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EVALUATION OF WASTE DISPOSAL SYSTEMS FOR URBAN LOW INCOME COMMUNITIES IN AFRICA

a research study

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by

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Copenhagen, October 1972

Uno Winblad

Chapter 1

INTRODUCTION

background

Over the past ten years urban conditions in Africa have been rapidly deteriorating. Many urban areas are increasing their population by 7-8% per year, and in some cities the annual increase is over 10%. Today around 30 million Africans are living in towns - according to current UN estimates another 100 million will be added during the course of one generation.

problem

The environmental problems accompanying this growth have now reached crisis proportions. Neither local nor central authorities are able to provide utilities and build houses to cope with the emergency. Urban populations do get housed one way or the other but most of this growth takes place in unplanned, under-serviced shantytowns - "transitional urban settlements" - (UN, 1971b). Shantytowns commonly grow at a rate of 12% per year and some at rates in excess of 20%. In Africa, as in Asia and Latin America, shantytowns are by far the fastest growing parts of urban areas (UN, 1971b) and in many cities the shantytown population is likely to double within the next four to six years (WORLD BANK, 1972). The problems this gives rise to may vary from one country to another but in spite of local and regional differences there are a number of identifiable urban conditions that have a degree of uniformity all over Africa. One of these is the lack of basic utility systems. Poor water supply, coupled with inadequate waste collection and no facilities for disposal of excreta, is a typical condition for most urban settlements in Africa. WHO estimates that in 1971 only 8% of the urban families in the developing countries of Asia and Africa had access to a sanitary sewage system (WHO, 1972).

What is often referred to as the "housing problem" has little to do with actual houses (ONIBOKUN, 1972) but rather with fundamental sanitation, that is, the provision of an adequate supply of drinkable water and a satisfactory system for disposal of excreta and household waste.

In many instances it is a question of life or death, not to speak of human dignity and self-respect. One cannot teach a child to read if he is debilitated by diarrhoea, or expect a man to take a great interest in improving his shelter if he has to wade through his own, his neighbours' and his animals' filth. (GRAVA, 1969)

The pollution of water with human wastes is the chief reason for spread of the enteric diseases (DIETRICH and HENDERSON, 1963). The incidence of typhoid fever, bacillary dysentery, infectious hepatitis and other enteric infections that may be transmitted by water can be more than 100 times higher in a developing country than in the more advanced of the developed countries (WHO, 1968).

WHO stated earlier this year that *The spread of cholera in recent years has brought forcefully to the notice of the public the basic sanitary principle that human excreta must be disposed of in such a way as to prevent their contaminating food and water. (WHO, 1972)*

In a recently published note the WHO Regional Office in Brazzaville expresses a strong concern about the epidemic outbreak of cholera in Africa south of the Sahara. In less than two years 85 000 cases have been notified and 13 216 deaths from cholera registered (Le Monde, 29th August, 1972).

In addition to water-borne enteric disease, urban development has also produced an increase in mosquito-borne infection in man (malaria, filariasis and arbovirus infections). The uncontrolled disposal of sewage and household waste has made this problem worse than before because latrines, cesspits and ill-kept sewage lagoons and stabilization ponds create ideal breeding conditions for mosquitoes (SURTEES, 1971).

The stereotype response to urban environmental problems in Africa is to apply standard solutions from the industrialized countries. Thus water-borne sewer systems are invariably put forward as the answer to the problems of human waste disposal (MACDONALD, 1952 and WHO, 1965). Such systems are expensive to install and operate even under the most favourable conditions. In a typical African urban area with an irregular settlement pattern, water shortage, and in the case of inland locations a lack of recipients, water-borne sewer systems will be prohibitively costly. The World Bank estimates the cost of water supply and water-borne sewerage at an average of US$200 per person (WORLD BANK, 1972). Compared to what a country like Tanzania can spend on urban development (see page 9) it is evident that the total capital requirement for utilities at conventional Western standards greatly exceeds the resources available. Even if the total net savings of a developing country in Africa were used to provide the urban population with utilities of such standards, the funds would be insufficient (WORLD BANK, 1972).

Sanitary systems based on standards and technologies of rich industrialized countries are simply irrelevant for Africa today and in the foreseable future. The great majority of people in Africa are not likely in this century to be able to afford any other sanitary installations than those they can build themselves.

A number of studies in the last few years have drawn attention to the deteriorating conditions of the rapidly growing cities in Africa, Asia and Latin America. Most of them are confined to general descriptions or to sociological and geographical surveys and there has been virtually no systematic analysis of the costs of urban development. Few studies have been able to offer practical solutions to the environmental problems facing the cities.

aim

The aim of the research and development programme whose beginning is represented by this report is to offer such solutions by widening the range of choice of technical systems available to urban authorities and individual households in Africa.

hypotheses

Our first hypothesis is that for economic reasons human waste disposal for urban low income communities has to be based on non-network systems.

Our second hypothesis is that systems based on microbiological decomposition of faecal matter and household refuse will satisfy the performance criteria specified in Chapter 3.

outline of report

This introductory chapter is followed by a discussion of costs and standards in relation to different modes of urban development in Africa. Chapter 3 is an attempt to formulate general performance criteria for waste disposal systems. In Chapter 4 fifteen existing systems are classified, described and evaluated. Chapter 5 contains conclusions and recommendations.

Chapter 2

BASIC URBAN DEVELOPMENT

This chapter contains a discussion of costs and standards in relation to different modes of urban development in Africa. Distinction is made between three levels of development of human settlements: traditional, modern and intermediate.

Most pre-industrial societies have a building tradition based on self-help and mutual aid. Dwellings are built by the householders themselves, often with the help of their neighbours. The single dwelling unit or group of dwellings is self-contained and forms part of a balanced ecological system. Material for the house is available locally and can be collected without charge. No elaborate infrastructure is required. Each household or local community builds and maintains its own roads and water-wells and in a rural setting the disposal of excreta and refuse need not pose any serious problem. This level of development we may call "traditional".

During the initial stage of urbanization - while settlements are small and densities low - "traditional" houses and utility systems could also be used in urban areas. But not for long. The building material available is no longer free. What was a cheap and rational way of building within a subsistence economy may be neither cheap nor rational when materials like straw, bamboo, wood, and stone have to be purchased or transported from far away (NAIGZY, 1971). With increasing densities the ecological balance is upset and some kind of communal arrangement becomes necessary for the basic utilities of water supply, waste disposal, surface drainage, electricity supply and access lanes.

In urban areas all over Africa a new building tradition is emerging: the "intermediate" settlement. This is actually an urban adaptation of the rural building tradition. The "intermediate" house can be placed wherever one can build without purchasing land. The building materials come from the urban environment: old sacks, wooden boxes, tin cans, or whatever is available. Sometimes concrete blocks, doors, windows and roofing materials are purchased new, but for the most part waste material is used. The resulting structure has some of the characteristics of the "traditional" house: it is cheap, it is flexible and it can be put up by anyone. We may call this type of building "intermediate" as it contains elements of both "traditional" and "modern", that is "Western", cultures.

Unfortunately this new tradition does not solve the problem of basic utilities. In that respect it is as ill-adapted to an urban environment as "traditional" building cultures. In densely populated areas dwellings are no longer self-contained. The workable systems for water supply and waste disposal evolved by pre-industrial societies over the years do not work in urban areas. This is mainly due to the much higher population densities, but also to the breakdown of traditional organizational patterns.

Thus we have a situation where a large number of houses are built at costs most households can afford, but at unacceptably low public health standards. At the same time there is a limited production of houses of acceptable standards which cost far more than the great majority can afford.

For the purposes of the analysis the cost-variable can be broken down as follows:

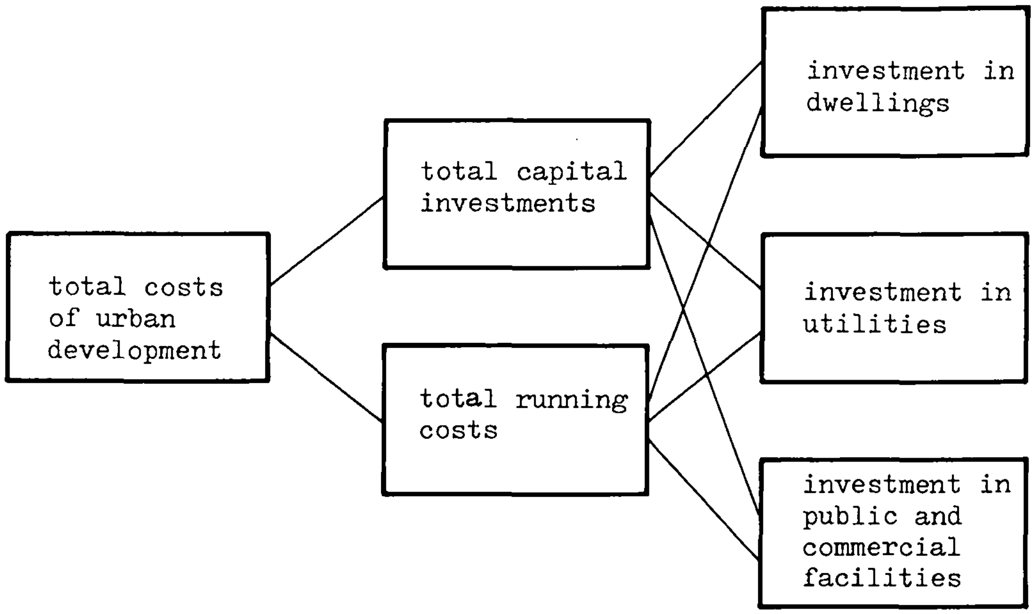


Fig 1: Breakdown of total costs of urban development

The scope of this chapter is limited to capital investments in dwellings and utilities.

The standards-variable can likewise be broken down into a number of constituent parts, but in this chapter, dealing with basic houses and basic utilities, we shall limit the discussion to standards related to basic requirements of health: safe water supply, facilities for personal hygiene, and a means of waste disposal (excreta as well as refuse) that fulfils the requirements outlined in the following chapter.

The situation is then illustrated in fig. 2.

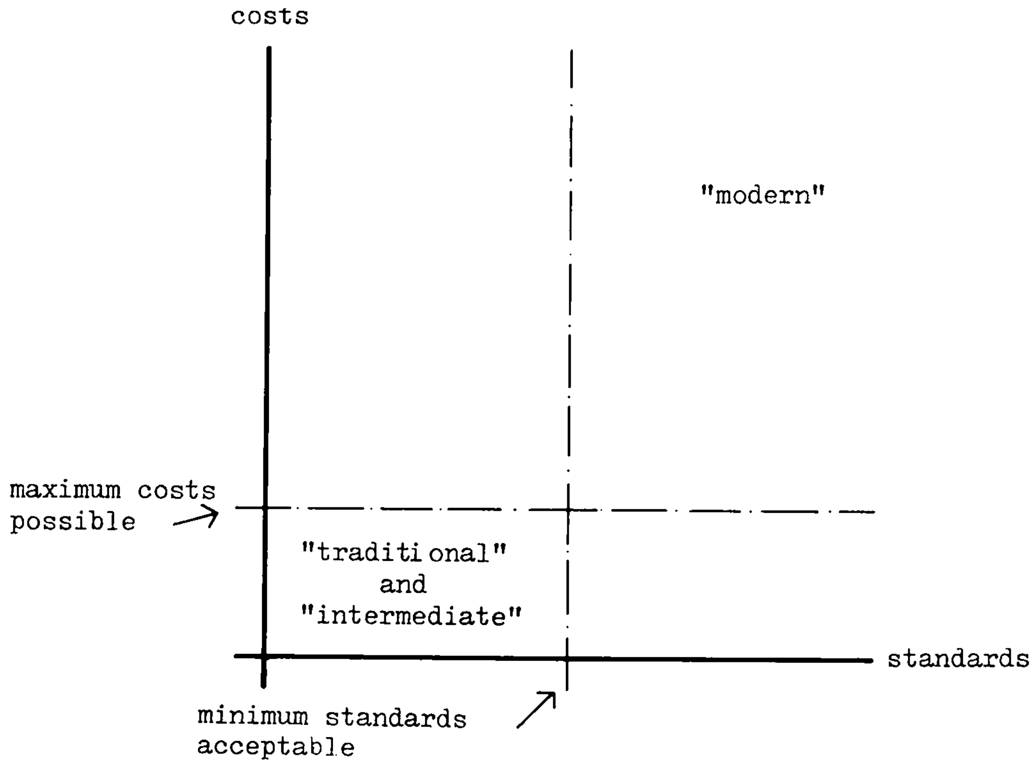


Fig 2: African urban settlements: relationship between costs, standards, and current modes of building.

The problem as illustrated in the figure above is that urban development within the cost limits set by available resources does not satisfy basic requirements of health, and conversely, "modern" development of acceptable standards is much too expensive. There are basically four ways of attacking this problem:

1) *increase the resources,* for example by increasing the GNP or by allocating more money to the housing sector of the economy;

2) *lower the standards,* for example by setting emergency standards or by temporarily letting two or more households occupy one dwelling;

3) *lower the costs of "modern" development;*

4) *increase the standards of "traditional" and "intermediate" development.*

A substantial improvement of the urban housing situation is not likely without action at all these levels. The message of this report, however, is that concentration on approach No. 4 in the first instance is likely to be the most rewarding. That is to say, we should concentrate on the possibilities of improving the standards of "traditional" and "intermediate" urban development.

So far research and development in the field of housing has been directed mainly towards the "superstructure", i.e. the building itself, its lay-out, materials and construction. Very little work has been done on the "infrastructure", i.e. the utility systems. For the dwelling unit present practices in Africa offer us a wide selection from the entirely self-built "traditional" buildings, through the "intermediate" houses made up of waste material, to "modern", often partially or completely prefabricated, units. In addition there are numerous combinations of these three ways of building.

There is no corresponding choice of materials, components and technical solutions for the utility system. Here we are limited to either archaic "traditional" systems: wells and pit-latrines - or to "modern" systems: piped water supply, and sewage collection networks and treatment plants.

A recent study of Swedish municipalities showed that investments in utilities are around US$600 per person (LINDSTRÖM, 1972) in Sweden. In British New Towns the average investment is of the same order, US$500 per person. But Tanzania, according to its current 5-year development plan (TANZANIA, 1969), can spend no more than US$8 per urban inhabitant (1969) per year on urban infrastructure.

One way of lowering the per capita investment in utilities is to increase population densities (DOWNING, 1969).

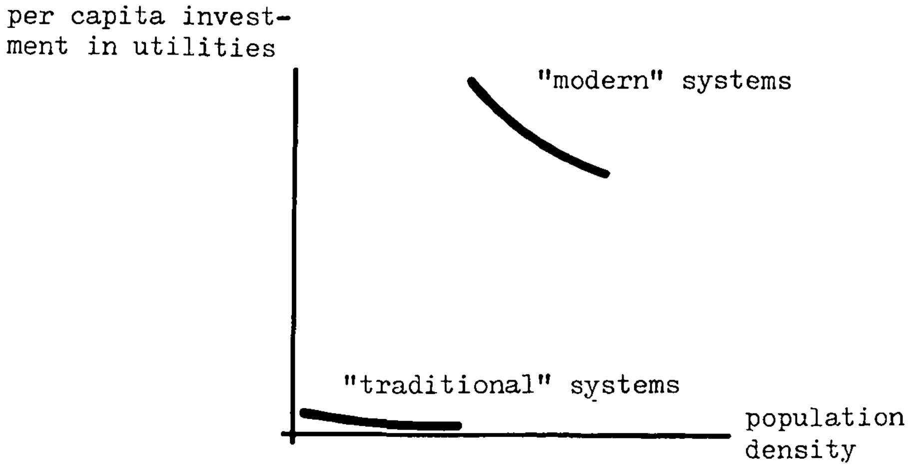


Fig 3: Relation between per capita investment and population density for "traditional", and "modern" utility systems.

As an example of the relation between population density and per capita cost of utilities we can take systems for the disposal of human waste. The most simple one would be to dispose of excreta directly in the fields. This may be an acceptable method in sparsely populated areas under certain climatic conditions. Another simple method is the pit-latrine. If properly built and maintained, and under favourable soil and climatic conditions, the pit-latrine can be used at low urban densities, say up to 10 households per hectare, if combined with a piped water supply. When densities begin to increase, more costly systems like aqua-privies and septic tanks have to be installed. As densities increase further, and multistorey housing is introduced, it may be necessary to build a collection network with some kind of primary treatment plant, followed, at still higher densities, by secondary and tertiary treatment. Extremely high densities may eventually require a recycling system of the kind used in spacecraft.

None of these systems is compatible with the way African cities are developing today. Densities are too high for the "traditional" pit-latrine (GRAVE, 1969), and an aqua-privy or a septic tank may cost as much as a "traditional" or "intermediate" house (ORAM, 1965). Collection networks in their present form are much too costly for any African city to afford for anything but a small part of the urban area.

For urban utilities we lack an equivalent to the "intermediate" house. In order to reverse the current trend towards steadily deteriorating urban conditions we have to develop "intermediate" utility systems, "basic utilities", to fill the gap between "traditional" and "modern" systems, see figure 4.

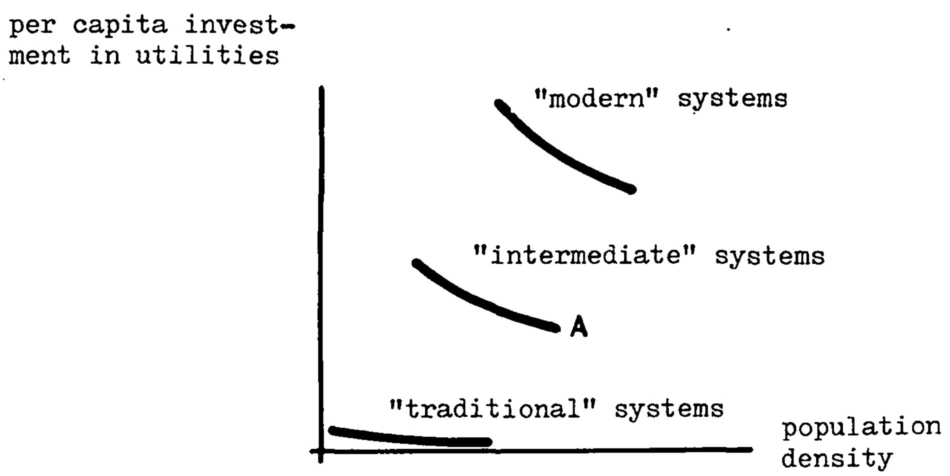


Fig 4: Relation between per capita investment and population densities for "traditional", "intermediate", and "modern" utility systems.

With "intermediate" systems the total investment requirement is kept well below the level for "modern" systems, while the investment per capita is further lowered by intensive use of the land, i.e.: at the highest densities the utility systems will allow (point A, figure 4).

Little has been done to develop such systems. Nor will they be developed unless the need is recognized and the requirements specified.

Chapter 3

PERFORMANCE CRITERIA

In this chapter an attempt is made to formulate some general performance criteria for waste disposal systems.

According to WAGNER and LANOIX "a latrine or other disposal method" should satisfy the following seven requirements (adapted from EHLERS and STEEL, Municipal and Rural Sanitation, New York, 1950):

1. *The surface soil should not be contaminated.*
2. *There should be no contamination of ground water that may enter springs or wells.*
3. *There should be no contamination of surface water.*
4. *Excreta should not be accessible to flies or animals.*
5. *There should be no handling of fresh excreta; or, when this is indispensable, it should be kept to a strict minimum.*
6. *There should be freedom from odours or unsightly conditions.*
7. *The method used should be simple and inexpensive in construction and operation.*

These requirements are not complete, nor are they formulated in such a way as to facilitate evaluation of different systems. As a first attempt to formulate them stringently we have divided them into six groups:

Ecological criteria

The system must not upset the ecological balance of the environment, that is discharges into water bodies, groundwater, soil and air must not exceed the self-regenerative capacity of the ecosystem.

Health criteria

The wastes must be collected, stored, transported and treated in such a way that pathogenes cannot be spread, either by direct contact with the excreta, or indirectly via water, soil, insects or animals.

Nuisance criteria

Odours and unsightly conditions must be kept below the level where they impede the proper use of the system or embarrass third persons.

Cultural criteria

Methods of collection, storage, transportation and treatment of the wastes must be compatible with local habits and religious practices.

Operational criteria

The system must not for its day to day functioning require any skills not normally found among the users.

Cost criteria

Investment and running costs should be compatible with the general income level of the society.

For use in existing squatter areas we could add: the system should fit into existing built-up areas and be capable of extension in small increments.

No widely used method fulfils all these requirements. The urban conditions in Africa today may make it necessary to alter the performance criteria on some points, but first it is necessary to investigate whether any known system could be developed to fulfil all the criteria. This is done in the following chapter.

Chapter 4

REVIEW AND EVALUATION OF EXISTING SYSTEMS

The purpose of this chapter is to review and evaluate the various methods and systems currently available for disposal of household waste.

A monograph published by WHO (WAGNER and LANOIX, 1958) contains a thorough description and evaluation of excreta disposal facilities for rural areas and small communities. Much of that material is also relevant to this study of waste disposal systems for urban areas in Africa. But the emphasis here is different: the main concern of this study is the identification of low cost systems suitable for high population densities and existing shantytowns.

WAGNER and LANOIX divide the different methods of excreta disposal into a) *the privy method* and b) *water carried methods*. That division was appropriate for their survey of methods applicable to rural areas but is not relevant to a study on the potential suitability of systems for urban areas. Besides, since the time when their study was published several methods have been developed which do not fit into either of the two groups.
GRAVAS (1969) division into a) *individual systems* and b) *collection networks* is more relevant to an urban situation but still not satisfactory, as "collection networks" refer to pipe networks only. Many systems he would classify as "individual" do in fact depend on road networks (e.g. for access by vacuum truck). Other "individual" systems depend on supply networks (water, energy).

We propose another classification, which better highlights the nature of the problem which we have to solve. This programme of study is concerned, in its present phase, with excreta disposal locally. Treatment plants on a metropolitan or regional level are outside the scope of this report. We distinguish between three principles for disposal of human wastes: *removal, infiltration* and *destruction.* Many systems use a combination of these principles.

(A complete inventory should also include methods of recycling waste. Such methods have been developed for spacecraft (PIPES 1961 and RICH 1965) and might also at sometime in the future be feasible on earth.)

Removal refers to all those methods where the excreta are collected and transported (whether carried away in buckets, by vacuum truck or by pipe network) to be discharged into a body of water or processed further by the use of some method based on the previous two principles.

Infiltration means absorption and dispersion in soil and groundwater.

Destruction refers to those methods where the excreta are reduced on the spot to inoffensive, harmless material.

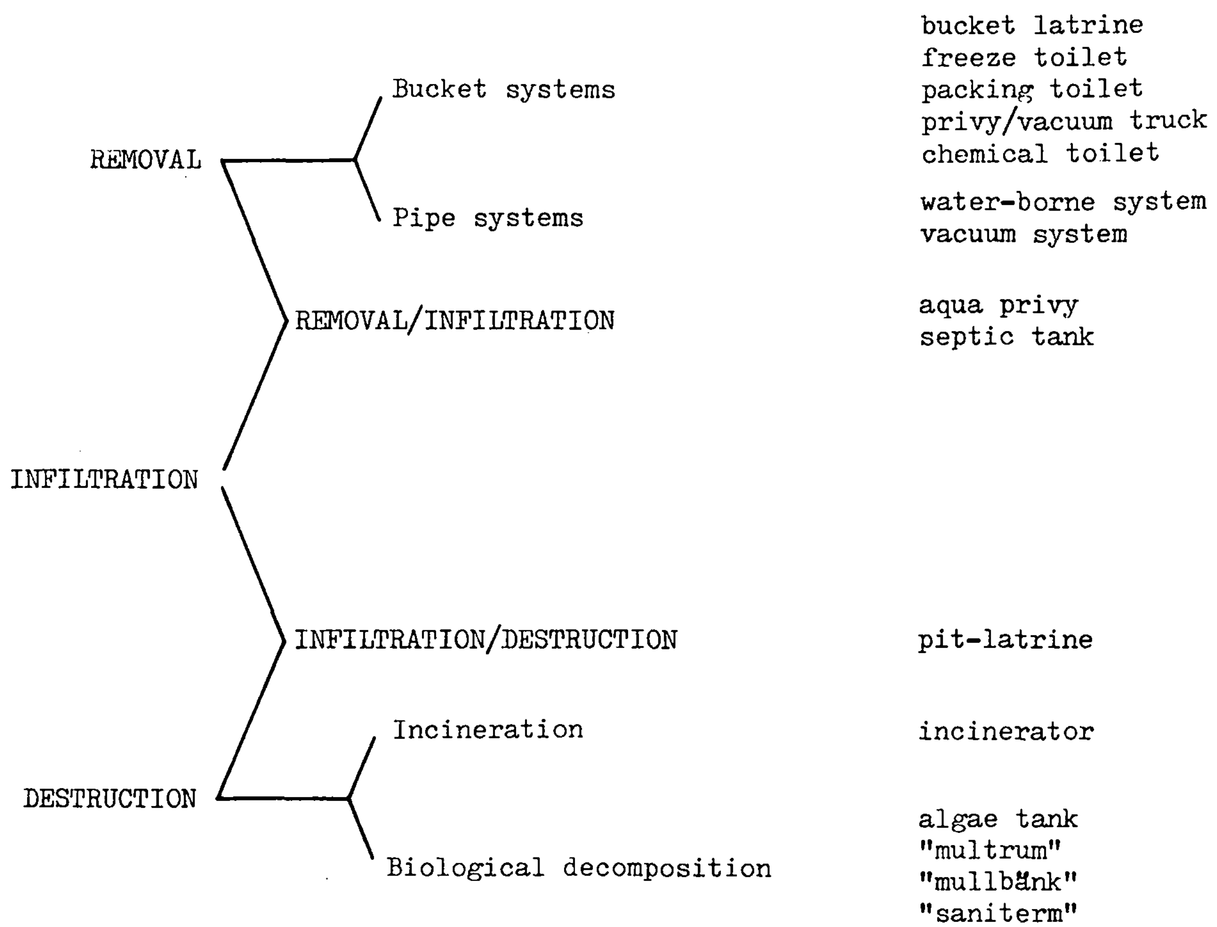


Fig 5: Classification of excreta disposal systems

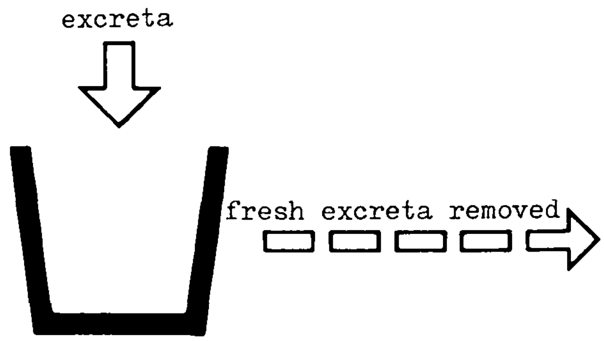
Some of the methods reviewed here may be much too expensive and complicated to be used in shantytowns in Africa but they are included to give an idea of the variety of technical solutions being tried today.

REMOVAL

Bucket systems

bucket latrine

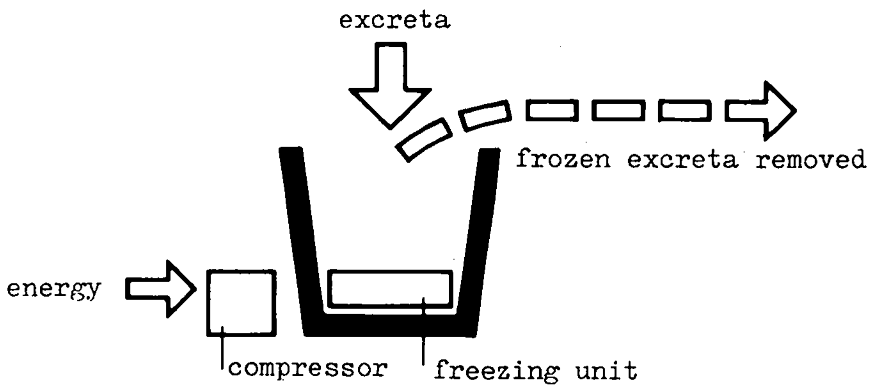
The system consists of a bucket in which excreta are deposited and which is removed for emptying and cleaning at frequent intervals.



This system has the advantages of low initial cost and no need for water, but used on a larger scale it tends to be expensive to operate and maintain. It creates obvious health hazards due to handling and spilling, the excreta is accessible to flies, and the system can be offensively odorous.

freeze toilet

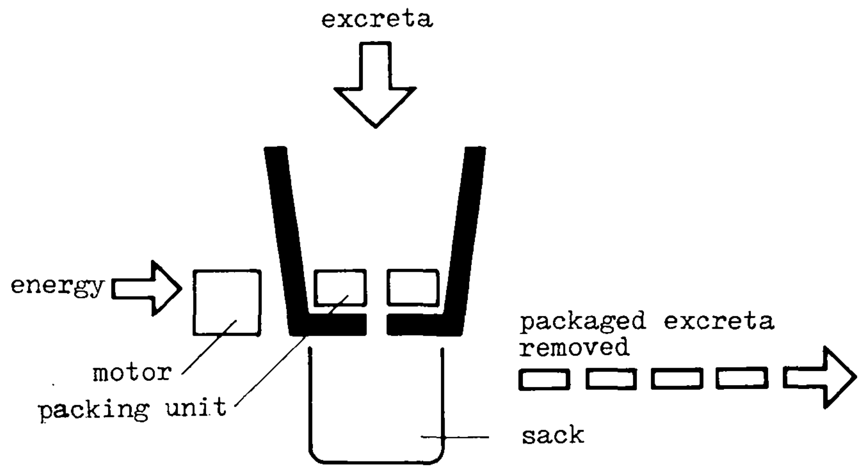
This is in principle a bucket latrine where the bucket is a deep freezer. The excreta drop into a plastic bag where the temperature is below -15°C. (The seat is heated!)



The freeze toilet eliminates the health hazards of the bucket system if the excreta can be kept frozen until they are deposited in a compost. The initial cost is high and the operating cost (in Sweden) US$0.02-0.03 per day.

packing toilet

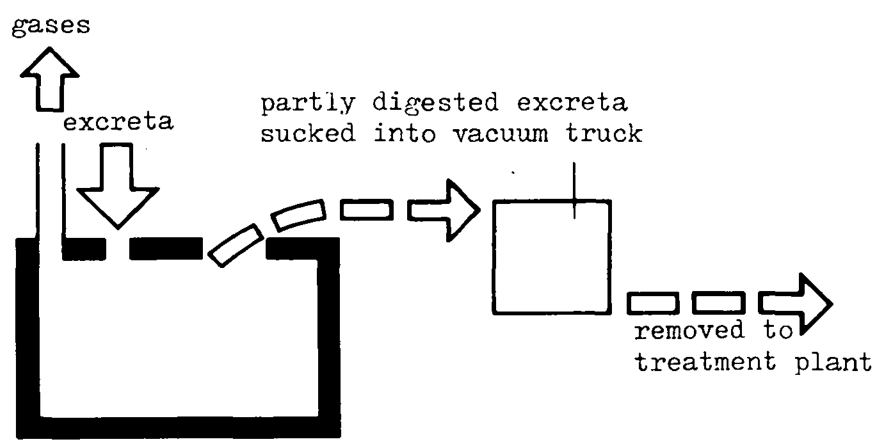
The packing toilet can be regarded as a refinement of the bucket latrine. It is a mechanical toilet where the excreta are collected in a plastic tube. After each use the tube is pulled down and automatically sealed. The tube with its "beads" falls down into a big plastic bag which has to be removed at intervals.



Advantages and disadvantages are similar to those of the freeze toilet.

privy vault/ vacuum truck system

The "bucket" in this system is a fixed ventilated concrete vault from which the accumulated excreta are collected at frequent intervals by what is known as a "vacuum truck" (cesspit emptier). The system is extensively used in Japan (PRADT, 1971).

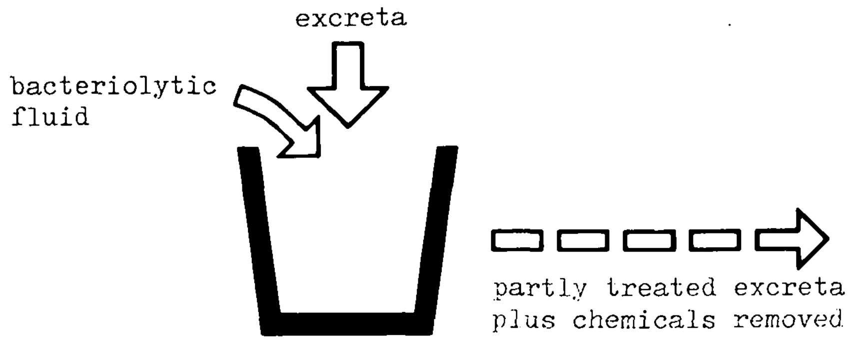


This system has several advantages compared to an ordinary water-borne system: initial costs are lower, no water is required, and the treatment plant can be smaller. Disadvantages are the odours, especially when the vault is emptied, and the reliance on special trucks.

chemical toilet

The simplest form of chemical toilet consists of a bucket containing a solution of some bacteriolytic agent. More elaborate systems have arrangements for flushing and may be connected to a tank.

A great variety of chemical agents are marketed for this purpose. The most common active component is formaldehyde. The excreta in the tank are liquefied and sterilized by the chemical.



Initial costs are low but chemicals are expensive. The chemicals can cause allergies. Desinfection of the excreta takes a long time and often takes place only on the surface. The chemical agent can spoil vegetation and ground water, make lakes odorous and fish uneatable. As they delay the natural decomposition they may disturb the process in treatment plants and composts (NORLIN, 1970).

ERRATA

page 20, line 17:

after "1.2 litres" insert "as compared to about 10 litres"

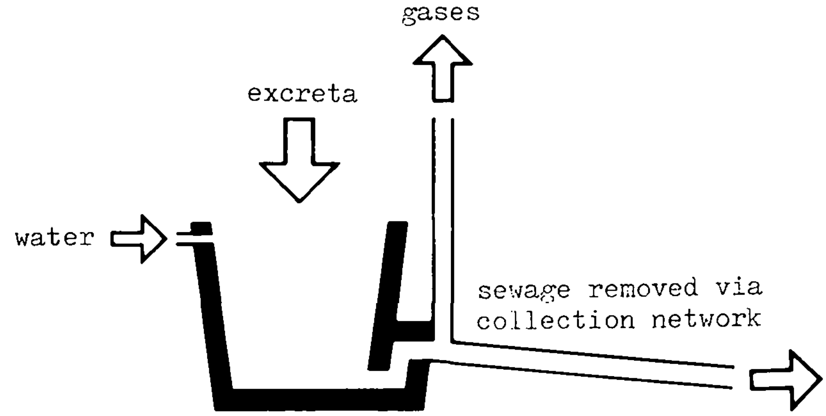
page 15, line 21:

instead of "previous" read "following"

Pipe systems

water-borne

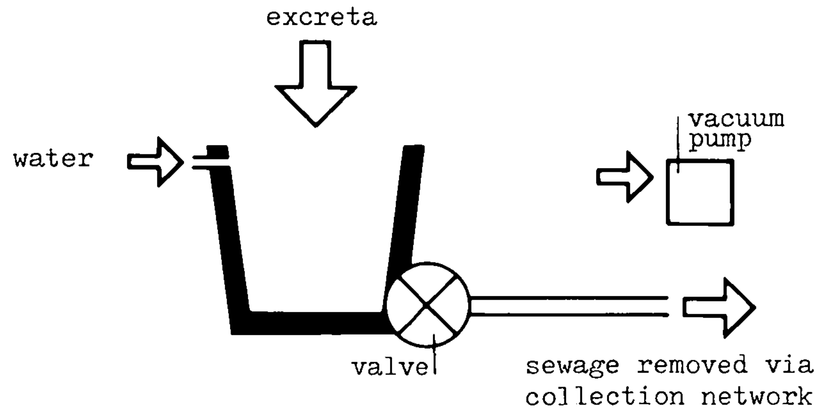
The water-carried sewer system consists of flush toilets connected to a pipe network transferring the sewage to a point of discharge (the sea, lake, stream or treatment plant).



The system fulfils health, nuisance and cultural criteria. The ecological requirement can be attained only if the sewage is processed in a treatment plant before final discharge in a recipient.

vacuum

The vacum system for excreta removal was developed in Sweden 15 years ago. Like the water-borne system it consists of flush toilets (of a special construction) connected to a pipe network leading to a point of discharge. The pipe network has a gauge pressure of minus 0.5 atmospheres created by a vacuum pump. The amount of water used per flushing is 1.2 litres for an ordinary WC. - The sewage can be transported about 5 metres vertically and 200 metres horizontally without the use of sub-stations.

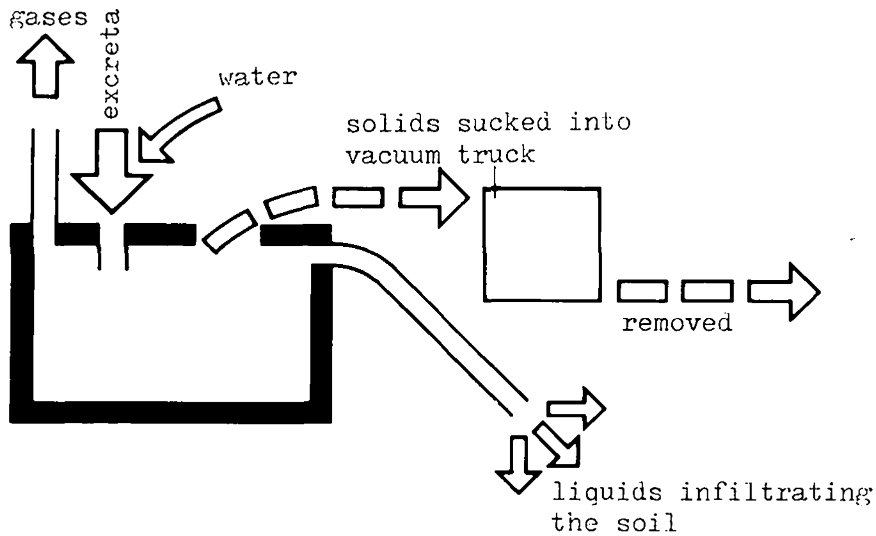


Compared to the ordinary WC, the vacuum system has the advantages of low water consumption and non-dependence on gravity fall.

REMOVAL/INFILTRATION

aqua privy

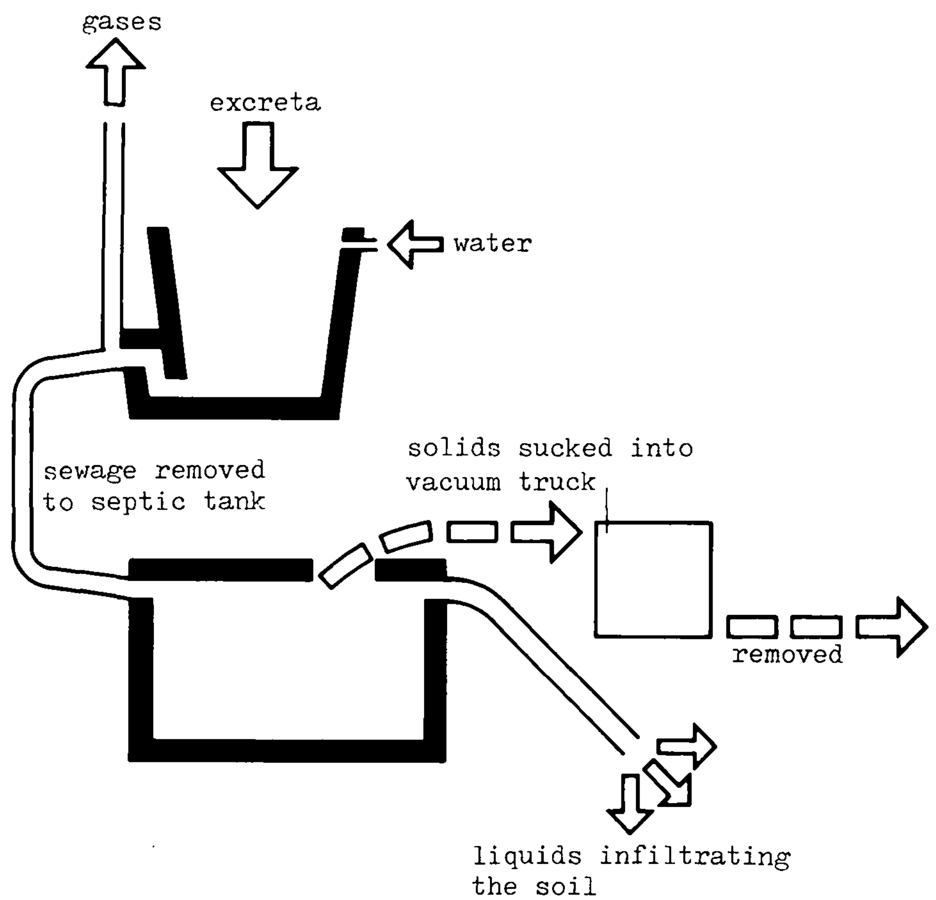
The aqua privy system consists of a water-tight tank with a constant water level. Faeces and urine undergo anaerobic decomposition and the digested sludge has to be removed at infrequent intervals. The liquid is evacuated to a soakage pit or filter trenches.



The initial costs are high. The operating costs are low but the tank has to be emptied. The disposal of the effluent pollutes the soil. The system requires subsoil with a fairly high permeability and large plots for adequate distance between adjacent systems.

septic tank

The septic tank system is an individual water-borne sewage disposal system consisting of drain, septic tank, and soaking pit or filter trenches. The incoming sewage is retained in the tank for a few days during which the heavier solids settle to the bottom as sludge. The sludge has to be removed at frequent intervals and the effluents are evacuated to, for example, a soakage pit or filter trenches.



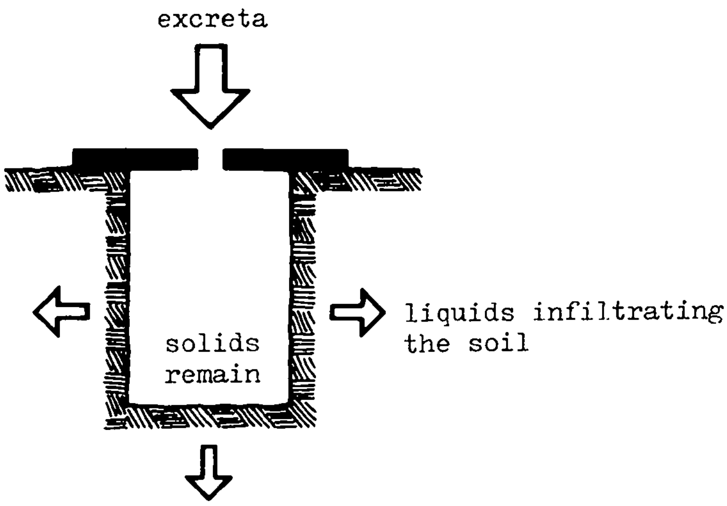
Advantages and disadvantages are the same as for the aqua privy with the additional disadvantage of higher water consumption.

INFILTRATION/DESTRUCTION

pit latrine

The pit latrine consists of a hole in the ground covered with a squatting plate or a slab provided with riser and seat. The liquid wastes seep off into the ground and the solids accumulate in the pit where they gradually decompose. When the pit is full, a new latrine is built nearby.

The pit latrine and its numerous variations like the bore hole latrine, the trench latrine and the leaking cesspool are described in detail in a WHO-publication by WAGNER and LANOIX (1958).



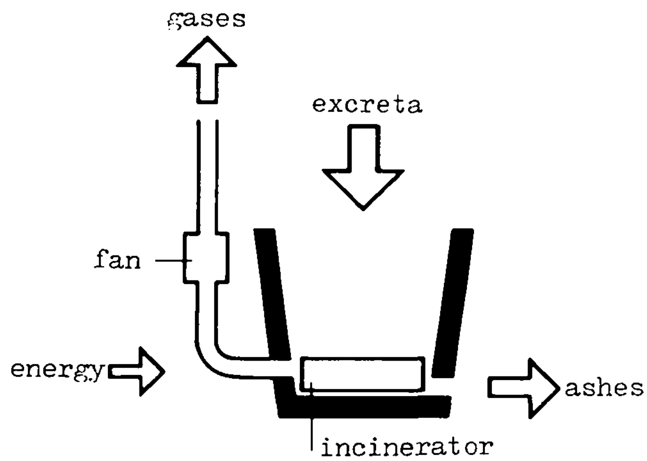
The pit latrine is the cheapest and simplest system for excreta disposal. The liquid wastes pollute soil and groundwater thus restricting the use of pit latrines to low (non-urban) densities.

DESTRUCTION
Incineration

incinerator

Combustion toilets for immediate destruction of excreta have been developed for use in weekend houses in the Scandinavian countries. Three basic types are available on the market: for electricity, for oil and for gas (gasol).

The systems used in Sweden are described and evaluated in a publication from The Swedish Institute for Consumer Research (DANIELSSON, 1970).



The capital cost is high, the operating costs (in Sweden): from US$0.01 per visit for the oil-operated models to $0.06 per visit for the electricity and gas operated types. The destruction is quick and complete but may cause a smell nuisance during the actual combustion (8-40 minutes depending on type).

Biological decomposition

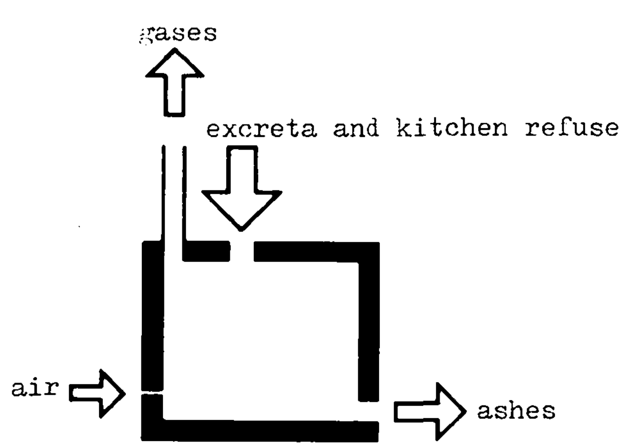
algae tank

An experimental sewage digestion plant for an individual household is under construction in the U.K. It consists of three interconnected tanks with a total volume of about 3 000 litres. The system requires very little water. Another advantage is that it produces methane gas for cooking. Too little is known about the performance of the system for a proper evaluation. It is, however, unlikely that it can fulfil costs and operational criteria for low income urban communities in Africa.

"multrum"

Destruction of excreta can be brought about by microbiological action turning the waste into an inodorous, inoffensive and stable product (WAGNER and LANOIX, 1958). The process, commonly termed "composting" (GOTAAS, 1956), is the basis for the "multrum" converter invented in Sweden some 30 years ago.

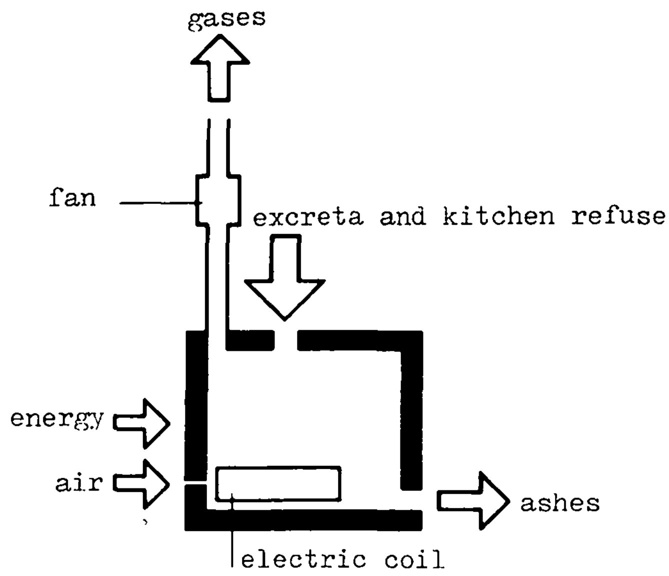
The "multrum" converter is a tight concrete or plastic container with an air intake and a ventilation duct. It is equipped with a toilet bowl and a garbage chute. Within the container excreta, urine and paper are mixed with organic kitchen refuse. Before being used, the floor of the container is covered with a layer of peat, soil and grass or leaves. The microorganisms in this layer together with those in the faeces decompose the input into fertilized humus. The water vapour and the CO_2 produced in the process are ventilated away. As the decomposition proceeds, the volume of the waste is reduced to less than 10% of the original. Due to the design of the converter the decomposing material is slowly pressed down to the storage chamber where it can be taken out, ready for use as a fertilizer.



The "multrum" fulfils all the requirements but the cost criteria. Due to the large volume required in Sweden it is still very expensive there.

"mullbänk"

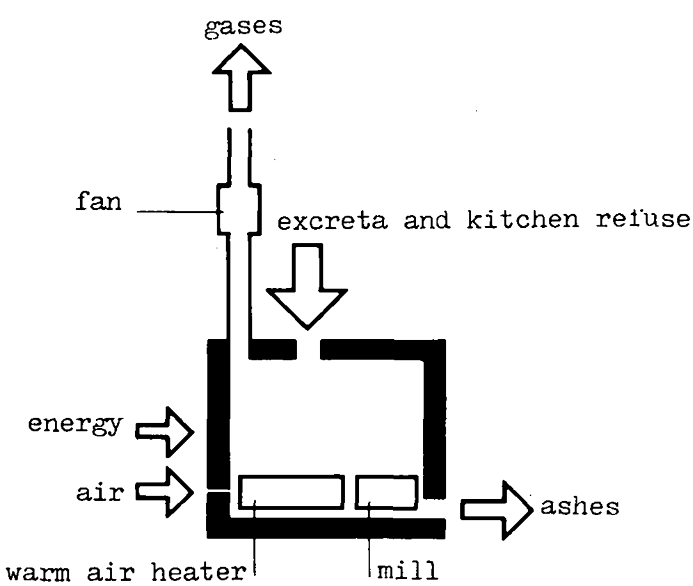
The "mullbänk" is based on the same principles as the previously described "multrum". The main difference is that the compost is heated to max 60°C by a thermostat regulated electric coil. The decomposition process in a "mullbänk" is considerably faster and the container can therefore be much smaller.



The cost is high. All other criteria fulfilled.

"saniterm"

The "saniterm" is similar to the "mullbänk" in that the compost is heated, in this case with a stream of hot air (70°C). The decomposition material is moved down to the storage chamber with the help of a hand operated mill.



The cost is high. All other criteria fulfilled.

COMPARATIVE EVALUATION

Summary

SYSTEM	INPUT REQUIRED		NETWORKS REQUIRED		EQUIPMENT REQUIRED		CRITERIA SATISFIED						REMARKS
	energy	water	roads	pipes	vehicles	sludge pumps	ecological criteria	health criteria	nuisance criteria	cultural criteria	operational criteria	cost criteria	
REMOVAL													
bucket systems													
bucket latrine	−	−	+	−	+	−	+	−	−		+	−	Ecological criteria fulfilled only if composted or processed in treatment plant
freeze toilet	+	−	−	−	−	−	+	+	+		−	−	
packing toilet	+	−	−	−	−	−	+	+	+		−	−	
privy vault/vac.truck	−	−	+	−	+	+	+	+	−		+	−	
chemical toilet	−	−	+	−	+	−	−	−	−		−	−	
pipe systems													
water-borne	−	+	−	+	−	−	+	+	+		+	−	
vacuum	+	+	−	+	−	−	+	+	+		−	−	
REMOVAL/INFILTRATION													
aqua privy	−	+	−	+	+	+	−	+	+		+	−	
septic tank	−	+	−	+	+	+	−	+	+		+	−	
INFILTRATION/DESTRUCTION													
pit latrine	−	−	−	−	−	−	−	−	−	+	+	+	
DESTRUCTION													
incineration													
incinerator	+	−	−	−	−	−	+	+	−		−	−	
biological decomposition													
algae tank	−	+	−	−	−	−	+	+	+		−	−	
"multrum"	−	−	−	−	−	−	+	+	+	+	+	−	
"mullbänk"	+	−	−	−	−	−	+	+	+		−	−	
"saniterm"	+	−	−	−	−	−	+	+	+		−	−	

None of the fifteen systems evaluated fulfils all the requirements. Systems based on *removal* either create health hazards or require costly networks. The collection network of a WC system represents about three quarters of all the construction expenses of a sewage system - in the USA $200 per person (LAWRENCE, 1967).

GRAVA (1969) claims that there is nothing in the basic design or detailed engineering of collection networks that could be modified for conditions in developing countries. The pipe systems are built at minimum standards even in the industrial countries - any reduction would create great health dangers and the need for extensive maintenance.

The capital requirements for systems based on pipe networks clearly exceed the resources available to the developing countries in Africa. The implication is that whenever such systems are introduced they can only be applied to a selected few households, leaving the majority of urban households without basic utilities.

Apart from high capital costs of pipe networks two more drawbacks should be mentioned: the pollution of recipients and the high water consumption (around 50 litres per person per day).

If vacuum trucks are substituted for pipe networks considerable savings can be made on capital costs. The operational costs are, however, likely to be high and the equipment has to be imported from abroad. Administratively the system is complex and experiences from Africa indicate a high rate of system failures as exemplified by the situation in Dar es Salaam earlier this year: The city has ten vacuum trucks but only three were in working order in May 1972 due to lack of spare parts. In May the fleet of vacuum trucks was dealing with orders placed the previous year (Daily News, 1972).

In places where labour intensive systems are desirable it might be possible to develop a hand-operated cesspit emptier that could be produced locally and pulled around town (on an ox-cart for example). With such an "intermediate technology" approach the privy vault/vacuum truck systems would fulfil cost and operational requirements. The process of treating the night soil is simpler than that for sewage because the per capita volume is very small (about one litre per day per person) and the characteristics fluctuate very little, PRADT (1971).

Among the other systems requiring removal, the bucket latrine should not be used at all on account of the health hazards and odours. The chemical toilet should also be avoided because of the large risk of pollution.

Attempts to abate the health hazards and the nuisance of the bucket latrine have produced solutions such as the freezing and packing of the wastes. These methods are too expensive and complex to be feasible for low income communities.

The systems based on *infiltration* are generally not suited for urban conditions because of soil pollution and the large plots required. There may be some exceptions, such as parts of Greater Khartoum where a combination of fairly large plots and favourable soil and climatic conditions make possible the use of pit-latrines.

The ideal waste disposal system for low income urban communities in Africa, especially for existing squatter areas, would be an individual unit where the waste is transformed on the spot into some inoffensive, harmless, and preferably useful, product. The quickest and most thorough *destruction* is brought about by incineration but the individual units available on the market today cause too much air pollution to be acceptable in densely populated areas. It may be possible to overcome this by some kind of filtration of the smoke but the initial cost of the combustion units, as well as their very high operating costs, prevent their use in developing countries.

Systems based on biological decomposition seem to come closest to the ideal. Composting of human wastes has been practiced by farmers and gardeners around the world for many centuries (GOTAAS, 1956). The method is mainly used in rural areas but also in some compact, high density desert towns in Algeria. In the town of Ouargla, with a population of 12 000 persons, composting of human wastes with palm leaves in individual (household) units is the predominant method although the overall population density within the wall exceeds 500 persons per hectare (ASKLUND et al, 1972).

The "multrum" converter makes it possible to compost human wastes under conditions fulfilling all the health and environmental requirements laid down in Chapter 3. In tropical areas where the decomposition process is likely to be considerably faster than in the Nordic countries it should be possible to reduce the size and thereby the cost of the "multrum", as proved by recent Swedish experiences with heated converters like the "mullbänk" and the "saniterm".

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

None of the systems described in the previous chapter fulfils all the requirements outlined in chapter three. The evaluation indicates that great cost savings could be made by basing human waste disposal on systems not requiring pipe networks. Among the non-network systems, those based on microbiological decomposition seem to offer the best possibilities for development.

To produce useful information for decision makers in charge of urban development in Africa, practical investigations have to be carried out on the spot. The next step ought to be field research based on the knowledge already put together during the preparation of this report. A suitable location would be a community where the use of presently available systems has created specific problems.

Research and development along these lines is likely to yield viable alternatives to present day practices in Africa. The need for alternatives to present systems of waste disposal becomes particularly marked when attempts are made to upgrade squatter areas and shanty-towns. A program of research aimed at development of non-network systems should first of all be directed towards the problems of existing areas followed by a second step where the findings are applied to "site and services" projects.

REFERENCES

ASKLUND, L., JOHANSSON, S., KALNINS-NILSSON, A. och SELANDER, K. *Ouargla rapport från en algerisk ökenstad.* Thesis (mimo) Department of Architecture, University of Lund, Lund 1972.

ASSAR, M. *Guide to sanitation in natural disasters.* WHO, Geneva 1971.

BENNINGER, C.C. "Design criteria for developing contexts: housing for Baroda, India", in *Ekistics*, Vol 33, No 196, p 162-165, Athens 1972.

DAILY NEWS, Dar es Salaam, 25 May 1972.

DANIELSSON, K., *Klosetter för fritidshus.* Statens Institut för konsumentfrågor, Stockholm 1970.

DANSEREAU, P., "Ecology and the escalation of human impact" in *Int. Soc. Sci. J.*, Vol 22, No 4, 1970.

DIETERICH, B.H. and HENDERSON, J.M., *Urban water supply conditions and needs in 75 developing countries.* WHO, Public Health Papers No 23, Geneva 1963.

DOWNING, P.B., *The economics of urban sewage disposal.* F.A. Praeger, New York 1969.

ELLIS, H.M. et. al., *Problems in community wastes management.* WHO Public Health Papers No 38, Geneva 1969.

GOTAAS, H.B. *Composting - sanitary disposal and reclamation of organic wastes.* WHO Monograph Series No 31, Geneva 1956.

GUSTAFSSON' M. *Mullen och människan.* Rabén och Sjögren, Stockholm 1972.

GRAVA, S. *Urban planning aspects of water pollution control.* Columbia University Press, New York 1969.

HAYNES, K.E. "A conceptual approach to waste control" in *Ekistics*, Vol 30, No 173 p 243-249, Athens 1970.

HUYCK, A.P. van, *Planning for sites and services programs.* Ideas and Methods Exchange No 68, Office of International Affairs, Washington DC 1971.

KONGSTAD, P., "Kan vi overføre vor bygningsteknologi til U-landene?" in *Byggeindustrien*, No 3, Copenhagen 1972.

LAWRENCE, C. H., "Economic considerations for sanitary sewers" in *Public Works*, March 1967, p 99-102.

LINDSTRÖM, C. R., *Undersökning av driftsförhållanden hos förmultningsanläggning för organiskt hushållsavfall*. MSc thesis, Royal Institute of Technology (KTH) Stockholm 1969.

LINDSTRÖM, H. "Bostadsbyggandets kommunalekonomiska konsekvenser" in *Att Bo*, No 1, Stockholm 1972.

MACDONALD, O.J.S., *Small sewage disposal systems with special reference to the Tropics*. Lewis & Co, London 1952.

MACGARRY, M.G., *The Treatment of sewage and production of protein through the mass culture of algae*. Asian Institute of Technology, Bangkok 1970.

NAIGZY, G., "Some traditional types of housing in Ethiopia" in OLIVER, P. (ed) *Shelters in Africa*, Berrie and Jenkins, London 1971.

NATH, V. "Planning for urban growth" in *Urban and rural planning thought*, Vol 9, No 3-4, p 105-136, New Delhi 1966.

NORLIN, A., "Alternativ för kemtoalett?" in *Ny Teknik*, No 20, Stockholm 1970.

OLUWANDE, P.A. "Importance of aided self-help for improved environmental sanitation in community rehabilitation" in *Jnl of the Society of Health Nigeria*, Vol 4, No 2, Lagos 1969.

ONIBUKUN, A. "Nigeria: Strategies for urban redevelopment" in *TPI Jnl*, Feb 1972.

ORAM, N.D. "Health, housing and urban development" in *Papua and New Guinea Medical Jnl*, Vol 8, No 2, Aug 1965.

PIPES, W.O., *Waste-recovery processes for a closed ecological system*, National Academy of Sciences, National Research Council, Bulletin No 898, Washington D.C. 1961.

PRADT, L.A., "Some recent developments in night soil treatment" in *Water Research*, Vol 5, No 8, p 507-521, London 1971.

RICH, L.G., et. al., *Waste disposal on spacecraft and its bearing on terrestrial problems*. US Department of HEW, Public Health Service, Washington D.C. 1965.

SCHUMACHER, E.F. and ROSE, G. "Intermediate Technology and its administration implications" in *Jnl of Administration Overseas*, Vol 8, No 2, p 89-96, London 1969.

SEBASTIAN, S. and BUCHANAN, I.C., "Feasibility of concrete septic privies for sewage disposal in Anguilla, B.W.I.", in *Public Health Reports*, Vol 80, No 12, p 1113-1118, London 1965.

SURTEES, G., "Urbanization and the epidemiology of mosquito-borne disease" in *Abstracts on Hygiene*, Vol 46, No 2.

TANZANIA, Second five-year development plan, Dar es Salaam 1969.

UNITED NATIONS, *Development and environment*, Report by a panel of experts meeting in Founex June 1971, Stockholm 1971 (a).

UNITED NATIONS, *Research and development activities of the Centre for Housing, Building and Planning* (E/C.6/115) New York 1971 (b).

UNITED NATIONS, *Report of the first all-African seminar on the human environment* (E/CN.14/532) Addis Ababa 1971 (c).

UNITED NATIONS, *The African social situation* (E/CN.14/POP/38) Addis Ababa 1971 (d).

WAGNER, E.G. and LANOIX, J.N., *Excreta disposal for rural areas and small communities*. WHO, Geneva 1958.

WINBLAD, U., *Basic Urbanization in Africa - a discussion of costs and standards*. Working paper for the UNIDO Meeting on Prefabrication in Africa and the Middle East, Bucharest 1972 (ID/WG.122/43).

WORLD BANK, *Urbanization*. Sector Working Paper, Washington DC 1972.

WORLD BANK, *Water supply and sewerage*. Sector Working Paper, Washington DC 1971.

WORLD HEALTH ORGANIZATION, *Environmental health aspects of metropolitan planning and development*. WHO Technical Report Series No 297, Geneva 1965.

WORLD HEALTH ORGANIZATION, *Official records* No 197, Geneva 1972.

WORLD HEALTH ORGANIZATION, *"Public Health aspects of urbanization in Africa"*. Working paper for the ECA Workshop on Urbanization Problems in Africa, Addis Ababa 1962.

WORLD HEALTH ORGANIZATION, *Water pollution control in developing countries*. WHO Technical Report Series No 404, Geneva 1968.

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