regent Estate, Msasani); - shock-loading due to sudden industrial effluents, (Vingunguti);
- Temporary reconstruction works to allow for construction of new sludge dumping station, (Mgulani).

No complaints have been reported for Lugalo pond, servicing the military area. Ukonga prison pond will not be constructed. The effluent will be disposed of into septic tanks.

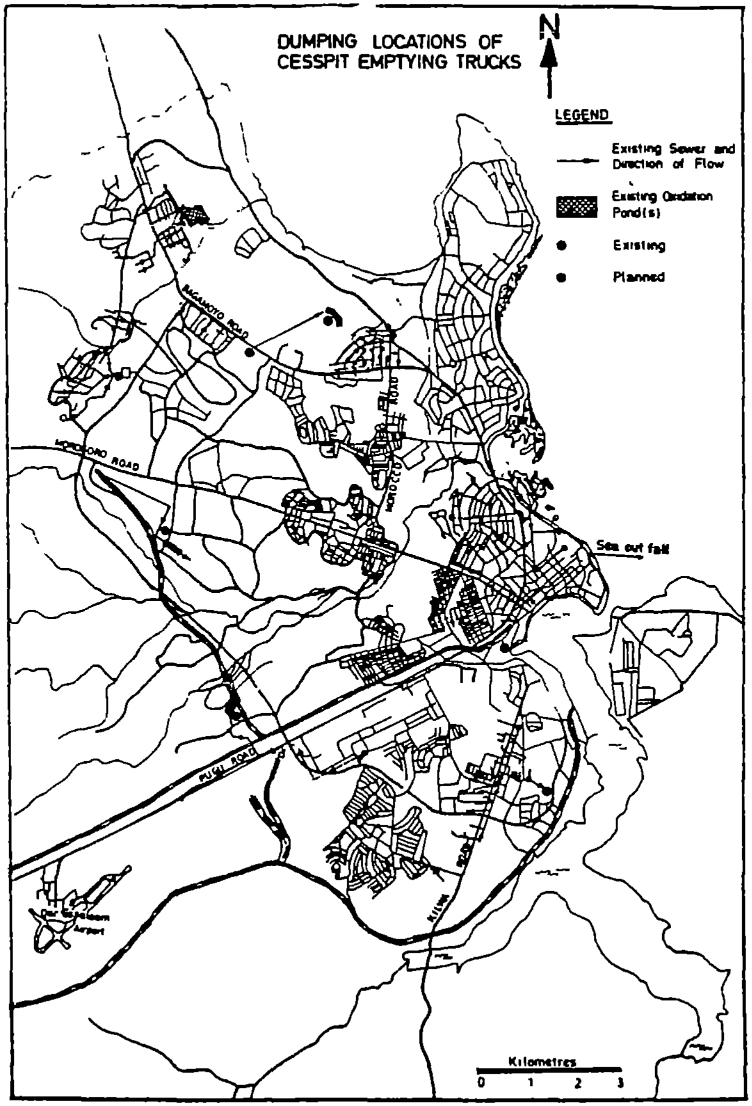

Figure 2 1

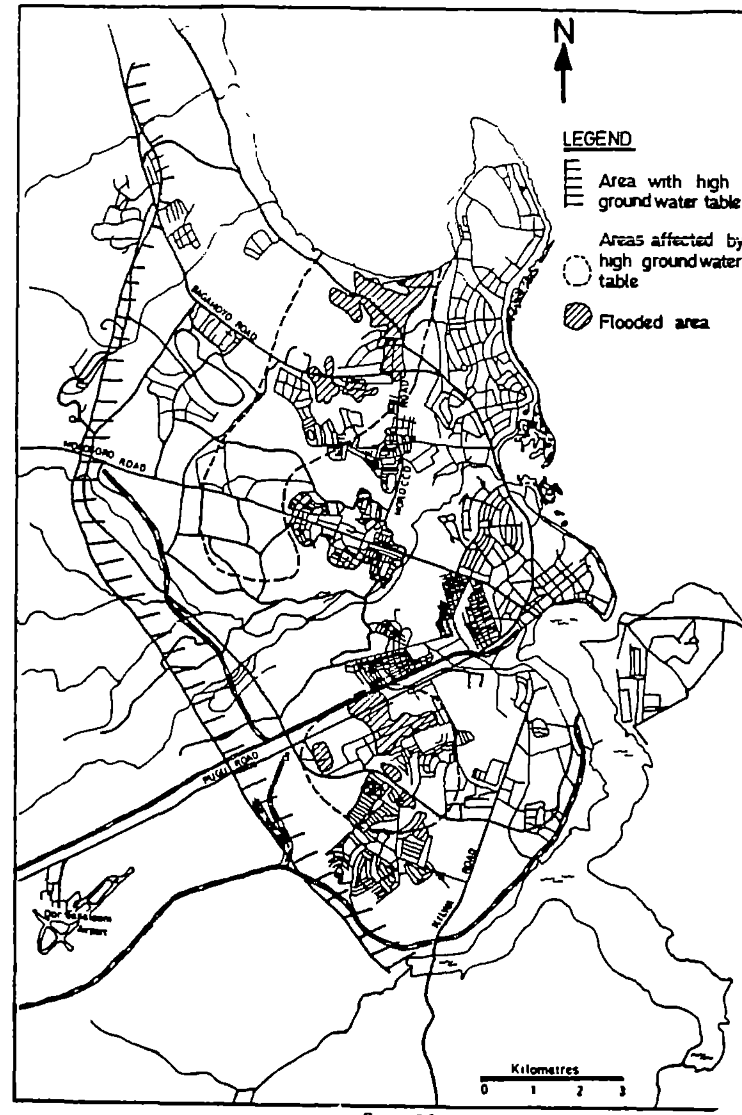

Figure 2.2

STATUS OF WASTE WATER STABILIZATION PONDS (November 1988)

Pond No	Name	Visited? Yes/No	Operational Yes/No	Remark 1: Under construction?	Remark 2: To be rehabilitated?	Design capacity Kg BOD/day	Design capacity M3/day	Area in Hectre: Facultative Anaerobic	Area in Hectre: Maturation Pond
11	University	Y	Y	no	no	300	478	1.00	0.45
12	Airport/TPDF	N	N	no	yes	140	282	0.60	0.20
13	Buguruni	N	N	no	yes	650	1,240	1.50	1.75
14	Regent Estate	Y	Y	no	no	975	1,950	3.25	2.00
15	Vingunguti	Y	Y	no	no	1,000	2,000	2.22	2.24
16	Mgulani	Y	N	yes	no	495	520	1.00	0.50
17	Lugalo Barracks	Y	Y	no	no	1,200	1,920	3.25	2.00
18	Ukongo Prison	Y	N	no	no				
19	Ubungo Ind. Area	Y	N	yes	no	1,200	2,400	2.50	2.50
Operational at present 1988						3,475	6,348	9.72	4.69
Operational after finalization of construction works (1989)						5,170	9,276	13.22	7.69
Operational after finalization of construction and rehabilitation works (1990)						5,960	10,806	15.32	9.64

TABLE 2.1

TREATMENT EFFICIENCY OF SELECTED PONDS

Observation	BOD In	BOD Out	BOD Effic	COD In	COD Out	COD Effic	SS In	SS Out	SS Effic	AMMONIA In	AMMONIA Out	AMMONIA Effic
Vingungu												
1	260	70	73%	420	130		750.0	430.0	43%	4.68	0.25	95%
2	220	70	68%	382	120	69%	716.0	509.0	29%	0.50	0.03	94%
3	235	68	71%	405	126	69%	730.0	520.0	29%	2.60	0.15	94%
4	239	69	71%	400	125	69%	734.0	520.0	29%	2.62	0.15	94%
5	112	56	50%	234	112	52%	0.8	0.1	88%	1.76	0.00	100%
6	168	60	64%	298	92	69%	1.0	0.3	70%	1.78	0.00	100%
7	213	61	71%	312	115	63%	2.0	0.1	95%	1.82	0.00	100%
8	267	69	74%	296	121	59%	0.7	0.1	86%	1.85	0.00	100%
9	194	52	73%	288	249	14%	6.5	0.1	98%	1.78	0.00	100%
10	186	63	66%	272	258	5%	0.1	0.1	0%	2.25	0.40	82%
11	172	69	60%	268	247	8%	7.5	3.0	60%	4.30	4.10	5%
12	197	57	71%	287	261	9%	0.1	0.1	0%	2.65	1.45	45%
13	169	63	63%	252	238	6%						
14	183	67	63%	259	249	4%			52%			84%
15	171	53	69%	205	202	1%						
16	145	59	59%	183	226	-23%						
17	188	69	63%	324	314	3%						
18	186	63	66%	167	139	17%						
19	172	57	67%	314	163	48%						
			67%			28%						
	In	Out	Effic	In	Out	Effic	In	Out	Effic	In	Out	Effic
Mgulani												
20	180	65	64%	389	120	69%	588.0	616.0	-5%	2.05	0.13	94%
21	170	65	62%	350	106	70%	520.0	410.0	21%	1.95	0.01	99%
22	175	64	63%	385	120	69%	545.0	600.0	-10%	3.70	0.30	92%
23	178	67	62%	388	122	69%	566.0	607.0	-7%	2.90	0.21	93%
24	177	65	63%	386	124	68%	567.0	608.0	-7%	2.84	0.22	92%
			63%			69%			-2%			94%
	In	Out	Effic	In	Out	Effic	In	Out	Effic	In	Out	Effic
Msasani												
25	180	65	64%	405	145	64%	560.0	360.0	36%	2.75	0.13	95%
26	175	66	62%	378	130	66%	540.0	385.0	29%	2.40	0.08	97%
27	176	68	61%	378	127	66%	545.0	386.0	29%	3.78	0.07	98%
			63%			65%			31%			97%
	In	Out	Effic	In	Out	Effic	In	Out	Effic	In	Out	Effic
Lugalo												
28	260	68	74%	425	135	68%	600.0	460.0	23%	0.25	0.00	100%

SOURCE : COURTESY OF DSSD 1987

TABLE 2 2

It is recommended that Airport TDF and Buguruni pond should be properly rehabilitated, while the construction works for Mgulani and Ubungo Industrial Area should be finalized. Treatment efficiencies are reported in Table 2.2.

Conclusively BOD removal efficiency varies between 63 and 74 percent, COD removal varies between 32 and 68 percent, SS removal varies between 84 and 100 percent. Large fluctuations have been observed, but the analyses show that adequate results can be achieved. In particular the removal at BOD and ammonia appears to be very consistent.

POSITION OF SAMPLING STATIONS.

SAMPLING POINT	NAME
1.	Sea Outfall Main Sewer
T2.	Swimming Club
T3.	Storm Water Outfall Ras Ohrokir
4	Storm Water Outfall 1 Ocean Road
5	Storm water Outfall 2 Ocean Road
T6.	Ras Upanga
7.	Storm Water Outfall 3 (Opposite Kilimanjaro Hotel)
8	Harbour Storm Water Outfall 4
9.	Mzinga Creek, near Mgulani Outfall
10.	Magomeni Bridge on Morogoro Road
11.	Outfall from Brewery
12.	Msimbazi River at Kigogo Road Bridge
13.	Buguruni drain to Msimbazi River
14.	Luhanga River near Tabata Dump
15.	Vingunguti Pond Outfall
16.	Outfall from Textile Factories
17.	Sinza River at Morocco Road
18.	Sinza River near Mwananyamala
19.	Lake Makurumla
20.	Ubungo Drain
21.	Lake Minyonyoni
22.	Lake Luhanga
23.	Msimbazi River downstream Muhimbili/ Brewery drain
T24.	Msimbazi Creek at Selander Bridge
25.	Kijitonyama River at Old Bagamoyo Road - Regent Estate Pond
26.	Kijitonyama River at New Bagamoyo Road at emptying point for vacuum trucks
27.	University Pond Outfall -University of Dsm
28.	Lugalo Pond Outfall -Lugalo Barracks
29.	Slaughter House Outfall -Tanganyika Packers-Kawe
30.	Point near Bicycle Factory in Mwenge
31.	Yombo River at Tazara Bridge
T32.	Mzinga Creek at Mtoni Bridge
T33.	Outfall from Tiper Refinery
34.	Swamp near Matsushita Elect. Co.
T35.	Ras Kandya, S.E. of Ras Kankadya
T36.	Msasani Beach Club
37.	Luhanga River at bridge along Port Access Road
38.	Upstream Tabata, Tabata Stream feeding Lake Luhanga
39.	Kijitonyama River - Sinza Area.

TABLE 2.3

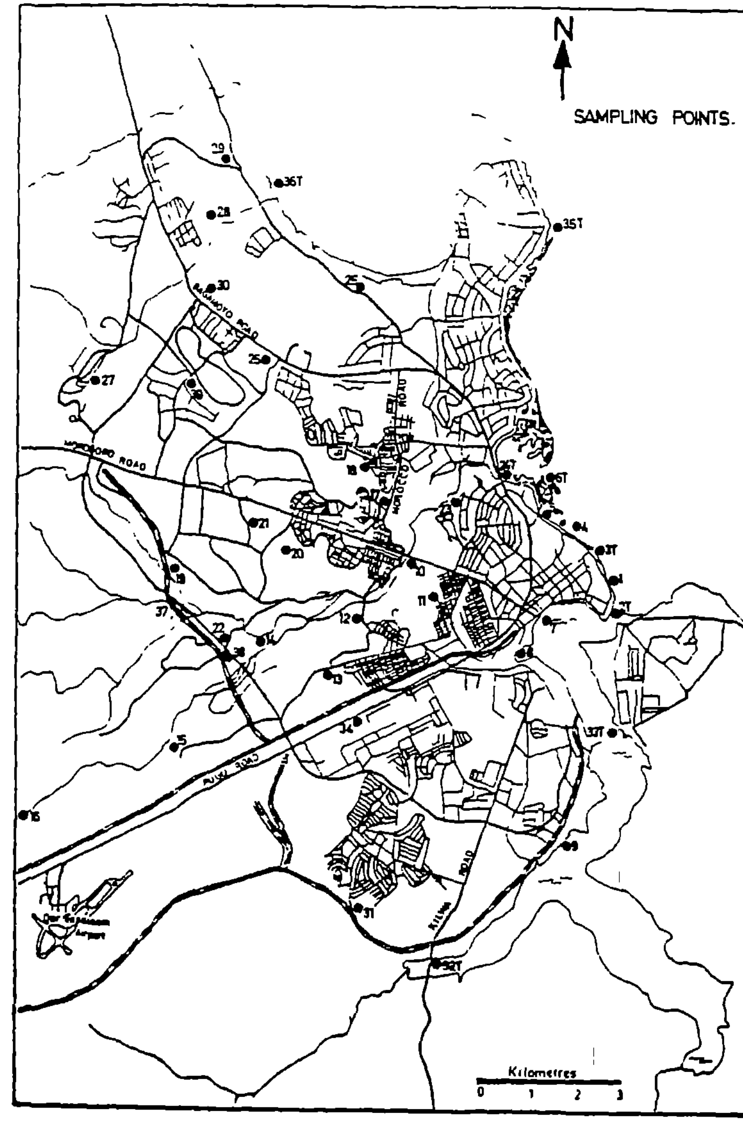

Figure 2.3

2.5 Major Industries and Institutions

The pollution caused by industries and institutions has been assessed by means of emission caluclations, visits to selected industries and water quality surveys. Such pollution is emitted to groundwater, ponds, sea outfall and rivers. In 1988 the study's emission caluclations estimate that industries and institutions together will release some 32,631 kg BOD per day. This corresponds to 604, 277 inhabitant equivalents, a moderate figure relative to a metropole with 1,723,000 inhabitants.

The larger part 24,473 kg BOD/day (75 percent) is released to surface water, 5,286 kg BOD/day (16 percent) is directly disposed of by the sea outfall, 1,632 kg BOD/day (7 percent) is lost from sewer system to groundwater and only 1,240 kg BOD/day (2 percent) is treated in stabilized ponds. No account has been made of instituional waste-water which also contributed to pollution loads.

During the visit to selected industries, only some 1000 kg BOD/day of effluents was identified. This estimate was made for industries operating far below their actual capacity. If the factories would work at their nominal capacity, they would release some 1,700 kg BOD/day.

This suggests that the emission assessment for industry and institutions is too high (which seems to be unlikely as only 600,000 Inhabitant Equivalents (IE) are predicted for industrial and institutional sources versus some 1,800,000 IE's for domestic pollution), or that industry contributes with many small sources, rather than with a few major sources. Indeed the absence of large processing industries in Dar es Salaam seems to confirm the latter and reconciles the findings. From the water quality survey little evidence of chemical pollution was found. In the solid-waste studies estimates have been prepared on the amount of chemical waste produced. Little of it has actually been traced during the survey.

Apparently polluted by industries are branches of the Msimbazi River (the drain from the Buguruni area and Tanzania Breweries, Lake Makurumla in the Ubungo Branch) and the small stream receiving effluent from Tanganyika Packers. The survey near the outlet of Tiper Refinery did not confirm the assessments of large oil losses mentioned in the solid waste study. Apparently the situation has improved since. Only evidence of old spills was found.

3. Storm Outfalls

3.1 Condition of Drainage System

Dar es Salaam has a limited drainage system. The existing system can be divided into:

- A piped system mainly in the City Centre, discharging into the harbour and into the ocean at Ocean Road.

- A system of open drains, partly lined and partly unlined. Lined tertiary drains exist e.g. in Kariakoo area. Lined secondary and primary drains serve part of the city centre. A rudimentary system of unlined tertiary and secondary drains exist in parts of urban Dar es Salaam.

- Some areas of Dar es Salaam have major discharge drains, all of these are unlined and in need of major rehabilitation. Most other areas of Dar es Salaam rely on natural water courses for drainage.

Large parts of Dar es Salaam have insufficient drainage. This applies notably to the unplanned areas of the city, where a large proportion of the poorer inhabitants live. Rain water in these areas has to evaporate or to infiltrate the subsoil. Parts of the habitated area of Dar es Salaam are prone to seasonal flooding. Large parts of river basins in Dar es Salaam cannot be put to any urban use, because of insufficient drainage and incidental flooding. These areas are inner urban breeding grounds for mosquitoes pestering the city's inhabitants with malaria.

Rainfall in Dar es Salaam only surpasses potential evaporation in two months of the year. Theoretically only during two months of the year there would be a surplus of rain water to be discharged by drainage. In urban built-up areas the increase of the impervious areas result in surface detention, overland flow and easy flooding of low lying areas. Part of these discharges drain to natural water course. Other parts remain in stagnant pools, slowly evaporating and infiltrating. High water tables and low soil permeability result in some areas of the city suffering muddy conditions for much of the year. Discharge of grey water in soakaways in these areas is also problematic, leading to discharges in open community operated drains and pools.

The sanitary and environmental conditions resulting from this development are sub-standard. The Physical Master Plan for Dar es Salaam (1979) and the Sewerage and Sanitation Masterplan (1980) recommended areas for urgent central and neighbourhood drainage works. Very few of these recommendations are implemented. In major lending evaluations for environmental and sanitary works in Dar es Salaam drainage is excluded. It seems, that the drainage of one of Africa's fastest growing metropolises is not an area of concern, although conditions at least in some areas of the city are quite appalling.

In those areas where grey water has to be partly discharged in the drainage system due attention must be paid to the environmental consequences, pathogenes, (BOD, COD) for receiving surface waters.

3.2 Pollution Caused by Drainage Systems

Most polluted water discharged in drainage systems reaches surface waters. The pollution load on the drainage system has been assessed. The pollution load from directly drained system is composed of: industrial and institutional waste-water directly disposed of, grey water released from settlements with pit latrines or septic tanks, and drainage from water supplied areas lacking sanitary facilities.

During the water quality survey and the biomarine survey due attention has been given to the stormwater outfalls and the rivers and small creeks approaching the sea. Apparently station No 8 (storm water outfall No. 4) has a bad quality caused by drainage from the non functioning sewage pumping station. (see fig. 2.3 and table 2.3). Relatively bad qualities have been identified at station T 24 (Salander Bridge), station No. 7 (Storm water outfall No. 3 opposite Kilimanjaro Hotel) station No. 4 (Storm water outfall No. 1), station No. 5 (Storm water outfall No. 2) and station T2 (Swimming Club).

No doubt the storm water outfalls and rivers flowing into the sea are sources of pollution. this is indicated by the quality of inland water resources.

Table 2.3 POSITION OF SAMPLING STATIONS

SAMPLING POINT	NAME
1.	Sea Outfall Main Sewer
T2.	Swimming Club
T3.	Storm Water Outfall Ras Chrokir
4.	Storm Water Outfall 1 Ocean Road
5.	Storm Water Outfall 2 Ocean Road
T6.	Ras Upanga
7.	Storm Water Outfall 3 (Opposite Kilimanjaro Hotel)
8.	Harbour Storm Water Outfall 4
9.	Mzinga Creek, near Mgulani Outfall
10.	Magomeni Bridge on Morogoro Road
11.	Outfall from Brewery
12.	Msimbazi River at Kigogo Road Bridge
13.	Buguruni drain to Msimbazi River
14.	Luhanga River near Tabata Dump
15.	Vingunguti Pond Outfall
16.	Outfall from Textile Factories
17.	Sinza River at Morocco Road
18.	Sinza River near Mwananyamala
19.	Lake Makurumla
20.	Ubungo Drain
21.	Lake Minyonyoni
22.	Lake Luhanga
23.	Msimbazi River downstream Muhimbili/Brewery drain
T24.	Msimbazi Creek at Selander Bridge
25.	Kijitonyama River at Old Bagamoyo Road - Regent Estate Pond
26.	Kijitonyama River at New Bagamoyo Road at emptying point for vacuum trucks
27.	University Pond Outfall - University of DSM
28.	Lugalo Pond Outfall - Lugalo Barracks
29.	Slaughter House Outfall - Tanganyika Packers - Kawe
30.	Point near Bicycle Factory in Mwenge
31.	Yombo River at Tazara Bridge
T32.	Mzinga Creek at Mtoni Bridge
T33.	Outfall from Tiper Refinery
34.	Swamp near Matsushita Electric Co.
T35.	Ras Kandya, S.E. of Ras Kankadya
T36.	Msasani Beach Club
37.	Luhanga River at bridge along Port Access Road
38.	Upstream Tabata, Tabata Steam feeding Lake Luhanga
39.	Kijitonyama River - Sinza Area.

3.3 Tabata Dumpsite

Runoff water and leachate from Tabata Dumpsite affects both surface and water quality. A special study of Tabata was executed by the Consultants due to its importance to the city. This assessment is however not presented in details in this paper.

4. Non-Point Sources

Leakage from sewerage systems (line sources), leachate from septic tanks, pit latrines and infiltrate from water supplied areas lacking sanitary facilities substantially contribute to the pollution of ground water resources. Assessments of this pollution is reported later in this paper.

PRESENT AND FUTURE EMISSIONS

1. Introduction

To identify the present pollution caused by sewer systems in Dar es Salaam an account has been made of:

- Dar es Salaam sanitary systems: sewerage, septic tanks, pit latrines and non-sanitated (but water supplied) areas.
- The functioning of present waste water stabilization ponds, the pollution caused by emptying of tanker trucks and pollution caused by some selected industries.
- The population projections.
- The waste water generation per capita.
- The pollution loaded to the surface and groundwater resources.

The present conditions have been modelled and projected. For this purpose data from 1982 and before were updated to reflect conditions in 1988 and then used to prepare the projections for the year 1991, 1999 and 2009. Consequently this part both accounts for the present and the projected pollution caused by sewerage systems in Dar es Salaam.

2. Water Supply

The basic information for the public water supply of Dar es Salaam was supplied by NUWA:-

- Capacity of water works : 270,800 cu.m./day
- Actually produced : 234,000 cu.m./day
- Distribution loss (leakage) : 40%
- Consumption : 140,400 cu.m./day
- Industrial and institutional consumption : 40,000 cu.m./day
- Domestic consumption : 100,400 cu.m./day
- Population : 1,723,000 capita
- Consumption per capita : 58.27 lpcd.

3. Water Consumption of Sanitary Systems

The water consumption of sanitary systems of Dar es Salaam is summarized in Table 3.1.

. POPULATION RELATIVE TO SANITARY LEVEL

Year	Population a	Sewered Houses +2.5% pa	Sewered Population b	Non sewered Population C = (a-b)	On-site sanitation population 0.8c = d	Pit-latrine Population 0.7d = e	Septic tank Population BOD 0.3d = f	Other 0.2c = g
1988	1,723,000	15,000	105,000	1,618,000	1,294,400	906,080	388,320	323,600
1991	2,134,510	16,153	113,071	2,021,439	1,617,151	1,132,006	485,145	404,288
1999	3,778,613	19,681	137,767	3,640,846	2,912,677	2,038,874	873,803	728,169
2009	7,715,697	25,194	176,358	7,539,339	6,031,471	4,222,030	1,809,441	1,507,868
	A		B	C	D	E	F	G

Notes : A = B+E+F+G C = D+G D = E+F

WATER CONSUMPTION PELATIVE TO SANITARY FACILITIES

Year	SEWERED HOUSES			NON SEWERED HOUSES WITH PUBLIC WATEP SUPPLY					
	Sewered Population	Consumption per cap/day	Distributed to sewered houses	Distributed to non sewered houses	Consumption per cap/day	Population	Septic tank Population	Pit latrine Population	Other sanit Population
	capita	lcd	m.cu/day	m.cu/day	lcd	capita	capita	capita	capita
1988	105,000	200.00	21,000	79,400	54.92	1,445,700	388,320	906,080	151,300
1991	113,071	206.06	23,299	104,849	57.58	1,820,795	485,145	1,132,006	203,644
1999	137,767	223.13	30,740	214,910	64.23	3,346,114	873,803	2,038,874	433,437
2009	176,358	246.48	43,469	510,611	72.00	7,091,829	1,809,441	4,222,030	1,060,358

WATER CONSUMPTION OF THE SYSTEMS INVOLVED.

Year	Consumption pit latrine population	Consumption septic tank population	Consumption other sanit. population	Consumption sewered houses	Total domestic consumption
	m.cu/day	m.cu/day	m.cu/day	m.cu/day	m.cu/day
1988	49,763	21,327	8,310	21,000	100,400.00
1991	65,186	27,937	11,720	23,299	128,148.00
1999	130,950	56,122	27,838	30,740	245,650.00
2009	303,986	130,280	76,345	43,469	554,080.00

TABLE 3 1

4. Waste Water Generation Per Capita

4.1 Domestic Waste Water

The average quantity solids, BOD and COD produced per person per day are summarized in Table 3.2.

Table 3.2 Average Solids, BOD and COD Produced per capita per Day (g/cap.day,) Fair, Geyer and Okun (1968).

State of Solids	Solids			5day, 20°C BOD	COD
	Mineral	Organic	Total		
Suspended	25	65	90	42	41
- Settleable	15	39	54	19	16
- Non Settleable	10	26	36	23	25
Dissolved	80	80	160	12	16
Total	105	145	250	54	57

Using the population projections of 1988 (7.4 percent growth per annum) leads to the folllowing projection for the domestic pollution load for Dar es Salaam, Table 3.3.

PREDICTED DISTRIBUTION LOADS OF DAR ES SALAAM

PRESENT SANITATION SYSTEMS	1988	1991	1999	2009
Total Population	1,723,000	2,134,510	3,778,613	7,715,697
Daily Domestic Pollution per Capita				
- BOD (5day 20 C) 54g/day (Kgs)	93,042	115,264	204,045	416,648
- COD 57g/day (Kgs)	98,211	121,667	215,381	439,795
- Suspended Solids 90g/day (Kgs)	155,070	192,106	340,075	694,413
- Dissolved solids 160g/day (Kgs)	275,680	341,522	604,578	1,234,512
- Total Nitrogen 7.9 g/day (Kgs)	13,612	16,863	29,851	60,954
- Total Phosphorous 1.5 g/day (Kgs)	2,585	3,202	5,668	11,574

TABLE 3 3

The results of this section are as follows in Table 3.4

POPULATION AND WATER CONSUMPTION RELATIVE TO SANITARY SERVICE

	1988	1991	1999	2009
Total Population	1,723,000	2,134,510	3,778,613	7,715,697
Population Served and Sanitary Level				
- sewer connections	105,000	113,071	137,767	176,358
- pit latrines	906,080	1,132,006	2,038,874	4,222,030
- septic tanks	388,320	485,145	873,803	1,809,441
- public water,no sanitation	151,300	203,644	433,437	1,060,358
- rural water supply and sanitation	172,300	200,644	294,732	447,510
Total population	1,723,000	2,134,510	3,778,613	7,715,697
Water Consumption and Sanitary Level				
- sewer connections, m.cu/day	21,000	23,299	30,740	43,469
- pit latrines, m.cu/day	49,763	65,186	130,950	303,986
- septic tanks, m.cu/day	21,327	27,937	56,122	130,280
- public water,no sanitation,	8,310	11,726	27,838	76,345
- rural water supply and sanitation				
Total Consumption M.cu/day	100,400	128,148	245,650	554,080

TABLE 3.4

DOMESTIC POLLUTION TO SEWER SYSTEMS

	1988	1991	1999	2009
DOMESTIC (Sewered houses)				
- water consumption (m.cu/day)	21,000	23,299	30,740	43,469
- garden watering	7,099	8,329	12,501	20,121
- water into sewer	13,901	14,970	18,239	23,348
- sewer losses 20%	2,780	2,994	3,648	4,670
- total collected in sewer (m.cu/day)	11,111	11,976	14,591	18,678
- northern area 17%	1,889	2,036	2,480	3,175
- southern area 2%	222	240	292	374
- central area 81%	9,000	9,701	11,819	15,129
Fresh sewerage strength				
- mg BOD/l (5 day 20C)	408	408	408	408
- mg COD/l	431	431	431	431
- mg SS/l	680	680	680	680
- mg DS/l	1,209	1,209	1,209	1,209
- mg tot N/l	60	60	60	60
- mg tot P/l	11	11	11	11

TABLE 3.5

INDUSTRIAL AND INSTITUTIONAL POLLUTION TO SEWER SYSTEMS

	1988	1991	1999	2009
SEWERED INDUSTRIES & INSTITUTIONS				
- water consumption (M.cu/day)	40,000	46,305	68,413	111,438
- water into sewer (25%)	10,000	11,576	17,103	27,860
- to other systems (75%)	30,000	34,729	51,310	83,579
- sewer losses (20%)	2,000	2,315	3,421	5,572
- total collected (M.cu/day)	8,000	9,261	13,683	22,288
- to sea (81%)	6,480	7,501	11,083	18,053
- to lagoons (19%)	1,520	1,760	2,600	4,235
Fresh sewerage strength				
- mg BOD/l (5 day 20C)	816	816	816	816
- mg COD/l (5 day 20C)	861	861	861	861
- mg SS/l	1,360	1,360	1,360	1,360
- mg DS/l	2,417	2,417	2,417	2,417
- mg tot N/l	119	119	119	119
- mg tot P/l	23	23	23	23

TABLE 3 6

5.1 Sewered Industries and Institutions

Reportedly 25 percent of the institutions and industries of Dar es Salaam are connected to sewer systems. No data on the strength of their foul sewage do exist at present. For the present purpose the strength of foul water from industry and institutions has been set equal to double the projected strength of foul sewage originating from domestic sources.

This results into the projections presented in Table 3.6.

5.2 Pit Latrines

The pollution caused by pit latrines is summarized in Table 3.7.

POLLUTION CAUSED BY PIT LATRINES

	1988	1991	1999	2009
- water consumption (M.cu/day)	49,763	65,186	130,950	303,986
- blackwater (10%)	4,976	6,519	13,095	30,399
- greywater (90%)	44,787	58,667	117,855	273,587
- to pit latrine (55%)	27,370	35,852	72,023	167,192
- to drainage system (45%)	22,393	29,334	58,928	136,794
Blackwater strength				
- mg BOD/l (5 day 20C), 50% of poll.	4,916	4,689	4,204	3,750
- mg COD/l , 50% of poll.	5,189	4,949	4,437	3,958
- mg SS/l "	8,194	7,815	7,006	6,250
- mg DS/l "	14,566	13,893	12,456	11,111
- mg tot N/l "	719	686	615	549
- mg tot P/l "	137	130	117	104
Grey water strength				
- mg BOD/l (5 day 20C)	546	521	467	417
- mg COD/l , 50% of poll.	577	550	493	440
- mg SS/l "	910	868	778	694
- mg DS/l "	1,618	1,544	1,384	1,235
- mg tot N/l "	80	76	68	61
- mg tot P/l "	15	14	13	12
Pollution to surface drainage syst.				
from grey water				
- BOD (5 day 20C) (Kg/day)	12,232	15,282	27,525	56,997
- COD "	12,912	16,131	29,054	60,164
- SS "	20,387	25,470	45,875	94,996
- DS "	36,243	45,280	81,555	168,881
- tot N "	1,790	2,236	4,027	8,339
- tot P "	340	425	765	1,583
Pollution to groundwater				
- BOD (5 day 20C) (Kg/day)	12,232	15,282	27,525	56,997
- COD "	12,912	16,131	29,054	60,164
- SS "	6,116	7,641	13,762	28,499
- DS "	97,857	122,257	220,198	455,979
- tot N "	4,829	6,034	10,867	22,503
- tot P "	915	1,143	2,059	4,264
Accumulating in pit latrine				
- emptying interval (days)	365	365	365	365
- BOD (5 day 20C) (Kg/year)	97,857	122,257	220,198	455,979
- COD "	1,032,931	1,290,487	2,324,316	4,813,114
- SS (Kg/year)	20,074,655	25,080,159	45,172,273	93,541,186
- DS "	3,968,630	4,958,186	8,930,268	18,492,491
- tot N "	195,124	243,777	439,072	909,214
- tot P "	37,206	46,483	83,721	173,367

TABLE 37

POLLUTION CAUSED BY SEPTIC TANKS

	1988	1991	1999	2009
- water consumption (M.cu/day)	21,327	27,937	56,122	130,280
- population	388,320	485,145	873,803	1,809,441
- blackwater (10%)	2,133	2,794	5,612	13,028
- greywater (90%)	19,194	25,143	50,510	117,252
- to drainage system (25% of grey)	4,799	6,286	12,627	29,313
Blackwater strength				
- mg BOD/l (5 day 20C), 50% of poll.	4,916	4,689	4,204	3,750
- mg COD/l , 50% of poll.	5,189	4,949	4,437	3,958
- mg SS/l "	8,194	7,815	7,006	6,250
- mg DS/l "	14,566	13,893	12,456	11,111
- mg tot N/l "	719	686	615	549
- mg tot P/l "	137	130	117	104
Grey water strength				
- mg BOD/l (5 day 20C)	546	521	467	417
- mg COD/l , 50% of poll.	577	550	493	440
- mg SS/l "	910	868	778	694
- mg DS/l "	1,618	1,544	1,384	1,235
- mg tot N/l "	80	76	68	61
- mg tot P/l "	15	14	13	12
Pollution to surface drainage syst.				
- BOD (5 day 20C) (Kg/day)	2,421	3,275	5,898	12,214
- COD "	2,767	3,457	6,226	12,892
- SS "	4,369	5,458	9,830	20,356
- DS "	7,766	9,703	17,476	36,189
- tot N "	383	479	863	1,787
- tot P "	73	91	164	339
Pollution to groundwater				
- BOD (5 day 20C) (Kg/day)	6,116	7,641	13,762	28,499
- COD "	6,458	8,048	14,531	30,091
- SS "	3,060	3,823	6,886	14,258
- DS "	48,928	61,128	110,099	227,990
- tot N "	2,415	3,018	5,435	11,255
- tot P "	458	572	1,031	2,135
Accumulating in septic tank				
- emptying interval (days)	365	365	365	365
- BOD (5 day 20C) (Kg/year)	41,939	52,396	94,371	195,420
- COD "	442,685	553,065	996,135	2,062,763
- SS "	10,034,965	12,537,117	22,580,817	46,759,574
- DS "	1,984,315	2,479,091	4,465,133	9,246,244
- tot N "	97,940	122,361	220,386	454,368
- tot P "	18,568	23,197	41,781	86,518

TABLE 38

5.3 Septic Tanks

The pollution caused by septic tanks is summarized in Table 3.8.

5.4 Settlements without sanitation but supplied with water

Part of the urban population in Dar es Salaam has water supply but lacks elementary sanitary facilities. the results for the pollution loads are summarized in Table 3.9.

6. Pollution Load to Waste-Water Ponds

The pollution load to the waste water stabilization ponds arises from:

- Foulwater generated by sewered houses, minus losses from sewer systems.

- Foulwater generated by sewered institutions and industries., minus losses from sewer systems.

- Sludges collected form pit latrines by the emptying services.

- Sludges collected form septic tanks by septic tank emptying services.

6.1 Total Pollution load of ponds

The pollution load to the ground water is composed of:

- Foulwater leakage from domestic sewer systems.
- Foulwater leakage from industrial and institutional sewer systems.
- Leachate from pit latrines.
- Leachate from septic tanks.
- Leachate from water supplied settlements lacking sanitary facilities.
- Leachate from Tabata solid waste dump.

This is summarised in Table 3.10.

7. Pollution Load to Groundwater

7.1 Total pollution load to groundwater

The total pollution load to groundwater is summarized in Table 3.11.

POLLUTION CAUSED BY POPULATION WITHOUT SANITARY FACILITIES
BUT SUPPLIED WITH PUBLIC WATER

	1988	1991	1999	2009
- water consumption (M.cu/day)	8,310	11,726	27,838	76,345
- population	151,300	203,644	433,437	1,060,358
- drained to surface water, 50%	4,155	5,863	13,919	38,173
- infiltrated to groundwater, 50%	4,155	5,863	13,919	38,173
Surface water pollution, 90%				
- BOD (5 day 20C) (Kg/day)	7,353	9,897	21,065	51,533
- COD "	7,762	10,447	22,235	54,396
- SS "	12,255	16,495	35,108	85,889
- DS "	21,787	29,325	62,415	152,692
- tot N "	1,076	1,448	3,082	7,539
- tot P "	204	275	585	1,431

TABLE 3 9

TOTAL POLLUTION LOAD TO PONDS.

	1988	1991	1999	2009
POLLUTION LOAD TO PONDS				
(sewers, pit latrines & septic tanks)				
Influent				
- volume of water to lagoons (M.cu/day)	4,458	5,068	7,233	11,637
- BOD (5 day 20C) (Kg/day)	2,184	2,467	3,438	5,287
- COD "	3,045	3,528	5,293	9,028
- SS "	85,994	107,000	191,044	392,556
- DS "	17,641	21,265	35,323	67,719
- tot N "	1,110	1,349	2,282	4,458
- tot P "	211	257	434	848

TABLE 3 10

TOTAL POLLUTION LOAD TO GROUNDWATER

	1988	1991	1999	2009
DAILY LOAD TO GROUNDWATER				
- BOD (5 day 20C) (Tons/day)	22	27	48	98
- COD "	23	29	51	103
- SS "	15	18	32	63
- DS "	157	196	350	720
- tot N "	8	10	17	36
- tot P "	1	2	3	7
Volume of polluted water to groundwater	47,021	60,726	118,822	270,836

TABLE 3 11

8. Pollutin Load to the Sea

The pollution load to the sea is composed of

- Discharge from the sea outfall composed of discharge from the domestic and the industrial/institutional sewer system in the central urban area.

- Discharge from waste water stabilization ponds receiving domestic and industrial/institutional waste water in the northern and southern urban area, including the sludges of pit latrines and septic tank emptying.

- Discharge from directly drained effluents comprising:

- * industrial waste water disposed off to rivers;
- * grey water drainage from settlements with pit latrines.
- * surface drainage of settlements served with water but lacking elementary sanitary facilities.

8.1 Total pollution load to the Sea

The total pollution load to the sea is summarized in Table 3.12.

9. Total Pullution Load of Dar es Salaam

The total pollution load of Dar es Salaam population, institutions, and industries is illustrated in Table 3.13.

TOTAL POLLUTION LOAD TO THE SEA

POLLUTION DISCHARGES	1988	1991	1999	2009
DAILY LOAD TO SEA				
- BOD (5 day 20C) (Tons/day)	56	68	111	212
- COD "	60	72	118	224
- SS "	121	147	247	479
- DS "	182	219	342	689
- tot N "	9	11	18	35
- tot P "	2	2	3	7
Volume of polluted water to sea	100,400	128,148	245,650	554,080

TABLE 3 12

TOTAL POLLUTION LOAD OF DAR ES SALAAM

POLLUTION DISCHARGES	1988	1991	1999	2009
DAILY LOAD TO SEA				
- BOD (5 day 20C) (Tons/day)	56	68	111	212
- COD "	60	72	118	224
- SS "	121	147	247	479
- DS "	182	219	342	689
- tot N "	9	11	18	35
- tot P "	2	2	3	7
Volume of polluted water to sea	100,400	128,148	245,650	554,080
DAILY LOAD TO GROUNDWATER				
- BOD (5 day 20C) (Tons/day)	22	27	48	98
- COD "	23	29	51	103
- SS "	15	18	32	63
- DS "	157	196	350	720
- tot N "	8	10	17	36
- tot P "	1	2	3	7
Volume of polluted water to groundwater	47,021	60,726	118,822	270,836
TOTAL DAILY LOAD TO ENVIRONMENT				
- BOD (5 day 20C) (Tons/day)	78	95	159	309
- COD "	83	100	169	328
- SS "	136	165	278	542
- DS "	340	415	711	1,409
- tot N "	17	21	36	71
- tot P "	3	4	7	13
Volume of polluted water (m.cu/day)	147,421	188,874	364,472	824,916

TABLE 3 13

IMPACT ASSESSMENT OF TABATA SOLID WASTE DUMP

1. Introduction

The present municipal waste disposal site - Tabata dump, has been studied to assess the operatinal techniques, the present and remaining capacity, the impact of the dump on ground and surface water quality, and the works needed to minimize such pollution.

Proposed improved operational techniques and works to allow both for such techniques and for migitative measures with respect to pollution are detailed in the study. However due to the sensitivity of this subject at present the authors do not wish to discuss this issue.

STAGED ACTION PROGRAMME

In the preceeding parts, recommendations have been made to maintain and improve surface water quality in Dar es Salaam. These recommendations have been summarized in a staged action programme for the period 1989-2009.

The programme is presented hereafter:

II. Stage One Recommendations (1989 - 1991)

1. Finalize the implementation and execution according to existing plans of the first stage of the existing Sewerage and Sanitation Masterplan. The rehabilitation works on the Buguruni ponds, the related sewerage system and a truck emptying station and also sanitary facilities for the swimming club and the fish market should be included in these works.

2. Implement in a pilot project the recommendations of the on going MAPET * study for sanitary low-cost on-site disposal of contents of septic tanks, VIP's and soakaway, and monitor the resulting groundwater pollution. If successful this disposal method might provide a financially feasible temporary alternative for truck emptying until 100% emptying by truck is financially feasible (through increased cost recovery) and environmentally acceptable (through the construction of more dumping stations and ponds). This pilot project

could possibly be executed on a grant basis by a donor financing the ongoing study. (*Manual Pit Emptying Technology).

3. Prepare a technical, environmental and financial update on Stage Two and Three of the existing Sewerage and Sanitation Masterplan.

4. Prepare a technical, environmental and financial study for a Staged Masterplan for Drainage of Dar es Salaam. Stage one of this plan shall be directed at area's prone to seasonal flooding, area's where grey water can insufficiently be infiltrated in the sub soil, and swampy area's that breed mosquitoes. Special environmental investigations are to be executed into consequences for surface water pollution if in some areas excess of grey water is possibly discharged into the drainage system.

5. Continue Central Government support for the Dar es Salaam Sewerage and Sanitation Department, until the department is established at its envisaged institutional and fainancial capacity.

6. Incorporate the responsibility for the fleet of emptying trucks of the Dar es Salaam Health Department into the Dar es Salaam Sewerage and Sanitation Department.

7. All truck discharge from sources that can be treated into pond systems, according to above monitoring programme, should be directed the to pond Dumping stations.

8. A monitoring programme is to be started on the qualitative and quantitative influents and effluent discharges from the ponds.

9. A similar monitoring programme is to be started on the qualitative and quantitative discharge from the existing sewer sea outfall.

10. It is proposed that a monitoring programme for surface waters, as done for this study, is executed for the twenty most polluted points on a yearly basis; once during the dry season, and once during the long rains.

11. It is proposed that the Water Utilisation Act, the National Industries Licensing and Registration Act and the National Environmental Management Act and all other

relevant acts are used to their full legal potential for the prevention and control of surface water pollution.

12. It is proposed that recommendations in this study on water and effluent standards and on methodology for testing of various parameters are studied in further detail through a collaboration of UNEP, and UNIDO with the Tanzania Technical Standards Effluent Committee.

II. <u>Stage Two Recommendations: (1992 - 1999)</u>

1. Implement Stage two of the adjusted Sewerage and Sanitation Masterplan, relying more on on-site sanitation, emptying trucks and ponds, and less on piped sewerage systems.

2. Implement Stage One of the Drainage Masterplan in the areas identified by the study in Stage One.

3. Apply to all newly constructed industries the Tanzanian Emission Criteria. Attach environmental conditions to licences and call for regular monitoring and reporting by those industries on effluents.

4. Execute the (industrial and sanitary) counselling programme according to the terms of references prepared during Stage One for highest ranking pollution sources. Cost coverage of implementation of resulting recommendations are to be shared after negotiations between polluter and the Central Government.

5. Select and prepare a new municipal solid waste disposal site with due respect to pollution preventive measures and with particular reference to the disposal of hazardous wastes.

6. Execute a new environmental impact study and compare results with results of the two studies executed in 1988 - 1991.

7. Raise where necessary and affordable Tanzanian Standards for receiving waters and emissions. Extend the Tanzanian priority list of potentially toxic chemicals.

8. Prepare on the basis of the new pollution sources ranking the terms of reference for industrial counselling during Stage Three.

III. Stage Three Recommendations (2000 - 2009)

1. Implement Stage Three of the adjusted Sewerage and Sanitation Masterplan. Phase out on-site disposal of on-site sanitation emptying.

2. Implement Stage Two of the Drainage Masterplan.

3. Attach to all licenses and discharge permissions environmental conditions according to Tanzanian Standards allowing for a time schedule to comply with those conditions before 2009.

4. Implement (industrial and sanitary) counselling programme prepared during Stage two. Implementation costs are increasingly to be recovered from the polluter.

5. Transfer in municipal disposal site to the selected disposal site prepared to reduce environmental hazards to minimal levels.

6. Raise where necessary and affordable Tanzanian Standards for receiving waters and emissions. Extend the Tanzanian priority list of potentially toxic chemical to international levels.

7. Continue monitoring and tracing of pollution sources. Execute a new environmental impact study and compare results with those of the studies executed earlier.

MODELLING OF HYDROLOGY - ENERGY - ENVIRONMENT LINKAGES IN TANZANIA

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A given pattern and quantum of energy production has its own set of environmental consequences. Water is the crucial factor if the environment is to be ameliorated through afforestation. Thus, water, energy and environment are closely linked.

ENERGY

As is well known, the GDP per capita of a country is directly related to the nature and magnitude of the pattern of consumption of energy. The gross energy consumption of 17 GJ/p.c./p.a. in Tanzania is not markedly different from about 25 GJ in the case of other Developing countries, and about 50 GJ in the case of Industrialised countries. The difference lies in the nature of the energy carriers and end-use. About 90% of the total energy in Tanzania is derived from the inefficiently used fuelwood (at the rate of 1.2t/p.c. /p.a.). On the other hand, the Industrialised countries use high efficiency energy carriers such as electricity, liquid and gaseous fuels, and processed solid fuels. For instance, if a person uses natural gas or propane for cooking, he/she would need only about 0.05 kw of energy per annum, whereas if fuelwood is used for cooking, the energy required would be several times higher (0.25 to 0.6 kW, representing 0.4t to 1.0t of firewood).

Electricity consumption in Tanzania (less than 40 kwh/p.c./p.a.) is about one-tenth of that in the Developing countries, and one-hundredth of that in Industrialised countries. As a matter of fact, energy consumption in Industrialised countries has either reached a plateau or even going down marginally, because the newer technologies, particularly those based on electronics, use less energy, even though they are more efficient. This leads to a higher GDP increment for the expenditure of the same amount of energy. The energy efficiency is just $8/GJ for

Tanzania, whereas it is \$200/GJ in Industrialised countries. Evidently, Tanzania needs to produce more energy in the form of efficient energy carriers, and put the energy to a more productive end-use. But this is easier said than done, as the process needs huge amounts of foreign exchange. Prudence lies in pursuing this approach, while simultaneously embarking upon a strategy of enhancing energy production which does not need foreign exchange.

Tanzania has substantial reserves of high-ash coal (prognostic reserves: 1900 m.t.; proven reserves: 300 m.t., in Ketewaka - Mchuchuma, Songwe - Kiwira and Ngaka coalfields), hydropower (4000 MW, representing about 20,000 GWH/a of electricity generation), and gas (1.3 trillion cu.ft., equivalent to about 60 m.t. of coal, at Songo Songo and Mnazi Bay). Though coal and natural gas are non-renewable resources, the known reserves will last a few hundred years at the present rate of use. Out of these energy resources, only a small fraction has been, and is being developed (about 160,000t. of coal from Ilima and Kiwira; about 330 MW of hydropower at Kidatu and Mtera). A 100MW, pitmouth, coal-fired power station is planned at Kabulo Ridge. Several options exist for the utilisation of Songo Songo gas (such as, piping to Dar es Salaam for domestic and industrial purposes, making of urea fertilizer, use of liquified gas in automobiles, etc.). An attractive possibility is the development of a 100 MW power starting at Songo Songo (at \$400/kw) using advanced gas turbines with heat to electric conversion efficiency of 50%.

Tanzania has about 840 m. cubic meters of solid round wood standing in an area of 28 m. ha. This is being felled at the rate of 1.5m. ha/p.a. to provide fuelwood for domestic and other uses. If this trend continues, there will be no trees left in Tanzania in twenty years' time, with horrendous consequences to environment and sustainability of life. Some high quality, rare timber trees should be protected in the same manner as the protection of endangered wild life, namely, banning their destruction. Tropical forests constitute a unique and vital ecological system. They are the repositories for an incredible variety of germ plasm. The reason why they are being destroyed is their timber resources (one hectare of Amazonian forest contains about 90 m^3 of merchantable timber worth about \$ 1000/=). In their greed, the timber merchants are killing the goose that lays the golden egg. Recent studies of the comparative economics of forest utilisation provide the most convincing evidence that proper utilisation of non-wood resources, such as edible fruits, nuts, oils, fiber, latex, etc. could provide economic returns while conserving the forest.

To provide 30 m.t. of fuelwood that Tanzania requires, it is necessary to plant and maintain 2 m. ha/p.a. of fast-growing tree crops with yields of 15t/ha/p.a. and good fuel value (4500 kcal/kg). Tree varieties are available to suit practically any kind of agro-climatic conditions and geomorphic situations (such as, aridity, salinity, water-logging, steep slopes). There are leguminous (Australian) acacia trees which actually enrich the soil as they grow. Leaves of some trees can be use as fodder. Some trees provide fruits, nuts, oils, medicines, etc. Thin branches could be used as fuel, and stout wood can be used as timber. Above all, the existence of forest cover would have a profound beneficial effect in ameliorating the soil, groundwater and biomass regimes. In areas which are thinly populated, (e.g. area between Lake Eyasi and Mwadui), forests can be planted from air by the dispersal of granules containing seeds and nutrients embedded in a matrix (Australia and USA have done such aerial planting of forests in a big way). It should be emphasized that planting of trees in an area as large as 2 m. ha/p.a. would just cover the fuelwood requirements of the country, i.e. without further cutting of natural forests. The damage done to the ecosystem by the burning of grass and trees is so serious that this pernicious practice should be deemed to be a criminal offence.

Growing of energy forests should go hand in hand with more efficient use of fuelwood, through the popularisation of "Bangalore-type" fuel-efficient, smokeless stoves built in homes with local materials but to an optimised design; fuel-efficient jikos for burning fuelwood, charcoal and biowastes; stoves which can use "Chinese - type" briquettes made from coal fines, etc. In some countries like Thailand and Sri Lanka, making various types of jikos has become a booming business.

Power alcohol produced from cassava could be blended with gasoline (gasohol) and used as fuel in automobiles. Thailand which produces 18 m.t. of cassava per annum, was exporting the material to EEC countries as animal feed. When that market disappeared due to EEC restrictions, Thailand did not give up, but mastered, with the assistance of UNEP, the technique of converting cassava into power alcohol. Tanzania can benefit from Thailand's experience. Development of biogas and solar-powered systems also satisfy the characteristics of people-oriented, decentralized, environment-friendly technologies.

Apart from degradation of biomass, soil and hydrological regimes, deforestation affects the solar albedo and hence, the climate. Dusts arising from desertification decrease the atmospheric transparency, and raise the temperatures. Intact tropical forests soak up CO_2 (the Amazonian rain forest is called the "lungs" of the world). On the other hand, burning of rain forest adds CO_2 to the atmosphere (estimated to be around 1.6×10^9t/yr.), thus causing double damage.

ENVIRONMENT

Environment is "every thing that surrounds us". The Industrialised countries have been responsible not only for "acid rain" which affects them directly, but also carbon dioxide and CFC emissions which through their "greenhouse" effect and ozone hole, affect all of us. Agrochemicals, municipal wastes, industrial effluent, mine dumps, etc. pollute the soil, water, air and biota in complex ways, with health consequences ranging from instant death to enhanced probability of disease in the exposed population. In the case of Tanzania, the environmental pollution caused by agrochemicals, and industrial effluent is superposed on the far more serious and wide-spread environmental degradation caused by the deforestation arising from the use of fuelwood as the principal energy source. The impact on the ecosystem due to the use of fuelwood as the principal energy source is schematically shown in Fig. 1. A possible pathway for the development of sustainable?

It is not adequately realised that certain kinds of wastes can indeed be turned into resources. For instance, methane fuel can be produced from waste water through anaerobic digestion. Power alcohol can be produced from cassava and sugar wastes. Biowastes can be used in cooking with fuel-efficient jikos, and for the generation of producer gas to drive stationary engines to produce power. Chemical pollution may be mitigated by educating the people about safe methods of storing, handling and application of hazardous agrochemicals, and substitution where possible, of degradable chemicals; and by the use of microbial techniques to degrade certain kinds of toxic chemicals, etc.

CONCLUSIONS

It is desperately important that the degradation of soil, biomass and hydrological regimes, caused by deforestation, be reversed. Computer simulation techniques can be used to project the environmental and socio-economic implications of different energy mixes (hydropower, coal-fired, natural gas - geared, biomass - based energy systems) in order to determine the most economical and environmentally being ways of enhancing the energy production and consumption in Tanzania.

REFERENCE

Jian-Kun, H. et al (1987) Afr. Environment, nos.20, 21,22, p. 195-205.

Question by Dr. Mwanthi

In your presentation you gave cassava as a possible alternative source of energy to firewood but is it so plentiful in Tanzania as to be able to fulfil this role without difficulty?

Answer

In Thailand where the example of the use of cassava as a source of energy was drawn they grow plenty of cassava whose marketing was a problem at one time because it is not eaten much there. So they solved the problem of marketing it by using it as a source of ethanol, an alternative energy source. Although in Tanzania cassava is fairly plentiful the crop is used for food and therefore not much of it can be available for energy production at the moment. However, it is possible to plan and execute future production of cassava on a large scale in Tanzania. Once this is achieved then it will be possible for the crop to be used as an energy source in this country.

Comments by Gijzen

I do not think that it is good to use human food to generate energy. Instead Lignocellulose agricultural wastes could be used as a potential source of energy. The production of biogas from these waste materials should be given a high priority.

Answer

I agree with you.

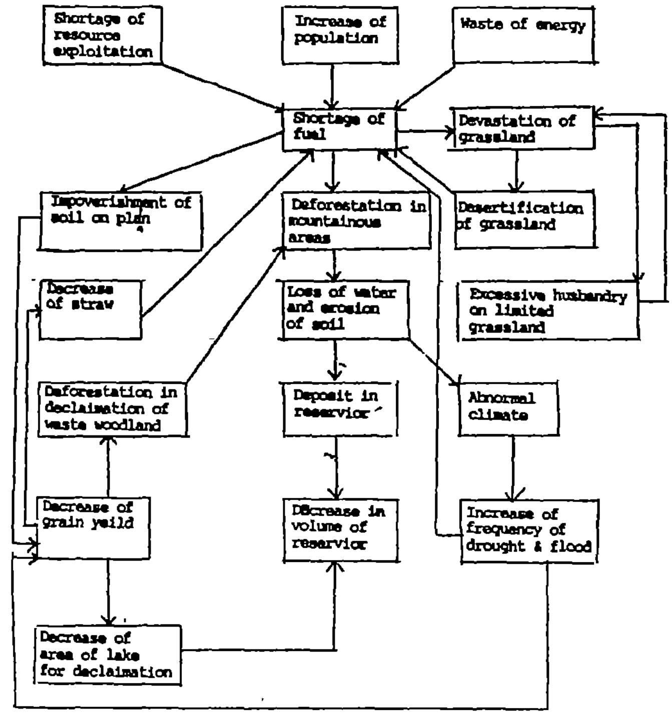

Fig. 1 . Impact on the ecosystem due to the use of woodfuel as the principal energy source , as in Tanzania (after Jian-Kun et al , 1987)

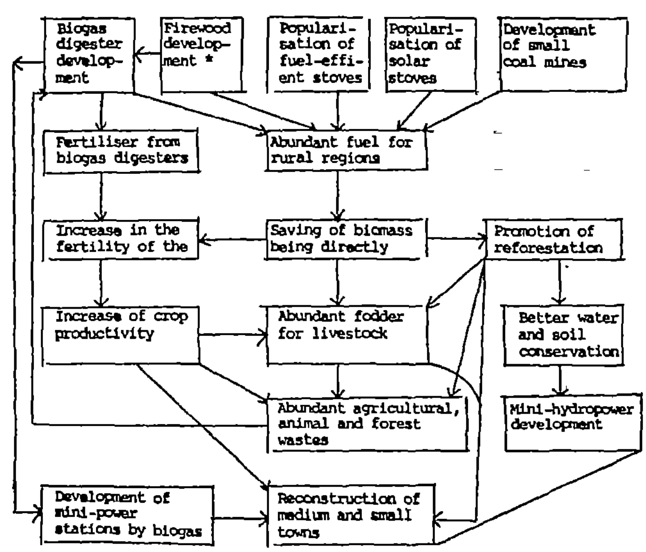

Fig. 2. Model of sustainable and environment-friendly energy systems for LDC's in Africa (e.g. Tanzania) (after Jian-Kun,H. et al , 1987)

CONSEQUENCES OF HUMAN ACTIVITIES ON THE MARINE ENVIRONMENT OF ZANZIBAR

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ABSTRACT

The consequences of human activities on the marine environment in Zanzibar Islands are discussed. These include the disposal of waste waters, the use of chemicals for preventive medicine, crop and animal husbandry, harbour development, exploitation of living and non-living resources, and oil transportation. It is cautioned that the danger posed by these activities is more real than apparent and is increasing in magnitude as a consequence of increase in human population and the need to revamp the economy. Examples of the deleterious effects of these activities on the marine life are given. Suggestions on the possible strategies to arrest these mounting problems are given. the need for conducting adequate impact assessment studies before any coastal zone use is emphasized.

INTRODUCTION

Man makes a variety of important uses of the ocean, ranging from exploitation of living and non-living resources, recreational, to the disposal of wastes. Extensive use of the ocean introduces factors which destabilize the natural processes and on occasions results in harmful and hazardous effects to life and may hinder further use of the ocean. These negative effects of man's use of the ocean are referred to as marine pollution which has been broadly defined as the introduction by man, directly or indirectly, of substances or energy into the marine environment which have deleterious effects to life and/or limit the use of the ocean (UNEP, 1982).

Pollution can be caused directly by man's interference in the marine environment or indirectly through his activities on land. Terrestrial activities can produce pollutants which are transported to the ocean through rivers, seepage and exchange at the air-sea interface. Ocean processes act on the pollutants such that they are dispersed from their point of introduction to other areas where they continue to cause harmful effects to man and/or the environment. Consequently, pollution does not respect national boundaries, the source in one geographic area can cause harm in another. An understanding of the extent of pollution, therefore, requires a knowledge of the sources, agents of dispersion and effects of the pollutants. In this paper we discuss the state of pollution in the marine waters of Zanzibar Islands.

Zanzibar Islands comprise two major islands; Unguja and Pemba; five minor habitable islands and several small islands all together covering an area of about 1000 sq. km. The minor islands with human settlement include Tumbatu and Uzi in Unguja; Panza, Makongwe, Kojani, Fundo and Njao in Pemba. The smaller, non-habitable islands are visited by camping fishermen from time to time. In addition to the islands, Zanzibar waters have a chain of reefs and sand banks. The minor islands, reefs and sand banks are mainly found on the western side of the main islands.

The configuration of the coastline of the main islands is more straight on the eastern than the western sides. The eastern coast of Pemba is interrupted by two bays, Adamson and Mtangani, while that of Unguja by Chwaka Bay. The western coastline in both islands has numerous indentations which include bays, peninsula and estuaries. These are more pronounced in Pemba than Unguja. Extensive mangrove cover is found on the western side of the Islands.

Zanzibar Islands are flanked by the Indian Ocean on the eastern side and by Tanzania Mainland on the western side. The Islands are separated from the Mainland by Zanzibar and Pemba channels.

SURVEY METHODOLOGY

The information reported in this paper was collected from three sources: interviews with relevant ministries and departments, on site assessment of polluted areas, review of published and unpublished manuscripts.

The Ministry of Industries and Trade was visited and interviewed on the state of the industries. The department responsible for municipal waste disposal and drainage was also interviewed. They provided information on the current state of the drainage and waste water systems in Zanzibar Town and the proposed centralized sewerage. Port development works were visited and information on the dredging activities was obtained including the sites where the dredged material is being dumped. Visits were made to the Mahonda Sugar Factory, Mtoni Shoe Factory, Mbweni

Tractor Repair Workshop, Cigarette Company and Clove Distilleries. Visits were also made to Funguni Creek, Gulioni, and Maruhubi Hotel.

WASTE WATERS

The Zanzibar Municipality and other small towns are experiencing rapid population growth and industrial development. Population increase is resulting in unplanned expansion of residential areas in the suburbs with very poor sanitation. The few industries that exist on the islands produce a variety of effluent which are discharged into the sea without any treatment. These waste waters are hazardous to the marine environment.

1. Sewage

The sewerage in Zanzibar's stone town is not a centrali system. Only a portion of this historic town is served by the main sewer whose outfall is at Funguni Beach. The rest of the stone town is served by about 30 outlets that receive sewage from septic tanks and their outfalls discharge raw sewage on the beach areas (Figure 2). The outlets also collect storm waters. The flow of the waste waters to the sea is slow because it is mainly dependent on gravitation. Although there are several pumps which are supposed to pump the waste waters, only two of these are in working condition. These are located at Funguni and Maisara. As a consequence most of the town area is flooded during the rainy season. The aesthetic conditions are so bad that raw sewage can sometimes be sighted on the streets. The developing residential areas are only served by septic tanks which are not linked to the outlets.

Realizing the importance of proper waste water disposal, the Zanzibar Government has initiated a move to have a centrali sewerage. The proposed system will cater for most of the areas in the municipality (Figure 3). However, because this system will have more than one outfall, it is important that these are placed strategically to have maximum dilution effects. The near shore currents off Zanzibar town have components which flow towards the beaches (Mwaipopo per. comm.). Therefore, care should also be taken not to locate the outfalls in a place where the sewage is swept to the beaches by these currents.

The dumping of raw sewage into the sea results in contamination of coastal waters with pathogens and creates high BOD especially in and within the vicinity of the outfalls (Table 1). Coliform counts range from

2-7/100 ml. Several clinical cases have been reported whose cause has been attributed to contaminated coastal waters (Ngoile, 1987).

The effect of sewage on marine life is variable. Direct depressive effects of sewage to the marine biotic environment is localized to the outfalls. Benthic animal communities are affected by suspended solids, sedimentation, and eutrophication.

TABLE 1: The Characteristics of Zanzibar Town Sewage receiving waters

Location:	SS%	DO mg/l	OD mg/l
FUNGUNI CREEK	59	0.337	40
MAMBOMSIIGE	49	0.453	2
NEAR V.I. LENIN HOSPITAL	41	0.470	5

SS% = Suspended Solids; DO mg/l = Dissolved oxygen; OD mg/l = Oxygen Demand

On the other hand mangroves, for example, tend to grow favourably in response to sewage loading. The only adverse effects noted have been when the concentration of suspended particulate matter are so great that the aerial roots become clogged during the flooding tide. Walsh (1967) reported that large amounts of nitrates and phosphates were removed from sewage waters running through a mangrove swamp. The fine clay associated with mangroves have a high nutrient absorption capacity. Hesse (1962) has described the affinity of mangroves soils for phosphorous. Ammonium ions can also be trapped within the lattice structure of clay minerals and rendered unavailable for biological transformation (Bremner, 1965; Maye, 1972). However, oxygen levels are low in mangrove waters (Walsh, 1967; Austin, 1971), so significant mortality of mangrove fauna might be expected with sewage input. Venkatesan and Ramamurthy (1971) found that bacteria capable of denitrification are abundant and ubiquitous in mangrove soils. Reduction of nitrates is an anaerobic process (Greenland, 1963; Tusneem and Patrick, 1971).

This characteristic of mangrove towards sewage effluent might explain their luxuriant growth on the area facing Bwawani Hotel and Gulioni area which receive direct raw sewage from Funguni outfall. However this mangrove ecosystem is very poor in other forms of marine life. There is a strong smell of hydrogen sulphide and there is a large population of _Nereis_. Hook and line fishermen are often seen digging for the polychaete for bait. There is also an overgrowth of _Ulva_ and _Enteromorpha_ to the exclusion of other species. These species are known to favour highly eutrophic areas.

2. Industrial Wastes

Industrial effluent do not seem to constitute a problem in Zanzibar at the moment due to the fact that there are comparatively few industries of which only a small proportion are operating. This is, however, temporary because in the move to rehabilitate the economy most of the dormant industries will be revived. A sample of these industries and their effluent characteristics is shown on Table 2.

The Mtoni Shoe Factory (Mwendo) is currently not operating (closed down in 1984). The factory has no treatment ponds for the effluent which flow directly into a stream that leads into the ocean near Maruhubi Hotel. It is suggested that the effluent from this factory may have decimated the mangrove stand at the mouth of the stream. As a result of the death of the mangrove flora the area is exposed to beach erosion which is affecting the slave ruins and Maruhubi Hotel. This historic and recreational area is affected by erosion because of the removal of the mangrove barrier.

Table 2: Characteristics of effluents activities from selected industries & other in Zanzibar

Industry	Quantity of waste m^3/day	Effluent content	Potential hazard
Textile mill	250	Hydrogen peroxide, soda-ash, caustic soda, soap and dye-stuffs	unknown
Leather & Shoe factory	40	Linsan; casein; phthalic anhydride oil, oxalic acid; Tanigan; puc; Bayderm; Basyntan; Albumin; Bleaching powder; Ammonium hydroxide; Magnesium Sulphate; Sodium Sulphate; Sulphuric acid; Sodium carbonate; Sodium bichromate; sodium sulphide.	Organochlorines; disrupt osmoregulation; cause death to fry; cayses thinning and cracking of egg shells; embryo mortality reduce hatchability; Oil causes asphyxiation t through coating.
Mbweni tractor repair shop	-	Lead tetraoxide; sodium cyanide; Pottassium cyanide;	Reduce fertilizing capacity; of spermatozoids; spermotoge-nesis; and androgen synthesis; causes testicular damage;
Small Scale Industry	-	Phosphoric acid; sulphuric acid.	Corrosive, forms compounds with other substances
MAHONDA Sugar Factory	-	baggese, partiuulate materials	Cause turbidity, oxygen depletion as they decay
Dredging for Port expansion	300	Sand & Mud	Burrying living organisms; increased turbidity, abrasion

The Mahonda Sugar Factory has a potential capacity of producing 6000 tons of sugar and 540m^3 of liquor. Sugar production started in 1973 and the sugarcane is processed from July to November. The bagasse is used as fuel and the molasses form the raw material for liquor production. However, the waste water from the factory is discharged into a drain which ends up in a river. At least three fish kills have been reported in the river where the effluent are dumped (Kamukala and Lann 1987).

Grigg (1972) found a considerable reduction in the abundance and diversity of corals and fish in the vicinity of a number of sugar mill effluent outfalls. Maragos (1972) found that reduced light intensity, due to waste water induced phytoplankton blooms and suspended silt, markedly reduced growth rates of the corals Pocillopora damicornis and P. meandrina. Coral species diversity has also been shown to decrease with increasing turbidity (Brock et al, 1966; Roy and Smith, 1971).

PESTICIDES AND OTHER CHEMICALS

Zanzibar has a monocultural economy, largely dependent on cloves for much of the foreign exchange earnings. Other agricultural crops include coconuts, different types of spices, bananas, cassava and an assortment of vegetables. Livestock includes mainly cattle and goats. The husbandry of these crops and livestock requires the use of pesticides, fertilizers, and fungicides. Different types of chemicals are also required to fight vector borne diseases like malaria, bilharzia etc. The level of the economy dictates the use of cheap pesticides which may have been restricted or banned in developed countries. More than 90 different chemicals are used and stored in several locations on the Island. The major pesticides are organophosphor, organonitrogen and organochlorine based (Table 3).

Production of cloves fell in the mid-seventies due to an acute disease known as dieback. This disease is caused by a fungal infection which affects the clove trees. A program to cure the trees from the infection was initiated and involves the use of fungicides. Malaria was almost eradicated in the Islands of Zanzibar by the early 1970, however the strict control regulations were relaxed and there is now a high incidence of the disease. A program has been initiated to control the disease and involves the use of DDT and malathion. These pesticides are sprayed in the environment including houses. Other health related chemicals include ethoprophos, dimethoate, phosphamidon and sodium arsenite.

The pesticides, herbicides and fungicides which are used indiscriminately in appreciable quantities reach the ocean either directly through seepage and run-off or indirectly through creeks and rivers. The pesticides, especially the organochlorides are fairly stable and volatile. A proportion of them enter the atmosphere at the time of application and are precipitated directly into the sea or back on land and seep into rivers. It has been estimated that 70% of the pesticides enter the atmosphere at the time of their application and about 50% of DDT evaporates from the soil surface (Hurting, 1972; Lloyd-Jones 1971). Depending on the direction of the prevailing winds these air borne pesticides can be transported in the atmosphere for long distances before entering the hydrosphere through precipitation (Gardener et al, 1985; Schneider et al, 1985). Organic mercury fungicides have been identified as the main source of mercury in the sea (Patin, 1982).

The level of concentration of pollutants in the water, sediments and biota has not been determined in Zanzibar waters. There is an urgent need for such studies to be carried out because the information is important for formulating corrective measures and management of the application of these chemicals.

PORT DEVELOPMENT

The expansion programme of the Zanzibar and Mkoani (in Pemba) harbours to enable them accommodate large vessels and thereby increase the volume of trade with external partners is a very welcome economic move. However, expansion works which involve dredging and the dumping of the dredged material at sites within the inshore waters is bound to spell a number of hazards to marine fauna and flora.

In Zanzibar the expansion works are on the southern end of the port. The provision for the disposal of the dredged material is such that all dredged material may be disposed of at sea in the area north of latitude 65 South and west of longitude 39 10 East, The provision further specifies that no material shall be disposed of on or within close vicinity of coral reefs such that the marine habitat may be destroyed or damaged. This provision should be weighed against the actual dumping practice and the movement of currents in the area. The southeastern end of the specified dumping area does have a rich overgrowth of corals and there is a permanent easterly current flowing through this area. We have no doubt therefore that the dredged material is going to adversely affect the marine life.

TABLE 3: Pesticides and Other chemicals used in Zanzibar and their toxicity

Category	Active	Use	Toxicity
Organo-phosphorus Pesticides	Dicrotophos	Insecticide/ mites	B
	Phosphamidon	Insecticide	B
	Triclalorfon	Insecticide	C
	Malathion	Insecticide/ mite	C
	Fenitrothion	Mites	C
	Ethoprophos	Nematodes	C
	Dimethoate	Insecticide/ mites	C
	Monocrotophos	Insecticide	B
	Glyphosate	Herbicide	C
Organonitrogen Pesticides	Mancozeb	Fungicide Insecticide/ Mites	C
	Carbonfuran	Nematodes	C
	Atrazine	Herbicide	C
	Paraquat	Herbicide	B
	Aldicarb	Insects/ Nematodes	A
Organochlorine Pesticides	Aldrin	Insecticide	C
	Chlorothalonie	Fungicide	C
	DDT	Insecticide	C
	Dalapon	Herbicide	C
	Dieldrin	Insecticide	C
	Y-HCH	Insecticide	C
	PCP	All purpose	B
	Endosulfan	Insecticide	C
Miscellaneous	Warfarin	Rodents	B
	Meth.ethylmerc Chl.	Fungicide	B
	Cypermethrine	Insecticide	-

Toxicity: A: Very toxic Oral LD50 L25 mg/kg
B: Toxic " " 25-200 mg/kg
C: Harmful to health Oral LD50 200-2000 mg/kg

Source Van Veen and Breedveld (1987).

The dumping of dredged material causes destruction to the habitat and physically damages the marine biota. The rich and varied biota found in the crevices of a reef are undoubtedly more vulnerable to siltation than the organisms on the reef surfaces. As dredged sediments settle on a reef community, they tend to fill and plug the crevices, thereby destroying not only the habitat but also extensively killing this sub-community. Brock et al (1966) have given a detailed account of the destruction of corals and reduction of fish and echinoderm populations due to the dumping of dredged materials. Deterioration of reef communities continue for sometime even after dredging and dumping due to the resuspension of the sediments.

Moreover, the effects of sediment pollution varies with or according to stream flow. Under high flow conditions, the sand areas constitute a highly unstable habitat, while rubble areas may be considered "islands" of productive habitat in the middle of the "sea" of unproductive sand areas. As the sediment inputs increase the number and size of these islands decrease accompanied by marked decrease in faunal density. Under low flow conditions the sand areas may form a stable substrate and develop distinctive fauna, normally low in species diversity. It has been shown that corals are "size-specific sediment ejectors" and that silt, the smallest size is the only size which is removed effectively by all species tested (Hubbard and Pocock, 1972). Silt is light enough to be removed by ciliary action. Differences in sediment rejection were shown to be a function of the variation in the poly's size, distentional capacity and the geometry of the calyx (Marshal and Orr, 1931; Hubbard, 1973). Therefore the threat caused by sediments to corals varies with particle size and species of coral. Where corals do survive in turbid waters, their growth rates and the depth to which they grow will be reduced, since classification in corals is light dependent (Goreau and Goreau, 1959). Corals have been reported to decrease in species diversity with increasing turbidity (Brock et al, 1966; Ray and Smith, 1971). Further more strong currents carrying sand and other coarse suspended materials can inhibit coral growth by abrasion (Crossland, 1928; Storr, 1964).

Increased turbidity has been observed at the dump site behind Bawi Island (Mwaipopo per.comm.). Also, the current patterns at this site are such that the sediments of the dredged material is likely to be transported to the reef between Bawi and Changuu Islands. This area is rich in fish, echinoderms and other invertebrate fauna which are prone to destruction. The amount of dredged material is about 300 m^3 per day which is about 540-750 tons per day (density of sand and mud 1.8-2.5 tons/m^3). Already about 36000 tons of dredged material have been dumped at Bawi-Murongo reef complex.

THE IMPACT OF FISHING OPERATION ON THE ENVIRONMENT

Some of the fishing techniques currently in use degrade the environment in several ways (Table 4). Traps are usually set individually with or without bait. The traps are weighted down by a pair of stones attached on the sides and marked by attaching a rope to a floating bamboo. The high incidence of thefts have forced some of the fishermen to set the traps without markers and recover them by diving. A proportion of these traps (average 5%) are lost. The loss is higher with unmarked traps especially during the southeast monsoon because the strong currents drift the traps from the point where they were set. Basket traps last for three months (Ngoile 1982). Consequently the lost traps continue fishing until they disintegrate.

Encircling nets operate on the beach or in the open water around patch reefs. Although the former is banned in Zanzibar, in the latter case the fishermen survey the isolated coral heads and select one which has a high concentration of fish. The net is encircled around the selected reef and the fish are scared by breaking and trampling coral heads. As the fish try to escape they are caught in the net. This is a destructive form of fishing and does not only damage the reef but provides a catch consisting mainly of immature fish. This method of fishing is common in Zanzibar islands where dynamite fishing is illegal. There are 43972 m. of encircling nets in the islands. Gill nets were introduced in the late 1960's. These are non degradable and continue fishing indefinitely if lost. However, these are set as drift nets and, because they are very expensive and scarce, fishermen are particularly careful not to lose them. Monofilament gillnets have been banned and are not in use.

The most destructive form of fishing in Tanzania is dynamiting. This form of fishing has been used in the inshore waters since the early 1960s. Although in the early days it was more commonly practice in areas near big town, viz. Dar es Salaam, Tanga, Mtwara, and Lindi, it has spread to almost all coastal areas on the Mainland. It has been suggested that unavailability of fishing gear has promoted this destructive form of fishing. Dynamite fishing causes a major destruction to the coral reef environment and the fish are killed indiscriminately. Part of the decline in the productivity and catch rates of the artisanal fishery has been attributed to dynamite fishing (Tarbit 1984). Dynamite fishing is not only destructive to the environment but some fishermen have been seriously injured during the detonation of the explosive. Dynamite fishing has degraded the coral reef environment to such an extent that most of the marine sites earmarked for the establishment of marine parks in 1968 (Ray, 1968) have been reduced to rubble. As pointed out above dynamite fishing is illegal in the Islands. However, recent information indicates that the reefs on the western side of Pemba are already being blasted (Dr. T. Clarke Pers. comm.). This is also true for the outer reefs off Zanzibar town and Kizimkazi. There is an urgent need therefore to introduce conservation measures in Zanzibar waters to salvage the limited stocks of virgin coral reefs.

Shells for ornamental purposes are being collected all along the coast. They are collected along the beaches and in reef areas during low tide. They are intended for the tourist market but a great proportion is being exported. A great deal of damage to the intertidal and near shore areas is caused by shell collectors. They trample the seabed, break corals, and overturn rocks and stones when searching for the shells. This activity is very intensive along the shore of Zanzibar islands (Halsted and Halsted 1982). It is estimated that the damage caused on the reefs by shell collectors and open water encircling nets may be of the same magnitude or even greater than that of dynamiting (Ngoile 1987). There is need for regulatory measures to be imposed on the shell collecting fishery.

OIL TRANSPORT

The major sources of oil pollution in the marine waters of Zanzibar is the oceanic tanker route in the Indian Ocean. The Middle East is the major oil producing region in the world. The oil is transported to Europe and America through the Suez Canal and around the Cape of Good Hope, South Africa, the latter being the major route. Ferrari (1983) presents interesting statistics on oil pollution in the East African Region. According to his estimates there are 644 ships cruising in the region in any one day discharging 33250 metric tonnes of oil per year into the ocean. The oil is discharged during cleaning operations and normal emissions from the ships. However the main contributors to the oil discharge are tankers transporting oil to countries in the region. These contribute about two thirds of the above discharge. The patterns of currents in the Indian Ocean have an effect of dispersing the oil towards the East African Coast. It reaches the beaches of Zanzibar Islands in the form of tar flakes and tar balls. These are deposited on the beaches, and are more commonly sighted during the south-east monsoon

(EAMFRO 1972). Large concentrations of tar balls are sighted on the beaches at the southern tip of Unguja Island around Ras Kizimkazi.

TABLE 4: Fishing implements which inflict environmental degradation.

	Unguja	Pemba	Total
Boats	2183	2030	4213
Encircling nets*	11342	16141	27483
Beach Seining-Mosquito nets*	243	1611	1854
Bottom set lines*	6069	1095	7164
Handlines	6158	3413	9571
Dema traps	6305	2719	9024
Towe traps	679	821	1500
Harpoons	179	20	199
Lobster speargums	348	90	438
Hand held spears	954	1558	2512
Fishermen of foot (shell collectors)	2847	2640	5487

* Measured in Pimas (A pima is approx. 6')

Oil pollution in the open sea affects mostly sea birds (GESAMP, 1977). In coastal areas, oil pollution causes several serious environmental disturbances (GESAMP, 1977; API, 1980). Littoral communities which include mollusks and seaweeds of economic importance are tainted and stressed by the oil which washes ashore. Oil pollution also damages shallow reefs and taints intertidal areas and beaches. Tar balls have been reported and are a nuisance on resort beaches in Kenya and Tanzania. No assessment of the impact of oil on the marine biota in Zanzibar has been done. The need of detailed survey is important, considering the amount of oil discharged on the high seas in the Indian Ocean.

OTHER ACTIVITIES

The Zanzibar Port handles all the imports and exports for the Islands. Most of the goods are transhipped from Dar es Salaam Port using the ships owned by the Zanzibar Shipping Company, a government parastatal. The company has two passenger/cargo ships, two tankers, a tug and several storage barges. In addition there are three private ships, a hydrofoil, a research vessel, schooners and numerous dhows. Foreign ships also call at Zanzibar Port but most of these do not come along side, the goods are loaded/off loaded at the anchorage. These ships pose an environmental threat by the oil they emit during their normal activities. The effect of oil pollution has been discussed at length in the previous paragraph.

In an attempt to diversify the monoculture economy, the Zanzibar Revolutionary Government is very keen to develop the tourist industry. Both local and foreign companies are urged to invest in tourism and there has been an encouraging response as several companies have applied for sites for developing tourist facilities.

The number of tourists visiting the Islands has been on the increase since 1981 (Table 5). It is projected that by 1998 the number of tourists would have trebled from the number who visited the islands in 1981. This implies that tourist facilities on the islands will have to be enhanced. There are several companies which have or are in the process of acquiring sites for the construction of hotels. These sites include beaches and some of the islets.

Within Zanzibar Town, limited tourist facilities exist on Changuu (Prison) Island. Plans are underway to lease Chapani (Grave) Island and requests have been submitted for Bawi. One company, Lady Zanzibar, has been granted permission to start a floating SCUBA diving club. Existing shore facilities include Machuwini, Bububu, Maruhubi, Bwawani Hotel, Starehe Club, Africa House and Inn by the Sea resort. There are also numerous hotels and guest houses in Zanzibar town which cater for tourists. Proposed shore sites include Mangapwani and the former Extelecoms House at Ras Shangani. The facilities on these sites will be developed by Serena group of Hotels.

Tourism has several negative effects to the environment ranging from the indiscriminate construction of tourist facilities to the tramping of the intertidal areas by the tourists. The leasing of islets for the construction of hotels is a great threat to the marine environment. This may lead to beach erosion and even disappearance of the islets.

The disappearance of the Maziwi Island off Tanga should be a good lesson for us. Therefore very careful consideration should be given in granting lease to the islets for the purpose of building tourist hotels.

RECOMMENDATIONS

1. It is recommended that treatment/stabilization ponds should be included in the proposed centrali sewage system for Zanzibar Municipality and the outfalls should be strategically placed for faster dilution and to avoid circulation of the sewage onto the beaches by the local inshore currents.

2. Regulation measures to the use of pesticides should be introduced and the use of organochlorines should be discouraged.

3. Impact assessment studies should be carried out before developments such as harbour extension, tourist facilities etc. are carried out.
4. Support for research in marine pollution in the Islands should be provided to assess the effects on the marine biota.

Table 5: Observed and projected number of tourists visiting Zanzibar Island

OBSERVED		PROJECTED	
Year	Tourists	Year	Tourists
1981	18,977	1990	31,867
1982	17,861	1991	33,900
1983	10,243	1992	35,932
1984	8,967	1993	37,964
1985	16,268	1994	39,996
1986	22,846	1995	42,028
1987	30,013	1996	44,060
1988	32,219	1997	46,093
1989 (Jan.-June)	29,835	1998	48,125

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Question by Dr. M. Gerges

Has sample collection/analysis been done in order to establish the extent of pollution?

Answer

Only a preliminary survey has been done. A study of the real situation is to start soon.

Question

How far will the sewage disposal pipe reach?

Answer

The pipe will go beyond the growth of the corals.

Suggestion by Dr. Gerges

The pipe must be strong enough, deep and long enough away from the thermocline in order to avoid recirculation of the waste.

COMPETING FORCES IN CONTROL OF THE ENVIRONMENT

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ABSTRACT

Civilization is closely connected with the control of the environment. The point is driven home by the results of modern technological advances, which for the first time in the history of mankind give the possibilities of influencing the environment to unprecedented magnitude. The conquest of space is a momentous historical landmark and the genetic code is accessible for manipulation by scientists. Man can decide where and how the mighty rivers of the world should flow. The global awareness of those capabilities is quite considerable in contrast to our lack of appreciation for the works of nature. Yet nature quietly, through various complex physicochemical reactions, ensures our survival. Our food supply is dependent on photosynthesis, a complex reaction of nature, for which the partial elucidation was rewarded with the 1988 chemistry Nobel prize. Our access to mineral resources is dependent on the deposition and distribution of mineral matter through physicochemical action of nature on the rocks. Nature also cares to neutralize our mistakes by rendering chemical poisons of our own creation into harmless products. Unfortunately the contamination of the environment by man is now proceeding so fast that nature cannot cope with the restoration. This threatens mankind with suffocation. However man has also the ability to assist nature in the regeneration of a healthy environment. This paper sets out to show the possibilities.

AGROCHEMICALS

HEALTH HAZARDS ASSOCIATED WITH AGROCHEMICALS IN TANZANIA

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ABSTRACT

The intensive use of Agrochemicals in Tanzania has led to considerable concern in environmental degradation and health hazards to people. We have cases of pesticide contamination of drinking water wells/ponds, and near farms, poisoning cases which are either deliberate or accidental, occupational health hazards to spraymen and factory workers. Though the situation of chemical handling has improved through the years, it is still not satisfactory. There is a need to examine the legislation and strengthen it. Whereas we have regulations governing pesticide registration, more efforts are needed to enhance awareness on proper handling of chemicals, i.e. pesticides right from manufacturing, packaging, transport, storage and use.

INTRODUCTION

Between 1975 and 1985, 2953 cases of pesticide poisoning have been reported to the Government Chemical Laboratories (Appendix I). This includes deliberate and accidental poisoning.

Agrochemicals pose a health hazard to human beings but they are essential in crop production, animal husbandry and public health. In Tanzania where agriculture is the backbone of the National economy, about 96% of all agrochemicals used in the country are deployed in this sector (for both crop and animal production), the rest are used in public health.

There are two categories of agrochemicals: Pesticide and Fertilizers. The health hazards posed by pesticides cause much more concern in Tanzania, due to a higher degree of exposure to pesticides. Nevertheless the limited number of farmers exposed to fertilizers are equally at risk, if the fertilizers are mishandled. This paper will concentrate on pesticides.

HEALTH HAZARDS ASSOCIATED WITH THE USE OF PESTICIDES

The factors which have increased pesticide health hazards in Tanzania are:-

1. The ever increasing quantities of pesticides being used.

2. The change in the types of pesticides being used.

3. The change in their usage patterns.

   In 1977 over 5,960 tons of pesticides were used in this country. This figure, although appearing small, was equivalent to about one-third kg pesticide for every person in Tanzania. As the consumption of these chemicals has increased since then (see appendix II) the amount of pesticide consumption per capital in Tanzania is rapidly approaching 1 kg. This is a very high ratio.

   The increase in the amount of pesticides used has undoubtedly increased the health hazards as well. Further, as depicted in the cotton industry, there has been a change in the types as well as usage patterns of pesticides in Tanzania. Organophosphorus, carbamate and even pyrethroids have replaced or at least supplemented organo-chlorine pesticides. These newer types are often non toxic.

   As for usage patterns, the cotton and coffee authorities have come to prefer liquid formulation to solid ones. Liquid formulations however, are often more hazardous to handle than solid formulations. Hence the risk of health hazards to pesticide handlers have increased.

4. Poverty, hence inability to purchase proper protective gear, new spray equipment, necessary spare parts for malfunctioning spray equipment, etc.

5. Lack of adequate well trained supervisors to oversee proper ways of pesticide handling during storage, transportation, mixing, use and disposal.

6. Ignorance on the part of pesticide handlers, of the dangers of careless and indiscriminate use of pesticide.

7. Deliberate misuse of pesticide, e.g. in attempted suicide and homicide.

8. Inadequate medical facilities (e.g. lack of antidotes, first aid kits, nearby and well equipped clinics) to deal promptly with victims of pesticide poisoning.

9. Lack of a clear-cut national policy and planning on the handling, use and disposal of pesticides.

Pesticide formulations are the dilutions of pesticide concentrates to a number of substances to a concentration and state most appropriate for handling. In a formulating plant, pesticides in their most toxic form are handled. This means that workers involved are at a great risk of being poisoned, indirectly. Industrial production of pesticides in Tanzania is mostly limited to formulation of only a few pesticides, but this industry provides employment to many Tanzanians, of varying levels of awareness of pesticide safe handling. These are formulated as dusts, emulsifiable concentrates, pressurized aerosols, mosquito coils and various insect killer spray solutions. All technical materials and other ingredients like solvents, stabilizers, and emulsifiers, are imported from overseas, except for pyrethrum and kaolin which are locally produced. To ensure safety of workers in a factory dealing with hazardous substances, several precautions must be taken by the plant authority. Some plants in Tanzania have shown concern over this matter, but some still need to be encouraged to do the same.

TOXICOLOGICAL CONSIDERATION

From the toxicological point of view, pesticides are toxic compounds which people may use, or to which they may be involuntarily exposed. All possible hazards are evaluated in the development process of the pesticide to ensure that it is harmless if properly used. If the product is found to be extremely toxic, its further development can be abandoned. Despite the inevitable health hazards associated with toxic substances, there exists for humans a level of contact below which there is no significant threat to man's health. The exceptions are carcinogens and mutagens.

Group at risk

Occupational groups at risk of pesticide poisoning include manufacturers, formulators of pesticides, mixers, and peasants workers. Industrial workers can also bring pesticides home on their clothes, skin, and hair, putting household contacts at risk. Pesticides can contaminate the food on which they are used if the food is not washed properly. They can also contaminate water supplies. If containers are not labelled properly, others, especially children, may inadvertently ingest them. Additional risk is posed to people who use pesticide containers to store water and other liquids after they have been used for pesticide storage.

These phenomena have often been seen in Tanzania. The following are instances of pesticide poisoning which occurred due to various most common ways of mishandling in Tanzania.

1. Unlabelling

(a) The pesticide intended to be used for killing maize stalk borers, was sold to the Department of Agriculture by one company (SAISCO). This company deals with seeds distribution. When it was brought for sale, there was no information pertaining to the use of the pesticides. Unfortunately those who purchased it and used it on their farms, caused serious damage to their maize. This chemical was then brought to the Government Chemist for chemical analysis, in February, 1984. It was later found that the chemical was a herbicide (weed killer) known as ammonium sulphate.

(b) November 1983 in Mafinga: Managers of technical services, were informed by the Area Commissioner that the natives are using a herb called "Lidupala" in local language for killing the stock borers. this powdered chemical was obtained from local trees. The local people applied this chemical on their maize plants. They collected the sample for chemical analysis at the Government Chemical Laboratory and found to contain "Organosulphur" and "Organo nitrogen". These are toxic elements, and therefore harmful to human beings if ingested in large quantity. There was no history of the origin of the sample or the botanical name of the tree or tree from where the extract was obtained.

2. Poor storage

(a) In January, 1986 at Uyole Agricultural Centre: The Centre milking cows broke the fence and went to a Research building and ate aldrin insecticide which had been kept there for years. Prior to this they had gone through a potato research trial which had been sprayed with thiodan. Due to this poisoning, four cows died almost instantly and the fifth one died in the evening of the following day, only one cow was showing the signs of poisoning.

Two major steps were taken by the Centre, namely all carcasses from the dead animals were burnt under the supervision of the centres veterinarians. The sale of milk was stopped to their customers including the workers.

The milk samples were brought to the Government Chemist for chemical analysis. It was found to contain "Organochlorines" and "Organosulphurs".

(b) Most areas in Tanzania, especially where there are cotton, coffee, maize farms and so on, there is a tendency of authorities not storing properly the pesticides used in their farms. As a result during the rainy season most of the pesticides are dissolved by rain water and flow to wells, rivers and ponds used for domestic purposes, and to the farms in large concentrations. These pesticides may cause harm to the people who live in those particular areas.

It was reported in the Daily News on the 8th August, 1988 that in Kibaha, at Vikuge Seed Farm there are 50 tones of mixed up pesticides stored without any covering against rain.

Much of it was obviously dissolved by rain and washed to the lower areas and all of the nearby plants were severely affected. A few of the stored pesticides were brought to the Government Chemist for chemical analysis. They were found to contain "Organo-chlorinated compounds". The report was sent to the National Environment Management Council (NEMC) for further investigation and action.

However NEMC with the plant protection section of the Ministry of Agriculture and TPRI have started a nation-wide inventory on pesticide storage and wastes, and also a programme to raise the awareness on the proper use and storage of pesticides in the country.

3. Misuse of Pesticides

(a) The Daily News of Thursday December 27, 1973 reported the death of six people after drinking DDT. Six people in Kadete, Mwakaleli in Rungwe District had died after they drank DDT insecticide after being advised that it was medicine to cure worms.

(b) On the 17th March, 1970 the Standard newspaper reported that 14 people had died of insecticide poisoning throughout the country since January, and the Government Chemist was to seek action against unlicensed selling of the commodity.

An official said that deaths were higher in Kilimanjaro and Arusha regions than any other part of the country. Because people knew that insecticides are very poisonous and cheaply obtained and so some buy them for poisoning other people.

The news said that herbs added to local brews to make them more intoxicating contained a lot of poisonous material and are another cause of death. The official said that seven children who died in February of the same year at Zirabwa Village in Kisarawe district did in fact take an insecticide by mistake, thinking that it was food.

CONCLUSION

The situation of chemical handling in Tanzania has improved through the years, but it is still not satisfactory. There is an urgent need to strengthen legislation (on labelling, storing, transporting and distribution of chemicals) and to strive to enhance awareness on Health Hazards of Chemicals.

Most industries release their by-products to the surroundings or into nearby waterways, The National Environment Management Council is currently monitoring these problems of environmental pollution. It has been recommended that excessive release of by-products to the soil must be avoided. Pollutants must not be left on the ground, where they will contaminate the soil and water, and agrochemicals should not be applied immediately after rainfall. Also the land should not be irrigated after application of agrochemicals.

Most of the pesticides have a high degree of toxicity, so it is essential to know how toxic a particular pesticide is, in order that the proper precautions may be taken for safe handling. Chemical exposure in Tanzania is greatly influenced by the warm climate, as most areas have temperatures of over 25°C. A good example is Dar es Salaam where most industries are located where the temperature often rises above 33°C. High temperatures cause most liquid chemicals to vapourise easily and hence to be inhaled easily. High temperatures also make the chemicals more absorbable through the lungs, skin, and digestive tract.

RECOMMENDATIONS

1. The safe and effective use of pesticides must be the aim of industry, government extension services, organizations and farmers themselves,

cooperation, understanding and trust are required by all concerned to achieve this.

2. (a) Everybody who handles pesticides should take great care when doing so. When accidents happen, it is mostly through misuse while safe handling is mainly common sense and not difficult to practice.

(b) It is the responsibility of all concerned to encourage a better knowledge and understanding of the "dos" and "don'ts" - particularly among agricultural workers, who actually apply the pesticides.

This calls for awareness and training in proper application methods. This is an essential task to be tackled by the government, agriculturalists, and industry. This topic will require continuous emphasis in order to ensure that pesticides are safely and effectively used, thus yielding benefits in the form of increased food and industrial production.

(c) <u>Transportation</u>: Whenever possible do not load pesticides on to vehicles which carry passengers, livestock or food stuffs.

(d) <u>Storage</u>: Pesticides should be away from stored food or animal feed. Pesticides are valuable products, which may deteriorate and become useless if not stored under proper conditions. Pesticides must always be securely stored, to ensure that they are kept away from children and unauthorized persons.

(e) <u>Measuring and Mixing</u>: One should always adhere to the recommended dose, rates and dilutions. Higher doses will not produce better effects, while lower doses will be less effective.

(f) Farmers should be given advise (i) To use the recommended dose, and wear protective clothing when measuring and mixing, keep children, and animals away, and to mix pesticides away from houses and livestock. (ii) To prevent skin contamination by putting on special clothing. All the clothing should be well washed after a full day's use.

3. There are a number of basic principles common to most situations, which enable users to obtain the most effective results, while safeguarding themselves, other people and the environment. Such technique must be taught to all operators,

on the course of local, and national training schemes.

4. <u>Prevention:</u> It is easier to prevent poisoning than to treat it, so handle pesticides carefully. People can be taken ill, from natural causes. When handling pesticide poisoning causes it is important to establish what pesticide is involved, before treatment is given.

5. The government should:

   (i) Take action to introduce the necessary legislation for the regulation, including registration of pesticides and make provisions for its effective enforcement, including the establishment of appropriate education, advisory, extension and health care services. The FAO guidelines for the registration and control of pesticides should be followed as far as possible, taking into full account the local needs, social and economic conditions and availability of pesticide application equipment, where not possible, alternatives should be sought.

   (ii) Continue and strengthen the present registration procedure and from time to time review the pesticides to be marketed in the country. Their acceptable use and their availability to each segment of the public.

   (iii) Establish national or regional poisoning information and control centres at strategic locations to provide immediate guidance on first aid and medical treatment, accessible at all time. Government should collect reliable information about the health aspects of pesticides. Suitably trained people with adequate resources must be made available to ensure that accurate information is collected.

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APPENDIX I

Reported cases of pesticide poisoning in Tanzania. This includes deliberate and accidental poisoning since 1975.

YEAR	NON FATAL	FATAL
1975	146	108
1977	154	132
1977	144	86
1978	235	139
1979	150	180
1980	151	159
1981	111	117
1982	133	108
1983	122	98
1984	137	101
1984	150	92
	Total 1,633	1,320

APPENDIX II

Tanzanian coffee industry Pesticide inputs 1975 and 1985/86

PESTICIDE	1975		1985/86		CHANGE
	Tons	Litres	Tons	Litres	
Cu-oxide	990	-	1,330	-	+345%
Cu-oxychloride	550	-	1,410	-	+182%
Cu-hydroxide	0	100,000	1,755	44,000	+++
Endosulfan	-	-	420	44,000	-56%
Orthodifolaton	150	-	420	-	+180%
Chlorothalon	-	-	-	373,000	+++
Triadimefon	-	-	50	674,000	+77.7%
Fenitrothion	0	150,000	50	674,000	+77.7%
Dieldrin	-	50,000	-	87,200	+74%
Bavistrin	60	-	0	-	-100%
Derosal	-	200,000	-	0	-100%
Glyphosate	-	0	-	14,000	+++
Paraquat	-	0	-	35,000	+++
Chlorophyrofos	-	0	-	20,000	+++
TOTAL	1,700	500,000	4,965	1,247,000	

Question by Dr. Mwanthi

How was the data on deaths caused by pesticides obtained?

Answer

All the data was obtained from the police. Many of the cases are not normally reported.

Question by Prof. Tole

The figures presented for the fatal cases as a result of pesticide abuse/misuse appear to be constant since 1975. It is an improvement. What has happened?

Answer by Dr. M. Gerges (UNEP)

Awareness of the public may have helped to reduce the number of deaths. More and more people can handle the pesticides safely.

Remarks/Recommendations:

1. It is important that the one who goes to buy the agrochemicals is aware of the composition and hazards of the chemicals he wants to purchase.

2. Efforts to have a convention for trade of hazardous chemicals are being made by UNEP.

3. Labels do not always indicate the correct contents of the purchased goods. There is a need for control programme by the government concerned.

4. There is need for more education to the public on the uses and dangers of pesticides. Workers who handle these chemicals must be properly trained and supervised.

DDT AND ENDOSULFAN RESIDUES IN FOUR TROPICAL FISH SPECIES

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ABSTRACT

Residues of DDT and its metabolites DDE and DDD, and endosulfan and its metabolite endosulfan sulphate were studied in four fish species, namely, *Oreochromis mossambicus* (Trewavas), *Tilapia zilli* (Gervais), *Labeo gregorii* (Boulenger) and *Clarias mossambicus* (Peters). The fish were obtained from an irrigation scheme where DDT and endosulfan had been used for the control of agricultural pests. The distribution of the pesticide residues and their metabolites in muscle, eggs and liver tissues in the fish species were investigated. The concentration of residues was determined by gas liquid chromatography. Some of the factors influencing variations in the residue concentrations are discussed.

INTRODUCTION

The organochlorine pesticides, DDT and endosulfan, have been extensively used in Kenya and other tropical and subtropical countries for control of agricultural pests. In Kenya, DDT has been used for the control of maize and cotton pests. Recent years, however, have seen the progressive substitution of DDT with the relatively less persistent pesticide, endosulfan. Endosulfan has a lower mammalian toxicity (Devi *et al*. 1981, Douthwaite et al. 1981), and lower persistence in fish than DDT (Mathiessen *et al*. 1981, Munga & Foxall, in prep.). The low persistence of endosulfan in fish is attributed to the ease of metabolism of the pesticide (Devi *et al*. 1981, Douthwaite *et al*. 1981, Mathiesen *et al*. 1982) to non-toxic products (Gorbach 1972, Rao *et al*. 1980, Rao & Murty 1982). DDT, on the other hand, is detoxificated through its principal metabolites DDD and DDE, with the former being easily metabolized further to non-toxic products (Cherrington *et al*. 1969, Wedemeyer 1968). The latter metabolite has toxic properties, is more stable and tends to accumulate in, particularly, adipose tissues. Thus, high levels of DDT in biological tissue may indicate recent exposure to the pesticide, while high levels of DDE may indicate chronic exposure to DDT or/and DDE.

In this study, muscle, eggs and liver tissues from fish obtained from Hole irrigation scheme in the lower Tana river basin, Kenya, were analyzed for DDT, DDD and DDE, and endosulfan and endosulfan sulphate. The aim of the study was to get an indication on the relative concentration levels and distribution of the residues in the tissues.

EXPERIMENTAL

Sampling

Fish samples were obtained from water storage dams in the Hola irrigation scheme (Figures 1 & 2). Samples were obtained during sampling trips; between 19th and 21st August, and between 9th and 13th November, 1983. The former trip was during endosulfan aerial spraying of cotton fields, while the latter trip was 48-50 days after cessation of endosulfan spraying. Four fish species were considered; namely, *Oreochromis mossambicus* (Trewavas), *Tilapia zilli* (Gervais), *Labeo gregorii* (Boulenger) and *Clarias mossambicus* (Peters). The fish tissues analy for residue concentrations were lateral muscle, liver and eggs.

Apparatus and chemicals

All the apparatus used were chemically cleaned while the chemicals were purified by standard method.

Extraction procedure for fish tissue

Minced duplicate subsamples (2.0-2.5 g) were accurately weighed and each thoroughly mixed with anhydrous sodium sulphate (6.0 ± 0.1 g) to effect drying. The mixture was then extracted in a Soxhlet apparatus using hexane and finally concentrated under a nitrogen atmosphere. Blank control samples were also appropriately processed. A gravimetric method was used to determine the fat content of samples extracted.

Clean-up of extracts

The clean-up of extracts was performed using miniature columns of neutral alumina, modified from the procedure by Holden and Marsden (1969). A sample extract (≤ 10 mg) in hexane (1.0 ml) and applied to the alumina column (8 mm.id). The column was eluted with hexane (10 ml) to give a fraction of residues of DDT, DDD, DDE and endosulfan I. The first elution was followed with acetone-hexane (1; 99, 15 ml) to give a second fraction which contained residues of endosulfan II and endosulfan sulphate. To each of the fractions, in vials, undecane (0.2 ml) was added, and the mixture concentrated under nitrogen.

Qualitative and quantitative analysis of the residues

The identification and quantification of residues of p,p'-DDT, p,p'-DDE, p,p'DDD, endosulfan I, endosulfan II and endosulfan sulphate was performed with a Pye Unicam 104 GLC equipped with a Ni^{63} ECD. The operating conditions were as follows:-

Column oven temperature: 200x°C
Detector oven temperature: 300 or 350x°C
Columns: glass 1.8 m x 4 mm i.d.
Stationery phase: (1) 1.5%-OV17/1.95%-OV210 on Diatomite Cq
(2) 3%-OV1 on Diatomite Cq
Carrier gas: nitrogen
flow rate 60 ml/minute

The external standard procedure was applied for confirmation of residue identification and quantification, with pure samples (99% purity) of the pesticides from EPA as standard references.

RESULTS AND DISCUSSION

Relative concentrations of residues in tissues

The mean concentrations of residues of DDT and endosulfan and the mean fat contents in lateral muscle, liver and eggs of L. gregorii are presented in Table 1. The low sample numbers notwithstanding, the residue levels obtained gave an indication on variations between the different tissues. The liver had the highest concentration of residues, followed by lower concentrations in eggs and muscle tissue. The relatively high concentrations of the organochlorine pesticide residues in the liver had a direct bearing on the high fat content of the organ. The relationship between the fat content and residue concentrations emphasized the function of adipose tissue as the main reservoir for the DDT and endosulfan residues (Mathiessen et al. 1982).

The relative concentrations of DDT and endosulfan residues in the tissues for C. mossambicus (Tables 2 & 3) showed a different pattern to that depicted by L. gregorii samples. Thus, the liver for C. mossambicus had relatively lower concentrations of DDT residues than in eggs (Table 2), and the lowest concentrations of endosulfan residues were found in the liver (Table 3). To get a clearer picture of the factors affecting the patterns of relative residue levels in the fish tissues, comprehensive data, under controlled conditions, on concentrations of all detoxification products was required. However it suffices that the present observations could be associated with the dynamics of storage, metabolism and excretion of the pesticide residues, with reference to the fish species.

Metabolites of DDT in tissues

The mean concentrations and relative proportions of p,p'-DDT, p,p'-DDE and p,p'-DDD in lateral muscle samples (Table 4), liver (Table 5) and eggs (Table 6) in *C. mossambicus, L. gregorii, O. mossambicus* and *T. zilli* are presented.

Residue concentrations of the DDT derivatives in the tissues varies widely, as depicted by the wide ranges. However, the relative proportions of the derivatives in the tissues expressed in percentage ratios (%) showed much less variations as indicated by low standard deviations. *C. mossambicus* had slightly higher muscular proportions of p,p'-DDE, and lower proportions of p,p'-DDT and p,p'-DDD than had the other fish species (Table 4). The high relative muscular concentrations and proportions of p,p'-DDE indicated chronic exposure of the fish to p,p'-DDE or p,p'-DDT. This was in view of other sources of DDE to the fish (Guenzi & Beard 1967) other than through metabolism of DDT in the fish tissue. The relatively low muscular proportions of p,p'-DDD confirmed that the metabolite was easily degraded further to excretable products (Cherrington *et al*. 1969, Wedemeyer 1968) in all the fish species studied.

The relative proportions (% ratios) of p,p'-DDE and p,p'-DDD in liver (Table 5) and eggs (Table 6) for *C. mossambicus* and *L. gregorii* were quite similar, despite wide variations in residue concentrations in the tissues. No p,p'-DDT residues were however, detected in either tissues, which indicated that the pesticide was more readily metabolised. As in muscle tissues, the predominant metabolite in liver and eggs was p,p'-DDE.

Endosulfan and endosulfan sulphate in tissues

The relative proportions of endosulfan I, endosulfan II and endosulfan sulphate in lateral muscle samples (Table 7) showed greater variations than in the case of DDT and its metabolites. Considering the wide variations in muscular residue concentrations and proportions, there was no discernible difference in the data between *C. mossambicus* and *L. gregorii*. The proportions of endosulfan II in muscle tissue of *O.* mossambicus and *T. zilli* tended to be lower than for the *Clarias* and *Labeo* species.

The composition of the endosulfan residues in the fish tissues could be influenced by, among other factors, the relative availability of the endosulfan isomers, the routes and rates of uptake and metabolism by the fish. The predominant route by which the pesticides were expected to enter the water was by direct fallout of pesticide spray or spray drift (Munga & Foxall, in prep.). Thus, there was a high likelihood that the composition of endosulfan introduced was approximately that of the technical material, of about 70% endosulfan I and 30% endosulfan II. The availability of the endosulfan isomers to fish depends on their interaction with water (relative solubility), sediment, silt and organic matter (adsorption and absorption) (Byers et al. 1965, Douthwaite et al. 1981).

With reference to the composition of technical endosulfan it was apparent from the muscular residue proportions of endosulfan I and endosulfan II of C. mossambicus and L. gregorii (Table 7) that the former isomer was metabolized faster than the latter. In addition, the slightly higher proportion of endosulfan II in Clarias muscles could be due to a more ready availability of residues of the isomer adsorbed onto bottom sediment and organic matter which the fish took up through feeding at the bottom (Munga & Foxal, in prep.).

The muscular residual proportions of endosulfan I in O. mossambicus and T. zilli were relatively higher than that of endosulfan II (Table 7). Endosulfan II was expected to be in lower concentrations and thus less available in the water because of its tendency for strong adsorption to organic matter, silt and sediment (Douthwaite et al. 1981, Greve & Wit 1971). Thus O. mossambicus and T. zilli which are essentially surface dwellers (Munga & Foxal, in prep.) were expected to be less exposed to endosulfan II than the Clarias species.

Taking into consideration the relatively few eggs and liver samples analy, there was no obvious indication from that data to confirm some of the factors that could influence the observed residue levels and relative proportions of isomers in the tissues (Tables 8 & 9). However, the relative proportions of the isomers in the eggs and liver tissues could be influenced by the extent of accumulation of residues and rate of metabolism in the organs.

Generally, muscle samples had relatively higher concentrations and proportions of endosulfan sulphate than eggs and liver tissues (Tables 7, 8 & 9). This could indicate that metabolism and excretion of endosulfan sulphate occurred more readily in the liver and eggs than in the muscle tissue (Devi et al. 1981, Rao & Murty 1982). The rapid metabolism and or conversion of endosulfan sulphate in eggs was demonstrated by the absence of detectable levels of the metabolite in samples obtained 48-50 days after cessation of endosulfan spraying (Table 8).

CONCLUSION

The concentrations of DDT and endosulfan residue in L. gregorii showed a strong relationship with fat content of tissues. Thus, the liver, with the highest fat content, had higher residue concentrations than eggs and muscle tissues, thus emphasizing the function of the liver as a storage and detoxification organ. In all the tissues, analy p,p'-DDE residues were predominant , an indication of chronic exposure of the fish to p,p'-DDT or p,p'-DDE. Relative concentrations of endosulfan and proportions of the isomers in the fish tissues was apparently influenced by, among other factors, the availability of the isomers, routes and rates of uptake and metabolism, and with reference to the fish species. The relatively lower concentrations and proportions of endosulfan sulphate in eggs and liver, as compared to concentrations in muscle tissues, indicated the ease of metabolism of the sulphate in the eggs and liver tissues.

Table 1: DDT and endosulfan residues in *Labeo gregorii* tissues

Tissue	Sample No	Mean fat content (%)	Mean residue concentrations (mg kg^{-1} wet mass) dDDT	dendosulfan+
Muscle	6	0.36	0.10 (0.01-0.45)	0.004 (.001-0.008)
Liver	2	8.59	1.01 (0.82-1.25)	0.05 (0.04-0.06)
Eggs	6	2.04	1.86 (0.25-8.39)	0.02 (0.002-0.04)

* dDDT=p,p'-DDT + p,p'-DDE + p,p'-DDD
+dendosulfan = endosulfan I + endosulfan II + endosulfan sulphate

Table 2: DDT residues in *Clarias mossambicus* tissues

Tissue	Sample No	Mean fat Content (%)	Mean residue concentrations dDDT (mg kg^{-1} wet mass)
Muscle	5	0.34	0.03 (0.08-0.59)
Liver	5	3.51	2.91 (0.22-9.77)
Eggs	4	0.49	6.01 (0.14-17.6)

Table 3: Endosulfan residues in *Clarias mossambicus*

Muscle	Sample No	Mean fat Content (%)	Mean residue concentrations (mg kg^{-1} wet mass)
Muscle	4	0.30	0.07 (0.01-0.14)
Liver	3	2.60	0.01
Eggs	4	0.49	0.07 (0-0.26)

Table 4: DDT residue in muscle samples

	Sample NO.	Mean residue concentrations (mg kg^{-1} fat mass)				Ratios (%)		
		p,p'-DDT	p,p'-DDE	p,p'-DDD	DDT	p,p'-DDD / DDT	p,p'-DDE / DDT	p,p'DDT / DDT
C.mossambicus	5	1.1	134.3	4.1	139.5	1.5	94.6	3.9
		(0.5-2.5)	(13.2-353.8)	(0.4-11.9)	(14.2-358.8)	±1.3	±2.6	±2.5
L.gregorii	13	0.3	19.6	0.8	20.7	3.1	[illegible].6	8.3
		(0-1.0)	(0.7-92.9)	(0.1-3.3)	(0.8-93.7)	±6.2	±10.4	±6.1
O.mossambicus	27	0.6	18.2	1.0	19.7	3.5	87.6	9.9
T.zilli		(0-6.2)	(0.8-124.9)	(0-3.6)	(2.0-133.7)	±5.1	±12.6	±12.1

Table 5: DDT residues in liver samples

	Sample No.	Mean residue concentrations (mg kg^{-1} fat mass)				Ratios (%)		
		p,p'-DDT	p,p'-DDE	p,p-DDD	DDT	p,p'-DDD / DDT	p,p'-DDE / DDT	p,p-DDT / DDT
C.mossambicus	5	NDa	74.6 (5.4-144.9)	2.1 (0.4-5.9)	76.8 (5.8-146.3)	5.9 ±5.3	94.1 ±5.3	0
L.gregorii	2	NDa	10.7	0.1	12.8	11.3	98.7	0

a Not detected.

Table 6: DDT residues in eggs;

	Sample No.	Mean residue concentrations (mg kg^{-1} fat mass)				Ratios (%)		
		p,p'-DDT	p,p'-DDE	p,p'-DDE	DDT	p,p'-DDT / DDT	p,p'-DDE / DDT	p,p'-DDD / DDT
C.mossambicus	4	ND	714.0 (12-2780)	15.2 (0.2-55.5)	729.2 (12-2830)	0	95.5 ±4.1	4.5 ±4.1
L.gregorii	6	ND	22.9 (8.2-43.5)	1.0 (0.2-1.5)	23.9 (8.4-44.8)	0	95.5 ±2.2	4.5 ±2.2

Table 7: Endosulfan in muscle samples

	Sample NO.	Mean endosulfan residues (mg kg^{-1} fat mass)				Ratios (%)		
		I	II	SO_4	Total	I / I+II	II / I+II	SO_4 / Total
C.mossambicus	3	1.14 (1.07-2.34)	1.13 (0.25-2.57)	16.19 (7.38-22.18)	18.44 (9.02-27.07)	37.6 ±33.8	62.4 ±33.8	87.5 ±8.7
L.gregorii	8	0.64 (0-2.12)	0.46 (0.25-1.18)	0.77 (0-1.44)	1.87 (0.64-4.46)	50.3 ±23.6	49.7 ±23.6	40.0 ±27.1
O.mossambicus	6[a]	0.08 (0-0.13)	NO	7.14 (0.45-23.19)	7.23 (0.45-23.32)	100	0.0	98.1 ±1.9
& T. zilli	6[b]	0.17 (0-0.69)	0.04 (0-0.16)	0.69 (0.52-0.98)	0.90 (0.52-1.34)	73.9 ±48.2	20.7 ±36.3	81.1 ±23.5

(a) Sampling date : 19th August, 1983

(b) Sampling date : 11th November, 1983.

Table 8: Endosulfan residues in eggs.

	Sample NO.	Mean endosulfan residues ($mg\ kg^{-1}$ fat mass)				Ratios (%)		
		I	II	SO_4	Total	$\frac{I}{I+II}$	$\frac{II}{I+II}$	$\frac{SO_4}{Total}$
C. mossambicus	I[a]	1.56	0.45	ND	2.01	77.6	22.4	0.0
	I[b]	0.81	0.08	40.19	41.08	91.0	9.0	97.8
	2[c]	1.03	0.21	ND	1.24	90.4	9.6	0.0
L. gregorii	5[d]	0.47	0.39	0.11	0.97	60.5	39.5	10.0
		(0.31-0.68)	(0-0.71)	(0-0.37)	(0.4-1.57)	±23.0	±23.5	±9.5
	I[c]	0.07	0.03	ND	0.10	70.0	30.0	0.0

(a) sampling site SI, sampling date 19th August, 1985
(b) sampling site S3, sampling date 19th August, 1985
(c) sampling date 9th - 11th November, 1985
(d) sampling date 19th August, 1985

Table 9: Endosulfan residues in liver samples

	Sample NO.	Mean endosulfan residues ($mg\ kg^{-1}$ fat mass)				Ratios (%)		
		I	II	SO_4	Total	$\frac{I}{I+II}$	$\frac{II}{I+II}$	$\frac{SO_4}{Total}$
C. mossambicus	I	0.09	0.03	$2.0x10^{-4}$	0.12	75.0	25.0	0.2
L. gregorii	I	0.29	0.18	ND	0.47	61.7	38.3	0.0

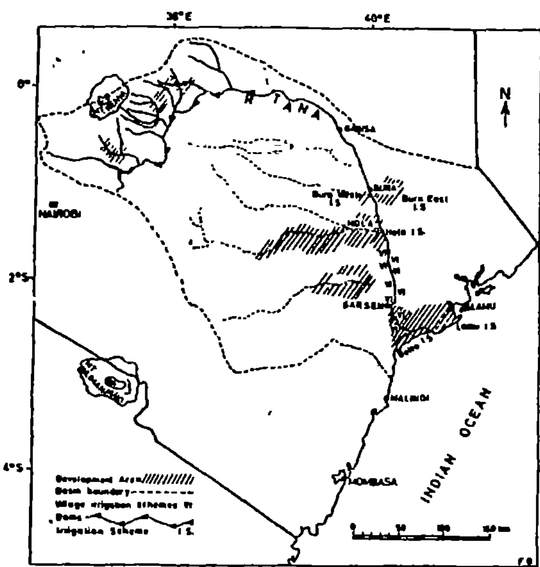

Figure 1 : Map of the Tana River basin showing irrigation schemes and other developments.

(Source: Tana & Athi Rivers Development Authority - Nairobi)

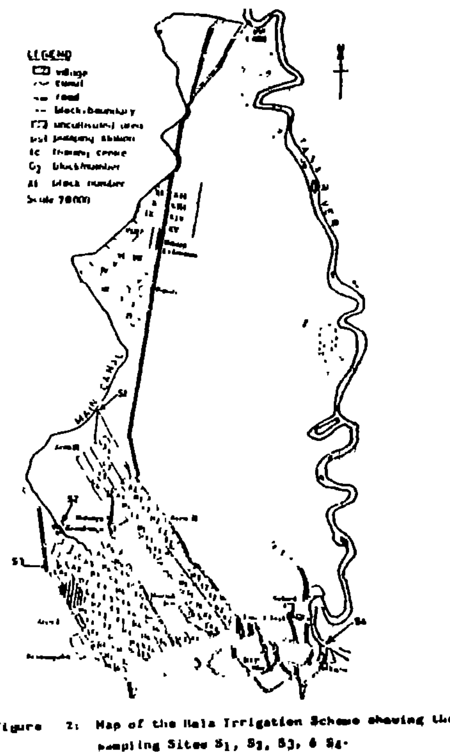

Figure 2: Map of the Hola Irrigation Scheme showing the sampling Sites S_1, S_2, S_3, & S_4.
(source: National Irrigation Board, Hola).

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Question by Prof. S. Zaman

Since the concentration of the pesticide residues is likely to be higher in older than in younger fish, a distinction of the two groups is important.

Answer

In order to avoid variations due to age/maturity stages, sampling for analysis/investigation was done in only a limited range of fish size.

Question by Dr. Opuda-Asibo

There is a tendency for organo-chlorides to settle in fatty tissues. Why were the analyses for the presence of these substances not done for fatty masses.

Answer

Analyses for the presence of organochlorides in fish samples were done for both wet and fatty-tissues of the organs used (kidney, liver etc.).

AGROCHEMICAL HAZARDS: A SITUATION ANALYSIS ON HANDLING OF AGROCHEMICALS IN SELECTED COFFEE FACTORIES IN KIAMBU - CENTRAL PROVINCE OF KENYA

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ABSTRACT

Agriculture is the backbone of Kenya's economy; however, it is amazing that thirty percent (30%) of the crop is destroyed by pests, either in farms or in stores. As a result, local farmers have doubled the use of agrochemicals, and by so doing they expose themselves to hazards and subsequently the immediate environment as well as the environment at large. Apart from the agricultural workers being at high risk of exposure of agrochemicals, coffee factory workers who sell agrochemicals to rural, in small scale farmers are likewise at high risk of exposure to agrochemicals. Many have presented themselves to health facilities with both acute and chronic agrochemical related health problems. In order to assess the situation, a situational analysis study was carried out in Kiambu district, among individuals working in few selected coffee factories. The major findings were that: Workers handle toxic agrochemicals such as Difolaton (Captafol), Sumthion, Malathion, etc. This had resulted into health complaints and consequently a high turnover among the agrochemical handlers. This may be explained by the fact that 30% of workers interviewed did not wear any form of protective clothing. And of those who did not wear clothing 60% claimed that the management did not provide them with the clothing. Those findings and many more have necessitated mounting of a health programme in the study area with a view of involving community members to solve these problems, since these are their problems and they should solve them.

INTRODUCTION

Agriculture still stands out as the backbone of the Kenya's economy, however, it is amazing to note that 30% of the crop is destroyed by pests while in the farms or in the stores[1]. To overcome this pest menace, the local farmers, and particularly small scale farmers, have gone to the extent of doubling the use of fertilizers as well as pesticides[2]. All the three countries of East Africa are annually increasing their importation of pesticides from European and Northern American countries. For example, in Kenya, the sales of pesticides in 1981 were US$ 14 million, but by 1986 this had more than doubled to US$ 36 million. In 1981 the total purchase of pesticides was 4,400 tones, rising to 5,100 tones in 1984. Further information on the amounts imported into the country is in the appendix.

Before any of these agrochemicals reach the target users, they are handled through a system called the "distribution network". This network starts from the Principals (manufactures), Main distributors who are not Kenya Grain Growers Co-operative Union (KGGCU), ordinary distributors and lastly, the Co-operative Unions and Societies. As they are transported from one point to another they pose significant occupational and environmental health risks to people and mammals throughout the world.

Workers depending on the kind of working environment are exposed to certain health hazards. These vary from place to place and may include noise, excessive heat or cold, air dust, fumes, chemicals etc, all of which come into contact with the body through different portals of entries. For example agricultural workers are considered to be a high risk group because they are exposed to hazards from the fungicides, pesticides, herbicides and fertilizers among others. Likewise coffee factory workers, whose work is to sell agrochemicals particularly pesticides to small scale farmers are constantly exposed to the hazards through inhalation of the fumes/dust and through skin contact[3].

Agrochemical hazards tend to be more serious in developing countries, where agrochemical use is wide spread, where pesticides banned elsewhere because of their carcinogenic, mutagenic and teratogenic properties are being used, where workers and health professionals may not be adequately trained and informed in recognition and prevention of the poisoning, where methods of minimizing exposure such as by use of personal protective equipment are not deployed, simply because they may not be available, accessible or even affordable by the pesticides handlers[4].

The nature, magnitude and severity of agrochemical poisoning in developing countries has not been adequately investigated. However, a recent study found a 7% rate of pesticides poisoning among Sri Lanka and Malaysian agricultural workers[4]. Applying this finding to the estimated number of pesticides exposed workers in Kenya would give 350,000 cases annually.

Although Kenya's Factory Act (1971) and Pest Control Act (1982) require that the management ought to provide the factory workers, particularly those handling agrochemicals with, adequate protective clothing such as hand gloves, overalls, gumboots, respiratory musks etc, you find that this requirement is not implemented. In some incidence the management is aware of this requirement, however, their efforts to implement this aspect is hampered by financial constraints and in situations where the management has played its part, the workers themselves do not take the initiative to wear the provisions.

As a result of these constraints and failure of workers to co-operate, many workers, particularly working in agriculture and coffee co-operative factories, are highly exposed. Many have complaints which range from headaches, contact dermatitis, vomiting, asthmatic attacks, hypertension, chronic bronchitis to certain forms of cancers[7].

FOCUS ON THE STUDY AREA

Githunguri location in Kiambu district, Central Province of Kenya is located at a distance of approximately 60 km to the North west of Nairobi. It is 2,000 meters above sea level, with a population of about 170,000 people as projected from the 1979 national census. Like all other locations in the country, it is administratively headed by a chief. It is further divided into sub-locations, each headed by an Assistant Chief. It is in general a high potential agricultural area. The average size of land per household is below five acres. Coffee and tea are the major cash crops grown. There are more than fifteen coffee factories in operation. It is at these factories where small scale farmers deliver and sell their coffee produce and at the same time buy agrochemicals, particularly pesticides on credit terms.

Although many types of agricultural workers may be at risk of pesticides exposure, sellers too, particularly those at coffee factories are often at high risk because of long hours of exposure and due to lack of adequate protective clothing[5,7].

In order to assess the extent of the problem a community based study was carried out in Githunguri location of Kiambu District, Central Province.

The study had three major objectives:

1. To establish the extent of the use of agrochemicals among the small scale farmers, and assess their attitudes and behaviour as well as general awareness of the health dangers posed by improper handling.

2. To assess the situation of agrochemical handling, specifically at few selected factories.

3. To mount a community-based health education programme to educate the trainers on how to use and handle pesticides safely. Then the trainers, in turn would train the section of community, by targeting on school children, health care seekers, farmers and so forth.

This paper focuses on the second and third objectives, which is a situational analysis study carried out in few selected coffee factories in Githunguri - Kiambu district, and the manner in which the problems can be managed to reduce the health risks posed by agrochemicals, particularly pesticides.

The specific objectives of the study were:

1. To establish the number of workers in these selected factories who are directly involved in handling of pesticides.

2. To determine the duration one has worked in the factory or similar one in the same locality.

3. To determine the type of agrochemicals sold at each factory.

4. To ascertain if protective clothing is worn while selling agrochemicals.

5. To come out with feasible recommendations on how to manage the situation.

Methodology

A structured questionnaire was developed and administered to respondent from 8 coffee co-operative factories, where small scale farmers deliver/sell their coffee produce and in turn buy agrochemicals. During the interviewing, observations were made, regarding the location of the store, the mode of portioning and selling.

Findings (Results)

Eight coffee factories were visited and 19 individuals who are directly involved in selling of agrochemicals were interviewed. About 70% of the workers fell under the ages of 20-30 and about 21% were less than 19 years or more than thirty one years of age. This tends to explain that many young people are at high risk, and if they continue in such places they risk developing both acute and chronic health problems. More than half were married while less than half were either married or singles.

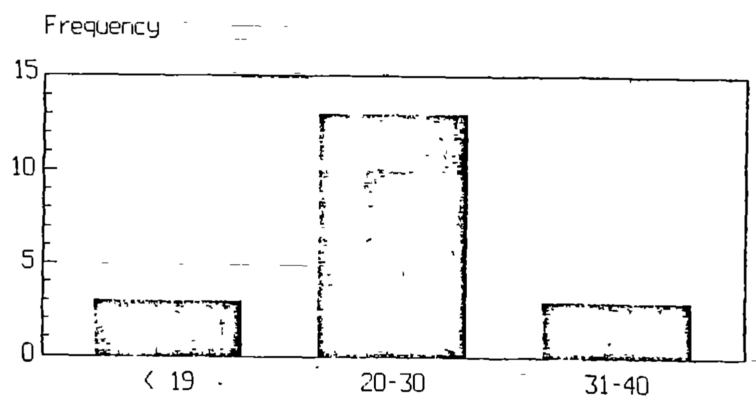

Figure 1: Respondents by age.

Table 2. Number of individuals interviewed by factory and sex.

Name of Factory	No. of male	No. of female	Total
Karweti	-	3	3
Gititu	1	1	2
Kiaria	2	2	4
Nyaga	2	-	2
Gochi	1	1	2
Giagithu	1	2	3
Nyakabugi	-	1	1
Kimathi	-	2	2
	8	11	19

A total of 19 respondents were interviewed, 8 were males and 11 were females. The average number of coffee factory workers directly involved in pesticides handling in each coffee factory was found to be about 2.

Table 3. Level of education by each factory

Factory	Level of Education			Total
	None	Primary	High School	
1.	-	-	3	3
2.	-	-	2	2
3.	-	1	3	4
4.	-	-	2	2
5.	-	-	2	2
6.	-	1	2	3
7.	-	-	1	1
8.	-	-	2	2
TOTAL	-	2	17	19

About 89% of the workers had high school level of education and 11% had primary level of education. It can be argued that the majority are young people who have attained high school level of education. Perhaps they have not managed to secure other types of jobs, hence they have been left with no other choice but to work in these factories which are based near their homes.

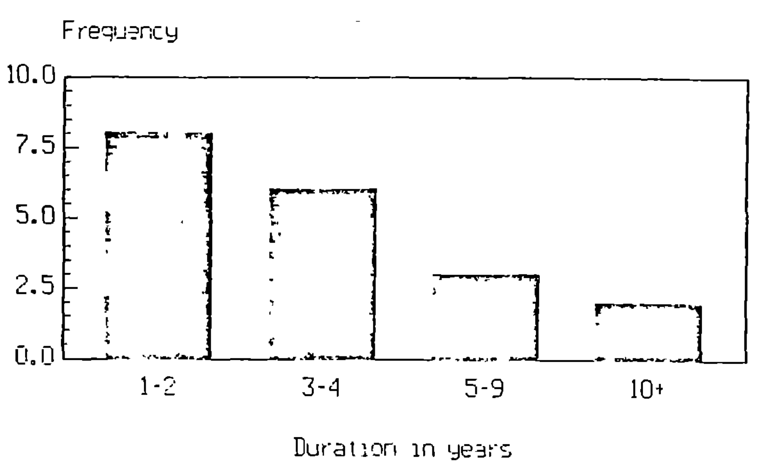

Figure 2. Period worked in the Factory

On the whole 42% respondents had worked for a period of about 1-2 years while the other percent had worked for periods varying from 3 years to more than ten years. This means that more than 50% are of high risk due to the number of years they have been working at the factory.

Table 4: Present types of agrochemicals sold to local farmers (small scale farmers

Type	Frequency Number	Name of agrochemicals by order of frequency
Copper-Green	8	1. Copper Green
		Daconil 8*
Copper Red	2	2. Gramaxone 7*
Difolaton	8	3. Malathion
		Fentrothion and
		Round up 6*
Galcide (Rocide)	6	4. Rocide, symthion,
		fertilizers C.A.N &
		D.A.P. 5*
Daknale (Daconil)	8	
Folimate	4	5. Folimate, A.S.N.
Folin Feed	1	Gusathion and
		Diathane 4*
Fentrothion	6	Diathane 4*
Procida	1	6. Deldrin, Fertilizer
		20.10.10
Sumthion	5	Inacide 3*
Deldrin	3	
Round up	6	7. Copper Red
Gramaxone	7	Fertilizer 20.20.0 2*
Kydrine		
Fertilizers	1	8. Folin feed 1*
20.10.10	3	Kydrine
20.20.0	2	Fungicide
C.A.N.	5	
A.S.N.	4	
D.A.P.	5	
Fungicide	1	
Inacide	3	
Gusathion	4	
Diathane	4	

Table 5. Distribution of toxic pesticides as mentioned by the respondents N = 19

Type	Frequency	Order by virtue of toxicity
Copper Red	7	1. Difolaton
Green	1	2. Copper Red
Fenthrothion	6	3. Sumthion and Fentrothion
Gramaxone	2	4. Kocide and Round up
Gusothion	2	5. Gramaxone
Difolaton	16	Gusathion
Sumthion	6	Malathion
Kocide	3	Daconil
Malathion	2	6. Copper green and folimate
Round up	3	
Daconil	2	
Folimate	1	

From the respondents awareness and point of view, the most toxic agrochemical is Difolaton and the least toxic are Copper and Folimate.

Table 6. Wearing of protective clothing

Wear protective clothing	No. of respondents	Percentage
Yes	14	73.7
No	5	26.3
TOTAL	19	100.0

Table 7.1 Reasons for not wearing protective clothing when giving out agrochemicals N = 5

Reason(s)	No. of respondents	Percentage
Protective clothing not available	3	60
Clothing are in bad conditions	2	40
TOTAL	5	100

Sixty percent were not provided with protective clothing, and 40% claimed that the clothing were in bad condition, which could be interpreted to mean they were torn, soiled with chemicals or shared, which could be rejected by many of the workers.

Table 7.2 Type of protective clothing worn N = 19

Type	No. of respondents	Percentage
Hand gloves	14	73.7
Respiratory Masks	14	73.7
Gumboots	8	42.1
Overall	11	57.9
Others	6	31.5

NB. N = 19, as denominator for each category

When asked about health problems related to handling of agrochemicals, 18 (94.7%) stated had acquired and only one (5.3%) stated had not acquired any health problem related to handling of agrochemicals.

Table 8: Health complaints as a result of handling agrochemicals N = 18

Health complaints	No. of respondents	Percentage
Headaches	9	50
Stomach aches	8	44.4
Dizziness	2	11.1
Chest pains	2	11.1
Skin rush (contact dermatitis)	4	22.2
Vomiting	1	5.5
Coughing	5	27.7
Sneezing	3	16.6
High Blood Pressure	1	5.5
Swollen face	1	5.5
Difficult in breathing	5	27.7
Fever	1	5.5

The most common health complaints were, headaches, stomach aches, coughing, difficult in breathing, sneezing and contact dermatitis, while the least common were vomiting, high blood pressure and fever.

Table 9. Sought medical attention for health complaint

	No. of respondents	Percentage
Sought	9	47.4
Did not seek	10	52
TOTAL	19	100.0

Table 10. Types of medical facilities where treatment was sought

Health facility	No. of respondents	Percentage
Dispensary	1	9.1
Health Centre	5	45.5
District Hospital	4	36.4
Private	1	9.1
TOTAL	11*a (9)	100.0

* The total number of respondents should be 9, however two patients went to two places at the same time.

Table 11. Reason(s) for not seeking medical attention N = 9

Reason(s)	No. of respondents	Percentage
Self medication (in form of raw eggs)	6	66.7
Felt not a serious problem	1	11.1
Ignored	1	11.1
No response	1	11.1
TOTAL	9	100.0

As in Tables 10 and 11 respectively, nine sought medical attention and 9 did not because of the reasons indicated here (Table 11), one however did not do either because he/she did not acquire any health problem. This could be because he/she was in the category of 1-2 years and perhaps he/she had just started working when we launched the interviewing. Of those nine who went to health facilities, eight felt better.

When asked whether they had anything to say about agrochemicals in general, 18 (93.7%) said yes, while 1 (5.3%) said no. Responses of those who had something to say are shown on Table 12.

Table 12: Listed responses.

Responses	No. of respondent	Percentage
Agrochemicals are occupational health hazards	3	15.8
Should be supplied to factory while re-packed in small quantities	8	42.1
People handling in factories need proper protective clothing	5	26.3
The store should be built away from the office	2	10.5
No response	1	5.3

As it can be seen in Table 12, there is need to wear protective clothing and to supply agrochemicals in small packages that can be afforded by small scale farmers. This would minimize the dangers of exposure while portioning.

OBSERVATIONS

1. Many of the factory workers were highly exposed even those who were not directly involved in selling. This is explained by the fact that in all coffee factories, the store and the office shared one building.

2. Protective clothing were only worn when new, after they got soiled, the workers neglected them.

3. Majority of the agrochemicals were packed in bulk and were dished to farmers in small quantities, hence increased the risk of exposure to both the farmer and the seller.

4. Although lagoons to contain the effluents are present in all factories visited, some factories secretly release effluents into the stream.

RECOMMENDATIONS

A joint workshop between the researchers and relevant members of the community came up with recommendations; which form the basis of management, control and prevention. Some of the recommendations are:

1. Coffee factory workers who handle agrochemicals should wear protective clothing to set out a good example to the rest of the community members.

2. The use of cheap labour at the coffee factory stores should be stopped forthwith.

3. Researchers should explore Ngungu's method of treating coffee factory effluents.

4. Pesticides should not be stored in containers other than the originals.

5. Pest Control Board and Pesticides Chemical Association of Kenya, should request the agrochemical manufacturers to pack in small quantities e.g. one kg, two kg etc. This would reduce the risk of exposure.

6. Ministry of Water should intensify monitoring of stream waters along the factories to ascertain if actually they are being polluted, and if so take the necessary legal action.

These recommendations and others not mentioned here are being implemented through health education, using various target groups. These groups include: coffee factory workers, women groups, health care providers, teachers, community leaders etc.

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APPENDIX

Table 1A. Market value of pesticides in Kenya, 1986 (in US $)

Selected Crops	Value
Coffee	$ 14,275
Cotton	2,399
Maize	2,046
Wheat	1,854
Barley	1,220
Sugar cane	914
Tea	684

Source: Ofafa P.O. The Agrochemical industry (in Kenya) Pesticide Chemical Association of Kenya - GIFAP Workshop on Responsible Effective Crop Protection, Nairobi, 11 - 12 February, 1988.

Question by Dr. Opuda-Asibo

Were the workers aware of the objectives of the study?

Answer

In order to avoid subjectivity, the workers were not informed of the objectives of the study.

Question by Mr. H.B. Pratap

Was the investigation on health complains based on sex of the workers?

Answer

No.

Recommendation by Mr. Pratap

Such a distinction should be made because in Tanzania similar studies have found out that females are affected not only in the general health, but their reproductive system may be disturbed.

(Poster)

PESTICIDE HAZARDS

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All over the world the use of pesticides has become an increasingly necessary practice in the consistent and economic production of high quality crops to meet world demand. Unfortunately it is difficult to use pesticides without spreading them to non-target areas. Hence the use of these pesticides has passed some serious problems on mankind and environment. For instance loss of human life, livestock, vegetation, food stuff and money are some of the results of misuses and poor handling of these useful chemicals.

When talking of pesticides we are referring to fertilizers and insecticides - these can be in solid, liquid or gaseous form. Pesticides can enter and poison the body through accident, homicide or suicidal ingestion. Other affected areas such as water bodies, soil and air are polluted by wash-offs, leaching and vaporization, depending on the weather and form of pesticides. Pesticide hazards or poisoning can be observed after a single exposure, or through repeated exposure thus leading to continuous accumulation of residue. This effect can be observed after a period of time. There is a remarkable percentage of these hazards which are due to ignorance and indifference. These are aggravated by methods of applying the chemicals on the nerve centre of the pests. Since most pests often hide in obscure corners of human, animal, water or plant bodies or cracks and sewers of buildings, most pesticide applicators aim at saturating the whole infested area with a pesticide. In this way, the applicators increases the risks of applied pesticides reaching non-target areas or organisms. Also there are risks incurred by a number of applicators or formulators of these chemicals who often handle pesticides while they are least protected, even where protective appliances are available. Use of inadequately or non-labelled containers, allowing their contents to be mistaken for food stuff is another source of fatal exposures. Information like how to use, dilutions, antidote warnings, shelf-life, if it has been restricted, are vital. The use of discarded and under-contaminated pesticide containers for storing food, water or oil for human/animal consumption, is another common cause of poisoning. Re-packing of these chemicals into containers labeled otherwise (e.g. beer bottles, flour bags etc.) is not a good practice. Many people also believe that grains or legumes preserved by pesticides are safe enough for eating by human beings not knowing that some of the applied pesticides penetrate under the product and can hardly be washed off or destroyed by normal cooking.

Pesticides are valuable products, which may deteriorate and become useless or hazardous if stored in extreme temperatures; therefore proper arrangement and ventilation is necessary especially in a warehouse or store room. They should be locked in to ensure that they are kept away from children and unauthorised persons, animals, food stuff and water supplies. Dumping of pesticides that are no longer used/banned or expired is a dangerous practice. Leaving these chemicals in open space can cause severe damage to the land, air (by volatile chemicals), animals grazing nearby or water bodies since they can easily leach. The unwanted pesticide should therefore be properly disposed of according to instructions by the formulators. Bad trading in the sense that once you purchase big quantity at a time, at the end of application you will find yourself with surplus which you can not store properly. For retail purposes therefore manufacturers should pack only enough for an application or season. Selling of pesticides on the same counter with food or feed stuff should not be allowed since these can result into poisoning.

To make sure that users and formulators of these pesticides are aware of all these hazards, an education programme is necessary, whereby posters, TV programmes, pamphlets, seminars, radio programmes and agricultural workers are involved. Also strict pesticide regulations should be introduced and implemented and those who go against it should be taken to court.

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PESTICIDES POLLUTION IN TANZANIA

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ABSTRACT

The extent of pesticides pollution in the Tanzanian environment is reviewed. Concentration levels of various organochlorine pesticides in waters, soils, lake sediments, birds, fish and aquatic plants in various environments of Tanzania are presented. The pesticides include DDT (and its metabolites DD and DDE), endosulfan (and its sulphate metabolites), lindane, aldrin, dieldrin (and its newly discovered metabolite "tanzadrin").

Most of these pesticides are found in smaller concentrations than the recommended FAO/WHO Maximum Residue Limits (MRL), except a few, which point to the possibility of local pollution. Highlights of the findings on the ongoing studies on copper pollution in soils and coffee beans due to many years use of copper fungicides in coffee growing areas of Kilimanjaro, north-east Tanzania, are made. Finally, it is recommended to intensify pesticides research in view of the scanty information available, and in light of the recent knowledge that pesticides could degrade faster in the tropics, and also form different metabolites from those quoted in temperate regions.

Question by Dr. H.J. Gijzen

There is a remarkable difference between the half-lives of pesticides in the temperate zone and in the tropics. Have the causes of the differences been established?

Answer:

No specific studies have been done but the differences are most likely a result of many climatic factors acting on the pesticides. In the near future a nine countries coordinated project is to begin in order to study the degradation of DDT in the respective regions. The results should give an idea of the factors influencing the rate of degradation of the pesticide.

Recommendations/Remarks

Prof. M.R. Khan

It will be difficult for us scientists to convince the public about the dangers of pesticides if highly placed people (leaders) declare the pesticides completely harmless.

Prof. Zaman

More knowledge on how to handle the hazardous chemicals and their side effects is necessary for the public.

Dr. Mwanthi

The biggest problem of all is control of pollution. Plans are there but their implementation is lacking or not well done. It is difficult to control pollution without legislation. So far proper laws to help enforce waste management are lacking.

Prof. Khan

The public is not aware of their rights as far as the quality of consumer goods is concerned. Institutions like TBS and the Government Chemist should have powers to monitor and control the standards of the goods.

Dr. Jonalagadda

DDT has been banned in many developed countries after a thorough and longterm study which confirmed its toxic effects to life on the whole. We in the developing world should stop wasting funds on studying its behaviour since all of the bad effects have been established.

Dr. M. Gerges

A list of potentially toxic substances is issued regularly by UNEP to anybody who asks for it. Useful information on how to handle, label and ship such chemicals is given.

Mr. Pratap

The use of DDT has been shown in India to cause health problems even in very low concentrations. Reports by WHO from other parts of the world have confirmed the toxic effects of the pesticide. On this basis the statement given by the Director of Tanzania Medical Research Institute that DDT is completely harmless to humans when sprayed inside houses should be withdrawn.

HEAVY METALS

SOME APPLICATIONS OF X-RAY FLUORESCENCE TO ENVIRONMENTAL POLLUTION

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ABSTRACT

Application of x-ray fluorescence to environmental pollution is described. A description of the Fundamental Parameters method as can be used for environmental samples is given. Typical detection limits achievable in our laboratory are given. Results obtained for analysis of pollution in a Creek in Dar es Salaam are also presented.

INTRODUCTION

X-ray fluorescence can be used routinely for analysis of elemental concentrations of essentially all elements with atomic number equal to or greater than thirteen. The technique is rapid and can be used for multi-element analysis and is often non-destructive[1,2,3]. Diverse types of samples including environmental samples can be rapidly analysed with reasonable accuracy. Both radio-isotopes and x-ray tubes are popular as source of x-rays which irradiate the samples.

When x-rays of sufficiently high energy strike a sample, core electrons of atoms in the sample may be ejected, leaving out a vacancy which may be filled by an outer electron, thereby giving out characteristic x-rays of the excited atom. If efforts are made to collect these characteristic x-rays using an appropriate detector, then quantitative analysis of elemental concentrations can be carried out.

In general the number of characteristic photons reaching the detector depends on the following:

1. Intensity of exciting radiation.
2. Concentration of the element to be analysed.
3. The nature of the matrix in which the element of interest is found.
4. Atomic properties of the element of interest.
5. The geometry.

THEORETICAL BACKGROUND

The nature of samples one works with in x-ray fluorescence can be put in three groups, i.e. thick, intermediate and thin. This classification depends on how much the incident or fluorescent radiation is absorbed by the sample. Many interesting environmental samples can be considered thin. Matrix effects are then minimal and is almost equal to having the element of interest placed on the surface of the sample. Under these conditions, the fluorescent radiation intensity I^i (of element "i") reaching the detector can be expressed by

$$I^i = G'K_iM_iA_i \qquad - \text{eq (1)}$$

where,

- G' : is a constant depending on the geometry and intensity of exciting radiation.
- K_i : incorporates the probability of excitation and detection of element "i".
- M_i : is the concentration of element "i" in the sample
- A_i : expression depending on the absorption properties of the matrix.

Fundamental Parameter Approach

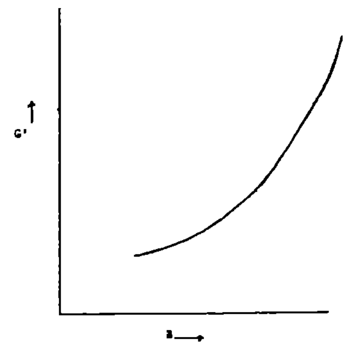
In the so called Fundamental Parameters approach, K_i in equation (1) is calculated from tabulated atomic constants. In principle, this approach then requires a single thin standard to calculate G'. In practice several standards are used and one must keep the following facts in mind:

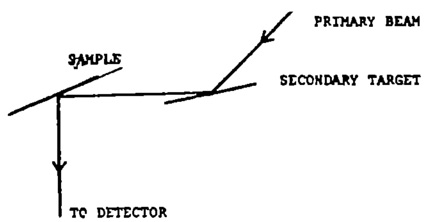
a) Standards may not be thin enough.
b) Shelf-life of standards may be short.
c) Standards may not be homogenous.
d) For low atomic number elements absorption due to filter paper, on which standards are usually evaporated, may be significant.
e) Atomic constants may not be accurate enough.

Alternatively thick standards of known stoichiometry are used (e.g. KBr, pure metals, ZrO_2 etc.). In this case A_i can be calculated from atomic constants (such as mass absorption coefficients). It is then convenient to form

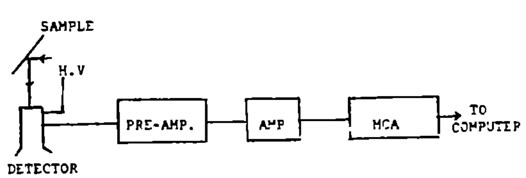
$$G = K_i G'$$

and plot G versus Z





THREE AXIAL GEOMETRY



BLOCK DIAGRAM

Figure 2

Experimental Set-up

Both x-ray tubes used with or without secondary targets and radioisotopes are commonly used as sources of exciting radiation. The figure below shows a three axes arrangement for a more effective background reduction. The following figure gives a block diagram for the equipment.

Detection Limits

A very useful parameter that describes the performance of the spectrometer is the detection limits achievable for various elements. This quantity is defined when the net signal from a sample equals three times the standard deviation of the background counts at the respective fluorescent line. Mathematically it is given by

$$D.L. = \frac{3c}{R_p} \quad \frac{R_B}{t}$$

where C is the concentration of the element in the sample
R_B is background count.
R_p is net peak.

For our set-up the following table shows typical values achieved under various conditions indicated. It is obvious that detection limits depend on various excitation conditions and on the spectrometer.

Table 1: Detection limits in ppm with different excitation and detection parameters

	Fe	Cu	Zn	Br
A	0.52	0.08	0.08	0.16
B	0.66	0.11	0.14	0.18
C	0.57	0.17	0.10	0.16

A: No silver collimator in sec. target sample path
B: Same as A but with silver collimator
C: Same as A but with collimator between sample and Be window.

Table 2: Detection limits with different tube parameters

Excitation time in sec.	Detection limit in ppm	Tube current in MA
50	41.25	5
100	30.15	10
300	9.50	20
400	6.75	40
500	5.60	50

Sample Application

Typical results of application of the technique to the study of heavy metals in a local creek, the Msimbazi Creek is given below. In this application water samples from two points along the Msimbazi valley were collected and co-precipitated using APDC. The precipitate was collected on a filter paper and later irradiated with x-rays.

Table 3: Results obtained from samples collected at two points in Msimbazi Creek. Values given in mg/l

Element	Cr	Mn	Cu	Pb	Hg
Blank	-	-	13.5±3	2.8±1	
Station I	-	-	57.7±11	3.1±1	
Station II	64.7±14.0	54.5±21.9	51.2±9	8.4±2.3	

DISCUSSION AND CONCLUSIONS

X-ray fluorescence is a powerful technique for environmental samples. Very low elemental concentrations can be determined. When applied to water samples. The same is true for aerosols. Unfortunately the technique cannot give any information on the valence state of the element being analysed. This is a major drawback.

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<u>Question by Dr. Opuda-Asibo</u>

I am inclined to ask about the sensitivity of the test, is there a definite way of standardizing this test and is there a zero standard? For, the results you have presented show that the test is very sensitive.

<u>Answer</u>

The test is very sensitive. Sometimes one uses commercially available standards which are normally checked carefully before being used in the analytical work. So in principle the test is very sensitive and easy to apply on a routine basis.

TRACE METAL POLLUTION ALONG THE KENYAN COAST

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KENYA

ABSTRACT

The depth distribution of total Al, Fe, Mn, Zn, Cu, Pb, Cd, and P°C were determined in sediment cores from a series of stations in Tudor, Makupa and Gazi creeks of the Kenyan coast. The results show varying distributional profiles in the three creeks. Al and Fe increase with depth in Makupa creek and this may be due to dilution at the top by mineral phases of non-detrital origin. Mn is mainly interlattice aluminosilicate bound in the three creeks except at the inner Tudor creek where there is excess Mn. Makupa creek shows the highest levels for the trace metals (Zn, Cu, Cd and Pb) among the three creeks. Aluminosilicates, Fe-oxyhydroxides and particulate organic carbon are anticipated to be responsible for the distribution of Zn, Cu, Cd and Pb in Tudor and Gazi creeks mainly by adsorption and scavenging. R-mode factor analysis of the correlation matrices suggests continental crustal source for Zn and Cu in Tudor creeks and non-crustal source for Zn, Cd and Pb in Makupa creek. High enrichments relative to average crustal composition for Zn, Cd and Pb in the three creeks is attributed to increased anthropogenic loading of the creeks.

INTRODUCTION

The behaviour of heavy metals in natural aqueous system has attracted researchers because of the environmental issues involved. Man's activities have increased the quantity and distribution of heavy metals in the atmosphere, on land and the aquatic environment. The extent of this widespread contamination has caused concern about their possible effects on plants, animals and human beings. At present, the anthropogenic input of certain heavy metals into the environment equals or exceeds the amount released by natural sources (de Groot 1976). Bowen (1979) concluded that when the rate of mining of a certain given element exceeds the natural rate of recycling by a factor of ten or more, then the element should be considered a potential pollutant. Thus Ag, Au, Cd, Hg, Mn, Pb, Zn and Cu among others ore already potential pollutants (Pendias and Pendias 1985). In some cases the discharge of heavy metals into restricted areas such as lagoons and creeks may reach extreme proportions. Thus fatalities related to the presence of Hg in the aquatic environment have occurred in the Minamata Bay of Japan (Fujiki 1972).

Protection and management of coastal waters require knowledge of the distribution and fate of the toxic metals both within the sediments and the water column. Urban and industrial development along the Kenyan coast has resulted in many potential sources of toxic compounds being deposited in the adjacent creeks which are not only breeding grounds for important commercial fishery species, but also act as sites for recreational activities. These compounds may have insidious effects on the flora and fauna that may appear in many levels of the food chain that eventually lead to man.

Unlike organic pollutants, heavy metals are not usually eliminated from the aquatic system by natural processes like bacterial action. Toxic metals such as Hg, Cd, Cu, and Sn tend to accumulate in the bottom sediments where they may be released by various processes of remobilization (Forstner and Wittman 1979) thereby increasing their bioavailability. Determination of trace metal concentrations in the surface water samples collected from coastal waters like creeks and estuaries at short intervals may reveal fluctuations of several orders of magnitude. This may result from variations of water discharge from rivers and the predominance of certain source areas leading to irregular effluent emission. Exchange processes between the interstitial and surface water which are often influenced by Eh, pH, salinity, temperature and biological activities in the water column and the underlying sediment may also influence the fluctuations in the water column. Therefore the problems associated with varying levels of trace metals in the water column can be better understood by the analysis of these elements in the sediments. This is because sediments can provide useful information about the presence of these metals in the water column since they can reflect the prevailing conditions of the water system and they can also act as a sink or source for these metals in the water column.

Tudor and Gazi creeks belong to some of the most important biotopes in the tropical waters of the East African coast especially the mangrove biotopes. Increase of man's population has increased the stress exerted on these biotopes by the effect of dumping of industrial wastes, discharge of municipal sewage and by cutting of mangroves. Therefore the sediments in these biotopes are sites where an important fraction of material flow through the ecosystem is temporarily trapped together with signs of pollution by man. This is in fact true because sediment particles act as a depot for toxic metals that have an affinity to the sediments. By bringing together mineral, organic and metal contaminants which are not in chemical equilibrium, sediments can enhance chemical, biochemical and biogeochemical reactions which have direct bearing on the biological communities inhabiting the sediments and the water column.

This work was undertaken to determine the concentrations and vertical distribution of some heavy metals (Zn, Cu, Cd and Pb) in the sediments of the three creeks and also to assess their enrichments against the natural (crustal) background levels and to identify the sources that may be responsible for the enrichments.

MATERIALS AND METHODS

Sampling

A total of six sediment cores were collected from a series of stations from Tudor, Makupa and Gazi creeks of the Kenyan coast (fig. 1). Cores were sampled by Scuba diving and manually pushing the corer into the sediment. The corer was stoppered at the bottom, carefully retrieved into the boat, stoppered at the top and transported to the laboratory where they were subsampled into sections. The subsamples were dried in an oven at 80°C, ground with a pestle and a mortar and finally homogenized.

Sediment digestion for metal analysis

About 100 mg of the dry homogenized sample was accurately weighed into a pre-treated PTFE bomb. The bombs were submerged into a boiling analytical grade reagent concentrated nitric acid for a minimum of 8 hrs, washed with distilled water, rinsed several times with milli-Q water and finally dried in a laminar flow hood. 6 ml of concentrated Nitric acid, 4 ml concentrated Hydrochloric acid and 2 ml of concentrated Hydrofluoric acid (all Merck, Supra pure products) were respectively added and the bombs tightly closed. The mixture was heated for a minimum of 12 hrs at 85°C then cooled to room temperature. The digest was evaporated to near-dryness and quantitatively transferred into a 25 ml acid cleaned volumetric flask and diluted to the mark with milli-Q water. The final solution was submitted for analysis.

Al, Fe, Zn, Cu, Ca and Mn were determined by flame atomic absorption spectrophotometry with a Varian 275 AAS spectrophotometer, while Cd and Pb were determined by graphite furnace (flameless) atomic absorption spectrophotometry using a Perkin Elmer AAS5000 spectrophotometer equipped with AS40 sequencer autosampler and HGA500 Graphite Furnace with L'vov platform in a pyrolytically coated graphite tube. A solution containing 5% ammonium orthophosphate and 0.1% magnesium nitrate was used as the matrix modifier. Before analysis of the samples, the method was checked for accuracy against the lake sediment (SL-1) standard of the International Atomic Energy Agency (IAEA) and estuarine sediment (1646) standard of National Bureau of Standards (NBS) both containing certified concentrations of Al, Fe, Mn, Zn, Cn, Cd and Pb. The precision of the method expressed as percent error of variation ((A-B)/A x 100, where A and B are certified and observed values respectively) were between 2-6% for both standards. Reproducibility was checked for by duplicate analysis of the samples and expressed as relative standard deviation (RSD). The results gave RSD's of between 0.2 and 17%. There was no duplicate analysis for Cd. The high RSD's of up-to 17% obtained for some samples could be due to intromoganity.

Sediment digestion for Particulate Organic Carbon (P°C) analysis

Between 50 and 100 mg of the dry homogenized sediment sample was accurately weighed into a stoppered erlenmeyer flask. 1 ml of 85% phosphoric acid and 1 ml of distilled water were added respectively. The mixture was heated between 100 and 110°C for 30 min to get rid of carbonates. After cooling to room temperature, 1 ml of mercuric sulphate solution (10 mg of $HgSO_4$ in 10% H_2SO_4) was added to complex the halogens especially chloride and the mixture was shaken for 2 minutes. 10 ml of $K_2Cr_2O_7$ solution in H_2SO_4 (4.84g of $K_2Cr_2O_7$ dissolved in 20 ml of distilled water and brought to 1 litre with concentrated H_2SO_4) was added and the mixture heated between 100 and 110°C for 1 hr. After cooling to room temperature the mixture was brought to 50 ml with distilled water, centrifuged, and the supernatant was separated and submitted for analysis employing the method adopted from Parsons et al (1984).

RESULTS AND DISCUSSION

The concentration of Al, Fe, Mn, Zn, Cu, Cd, Pb, Ca and P°C in Tudor, Makupa and Gazi creek sediments are presented in Tables 1-4 as total concentrations (μg/g) in the solid phase of the sediments. Their depth distribution show varying profiles in the three creeks. Al and Fe increases with depth in Makupa creek and this may be due to dilution at the top by mineral phases of non-detrital origin, e.g. carbonates as reflected by the Ca profile which decreases with depth. Mn is mainly interlattice aluminosilicate bound as reflected in their depletion relative to crust. Therefore the existing Mn may have very little role in the distribution of the trace metals except at the mouth of the river in Tudor creek where there is excess Mn. Zn, Cu, Cd, Pb and P°C profiles show a subsurface maxima followed by decrease towards the bottom of the core which reveals that the trace metals are associated with each other to some extent. Except for the major elements and P°C which show little variation, trace metals Zn, Cu, Cd and Pb are almost an order of magnitude higher in Makupa creek than in Tudor and Gazi creek, suggesting more intense anthropogenic inputs in Makupa creek.

In Tudor creek, the major and minor elements reveal almost similar distribution profiles with depth (i.e. a decrease with depth) except Mn whose profile changes from station to station. For Mn, this may reflect the different conditions prevailing within the sediments of the stations. The absolute concentration of Mn also decreases with distance from the river mouth (St 1) to the entrance to the open sea (St 3). The amount of Mn at St 1 is almost 20 times more than the amount at station 3. Sundby et al (1981) observed that coastal waters have a thin oxidized layer within the sediments where the upward diffusing Mn have little contact time with the solid phase essential for the MnO_2 catalyzed oxidation and precipitation. Thus some of the upward diffusing Mn can escape the thin oxidized layer of the coastal sediments into the water column instead of precipitating entirely within the layer. Therefore the low levels of Mn in these stations may be the result of Mn diffusing into the overlying water column.

All the elements analyzed for Gazi creek reveal subsurface maxima with eventual decrease towards the bottom of the core. This may be an indication that similar processes are controlling the distribution of those elements in this creeks.

FACTOR ANALYSIS

R-mode factor analysis was performed on the data of the elemental and P°C composition of the sediments in order to study the correlation among the elements analyzed and to elucidate the implications on their variabilities. Factor analysis is a statistical technique to study the correlation matrix by solving for eigen values and vectors which are linear combinations of the original variables (Boutron 1979). The computer program for factor analysis was adopted from SPSS (Statistical Package for Social Science) for the IBMC/XT 1984. Those factors which when summed accounted for more than 90% of the variation were taken to be significant enough to account for the total Variance.

In Tudor creek, core TC1 (Table 1) is characterized by high positive loading for Al and moderate loadings for Fe, Mn, Cu and P°C on factor 1 suggesting that apart from the aluminosilicates as represented by Al which may control the distribution of the trace metals e.g. Cu by adsorption, other phases like Fe-oxyhydroxide and N-oxide also play a role in their distribution. This is seen in factor 2 where Fe, Cu and Pb are significantly loaded suggesting that Cu is absorbed on the Mn-Fe-Oxyhydroxide mixed phase and aluminosilicates while Pb is exclusively adsorbed on the Fe-oxyhydroxide phase. It is in this core where there is excess of both Mn and Fe as shown by their enrichment factors in the next section. The enrichment of both Mn and Fe suggests Mn-Fe redox geochemistry to be taking place in this core (Thomson et al 1986; Sundby et al 1981). The significant loading of Fe on two factors of which one is aluminosilicate, is consistent with the existence of an `excess' Fe fraction. The excess fraction is likely to be an Fe-oxyhydroxide phase (Singh and Subramanian 1985). This latter phase is a potential site for organic matter scavenging (Tipping 1981).

Cd and Zn are both loaded on separate, factors indicating their distribution to be independent from aluminosilicate and Fe-Mn oxyhydroxide. This suggests that crustal continental drainage is not a significant contributor of Zn and Cd in these sediments. i.e. Zn and Cd do not appear on the same factor with Al which is generally used as a reference element of the crustal continental source (Boutron 1979).

Factors extracted for core TC2 (table 2) splits the elements into two groups: (1) aluminosilicate, Fe-oxyhydroxide and P°C group (Al, Fe, Cu, Pb and P°C) (2) Zn and Cd group. The first group reflects a smaller particle sediment fraction (aluminosilicates) which absorbs Cu and Pb. The association of P°C with aluminosilicates and Fe-oxyhydroxide in this group suggests adsorption of dissolved organic matter upon these phases which may act as an efficient site for scavenging trace metals. Zn and Pb appear on the aluminosilicate (Table 2) suggesting crustal source for them. However, Zn appears significantly on both factors 1 and 3 indicating that continental crustal drainage is not the only contributor of Zn in this core. The association of Zn and Cd as reflected in factor 3 (Table 2) suggests that they are controlled by similar processes to some extent in their distribution and therefore may be having a similar source. Forstner and Wittman (1979) observed that Zn and Cd are always associated with the same natural occurrence. In this case Pb is significantly loaded in a single factor independent of Al, suggesting insignificant contribution from crustal source for Pb.

Lack of significant association of Cu, Cd, Pb and Zn with aluminosilicates in this core suggests that the source of these elements are not only crustal material but also sources of anthropogenic nature of disgenic processes within the sediments.

Factor loadings for core K1 of Makupa creek show that the elements can be split into two distinct groups (1) a trace metal and (2) aluminosilicate and organic matter group. Factor 1 reflects high positive loading for the trace metals which may be an indication that trace metals in this case are derived from an independent non-crustal source since they are not associated with Al in any form (Boutron 1979). The high correlation among Zn, Cn, Cd, Pb and P°C is then indicative of complexation and/or adsorption by organic matter or may be an accidental relationship reflecting increased anthropogenic inputs (Kemp 1976).

The sediments of Makupa creek show the trace metals Zn, Cn, Cd and Pb are governed by processes different from those governing Al and Fe. This is a strong indication that the main source for these metals is not crustal. this is confirmed when inspecting enrichments relative to crust (next section). EFs are all greater than 1 and are the largest observed in this study. This clearly indicates that manmade activities are responsible for the trace metal inputs in Makupa creek.
Core G1 from Gazi creek is characterized by high positive loading for Al, Fe, Pb, and P°C indicating that Al and Fe phases control the distribution of Pb and P°C by adsorption. Factor 2 is a Zn factor with moderate loading for Fe indicating that excess Zn is adsorbed on Fe-oxyhydroxide phase. The trace metals Zn, Cn and Pb seem to be controlled each by different processes, an indication that they may be having independent sources.

Enrichment Factors

The main source for the elements analysed in these sediments can be crustal weathering and man's activities. To identify the sources associated with each element, the marker element Al was chosen to represent crustal material (Maenhaat *et al* 1970). From the elemental concentrations observed, enrichment factors (EF) with respect to Al crustal values were calculated as follows:

$$EF= \frac{(Me/Al)\ sediment}{(Me/Al)\ crust},$$

where (Me/Al) sediment is the ratio of the concentration of the element of interest to aluminum in the sediment and similarly for (Me/Al) crust. Data for world average crust were adopted from Bowen (1979). An element whose principal source is continental crust should have an EF of unity with some deviations possible due to inhomogeneity in crustal composition. Thus EF greater than 1 indicates enrichment and EF less than 1 indicates depletion relative to crust. Enrichment factors are presented in tables 1-4 (figures in bracket).

All the cores from the three creeks show moderate enrichments relative to crust. Mn is only enriched in the upper part of core (Table 1) of Tudor creek suggesting immobilization of excess Mn in the upper part. Bonatti *et al* (1971) showed that elements with higher redox potential (Eh) are more easily reduced. Thus Mn with Eh 0.5 V will be reduced before Fe with Eh-0.2V. This indicates that excess Mn^{4+} is being reduced to Mn^{2+} with subsequent dissolution into the pore solution resulting in upward migration where they are immobilized as Mn-oxides. Zn shows enrichments between 1 to 2.7. This supports the interpretation of factor analysis which suggested crustal origin and anthropogenic inputs. With these low enrichments, if anthropogenic input for Zn exists, then their source strength is not very important to date. Cu is relatively depleted to crust suggesting mobilization of excess Cu into the pore solution and the water column (Balistrieri and Murray 1986). Cd shows higher enrichments of nearly an order of magnitude in core TC2 while Pb shows moderate enrichments in the two cores with EF of 3 as the highest. Their enrichments show an increase from the inner creek to the outer creek. Factor analysis suggested no crustal source for these elements, therefore the increase towards the outer creek reflects direct input by man. The outer creek is situated at the main part of Mombasa town.

In Makupa creek, Fe and Cu are moderately enriched with EFs between 1 and 3. Zn Pb and Cd are strongly enriched with EFs of up to 8. The enrichments in this core reflects the concentration profiles for the trace metals suggesting increased anthropogenic loading of the surface sediments or some diagementic processes. Factor analysis indicated non-crustal source for these elements hence the high enrichments can only be attributed to anthropogenic loading of the creek. The higher enrichments for Zn, Cd and Pb for both Tudor and Makupa creeks, stresses the importance of man-made activities as a source of these elements. If digenetic changes were responsible for these enrichments, then their local excesses should be compensated for by a depletion elsewhere within the cores. However Cd, Pb and Zn show a near conofart distribution in the entire cores in terms of enrichments and distribution.

Gazi creek is quite remote from any industrial activities and there are no visible human activities which can influence the levels of trace metals in this creek. Trace metals in this core show no enrichment relative to crust except Pb which shows relatively high enrichment in the entire core (EF=4). Thus even at this relatively remote location, the impact of man made activities can be felt for Pb. The mechanism involved is likely to be atmospheric deposition (wet and dry) of Pb-enriched fine particulates produced from the combustion of leaded gasoline and the cement industry located northward near Mombasa.

In general, the sources of anthropogenic inputs for Cd, Pb and Zn in these creeks could be associated with burning of fossil fuel (automobile exhaust of leaded gasoline), domestic effluents and production of cement. Forstner and Wittmann (1979) estimated that 220 tons/yr and 33000 tons/yr of Cd and Pb, respectively, are being emitted into the atmosphere from fossil fuel burning and cement production. They further estimated that 50% of these are washed into the oceans. With industrial activities and automotive transport using a lot of fossil fuel, an oil refinery and a cement production unit just within the environs of these creeks, the higher enrichments observed expected and may even increase with time.

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Table 1. Total Al, Fe, POC (% by wt), Mn, Zn, Cu, Cd and Pb (ug/g) reported with their corresponding factor loadings and their enrichment factors for core K1.TC1

Sample	Section (cm)	Al	Fe	Mn	Zn	Cu	Cd	Pb	POC	% of variation	Cumulative %	Eigen value
1TC1	0-1.0	5.1	2.5(0.98)	956(1.63)	56(1.23)	22(0 72)	0 05(0 76)	18(2 08)	1 2			
2TC1	1.0-2.0	4.3	2.3(1.08)	882(1.75)	64(1.64)	18(0.89)	0 03(0.53)	18(2 44)	1.1			
3TC1	2 0-3 0	4.3	2.1(0.96)	698(1 39)	56(1 44)	16(0.62)	0 04(0 71)	17(2 31)	1 0			
4TC1	3.0-4.0	4.4	2.1(0.93)	699(1.37)	57(1.44)	16(0 61)	0.03(0.52)	16(2.14)	1 2			
5TC1	4.0-6.0	4.8	2 2(0.94)	710(1.33)	57(1.38)	15(0 54)	0 08(1.00)	16(2.05)	1 0			
6TC1	6.0-8.0	4.4	2.0(0.91)	708(1.39)	60(1.52)	15(0.57)	0 04(0.70)	17(2 28)	1.0			
7TC1	8.0-10.0	4.5	1.9(0.85)	759(1.45)	50(1.23)	16(0 59)	0 09(1.54)	16(2 09)	0 8			
8TC1	10.0-12.0	4.8	1.9(0.78)	721(1.28)	26(0.60)	13(0.45)	0 1(1 54)	15(1 82)	0 9			
9TC1	12.0-14.0	4.3	1.9(0.88)	535(1.08)	25(0.65)	12(0.47)	0 1(1 80)	17(2 34)	0.8			
10TC1	14.0-16.5	4.3	1.8(0.84)	393(0.78)	25(0.64)	13(0.50)	0.09(1.60)	16(2 18)	0.9			
11TC1	16.5-19.5	4.2	1.7(0.83)	237(0.49)	21(0.56)	11(0.44)	0.03(0 55)	15(2 00)	0 8			
Factor 1		0.986	0.527	0.642	0.131	0.588	0.131	0.058	0.529	65.9	65.9	5.272
Factor 2		0.057	0.632	0.421	0.343	0.582	-.0126	0 945	0.436	17.8	83.7	1.424
Factor 3		-0.147	0.346	0.016	0.457	0.353	-0 950	0.138	0.588	7.9	91.6	0.629

Table 2. Total Al, Fe, POC (% by wt), Zn, Cu, Cd and Pb (ug/g) reported with their corresponding factor loadings and enrichment factors for core TC2.

Sample	Section (cm)	Al	Fe	Zn	Cu	Cd	Pb	POC	% of variation	Cumulitive %	Eigen value
1TC2	0-1.5	5.5	3.2(1.18)	88(1.79)	24(0.73)	0.2(2.81)	19(2.04)	2 2			
2TC2	1.5-2.5	5.5	3.1(1.12)	79(1.61)	25(0.76)	0.1(1 41)	17(1.81)	2.1			
3TC2	2.5-4.0	5.5	2.9(1 05)	86(1 75)	25(0.76)	0.1(1.41)	19(2.04)	1.9			
4TC2	4.0-5.0	5 4	2.8(1.04)	69(1.42)	25(0.77)	0.1(1.42)	17(1.85)	2.2			
5TC2	5.0-6.0	4.5	2.2(0.95)	68(1.67)	21(0.77)	0.1(1.70)	15(2.21)	1 4			
6TC2	6.0-7.0	4.9	2.3(0.92)	72(1.62)	19(0.84)	0.1(1.56)	16(1.90)	1.5			
7TC2	7.0-8.5	4.8	2.1(0.94)	86(2.09)	25(0.91)	0.1(1.68)	16(2.06)	1 2			
8TC2	8.5-11.0	4.7	2.2(0.93)	65(1.55)	25(0.89)	0.1(1.65)	16(2.02)	1.7			
9TC2	11.0-13.5	4.9	2.4(0.96)	66(1.49)	25(0.85)	0.6(9.4)	16(1.92)	1.5			
10TC2	13.5-16.5	4.2	2.2(1.03)	81(2.14)	18(0.71)	0.2(3.65)	16(2.23)	1 4			
	FACTOR1	0.892	0935	0.147	0.945	-0.062	0.743	0.960	57.8	57.8	4.044
	FACTOR2	0.144	0.278	0.972	0.015	-0.118	0.588	-0.015	18.6	76.4	1.304
	FACTOR3	0.351	0.138	-0.014	0.313	0.064	0.178	0.164	12.0	88.4	0.845
	FACTOR4	-0.036	0.015	-0.139	0.078	0.989	0.007	-0.126	8.5	97.0	0.596

Table 3. Total Al, Fe, POC (% by wt), Zn, Cu, Cd and Pb (ug/g) reported with their corresponding factor loadings and enrichment factors for core K.

SAMPLE	SECTION(cm)	Al	Fe	Mn	Zn	Cu	Cd	Pb	POC	% of variation	
K1	0-2	6	3.9(1.2)	.128(.16)	311(5.6)	84(3.3)	.21(3)	43(4.1)	3.2		
K2	2-4	5.9	4.1(1.4)	112(.16)	332(6.7)	93(3 3)	.23(4)	43(4.1)	3 2		
K3	4-6	6.9	4.5(1.4)	116(")	372(5.6)	109(3.3)	.25(4)	47(4.1	2.7		
K4	6-8	6.2	4.3(1.4)	115(")	366(6.7)	123(3.3)	.28(5)	49(4.7)	2.8		
K5	8-10	6.3	4.3(1.4)	95(")	355(6.7)	107(3.3)	.26(5)	44(4.1)	2.7		
K6	10-12	6.3	4.2(1.4)	110 "	293(5.6)	85(1.7)	.23(4)	42(4.1)	2.4		
K7	12-14	6.4	4.0(1.2)	109 "	288(5.6)	65(1.7)	.23(4)	39(3.5)	2.1		
K8	14-16	6.7	4.2(1.2)	94 "	286(4.4)	74(1.7)	.22(3)	37(2.9)	2.1		
K9	16-18	5.6	3.5(1.2)	93(.10)	247(5.6)	52(1.5)	.18(3)	35(3.5)	2		
K10	18-19.5	6.1	4.9(1.6)	95(.16)	285(5.6)	50(1.3)	22(4)	36(3.5)	1.9		
K11	19.5-21	7.1	6.4(1.8)	118(.16)	331(5.6)	92(1.7)	.23(3)	38(2.9)	2		
	FACTOR 1	0.309	0.093	.025	0.842	0.836	0.951	0.766	0.344	58.2	58.2
	FACTOR 2	-0.086	-0.03	.821	0.421	0.425	0.007	0.506	0.83	19.8	78
	FACTOR 3	0.515	0.974	.161	0.212	0.065	0.145	-0.212	-0.272	9.9	87.9

Table 4. Total Al, Fe, POC (% by wt), Zn, Cu, Pb (ug/g) reported with their corresponding factor loadings and enrichment factors for core G.

SAMPLE	SECTION(cm)	Al	Fe	Mn	Zn	Cu	Pb	POC	% of variation	Cumulative %
G1	0-2	0.9	.3(.6)		5(.6)	5(.8)	5(3.0)	1		
G2	2-4	1	.4(.8)		10(1.1)	5(.8)	5(3.0)	1.3		
G3	4-6	1.4	.5(.8)		8(.7)	5(.7)	6(2.4)	1.8		
G4	6-8	1.4	.6(1)		5(.4)	7(.8)	6(2.4)	2.1		
G5	8-10	1.4	.6(.8)		5(.4)	7(.8)	5(2.4)	1.6		
G6	10-12	1.5	.4(.6)		5(.3)	10(1.2)	7(3.0)	1.9		
G7	12-14	1.3	.6(.8)		8(.7)	8(1.0)	3(2.4)	2.5		
G8	14-16	0.4	.4(.6)		8(2.2)	6(2.0)	4(4.1)	1.8		
G9	16-18	0.7	.2(.4)		5(.7)	5(1.2)	4(3.0)	0.6		
G10	18-20	0.8	.2(.4)		5(.7)	5(1.0)	5(3.0)	0.9		
G11	20-22	0.6	.3(.6)		--	2(.5)	2(4.0)	1.2		
G12	22-24	0.4	.04(.2)		3(.3)	--	2(2.4)	0.2		
G13	24-26	0.4	.04(.2)		--	--	2(2.4)	0.2		
G14	26-28	0.5	.06(.2)		5(1.1)	--	2(2.4)	0.3		
	FACTOR 1.	0.863	0.629	0.761	0.165	0.121	0.867	0.821	63.2	63.2
	FACTOR 2.	0.395	0.616	0.498	0.836	0.173	0.421	0.447	15.2	78.4
	FACTOR 3.	0.176	0.309	0.152	0.233	0.954	0.158	0.302	11.9	90.3

USE OF TILAPIA AS INDICATOR OF HEAVY METAL POLLUTION IN EASTERN AFRICA: A STUDY ON CADMIUM EXPOSURE

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ABSTRACT

In East African countries, increasing urbanization and industrialization has led to continuous discharge of industrial effluents and domestic sewage in lakes, rivers and coastal environment. Amongst the different types of heavy metal pollutants, cadmium is frequently present in natural water bodies as a result of discharges from industrial processes or other anthropogenic contamination. Exposure of the African freshwater tilapia (Oreochromis mossambicus) for 2, 4,14 and 35 days to 10 μg/l of water-borne cadmium was found to manifest physiological stress. Cadmium caused transient disturbances in osmo-ionic regulation, elevated plasma cortisol and glucose levels and alteration of gill structure, followed by complete recovery after 35 days. The results indicate that the adaptive response may have an endocrine basis and the recovery was possibly due to physiological adaptation. It is proposed that tilapia could be used as a bio-indicator for monitoring freshwater pollution in Eastern Africa.

INTRODUCTION

Fishes of the lakes and rivers of Tanzania have long been the focus of scientific investigation, but little is known about the effects of trace metal pollutants and other forms of environmental pollutants. The Fisheries' Division of Tanzania's Ministry of Lands, Natural Resources and Tourism shows a harvest of about 141,000 tons of fish from its large freshwater bodies, mainly the Lakes Victoria, Tanganyika and Nyasa and another 3,500 tons from minor freshwater bodies. Tilapia are estimated to provide about 40% of the harvest and have a high market value. It is thus clear that freshwater fisheries are of significant economic value to Tanzania.

During the last two decades, awareness on environmental problems has greatly increased in developing countries. Post-independence Tanzania has seen substantial progress in the agricultural and industrial sectors to meet the demand of consumer goods and food crops to feed the increasing population. However, in the process of development freshwater bodies have often been used as waste disposal sinks, with little attention being given to their negative impact on fish productivity and ecological conditions. As a consequence of development, environmental problems are certainly increasing. Freshwater pollution problems have emanated in recent years from rapid urbanization, extensive use of modern agricultural practices and industrialization. Todate, no extensive research has been conducted in Tanzania to give qualitative and quantitative assessments of the pollutants and nor is any monitoring programme in existence.

Among various heavy metal pollutants, cadmium is frequently present in natural freshwater bodies as a result of discharges from mining and industrial processes or anthropogenic contamination. The African freshwater tilapia (Oreochromis mossambicus) was exposed to low concentrations of water-borne cadmium (10 g/l) for 2, 4, 14 and 35 days. The Working Group on cadmium Toxicity (EIFAC 1977) have suggested that chronic exposure to low concentrations of cadmium is more relevant to the understanding of the mechanisms involved in the intoxication process in teleost fish. The investigation deals with the study on the effects of water-borne cadmium on osmo-ionic regulation, plasma cortisol and glucose levels as indicators of primary stress. Since tilapia fish live in intimate contact with the aquatic environment, the gills which are important respiratory, osmoregulatory, and excretory structures are most susceptible to cadmium. The ultrastructure of the gills was studied to evaluate the effects of water-borne cadmium.

OSMO-IONIC REGULATION

It is well established that freshwater fish take up most of the ions necessary for homeostasis from water via the gills (Maetz 1974, Eddy 1982). Cadmium induced plasma ionic disturbances in tilapia apparently caused by impaired uptake of ions via the gills. Short-term exposure of tilapia to 10 μg Cd/l induced significant hypocalcemia and hypermagnesemia (Table 1). After 2 and 4 days of cadmium exposure, plasma calcium decrease to 1.65 mmol/l (32% $p<0.001$) and 1.93 mmol/l (19%, $p<0.001$) whereas increased plasma magnesium levels of 0.81 mmol/l (19%, $p<0.5$) was evident only after 2 days. For plasma sodium and potassium no significant changes were observed during the experiment. Osmo-ionic impairment has been reported in various studies involving exposure of fish to sublethal concentrations of heavy metals. Larsson (1975) showed that short-term cadmium exposure caused a decrease of plasma calcium and potassium levels, whereas plasma magnesium and phosphate were significantly elevated. Also reduced plasma calcium and elevated plasma magnesium has been observed in European flounders exposed to water containing 5-500 µg Cd/l for 4-9 weeks (Larsson et al 1981), and rainbow trout exposed to 6.4 µg Cd/l for 178 days (Giles 1984). Similarly in brook trout exposure to cadmium significantly increased plasma chloride levels but had no effect on plasma sodium (Christensen et al 1977) whereas reduced plasma sodium has been reported for cadmium exposed rainbow trout (Giles 1984) and goldfish (McCarty and Houston 1976). Similar changes in the plasma ionic composition have been observed in fishes exposed to zinc and copper (Lewis and Lewis 1971), mercury (Lock et al 1981) and Chromium (Van der Putte et al 1983).

ENDOCRINE REGULATION OF IONIC HOMEOSTASIS

Fish do not possess parathyroid glands as a source of hypercalcemic hormones, instead the pituitary hormone prolactin is considered as an important osmoregulatory hormone of freshwater fish as it is known to decrease water and ion permeabilities of gill, kidney and gut epithelia (Bern, 1983).

The hypercalcemic action of prolactin has been demonstrated in tilapia *O. mossambicus* (Wendelaar Bonga et al 1984). Cortisol in fish is the main end product of corticosteroidogenesis which takes place in interrenal cells, located in the posterior part of the head-kidney (van Overbeeke 1960). Cortisol has mineralocorticoid as well as glucocorticoid properties (Donaldson 1981). Elevated plasma cortisol levels of fish in polluted waters are considered a primary stress response. Exposure of tilapia to 10 µg Cd/l for 2, 4 and 14 days elicited a significant elevation of plasma cortisol levels (Fig. 1). The cortisol response is biphasic, an initial rise is followed by a gradual decline to control levels after 14 days. In a study on trout, James and Wigham (1986) reported minor and time dependent changes in plasma cortisol levels in response to water-borne cadmium. Exposure to 0.05 mg Cd/l for 24 hr significantly increased plasma cortisol titres followed by a decrease after 72 hours. Schreck and Lorz (1978) were unable to find a clear effect on plasma cortisol of Coho Salmon exposed to 4 to 12 mg Cd/l. Since sampling in their study began 67 days after exposure of fish to sub-lethal cadmium concentrations, compensation and subsequent return of plasma cortisol to control levels may have occurred at the time of sampling. Moreover, the high cortisol levels (>60 μg %) as found in their control fish, which are at present time considered to be too high for non-stressed salmonids (1-10 μg %; Sumpter et al 1986) may also have contributed to the lack of a significant response of cortisol to cadmium. Similar studies on other heavy metals include the exposure of rainbow trout to chromium (Hill and From 1968) and Sockeye Salmon to copper (Donaldson and Dye 1975).

Furthermore, cortisol as a primary stress hormone also has pronounced effects on carbohydrate metabolism of freshwater fish (Mazeaud et al 1977). Cortisol promotes catabolism of peripheral tissues which via increased gluconeogenesis leads to hyperglycemia in fish (Chan and Woo 1978). In tilapia 10 μg Cd/l caused a transitory hyperglycemia on days 2 ($p<0.001$) and 4 ($p<0.01$) followed by a recovery after 14 days (Fig. 2).

This study indicates the usefulness of measuring plasma cortisol concentrations to evaluate a rapid response of fish to a stressful situation. Since prolonged exposure of tilapia to low cadmium concentration could result in a return of cortisol to the control levels due to compensatory responses, the practicality of using cortisol levels as a general index of environmental stress on fish health is important for assessment of water pollution.

GILL ULTRASTRUCTURE

Fish gills are important osmoregulatory, respiratory and excretory structures and have often been reported as the primary site of toxic action of water-borne heavy metals and other chemical pollutants (Mallat 1985). The effect of low cadmium concentration (10 μg/l) on gill structure was remarkable. Structural alterations such as epithelial uplifting, occurrence of non-tissue spaces, dilated tubular system and swollen mitochondria of the chloride cells, apoptosis and necrosis were apparent after 4 and 14 days (Table 2). Gill damage caused by water-borne cadmium have been reported in rainbow trout (Bilinski and Jones 1973), mummichogs (Voyer et al 1975) and morphological changes in zebrafish and rainbow trout (Karlsson et al 1985). Similarly alterations of the gills have been observed in fish exposed to other heavy metals such as mercury (Naidu et al 1983), copper (Gupta and Rajbanshi 1981), zinc (Crespo et al 1981, Khangarot 1982), chromium (van der Putte et al 1981) and tributyltin (Pinkey et al 1989). Although no deaths were recorded during the experiment,

increased non-tissue spaces and uplifting of epithelial cells indicate that the relative diffusing capacity of gases diminishes with increasing distance for diffusion.
The swollen mitochondrial cristae and dilated extensive tubular system suggest that oxidative phosphorylation and ionic pumps are impaired, which could cause cell death (apoptosis). Also necrosic (cell death due to toxicity) of the chloride cells and pavement cells was evident after 14 days, but not apparent after 35 days. The results show that cadmium, like other heavy metals, caused structural damage of the gills of tilapia at low concentrations similar to that observed in natural freshwater bodies.

CONCLUSION

Studies on the effects of heavy metals undertaken to-date have been essentially concerned with acute toxicity and bioaccumulation, but information on prolonged exposure to sublethal levels of heavy metals on the physiological adaptation and reproduction is scarce. The results of this study provide information on the physiological status of tilapia effected by low cadmium concentration. The recovery observed after 35 days of exposure to 10 μg Cd/l does not mean that this concentration is harmless to tilapia. On the contrary, such a low concentration appears to put an extra burden on the fish. Only through extra physiological and biochemical counter measures can these fish be able to survive. It is evident that the extra energy required for implementing these measures will be at the expense of energy required for other essential processes such as growth and reproduction, thereby reducing their chances for survival. Hence, parameters such as osmo-ionic regulation, plasma cortisol, gill structure and other similar physiological methods on tilapia (indicator species) could be successfully used to evaluate fresh water pollution in Eastern Africa.

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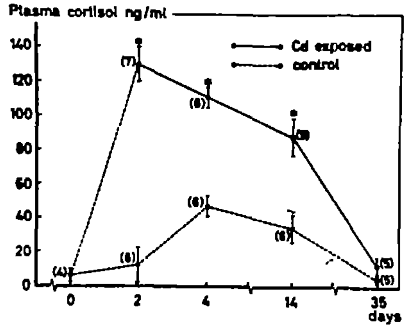

Fig 1 Effect of water-borne cadmium (10 $\mu g/l$) on plasma cortisol of Oreochromis mossambicus

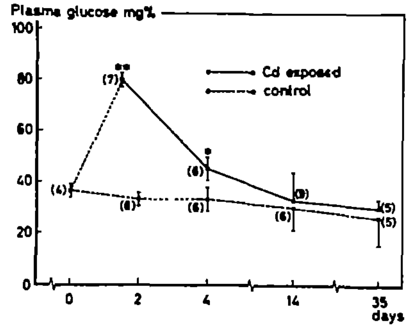

Fig 2. Effect of water-borne cadmium (10 $\mu g/l$) on plasma glucose of Oreochromis mossambicus

Table 1: Effect of 10 μg Cd/l on Plasma ions (mmol/l) of Tilapia (Oreochromis mossambicus)

N	DAYS	Ca^{++}	Mg^{++}	Na^{+}	K^{+}
10	0	2.42±0.11	0.61±0.10	141.8±12.3	6.96±1.09
10	2	1.65±0.09***	0.81±0.09*	139.0±12.8	5.77±0.96
10	4	1.93±0.14***	0.67±0.12	129.4± 8.7	6.54±1.04
10	14	2.48±0.15	0.58±0.04	137.8± 7.0	8.23±1.29
5	35	2.55±0.41	0.58±0.18	138.2±13.9	7.92±1.31

ANOVA *** $p<0.001$ * $p<0.05$

Table 2: The ultrastructural alterations in the gills of tilapia (Oreochromis mossambicus) exposed to 10 μg Cd/l.(+, ++,+++, indicates the magnitude of gill damage)

LESION	DAYS 4	14	35
1. Epithelial lifting	+++	++	+
2. Hypertrophy	+++	+++	+
3. Hyperplasia	++	+++	+
4. Chloride cell damage	+	++	-
5. Mucous Secretion	++	+	-
6. Chloride cell proliferation	+++	++	+
7. Apoptosis	+	++	+
8. Necrosis	-	+++	+

MAJOR IONS GEOCHEMISTRY OF THE ATHI RIVER BASIN IN KENYA

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ABSTRACT

The Athi Basin is underlain by three major rock types, volcanic, metamorphic and sedimentary. Each of these rock types contributes considerable influence on the groundwater quality and quantity in the basin.

The Tertiary volcanics, mainly phonolites and trachytes when fresh, have poor porosity and permeability but where they are fractured due to faulting and jointing, they form good aquifers. The quality of their waters fall within the primary alkalinity field of Palmer's classification as the major cations (Na^{+1} + K^{+1}) and the major anions (CO_3^{-2} + HCO_3^{-1}) . The fluoride content in these waters is high (1.5 ppm) and must be used with a lot of caution for domestic purposes.

The metamorphic rocks which are mainly gneisses have their aquifers associated with fractured zones (faults and joints) as well as with weathered overburden areas. The quantity of water in the metamorphic terrain is limited, but their quality is good and plots in the \`secondary salinity' and \`secondary alkalinity' fields of Palmer's classification.

The sedimentary terrain which consists of Mesozoic sediments and Quaternary sediments have high yielding aquifers and their waters plot in the \`primary salinity' and \`secondary salinity' fields respectively.

INTRODUCTION

The Athi Basin is one of the five major drainage basins of Kenya (See fig. 1). Its headwaters originate from the highlands to the North of Nairobi and from the Ngong Hills thereby forming the Upper Athi River Basin. The major tributaries which are associated with the drainage system of this area include the seasonal Mbagathi, Kitengela and Stony Athi and the perennial Nairobi, Ngong, Ruiru and Ndarugu streams.

The total rivers's discharge at station 3DA2 fluctuates from a minimum of $6m^3$/sec to a maximum of $64m^3$/sec and tends to fluctuate with rainfall. There is a marked lag of one month between rainfall and maximum discharge. Groundwater contribution to the surface run off is at its maximum just before the river leaves the tertiary volcanics after the gauging station where a gain of $1.14m^3$ is noted. Thereafter the river is influent and continues to lose its water to groundwater until it enters the Indian Ocean at Mambrui. There appears to be a significant interaction between surface and groundwater at this area of the river. This interaction facilitates recharge into the groundwater storage on the one hand and accounts for the contribution of saline conditions by the groundwater to the surface water. This interaction is the subject of this paper and the characteristics and composition of the waters in this area will be discussed.

GEOLOGICAL SETTING

The Upper Athi River Basin is covered by Tertiary lavas (see Fig. 2). These are composed of phonolites, trachytes, basalts, and welded tuffs and range in age from late Miocene to early Pleistocene. The oldest rocks in the area are Kapiti phonolites which flowed from the Rift region, followed by a period of sedimentation in which tuffs and sediments were laid down. These were followed by outpouring of lava, which included Mbagathi phonolitic trachyte, Nairobi phonolite, and Nairobi trachyte. The Ngong hills volcanic activity took place at about the same time in which basalts were erupted. The last volcanic activity was accompanied by avalanches of tuffs which are intercalated by trachytic flows. The succession of lavas is summarized in Table 1.

The nature of the volcanics in this area is such that the tuffs and trachytes weather to give permeable surfaces which aid in the infiltration and percolation of water into the aquifers. Faulting is also a phenomenon which is associated with depressions and may alter the direction of flow of both groundwater and surface water. Sandwiched sediments between lava flows do serve as conduits through which groundwater may flow great distances.

Table 1: Succession in the Nairobi area (After Saggerson, 1967)

Recent	Soils and murram deposits
Pleistocene	Limuru, Tigoni, Karura trachyte Kiambu trachyte Kabete trachyte
Pliocene	Kerichwa valley tuff Nairobi trachyte Ngong basalts Nairobi phonolite Mbagathi phonolitic trachyte Athi tuffs and sediments
Miocene	Kapiti phonolite Marked unconformity
Precambrian	Mozambiquan metamorphic rocks

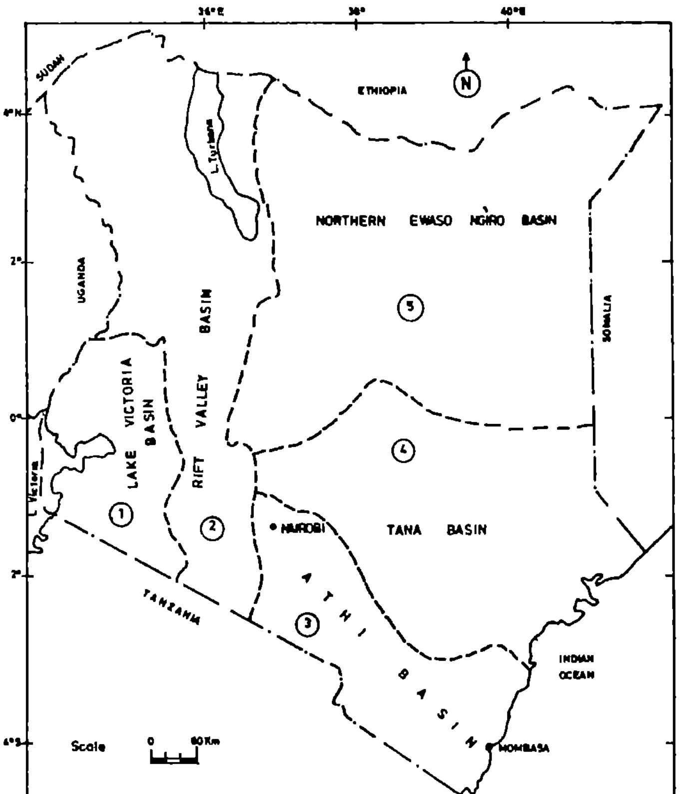

Fig 1 HYDROLOGICAL BASINS OF KENYA

Legend

- ——— BASIN WATERSHEDS
- —·—·— INTERNATIONAL BOUNDARY
- ● TOWN

(After Mailu, 1986)

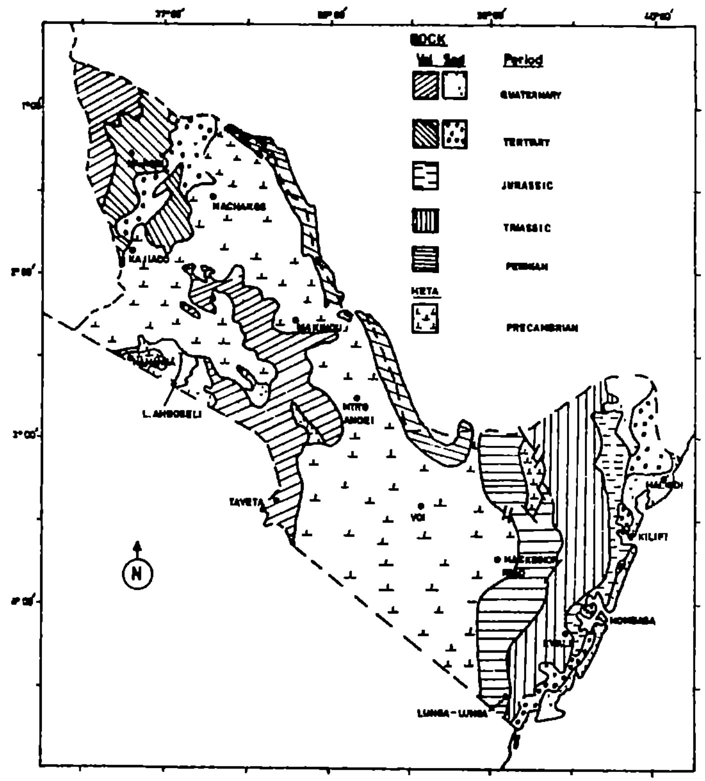

Fig 2 THE GEOLOGY OF THE ATHI BASIN

SCALE.

LEGEND

- ------ Boundary of the Basin
- ——— Geological Boundary
- ● Town

Vol.- Volcanic, Sed - Sedimentary, Meta - Metamorphic

(After Mailu, 1986)

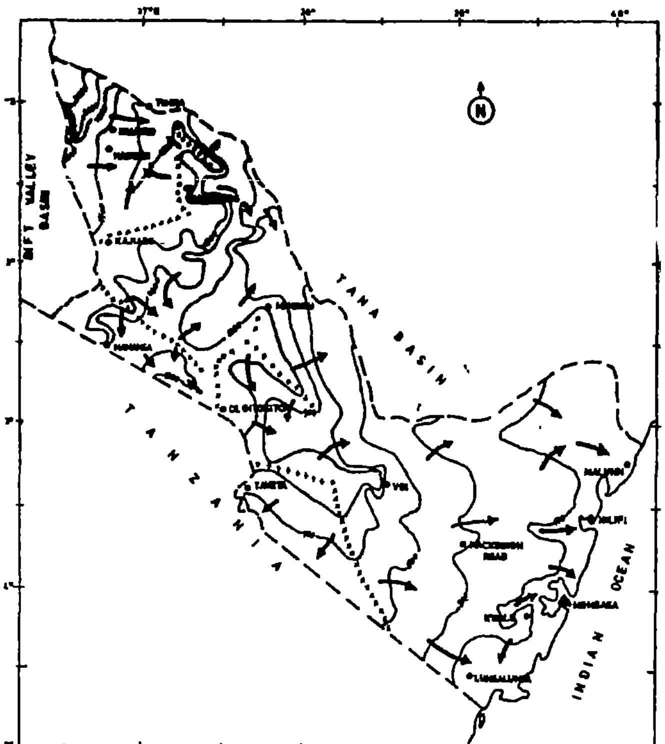

Fig. 3 THE GROUNDWATER FLOW IN THE ATHI BASIN

Scale

Legend

CONTOUR OF EQUAL PIEZOMETRIC SURFACE CONTOUR INTERVAL 300 m.

GROUNDWATER FLOW DIRECTION

GROUNDWATER DIVIDE

BOUNDARY OF THE ATHI BASIN

TOWN

(After Mailu, 1986).

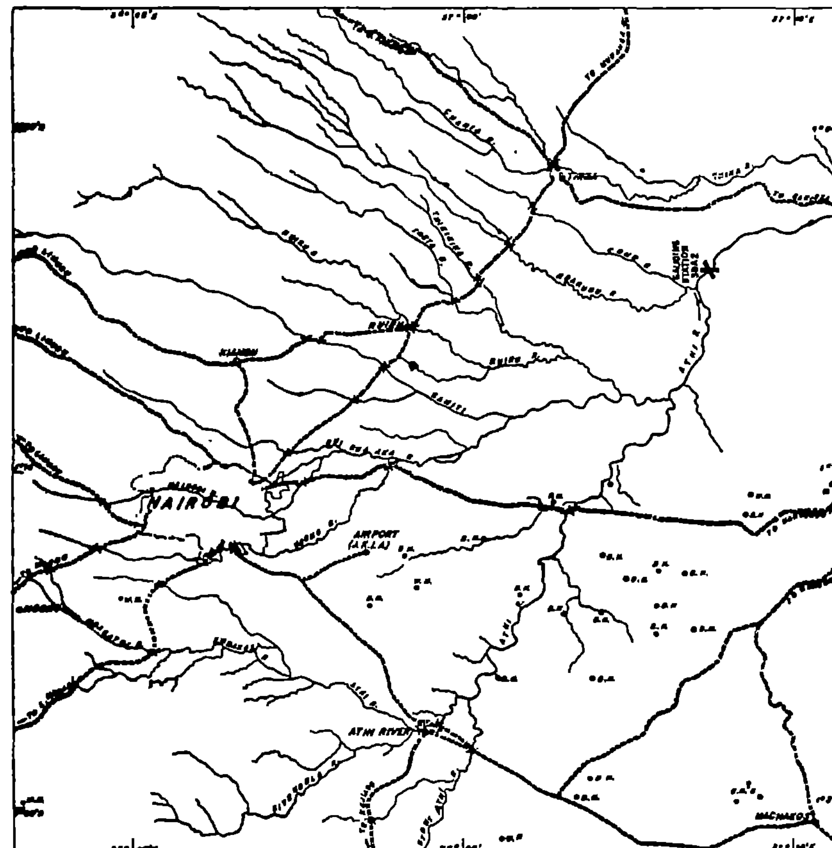

FIG.4—THE UPPER ATHI RIVER BASIN

Surface Water flow

The perennial streams and their tributaries originate from the eastern flanks of the Rift Valley and flow eastwards following the gentle tilt of the land (Geaverts, 1957, 1964). The major streams are the Ngong, Nairobi, Ruiru and Ndarugu (see Fig. 4). These streams form a parallel drainage pattern and exhibit youthful characteristics through their courses. Their discharge at various gauging stations indicates that there is a general loss of water downstream. This loss is mainly attributed to obstraction as well as to evaporation. Most of these streams flow through farmland where their waters are used for irrigation purposes, especially in the coffee estates. Evaporation plays only a minor role in stream water losses.

It is worthwhile noting that significant stream losses coincide with relatively high borehole yields which is a good indication of the influent nature of the streams. The seasonal streams of Mbagathi, Kitengela and the Stony Athi have actual surface run-off only during the rainy (wet) season (April-June). They often dry off during the dry season. Their contribution to the river discharge is for about one month in each of the rainfall peaks when seasonal rainfall exceeds potential evaporation.

Groundwater Flow

The groundwater flow in the Upper Athi area is mainly controlled by the structures of the rocks. The Tertiary volcanic rocks overlie an old weathered surface while they are overlain by another weathered surface. This, the contact of the ancient sub surface, forms an aquifer and the contact between impervious lavas and the overlying trachytes and tuffs forms another aquifer.

The control of the groundwater by Precambrian terrain is noted at one of the gauging stations where the stream discharge suddenly increases to values above values obtained from recording stations upstream. Thus increase cannot be accounted for by any surface flow (Maina, 1982, Mailu, 1986). It is accounted for by the effluent nature of the groundwater when the flow comes against the impermeable Precambrian intrusion. The demarcation of the aquifers and their geological controls is also evident from resistivity surveys which have been carried out to the south-west of the area (Mathenge, 1989). The structures facilitate recharge into groundwater and especially fissured zones along faults as well as joints. the general direction of flow is towards the ancient sedimentation basin and then towards the south-east (See Fig. 3). There is a good coincidence between groundwater flow and surface water flow (See Fig. 4).

HYDROGEOCHEMISTRY

The major constituents of the groundwater around Nairobi are such that the alkalies (Na and K) exceed the alkaline earths (Ca and Mg). They also plot in the weak acids field, implying that there is a significant effect by salinity. In the diamond shaped field these waters plot in the lower area which is a neutral field. This is a field where no anion and cations pairs exceed 50%. The surface waters on the other hand indicate that they are slightly acidic due to the presence of significant amounts of sulphate. This is especially so in the Stony Athi and the Nairobi River waters. The dominant cations remain to be the alkalies (Na+K). For the perennial streams, it has been noted that Na and Mg remain constant both in the recharge areas and in discharge areas (Maina and Gaciri 1984). The characteristics of the groundwater implies that they are mostly carbonate-bicarbonate waters. In the drier parts to the south-west however, the waters tend to tap sulphates and chlorides from the ancient sedimentary basins in which evaporites were deposited. Mixtures of both groundwater and surface water are noted but with a dilution factor in the Athi River at the gauging station 3DA2 (Fig. 5).

Other significant constituents which interfere with the chemical equilibrium between the cations and anions are fluoride and iron. These are in high concentrations in the groundwater and in the intermittent streams (Table 2). The perennial surface streams show a low content of these constituents.

TRACE ELEMENT CONTAMINATION

Analyses of stream waters from the tributaries of the Upper Athi Basin indicate that each stream has its own predominant trace elements depending on the activities which are prevalent along its course.

Industrial pollutants are particularly enriched in the Embakasi, Nairobi and Ngong streams where the concentration of metals are beyond recommended safe levels for Cd (0.015 ppm), Pb (0.26 ppm) and Cr (0.09 ppm). Agricultural contamination is noted in the Ndarugu, Ruiru, Ruaraka and Kamiti streams which are particularly enriched in Cu, Zn, Pb and PO_4^{3-}. All these are most likely flushed from the coffee estates where large amounts of fertilizers and pesticides are utilized. Domestic contamination is noted in the Kitengela, Nairobi, Ngong and Ruaraka. This is indicated by the high Total Dissolved Solids (TDS) observed in these streams at a mean of 300 ppm and a mean BOD of 50 ppm. The sources of the contaminants are detergents, animal and human waste in the slum areas and municipal sewage.

Table 2: Composition of the surface water of the Upper Athi Basin in ppm

Stream	K	Na	Ca	Mg	Fe	SO_4^{2-}	HCO_3^-	Cl	F
Ruiru	10.3	88.5	58.5	15.5	6.0	8.2	394.0	11.3	1.5
Nairobi	13.0	45.0	20.4	4.0	2.1	29.0	62.1	42.0	0.7
Mbagath	20.0	150	16.4	5.0	-	34	300.0	85.0	8.5
Stony Athi	2.0	460	3.0	1.0	-	326	300.0	360.0	18.0
Mean of all the streams	11.1	165.4	31.3	8.2	-	81.1	272.0	101.9	7.6
Mean of ground water	8.9	48.5	10.5	1.8	4.3	4.0	32.3	17.5	1.7

Although the monitoring of the streams, both for quantity and quality, has been the concern of the Ministry of Water since 1983; not much has been done by the City Inspectorate to control the discharge of effluents from industries and hence these deleterious levels of contaminants.

Finally, it is worthwhile to note that at a distance of about 60 km from the gauging station of the Upper Athi, virtually all the contaminants are naturally cleaned by the system (by the time the river reaches Wamunyu). Samples at Wamunyu indicate a clean natural water system wholly at equilibrium with the containing rocks and free from all the deleterious effects noted in the Upper course.

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THE USE OF CAST-IRON COOKWARE AS A SOURCE OF IRON IN THE DIET OF RURAL BOTSWANA

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ABSTRACT

This preliminary study showed that foods cooked in cast-iron cooking pots gained significantly in iron content. Atomic absorption spectrometry was used to determine the iron content before cooking, after cooking in glassware, and after cooking in cast-iron pots. Foods cooked in cast-iron pots gained in iron content from between 79.9% for morogo to 518% for rice, whilst those foods cooked in glassware decreased in iron content from between 4.6% for beef brisket to 35.9% for morogo. It is concluded that the use of cast-iron pots would significantly increase the iron content of diets in Botswana. This should lead to a decrease in clinical problems caused by iron deficiency.

INTRODUCTION

Anemia, resulting from iron deficiency, is quite common amongst girls and women in most parts of the world (1). The recommended dietary allowance for girls and women in the USA is 18 mg of iron per day, but numerous surveys in America have shown that the average intake is only about 10 mg per day, which is considerably less than the recommended allowance (2). Previous studies have indicated that iron consumption may be increased by the use of cast-iron cookware (3). However, a report published in 1953 in the Transactions of the Royal Society of Tropical Medicine and Hygiene showed that iron intakes reaching toxic level were common in parts of Southern Africa where cast-iron pots are used in brewing beer (4). In the USA, surveys conducted by the Interdepartmental committee on Nutrition for National Defence detailed other examples of iron uptake from cookware, and these have been summarized by other workers (5, 6). Cast-iron cooking pots have traditionally been used for many years amongst rural Botswana. Recently, however, aluminium pans of low quality have increasingly come into common usage. This is an unfortunate trend as recent investigations have shown that the uptake of very small quantities of aluminium by the body can be detrimental to health, especially amongst young children. Measurements taken at the Princess Marina Hospital in Gaborone have shown that iron serum levels as low as 10 ppm are not uncommon amongst females (7). This study was undertaken to test the suggestion that a return to cast-iron pots should help to solve the apparent wide-spread of iron deficiency.

MATERIALS AND METHODS

Six different foods in common usage were tested, these being pumpkin, potato, rice, beef brisket, sorghum and morogo. A Varian 1275 Atomic Absorption Spectrometer was used to measure the amount of iron in these food samples. The iron content was measured in the food prior to cooking, after cooking in glassware, and after cooking in cast-iron. Experimentally, both cooked and uncooked foods were dried in an oven at 105°C for four hours and then about 2 g of each sample was accurately weighed. The samples were treated with a mixture of sulphuric, nitric, and perchloric acids to digest the iron and then diluted with distilled water. Hydrated ferric chloride was used to prepare standard curves.

RESULTS AND DISCUSSION

Table 1 shows the iron content of the foods in mg/kg of dry weight before cooking, after cooking in glass, and after cooking in cast-iron. Table 2 summarizes the % iron uptake or loss after cooking. As the results show, all the six foods tested lost iron when cooked in glassware, and this decrease varied from 4.6% for beef brisket to 35.9% for morogo. The second column of figures is much more interesting, and it shows that all six foods tested gained significantly in iron content after cooking in cast-iron pots. The lowest percentage gain was 79.9% for morogo, whilst the highest was a startling 518% for rice. Therefore, from these results, it is obvious that the use of cast-iron cooking pots would significantly increase the amount of iron in foods.

The question now arises - how much of this iron absorbed by foods cooked in cast-iron cooking pots is biologically available? It has been stated that iron absorbed by foods is biologically available, but this is a complex matter (8). Some studies have suggested that less than half the total iron content of most foods is released into solution, so that estimates of dietary iron are often misleading (9).

Table 1: Iron Content of Food (mg/kg dry weight)

FOOD	UNCOOKED	COOKED IN GLASSWARE	COOKED IN CAST-IRON
Pumpkin	77.5	67	248
Potato	114	77.5	310
Rice	31	20.5	192
Beef Brisket	109	104	217
Sorghum	155	140	362
Morogo	259	166	466

Table 2: Percentage iron uptake or loss after cooking

FOOD	COOKED IN GLASSWARE	COOKED IN CAST-IRON
Pumpkin	-13.5	+220
Potato	-32.0	+172
Rice	-33.9	+518
Beef Brisket	- 4.59	+ 99.1
Sorghum	- 9.68	+134
Morogo	-35.9	+ 79.9

In conclusion, it is obvious that the use of cast-iron cookware is desirable, but to promote their usage presents some difficulties. Aluminium pots are much cheaper, and also much easier to use because of their relative lightness. A community health programme to inform people of the benefits to their health gained by using cast-iron pots would be useful, especially if government could be persuaded to subsidize their manufacture.

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POSTER

HEAVY METAL LOAD IN ESTUARINE SEDIMENTS CONTAMINATED BY ACIDIC MINE DRAINAGE

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INTRODUCTION

Outcrops of mineralised zones, mining sites and spoil heaps of disused mines are among the major sources of heavy metals to the aquatic environment. Even though pyrite is regarded as a nuisance in the mining industry, it can, however, cause far reaching environmental hazards.

The exposure of pyrite (which is common in most ancient magmatic rocks and more recent sedimentary deposits) and other sulphur bearing minerals to atmospheric oxygen and moisture, results into the formation of very strong sulphur acids (Stumm & Morgan, 1981). Apart from exarcebating the effects of ordinary weathering, these acids can as well be responsible for: reduction of soil fertility by excessive leaching of essential nutrients (Tamm, 1976), discouraging the growth of aquatic macro-organisms (Carpenter, 1924; Abdullah & Royle, 1972) and enhancement of high rates of microbiological alkylation of some elements (e.g. Fagerstrom & Jernelov, 1972). Following a pH rise to approximately 4, iron (III) precipitates from solution and flocs of hydrous oxides of iron can be transported in the water column or deposited at the bed of the river along with the associated heavy metals (Forstner & Wittmann, 1983).

The present report is based on the observation that during the mixing of riverwater and seawater end embers, inorganic pollutants are removed from the solution, and due to the circulation pattern of some estuaries, some solid pollutants can be permanently buried in the estuarine bed sediments. This study was intended to investigate the potential of sediments of a shallow estuary in preserving the historical record of pollution which was caused by mining activities during the 19th century. Currently, the estuary is receiving effluents from spoil heaps, tailings and pit overflows of a disused mine.

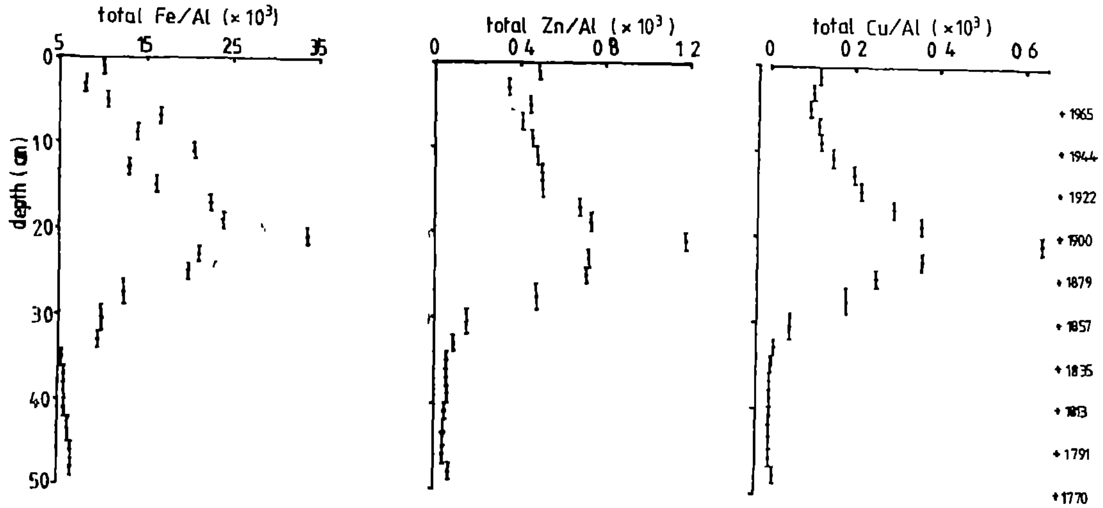

Figure 1: The vertical variation of total metal/aluminium ratios in the estuarine sediments caused by mining activities in the watershed (estimated period of intensive mining was between 1768 and 1883).

0 to 10 cm horizon represents post-mining period
10 to 29 cm horizon represents mining period
29 to 50 cm horizon represents pre-mining period

The sediment geochronology was obtained by ^{210}Pb dating technique. The depositional history of the top 30 cm of the sediment column was almost particle by particle, and a uniform sedimentation rate of 0.23 cm/yr was assumed for the whole core length.

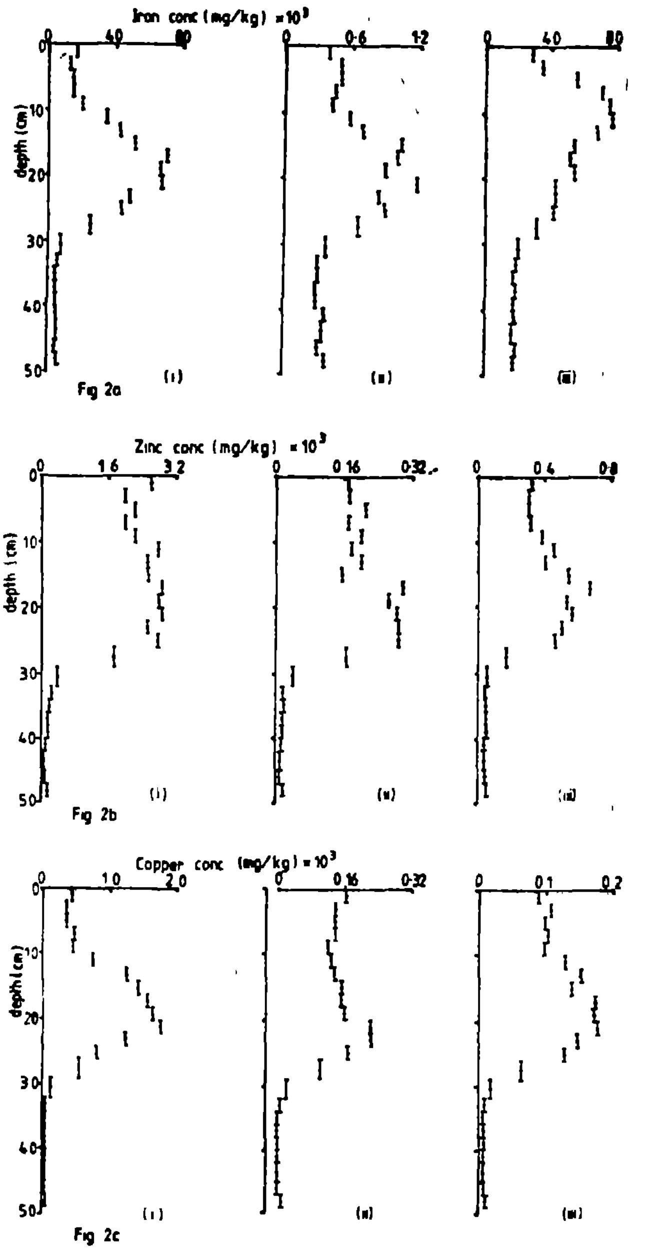

Figure 2: Concentration-depth profiles of heavy metals in the sediment phases sequentially extracted with:

(i) hydroxylammonium chloride-acetic acid
(ii) hydrogen peroxide-nitric acid
(iii) hydrofluoric-nitric acids (all concentrations are quoted on dry weight basis).

The colour of the sediment column ranged from brownish to red for the upper 29 cm indicating oxidizing conditions. Highest metal concentrations were leached with the reducing reagent, emphasizing the role of hydrous iron oxides in the scavenging of heavy metals from the water column.

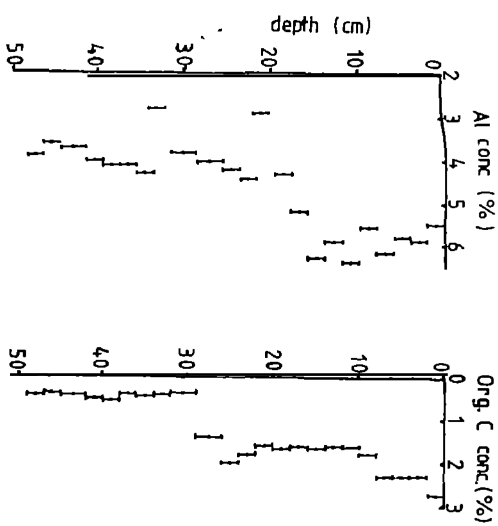

Figure 3: Vertical distribution of organic carbon and Aluminium in the sediment core

The chromic acid oxidisable organic carbon is low in the sediment, and the profile suggests a low rate of organic matter remineralisation. The aluminium data and XRF trace showed a change of lithology below the 20 cm depth interval, suggesting the presence of two distinct sediment types, i.e. the recent polluted and the old clean sediment.

CONCLUSION

This study has shown that some shallow estuaries can act as efficient traps and permanent sinks for particulate material from the water column. The results suggest that relatively low level concentrations of both dissolved and particulate matter are imported by the sea

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SEAWEEDS AS HEAVY METAL POLLUTION INDICATORS

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ABSTRACT

The heavy metal contents of seventeen species of marine and fresh water algae along the coast of Dar es Salaam were determined. Compared to heavy metal present in similar algae along coastal Japan, several algal species around Dar es salaam have been found to be excellent heavy metal accumulators and thus potential heavy metal pollution indicators.

INTRODUCTION

There has been a great interest in recent years in studying the high concentrations of various trace metals found in marine and fresh water plants[1-4]. Marine algae have been known to selectively concentrate various dissolved metals from the aquatic environment and this has been used to indicate the level of pollution of marine environments[5,6]. The potential advantages of using algae as indicators of heavy metal pollution in aquatic systems include the following :

i) the high levels of accumulation found in most marine species increases the sensitivity of detection,
ii) plants can integrate the heavy metal pollution of a system over time,
iii) it is practical to assume that metal accumulation by a plant gives a clear indication of the fraction of the metal in the environment which is likely to affect the aquatic ecosystem,
iv) dried plant materials are easier to keep compared to water samples due to compactness and stability,
v) a biological pollution indicator organism is available at all times of the year, relatively stationary and widely distributed.

In Japan, the contents of various pollutant metals found in several species of seaweeds has been used to show the level of pollution of the marine environment along the Japanese coastline[7]. We at the chemistry department are also studying concentrations of various metal pollutants in many species of marine algae found along the Dar es Salaam coast as an indication of the level of pollution of Dar es Salaam coast as well as to identify species that are potential heavy metal pollution indicators. So far cadmium, zinc, copper, chromium, manganese, iron, cobalt, nickel and lead contents of several marine algae of Dar es Salaam have been determined.

MATERIALS AND METHODS

The seaweeds were collected at Mbudya Island off the Dar es Salaam coast and along Oyster bay near Police Officers Mess on the coast. The different species of seaweed studied are listed in Table 1. Samples of seaweed after collection were washed thoroughly with distilled water and dried in an oven at 105°C for four hours. 2.0 g of the dried sample were wet digested in tubes using initially 5 ml of concentrated nitric acid and then 5 ml concentrated sulphuric acid. When the digestion reaction had subsided the tubes were placed in a hot-block digestion apparatus and were heated at 60°C for 30 minutes. The samples were allowed to cool, 10 ml of conc. nitric acid was added and reheated slowly to 120°C. When the samples had turned black they were allowed to cool and hydrogen peroxide was added in 1 ml portions until the sample solutions became clear. The tubes were removed and the contents made up to 50 ml with distilled water. This solution was analysed for various metals of interest. Analysis were carried out using a Perkin Elmer model 2380 atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

The concentration of the heavy metals zinc and copper found in the marine algae Ulva pertusa and Chaetomorpha crassa (species also studied along the Tomo Island coast, Japan) show the much lower level of pollution of the Dar es Salaam marine environment as compared to that of Japan (Table 2). But we note that there is accumulation of these elements and thus pollution of the environment is taking place.

Concentrations of zinc, copper, lead, chromium, manganese, iron, nickel, cobalt and cadmium found in various species of marine algae along the Dar es Salaam coast are listed in tables 3, 4 and 5. The results show that many of these algae species are potential heavy metal pollution indicators as they concentrate metals to similar levels as the algae species mentioned above. This work is continuing and several more heavy metals will be studied in the above species and in some fresh water algae to be collected from different areas of Dar es Salaam.

Table 1: List of the marine algae studied

No.	DIVISION	ALGAL SPECIES	CODE
	Chlorophyta	*Ulva pulchra*	1
		Ulva pertusa	2
		Halimeda discoidea	3
		Codium dwarkense	4
		Cladophora fascicularis	5
		Enteromorpha ramulosa	6
		Caulerpa occidentalis	7
		Shaetomorpha crassa	8
	Phaeophyta	*Sargassum duplicatum*	9
		S. polycystum	10
		S. torvum	11
		Padina tetrastromatica	12
		Turbinaria ornata	13
		Hormophyta triquetra	14
	Rhodophyta	*Hypnea nidifica*	15
		Galaxaura elongata	16
		Chondria armata	17

Table 2: Concentrations of zinc and copper of same species at different locations

Species	*Ulva pertusa*			*Chaetomorpha crassa*		
	Dar es Salaam		Japan	Dar es Salaam		Japan
Metal (µg/g dried algae)	Mbudya island	Oyster bay	Tomo Island	Mbudya Island	Oyster bay	Tomo Island
zinc	24.0	25.5	138.0	75.0	70.3	154.0
copper	6.0	6.0	13.1	11.8	13.6	11.7

Table 3: Chromium, Manganese and Iron in marine algae ($\mu g/g$ of dried algae)

Algae code no.	Cr		Mn		Fe	
	OB	MI	OB	MI	OB	MI
1	0.75	0.75	3.5	3.6	230	230
2	0.88	0.87	10.0	10.0	291	290
3	1.25	1.25	30.5	30.0	2180	2180
4	1.38	1.36	18.5	19.0	241	242
5	2.25	2.25	27.5	28.0	3085	3080
6	2.14	2.15	17.0	16.8	2180	2182
7	0.50	0.50	17.5	18.0	331	330
8	3.13	3.15	29.5	30.0	1065	1066
9	1.50	1.50	13.5	13.6	195	195
10	2.00	2.00	12.0	12.1	189	190
11	1.75	1.75	16.0	16.0	182	180
12	1.50	1.49	58.5	58.6	1190	1189
13	1.12	1.12	6.5	6.5	233	235
14	1.12	1.10	13.0	13.0	344	345
15	2.38	2.35	1.7	1.7	1110	1108
16	2.00	2.00	13.0	13.0	120	119
17	0.75	0.73	26.5	26.5	350	351

Table 4 : Cobalt, Nickel and lead in marine algae ($\mu g/g$ of dried algae)

Algae code no.	Co		Ni		Pb	
	OB	MI	OB	MI	OB	MI
1	0.95	0.95	0.91	0.92	1.60	1.60
2	0.95	0.95	0.63	0.65	0.91	0.91
3	0.95	0.95	2.30	2.30	0.80	0.82
4	0.90	0.90	1.93	1.90	0.17	0.20
5	1.10	1.10	0.70	0.70	1.15	1.13
6	1.20	1.20	0.55	0.55	0.70	0.74
7	0.78	0.80	1.13	1.12	1.70	1.68
8	----	----	0.85	0.85	1.70	1.70
9	----	----	0.85	0.85	1.15	1.10
10	----	----	0.35	0.36	0.95	0.90
11	----	----	1.02	1.04	2.80	2.85
12	----	----	0.38	0.38	2.15	2.17
13	----	----	1.08	1.10	1.70	1.68
14	----	----	0.62	0.60	1.45	1.42
15	----	----	0.62	0.64	1.90	1.90
16	----	----	3.00	3.00	----	--
17	----	----	----	----	1.95	1.96

-- : not found, OB: Oyster Bay, MI: Mbudya Island

Table 5: Copper, Zinc and Cadmium in marine algae ($\mu g/g$ of dried algae)

Algae code no.	Cu		Zn		Cd	
	OB	MI	OB	MI	OB	MI
1	7.00	7.00	28.0	27.9	0.27	0.25
2	8.50	8.50	56.0	55.0	0.23	0.23
3	11.50	11.50	32.5	33.0	0.22	0.20
4	3.00	3.10	23.5	24.0	0.17	0.15
5	0.50	0.50	35.5	35.0	0.08	0.08
6	0.50	0.50	26.5	26.0	0.10	0.10
7	3.50	3.52	28.0	29.0	0.06	0.07
8	6.00	6.00	74.0	74.0	0.10	0.10
9	2.50	2.50	36.5	37.0	0.05	0.06
10	2.50	2.50	70.0	71.0	0.48	0.50
11	1.00	1.00	30.5	30.4	0.08	0.08
12	1.00	1.00	33.4	34.0	0.12	0.14
13	5.50	5.50	32.5	32.0	0.05	0.05
14	5.50	5.54	21.0	21.0	0.14	0.15
15	1.50	1.50	23.5	24.7	0.12	0.12
16	3.00	3.00	24.5	25.0	0.09	0.09
17	2.00	2.00	45.0	47.0	0.12	0.10

-- : not found, OB : Oyster Bay, MI : Mbudya Island

CONCLUSION

The amounts of chromium, manganese, iron, cobalt, nickel, copper, zinc, cadmium and lead in species of marine and fresh water algae were determined and are presented on a dry weight basis. It is found that several species are capable of concentrating heavy metals. Among the green sea weeds, *Halimeda discoidea* concentrates Cu, Ni, Fe and Mn, *Cladophora fascicularis* concentrates Fe, Cr and Co while *Chaetomorpha crassa* concentrates Cr and Zn. In the brown sea weeds *Sargassum polycystum* concentrates Zn and Cd while *Padina tetrastromatica* accumulates Mn and Pb. These different species may be used for studying specific heavy metals pollution.

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MINING ACTIVITIES AND POLLUTION

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ABSTRACT

Mining usually causes change in environment. Besides destroying natural forests, causing instability of top soil, mining and associated activities may cause pollution:

1) The mineral which is being extracted may itself be dangerous; e.g. highly radioactive phosphates.

2) Fine dust, often poisonous, produced during mining may pollute the atmosphere.

3) Overburden and wastes dug up during mining are accumulated in dumps; running water draining the dumps carry pollutants to the agricultural land and may even percolate into the groundwater of the neighbourhood.

4) Illegal small-scale processing of gold by using cyanide and mercury pollutes the whole environment.

5) Waste water released from mineral processing plants may pollute surface and groundwater.

It is recommended that management of pollution in the organized sector of mining be entrusted to an independent body composed of specialists in the different fields of environmental sciences. This body may formulate ways and means to check environmental pollution in the mining areas. Unauthorized mining and other activities has to be stopped by the mining inspectorate and other appropriate agencies of the Government.

Question by Dr. Ngoile

What is the difference between organized and unorganized mining.

Answer

Organized mining is controlled by a central body e.g. government or company, whereas unorganized mining is not controlled.

Remarks: Prof. Aswathanarayana

1. Many of the mining activities are carried out by individuals without licenses.
2. It is difficult to assess areas affected by mining activities because they are scattered. Many gold mining areas are left with holes to land degradation.
3. Mercury is used to capture gold and is subsequently dumped into streams. So far no research has been done to assess the extent of pollution for the purpose of control.

Question by Dr. Bilal

Is the mining of phosphates controlled and organized.

Answer

Phosphate mining near Lake Manyara is organized and hence controlled. The problem in mining it is that during processing dust with radioactive elements is likely to be produced. Workers inhale the dust and possibly their health is being affected. Research on the ill-effects of the dust has been proposed.

MONITORING METHODS, MODELLING AND MANAGEMENT

HEAVY METAL ANALYSIS IN WATERS FOR POLLUTION MONITORING AND CONTROL

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ABSTRACT

In any analysis, be it for trace metals, heavy metals, bacteriological, microbiological or others, the results can be no better than the sample on which it is performed. This paper emphasizes the need to take samples properly so that the results can truly represent the sampled material. Discussed are the objectives of sampling, possible errors liable to be made during the sampling process, sources of contamination and remedies to this, and other factors that may affect the results. Citing the sampling of water for the determination of heavy metals during pollution monitoring as an example, suggestions are made on the appropriate techniques, the right equipment and ways of preserving the samples before analysis. Altogether, it is recommended that consultations with laboratories should be made before sampling is undertaken.

INTRODUCTION

It is an old axiom among analysts of any kind that the result of any test can be no better than the sample on which it is performed. Therefore any proper or improper sampling will definitely lead to incorrect and erroneous results, respectively. The main objective of sampling is to collect a portion of material small enough in volume to be transported conveniently and handled in the laboratory while still accurately representing the material being sampled. This implies that the relative proportions or concentrations of all pertinent components will be the same in the samples as in the material being sampled, and that the sample will be handled in such a way that no significant changes in composition occur before the tests are made.

During sampling, recording of every sample collected and identification of every bottle, preferably by attaching an appropriately inscribed tag or label is of ultimate importance. Sufficient information should be recorded to provide positive sample identification at a later date, as well as the name of the sample collector, the date, the hour, and exact location, the water temperature, and any other data that may be needed for correlation, such as weather conditions, water level, stream flow, etc. Fix sampling points by detailed description, by maps, or with the aid of stakes, buoys or landmarks in a manner that will permit their identification by other persons without reliance on memory or personal guidance.

It is of notable importance to be aware of the many factors that affect results, especially the presence of suspended matter or turbidity, the method chosen for its removal, and the physical, chemical and biological changes brought about by storage or aeration. The places from where samples are collected also matter very much. For example, when samples are collected from a river or stream, analytical values may vary with depth, stream flow, distance from shore and from one shore to the other. Therefore clear marking of the exact location from where the sample was taken is a must. This is of great help to others who come to do the sampling at a later date, as is the case where environmental pollution monitoring is concerned.

Contamination is also one of the worst hazards that may affect the results. After obtaining a sample that meets the sampling programme, it should be handled in such a way that it does not deteriorate or become contaminated before it reaches the laboratory. Before filling, rinse sample bottles two or three times with the water being collected, unless the bottle contains a preservative or dechlorinating agent. Depending on analyses to be performed, fill container fully (most organic/inorganic analyses) or leave space for aeration, mixing, etc. (microbiological analyses). For samples that will be shipped, preferably leave an air space of about 1% of the container capacity to allow for thermal expansion. Multiple sampling of the same sample for comparison's sake is highly recommended.

Complete and unequivocal preservation of samples, whether domestic waste water, industrial wastes, or natural waters, is a practical impossibility. At best, preservation techniques only retard chemical and biological changes. Some chemical changes that may take place in water samples to be analyzed for metals are listed below:

i) Certain cations are subject to loss by adsorption on, or in ion exchange with the walls of glass containers, e.g. Al, Cd, Cr, Co, Fe, Pb, Mn, Ag, and Zn, which are best collected in a separate clean bottle and acidified with nitric acid to a pH of less than 2 to minimize precipitation and adsorption on container walls.

ii) Iron and Manganese, in their higher oxidation states, may precipitate out or dissolve from a sediment, depending upon the redox potential of the sample, co-precipitation with other heavy metals is possible.

iii) Sulphur, SO_3, Fe(II), I, and CN may be lost through oxidation.

iv) Sodium, Silica, and Boron may be leached out of the glass container.

In actual fact, no single method of preservation is entirely satisfactory. The preservative should be chosen with due regard to the determinations to be made. The table included in this presentation, as quoted from reference 3, summarizes some special sampling and handling requirements, according to the different tests that have to be made. As an example, for the determination of heavy metals and such cations like Fe and Mn, after taking the sample, immediately filter to remove any suspended solids through a membrane filter and acidify the filtrate with concentrated nitric acid. In our laboratory we prefer superpure concentrated nitric acid, 5 drops to every 100 ml of sample. Store in a plastic bottle with a plastic cap. The plastic should not be coloured, to avoid introducing such elements like lead or cadmium, that may be contained in the pigment.

Lastly, it should be noted that often, in water and wastewater work, the laboratory conducts or prescribes the sampling program, which is determined in consultation with the user of the test results. Such consultation is essential to ensure selecting samples and analytical methods that provide a true basis for answering the questions that prompted the sampling.

TABLE 105:I. SUMMARY OF SPECIAL SAMPLING OR HANDLING REQUIREMENTS*

Determination	Container	Minimum Sample Size *mL*	Preservation	Maximum Storage Recommended/ Regulatory†
Acidity	P, G(B)	100	Refrigerate	24 h/14 d
Alkalinity	P, G	200	Refrigerate	24 h/14 d
BOD	P, G	1000	Refrigerate	6 h/48 h
Boron	P	100	None required	28 d/28 d
Bromide	P, G	—	None required	28 d/28 d
Carbon, organic, total	G	100	Analyze immediately or refrigerate and add H_2SO_4 to pH < 2	7 d/28 d
Carbon dioxide	P, G	100	Analyze immediately	—/—
COD	P, G	100	Analyze as soon as possible, or add H_2SO_4 to pH < 2	7 d/28 d
Chlorine, residual	P, G	500	Analyze immediately	0.5 h/2 h
Chlorine dioxide	P, G	500	Analyze immediately	0.5 h/2 h
Chlorophyll	P, G	500	30 d in dark; freeze	30 d/—
Color	P, G	500	Refrigerate	48 h/48 h
Conductivity	P, G	500	Refrigerate	28 d/28 d
Cyanide				
Total	P, G	500	Add NaOH to pH > 12, refrigerate in dark	24 h/14 d
Amenable to chlorination	P, G	500	Add 100 mg $Na_2S_2O_3$/L	—/—
Fluoride	P	300	None required	28 d/28 d
Grease and oil	G, wide-mouth calibrated	1000	Add H_2SO_4 to pH < 2, refrigerate	28 d/28 d
Hardness	P, G	100	Add HNO_3 to pH < 2	6 months/6 months
Iodine	P, G	500	Analyze immediately	0.5 h/—
Metals, general	P(A), G(A)	—	For dissolved metals filter immediately, add HNO_3 to pH < 2	6 months/6 months
Chromium VI	P(A), G(A)	300	Refrigerate	24 h/48 h
Copper by colorimetry*				
Mercury	P(A), G(A)	500	Add HNO_3 to pH < 2, 4°C	28 d/28 d
Nitrogen:				
Ammonia	P, G	500	Analyze as soon as possible or add H_2SO_4 to pH < 2, refrigerate	7 d/28 d
Nitrate	P, G	100	Add H_2SO_4 to pH < 2, refrigerate	48 h/48 h
Nitrate + nitrite	P, G	200	Analyze as soon as possible or refrigerate; or freeze at −20°C	none/28 d
Nitrite	P, G	100	Analyze as soon as possible or refrigerate, or freeze at −20°C	none/48 h
Organic, Kjeldahl	P, G	500	Refrigerate; add H_2SO_4 to pH < 2	7 d/28 d
Odor	G	500	Analyze as soon as possible; refrigerate	6 h/—
Organic compounds				
Pesticides	G(S), TFE-lined cap	—	Refrigerate, add 100 mg $Na_2S_2O_3$/L if residual chlorine present	7 d/7 d
Phenols	P, G	500	Refrigerate, add H_2SO_4 to pH < 2	*/28 d
Purgeables by purge and trap	G, TFE-lined cap	50	Refrigerate; add 100 mg $Na_2S_2O_3$/L if residual chlorine present	7 d/14 d
Oxygen, dissolved	G, BOD bottle	300		
Electrode			Analyze immediately	0.5 h/1 h
Winkler			Titration may be delayed after acidification	8 h/8 h
Ozone	G	1000	Analyze immediately	0.5 h/—
pH	P, G	—	Analyze immediately	2 h/2 h
Phosphate	G(A)	100	For dissolved phosphate filter immediately, refrigerate; freeze at −10°C	48 h/48 h
Salinity	G, wax seal	240	Analyze immediately or use wax seal	6 months/—
Silica	P	—	Refrigerate, do not freeze	28 d/28 d
Sludge digester gas	G, gas bottle	—	—	—
Solids	P, G	—	Refrigerate	7 d/7–14 d
Sulfate	P, G	—	Refrigerate	28 d/28 d
Sulfide	P, G	100	Refrigerate; add 4 drops 2*N* zinc acetate/100 mL	28 d/28 d
Taste	G	500	Analyze as soon as possible; refrigerate	24 h/—
Temperature	P, G	—	Analyze immediately	—/—
Turbidity	P, G	—	Analyze same day, store in dark up to 24 h	24 h/48 h

* See text for additional details. For determinations not listed, use glass or plastic containers, preferably refrigerate during storage and analyze as soon as possible. Refrigerate = storage at 4°C, in the dark. P = plastic (polyethylene or equivalent); G = glass, G(A) or P(A) = rinsed with 1 + 1 HNO_3, G(B) = glass, borosilicate; G(S) = glass, rinsed with organic solvents.

† Environmental Protection Agency, Proposed Rules, *Federal Register* 44, No. 244, Dec 18, 1979

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2. Black, H.H. (1952) Procedures for Sampling and Measuring of Industrial Wastes. Sewage Ind. Wastes 24:45.
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<u>Comments by Dr. Gerges</u>

In addition to emphasizing on proper sampling we must also emphasize on the standardization of analytical techniques for even if the sampling has been properly carried out poor or improperly standardized analytical techniques can spoil the results.

<u>Answer</u>

I fully agree with you. However, the emphasis on proper sampling and handling of samples during transit that has been presented here is meant mainly for those people who would like to send samples to our laboratory for analysis. We in our laboratory shall always carry out the sample analyses in a properly standardized way but if the sample sent to us will have been collected and handled incorrectly then the results will be very bad regardless of the degree of sophistication and standardization employed in the analytical process.

<u>Question by Dr. Mathuthu</u>

Is it not that sampling from the same place consistently is biased sampling?

<u>Answer</u>

No. This is the recommended sampling technique. So water samples should be collected at the same site and the samples should be taken in the same way always. This will facilitate easy comparison of the date from different study sites.

Question by Dr. Opuda-Asibo

Do you normally carry out water sampling and if so, do you have any standard sampling procedures that you recommend and is there any way you can make your services well known to us in the Eastern African Region so that we can send our water samples to you instead of sending them to Europe?

Answer

Yes we do carry out water sampling from time to time and the sampling procedures we use are given in the paper I have presented in the present symposium. As for our services to be known in other countries in Eastern Africa, yes we like it to be known to all here and beyond that we are ready to provide water analysis services to all interested institutions and individuals at very competitive charges provided the samples are first of all collected and handled in the right way as I pointed out earlier. For those interested in contacting us for such services our address is:

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EVALUATION OF MICROBIOLOGICAL METHODS FOR MONITORING POLLUTION IN MARINE AND FRESH WATER

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ABSTRACT

A good water quality of aquatic environments is of crucial importance for all living organisms on earth. For human beings the quality of water bodies has an immediate effect on health aspects (drinking water, bathing etc.) and economic aspects (fish production, irrigation).

Due to many different sources of pollution, water bodies many be affected in such a way that the quality of the water is no longer acceptable for the various applications. Therefore it is extremely important to monitor pollution in aquatic environments. In this paper we will describe some major monitoring methods which are used in order to assess the quality of water bodies. The following monitoring methods for water and waste-water are discussed: dissolved oxygen determination, biochemical oxygen demand, chemical oxygen demand and some microbiological examination methods with emphasis on fecal and total coliform determination.

The advantages and disadvantages of the various monitoring methods are discussed. The determinations are used as indicators of pathogenic organisms and organic pollution. The suitability of *Escherichia coli* as an indicator organism in marine environments is also discussed.

INTRODUCTION

Environmental pollution in industrialized countries has been a serious problem already for many years, but at present also developing countries are facing more and more serious environmental pollution problems. Although both soil and air and water pollution may occur, the most serious problems in developing countries are encountered in pollution of waterbodies and soil in and around large cities. In urban areas the population density is highest and often an adequate sewage system is absent. In the near future the extend of pollution will increase because of further industrialization and urbanization in developing countries.

In Tanzania, sewage is not yet treated before it is disposed off into the ocean or rivers, except for a few oxidation ponds in Dar es Salaam. It is evident therefore that monitoring of water pollution is necessary, especially because river water is used for bathing, washing and even as drinking water. Monitoring is also important for the fish industry, because shellfish can be contaminated with pathogenic bacteria, especially when caught near the coast and sewage disposal sites. Even for the tourist industry monitoring of the quality of bathing water is essential.

In this paper some monitoring methods for the examination of water quality are described and discussed.

The following methods are included:

1. Dissolved Oxygen (DO) determination
2. Biochemical Oxygen Demand (BOD) determination
3. Chemical Oxygen Demand (COD) determination
4. Microbiological Examination methods

Different types of water can be examined and it will be clear that the standards for drinking water are different from the standards for swimming water or the effluent of a wastewater treatment plant. The monitoring methods are not exclusively used to determine whether for example drinking water meets the standards, but they are also used to determine the efficiency of waste water purification processes.

DISSOLVED OXYGEN

Although oxygen is the second most plentiful gas (after nitrogen) in the atmosphere, its solubility in water is rather low. The maximum solubility of oxygen in water exposed to water-saturated air at atmospheric pressure (101.3 kPa) and at 20°C is only 9.1 mg/l. Besides its limited solubility, also the exchange of O_2 between large water bodies and the atmosphere is slow. The presence of oxygen in water is crucial for the existence of all higher forms of live in the water, i.e. invertebrates, fish and higher plants. Moreover, the presence of oxygen in the water enables the biological self-purification process to take place (oxidation of organic matter by heterotrophic microorganisms).

Table 1. Solubility of oxygen in water exposed to water-saturated air at atmospheric pressure.

Temperature (°C)	Oxygen solubility (mg/l)	
	Pure water	Seawater
0	14.6	11.7
5	12.8	10.3
10	11.3	9.2
15	10.1	8.3
20	9.1	7.5
25	8.3	6.9
30	7.6	6.3
35	6.9	5.8
40	6.4	5.4
45	5.9	5.0
50	5.5	4.6

Dissolved Oxygen (DO) levels in aquatic ecosystems depend on a number of physical, chemical and (micro-) biological activities in the water:

a) <u>Temperature of the water</u>

The solubility of oxygen in water decreases drastically with an increase in temperature (Table 1). Because of its low oxygen content it is not allowed in many countries to freely discharge process water above a certain temperature limit without prior cooling and aeration of the water.

b) <u>Production of oxygen by photosynthetic organisms</u>.

Oxygen will be produced by plants and by photosynthetic aerobic microorganisms which are present in the water. Photosynthetic production of oxygen in waters occurs only in the surface layers of the waterbody where light is available.

c) <u>Exchange with atmosphere and exchange between water layers</u>.

The exchange of oxygen between a large water mass and the atmosphere is rather slow. The rate of exchange will mainly be determined by the surface/volume ratio of the waterbody. Well mixing of different water layers, rapid water flow and turbulence will contribute to a higher rate of oxygen exchange.

d) <u>Consumption of oxygen</u>

Oxygen consumption in waterbodies occurs mainly by heterotrophic facultative anaerobic microorganisms in the presence of organic matter. Oxygen dissolved in the water is used in the decomposition (oxidation) of organic matter to CO_2 and H_2O. Therefore the oxygen level and the rate of oxygen uptake of a waterbody will directly affect its biological purification activity. Because of this, monitoring for DO should be considered as a key test in water quality determination.

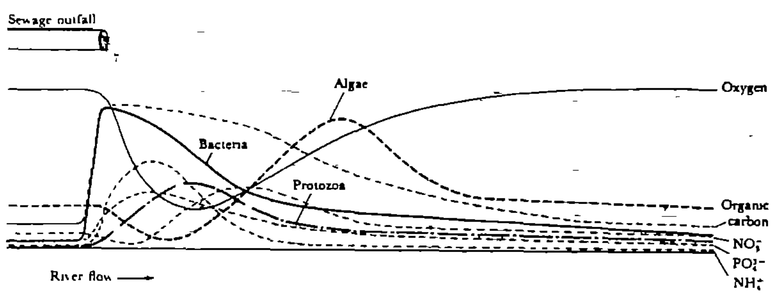

Figure 1. Chemical and biological changes in a river at various locations downstream from sewage discharge (Brock <u>et</u> <u>al</u>., 1984)

The oxygen relations in rivers are of particular interest, especially at locations where organic pollutants of domestic or industrial origin are discharged. In Fig. 1 the major chemical and biological changes resulting from sewage outfall are indicated. The large amount of added organic matter will lead to a marked oxygen deficiency in the water. Further downstream, when most of the organic matter

has been mineralized by heterotrophic bacteria, the DO level of the water may increase again. The growth of algae is stimulated by the release of inorganic nutrients from the organic matter decomposition. Ammonia (NH_4^+) is oxidized to NO_{3-} by nitrifying bacteria. The decrease in bacterial numbers is brought about by protozoa which feed on bacteria.
The available methods for DO analysis are basically two:

a) Titrimetric method

The Winkler or iodometric method and its modifications are based on the oxidizing property of dissolved oxygen.

b) Electrometric method, using oxygen electrodes.

The membrane electrode method is based on the rate of diffusion of molecular oxygen across a membrane.

The choice of methodology depends mainly on the accuracy desired, the presence of interfering compounds and convenience. A detailed description of both methods is given in APHA (1985).

a) Iodometric Methods

The most reliable and precise titrimetric procedure for DO analysis is the iodometric test which is based on the addition of divalent Manganese and strong alkali.

If the titration end point is determined visually, a precision of about ± 50 µg/l can be maintained. Electrometric end point detection will improve precision to ± 5 µg/l.

b) The Membrane Electrode method.

A big disadvantage of the iodometric test is that it is not suitable for field application. Membrane electrodes of the galvanic as well as the polarographic type, provide a convenient and reliable method for field work analysis of DO. Moreover the method gives good results for DO analysis in polluted and coloured waters.

Under steady-state conditions the current is linearly proportional to the concentration of molecular oxygen. Since membrane electrodes can be used for analysis in situ, errors caused by sampling or storage are eliminated. With most commercially available membrane electrodes a precision of ± 50 µg/l can be obtained.

BIOCHEMICAL OXYGEN DEMAND (BOD)

Wastewater has a self-purifying capacity because of the presence of microorganisms and oxygen in the water. Bacteria and other microorganisms in the water catalyze the so-called mineralization process in which organic compounds are being converted to inorganic compounds. This oxidation process requires large amounts of oxygen, i.e. the oxidation of 1 gram of sugar requires about 1 gram of oxygen. Also inorganic reduced compounds such as sulfides, ferrous iron or nitrogenous compounds can be oxidized which also results in a substantial oxygen consumption. The oxidation of 1 gram of NH_3 will require about 4 grams of oxygen.

Table 2 gives an indication of the amount of water that would be needed to bring about the complete oxidation of 1 gram sugar, 1 gram ammonium or a combination of both. The data are based on the oxygen content of the water as indicated in Table 1 and do not account for possible oxygen exchange between water and the atmosphere.

Table 2. Amount of water (in litres) needed for the complete oxidation* of organic and inorganic compounds.

Pollutant	fresh water	sea water
1 gram sugar	120	145
1 gram ammonia	482	580
1 g sugar + 1 g ammonia	602	725

* conditions: air saturated water 25°C and atmospheric pressure

If wastewater is loaded with organic pollutants such as industrial wastewater or sewage, the water will very quickly become deficient in oxygen, resulting in anaerobic conditions. A good example of this phenomenon in Dar es Salaam is the Msimbazi river which receives a high load of mainly industrial wastewater. As a result the Msimbazi river was found to be completely anaerobic on many locations.
The Biochemical Oxygen Demand (BOD) provides a measure for the oxygen consumption by microbial activities in a water sample. The BOD of a given sample is defined as the amount of oxygen (in mg/l) that is consumed by

microorganisms when incubating a sample in a closed bottle in the dark at a fixed temperature and for a fixed period of time. Light is excluded in this standardized test in order to exclude oxygen production by photosynthetic processes. In countries with a moderate climate, samples are incubated at 20°C in the dark for 5 days in which case the oxygen demand is expressed as BOD^{20}_5 (APHA, 1985). However, many variations of oxygen demand measurements may exist. Dissolved oxygen is measured initially and after incubation.

In most cases it will be necessary to dilute the sample before incubation, because most (waste) waters contain more oxygen consuming compounds than the amount of dissolved oxygen available in air saturated water. The dilution water should contain all nutrients which are required for the growth of bacteria. An inhibitor to prevent the oxidation of ammonia can be used in order to differentiate between carbonaceous oxygen demand and nitrogenous oxygen demand.

Generally analysis of a sample should begin within 6 hours after collection. In cases where this is not possible, the samples should be stored at 4°C and be analysed within 24 hours. The low temperature will limit microbial activities during storage. The BOD value can be calculated according to the following formula:

$$BOD_5^{20}\ (mg/l) = \frac{D^1 - D^2}{P}$$, in which

D_1 = DO (mg/l) of diluted sample immediately after preparation
D_2 = DO (mg/l) of diluted sample after 5 days incubation at 20°C
P = Decimal volumetric fraction of the sample

Since not all of the potentially biodegradable compounds are oxidized within 5 days, the BOD_5^{20} represents only about 60-65% of the total BOD of a water sample. An experimental determination of total BOD would last a long time, since this value is reached asymptotically. By setting the test conditions (i.e. BOD_5^{20}) a compromise is made between shortening the incubation period and accepting that only part of the organic matter will be mineralized. By doing so it is assumed that the percentage of the total BOD that will be reached after 5 days is reproducible and is similar for different samples. This assumption is in practice not justified and

therefore the existing method only provides an indication of the actual oxygen consumption. Although the BOD test is a crude method and only gives an indication of pollution, no better alternative is available at present.
The BOD value of a sample will be strongly affected by the following parameters:

a) The initial oxygen content of the water.

The oxygen content of water samples taken from various locations may differ markedly. Heavily polluted waters are likely to have a low DO content, whereas pure water may be saturated with oxygen. In order to standardize the procedure, the sample should always be air saturated at the beginning of the BOD test. In case a high dilution of the original sample is necessary, the sample will become air saturated by addition of a large volume of dilution water. If this is not the case, the sample should be aerated before starting the BOD test.

b) The microbial population present.

For a good BOD measurement it is essential that a population of microorganisms is present in the water which is capable of oxidizing the biodegradable organic compounds in the water sample. Industrial and domestic wastewaters or effluents of aerobic wastewater treatment plants usually contain large populations of heterotrophic microorganisms. Some water samples such as high temperature effluents or waters with extreme pH values do not contain sufficient microorganisms. In such cases the water sample should be seeded with microorganisms from a source that contains an extensive population of microorganisms (i.e. effluents of aerobic treatment plants). The BOD of the seeding material should be determined as for any other sample and subtracted from the total value obtained for the seeded sample.

c) Presence of toxic compounds in the water.

In wastewaters that contain a high amount of toxic compounds, microorganisms may be inhibited or even be completely eliminated from the sample. In most cases the BOD of such samples can be determined by preparing a strong dilution in combination with seeding of the sample as described under b).

d) Type and amount of pollutants present.

The type and amount of organic pollutants will directly affect the BOD value of a sample. The BOD value in fact is a measure for the amount of biodegradable waste materials. However, different types of organic compounds usually also differ with respect to their rate of mineralization. The rate of glucose degradation for instance will be higher than that of starch or cellulose. Lignin is even considered to be almost undegradable during the short incubation period of a BOD test. Some organic compounds may inhibit the degradation of others, causing sequential oxidation.

As mentioned earlier, also inorganic compounds like NO_2^-, NH_3, Fe^{2+} or S^{2-} are liable to oxidation. The oxidation of NO_2^- and NH_3 requires a very specific microbial population and usually proceeds at low rates, whereas oxidation of Fe^{2+} and S^{2-} may also occur in a purely chemical way (non-microbial).

CHEMICAL OXYGEN DEMAND (COD)

The Chemical Oxygen Demand is used as a measure for the total amount of oxygen needed in the complete oxidation of organic matter in a sample by a strong chemical oxidant. Dichromate is generally used in COD determination because of its superior oxidizing ability which is applicable to a wide variety of samples.

For samples of a specific source, COD values can be related empirically to BOD. A detailed description of the COD determination is given in APHA (1985).

MICROBIOLOGICAL EXAMINATION

Microbiological examination of water (drinking water, bathing water etc.) is of crucial importance for human health, especially in the tropics, because there the diversity and severity of waterborne diseases is greatest. Moreover, medical services are poor, many people are undernourished and ill-housed. Also economic aspects are involved in case of fish and shellfish production, irrigation and tourist industry.

In an attempt to investigate the risk of water-borne diseases originating from recent fecal contamination of the water it seems most logical to isolate and identify pathogenic organisms in the water.

However, at the time we would discover pathogens like the ones responsible for cholera or typhoid in drinking water it is already too late to prevent the outbreak of a disease. Moreover, such pathogens are normally present in small numbers and might not be traced by the monitoring methods. For this reason the microbiological methods concentrate on so-called indicator organisms. The usual indicator organisms are the coliform bacteria, but many tests for food and water specify the determination of fecal coliforms. The predominant fecal coliform is Escherichia coli. This organism is therefore most often used as indicator organism.

Before the indicator organisms will be discussed in more detail, we will describe the different methods for detection of recent fecal contamination.

Methods

The two methods most often used are: the Multiple Tube Fermentation (MTF) method and the membrane filter (MF) method.

a) The Multiple Tube Fermentation test

In this test coliforms are detected in three stages; presumptive, confirmed and completed (Fig. 2).

In the presumptive test dilutions of the water sample are added to tubes of lactose broth containing a pH indicator. The tubes are incubated for 24 to 48 hours at 35°C. The production of gas is detected by small inverted vials (Durham tubes) present in the test tubes. If carbon dioxide is produced (because of lactose fermentation) and if the colour of the medium has changed from colourless to yellow (acid production) the reaction is considered to be positive. By means of Most Probable Number (MPN) tables, the number of coliforms in the water sample can statistically be determined. In the confirmed test eosin methylene blue (EMB) agar containing lactose is inoculated with samples from the highest positive dilutions. If there are coliforms, they form dark-centered colonies. These colonies indicate a positive confirmed test.

These colonies can also be used in the completed test, where very specific media are inoculated and after growth the bacteria can be examined for the presence of spores and be subjected to Gram-staining.

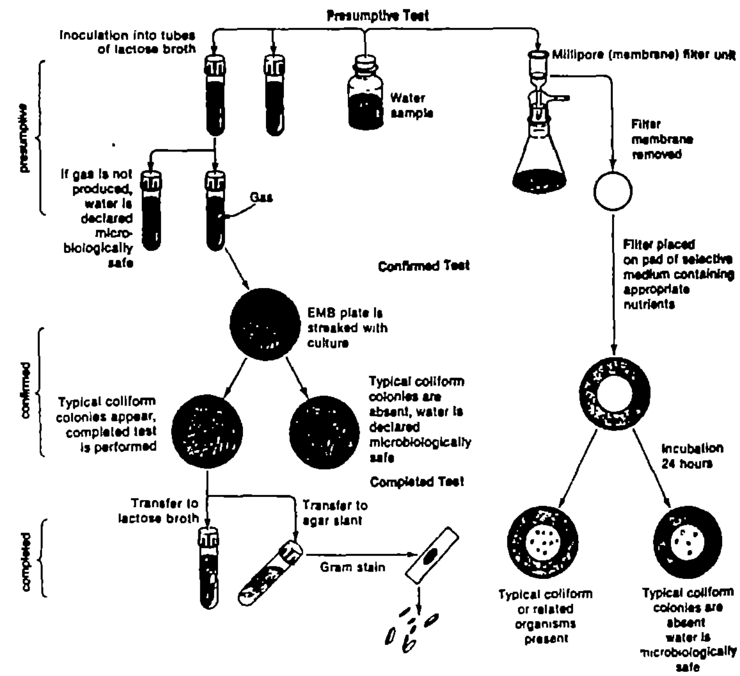

Figure 2. Multiple Tube Fermentation test and Membrane Filter method. (Wistreich and Lechtman, 1988)

b) <u>The Membrane Filter method</u>

An amount of 100 ml of sample-water is drawn through a paper-thin membrane filter with pores of about 0.45 μm. The membrane is then placed on a pad of nutrient medium, which can be LES Endo agar or M-endo medium (Fig. 2). After incubation at 35°C for 24 h, the typical coliform colonies, with a pink to dark-red colour with a metallic (green-gold) surface sheen, are counted.

Sheen colonies can be verified by inoculation of lauryl tryptose broth and brilliant green lactose bile broth. After incubation for 48 h at 35°C gas production verifies the colony as a coliform.

<u>Fecal coliforms</u>

Fecal coliforms can be determined by using both the Multiple Tube Fermentation test and the Membrane Filter method. Incubation is done at an elevated temperature of 44°C, because fecal coliforms are able to grow at this higher temperature.

Several other MTF methods and MF methods are described in Standard Methods for the Examination of Water and Wastewater (APHA, 1985). There is however a need for faster examination methods than the 48 hours needed by the conventional methods. When it is questionable whether a bathing beach has to be closed or whether water is still fit for human consumption after repairs of a broken water pipe it is essential that results are available within 8 hours (one working day).

Some of the fast methods are described here. In some methods specific substrates release a signal molecule (coloured or fluorescent) upon hydrolysis by coliform organisms. This shortens the time for confirmation (Feng and Hartman, 1982) and detection (Edberg and Edberg, 1988).

An example of a detection method by using a fluorescent marker is described by Berg and Fiksdal (1988). 4-Methylumbelliferone-B-D-galacto side is a combined indicator-nutrient. It is added to the medium and hydrolysed by galactosidase positive coliforms resulting in a fluorescing methylumbelliferone (MU). The activity is enhanced by adding the detergent sodium lauryl sulfate to improve the transfer of substrate and/or enzyme across the outer membrane. The detection limit is 60-100 total coli's per 100 ml within 15 min, which is high due to background fluorescence. The high detection limit makes the method unsuitable for drinking water. The use of MU-B-D-galactoside in a direct membrane filter method and a 6 h incubation permits the detection of 1 fecal coli per 100 ml sample and requires only a hand-held long-wave UV-lamp. The precision of the test is comparable to the MTF test.

Another method is described by Edberg *et al*. (1988). In this test two hydrolysable indicator-nutrients are combined: ortho-nitrophenyl-B-D-galactopyranoside (ONPG) and 4-methylumbelliferyl-B-D-glucuronid (MUG). ONPG is hydrolysed by coliform bacteria and changes the colour of the medium from colourless to yellow, MUG is hydrolysed by *E. coli* and can be detected by a long-wave (366 nm) UV-lamp. No statistical difference was found when this test was compared with the MTF test, but this test is able to detect one coliform per 100 ml within 24 hours.

In another test [^{14}C]-mannitol is used as a substrate. $^{14}CO_2$ is collected as $Ba^{14}CO_3$. Incubations are done at 35°C and 44.5°C. There was a good correlation with conventional tests at fecal coli concentrations of 10 cells per sample or higher. The results are available after 4.5 hours (Reasoner and Geldreich, 1989).

It can be concluded that faster methods are now available and the accuracy can compete with the conventional MTF and MF test.

INDICATOR ORGANISMS

There are several criteria for indicator organisms of fecal contamination. The most important criterion is that an indicator organism has to be consistently present in human intestinal wastes, in such high numbers that it can easily be detected in water contaminated with feces. Secondly, an indicator organism should be able to survive in the water at least as long as the pathogenic organisms would. Last but not least: an indicator organism should be detectable by simple monitoring methods.

The usual indicator organisms are the coliform bacteria. They are defined as aerobic or facultative anaerobic, Gram-negative, non-sporeforming, rod-shaped bacteria and are able to ferment lactose to carbon dioxide. From the following it will be clear that fecal coli are not always the best indicator organisms. For example Collin et al. (1988) found that for drinking water fecal streptococci had a better predictive value over coliforms. For monitoring natural waters the choice of a suitable indicator organism is more complex, especially for shallow water and tropical waters. Valdes-Collazo et al.(1987) described that E. coli can survive indefinitely in the tropical waters of Puerto Rico. Also others (Evison and James, 1973; Fujioka et al., 1981; Hazen and Esch, 1983; Lavoie, 1983 and McCambridge and McMeekin, 1981) have shown that in other tropical waters high densities of fecal coliforms can be found in the absence of fecal contamination.

Another study compares the in situ survival of Vibrio cholerae and Escherichia coli (Perez-Rosas and Hazen, 1988). The simultaneous monitoring of E. coli and V. cholerae levels established that E. coli cannot be used as indicator for V. cholerae or other fecal pathogens in coral reefs, since V. cholerae is able to survive longer in seawater. In seawater with salinity of $35°/_{00}$ and temperatures above 25°C, V. cholerae is not able to survive (Hood et al., 1986; Seidler and Evans, 1984), but coral sands and seagrass beds can harbor V. cholerae and E. coli for much longer time than previously thought.

Moreover some studies indicated that E. coli dies off faster than Salmonella spp. (Gallagher and Spino, 1968; Gudding and Krogstad, 1975). Also Pseudomonas aeruginosa and Klebsiella pneumoniae tended to survive longer than E. coli. (Burton et al.,1987). Rhodes and Kator (1988) studied the in situ survival of E. coli and Salmonella spp. in estuarine environments. Their most important findings are that these organisms are able to grow and survive during warm temperature conditions. At temperatures below 10°C Salmonella spp. are more persistent than E. coli. They indicated that survival was a function of interacting biological and physical factors.

Beard and Meadowcraft (1935) observed that E. coli survived longer than Salmonella typhosa in sterile seawater. Others (Munro et al. 1987) indicated a possible active adaptation of E. coli cells to seawater, like sensitivity to antibiotics, heavy metals and bacteriophages. To make things even more complicated it has been found (Brayton et al., 1984; Roszak et al., 1984) that coliform bacteria are able to evolve towards a non-culturable stage, although they remain viable. This would make it very difficult to identify the presence of those adapted cells.

In shallow water there is also an influence of sediments. Studies in the past revealed much higher numbers of indicator and pathogenic bacteria in sediments than in the overlying water. Bacteria in the sediment are protected from bacteriophages and microbial toxicants (Roper and Marshall 1974). The first sediment studies reported a 90% die-off of both fecal coli's and Salmonella spp. after 7 days. This rate is much lower than die-off rates observed in water, which often occurs within 3 days (Hood et al. 1983).

The adsorption, sedimentation and extended survival of enteric bacteria in sediments can create a potential health hazard. Bacteria can be re-suspended any time. Moreover, coastal mudflats are important habitats for a variety of intertidal species, including commercially important shellfish. Also sewage is often dispersed onto tidal mudflats, making the situation even worse. This implies that the present situation, where overlying waters are monitored for the presence of fecal coliforms is not adequate. The U.S. Food and Drug Administration Standard for approved shellfish harvest water is a maximum of 14 coli's per 100 ml (Goyal 1983). The actual concentration in the sediment, however, may be many times higher (Shiaris et al. 1987).

Santiago-Mercado and Hazen (1987) compared four membrane filter methods for fecal coliform determinations in tropical waters and they came to the conclusion that marine water samples gave poorer results than freshwater samples for all four methods used. In general densities are higher than actually present, because E. coli appears to be a normal inhabitant of tropical waters. Fecal contamination may be indicated, where none is present (Fujioka et al. 1981). For temperate waters the methods give realistic results (Pagel et al. 1982).

From the above information it can be concluded that especially in tropical waters it is very difficult to monitor fecal pollution. In the future one has to improve the indicator system and to determine which bacterial genus would most closely indicate fecal contamination in tropical waters, or establish a method where pathogens can be monitored directly.

MONITORING IN TANZANIA

In Tanzania only a few studies have been done to monitor water quality. The best impression of the quality of the water is obtained by combining the described methods for dissolved oxygen, biochemical- and chemical oxygen demand and the microbiological examination. By doing so it will be possible to examine the efficiency of oxidation ponds and sewage systems. Moreover the extend of pollution can be analysed for various waterbodies which are used as a source of drinking water, irrigation or for bathing. On the basis of the results of these pollution studies measures can be formulated to decrease the level of pollution in waterbodies to acceptable levels.

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Remark by Dr. M. Gerges

It is good that this work is being done here. One of the components in UNEP's Monitoring Programme involves microbiological contamination studies especially as regards to human health.

DOMESTIC ANIMALS AND ANIMAL-RELATED ACTIVITIES AS SOURCES OF ENVIRONMENTAL POLLUTION

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ABSTRACT

Environment is defined as, all that surrounds the human being, including the human being him/herself. Domestic animals are part of the human environment and have been sources of pollutants to the environment for periods immemorial, depending on several factors at play, including domestication. They excrete faeces, urine, shed hairs, make noise and also shed infections agents and parasites (*Salmonella*, Tuberculosis bacteria, Hydatid disease parasites, *Escherichia coli*, *Brucella* bacteria, etc.). Intervention by human beings in an attempt to manage livestock for increased production, has in itself become a problem, especially when livestock are kraaled together, in any form of confinement or collection. This has enhanced the spread of zoonotic diseases to humans. During the process of procuring and processing meat and milk products, waste products are usually dumped in the environment leading to pollution of water sources by waste water, waste-milk and faecal effluents. During the process of controlling animal diseases, environmental pollution has been enhanced through the use of disinfectants, acaricides, insecticides, herbicides, and fertilizers. This paper discusses the sources of these environmental pollutants and examines their control in the region (Eastern Africa).

INTRODUCTION

Environmental health is concerned with the relationship between human health and well-being, and the environment. Environment has affected human-kind over ages and now is affecting human-kind even more drastically as a result of human activities. Activities like industrialization, urbanization, domestication of animals, agriculture plus many other social and recreational activities. All these act as SOURCES of noxious material both to human health and environment. In this analysis human health and well-being is greatly negatively affected as a result of these pollutants. There are many natural sources of pollutants which include volcanic discharges (particulate matter and gases); geothermal, forest fires (smokes and volatile substances); torrential rains (silt load and land slides) and domestic animals. Most natural sources are widely dispersed and so unlike concentrated domestic animals, the resultant concentrations of their discharges have been below critical levels.

At all stages of raising, fattening of food animals, slaughtering and processing of their products, some materials of animal origin are regarded as potentially hazardous to human health and the environment. Such materials may include carcasses of animals which die of zoonotic illness, affected parts of carcasses as condemned during hygiene inspection, animal wastes, excreta, urine, manure and slurry. Other domestic animals such as dogs and cats pollute the environment with their cadavers, urine and faeces, as well as hairs and noise. The above materials pose a more serious Public Health problem as a result of involvement of pathogenic micro-organisms during putrefaction, disease or pollution of soils, air and waters. Thus dogs may contaminate the environment with their faeces which may be infected with hydatid disease eggs, hookworm eggs (Anchylostoma ceylanicum); their urine contaminated with Leptospira; their hairs with skin/hair/nail forms of ring-worm causing fungi; with fleas, ticks; pollute the air with noise in urban areas, especially during the mating season; and they are dangerous sources of rabies. The cats besides being noisy during their mating season, are a source of allergenic hairs, ringworm fungi, toxoplasma oocysts in their faeces, etc.

Domestic food animals on the other hand, are known to be sources of a wide range of infectious agents which pollute the environment. The list could include Brucellosis, Tuberculosis, Leptospirosis, Salmonellosis, Psittacosis, Q-fever, Schistosomiasis, Trypanosomiasis, Shigellosis (from primate colonies), Taeniasis and Cysticercosis, Tetanus, Trichinosis, Tularemia, Pasteurellosis, Yersimiosis, to name a few (Benenson, 1980). Most of these are transmitted to humans either directly (animal to human and vice versa), or indirectly through water, soil, air and food pollution.

In an attempt to control animal diseases and to improve agriculture, the use of chemicals in form of insecticides, acaricides, herbicides has greatly contributed to the contamination of the environment. These have polluted the environment permeating all sources to include food, water and air.

In order to understand environmental pollution, SOURCES of the pollutants must be clearly determined and their CRITICAL PATHWAYS of reaching the CRITICAL POPULATION (humans, animals or plants) be understood (source-transfer-final hosts).

Several solutions to these pollution problems have existed. These have included utilization of animal wastes for useful purposes such as rendering treatment; use of animals and plants as indicators (sentinels) of environmental pollution; proper managemental practices involving animal waste, water use; surveillance associated with well defined legislative powers; community efforts; established laboratories of quality control and availability of funds to implement these intended solutions with continuous surveillance.

SOURCES OF POLLUTANTS, PUBLIC HEALTH HAZARDS, MANAGEMENT

Discharges from Domestic Animals

(i) Food Animals:

Due to reduction in free-range grazing areas, food animals are getting increasingly concentrated in certain confines throughout much of Eastern Africa. Human population pressure, as well as large livestock populations have greatly influenced this trend. The introduction of new livestock rearing techniques of intensive nature (zero-grazing, commercial poultry/pig rearing, feedlot fattening) has also increased the concentration of food animal wastes. With average weight of 20 kilograms of dung being voided daily by an average bovine (Johnstone-Wallace and Kennedy, 1944) it therefore follows that, in cases where manure does accumulate, it will qualitatively change due to anaerobic environment. Some pathogenic organisms are found in animal manure from diseased animals or healthy carriers, as a result of excretion via faeces, urine and exudates. There is none or limited information in African literature regarding isolated pathogens in domestic animal waste; however, several efforts have been attempted in other countries in Europe and North America (Larsen and Munch, 1986; Walton and White, 1981; Diesch, et al., 1975). Bacteria such as Clostridium perfringes, Enterotoxigenic Escherichia coli, Neisseria, Pasteurella, Salmonella dublin, Staphylococcus aureus, Pseudomonas, Streptococci (group g), Erysipelothrix rhusiopathie, Mycobacterium bovis and Mycobacterium paratuberculosis, Brucella abortus, Leptospira pomona, etc. have been recovered in bovine and swine faeces and slurry (Wood and Packer, 1972; Glock and Schwartz, 1975).

Most pathogenic bacteria are only parasitic in the host and do not multiply outside the host. In the alien outside environment, they survive for limited periods of time depending on bacterial and other biotic factors. Studies on bacterial survival in the environment have been carried out in relation to disinfection [thermal, chemical and irradiation (van Donsel, et al., 1967; Mancini, 1978)] and survival under aerated and anaerobic conditions. Composting (solid animal manure) has been used as a means of decontaminating manure by way of heat produced (Plymm-Forshell, 1983). Undiluted urine has been found to kill more Salmonella due to ammonia levels and high alkaline pH compared to the one where water was added (Warren, 1962). The use of slurry (liquid manure = mixture of faeces + urine + water) as a means of disposal of animal wastes has been shown to lead to a slow exponentially related (T_{90}-Decimal reduction time) microbial reduction dependent on temperature, aeration and dry matter content in the slurry (Jones, 1976). Thus in aerated slurry with a maintained temperature, more pathogenic bacteria died. Anaerobic digestion (Biogas production) has been found very effective in inactivating most pathogenic bacteria in sludge (Carrington et al., 1983). Due to increasing loads of pathogenic bacteria being discharged by clinical and carrier livestock, it has been found increasingly necessary to use slaked lime (3%) in slurry before the slurry is spread out (Munch and Schlundt, 1983). However, this is rather expensive (quantities and environmental safety).

Pathogenic bacteria are transported to water sources by surface or sub-surface run-off from lands where wastes exist as a result of grazing animals or introduction of effluents from infected premises. It is also a risky practice to spread waste containing infectious agents on fields with growing crops, especially those intended for raw consumption (animal-manure-crop-animal/human critical pathway). Studies by Ayanwale, et al. (1982) in goats fed corn silage from a field fertilized with sewage sludge showed no significant involvement of Salmonella in infecting such goats. However this needs to be further investigated in the East African region especially during the rainy season. This is more critical since animal manure is bulky, stinks and is difficult to transport and therefore is not competitive as a fertilizer. The use of poultry manure to feed fattening cattle, has become one example of good utilization of animal wastes (Zucker, 1978).

Microbiological analysis of water is needed using coliforms and faecal streptococci as indicator bacteria of water contamination from faecal effluents (EPA, 1976); and the use of enteroviruses as indicators of water and waste water pollution (Gerba, et al., 1979; Marzouk, et al., 1980).

(ii) Companion Animals and Dead Animals:

Although dogs and cats make up most of the worlds companion animal population, many other species such as cage and aviary birds, small rodents, tortoises, and other reptiles may be found as pet animals. Pet animals especially dogs bring tremendous economic and emotional investment to their owners by being companions and protectors. Often times they are under the custody of their owners. However, in many towns, dogs and cats breed outside dwellings and control, with the resultant real population representing a major public health hazard. They are a threat through biting, transmission of zoonotic disease, Toxoplasmosis, Salmonellosis, Brucellosis, Rabies, Pasteurellosis, Leptospirosis, Cat-scratch fever; allergies due to contact; and too much noise and odour. Cadavers of stray pets in urban places are significant pollutants and are emotionally unsightly. These ought to be buried on-site, centrally; in disposal pits; incineration on-site, centrally; rendering and disinfection of the premises. All this needs organizations, transport and funds to run the service. Legislation is also needed for sanitary disposal of carcasses and proper urban authorities programme for their control, to include population control, noise control and public education emphasizing the legislative provisions (WHO/WSAVA, 1981; WHO/VPH, 1985). Particular emphasis should be placed on the control of hydatid disease, echinococcosis tapeworm in dogs. Dogs be registered; unwanted dogs eliminated; bitches be sprayed; and chemotherapy be carried out regularly. Following chemotherapy the oocysts in the dog faeces will still be viable and therefore will pollute the environment since large quantities than usual may be voided. All purge faecal material ought to be removed or burned to avoid spread of oocysts to human and other animals (FAO/UNEP/WHO, 1981). This measure to manage companion and other dead animal wastes is very expensive requiring adequate funding for transport, labour, chemicals and equipment.

Food of Animal Origin

The critical pathway by which food animals and eventually human beings get contaminated with infections or toxic chemicals, usually involves environmental contamination. Contamination of red-meat with cysticercus cysts (Taenia saginata and Taenia solium), trichuella cysts, tuberculosis bacteria, Salmonella, Listeria, Bacillus cereus, Brucella bacteria and several others, all originate from the environment. Proper disposal of human excreta, dead animal carcasses and wastes will be very essential in controlling these contaminants (WHO/VPH, 1982; WHO/VPH, 1983). Strong surveillance, veterinary inspection, good manufacturing practices, animal husbandry practices, human environmental sanitary hygiene, will go a long way in the management of infections reaching human through foods of animal origin (meat, milk, eggs, honey, fish, etc.).

Due to accidental or environmental contamination, several toxic elements and compounds may be found in the food chain involving food animals. These include pesticide residues used deliberately, toxic elements such as lead, arsenic, mercury, cadmium, copper, tin, mycotoxin, any other filth, etc. Companion animals have been used as indicators of environmental related human hazards involving toxic elements, pesticides, carcinogens, etc. (Garbe, 1988). Vector control, environmental disinfection, weed control and fertilization of soils, have continued to be human practices which attempt to control disease and improve food yield for humans. However, their safe use in Public Health is still not yet implemented due to ignorance, lack of surveillance technology or lack of alternative chemicals. Attempts must be made to use pesticides judiciously with surveillance (WHO, 1967).

CONCLUDING REMARKS

Environmental pollution by domestic animals and through activities related to the keeping of these animals is a reality. However, in the East African region, the effects of these pollutants and activities have not been critically studied. There is need to institute environmental studies to understand several aspects of domestic animals as sources of pollutants. The question is "Where are the pathogens and/or toxic elements before they reach the human being?" Obviously this begs the answer, "Domestic animals and the environment". Studies are necessary on water and soil microbiology in relation to pathogenic organisms, bacteria, fungi and parasites (eggs, vectors). Studies on food quality especially foods of animal origin to include the use of preservatives (are they safe); pesticide residues, etc. Studies also need to be carried out on the influence of animals in pollution of urban soils, parks, water and air. Coordinated funded research efforts are hereby called for and hopefully this Symposium will lead towards this endeavour as a future undertaking. I believe that there is multidisciplinary manpower (Health Scientists, Veterinarians, Chemists, Zoologists, Entomologists, Biologists, Botanists, Agricultural Scientists, Lawyers, Engineers, Legislators, Administrators, Urban Authorities, etc.) in Eastern Africa (though scanty), which could be coordinated in a cooperative effort to achieve this.

I believe too, that most of the needed equipment and laboratory materials are available in a scattered fashion; however, there is need to identify these facilities, share their utilization and encourage collaborative studies.

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Question by Prof. Zaman

In India, there was an epidemic of anthrax which caused deaths of many animals in a valley. After that epidemic the disease was difficult to control. Why was that?

Answer

In order to contain anthrax contamination, it is necessary to scoop the top soil by a layer of 6 ft after removal of the dead animals. Otherwise, anthrax spores could be there for as long as 60 years.

POLLUTION AND WILDLIFE IN EASTERN AFRICA: THE NEED FOR LONG-TERM RESEARCH

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ABSTRACT

The increase in concern of individuals and governments with the problems of the environment has often focussed on industrial, agrochemical and urban issues. It has only belatedly been realized that pollution also can have far-reaching ecological and economic effects on wildlife resources, including plants, animals and the natural environment.

Eastern Africa, with its great variety of natural habitats and high diversity of plants and animals, until recently enjoyed relatively low levels of agricultural and industrial pollutants when compared to Europe and North America. However, as the human population rapidly expands and concentrates in urban areas, and as agricultural and industrial activities become more intensive, pollution from all these sectors rapidly increases. Although the deleterious effects of various pesticides and pollutants on wildlife, especially birds, are well-known in temperate and tropical regions (Findholt, 1984; Diamond, 1984), few studies document the hazards of pollution to wildlife in Eastern Africa.

Christiansson & Ashvud (1982) discuss the potential for damage of a paper factory in southern Tanzania to nearby moist tropical forest. Ulfstrand & Sodergren (1972) sampled organochlorine residues in East African birds, and Frank et al. (1977) surveyed chlorinated hydrocarbon residues in Kenyan birds of prey. Koeman et al. (1972) considered contamination of Lake Nakuru with metals and chlorinated hydrocarbon pesticides. Bryceson & Mwaiseje (1979) examined pollution in marine habitats near Dar es Salaam, and Dubois, Berry & Ford (1985) studied the effects of catchment land use on coastal resource conservation in Kenya.

All of these studies can be regarded as short-term, and a search of the literature revealed no long-term, repeated monitoring studies on the presence of various pollutants, such as DDT, PCB's, metals, oils, plastics, etc. on animals and plants in eastern

Africa. Thus, there is an absence of baseline data against which to compare present and future findings. The lack of these data may simply indicate the absence of research organisations to meet this need, or that such long-term research, involving routine sampling at regular intervals, is not considered popular or not regarded as important by governments, researchers and funding agencies. Even if adequate national research facilities and funding existed, and base-line data were available, often only a portion of the total complex pollution problem would be available at any one site or within a single country. The problems of pollution are not limited by political boundaries, and in many cases, members of complex ecosystems are also long or short distance migrants. Examples of intra-African and inter-African migrants can be found among invertebrates and vertebrates. Birds are the best studied of the latter, but others include bats, marine fish, sea turtles, and marine mammals.

Among members of the Eastern African avifauna, many species are migrants and may pass through or even spend the boreal winter in the area (Fig. 1). Some of these are entirely carnivorous, while others are herbivorous. Some are associated with water and indeed are limited in their distribution by the presence of suitable, unpolluted wetlands.

Elsewhere, where similar north-south migration patterns are also found, concern has been expressed that while species may receive various forms of protection and be exposed to lower levels of pollution in one portion of their range, in another portion, often the wintering grounds in the tropics, such protection is lacking. For example, in North America, where many organochloride pesticides are now banned, migratory birds now acquire these pollutants on the Latin America wintering grounds (Henry et al., 1982). It is also possible that a similar situation exists for migrants which may acquire pesticides (banned in Europe but still available in Eastern Africa), metals, etc. in Africa. Conversely, it is possible that Palaearctoc ogramts to Africa carry with them ingested lead shot, thus introducing lead pollution to areas where it has been absent. Pollutants have also been found in marine mammals in remote areas far from mainland sources, and migratory marine turtles may suffer from oil pollution, ingestion of and entrapment by plastic refuse, etc. All marine turtles and most marine mammals are endangered species. Given our present lack of data about levels and effects of pollutants, the long-term conservation and management implications for populations of such migratory animals exposed to pollution are indeed grave.

Two points need to be emphasized: (1) The need to ensure sound national research programmes to monitor and act on pollution problems (2) The need to recognize that pollution in wildlife is an international problem, involving protection of animals, plants and habitats in different hemispheres under very different ecological conditions. Studies of pollution in such complex biological systems must involve long-term international scientific and governmental cooperation if they are to be meaningful.

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ENVIRONMENTAL DEGRADATION AND ITS IMPLICATIONS ON FOOD PRODUCTION AND NUTRITIONAL STATUS IN RURAL AREAS

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INTRODUCTION

Just a few years ago, the word "environment" was still only rarely used; It is now everywhere in everyday use. And for a very long time a marginal aspect of development, environment is increasingly being seen by politicians economists and planners as a central factor in economic and social problems. Environment refers to everything that surrounds us; the air that we breath, the vegetation world around us and the land from which we cultivate our crops, the seas and rivers from where we get our drinks. If there is today a deep concern to protect and enhance our environment, it is not only because it is indispensable to life in all its forms but also because it is threatened from over exploitation and pollution.

We are living in an age of technical progress that is advancing very fast and the benefits of which are accompanied by some harmful effects on mankind, as well as the environment. While it is incumbent on all of us to take part in the defence of the environment, it is necessary first of all to identify what sort of environment we talking about. For serious environmental issues in one part of the world may not be the issues at all in another. Are environmental issues in urban areas the same as those of the rural dwellers? The factory workers or agricultural workers?

In tropical Africa, we are inclined to think that the biggest environmental issues are those facing agricultural production and maintaining food security in rural areas. About 85% of the population live and work in rural areas. It is there where the problems of producing and distributing food, and the steady degradation of the natural environment are the most severe.

Each farming season several thousand hectares of arable land are cleared for cultivation and thousands of trees are felled for firewood and charcoal with serious consequences for the ecosystem.

This paper is concerned with nutritional and food production changes associated with the degradation of the environment in rural areas. These changes include settlement patterns which have effects on resource use, such as farming, grazing, fuelwood and building materials and land degradation, which encompass vegetation depletion, soil erosion and soil degradation and a lowering of water availability in agricultural soil. These developments have implications on agricultural production, cooking and eating patterns as indications of soil degradation, land cover and soil erosion not allowing food production to take place and women not being able to cook as frequently as is necessary.

The Concept of Environment

In this paper the words environment and ecosystem may be used interchangeably but with more bias and focus on vegetation, land and water in so far as they have more direct impact positively or negatively on agricultural production, nutrition and health of the rural population. Environment can be said to be the sum of total activities of land, the sun, wind, water, wildlife and other natural resources such as bacteria, livestock, and the most dominant and active component in the environment, namely the people. The above environmental components interact and affect one another directly or indirectly in a particular pattern, resulting in adverse effects. For example, the overuse of vegetation without control leads to a reduction of the level of ground water and as a result, soil erosion and degradation takes place. Such weathering away of soil or soil erosion in turn means reduced soil fertility, and hence decline in the productivity of soil. Poor soil fertility means reduction in the lands or environmental capacity to support human and livestock development and reproduction. Experience indicates that the capacity to support that sustainable production and reproduction could elude us if no drastic measures are taken at every level of society.

Scope of the Paper

After a theoretical overview of the concept of environment and the dynamic character of it various elements in the introductory part of the paper, a selection of examples of human activities and decisions which trigger some positive as well as negative impacts on the environment's balance and their effects on soil activities of the effected population will be presented. Activities such as human settlements, clearing bush for agricultural production and firewood collection are discussed in relation to vegetation depletion and soil erosion and a reduction in food production.

These aspects are highlighted to show that without rational utilization of resources on a planned basis, humanity can destroy the very basis of its own survival. The result can be social chaos and insecurity in our societies. The primary intention of the paper is to raise public awareness of the dimensions of the problem and consequences of neglect and, thus the crucial significance of maintaining a healthy environment in rural areas.

ENVIRONMENTAL CONCERN AND THE INTERNATIONAL COMMUNITY

For a long time environmental issues have been a marginal aspect of development. This is increasingly being seen by politicians, academicians and development planners as constituting a central factor in social and economical problems. In the developed countries of the North, where industrial pollution of air, land, seas and rivers, have reached alarming proportions, public interest and concern over environmental matters, have led to the emergence of ecology party organizations and development aspects now consider the question as fundamental to good planning.

In the developing countries, where ecological imbalances have posed development dilemmas and caused poverty, famine, starvation and malnutrition, the significance of the environment and its role in the development process is being recognized and understood gradually. While this remains to be the position, what must be sorted out is the type of environmental issues to be addressed as a matter of priority in each individual country, for each country may have different environmental circumstances. While the focus of environmental matters have yet to be organized, attempts have been made to create in Tanzania necessary institutions for the implementation of environmental policies, Institutions such as the National Environmental Management Council (1983) in the Ministry of Lands, Tourism and Natural Resources, need to identify priority areas in terms of the Tanzania situation.

While the need to examine pollution in areas of housing and water in the urban setting must not be overlooked, this paper would be tempted to advocate that the NEMC needs to focus its attention to the environmental aspects, that could threaten the base of agricultural production in Tanzania. Food and fuelwood production are the two major challenges confronting millions of small farmers in the rural areas.

In the meantime several non-governmental organizations have taken up the mater very seriously. However, their efforts have so far been directed at community level forestry involving tree planting around schools and public buildings. Agroforestry to enhance soil fertility, reduce soil erosion in the farms so as to increase and sustain agricultural production and at the same time minimize the excessive use of chemical fertilizers and pesticides, has yet to be started. In Tanzania, the non-governmental organizations currently engaged in tree planting campaigns include NORAD in Rukwa Region, TCRS in Singida Region, and the Irish NGO CONCERN based in Ismani area of Iringa Region.

Although environmental pollution has been with us for a long time in our houses, land and rivers, it was not until the US Conference on the Human Environment held in 1972 in Stockholm that nations began to analyze seriously the problems and take concrete actions at both national and international levels. The conference declared that:

> "the protection and improvement of the environment as a major issue which affects the well being of peoples and economic development throughout the world".

It emphasized that "protection and improvement of the human environment was the duty of the peoples and their governments."

Size of the Problems

It has been suggested that about forty years ago that such passionate concern and debates about the environment were unthinkable, let alone government be forced into action; and that if anybody raised an issue on the environment would have been considered a very serious candidate for a mental institution. But today these issues are real.

- Our planet is becoming overcrowded.
- The ozone layer, which protects the earth's surface from ultraviolet flux of the sun is believed to be depleting as a result of pollution.
- Lead which emanates from the fumes of motor vehicles is increasing in the air we breath and this constitutes a great health hazard, especially to children who are particularly vulnerable to it. Lead is believed to retard brain and development.

- Iodine trace element which prevents the occurrence of goitre is slowly disappearing from the soil as a result of erosion and deforestation in some regions. Like lead, iodine deficiency in the diet causes the disease goitre and it interferes with proper metabolism of the thyroid glands. It also interferes, with proper growth.

Goitre incidence is very serious in Rukwa Region of Tanzania. A Study conducted by the TFNC (1983) showed the incidence of the disease as ranging between 62% to 95%. The distribution of iodine deficiency by district were as follows:

Sumbawanga	78.6%
Nkasi	80.9%
Mpanda	69.5%

While Rukwa Region is deficient in iodine content, Kilimanjaro and Arusha Regions have excessive fluorine. Too much intake of this micro-nutrient in the diet leads to the mottling of teeth. The implication of this on the health of the affected people is not clear.

Carbon dioxide concentration in the atmosphere have reached high levels as a result of increasing use of fossil fuels and forest clearing.

River pollution, through discharges for toxic wastes and industrial effluents have made rivers, very unsafe for human consumption. The rapid disappearance of trees and grasses through over-cutting and grazing is threatening agricultural production and proper nutrition in rural areas.

<u>A question of willingness</u>

There is already enough evidence to suggest that there is an increasing awareness of the issues at stake. But the task ahead seems formidable and the question is whether humanity has the ability and the will to face it. The issue is no longer scientific for there is already enough scientific knowledge about environmental pollution and its protection. What seems to be the big issue is the will to act.

In a situation where developing Countries are engulfed in economic crisis, the issue of environment may not get the attention it should get. Areas for attention that could be the impediment are social and political. International cooperation is important because the atmosphere, the seas and rivers are the properties of all nations: air, wind, fish etc. have no boundaries.

The same is true in the area of food production. A destruction of vegetation in a nation leading to a decline in agricultural production affects other nations directly or indirectly. Importance of regional agreements on environment is therefore necessary for sustainable development. For example, the exploitation of resources in Lake Tanganyika and Lake Victoria can be undertaken jointly by countries that are found within the catchment areas of those lakes.

PROPOSITIONS

Environmental matters are not issues which affect seriously the rich. They are first and foremost a matter for the poor people of our societies. It is this respect that the paper underscores the following propositions on the environmental question in the developing world:

- That environmental protection leads to development.
- That environmentally unsound developments hits hardest at the poor people in poor countries.
- That environmental degradation resulting in damage to soil, rivers, forests and vegetation, can be a major source of political and military instability leading may be to revolution and perhaps war.
- That there is need for public debate, understanding and cooperation among nations on environmental issues in order to enhance sustainable development.

The Poor, Water, Forest and Land

To illustrate areas in which the poor are hardest hit we take the cases of water, forest and land. If many of our rivers streams, pools and lakes are polluted by pesticides, industry or sewage, it is the poor who are directly poisoned or who suffer from diarrhoea. The rich have their own taps, filters or private wells. If very few vegetation and trees are left, the poor must walk further and further, and sometimes hours a day to gather firewood. This exercise affects the frequencies of cooking and sometimes also the types of food cooked. The nutrition and health of the poor suffer consequently. There is evidence to show that serious under-nutrition occurs in rural areas. The most affected are women and children.

In the case of land, which is perhaps the most fundamental natural resource of all - when the land is damaged, polluted, washed away in the rain, it are the poor who are pushed even further onto marginal land, which in most cases is too barren to cultivate or too steep or swampy to build a decent home. Land fertility and forest clearance can worsen the situation. When tropical forest is cleared for large-scale agriculture, the top soils wear out. The soils on which most rain forests grow are poor and infertile, with 95% of their nutrients held in vegetation. And once the trees are gone, crops can only be grown, or cattle grazed for a few years before yields drop so low as to be valueless. Large-Scale clearance of forests for timber or agriculture, can usually be controlled by government action and policy regulations, if the political will exists.

Poverty, Revolution and the Superpowers

It is suggested that an environmentally sound development needs to understand the links between population, resources, environment and development. As population grows and the environment deteriorates, poverty deepens and desperate people search for a way out. It is perhaps not surprising that the rate of urbanization is rising very fast in the developing countries. These are environmental refuges leaving the rural areas whose ecological base is being gradually damaged to an extent that it can no longer support its growing population. A look at our national statistics indicates that African Countries are producing such refugees at an alarming rate. "Some Countries are reported to be having the figure of about 40% of the total population" this trend, if not checked could lead to environmental revolutions and wars.

The above phenomenon could easily be exploited by the ongoing superpower rivalry in the developing world, directly or indirectly, through their client Governments. In Central America, for example, the super powers have been turning into an internationally military crisis, whose fundamental causes are largely environmental. Present US involvement in Central America started in El Salvador, where the US has been assisting the Government in a Civil War against a purely peasant based guerilla movement.

A 1982 report prepared for USAID on El Salvador reported almost complete deforestation, massive soil erosion and loss of soil fertility, siltation threatening hydropower development, large-scale extinction of flora and fauna, diminishing groundwater resources, deteriorating water quality and widespread health-threatening environmental pollution. The majority of El Salvador's population is hungry, illiterate infested with parasites, malnourished, poorly housed, under-employed and has little opportunity for self-improvement. This environmental phenomenon leads to social unrest and insecurity.

The above account shows that it is impossible to prevent social unrest, political turmoil and perhaps war if the degradation of the base of a country in natural resource is allowed to continue unchecked. In this regard a US environmentalist Peter Thacler, former Deputy head of the UN Environment Program is reported to have put it plainly to the World National Parks Congress in Bali in 1982.

> "The ultimate choice is between conservation and conflict. Trees now or tanks later. The choice for governments is either to find the means by which to pay now to stop the destruction of natural resource base or to be prepared to pay later, possibly in blood".

The question of environmental protection in order to sustain agricultural production and health is a real problem in tropical Africa in the contemporary times. Tanzania has been chosen to illustrate the seriousness of the situation.

TANZANIA AND THE ENVIRONMENT ISSUES

Human Habitat, Wood fuel Crisis and Environmental Degradation in rural Areas

Like in the case of the majority of farmers in the tropics, food and fuelwood production are the two major challenges confronting millions of small farmers in Tanzania. Demands for these two crucial based life requirements have recently increased due partly to the unprecedent levels of population growth in both rural and urban areas; and also partly to the massive human settlements policy of villagization which was carried out in early 1970's in Tanzania.

The concentration of the population in designated areas meant a shift from extensive cultivation to intensive methods. Suitable land for increased production of the two products has correspondingly increased and has resulted in encroachment into marginally productive land. The overall result of population pressure on land has been the decline in soil productivity compounded by improper crop production methods.

Massive injudicious destruction of trees and forests in an attempt to put more land under crop production is one such method that has led to the decline in land

productivity and fewer trees for firewood. Soil erosion on a massive scale from uplands where most crops and forests are grown has consequently occurred with subsequent siltation (Mtera Dam in Iringa is a point). The resulting floods have led to heavy losses of both human life and properties (frequent incidence of Rufiji river basin).
It seems logical that trees, and crops should co-exist for sustainable agriculture to take place. They did, and that is the reason why our forefathers were able to produce food crops and forest products albeit at low levels without degrading the productivity base. Recycling of nutrients and maintaining low levels of soil losses have been the major contribution of trees in maintaining a stable crop production environment, as long as human settlements were kept under control.

Between 1969 and 1976 the Tanzania state gathered the rural population into Ujamaa Villages. There are today well over 8000 such villages in the rural areas. About 85% of the national population lives in these villages. The purpose of the exercise was to let rural population live and work together for their common good. the main aim was for them to increase food production. While the superiority of this exercise in social organization has been acknowledged, it is, however now recognized that the exercise has had some adverse effects on vegetation degradation. A study conducted by Kikula (1986) in the Mufindi District of Iringa Region has shown that the movement of the rural population during the Villagization Programme had a negative impact on vegetation as well as soil fertility.

So as thousands of small farmers were brought together into villages the need for intensive farming and the use of new farming techniques and technology became imperative. The first to be depleted were the vegetation resources around settlements, because of the concentration of population. This is because generally the nearest source of forest products (for woodfuel and building materials) tend to be utilized before those placed far away (Kikula and Nilsson, 1982). A similar principle appears to apply to other land resources (Morgan, 1969 and McCall, 1985). The second to be depleted was soil fertility. This situation ushered in the extensive use of chemical fertilizers in an effort to increase food production.

Since 1976, at the instigation of the World Bank, a new technology in the form of hybrid maize was introduced into the Tanzania agricultural system. This exercise was also accompanied by the application of chemical fertilizers and pesticides. While the use of the new technology has been adapted (Mascarenhas, 1986) and has contributed to a tenfold increase in food production between 1976 and 1985 in Rukwa Region, the negative impacts on the environment is now being felt by the small farmers. According to oral discussions by the author with agricultural officers in Sumbawanga, the region has about 60% fertility. Since Villagization and the use of chemical fertilizers, this fertility is exhausted and cannot give any good yield without the application of fertilizers. Unfortunately many farmers are now not able to use fertilizers as they cannot afford the high prices. Because of the state of the soil, yields of maize crops are declining.

The introduction of the new technology has meant changing habits in farming systems, eating habits and nutritional status among rural population. In the Southern Highlands Regions of Iringa, Mbeya, Ruvuma and Rukwa, maize has replaced millet as the staple crop. It is suggested that the prevalence of malnutrition in Rukwa Region is attributed partly to the changed farming and eating habits. The above situation is even further aggravated by the woodfuel crisis in the rural areas.

The Woodfuel Crisis and the Rural Poor

Traditional sources of energy provide approximately 85% of total energy consumption in East Africa. The main energy source is fuelwood and to a lesser extent its derivatives charcoal (Nkonoki, 1989). Trees are the main source of fuel in rural areas, where all households use fuel from local vegetation as the principal energy source (Kikula and Nelsson, 1982). According to a survey conducted in Rukwa Region, fuelwood is used for domestic purposes such as cooking and heating. Otherwise it is also used in crop processing, as in tobacco curing, beer brewing, making pottery, fish smoking, brick making, and in other small scale, rural based industries, especially metal works.

The availability of wood in East Africa is a crucial matter because nearly all the rural based populations use fuelwood almost exclusively for cooking and heating. The intensive use of firewood has contributed in part to serious environmental degradation in the form of deforestation and subsequent soil erosion and poor soil fertility in some parts of East Africa, notably in Northern Kenya, Central and Northern Tanzania and in the Karamoja areas of North Eastern Uganda.

This environmental catastrophe is aggravated by overgrazing by livestock, sporadic bush fires, uncontrolled felling of trees, declining water tables, draught and other factors. Some of the badly affected districts in these areas mentioned above are very close to being deserts and will certainly turn into deserts if urgent remedial steps are not taken to rescue the deteriorating trend. The implications of this development on food production and fuel supply and nutrition cannot be overstated.

In Tanzania for example, Mwandosya and Nkonoki (1984) estimated that 206,000 hectares per year of new forests or trees were needed to offset deforestation. Over the past ten years, afforestation efforts, in the country have been going on beginning with 3280 hectares of trees planted in 1975 and rising steadily at an average annual increase rate of 20% to a maximum of 15,000 hectares planted in 1983. Obviously, this level of afforestation, encouraging as it is, is much too small compared to the target of planting 206,000 hectares per year. The performance compared to the target was only 0.07% (ibid).

The Woodfuel Crisis and Nutritional Status

Increasing scarcity of trees in the rural areas does not only affect soil fertility and food production. It directly affects nutritional status and health of the rural population, especially of women and children. Fuelwood is the main forest product used by women. It is the main source of energy for about 90% of the population and is used primarily for cooking and in some cold places for heating houses.

Looking for firewood is often a difficult task for women in rural areas. Because of the scarcity of tree products in some areas, due to deforestation, women have to walk long distances year after year in search of fuelwood, losing more time and muscular energy in the process. In 1982 in Mufindi District, the maximum distance to the fuelwood source was 5 km. one way (Kikula and Nilsson, 1982) and in 1984 it had increased to 7 km for fuelwood and up to 8 km for building materials. Elsewhere in Tanzania people collect fuelwood from as far as 9.6 km, having started off at less than 5 km (Kikula et. al, 1983). A study conducted by Mnzava (1985) in Singida Region, showed that a round trip in search of firewood may be as long as 8-10 km in semi-arid areas.

A similar study conducted by the Forestry and Beekeeping Division in 35 Villages in Arusha, Dodoma and Singida Regions showed that where there are little firewood problems, women spend less than two hours to collect firewood. However, in areas with acute shortage of firewood, they spend over five hours. Where sources of firewood are extremely scarce as in parts of Mwanza, Mara, Shinyanga and Arusha Regions, alternative sources of energy such as cow dung and crop residues are used. In Busongo Village in Shinyanga region, for example, women use sisal stalks, cotton stalks and cow dung for cooking. During the dry season, they collect and pile cotton stalks and then let them dry for use. Cow dung is used for cooking hard-to-cook foods such as beans and mixed maize and beans.

The fuel situation described above has had negative impacts on the frequencies of cooking in most rural households of the seriously affected areas. In other parts of the country where fuelwood shortages are so severe, families prepare only one cooked meal a day, and because of the high fuel usage involved beans are no longer frequently cooked as in Nyumingura Village (Mara Region) and Arkatan Village (Arusha Region) (Forest Division, 1984). Beans are the main source of protein in the diet of the rural population. Lack of it can be a source of malnutrition in the population, especially among children.

The above account leaves us in no doubt that environmental degradation can and does have serious impact not only on agricultural production but also on women and nutritional status of the affected population. Food shortages, famine, starvation and under-nutrition that affect the rural poor are environmental issues, the solution of which must be sought in the context of environmental protection.

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A PHYSICAL MODEL FOR LEACHATE ATTENUATION POTENTIAL USING GLACIAL SANDS

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ABSTRACT

Leaching experiments were conducted for about three weeks at room temperature using undisturbed five U_{100} tube samples, containing glacial deposits collected from both saturated and unsaturated zones at sites close to the disposal site.

Only inorganic ions in both the effluent and influent leachate were chemically analyzed. Heavy metals and alkaline earth elements were analyzed using atomic absorption method. Sulphates and ammonia as nitrogen were determined on an Ultra-Violet Visible Spectrophotometer. Alkalinity and chlorides were determined by titration method. Break through curves were then constructed on arithmetic scale. Attenuation of heavy metals were found to be possibly attributed to a combination of processes including sorption and precipitation. The order of attenuation as observed on break through curves was Cu > Cr > Cd > Zn > Ni. Dissolution was observed that leachate attenuation was possible under the experimental conditions.

It is, therefore, concluded that the industrial chemical liquid waste disposal sites could easily be selected after studying the sub-surface geology.

TREATMENT AND RECYCLING

EFFLUENT RE-USE FROM INDUSTRIAL SEWAGE TREATMENT PLANTS FOR PROTECTION OF WATER SOURCES POLLUTION

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INTRODUCTION

Industrial sewage may be treated by conventional or non-conventional methods of sewage treatment; sometimes combined methods are also applied.

Effluent from treatment plants is commonly discharged directly to receiving bodies such as rivers, lakes, and the ocean. Frequently treatment plant designers assume a perfect operation, without consideration of how the effluent will be disposed during power failure or technical problems that may arise at the treatment plants. Choice of proper technology of industrial sewage treatment is also a problem which results on discharge of effluent partially treated or as raw sewage to water sources. Even though industrial sewage is treated to acceptable requirements, still it imposes problems of pollution to water sources. Discharging sewage which is partially treated to acceptable requirements results in ecological imbalances of water sources, health risks to the users of the receiving body, environmental pollution and high costs of water treatment when the receiving body is opted as a source of water supply for community. If the assimilation capacity of the stream is low it may result in dead stream.

The reuse of effluent is not only economically important but it increases the quality of the aquatic environment. On that basis it acts as a tertiary treatment of sewage. Reuse of effluent removes other constituents of sewage which are not removed by treatment plants or only removed at a minimum level. The reuse may be by recycling, for cooling purposes, irrigation and aquaculture, prevention of stream pollution by effluent can be achieved if the programme of reuse is incorporated from an early stage of industrial planning.

Evaluation for the feasibility of the industrial effluent reuse must be based on the contents of the sewage after treatment. While the evaluation of effluent for the reuse on prevention of source pollution has to be based on the quality of effluent after reuse. The technology of reuse should be simple, more efficient on pollution control, and affordable at the particular place.

Textile mills depend upon various types of raw materials in the processes of realizing the finished goods. The fiber used for industry may be, raw wool, cotton, man-made wool, cotton-viscose-rayon, and other man made fibers. A knowledge of raw materials, chemicals, and final products is indispensable for waste water management. The volume of flows from each step in the process, the strength of the chemical characteristics, temperature, source and variation in flow are the details to be obtained. Industrial sewage should be treated by the method which will reduce the receiving body's pollutants to minimum concentration.

Waste-water Treatment From Textile Industries In Tanzania

There are several textile industries in Tanzania located in different regions. The main sources of waste waters from textile industries depend on the production units. The various processes yielding the waste water are: Scouring and washing, slashing, cooking, de-sizing, bleaching and retting of flax, hemp and jute, mercerizing, chemical treatment, dyeing, printing, finishing and others. Other sources of waste-water are from garages and toilets. The flow diagrams below show several sources of liquid wastes from textile industries.

Table 1.0 shows the methods of sewage treatment and effluent disposal from textile industries in Tanzania. Most of the textile industries are located in towns. They use common materials (input) for productions, thus the layout of the production units are similar.

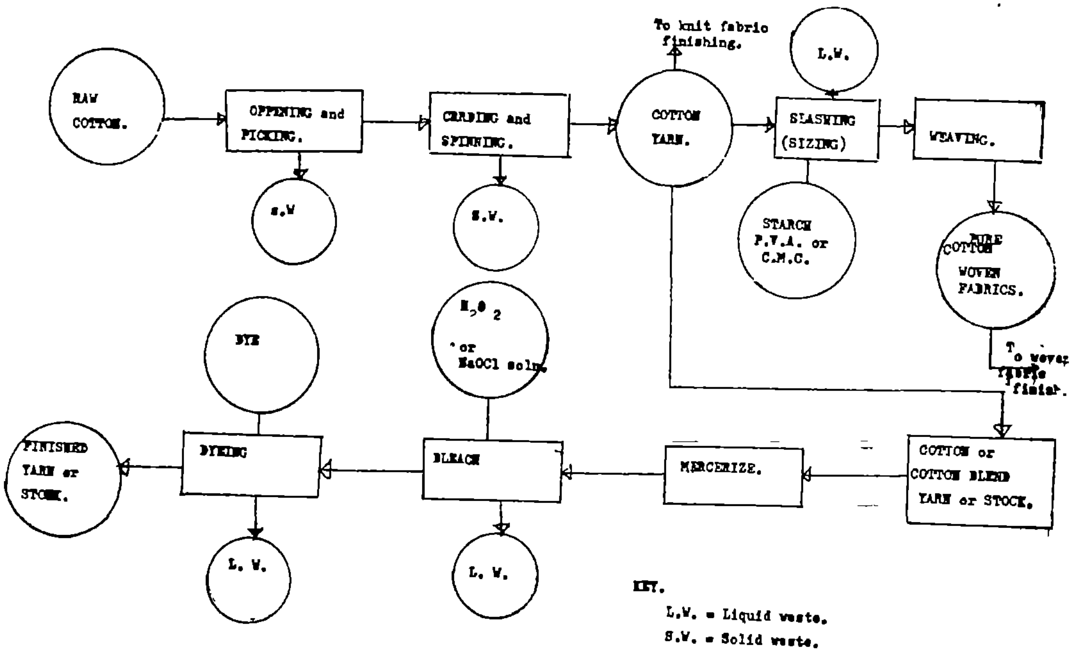
Untreated sewage pollute the receiving bodies due to presence of high concentrations of BOD, COD, dissolved solids, colour, suspended solids, copper, zinc, oil, grease, acids, alkalis, and other common pollutants from textile industries. These pollutants upset the natural conditions of the receiving bodies, resulting into odour and unpalatability of water. They also cause high sedimentation, turbidity, oxygen consumption, toxicity, temperature change and bad smell due to anaerobic oxidation of wastes in the stream.

Experience has shown that analysis on the biological purification capability of the receiving bodies is not done before the discharge of waste-waters. Pollution reveals when there is a need of using the stream for urban water supply, of which if, it is to be used as a source, then its treatment may be high costing.

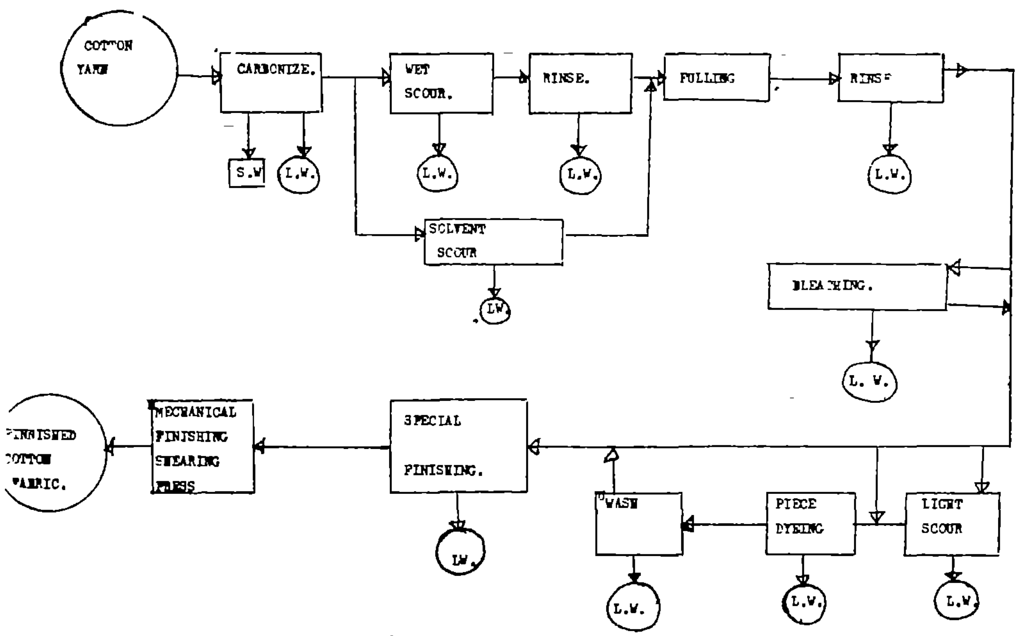
Table 1.0 Location of textile industries in Tanzania.

Industry	Region	Method of sewage treatment	Disposal of effluent
Urafiki	DSM	None	Msimbazi Stream
Sunguratex	DSM	None	Msimbazi Upstream
Kiltex	DSM	None	*******
Mutex	Mara	None	Lake Victoria
Mwatex	Mwanza	Ponds	Open Channel
Kiltex	Arusha	*****	Temi River

***** Not visited.



PRE TREATMENT OF COTTON DYEING AND FINISHING



FABRIC FINISH.

The types of impurities discharged from various units of operations in the textile mills include: waxes, natural fats, starch, enzymes, acetate, bleaching agents, sodium carbonate, sodium chloride, hydrosulphite and sodium sulphate..

The typical characteristics of sewage from industries which use cotton as raw materials for production is as shown in Table 2.

Table 2: Textile wastes - Typical Characteristics

Source	Total Water Usage L/Kg	pH	Total Solids mg/L	Suspended Solids mg/L	COD mg/1	BOD_5 mg/L
Cotton+ Woven Fabrics	60-500	8-12	500-2000	50-250	100-500	100-200
Cotton/ man-made woven Fabrics	60-500	6-9	200-2000	50-200	100-1000	100-500

Methods of Textile Waste-water Treatment

Based on the characteristics of the wastewater from textile mills the following methods are applicable prior to disposal or effluent reuse. Table 3 shows the various alternative treatment units.

Table 3: Treatment methods of waste-water from textile industries.

Treatment method	BOD Loading	Retention time	Efficiency of BOD removal %
Anaerobic contact process	3-12	6-12 hours	90
Extended Aeration	0.03-0.18	1-5 days	95
High rate process	1.5-7.0	2 hours	50-70
Activated sludge	0.3-1.2	0,3-1.2 hours	90
Anaerobic ponds	240-320 Kg BOD/1000m^3 pond volume	7-10 days	85
Anaerobic Filters			
Stone media	0.24-8.2 Kg BOD/m^3d.	*******	75-80
Plastic	80.5-140 Kg BOD/m^3d.	*******	48-81

Dyes may be removed by the use of chemicals such as lime and aluminium sulphate. These remove acid black, dispense blue, reactive red and direct blue.

Control of Pollution from Textile Industries

Based on the concentration of waste-water and on the regulation of protection of sources, textile industries have to treat the sewage before these are discharged into streams or any other receiving bodies.

Two methods may be used to control the pollution due to textile waste water mismanagement.

A. Internal Measures For Pollution Control. This may be done by any of the following ways:

- Change of production processes
- Water reuse
- Recirculation of cooling water
- Separation of different types of water
- Control of accidental discharge and
- Smooth water flow.

B. Industrial wastewater treatment by:
Mechanical treatment (sedimentation), Chemical treatment (precipitation, neutralization, and ion exchange), and biological treatment (oxidation ponds, trickling filters, and activated sludge).

Separation of different types of water is important; Sewage from toilets is to be separated from industrial sewage to reduce complication on microbial removal during treatment.

Effluent Reuse:

Reuse of waste-water from textile industries may be divided into two categories.

Category I: In Plant Reuse:

Wash-water-recycling is considered as in-plant reuse. Economical reasons which lead to a recycling of water may be an urgent water deficit. Ion exchange or sedimentation may be used to treat wash water before reuse because it contains settleable or dissolved solids at high concentrations. The waste-water from cooling may be reused for washing, toilet flushing and for dilution purposes. The only treatment required is aerating in open channels that may help to reduce the temperature of cooling water. The channels should be designed to allow gravity flow.

Category II: Effluent Reuse From Waste-water Treatment Plants

The effluent from waste-water treatment plants may be used for irrigation and aquaculture. Quality of effluent from treatment plants will guide on the type of crops to be irrigated. Plants take the basic nutrients from water for growth thus reducing the concentration of pollutants in the effluent.

Soil helps to purify the effluent by physical, chemical, and biological mechanisms in soil. Characteristics of soil should be known before the application of the effluent to it. The source of effluent for irrigation may be from the outlet of the last treatment unit or the outlet of the fish ponds.

Fish ponds reduce the pollutants in effluent from the main treatment plant by prolonged retention time in the fish ponds. Also fish requires various nutrients from water. After irrigation or aquaculture the effluent may be disposed in the streams.

Merits of Effluent Reuse:

- Standard methods of environmental management
- Increases the fertility of the soil
- Sources of income for maintenance and operation of waste-water treatment units.
- Reduction of water treatment costs and maintenance of the ecological balance of the receiving bodies and the soil.

RECOMMENDATIONS

- Disposal of textile treated wastewater and raw sewage has to be reviewed in order to prevent pollution of receiving bodies.
- Effluent analysis from various industries should be conducted in order to know the concentration of pollutants and to advice the responsible industries to take measures of treating the sewage.
- Industries should not dispose effluent to receiving bodies when it is known that it will upset physical, chemical, and biological activities in the streams.
- When the assimilation capacity of the streams are not know then industries should not be allowed to dispose effluent.

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POSTER

ANAEROBIC WASTEWATER TREATMENT: A POTENTIAL TECHNOLOGY FOR DEVELOPING COUNTRIES

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SUMMARY

The performance of any reactor used in anaerobic wastewater treatment largely depends on the microorganisms retained in the reactor. In this study the effect of glucose on growth of microbial biomass and their activity was monitored over a period of 49 weeks in an upflow anaerobic sludge blanket (UASB) reactor. Reactor performance was monitored in terms of biogas production, degradation of volatile fatty acids (VFA) in the feed media and degradation of individual VFA in batch culture. Glucose increased sludge growth though it did not significantly increase the activity of the sludge. Preliminary investigations carried out to determine the environmental conditions of the site from which the sludge was collected revealed the presence of Methanosarcina and Methanothrix species in the sludge.

INTRODUCTION

Despite the current problems facing developing countries, like disposal of wastes generated by society and the need for fuel to satisfy energy needs of the society, substantial amounts of organic matter are discharged into the environment causing fast deterioration of surface waters. However, anaerobic wastewater treatment can concurrently solve the two problems as in this treatment organic matter in wastewaters can be converted into biogas (methane and carbon-dioxide) with little microbial biomass formation (Zinder, 1984), which can easily be disposed off or be used as a fertilizer.

In most developing countries, irrespective of the importance of public health, wastewater treatment gets little priority. However, increasing population which is accompanied with increases in water consumption, eventually creates hazardous pollution of the environment and especially water sources. In some developing countries efforts are being made to protect the environment and produce energy. In china (Zhao-Yi-Shang and Wu-Li-Bin, 1988), 5 million household anaerobic digesters and 10,000 large and medium sized digesters are now in operation to treat domestic, agricultural wastes and wastewaters from factories and cities. Biogas produced is used by city residents and rural farmers. Some of the other developing countries whose progress in anaerobic wastewater treatment has been reported include Brazil (Vieirra, 1988) and Colombia (Kooijmans et al; 1986).

Anaerobic wastewater treatment largely depends on the retainment of a consortia of microorganisms (bacteria) which can convert organic pollutants in the wastewaters to biogas. Since the retention time of wastewater in the reactor is directly correlated with reactor size, it is economically attractive to operate the reactor at short hydraulic retention time (HRT).

However, if the HRT is shorter than doubling times of the microorganisms, they would be washed out of the reactor. The UASB can, however, retain the microorganisms at a HRT of about 4 hours with little microorganisms wash out (Lettinga et al;1980). The retainment of bacteria in the UASB reactor largely depends on conglomeration of biomass in the reactor into granules with high settling velocities. Because of the good settling properties of the sludge and the upflow mode application of the reactor, a short retention time of the wastewater and a long microbial biomass retention can be combined. It has been reported that sludge fed with VFA - carbohydrate medium resulted in formation of granules (1-5 mm) with high activity and settleability (Hulshoff et al; 1986). The UASB reactor is simple, inexpensive and can be used at relatively low temperatures to treat both low and high strength wastewaters and has gained wide application in developed countries (Lettinga et al; 1980). The UASB reactor is currently being introduced in developing countries and this could also prove to be an "appropriate technology" in these countries.

MATERIALS AND METHODS

Sludge from Msimbazi river, in Dar es Salaam (where the tributary from Tanzania Breweries just crosses Morogoro Road) was used as an inoculum in two parallel UASB reactors (1.8 l each). Reactor one (R_1) was fed with synthetic wastewater of composition, 3:1:1 $g.l^{-1}$ of acetate, propionate and butyrate, respectively and 10 $ml.l^{-1}$ minerals nutrient solution. For reactor two (R_2) in addition to the feed of R_1 0.1% glucose was added. Sludge growth was monitored by noting the increase in sludge volume in calibrated reactors.

Biogas production was measured daily, by acidified tapwater displacement in a calibrated mariotte bottle. Degradation of volatile fatty acids analysis was by gas chromatography using isobutyric acid as an internal standard and nitrogen as a carrier gas at a flow rate of 33 ml per min. Oven, injection and detector temperatures were, 130, 170 and 175°C respectively. Degradation of individual VFA in batch cultures was determined by inoculating 1 ml of sludge from the reactor into serum bottles containing either acetate, propionate or butyrate 1 gl^{-1} each; filled to 3/4 total volume with mineral salts buffer solution. The serum bottles were then flushed with nitrogen. Thereafter VFA concentration was measured at time zero and after every two days for a period of 8 days by gas chromatography.

RESULTS AND DISCUSSION

Preliminary investigations of the environmental parameters of the sludge collection site showed that, the pH range was 5.6-6.9, water temperature (day time) 28-30°C, average flow rate, 6.0 x 10^2 m^3 hr^{-1}, rate of settling of the sludge, 30 m hr^{-1}, specific conductivity, 7.0-1.5x10^2 s cm^{-1}; methànogenic composition, mainly Methanosarcina and Methanothrix species as revealed by Lietz epiflourescence microscopy.

The change in sludge volume during the experimental period is shown in Fig. 1. It is evident that presence of glucose in synthetic wastewater increased sludge growth and granulation. Sludge granules of R_2 varies from 0.2-3.4 mm and the average value was 1.75 mm. For R_1 sludge granules varied from 0.2-3.4 mm and the average value was 0.97 mm. R_1 sludge volume decreased after day 290 while that one of R_2 continued to increase. The probable explanation is that, R_1 sludge disintegrated and was washed out due to poor granulation as it could not withstand biogas production and upward movement of the feed. In R_2 granules are spherically packed; biogas produced and feed moves up easily through the sludge bed interstitial spaces.

Biogas production and degradation of VFA over the experimental period are shown in Figs. 1, 2, 3 and 4.

It can be seen from the graphs that steady state was reached at day 160 in case of R_1 and at day 220 for R_2. This effect may be due to the fact that glucose favours growth of the fast growing acidogenic bacteria which in turn form more metabolic products (VFA) that inhibit the growth of slow growing methanogenic bacteria.

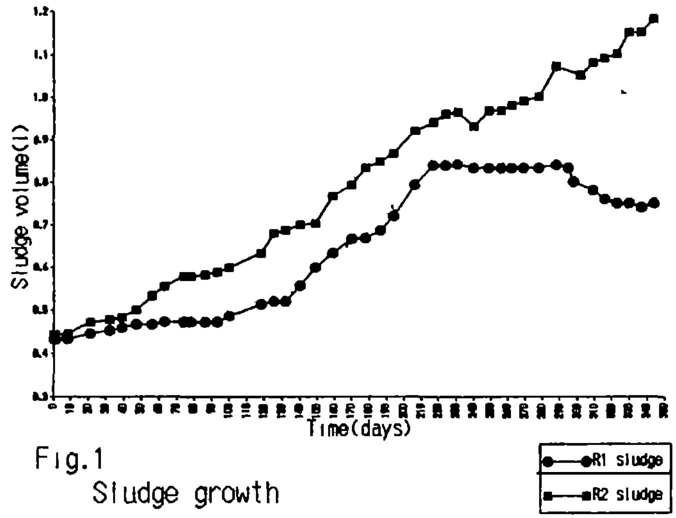

Fig.1
Sludge growth

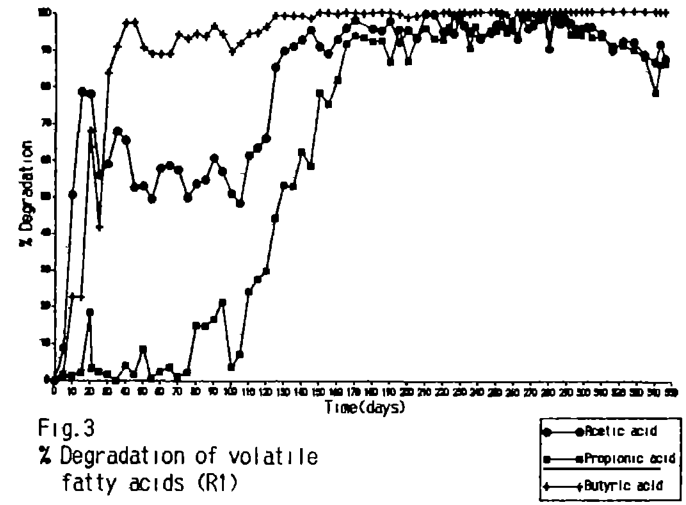

Fig.3
% Degradation of volatile fatty acids (R1)

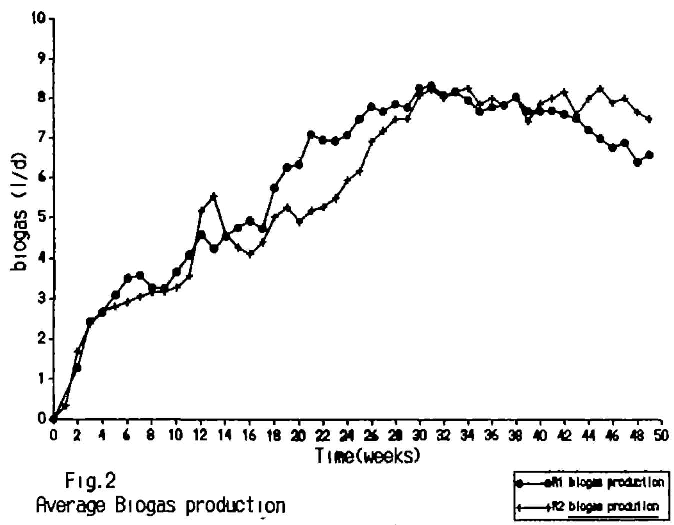

Fig.2
Average Biogas production

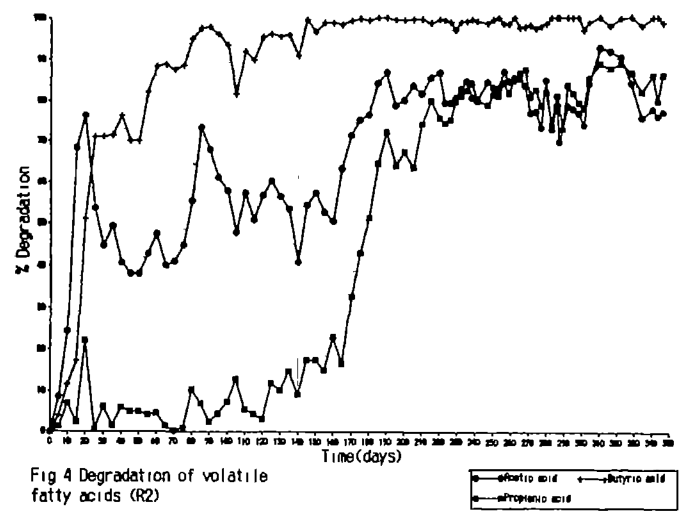

Fig 4 Degradation of volatile fatty acids (R2)

Towards the end of the experimental period, a slight drop in biogas production and degradation of VFA in R_1 was observed. This may be attributed to a decrease in sludge volume which might have been due to wash out of the bacteria from the reactor. It is also evident from Figs. 3 and 4 that the degradation efficiency of VFA is always lower in case of R_2, in particular for acetate and propionate degradation. Since, in addition to acetic acid and propionate in the feed, additional VFA are being formed from glucose, the high loading rate may be the reason why degradation is slightly lower.

The results of the specific activity test are shown in Table 1.

Table 1: Specific activity of the sludge.

	mM OF VFA DEGRADED PER *gVSS PER HOUR		
Reactor	Acetate	Propionate	Butyrate
1	0.992	0.496	0.850
2	0.767	0.333	0.718

* gVss = gram of volatile suspended solids.

The results indicate that the rate of degradation of individual VFA per gVss is generally higher in case of R_1 than in R_2, despite the fact that the difference is not significant at a probability of 0.05. This may be due to the presence of more active microorganisms which are involved in VFA digestion in R_1. In both reactor sludges, propionate is difficult to degrade and this was also observed in Figs. 3 and 4. The observations might not only be due to inhibition by acetate, but also due to the slow growth of the propionate degraders.

CONCLUSION

Since glucose increases sludge growth and its granulation and does not significantly lower its activity it can be used to acclimatize raw sludge. This could solve the problem of reactor start up whereby inoculum is obtained from full scale operational reactors. As in most developing countries, where anaerobic wastewater biotechnology is just beginning this could be a solution to avoid expensive importation of sludge. Anaerobic wastewater treatment biotechnology is promising in developing countries as it concurrently reduces the pollution load and produces energy in form of biogas.

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POSTER

RE-USE OF ORGANIC WASTES THROUGH COMPOSTING

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ABSTRACT

In Eastern Africa a lot of organic wastes of plant origin are produced from agricultural activities. Usually the wastes are just dumped without being treated and thus causing pollution of the environment. Composting of the organic wastes could not only reduce the danger of polluting the environment, but also produce a useful product, the compost. The compost so produced, could be applied to the soil as an organic fertilizer, also so as to improve soil structure. Alternatively, mushroom compost could be produced from the organic wastes for the cultivation of an edible mushroom.

INTRODUCTION

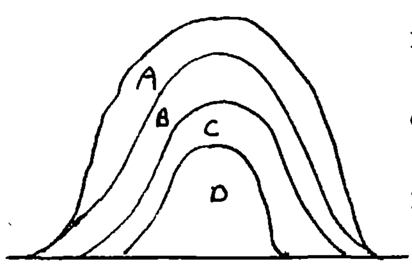
Human society through their industrial, agricultural and domestic activities, produces large amounts of organic wastes. For us in Eastern Africa, the major organic wastes are of plant origin from agricultural activities. They include maize, rice and wheat straw, animal manure and vegetable remains. In cities like Dar es Salaam, the amount of organic wastes from homes and at market places is enormous. Usually such organic wastes are dumped without being treated and pose an environmental pollution problem. Composting of plant residues could provide a method of reducing the pollution load and at the same time returning essential nutrients present in the waste to the land. Through composting, all the organic wastes can be converted into a non-polluting and useful product, the compost (Ross 1971, Chanlett 1973). This will maintain soil productivity and will reduce dependence on chemical fertilizers. In Tanzania at the moment, no composting is practiced.

COMPOSTING PROCESS

Aerobic Composting

The composting process is mainly an aerobic and partly an anaerobic biological process in which moistened vegetable matter is placed in a heap or pit and converted through fermentation and rotting into a stable product, the compost. The basic principle involves a mix of organic material, bacteria and oxygen to allow rapid decomposition (Kupchella and Hyland 1989). Soil organisms involved in the composting process include microorganisms such as bacteria, fungi and protozoa, and invertebrates such as earthworms, nematodes and flatworms.

During composting, the carbon part of the organic wastes is converted to CO_2 and/or CH_4. Nutrients like N, P, S etc. are preserved through the process of composting and become more concentrated. Some of the nutrients become absorbed on the cellulose fibers of the organic wastes, while others are accumulated in the form of microbial biomass. During the mineralization of organic matter by microorganisms, much heat is being generated. Temperatures in the composting heap may reach 80°C, (Wistreich and Lechtman 1988) thus destroying seeds of weeds and pathogens in the decomposing organic wastes. From time to time, the compost heap has to be turned inside-out and then piled again, so as to have uniform decomposition.



A. Outer, cool and dry zone (with ambient temperature)

B. Zone with Actinomycetes (Temperature 51 - 60°C)

C. Hot inner zone (Temperature 65 - 70°C)

D. Anaerobic zone (Temperature - about 48°C)

Figure 1: Zonation in a compost pile

Anaerobic composting

Anaerobic degradation of organic matter occurs in closed tanks in the absence of oxygen and results in the formation of CH_4 and CO_2 (Biogas). At present, this technology is almost exclusively practiced for the conversion of animal manure in order to produce biogas. If plant organic matter would be used in the process, also compost could be produced by anaerobic digestion (Fig. 2). An advantage of anaerobic composting is that part of the carbon is reduced to methane which can be used as a fuel.

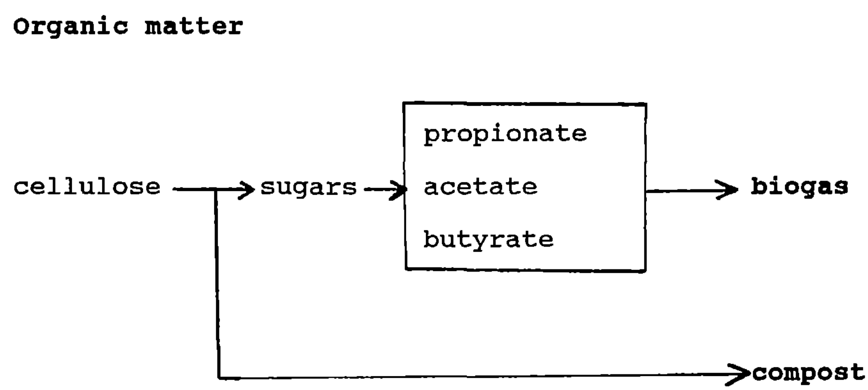


Figure 2. Anaerobic composting and biogas production

Uses of Compost

Compost is very useful when applied to soil. It is particularly useful for market gardening because it provides a good source of nutrients which can be rapidly assimilated by plants. The nutrients in compost are usually released slowly and become available to plants over a long period of time. It is an excellent alternative to chemical fertilizers in areas where soil has been exhausted by single crop cultivation, and also in semi arid areas (Thiam 1988).

Compost added to soil improves the structure of the soil by increasing humus material in the soil, resulting in a higher moisture retention ability of the soil.

In an increasingly competitive industry, the composting process produces a substrate which has nutritional characteristics for the growth of an edible mushroom. Such a selective substrate is called mushroom compost. The mushroom compost is a selective substrate whereby the mushroom mycelium is made to thrive better in it than competitor microorganisms. Moreover, in mushroom compost there is a concentration of nutrients for use by the mushroom only, while nutrients favoured by competitors have been exhausted.

CONCLUSION

Much organic waste materials are being produced in Eastern Africa which at the moment contribute to environmental pollution. Such materials can easily be composted by using simple and cheap technologies. The compost so produced could be used either as an organic fertilizer for crop plants, or for the commercial production of edible mushroom. On the other hand, the composting of organic wastes will reduce environmental pollution.

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POSTER

UTILIZATION OF BIOWASTE POLLUTANTS AS DOMESTIC FUEL

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ABSTRACT

Developing countries produce huge amounts of biowastes. These include rice husks, corn cobs, sawdust, groundnut shells, macademia shells, coffee husks, sisal waste, cotton stalks and coconut shells etc. Some of this biowaste material has no other industrial or agricultural use. This material can be utilized to produce energy in specially designed stoves or jikos for home cooking or as producer gas in gasifiers for power generation. This has the dual effect - prevention of pollution and utilization of the waste to produce energy.

This paper describes three types of stoves which have been developed and tested to burn biowastes for domestic cooking. One was designed to burn compacted saw dust while the other two were designed to burn loose biowaste material. Using several biowaste fuels, the performance of the heaters was compared using standard boiling and simmering tests. It was found that the sawdust stove was the most efficient. The biowaste stove 2 gave better promise for the combustion of loose biowaste fuels. All the three heaters are relatively inexpensive and are easily affordable by the rural population.

INTRODUCTION

For the majority of people in rural areas of developing countries, fuelwood and to a lesser extent, charcoal remain the predominant fuels for cooking and domestic heating. Cooking represents the largest single demand for fuelwood. This, coupled with a high population growth has led to the progressive reduction of the forested areas and a widening gap between fuelwood needs and availability. This situation could be redressed to a large extent if the rural population could be persuaded to use biowastes for heating and cooking purposes as much as possible. Developing countries produce large quantities of biowastes. Often, they constitute the largest single component in biomass production. Most cereal crops give wastes between 1.5 and 2.5 times the weight of the cereal (1). Rice, sisal, corn, groundnuts, coffee, coconut, jute etc. produce substantial amounts of biowaste material. Saw mills also produce large quantities of saw dust. Some of this material is returned to the soil, but there is still substantial amount of biowaste which cannot be returned to the soil because it decomposes slowly. It has little other use and causes pollution.

Most dried agricultural residues have an energy content in the range of 14 - 20 MJ/kg as compared to 20 MJ/kg for dry wood. Thus most of the biowaste pollutants can be used to provide some form of energy to rural areas. These could either be burnt to provide heat for domestic cooking or converted to producer gas which can drive stationary engines to generate power for pumping and other applications. It is important that these uses are achieved through efficient combustion without producing more pollutants. This paper describes three types of stoves (jikos) which were developed to cope with wastes of different grain size.

DESIGN CONSIDERATIONS

The cooking process consists of two phases - that of rapid boiling and simmering. A good stove should be able to perform efficiently during both these phases. This can be achieved by varying the charge and/or varying the supply of primary air. The most popular pot sizes for an average family of six members are in the range of 170 - 250 mm.(2) Based on these considerations, the stoves were designed to accommodate a maximum pot size of 220 mm diameter. One stove was designed exclusively to burn saw dust and the other two were designed to burn bio-wastes of large sizes. Detailed results of tests conducted on the saw dust stove have already been reported elsewhere(3), but some of these results have been included for comparison purposes.

Table 1 gives the calorific values (LCV) of the biowaste fuels.

TABLE 1: Lower calorific values of biowaste fuels

FUEL	CALORIFIC VALUE (MJ/kg)
Saw dust	17.3
Macademia shells	20.00
Maize cobs	17.58
Groundnut shells or briquettes	17.53

DESCRIPTION OF STOVES

A schematic representation of the saw dust stove is shown in Fig. 1. The material used is 3mm thick mild steel sheet (although this thickness could be reduced considerably). The stove is 400mm high with an ash collecting compartment and a variable air inlet at the bottom. The stove top consists of a cover plate which is used to support the pot. The cover plate also inhibits the burning of the saw dust from the top surface. The orifice in the centre of the cover plate directs the heat from the saw dust, burning radially outwards, onto the base of the pot.

Figs. 2 and 3 show the two different types of stoves designed to burn loose biowaste fuels mentioned in Table 1. Biowaste stove 1 has the perforated fuel container and combustion chamber placed in the centre with an insulated layer surrounding the chamber. There is an annular space between the insulation and the chamber through which the secondary air enters the perforations. The insulation consists of asbestos placed and sealed in between double walls.

Biowaste stove 2 has a novel design with a conical fuel container. There is a perforated cylindrical chimney in the middle through which the primary air passes and where combustion takes place. A chute provides for the introduction of the fuel without having to lift the pot. Tests on the saw dust stove had indicated that the provision of heat shield around the pot increases the efficiency of the stove by at least a factor of 2. Therefore all the stoves tested had a heat shield integral to the main body.

EXPERIMENTAL DETAILS

To charge the stoves, 0.8 to 1 kg of fuel was filled into the chamber initially. The saw dust stove was

charged by placing a wooden mandril vertically upwards in the centre at the base of the stove. The saw dust was poured in the annular space. Using a pressure plate it was compressed with the help of a press. The mandrill was removed and the pressure plate was replaced by the cover plate. The stove was ignited by inserting 10 gram of newspaper soaked in paraffin into the annulus and lighting it. The biowaste stoves were ignited by putting 5 grams of paper and 50 grams of kindling wood. When small bluish flames appeared around at least one piece of fuel, ignition was deemed to have occurred. This time was recorded. The stoves were extinguished by closing the air vents and the times to extinguish and relight the stoves were also measured.
A measured quantity of water (2.5 litres) was put in the pot. The height of the pot from the top of the stove was also varied. The efficiency of the stoves was measured using the standard boiling tests(4).

RESULTS

Mass Burning Rates

In the case of the saw dust stove, the mass burning rate of the saw dust was found to be dependent on its compaction. This could be related by the equation:

$$m = apn, \qquad (i)$$

where m is the burning rate in kg/hr,
p is the compaction pressure in kN/m2 and
`a' and `n' are constants.

In the case of biowaste stoves, the mass burning rate was found to be a function of the stove geometry and the size of the fuel. These were related by a burning rate law of the type:

$$m = axn, \qquad (ii)$$

where x is the particle size in mm.

Table 2 lists the values of the Coefficient `a' and the index `n' for different fuels and stoves.

Table 2: Values of constants a and n

Stove	a	n
Saw dust stove	1.0	0.08
Biowaste stove 1		
Groundnut shell briquettes	7.7	0.41
Maize cobs	11.8	0.43
Biowaste stove 2		
Groundnut shell briquettes	8.3	0.34
Maize cobs	3.5	0.20

Effect of Pot Clearance

The pot clearance has a predominant effect on the performance of the stoves. The optimum pot clearance varies with the burning geometry of the stove and the type of fuel. Fig. 4 shows the effect of pot clearance on the time required to boil 2.5 litres of water for the saw dust stove. This is also borne out by the efficiency curves for biowaste stoves 1 and 2.

Effect of Shielding

The saw dust stove was used to study the effect of shielding which is shown in Fig. 1(b). Fig. 5 shows the effect of shielding on the boiling time. With shielding the time taken to boil the same quantity of water is halved. Without shielding the best efficiency of the stove was 14.5%; with shielding, the best efficiency figure rose by a factor of 2.4.

Efficiency

The efficiency of the saw dust stove as a function of compaction of saw dust is plotted in Fig. 6, while Figs. 7(a) and 7(b) give the efficiency of biowaste stoves 1 and 2. It is clear that in the case of saw dust stove, there is an optimum value of compaction pressure which gives the maximum efficiency. Also the efficiency of the stoves depends to a large extent on pot clearance. The optimum pot clearance is a function of the type of fuel and the burning geometry of the stove. Macademia shells and the groundnut shell briquettes are shown to be better biowaste fuels. The biowaste stove 2 shows better promise if heat losses from it can be minimized. The sawdust stove gives the highest peak efficiency of about 33%.

Outside Surface Temperature

Fig. 8 illustrates the typical rise of outside surface temperature of the stoves. Predictably the sawdust stove has the least surface temperature rise whereas the biowaste stove 2 has the highest surface temperature. This underscores the need to provide insulation between the combustion chamber and the outside wall.

Extinguishing and Re-lighting Tests

During these tests, the stoves were allowed to burn fully for 10 minutes. These were then extinguished by closing the vents. After the stoves had cooled down to ambient temperature, they were re-lighted using the same procedure as was adopted for the initial ignition. Table 3 gives the times for first ignition and re-lighting of stoves. Except for the saw dust stove which was found to be easier to relight, the average time to relight the other stoves increased by a factor of 6. This increase is due to the charred outer surface layer around the fuel. Thus it is recommended that if for any reasons the biowaste stoves are extinguished, the semi- burnt fuel should either be reclaimed by shaking the fuel or preferably be removed altogether and the stoves should be charged with a fresh fuel.

Smoke Generation

The saw dust stove initially generated some smoke but after steady burning was achieved, the smoke was negligible. However, the biowaste stoves generated unacceptably high amounts of smoke. Therefore, they are suitable only for outdoor use. This raises the question of the social acceptability of these stoves. In limited trials around campus 98% of the users found the stoves not only acceptable, but also desirable to have. But more field trials are needed in rural areas to firmly establish this acceptability.

8. Material Costs

In terms of local currency, the total material and labour costs of the stoves, in 1989 prices are as follows:

Saw dust stove	Tsh.2000/=
Biowaste Stove 1	Tsh.1500/=
Biowaste stove 2	Tsh.1500/=

These prices are likely to come down when the stoves are mass produced. The operating life of the stoves is expected to be 2 to 3 years.

CONCLUSIONS

The saw dust stove is by far a better stove with the highest efficiency. Tests carried out on the two biowaste stoves using four different fuels showed that the biowaste stove 2 performed better than the biowaste stove 1 in terms of heating efficiency except in the case of maize cobs where the opposite was true. With improvements in insulation, stove 2 was expected to perform even better. Despite improvements in design of stoves, a considerable amount of heat is still lost to the surroundings. Any future studies should investigate the possibility of putting these escaping hot gases to good use by possibly preheating the incoming air supply.

Table 3: Lighting and re-lighting times

	Time to first ignition (min.)	Re-lighting time (min.)
Saw dust stove	2	6
Stove 1:		
Macademia shells	3.0	17.0
Groundnut shells	0.2	2.0
Groundnut Briquettes	2.5	14.0
Maize cobs	1.5	9.0
Stove 2:		
Macademia shells	2.0	12.0
Groundnut shells	2.0	10.0
Groundnut briquettes	2.0	12.0
Maize cobs	1.5	9.0

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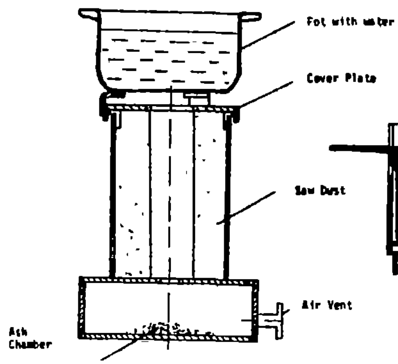

FIG 1 (a) SCHEMATIC OF THE SAW DUST STOVE

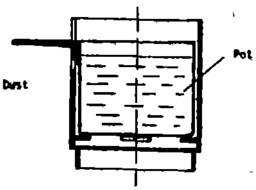

FIG 1 (b) SHEILDING TO REPLACE THE COVER PLATE

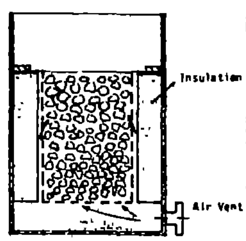

FIG 2 SCHEMATIC OF THE BIOWASTE STOVE 1

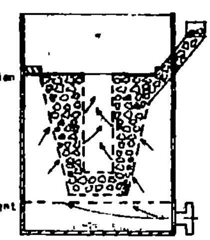

FIG 3 SCHEMATIC OF THE BIOWASTE STOVE 2

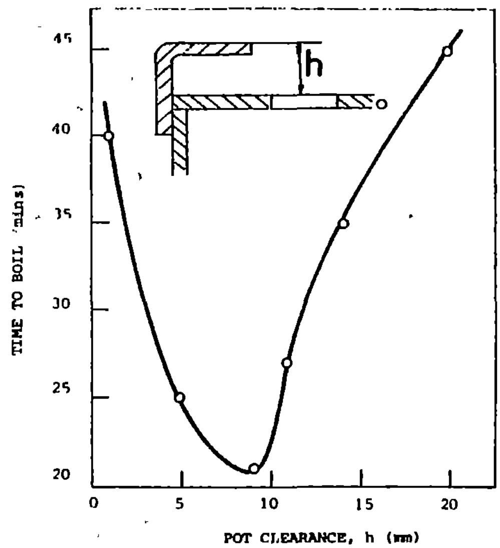

FIG 4: EFFECT OF POT CLEARANCE ON BOILING TIME

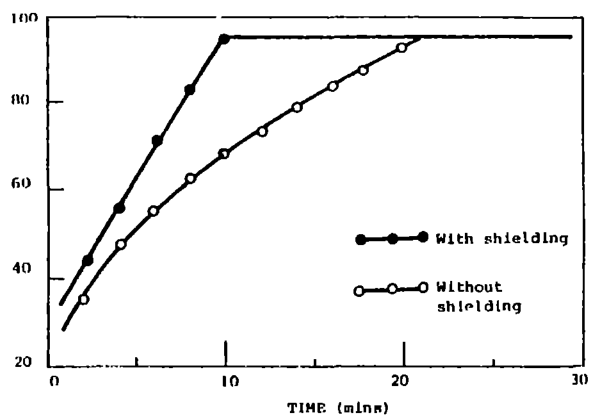

FIG 5: EFFECT OF SHIELDING ON TEMPERATURE RISE AND TIME TO BOIL

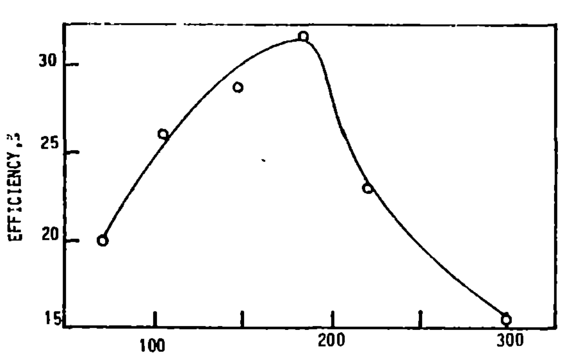

FIG 6;STOVE EFFICIENCY VS COMPRESSION PRESSURE FOR SAW DUST STOVE

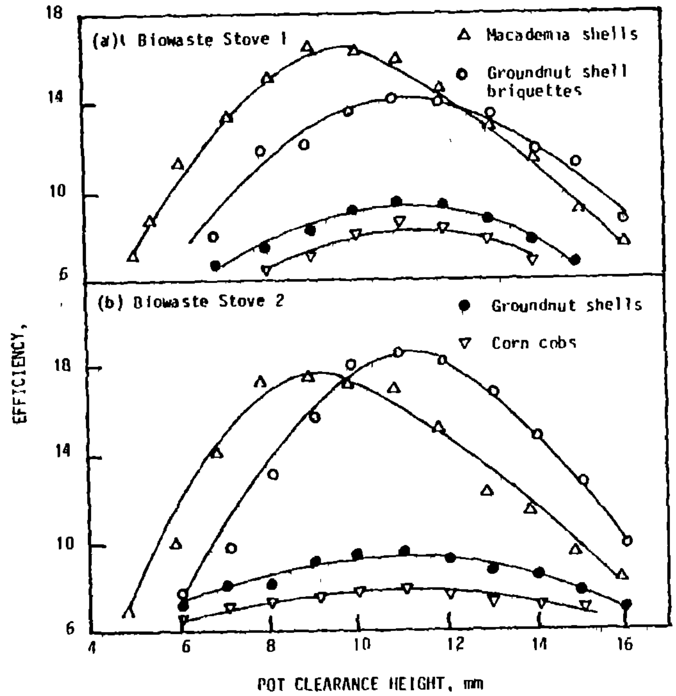

FIG 7: EFFECT OF POT CLEARANCE HEIGHT ON EFFICIENCY

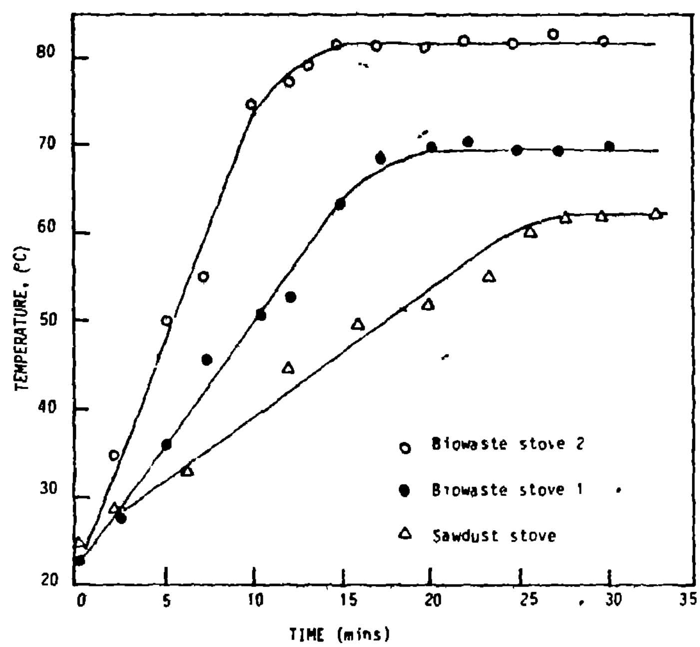

FIG 8: STOVE SURFACE TEMPERATURE Vs TIME

LAWS AND LEGISLATIONS

ENVIRONMENTAL LEGISLATION OF SEYCHELLES

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Department of Environment, Seychelles

INTRODUCTION

Seychelles recently initiated a project to collect together all international treaties and conventions and the legislation of Seychelles relevant to the management and protection of the environment. Compilation will be followed by a systematic review which will assist in identification of possible weaknesses and shortcomings and to serve as a guide to improve the administration of the environment.

The Republic of Seychelles is comprised of 115 islands, both granitic and coralline, situated in the western Indian Ocean between 4 degrees and 5 degrees south of the equator. A total land area of 45,250 hectares, occupying a territorial sea of 1,374,000 square kilometers supports a population of 68,000. (Department of Statistics, annual report 1988). It is significant that over 40 per cent total land area has been designated as National Park or Reserve to preserve the integrity of the natural ecosystems unique to Seychelles.

Fish products, both canned and frozen, form the majority (over 84%) of the Rs 35 million in exports from the Seychelles. Tourism is the largest earner of foreign exchange, bringing in Rs 374 million.

DEVELOPMENT

The majority of the population is centered on the granitic islands of Mahe, Praslin and LaDigue. Residential development is concentrated in the coastal areas and alongside the few roads that traverse the mountainous region.

Human activity is divided evenly between the private, public and parastatal sectors employing some 20,000 persons.

ACTIVITIES AFFECTING THE ENVIRONMENT

a. Residential development - limited suitable land for housing and limited success in enforcing minimum boundary requirements and building standards has resulted in overcrowding in certain areas and encroachment upon river reserves and national parks. Consequently, the attendant pollution of rivers and streams, together with pollution by noise and effluent indicate that human activities affecting vegetation and soil have to be carefully monitored to prevent disturbance to the ecological systems. control and disposal of solid wastes and industrial effluent presents one of the largest threats to the environment.

b. Industrial development - industrial development has not yet reached the stage whereby it presents a serious threat to the environment. The damage that has been caused is slight and can be overcome by simple remedial and precautionary measures. An effective system of planning, monitoring and enforcement is necessary to ensure that the harm caused by industrial development, as witnessed in other countries, is not introduced into the Seychelles.

c. Tourism - control in the early stages of hotel development has resulted in limited damage to the environment. Hotels and restaurants are generally carefully positioned so as to cause as little damage to the surroundings as possible whilst providing adequate facilities for the 72,000 tourists that visit the Seychelles annually. Absent are the headaches seen in overcrowded tourist areas elsewhere such as excessive litter, noise and infrastructure pressures that cause severe disruption to surrounding vegetation and wildlife.

Careful management is needed to regulate the taking of shells, coral and turtle for sale to tourists; the anchoring of pleasure boats, which cause damage to the coral; and the disposal of wastes from hotels and tourist activities.

d. Maritime Activities - Seychelles maritime needs are serviced by approximately 216 local vessels as diverse as 3.5 million dugout canoes, traditional wooden schooners and modern general cargo ships. The Port of Victoria handles about 410,000 tons of cargo per year with over 400 vessels calling at the port annually.

In the fishing industry significant development has taken place. In June 1987 a canning factory of 800 tons capacity was completed; and at the present time some 48 foreign tuna purse seiners are licensed to operate with an average annual reported catch of 160,000 tons.

Activities of this sector present the largest threat to the environment. Apart from the depletion of fish reserves within the area which is being constantly monitored, the major impact upon the environment is pollution from the numerous vessels which are using the territorial waters of Seychelles. Dumping of waste matter, the discharge of oils by ships, added to the serious threat of pollution by accidental oil spill, cause considerable concern.

e. Drilling, quarrying and reclamation - offshore exploration for oil is presently being carried out some 200 km from Mahe island. Large quantities of sand and gravel are removed for building materials and dredging and land reclamation are being carried out. Whilst all operations are carefully licensed and monitored, it is difficult to accurately estimate the impact upon the environment by these activities. However, possible pollution of ground water and subsequent sea water contamination from toxins in solid wastes deposited in land reclamation areas have been identified.

LEGISLATION

Seychelles has signed a number of international treaties and conventions concerned with the environment (see Annexure I) and has over the years formulated a wide variety of legislations to assist in the management and control of the environment incorporating, as far as possible, the requirements of international treaties and conventions. A sound policy has evolved whereby considerable control is exercised in all aspects of development. Planning permission is required for all forms of development under the Town and Country Planning Ordinance (chap. 160) and an environmentally conscious Town and Country Planning Authority regulates land utilization. Ten areas have been set aside for nature conservancy under the National Parks and Nature Conservancy Ordinance (Chap 159) and public access has been limited in 24 areas under the Protected Areas Act (Chap 40).

Other environmentally sensitive areas have been protected under the Crown Land and River Reserve

Ordinance (Chap 150) and the forest Reserves Ordinance (Chap 153).

Pollution resulting from human activities is controlled by the Public Health Ordinance (Chap 194) the Health and Sanitation (Prevention of Defilement of Rivers and Streams) Regulations (SI 4 of 1970) the Derelict Motor Vehicles (Disposal) Ordinance (18 1972) and the Public Utilities Corporation (Sewage) Regulations (SI 9 of 1987). The Environmental Protection Act (9 of 1988) came into effect on the 1st of April 1989 and was designed to control pollution by regulating disposal of wastes. Amendments to this act now under consideration will extend its scope to include the disposal of industrial wastes.

Pollution caused within the tourism sector is managed under the Beach Control Regulations (SI 77 of 1978) and the Licenses (Accommodation, Catering and Entertainment Establishments) Regulations (SI 16 of 1987).

Maritime activities are regulated by the Harbour Ordinance, (Chap 210) and the Marine Pollution Regulations (SI 51 of 1981) which gives power to the Harbour Master to control discharges from ships; the Merchant Shipping (Oil Pollution). (Seychelles) Order (SI 118 of 1975) which restricts and demarcates liability for oil pollution damage and provides for insurance and compensation for damage and defines the liability of ship owners; and the Dumping at Sea Act (Overseas Territories) Order (SI 36 of 1976). The fishing industry is controlled by the Fisheries Act (5 of 1986), the Licenses (Fisheries) Regulations (SI 21 of 1987), and the Harbour (Fishing Port) Regulations (SI 58 of 1988).

Strict control of potential pollution from offshore drilling is exercised under the Petroleum Ordinance (Chap 254), the Petroleum Mining (Pollution Control) Act (18 of 1976), the Oil Pollution (Compulsory Insurance) Regulations (SI 8 of 1976), the Petroleum Mining Regulations (SI 64 of 1976), the Petroleum Drilling Regulations (SI 35 of 1980) and the Offshore Installations (Emergency Procedures) Regulations (SI 36 of 1980).

The Land Reclamation Ordinance (Chap 152) and the Removal of Sand and Gravel Act (13 of 1982) requires licenses to be obtained before any operations can be commenced.

The protection management and control of animals and wildlife is regulated by the Breadfruit and Other Trees (Protection) Ordinance (Chap 122). The Wild Animals and Birds Protection Ordinance (Chap 143), the

Pig Production Control Act (24 of 1985) and the Licenses (Poultry Keepers) Regulations (SI 28 of 1987).

Recommendations which have been made are largely concerned with improvements to the administrative requirements of the present legislation and the need to improve pollution management and detection techniques. Further, greater influence by the Department of Environment at the development and planning stages is required. And an increase in the manpower requirements is needed for adequate surveillance and policing of potential pollution sources.

Legislation in force at present forms a sound basis for the management and control of pollution in Seychelles. However, amendments are required to overcome the problems identified in the maritime sector, in the utilization of marine resources and in the control of human activities harmful to the environment.

ANNEXURE 1

INTERNATIONAL TREATIES AND CONVENTION

TREATY OR CONVENTION	DATE OF SIGNING
International Convention for the regulation of whaling	19.3.1979
African Convention on the conservation of nature and natural resources	14.11.1977
International Convention on civil liability for oil pollution damage	01.5.1976
Treaty on the Prohibition of the emplacement of nuclear weapons and other weapons of mass destruction on the sea-bed and the ocean floor and in the subsoil thereof	28.6.1976

International Convention on the establishment of an International Fund for compensation for oil pollution damage	16.101978
Convention of the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin weapons, and on their destruction	11.10.1979
Convention for the Protection of the World Cultural and Natural Heritage	09.7.1980
Convention on the Prevention of Marine Pollution by dumping of wastes and other matter	29.6.1976
Convention on International Trade in endangered species of wild fauna and flora	09.5.1977
United Nations Convention on the Law of the Sea	Deç, 1982
International Convention for the Safety of Life at Sea	01.10.1976
Convention for the Protection management and development of the marine and coastal environment of the Eastern African Region	1988
International Convention Relating to intervention on the high seas in cases of oil pollution casualties	12.4.1988

Question by Dr. Ngoile

How was the sea reclamation done?

Answer

Materials for filling up were obtained from the surroundings. A study will be conducted to establish the impact of material removal from the areas used.

THE CONCEPT IN THE LEGISLATION OF EUROPEAN SOCIALISTIC STATES CONCERNING THE PROTECTION OF THE ENVIRONMENT AGAINST POLLUTION: THE EXAMPLE OF THE GERMAN DEMOCRATIC REPUBLIC

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ENVIRONMENTAL PROTECTION AND INTERNATIONAL RELATIONS

Nowadays environmental protection problems are non-renounceable elements in the subject of the international relations between states. The main reason for this is that the preservation of the environment and the effective utilization of the natural resources concern the interests of whole mankind. And also the particular problem of pollution of the environment is - more or less and especially under long-term view - not only a matter of the state causing the pollution, because the effects of pollution of the air, waters etc. are not boundable.

It is without question that a further progress in disarmament, the prohibition of nuclear weapons, as well as the step by step reduction of the conventional armament, is the most important problem existing at present not only concerning the survival of mankind but also concerning the protection of the environment including the particular problem of environmental pollution.

This connection was also reflected in the governmental conference held in March 1989 in Berlin, the capital of the German Democratic Republic, with the theme "Peace -Development - Environment: The Environmental Policy of the German Democratic Republic". This conference dealt with the content and conclusions of the report of the World Committee for Environment and Development (WCED) named "Our Common Future", discussed by the General Assembly of the United Nations in October 1987 together with the long-term strategy of the protection of the environment up to the year 2000, including a list of legal principles concerning the protection of the environment and a stable development and addressed to all states. In the frame-work of our symposium, I cannot go into detail concerning these legal principles but I want to emphasize at least that the socialistic states including the German Democratic Republic accept these legal principles as the basis for the formation and development of the international co-operation in the field of the protection of the environment and act in this sense. In the socialistic countries, the opinion is emphasized that the solution of a number of problems concerning the protection of the environment is decisive for the future of mankind and that the problems existing are not solvable by a single state but only - mutatis mutandis - by close co-operation between all states. This is not only to declare with words but should be reflected also in the domestic legislation of each particular state.

This demand does not only involve the direct relation to international documents (resolutions, conventions, treaties etc.) but includes also the fulfillment of the measures necessary for the efficient protection of the environment within the borders of the territory of the particular state. The latter shall be looked at a bit more detailed.

THE LEGAL BASIS FOR THE PROTECTION OF THE ENVIRONMENT

The protection of the environment is "expressis verbis" (expressive) anchored in the constitution of all socialistic states. For example, article 15 of the constitution of the German Democratic Republic reads as follows: "The state and the whole society care for the protection of the environment in the interest of the welfare of the citizens. The avoidance of pollution of waters and air as well as the protection of the beauties of the landscape of the native country are to be guaranteed by the competent state organs and are, besides, this also a responsibility of each citizen. The soil belongs to the most precious richness of nature. Therefore it has to be protected and to be utilized effectively". We can find more or less the same content also in the constitutions of the other European socialist countries.

A characteristic of the concept for the legislation in this field is the <u>combination of two aspects</u> of the protection of the environment: the protection of objects in the nature on the one hand and the effective utilisation of natural resources on the other. This is the result of a development of the legislation which began with legal norms being concentrated only on the first aspect, e.g. reflecting only the traditional aspect of the protection of the environment. It was the GDR which established as the first state among the European socialist states a complex Environmental Protection Act in this sense in 1970. This act had a model function for other European socialistic states which followed this way few years later. On the other hand the experience of the other European socialistic states concerning the legislation and its realization in this field was taken into consideration in the process of the amendment of the legislation of the GDR so that it can be said that the present legislation of the GDR in this field represents the developed standard of the legislation of the European socialistic countries as a whole. This is the reason why the concept of European socialistic states shall be explained on the example of the GDR.

The concept of the legislation in the framework of the Environmental Protection Act from 1970 is to summarize all essential aspects of the environmental protection in the wide sense mentioned above in a complex legal act. So the Act begins with the determination of the subject, the intention and general principles of the environmental protection, followed by basic norms concerning particular natural objects and elements of the nature like landscapes, relaxation areas, plants and animals, soil, forests, waters, air. a third part refers to the handling of waste establishing the legal duty for all enterprises to organize the reuse of all useable wastes of their production process and the dispose of non-useable wastes without negative effects to the environment. A final part concerns the protection against factors having negative effects on the environment, namely noise, waste heat, nuclear radiation etc. (Remark: only the first was included expressively into the Environmental Protection Act in 1970).

The basic legal norms of the parts of the Act mentioned above were precisized by additional regulations for each subject. The amendments were made within the framework of these particular regulations so that the Environmental Protection Act from 1970 has got a high level of stability being the basis for the realization of the long-term strategy in this field.

Basic Principles being reflected in the legal norms of the Environmental Protection Act as well as the particular regulations are especially:

1. The principle of realization of the unity of production and protection of the environment:
   That means: It cannot be accepted that particular enterprises etc. produce and injure the environment and the state or the society in

the whole shall redress the negative effects. Rather the producer is to be obliged to avoid negative effects on the environment as far as possible, and otherwise to correct the negative effects caused by him. The main point in this connection is not only to demand it but to enforce it.

It should be mentioned that according to the environmental concept of the socialist states the way out for a stronger protection of the environment is not the stagnation or even reduction of the quantity of production. As the reality shows, the stagnating or the so-called minus-development of production was never connected with a positive effect for the environment. Rather the environmental policy of the particular state as well as the consistency by its realization will be a guarantee for the necessary protection of the environment. A developed quantity of production based on a high standard of rationality can also deliver the developed amount of money necessary for a more efficient protection of the environment.

2. The principle of leading of the protection of the environment by the state:

That means to realize the determination of the level of demands, the establishment of binding legal obligations for different addresses and legal consequences for the case of their violation and the strict control about the fulfillment of the demands by the state organs at all levels. This includes the necessity of establishment of special rights and duties concerning the protection of the environment for the state organs themselves and concerns the national as well as international aspect of the protection of the environment. It also involves that the civil servants in the state organs must have the duty to give reports about their decisions to the representations of the people on each level.

3. The principle of the long-term and complex planning of the measures and means for the protection of the environment:

This means first of all that the limited money and material capacity is to be concentrated in the most important areas. For this purpose a rank of urgency of particular measures is to be decided upon in the framework of leading of the protection of the environment by the state. And after this the state has to care for the preconditions of their realization in the framework of the state planning. The criterion of the rank of measures has always to be to reach the highest effectiveness of the expenses for the protection of the environment.

4. The principle of the unity of legal obligations and the liability for damages of the environment.

   This means: A system of legal consequences has to exist within the legislation which comes into reality with necessity if binding legal duties were violated.

Concerning the avoidance or limitation of the pollution of the environment, the legislation combines two methods of legal regulation:

(a) the regulation of the protection of particular objects in nature itself. That means: Legal duties are established concerning these objects (landscapes, relaxation areas, plants and animals, soil, forests, waters, air). In connection with these objects, a number of actions which could have dangerous effects to them are prohibited.

(b) the regulation concerning particular factors having negative effects on the protected objects of the environment. That means: Special duties are established with the aim to avoid that factors of pollution of the environment (harmful chemicals, noise, heat, nuclear radiation etc. arising from the production or other processes) come to a negative influence on the environment.

The legislation uses both methods for the same purpose and so has a double effect on the protection of the environment.

LEGAL REGULATION CONCERNING POLLUTION OF THE ENVIRONMENT

There exists a more or less unitary system of legal instruments aimed at the minimization of the negative influence of factors of pollution of the environment being independent from the particular factor of pollution.

The starting situation in more or less all fields of pollution of the environment in our country was characterized by the fact that a negative heritage did exist from the past. Therefore sanitation programmes were set up for areas with a high level of pollution of air and waters, negative influences to forests caused by dust, gases, waste water, waste heat, or for areas with a high level of noise. These programmes included a catalogue of measures which are step by step complex to realize by the named addressees. Other instruments are state permissions needed for several actions having possible effects to the environment. This starts with the necessity of confirmation by the state concerning the place for the erection or any extension of a factory, is continued by the intention to use natural resources like water (including own wells, from lakes etc.) plots of land etc. and goes up to the disposal of waste of production (including disposal on places which belong to the enterprise). For all these actions the enterprise needs an expressive permission given by the competent state organ. Workers of enterprises which have access to stores of poisons need also a special state permission providing a special knowledge in this field. A special kind of state permissions concerns the emission of waste gases, waste liquids and noise respectively. Limits related to pollution levels at discharge points of factories are fixed and their observation is strictly controlled by the competent state organ but is at the same time to be controlled and to be reported in written form by the factory itself. A very strict regime of state control exists also concerning the intention to destroy any square meter of soil being used for agriculture, fishery or forests by erection of buildings, roads, mining (especially for extraction of lignite in open-cast mining) etc.

Another important instrument are economic stimuli. Who uses the air, public waters etc. for abolishment of waste arising from the process of production gets a special benefit from the society in comparison to others and has therefore to pay to the society for "special utilization" of the environment. The quantity of fees is decided in such a way that producers are economically interested in minimizing this "special utilization" of the environment for the purposes in question.

This complex of main instruments is completed by different measures of legal liability: The possible penalties vary from fine up to imprisonment for the individual person who is responsible. Heavy economic stimuli exist beside this. An enterprise has to pay a lot of money if it causes pollution of air, water etc. going beyond the limits fixed for this enterprise for the year in question.

RESULTS OF LEGAL REGULATIONS

The efficiency of the mentioned legal regulations can be seen by the results having been reached since the establishment of the complex Environmental Protection Act in 1970.

For example, the results concerning keeping the air clean:

- Since 1970 the production of goods has increased by 250 percent whereas the emission of sulphur dioxide did not increase within the same period. To recognize the importance of this fact one should keep in mind that lignite is at present and for the foreseeable future the major energy source in the GDR. Between 10 and 25 kg sulphur dioxide is set free by the process of combustion of one ton of lignite. A higher quantity in production usually demands more energy and this would be accompanied by a higher quantity of sulphur dioxide emission. But the legislation concerning keeping the air clean led to the development and application of techniques for purification of waste gases. Further, there were efforts to consume less energy in relation to a given quantity of production. So an equivalent of 80 million tons lignite was saved (relatively) only within five years (from 1981 to 1985).

- Filters are also installed in power and heat stations and dedusting equipments in enterprises of the chemical, metal working and cement industry on a wider scale than in the past. It has been possible over the five years from 1981 to 1985 to reduce dust emission by 30 per cent.

- The emission of nitric oxides continues to decline. Nitrogen levels have reduced by between 13 and 15 per cent through the measures taken to limit the maximum speed of vehicles to 100 km/h on motorways and 80 km/h on trunk and minor roads. The shift from road haulage to rail and water ways and the advancing electrification of the rail network has reduced emission of nitric dioxide by about a quarter.

- Great efforts were also made for the reduction and finally substitution of Fluoro Carbon Hydrogens (FCH) as power gas for sprays etc. Although the GDR has only a share of one percent in the world consumption of FCH she arranged far reaching measures in implementation of the international agreement about the protection of the ozone layer. The consumption of FCH as power gas in the aerosol industry was reduced to less than 50 percent through substitution by propane and butane. Other measures in this connection are the collection, centralization and recycling of cooling liquid from industrial refrigeration engineering and household refrigerators and home freezers with the possible effect of reduction of the FCH consumption by further 30 percent.

As another example, the results concerning protection and careful use of waters shall be given:

- The water consumption per unit of product was reduced by 24 percent between 1981 and 1985 thanks to the application of water-saving procedures and increased multiple use of industrial water.

- Since 1981, economically useful substances worth 33 million marks have been reclaimed annually from waste water, particularly lead, copper, silver, fibres, fats, oils, whey and yeast.

- In the petrochemical combine at Schwedt, the largest oil-refining plant in the GDR, almost 100 percent of the phenols and oil contained in its industrial effluent is recovered.

Since the beginning of the 1970's, the households of more than 2.3 million people in the G.D.R. have been integrated in the system of public sewage treatment. For this purpose, 550 sewage treatment plants were reconstructed, extended by a biological purification phase or newly built. Also in the industry, 171 sewage treatment plants were newly built, extended and reconstructed respectively. As a result of all these measures, the burden of organic substances in waste water was reduced by 30 percent.

CONCLUSIONS AND RECOMMENDATIONS

Based on the impressive results which were reached with the help of the Environmental Protection Act as well as the further regulation to its implementation, I wish to summarize the following conclusions and recommendations for the legislation in this field for other states:

1. Realization of a complex legal act for the protection of the environment in which the protection against pollution is harmoniously integrated.

2. Guarantee of the state leading of the protection of the environment including the strict implementation of the state environmental policy.

3. Realization of the unity of production and protection of the environment.

4. Guarantee of the unity of responsibility (bearing of legal duties) and liability for the violation of such duties.

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Question Dr. K. Kershaw

GDR contributes a lot to compounds established to have affected the ozone layer. How is the legislation helping in containing the situation?

Answer

Global environmental pollution is a common problem of all states. Cooperation of the respective states is necessary for its control. As regard the emission of sulphur dioxide which appears to affect the ozone layer, different countries have joined an International Convention to reduce the emission of these compounds.

Question by Prof. Mulokozi

Not only the application of DDT is prohibited in the GDR, but also its manufacture as well as its importation. On the other hand, the chemical (DDT) is required as an intermediate for production of another product. How is the situation in the GDR?

Answer

DDT is only prohibited for agrochemical use in the GDR.

POLLUTION CONTROL LEGISLATION IN TANZANIA

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INTRODUCTION

Tanzania, like any other country, is aware of the threat that pollution poses to its people and in dealing with this problem the country is a party to a number of international environmental control (protection) legislations. Internally, a range of pollution control legislations exists ranging from rules and regulations to safeguards and enforcement.

This paper addresses itself to those pollution control legislations that Tanzania has erected in order to deal with the problem of environmental pollution. A survey of the existing legal instruments against pollution is made with the aim of spelling out their contents. Strengths and weaknesses are pointed out and ways and means of making these legislations effective are suggested.

THE RANGE OF LEGAL INSTRUMENTS AGAINST POLLUTION IN TANZANIA

Tanzania can boast of having a considerably wide range of environmental protection legislations, including those which directly or indirectly deal with pollution control. Without being exhaustive, a wick run through these legislations would reveal the existence of the following pieces of legislations:

(1) Fisheries Act, 1970
(2) Fisheries (General) Regulations, 1973
(3) Fisheries (Explosives, Poisons, and Water Pollutions) Regulations, 1982
(4) Mining Act, 1979
(5) Petroleum (Exploration and Production) Transitional Rules, 1982.
(6) Water Utilization (Control and Regulation) Act, 1974.
(7) Water Utilization (Control and Regulation Amendment) Act, 1981.
(8) Urban Water Supply Act, 1981.

(9) Public Health (Sewerage and Drainage) Ordinance CAP 336.
(10) Natural Resources Ordinance, CAP 259.
(11) Town and Country Planning Ordinance, CAP 378.
(12) Rufiji Basin Development Authority (RUBADA) Act, 1975
(13) Protection from Radiation Act, 1983.
(14) Merchant Shipping Act, 1967.
(15) National Environmental Management Act, 1983.
(16) National Land Use Planning Commission Act, 1984.
(17) Local Government Act, 1982.

Besides these legal instruments, the Government has set up several research organizations which deal with various matters, including those pertaining to pollution.

KEY PROVISIONS OF SOME POLLUTION CONTROL LEGISLATIONS IN TANZANIA

For purposes of this section, we examine the following legislations: those relating to fisheries, water, mining, petroleum, public health, shipping, and radiation.

Fisheries:

The Fisheries Act, 1970 gives powers to the Minister to make regulations on preventing the pollution of territorial waters. The use of explosives for the purposes of fishing is prohibited. Furthermore, the use of poisonous or toxic substances for purposes of fishing is prohibited. Pursuant to the Fisheries (general) Regulations, 1973, it is prohibited to throw overboard certain substances like ballast, coal ashes, or other dangerous substances in water where fishing is carried out. The Regulations also prohibit anybody from putting any water lime, chemical substances or drugs, poisonous matter, dead or decaying fish or remnants, saw dust or anything injurious to fish or fishing grounds. All these restrictions are meant to safeguard the aquatic environment for sustainable fish production.

Under the regulation anybody who contravenes any of the provisions of the regulations is liable upon conviction to a penalty not exceeding Tanzania shillings 10,000/- or a term of imprisonment not exceeding 2 years or both, if he is a first offender. For the second and subsequent offenses upon conviction one is liable to a fine not exceeding Tanzania shillings 20,000/- or a term of imprisonment not exceeding 5 years or both.

The fisheries (Explosives, Poisons, and Water Pollution) Regulations, 1982, define water pollution as man made or man included alteration of chemical, physical, biological, or radiographical integrity of water. The Regulations prohibit anyone from causing or permitting to flow or pass into water any solid, liquid, or gaseous matter to a concentration which will be injurious to any aquatic flora or fauna. The Director of Fisheries is obliged to ensure that, that person or body of persons who contravenes the provisions of these regulations should clear the polluted water within reasonable time at his own expenses.

Water:

Water pollution is controlled directly by three pieces of legislation. The water Utilization (Control and Regulation) Act, 1974; Water Utilization (Control and Regulation) (Amendment) Act, 1981; and Urban Water Supply Act, 1981. According to the 1974 Act when water right is granted to anyone, the water used thereunder shall not be polluted with any matter derived from such use to such extent as to be likely to cause injury either directly or indirectly to public health, to livestock or fish, to crops, orchards, or gardens which are irrigated by such water or to any product in the processing of which such water is used. Furthermore, users are required to prevent accumulations in any river, stream or water course of silt, sand, gravel, stones, sawdust refuse, sewerage, sisal waste or any other substance likely to affect injuriously the use of such waters.

The 1981 Act, which amended the 1974 Act, provides that no person may discharge effluent from any commercial, industrial or other trade wastes systems into receiving waters without a consent duly granted by a Water Officer. This 1981 Act also established the Central Water Board which is empowered to research and investigate on pollution and to formulate and recommend steps to be taken.

The 1981 Urban Water Supply Act provides that any person who:

(a) washes his body or bathes in any part of the waterworks or catchment area or in any vessel used by the Urban Water Authority for supplying water from any public fountain;

(b) washes, throws or causes or permits to enter into any part of the water works or catchment area, or into any vessel used by the Authority for supplying water from any public fountain;

shall be guilty of an offence and shall be liable on conviction to a fine not exceeding one thousand shillings. The Act continues to provide that any person who deposits or allows to be deposited any earth, material or liquid in such manner or place that it may be washed, fall or be carried into the waterworks shall be guilty of an offence and shall be liable on conviction to a fine not exceeding twenty thousand shillings, and if that earth material or liquid is allowed to remain so deposed after notice in writing from the authority requiring it to be removed has been given to that person, he shall be liable to a further fine of one hundred shillings for each day during which the offence continues.

Mining:

The Mining Act, 1979, clearly stipulates that a person granted a mining licence under this Act should give a statement with particulars of the programmes of proposed mining operations including a statement for the proposal for the prevention of pollution, the safeguarding of fishing and navigation (if relevant), the progressive reclamation and rehabilitation of any land disturbed by mining, and for the minimization of the effects of mining on water areas (if relevant) and adjoining lands. According to this Act, no mining licence shall be granted to an applicant unless the programme of proposed mining operations takes (among other things) proper account of environmental and safety factors.
One serious flow in this Mining Act is that it creates an offence but does not provide for the punishment to be given out to those who happen to contravene the Act.

Petroleum:

To control pollution associated with petroleum exploration and production the Parliament enacted the Petroleum (Exploration and Production) Act, 1980; and Petroleum (Exploration and Production) Transitional Rules, 1982. This is in recognition of pollution which may result from seabed activities. The 1980 Act stipulates that all those involved in the exploration and production of petroleum in Tanzania should observe good oil practices - practices generally accepted as good, safe and efficient in the carrying out, exploration or development activities. The Act provides that any holder of a licence, whether of exploration or development, shall control the flow and prevent the wastage or escape in the exploration or development area of petroleum, gas or water and has a duty to prevent the escape in the exploration or development area of any mixture of water or drilling fluid and petroleum or any other matter.

Further to these provisions, the Act provides that the licence holder shall prevent pollution of any water well, spring, stream, river, lake, reservoir, estuary, harbour, area of sea by escape of petroleum, salt water, drilling fluid, chemical additive, gas or any other waste product or effluent. The licence holder is also obliged to furnish the Commissioner of Petroleum a detailed report on among other things, the techniques to be employed and the safety measures to be taken in the drilling of the well.

Under this Act, failure to comply with the above anti-pollution controls by any person or body commits an offence and is liable (upon conviction) to a fine not exceeding Tanzania shillings 100,000/=.

Public Health:

Public Health is protected from pollution (among other hazards, man-made or otherwise) by the Public Health (Sewerage and Drainage) Ordinance CAP 336.

Any person or body of persons or organization which/who contravenes this Act commits an offence and liable to a fine not exceeding Tanzania shillings 100/= and to a further fine not exceeding Tanzania shillings 100/= for each day on which the offence continues after conviction.

Shipping:

Marine pollution in Tanzania is controlled by the so called Merchant Shipping Act, 1967. The Act deals with pollution by ocean vessels particularly in respect of oil discharged into ocean waters deliberately or accidentally. The Act provides, among other things that: if any oil or oily mixture is discharged from any ship into a harbour or into the sea within 100 miles from the Coast of the United Republic of Tanzania the owner or the master of such ships shall be guilty of an offence and shall on conviction be liable to a fine not exceeding Tanzania shillings 10,000/=.

Radiation:

In recognition of the hazard which may emanate from the use of atomic energy and other radioactive materials like uranium, thorium, radium, and the like the Tanzanian Government passed The Protection from Radiation Act, 1983, which established a Commission which is responsible for all matters pertaining to the use of atomic energy and other radioactive substances so as to ensure the safety of the people. According to this Act, no one is allowed to install any plant designed for accumulation, storage, processing or disposal of nuclear fuel or of bulk quantities of other radioactive materials or waste which has been irradiated in the course of the production or use of nuclear power.

OBSERVATIONS OF TANZANIA'S POLLUTION CONTROL LEGISLATION

Indeed, Tanzania must be proud of the range of pollution controls that it has erected to pre-empty, prevent, and deal with environmental pollution. Not many other developing countries have such elaborate pollution controls. But, in reality Tanzania's pollution control legislation has failed to deal effectively with the problem of pollution - not because the law, regulation or enforcement are not there but because of some weaknesses inherent in the legislation itself and weaknesses inherent in law enforcement instruments of the State. Without being detailed, below we try to point out why Tanzania's pollution control legislation has failed to fulfil its obligations.

(1) Lack of adequate machinery for enforcement.
(2) Incredibly inadequate penalties to deter offenders.
(3) Lack of co-ordination between different sectors responsible for polluting the environment or preventing environmental pollution.
(4) Lack of accountability when pollution takes place.
(5) Laissez - faire attitude by the Government and other state law enforcing instruments.
(6) Poverty and underdevelopment.
(7) Lack of awareness on the part of the general public.
(8) The nature of industrial and other facilities inherited by the post-independent Tanzania.

SELECTED BIBLIOGRAPHY OF ENVIRONMENTAL POLLUTION IN TANZANIA

Prior to this Symposium, literature on environmental pollution in Tanzania was extremely scarce or hard to get hold of. Thus this Symposium will fill a considerable gap in Tanzania's pollution literature. However, prior to this Symposium a very useful set of papers, articles, etc. existed and below we itemize them in a bibliographical form to complement the literature that has been made available by holding this "Symposium on Environmental Pollution and its Management in Eastern Africa".

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<u>Question by Mr. Pratap</u>

Industries or individuals who pollute the environment cannot be taken to court for polluting the environment. What do you advise the environmentalists to do?

<u>Answer</u>

Can the government be taken to court?

<u>Question by Dr. Mathuthu</u>

Has anybody cared to study why the government is failing to control or enforce pollution legislation.

<u>Answer</u>

Nobody has done so.

MISCELLANEOUS

SOME ATMOSPHERIC GASEOUS/AEROSOL POLLUTANTS AS A NEW CAUSE OF REGIONAL WARMING

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ABSTRACT

Some man-produced compounds which escape and reside into the lower atmosphere (in gaseous or aerosol forms) execute significant molecular vibrations at room temperature. These compounds effectively turn the lower atmosphere into a bandpass (instead of an allpass) filter over the whole infrared spectrum. Consequently, a significant portion of the terrestrial radiation is trapped within the lower atmosphere leading to possible regional warming.

INTRODUCTION

Significant information regarding the climatic/weather system has been unearthed through the use of an electronic system (Fig. 1) specifically designed to mimic meteorological processes. The information so unearthed has already been published in the open literature [1-9]. It has been widely suspected that climatic change could possibly be brought about by considerable accumulation of greenhouse gases in the atmosphere. These gases may trigger global or regional warming by directly absorbing outgoing terrestrial infrared radiation and hence rising their own temperature and that of their surroundings. In this paper, we introduce a new greenhouse process in which certain man-made gaseous/aerosol compounds become airborne and hence make the lower atmosphere behave as a bandpass filter instead of continuing to act as an allpass filter. A notable consequence is that only that part of the outgoing terrestrial radiation within the bandwidth of the former filter is allowed to escape upwards. The ultimate result is global or regional warming.

ANALYSIS

The natural constituent particles in the lower atmosphere are in continuous thermal random motions. If these natural particles were the only ones present in the lower atmosphere, then the latter would effectively act as an allpass filter in accordance with the Frequency Shift Theorem. However, man-made industrial and other activities have resulted into emission of non-natural compounds (i.e. pollutants) into the lower atmosphere. Some of these pollutants execute molecular vibrations at room temperature and that all their vibrations are at frequencies within the terrestrial infrared spectrum[1]. Pollutants that fall into this category are: C_2Cl_4, S_2Cl_2, K_2, Cu_2, Cs_2, BiI, CsRb, Na_2, NaCs, NaRb, Rb_2, RbCs, C_2I_2, BBr, PBr_3, CBr_4, $SiCl_4$, $SiBr_4$, $GeBr_4$, $CHBr_4$, C_2Br_4, $SbCl_3$, $BiCl_3$,HgI_2, T_1I, $SiHBr_3$, ... etc. In the rest of this paper, we shall refer to each of the latter pollutants simply as a "vibrating atmospheric pollutant (in short VAP)".

In accordance with the Frequency Shift Theorem and analysis reported elsewhere[1,2], sufficient accumulation of VAP's in the lower atmosphere turns the latter into a bandpass filter as shown by the following equation.

Since the bandwidth implied in equation (1) above covers only a portion of the infrared spectrum[1], the effect of accumulation of VAP's into the lower atmosphere is to trap part of the (outgoing) terrestrial radiation into the latter and hence cause regional and/or global warming.

This new process of regional/global warming is clearly a result of man's activities and hence may be controlled or even eliminated at will by man. It can be envisaged that if nothing is done to put this process under control, the increasing level of industrialisation will emit more VAP's which, together with the well known greenhouse gases[3], will gradually warm up the lower atmosphere. Obvious consequences of such a warm up are a rise in sea levels and changes in climate.

BANDPASS PROCESS IN LIQUIDS

The analysis given in the preceding section may possibly be extended to liquids notably water in oceans, seas and lakes. Water (H_2O) in any phase does not execute significant characteristic vibrations at temperatures below 297^0K. If a given sample of water passes through infrared radiations (at normal temperatures), then dissolution into the water of substances that vibrate significantly at normal temperatures might alter the radiation-transmitting characteristics of the water sample. Thus, depending on the initial radiation-transmitting characteristics of the water sample, the resultant solution may transmit more or less infrared radiation compared to the original water sample.

CONCLUSION

We have described a new process by which regional and/or global warming may be effected. The main agents of this process are certain man-made compounds emitted into the lower atmosphere in gaseous or aerosol forms. These compounds execute significant molecular vibrations at normal temperatures and hence turn the lower atmosphere into a bandpass (instead of an allpass) window. The ultimate result is partial trapping of outgoing terrestrial radiation into the lower atmosphere inevitably leading to regional and/or global warming.

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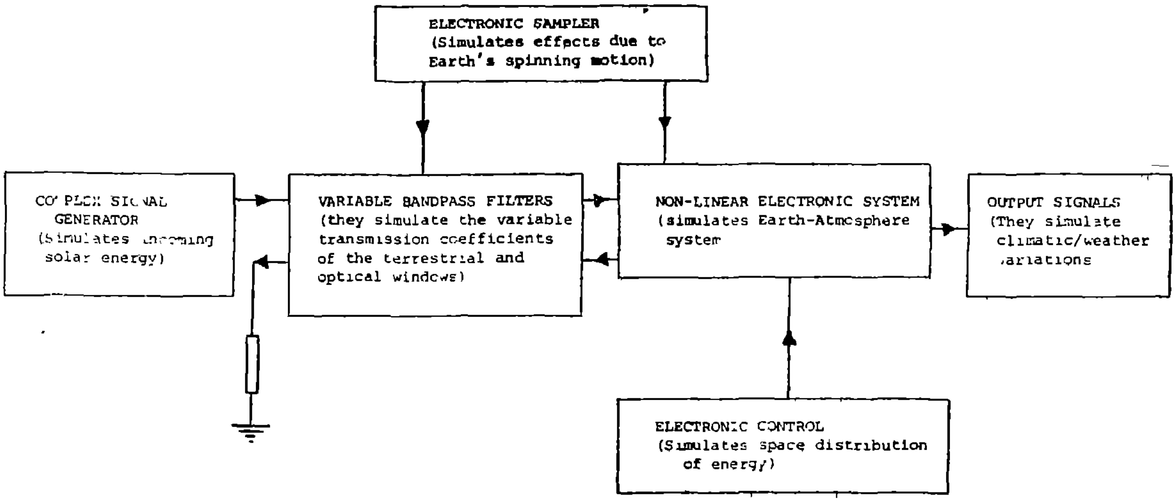

FIG. 1: BLOCK DIAGRAM OF AN ELECTRONIC SYSTEM WHICH SIMULATES CLIMATIC/WEATHER PROCESSES.

Question by Dr. Zaman

Can you say what the causes of glacial advances and regressions in the past were?

Answer

That was due to some distortions in the energy build up in the environment.

Question by Dr. Jonnalagada

What is the source of sulphur dichloride in the atmosphere?

Answer

I do not know the industry which produces that gas.

POSTER

AEROSOL COLLECTION MECHANISM AND ANALYSIS

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ABSTRACT

A method for aerosol collection using filters and impactor system is described. Energy Dispersive X-ray Fluorescence (EDXRF) Analysis has been used to quantify the samples. We report the results of the analysis with a detection limit of the order of 10 ng/sq.cm.

A great number of people have suffered from damages due to pollution both in their working and living places before the actual source is known.
In order to solve this problem control measures need to be considered. Knowledge of the chemical and physical properties of the pollutants makes it possible to evaluate the health hazard. Environmental samples need to be examined to check the extent of pollution. A number of samples need to be examined and thus there is a great need for fast collection techniques. In this paper we present the work involving a mechanism for sample collection and analysis.

1. Aerosol samples were collected using a Sierra-Anderson PM-10 TM medium flow air sampler.

2. Samples were collected along road sites. Elements such as Fe, Cu and Zn are mainly a contribution from the soil crust. Pb and Br are generated during the fuel combustion and are given out from the exhaust. Pb concentrations are added as component of anti-exploder in gasoline.

3. Two filters, quartz and teflon were used in the X-ray analysis. Teflon filters have shown to posses less significant impurities compared to quartz filters. The detection limits for teflon filters are better than quartz filters in EDXRF analysis. The analytical capability compares favourably for most of the elements with other techniques such as PIXE. The method proves to be one of the appropriate methods for routine multi-element analysis of environmental samples when

facilitated with sample changing system and the collecting impactor. The analysis of the samples have shown presence of Fe, Cu and Zn resulting from soil while Pb and Br originating from the vehicle fuel contribute to the environmental pollution.

ENVIRONMENTAL POLLUTION AND ITS EFFECTS IN TERRESTRIAL AREAS: CORAL LIMESTONE MINING ALONG THE DAR ES SALAAM COAST

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ABSTRACT

Excavation activities by their very nature of digging into the earth's crust are destructive to the environment. In East Africa, both small and large-scale mining operations have laid to waste large tracts of land. It therefore appears that no serious environmental considerations are taken or incorporated into the mining activities before and after holes are made into the earth.

Of particular interest are those Coral Limestone mining activities along the East African Coastline. A recent study of the Wazo-Kunduchi Coral Limestone Mining area North of Dar es Salaam City revealed that Tanzania has no proper laid down environmental legislation which has been incorporated into the STAMICO activities.

The study showed that the `heaps' and `pits' now disfiguring the Wazo/Kunduchi area have not only affected the surrounding terrain but have also initiated micro-climatic changes such as irregular temperature and moisture distribution, wind turbulence, hydrological imbalances, deforestation, soil erosion and siltation of river estuaries considered to be breeding, feeding and resting areas for the marine population.

According to the study, the rate of air, water, and health pollution is significant enough to cause alarm. If steps are not taken to curb the processes, the beach area may experience a further deterioration in tourism. Other potential effects are health hazards due to the cement factory which will affect the expansion of the Dar es Salaam City; growth of the fishing industry; and horticultural and agricultural activities etc.

The study ascertains the ecological implications of the mining activities and aims to serve as a basis for further research into the management and conservation of the area for other alternative uses.

Question by Dr. Mashauri

What is the impact of the asbestos cement factory.

Answer

After talking to the workers and management of the factory, effects are similar to those of the cement factory at Wazo Hill. The ill-effects include coughing, asthma and difficulties in breathing.

POSTER

THE ROLE OF INTENSE RAINFALL AND FLOODS IN ENVIRONMENTAL POLLUTION

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ABSTRACT

Intense rainfall and floods accompanied by rough winds, have been a cause for environmental pollution in many parts of the world.

There are two aspects of intense rainfalls and floods including cyclones in environmental pollution. First, convective rains and cyclones are accompanied by severe winds that pollute the atmosphere with debris and aerosols of all character. Secondly, the energy of the rain-drops and subsequent flooding destroys our habitats and finally resulting in water-borne diseases.

The fight against this natural disaster, has been tackled with immense success in developed nations. However in Africa, and therefore our eastern region, disaster unpreparedness has led to economic and social retardation and desperation unchallenged. The recent history of hazards of winds and flooding of almost two yearly and subsequent economic and human losses cannot tell any better of our primitive settlement schemes of design and construction in towns and in the countryside.

Just what areas are most susceptible to severe weather and floods in this region? To what extent? In what season and frequency. Who should be responsible for what in a rigorous undertaking to mitigate waterborne disaster. This paper tries to answer these questions. I believe this situation warrants a serious consideration by all concerned authorities in this region. It is an urgent challenge to all inter-governmental and governmental institutions.

BACTERIOLOGICAL POLLUTION OF POTABLE WATER

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INTRODUCTION

Human life on the earth depends on the environment because it gets food from the earth, oxygen from the air, fibre and fuel from the soil, water from the rivers, streams, springs, wells, lakes and warmth from the sun shine. To day all these sources of life are badly affected by the ever-increasing pollution around us.

The public health problems in developing countries arise not so much from industrialisation as in the case of industrialised countries, but mainly from such factors as absence of safe drinking water supply, inadequate sanitation, severe malnutrition and crowded housing conditions. Even where clean water is available, it is subject to contamination before use. The major cause of concern is biological pollution or the contamination of water with faecal waste. The pollution of water by pathogenic bacteria, viruses and parasites can be attributed either to the pollution of the water source itself or to the pollution of the water during its conveyance from the source to consumer. The pollutants may include the excretions, faecal and urinary, of human and animals, sewage and sewage effluents, and washings from the soil.

Infections are spread both by patients and by carriers who shed the pathogen in faeces or urine. The pathogenic bacteria transmitted directly by water or indirectly through water to food, constitute one of the principal sources of morbidity and mortality in many developing countries. They include the causative agents of the great epidemic diseases - cholera and typhoid - and of the less spectacular but far more numerous cases of infantile - diarrhoea, dysenteries and other enteric infections that occur continuously, and often with fatal results, among rural and urban populations, particularly in the developing countries.

BACTERIAL POLLUTION OF WATER SOURCES

Water, as a part of the human environment, occurs in four main forms - as ground water, in freshwater surface masses, in the sea and as vapour in the atmosphere. Potable water, in most of the countries, is obtained from upland surface water, streams, rivers, springs, shallow and deep wells. These water sources become contaminated from surface washings draining to a surface stream or entering underground supplies in lime stone formations through sink holes. Shallow wells may become contaminated because the distance travelled through the soil is insufficient to filter out the bacteria. Deep wells and springs which would otherwise produce safe water may be contaminated because they are not properly protected to prevent the entry of surface water, by the use of contaminated water pumps, or by contamination of ropes or buckets by unclean hands. Safe treated water may be contaminated through open reservoirs or damaged water pipes, specially in intermittent water supply.

A research study was conducted in rural areas of Abbotabad which showed that contamination was present in water samples collected from various sources. Water quality criteria and standards were adopted according to WHO international standards for drinking water. Bacteriological standard of water quality based on a faecal organism, Escherichia coli, that is not itself pathogenic but merely an indicator of possible contamination.

POLLUTION OF DRINKING WATER SOURCES IN ABBOTABAD

1. Stream water. The water is soft and bacteriologically pure, if catchment area is safeguarded against excessive pollution by human beings and animals. But bacteriological analysis of stream (Tables 1-3) show 100% heavy faecal contamination of human origin. It is a result of indiscriminate human defecation, ablution and bathing.

2. Springs are discharge point of water where the first impermeable layer of soil breaks to the surface. The water is quite potable and free from coliform organisms. Bacteriological analysis (tables 1-3) indicate 76.2% heavy faecal pollution. It means the springs are not safeguarded from contaminated soil and polluted soil water.

3. Deep wells. The water is normally much safer to drink than any untreated surface water, since the ground itself provides an effective purifying medium, such water constitutes a major source of drinking - water supplies. Nevertheless, 44% of deep wells samples show high bacterial pollution due to contaminated storage and water pipes.

4. Shallow well water is soil water which varies in quality and quantity with seasons; it is a poor source of supply, drying up in summer when need is greatest. However it is the most common water supply in villages. Bacteriological analysis (table 1-3) shows 100% pollution. But the hand pumps installed in shallow wells reduced the pollution by 50%. The important point is that there is no human faecal pollution in such cases.

CONCLUSIONS AND SUGGESTIONS

Stream and spring waters are heavily polluted by human faeces while tubewells and shallow well, hand pumped waters are comparatively less polluted and their mean values may attain the acceptable standard, if further contamination in storage containers is controlled. This amply demonstrates that the supply of piped water alone to the rural community was not the answer to the control of the water-borne infectious diseases (health hazards). Because in the absence of the environmental sanitation and use of contaminated storage such container water supplies are as proved to be contaminated by the faecal organisms as those of the stream, springs and open wells.

The uncontrolled pollution of water sources is due to people's disinterest. There is not enough social pressure for setting things right. The only solution lies in the education of the people and through public awareness. They have not only to understand the vital role the pollution control plays in their life, but to pressurize the local body officials and their elected representatives in the provincial as well federal assemblies to take appropriate measures for improving the worsening ecological conditions.

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TABLE 1: Bacteriological analysis of drinking water

Source of Water	No.	Cases Positive for Bacteriological Contamination	Cases with Negative or with Normal Bacterial growth
Spring	21	21	-
Streams	8	8 (100)	-
Deep wells (taps)	25	11 (44)	14 (56)
Shallow wells 6 - 15 feet	10	10 (100)	-
Hand pumps	6	03 (50)	03 (50)
Total No. of samples	70	53 (76)	17 (24)

Values between brackets represent percentage of total.

TABLE 2: Distribution of No. of coliform in various sources of drinking water

No. of Coliform/ 100 ml	Spring No.	Streams No.	Deep well (Tap) No.	Shallow No.	Hand pump No.
0-1	-	-	6	-	1
2-10	-	-	8	-	2
11-50	2	-	3	2	2
51-100	-	2	2	2	1
101-500	-	-	4	1	-
501-1000	-	2	2	1	1
1001-1800	1	2	-	-	-
1800	5	15	-	4	-
Total No.	8	21	25	10	6

TABLE 3

Contamination of water according to type of organism

Source of Sample	No.	E.Coli	Klebsiella	Pseudomonas	Proteus	Micrococci	Within Normal Range
Spring	21	16 (76.2)	2	3	-	-	-
Streams	08	8 (100)	-	-	-	-	-
Taps (Deep well)	25	11 (44.0)	3	1	1	-	-
Shallow well	10	5 (50.0)	3	1	1	-	-
Hand pumps	6	-	2	1	-	-	3
Total No.	70	40 (57.2)	10 (7.1)	5 (7.1)	1 (1.4)	1 (1.4)	13 (18.6)

RESOLUTIONS

THE FOLLOWING RESOLUTIONS WERE AGREED UPON

1. Environmental pollution is a real problem in many urban and rural areas in Eastern Africa. Examples of the situation in Tanzania, like Msimbazi Creek or the Tabata Dumping area have been discussed in this symposium.

2. Major pollutants in Eastern African include industrial wastes, agrochemicals, municipal wastes, mining and agricultural wastes.

3. Expected increase in population and industria-l ization in Eastern Africa will lead to the destruction of habitat if no proper preventive measures are taken immediately.

4. Environmental pollution induces destructive chain reactions. A clear example is presented by the increased pollution of rivers by industrial and domestic waters which even may affect the marine coastal environment.

5. Indiscriminate use of agrochemicals and lack of information on their use is a serious health hazard and a threat to the habitat. It was revealed that more than 100 deaths due to improper use of pesticides are reported yearly in Tanzania.

6. There is a need for proper environmental impact assessment before any major project is under-taken.

7. There is a need to enhance public awareness on the hazards of pollution and educating the public on safer ways of pest control, such as biological control.

8. Eastern African countries should take a serious look at weak spots in the enforcement of environmental legislation.

9. To deal with pollution properly, international cooperation is essential.

10. There should be an increased support for research in environmental problems.

11. A Regionally coordinating committee should be established which will be constituted as follows:

Chairman and Secretary from UDSM

Each country present elected a contact person.

The terms of reference for the committee are:

1. To plan for the next East African Regional symposium.

2. To increase awareness of environmental issues in Eastern Africa.

3. To work towards the formation of a society of environmentalists in Eastern Africa.

OFFICIAL CLOSING OF THE SYMPOSIUM ON ENVIRONMENTAL POLLUTION AND ITS MANAGEMENT IN EAST AFRICA: THURSDAY 14TH SEPTEMBER, 1989

The Faculty Dean, The Symposium Chairman, Symposium Participants, Ladies and Gentlemen.

I wish to thank you very much for giving me a second chance to address you. On Monday, the Chief Academic Officer and Acting Vice-Chancellor had read the Opening Address on my behalf. The original plans were to have the Minister responsible for Natural Resources to open the Symposium but due to the nature of his duties this was not possible.

Judging from the Abstracts circulated, the Symposium was very well attended in terms of both the spread of geographical regions as well as in terms of disciplines represented. The Universities of Nairobi, Zimbabwe, Dar es Salaam, Oslo, Moi, Makerere, Botswana and Kenyatta were represented while Departments of International Law, Geography, Zoology and Marine Biology, Physics, Chemistry, Geology, Community Health, Botany, Veterinary Medicine, Environmental Studies, Mechanical Engineering and Civil Engineering were represented. This interdisciplinary and international approach must have added breadth as well as depth to your approach to the subject.

I note from the newspapers that your discussions have already had an impact since people have read the proceedings as reported in the press and even reacted. This is very healthy indeed.

Judging from the list of participants and range of Abstracts presented in the Symposium document, other researchers based at national research institutions have also been actively involved in the discussions of this important theme. These include the Tanzania Breweries Ltd., the Rwegarulila Water Resources Institute, the Directorate of Meteorology, the Kenya Marine and Fisheries Research Institute, the Tropical Pesticides Research Institute, the Government Chemical Laboratory and the National Environmental Management Council. This is a very commendable feature since it is a clear indication that the matter is too important and too central to our lives to be left to the academics alone. It is my hope that this trend will continue and that we will see even a greater diversity at future symposia. And judging from faces in front of me, I am sure that we also have participants from the Tanzania Commission for Science and Technology (TCST) and elsewhere.

It would be a good thing to find out how close you were able to achieve the goals you set for yourselves. If you have come anywhere close to achieving a majority of them, then your time will not have been wasted. Some of the critics of meetings, conferences, workshops, symposia, congresses etc. state that we do not do very much after we have published proceedings of such meetings. I hope you will not be labelled with such negative comments. I hope you will all try your best to take the next step and see to it that something is done about the problem before us. It is not a problem of the industrialized countries alone, nor that of the developed countries only. It is a problem of us all.

There is need to make it one of the cardinal principles that all planning should take into account the environmental dimension. To sensitize people to the harm done to us as individuals or as communities, is your responsibilities. It is you who know what the ozone layer is all about. It is you who know when there is a hole in that layer. It is you who know what causes the hole and it is you who ought to propose what must be done to reduce pace at which the hole increases. One can take each specific problem and subject it to similar questioning. At the end of the day, we should have a comprehensive data bank on which to base policy decisions and to guide strategies for implementation.

Every symposium is as successful as the detailed planning that goes into each of them. Planning for dates, venues, papers, secretarial service, travel, finances and general welfare of all participants. The fact that you have come to the end in one piece speaks well for all who participated in both conceiving and in organizing the symposium. They all deserve our big thank you, if I may quote the Faculty Dean.

Next month, the Chairman of the South Commission and also Chairman of CCM will chair a very important conference on Science and Technology under the auspices of the Party here in Dar es Salaam. It is my hope that your Symposium proceedings, deliberations and recommendations will have an important contribution to make to that Conference.

Politicians are very good at mobilizing public opinion and in getting people to appreciate matters that affect their lives. I hope you will remember to involve them wherever you go.

I will now end my remarks by once more thanking you for inviting me to this closing session of the Symposium. For those visiting Tanzania from a far, we wish you a good journey home but come again. But next time come with your climbing gear and attempt an assent of Mt. Kilimanjaro. This is the centennial of the first climb by Hans Meyer, the German explorer which must be protected against pollution.

With these remarks I now declare your symposium officially closed.

Prof. G.R.V. Mmari
Vice-Chancellor,
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UNEP f... global efforts to fig... marine pollution

DAILY NEWS 15th September 1989

THE United ... Environmental Pro... (UNEP) has called for ... efforts to combat ma... ...ution.

U... ...ogramme Officer, D... ...am Gerges, who is ... Nairobi, told *Shihata* in ... Salaam that unless joint ...rts were made to protect ma... ...ne pollution, the resources would vanish

Dr. Gerges, who is attending a five-day symposium on environmental pollution which opened in the city on Tuesday, said "marine pollution is harmful to living resources particularly fish which is consumed by human beings"

However, Dr Gerges commended the Eastern African Region for its tireless efforts in implementing the UNEP Oceans and Coastal Areas Programme aimed at protecting and development of marine in the coastal regions

He urged developing countries to refrain from development programmes that destroy the environment which is vital for future generations

He said one of his major obligations at the symposium was to review the progress of the UNEP Programme on marine protection in the Eastern African Region

Under the Programme, scientists are supposed to identify various pollutants entering the marine environment from various sources including rivers, industrial wastes or even from the atmosphere

The scientists are also supposed to describe the effects of these pollutants on fish and determine the extent of harm

"The aim of this monitoring programme is to draw up recommendations to the governments on the control of marine pollution in the coastal areas", Dr. Gerges said

Meanwhile, participants to the on-going three-day symposium on environmental pollution and its management in Eastern Africa expressed concern over pollution of water sources due to lack of industrial sewage treatment, especially from textile factories

The participants were discussing a paper "effluent re use from industrial sewage treatment plants for protection of water sources pollution"

Pollution Symposium starts ... Dar today

DAILY NEWS 11th September 1989

AN Interna... ...posium on environ... ...pollution in Easter... ... starts at the Av... ... Institute (AVI) in ... ...aam today

... five-day symposium ex...ed to draw 100 environmen...al sicentists and policy makers from Eastern African countries and Europe, will discuss the control of pollution in the region

According to Dr. Huub Gijzen of the Faculty of Science, University of Dar es Salaam, a regional committee on environmental pollution will be formed after the symposium

"The symposium will deal with all aspects of environmental pollution including sources, monitoring, management, control and prevention" he said adding that besides the plenary lecturers there will be excursions to selected sites in Dar es Salaam

Participants will discuss papers on pollution by agro-chemicals, industrial wastes and natural sources of pollution and health hazards, Dr. Geijzen who is the Secretary of the organising committee said

Treatment and recycling of wastes, pollution monitoring methods, laws and legislation pertaining to environmental pollution, waster disposal and sites selection and preventive measures will also feature in the talks

The symposium organised by Dar es Salaam University Faculty of Science has been sponsored by the National Environmental Management Council (NEMC), Norwegian Agency for International Development (NORAD), the United Nations Environment Programme (UNEP) and the Netherlands Ministry of Foreign Affairs

Countries which will be represented are Angola, Botswana Comoros, Ethiopia, Seychelles, Somalia, Sudan, Tanzania, Uganda, Zambia and West Germany.

Various experts and officials from several United Nations affiliated agencies will also be in attendance Dr Gijzen said.

'Dumuzi invades maize farm

DAILY NEWS 10th September 1989

THE great grain borer, *dumuzi* has invaded Msimba maize farm in Kilosa Di... Morogoro Region.

Four agricultural e... ...ave been sent to the ... of various seeds No d... ...re given *Shihata*

Env... ...ment S... ...posium

...posium on environmen... ...pollution in East Africa ...rts tomorrow morning in Dar es Salaam

The meeting will discuss sources, management and control of pollutants, including agrochemicals About 100 participants are expected to attend.

Pesticides killed 1,320

ABOUT 1,320 people died of poisoning from pesticides in Tanzania between 1975 and 1985, *Maelezo* reported

A total of 2,953 cases of poisoning from insecticides were reported to police during the same period

The five day symposium on environmental pollution which ended yesterday in Dar es Salaam observed that the increase in the number of cases of poisoning was due to increased use of pesticides in farms and plantations

Change in the types and use of insecticides was also given as a contributing factor

It is estimated that about 1,200 tonnes of pesticides are used annually in Tanzania

An official from the government chemist Ndugu Sarati Rwegoshora told participants that shortage of modern sprayers was another obstacle in the use of pesticides

Tang... Serv... ticip... masc... man... gard... man... T... grou... wor... Shs... busi... H... ired... Sh... tak... sita...

DAILY NEWS 16th September 1989

HOME NEWS

'Msimbazi valley threatens public health'

By Christopher Mwalubandu

AGRICULTURAL and animal keeping activities in the Msimbazi valley in Dar es Salaam may cause serious public health problems in future, an expert said yesterday.

"The basin is a collector of industrial and domestic waste and there is evidence that it is heavily polluted", Dr Damas Mashauri, a Water Resources Engineer at the University of Dar es Salaam said.

The lecturer was presenting a paper at the symposium on environmental pollution and its management in Eastern Africa which is being held at the Audio Visual Institute (AVI) in the city.

He said: "We [illegible] take care of the waste before it [illegible] Msimbazi basin and [illegible] agricultural activities."

He said heavy metals [illegible] among common pollutants in the valley and he showed several food chains involving crops, chickens and cattle to demonstrate how the metals were conducted to the human beings.

As we feast on milk and its products, salads, eggs and meat from the valley our health could be at risk", he said and quoted an international publication reporting on a research conducted in the valley showing pollution by several metals.

He said there was need to organise development activities so that they did not go beyond the carrying capacity of the environment and which did not pose a risk to public health.

"In order to have meaningful development we must help the environment to sustain a flow of resources for our [illegible]", the lecturer who is doing a research in the Msimbazi basin said.

He said ways should be found to recycle wastes or treat them before disposal.

The Principal Advisor to the National Environment Management Council (NEMC) Mr. Borje Paulsson said planning procedures should be improved so that industries are separated from settlements while water and sanitary sites should be secured before plot allocation.

Mr Paulsson praised the Southern Paper Mill in Iringa for being able to treat wastes which are produced during the industrial processes.

"There is no discharge of mercury (which is dangerous to health) at Mufindi. Environmental considerations were included in the planning", he said.

The Acting Dean of the Faculty of Science at the University of Dar es Salaam Dr Mohammed Bilal said a masters degree programme in environmental studies is planned for October next year "to get people with knowledge on sound management of the environment".

The symposium continues this morning.

HOME NEWS

Waste water can be treated to produce biogas

[illegible] WATER produced by [illegible] activities can be treated to produce biogas, scientists said yesterday in Dar es Salaam.

In a joint paper presented at a symposium on Environmental Pollution in Eastern Africa, Ndugu Frank Kansiime and Dr. Huub Gijzen of the University of Dar es Salaam said:

"Organic matter in wastewater can be converted by anaerobic micro-organisms to methane and carbon dioxide (biogas)"

Anaerobes are organisms which do not need oxygen for their living.

They said *anaerobic* wastewater treatment was a potential biotechnology for developing countries.

In another joint paper by Dr. Gijzen and Ndugu Francis Magingo, the microbiologists said organic wastes could be re-used through composting, a process in which wet vegetables are placed in a heap to ferment and rot, producing *methane* and nutrients such as nitrogen, phosphorus and sulphur.

"Gems are destroyed during composting because temperatures may rise up to 70 degrees centigrade", they said.

They added that compost could be used as fertilizer for crops or for commercial production of edible mushrooms and thus reduce environmental pollution by over accumulation of organic matter.

Presenting a paper on Human Activity and Nature, Professor Adolf Mulokozi said exploitation of resources was done without responsibility.

"As chemists we should provide solutions for safe disposal of wastes and better management of the environment while allowing development to continue." the professor said.

When asked to comment on a statement by Shirika la Uchumi na Kilimo Tanzania (SUKITA) management that Msimbazi valley was not seriously polluted, participants to the symposium said:

"We leave it to wisemen and the informed public to make their own judgement. We have played our part. We stand by the report made in the *Daily News* of 12/9/1989".

Last Tuesday the *Daily News* quoted Dr. Damas Mashauri of the University of Dar es Salaam as having said Msimbazi valley was a collector of industrial and domestic wastes and that there was evidence that it was heavily polluted.

Sukita Managing Director Ndugu John Kapinga challenged the report saying the expert (Dr Mashauri) seemed to have generalised the Msimbazi pollution case, creating "unnecessary alarm to the general public."

The symposium which ends today was organised by the University of Dar es Salaam was sponsored by the United Nations Environment Programme (UNEP), Norwegian Agency for International Development (NORAD), the National Environment Management Council (NEMC) and the Netherlands Ministry of Foreign Affairs.

DAILY NEWS 14th September 1989

HOME NEWS

Sukit[illegible] challenges expert on pollution

By Hamidu Bisang[illegible]

SHIRIKA la Uchumi [illegible]no Tanzania (SUKITA) [illegible]ongly challenged a rep[illegible] water engineer that [illegible]ural and animal keepin[illegible]ities in the Msimbazi [illegible] in Dar es Salaam m[illegible]e serious public health [illegible]ns in future.

A[illegible]ng a press conference ye[illegible], SUKITA Managing [illegible]or John Kapinga said the [illegible]rt seemed to have generalised [illegible]e Msimbazi pollution case, creating "unnecessary alarm to the general public".

He challenged the engineer, Dr Damas Mashauri, to come up with scientific data to support his "findings of metal pollution in the Msimbazi Valley".

SUKITA is developing an agricultural complex in the valley between the Port Access Road and the Magomeni-Kigogo Road. Ndugu Kapinga ruled out industrial pollution in their are a because there were only two industries upstream — Kiltex and Sunguratex textile mills.

"These do not throw their wastes into the Msimbazi River. Moreover, they are not even steel industries to bring fears of metal pollution," he explained.

However, Ndugu Kapinga, who was sorrounded by his experts working at the project ranging from veterinary doctors to poultry experts and a water engineer, said they were also going to launch a scientific research to determine the extent of pollotion in the soil and water flowing in the valley.

Speaking at an international symposium on environmental pollution and its management in East Africa on Monday, Dr Mashauri said the valley was a collector of industrial and domestic wastes and that there was evidence that it is heavily polluted with metals being among common pollutants.

SUKITA has established a hatchery and is cultivating maize, paddy, beans, yams and vegetables. It also plans to start a dairy farm and a piggery.

The Msimbazi Valley Project Veterinary Doctor Nkala Maeda ruled out changes of chicken absorbing pollutants because they eat nothing from the valley.

"They drink tap water and their food is provided by SUKITA Animal Feeds plant. The only thing they eat from the valley is spinnach, which i doubt has any so-called metal wastes," he added.

According to a 1988 research report prepared by Jonathan Ak'habuhaya and Martin Lodenius on *Metal Pollution of Msimbazi River* on which Dr Mashauri based some of his facts, there was in general only moderate variations between metal contents at different sampling sites.

"However, the samples from Luhanga River and the upper part of Msimbazi River (betweenGongo la Mboto and Kigogo) usually contained less metals than samples collected further downstream (between Jangwani and Muhimbili Medical Centre).

"A comparison with existing data shows that the metal contents in the River Msimbazi ecosystem in average are at a normal level...., "the report says.

SUKITA experts invited Dr Mashauri to produce scientific data to support his report so that they could jointly work together to avert the danger of pollution. They were suprised that they were not contacted in the course of Dr Mashauri's research.

BUSINESS TIMES

'Hill' to host talks on pollution

By TIMES correspondent

AN international symposium to evaluate the present and future state of environmental pollution in Eastern Africa will be held at the University of Dar es Salaam in September this year.

According to Dr Huub J. Gijzen, the secretary of the organising committee, the symposium will bring together experts engaged in all aspects of environmental pollution in the region

"The symposium will deal with all aspects of environmental pollution which include sources, monitoring, management, control and prevention", he said

The five-day symposium is being organised by the Faculty of Science to mark the 20th anniversary of the establishment of the University of Dar es Salaam. The university was established in 1970 when the East African University was dissolved. It will be 20 next year.

Potential international donors for the meet include the Nairobi-based United Nations Environmental Programme (UNEP), Swedish International Development Authority (SIDA), Norwegian Agency for International Development (NORAD), UNESCO and the Netherlands Ministry of [illegible]

Locally, the [illegible] "fully incorporate" national institutions like the National Environmental Management Council (NEMC), the recently-established Tanzania Commission for Science and Technology, research institutions and other public institutions and experts dealing with pollution issues, according to Dr. Gijzen.

The symposium, the first of its kind to be organised by the university, will be in two parts: — environmental pollution (and its effects) and management, monitoring, control and prevention.

The first part will assess the present marine and fresh waters, terrestial and atmospheric pollution while the latter part will fo[illegible] recycling, [illegible] methods, [illegible] legislations, waste disposal and sites selection and preventive measures

Group photograph of symposium participants

Participants listening to one of the presentations

Participants discussing a poster on pesticide pollution

Closing speach by the Vice chancellor Prof. G.R.V. Mmari

11. PROWWESS/Africa: Femmes, Eau et Assainissement - Penser et Agir avec les Communautés Rurales: Atelier régional de formation des formateurs des pays francophones et lusophone, Ouagadougou, Avril 1989 by Aminata Traore 1989, (French). Report on the Regional Training-of-Trainers workshop for francophone and lusophone African countries held in Ougadougou, Burkina Faso, April 1989.

Strategies - Guidelines for Project Planning, M&E, Inter-Agency Strategies

12. PROWWESS/UNDP: PEGESUS by Deepa Narayan-Parker, April 1989 (English, Spanish), 11 pp. Analytical framework for designing and assessing projects and programmes, concentrating on goals and management tasks.

13. PROWWESS/UNDP: Goals and Indicators for Integrated Water Supply and Sanitation Projects, by Deepa Narayan-Parker, April 1989, (English, Spanish), 20 pp. Emphasis on design of indicators for planning and evaluation, within framework mentioned under item 10.

14. UNDP Central Evaluation Office: Findings, 1991, (English) 4 pp. Short description of an evaluation framework for water/sanitation projects, based on items 12 and 13.

15. PROWWESS/UNDP and INSTRAW: Interagency Task Force on Women - Proposals for 1989-90, 1988, (English). Reviews progress with respect to women's participation aspects in UN organizations active in the water/sanitation decade, assesses major challenges for the future, proposes a work plan for agencies concerned.

16. PROWWESS/UNDP: Taking the Pulse for Community Management in Water and Sanitation, by Deepa Narayan-Parker, September 1990 (English). A brief interim report of the Monitoring and Evaluation Workshop, Geneva, June 1990.

Tools - Field Manuals, Training Instruments etc.

17. PROWWESS/UNDP: Tools for Community Participation - A Manual for Training of Trainers in Participatory Techniques, by Lyra Srinivasan, December 1989, (English/Spanish, Portuguese and French forthcoming). A field manual for trainers in field projects. Particular emphasis on SARAR methodologies, experiences in application in PROWWESS/UNDP activities.

Complementing the manual, a video is available (English and French, forthcoming Spanish, VHS, systems PAL, NTSC, SECAM).

To order, contact PACT, 777 U.N. Plaza, New York, N.Y. 10017, U.S.A. for US$35.00).

18. Playing Cards for Better Health - Training Guide for the Treatment of Diarrhoea. PROWWESS has designed this simple training package which uses illustrated cards as a basis for training mothers to treat their children's diarrhoea. Designed by Ron Sawyer and Patricio Canton, and published by United Nations Children's Fund, the package was prepared on behalf of Mexico's Secretariat of Health which requested help in introducing a more participatory method.

11. PROWWESS/Africa: Femmes, Eau et Assainissement - Penser et Agir avec les Communautés Rurales: Atelier régional de formation des formateurs des pays francophones et lusophone, Ouagadougou, Avril 1989 by Aminata Traore 1989, (French). Report on the Regional Training-of-Trainers workshop for francophone and lusophone African countries held in Ougadougou, Burkina Faso, April 1989.

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14. UNDP Central Evaluation Office: Findings, 1991, (English) 4 pp. Short description of an evaluation framework for water/sanitation projects, based on items 12 and 13.

15. PROWWESS/UNDP and INSTRAW: Interagency Task Force on Women - Proposals for 1989-90, 1988, (English). Reviews progress with respect to women's participation aspects in UN organizations active in the water/sanitation decade, assesses major challenges for the future, proposes a work plan for agencies concerned.

16. PROWWESS/UNDP: Taking the Pulse for Community Management in Water and Sanitation, by Deepa Narayan-Parker, September 1990 (English). A brief interim report of the Monitoring and Evaluation Workshop, Geneva, June 1990.

Tools - Field Manuals, Training Instruments etc.

17. PROWWESS/UNDP: Tools for Community Participation - A Manual for Training of Trainers in Participatory Techniques, by Lyra Srinivasan, December 1989, (English/Spanish, Portuguese and French forthcoming). A field manual for trainers in field projects. Particular emphasis on SARAR methodologies, experiences in application in PROWWESS/UNDP activities.

    Complementing the manual, a video is available (English and French, forthcoming Spanish, VHS, systems PAL, NTSC, SECAM).

    To order, contact PACT, 777 U.N. Plaza, New York, N.Y. 10017, U.S.A. for US$35.00).

18. Playing Cards for Better Health - Training Guide for the Treatment of Diarrhoea. PROWWESS has designed this simple training package which uses illustrated cards as a basis for training mothers to treat their children's diarrhoea. Designed by Ron Sawyer and Patricio Canton, and published by United Nations Children's Fund, the package was prepared on behalf of Mexico's Secretariat of Health which requested help in introducing a more participatory method.