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*) HEALTH ORGANIZATION*
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# Treatment and Disposal of Wastes

## Report of a WHO Scientific Group

This report contains the collective views of an international group of experts and does not necessarily represent the decisions or the stated policy of the World Health Organization.

GENEVA
1967

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* * *

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No. 367



# TREATMENT AND DISPOSAL OF WASTES

## Report of a WHO Scientific Group

WORLD HEALTH ORGANIZATION

GENEVA

1967

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*Geneva, 6-12 December 1966*

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*Wld Hlth Org. techn. Rep. Ser.*, 1967, **367**

# TREATMENT AND DISPOSAL OF WASTES

## Report of a WHO Scientific Group

A WHO Scientific Group on the Treatment and Disposal of Wastes met in Geneva on 6-12 December 1966. Mr C. H. Atkins, Director, Division of Environmental Health, opened the meeting on behalf of the Director-General. Professor D. A. Okun was elected Chairman, Professor O. Jaag Vice-Chairman, and Mr R. R. L. Harcourt Rapporteur.

### 1. INTRODUCTION

No environmental health problem has had greater significance than the disposal of man's liquid and solid wastes. The accumulation of domestic wastes around camp sites undoubtedly caused ancient nomadic tribes to move to new, clean locations, thereby becoming one of the pressures forcing the dispersal of mankind. Down through the middle ages, wastes were frequently thrown into streets from windows and doorways, and countless numbers succumbed to pestilences spread by rats and flies that were supported by such wastes.

Today, the environment is being polluted as never before by the accumulation of liquid and solid wastes. This forms a staggering burden that is born of growing affluence, nurtured by rising population, matured by technology, and all but neglected by society.

Previous WHO scientific groups and expert committees have considered the broad aspects of water pollution and its control. Their reports have underlined the need for improvement in conventional waste treatment methods, for new and more economical treatment processes, and for research on the re-use of effluents and by-products resulting from treatment. As part of the continuing attention being given to this problem, a WHO Scientific Group on the Treatment and Disposal of Wastes was convened to review present knowledge of, and to consider the most important problems in, the treatment of waste waters and solid wastes, and to formulate recommendations on relevant research needs.

### 2. CURRENT PROBLEMS

The rapid increase in the density of world population as a result of urbanization and industrialization is making the satisfactory collection, treatment, and disposal of liquid and solid wastes a complicated problem of great magnitude, with serious implications for health.

The total use of water for municipal, agricultural, and industrial purposes is increasing considerably, with a resultant increase not only in the volume of the waste water, but also in the concentration of the pollutants it contains. The increased discharge of these waste waters into streams that are already diminishing in flow, because of increased withdrawals, makes it no longer possible to rely as much as in the past on the self-purifying capacity of receiving bodies of water. The decreasing available dilution for wastes, the increasing need for re-use of water, and increasing public interest in the maintenance of clean streams compound the problem of waste-water treatment and disposal. New and improved processes must be developed so that a higher percentage of the pollutants can be removed. Research is now being conducted into so-called "tertiary" methods of treatment for pollution abatement and also into the direct re-use of waste water for agriculture, industry, recreation, and even municipal water supply in areas of water shortage.

Another problem, of increasing importance, is that of the collection and disposal of solid wastes, including refuse from municipalities and solids resulting from the treatment of sewage and industrial wastes. Failure to deal satisfactorily with the never-ending flow of solid wastes constitutes a clear threat to public health and contributes to air, water, and soil pollution as well as to the propagation of flies, rodents, and other vectors of disease. In spite of this danger, however, achievements in the management of solid wastes are small when contrasted with the advances made in the treatment of waste water.

The importance of the problem is emphasized by the fact that in the highly industrialized countries up to 20% of municipal budgets are spent on the collection and disposal of solid wastes, and even more will be required if the job is to be done adequately.

The disposal of wastes must take place within a closed environment comprising only earth, air, and water. When the liquid, solid, or gaseous residues from waste treatment are disposed of, they must be discharged into one or more of these phases of the environment. Any or all of the phases may be polluted, and any solution to the general problem of the disposal of wastes therefore involves a decision as to which part of the environment can accept residues with least damage to the whole. In other words, in deciding on a site for the disposal of residues, their total effect on the environment must be studied. Wastes must no longer be transferred from one environmental phase to another without adequate study. This is particularly important in view of the fact that some residues persist permanently. Taking the mobility of air and water into consideration, it appears that land provides the safest and most feasible repository in most situations.

Systems for the collection and disposal of wastes are complex and expensive to install and operate. Processes and treatment units are designed to function within limits, and if the latter are exceeded the result may be excessive costs, overloading and break-down of the system, and damage to the environment. All operating agencies should adopt administrative and economic measures to ensure the efficient operation of disposal plants.

Disposal systems are usually provided by public agencies as a service, the cost of which may be reduced by the value of recovered materials or by disposal of residues in such a way as to fulfil a useful purpose. It must be remembered, however, that salvage of part of the wastes for re-use, while reducing the volume of residue, merely postpones its final disposal.

Although the individual has little responsibility in the collection and disposal of wastes, his personal attitude, in preventing the indiscriminate scattering of wastes around him, is important. Much of the private and public indifference to the need for improvement in waste disposal has its origin in irresponsible personal attitudes.

## 3. WASTE WATER

### 3.1 Data

The present status of waste-water collection, treatment, and disposal varies widely throughout the world. Some communities in highly developed countries provide satisfactory sewerage service to all their members—public, private, and industrial—while other urban centres, particularly in developing countries, have little public sewerage and no treatment plants. Moreover, in most urban centres there is an extremely urgent need to match public services to rapid growth. The world's population growth is great, but urban growth rates are more than twice the national rates. Such growth may occur vertically, leading to great density of population, or horizontally, yielding the so-called " urban sprawl ". Thus even cities that are adequately served now are required to undertake massive investments for the future.

In addition to the increased production of waste due to the growth in population, the *per capita* contribution of waste water is also increasing. In many cities the latter is as much as 600 litres per day and no limit is in sight. Such increases in *per capita* production of waste water result from the increased availability of piped water supplies and improved standards of living. Water-using labour-saving devices such as washing machines and garbage grinders have a significant effect on household water consumption. Unfortunately, precise data on waste-water volume are not available in a community until after its sewerage system is built, so that comparative data from other similar communities are sorely needed.

Not only is the volume of waste water very large but its content of organic and mineral pollutants is also large, amounting to up to 10 litres of wet sludge *per capita* daily or about 50 kg *per capita* of dry solids annually, not including industrial wastes. Handled expeditiously and with full use of modern technology, these putrescible solids need not pose an aesthetic or hygienic problem in urban centres. Where sewerage and disposal systems are inadequate, however, they create health hazards and public nuisances that hinder the orderly development of a community.

The magnitude of the problem is emphasized by the investment being made annually for waste-water management. In some countries this may be as much as $15 *per capita*, representing a capital investment of $100 to $200 *per capita*. More often than not, even these high expenditures are insufficient to provide adequate service.

In the design of an adequate waste-handling system, the information required includes the following:

(*a*) *Basic design data*: population served by existing systems as well as population in urban areas not served by waste-water disposal systems; population growth trends and estimates; volume and composition of waste water and its variations.

(*b*) *Recipient waters*: basic data on the condition of natural water; classification of receiving waters according to use, pollution, etc.

(*c*) *Installations*: surveys of existing installations, and data on the efficiency of their operation (including reports of difficulties encountered with, and failures of, waste-water and sludge treatment and disposal systems); information on costs of collection, treatment, and disposal systems (including construction, maintenance, operation and amortization), gathered in such a way that systems in one area can be compared with those in another; information on the extent of re-use of waste water and the problems involved.

(*d*) *Sludge*: data on the quantity and quality of waste-water sludge (including its content of organic substances, moisture, plant nutrients, and toxic substances, and its calorific, soil-conditioning, and fertilizing values); information on methods for removing water from, and disposing of, sludge, and on the cost of sludge disposal and utilization; data on the extent to which sludge is disposed of in conjunction with other solid wastes by composting or incineration.

The gathering of data on the quantity and quality of waste water and its effect on the water environment is often inadequate, in part because of a lack of the engineers and chemists, biologists, and other scientists required to carry out the necessary surveys. Where data have been collected, it has been painstakingly accomplished at great cost. Furthermore, these data are often not readily amenable to analysis and interpretation because of the techniques used in gathering them.

Many properties of waste water (e.g., flow, pressure, temperature, pH, dissolved oxygen, turbidity, colour, and salinity) can readily be monitored automatically and can be analysed and stored electronically. Available technology has not been applied as fully as it might, nor is research adequate to develop methods for routine monitoring of other properties. Monitoring should be compatible with a control and alarm system designed to protect the environment against the ever-present possibility of new pollution due to the breakdown of waste-handling installations.

### 3.2 Waste-water disposal problems

Increasingly rapid urbanization and industrialization is causing an even more rapid rise in the pollution of water and in many areas of the world has resulted in major public health hazards as well as in a general deterioration of natural water sources. Drinking water sources are often threatened by increasing concentrations of pathogenic organisms, as well as by many of the new toxic chemicals disposed of by industry and agriculture.

Rivers and lakes have in many cases become the recipients of quantities of putrescible organic substances far exceeding their natural purifying capacities, resulting in deterioration of water supplies, severe nuisance conditions and far-reaching economic and health consequences. The quality of lakes that serve as recipients of so-called " completely treated " waste waters has frequently deteriorated due to an increase in nutrient content, and consequent growth of algae and other plant life, through eutrophication. Classical treatment methods remove only a portion of the critical nutrients, such as nitrogen and phosphorus, that accelerate this process.

Wastes from the manufacture of insecticides and residues from their application have killed large numbers of fish and are also a hazard to the health of man and animals. Other industrial wastes may cause aesthetic nuisances, as is the case with dyes, malodorous substances, and detergents. Many of these toxic and nuisance-causing chemicals are removed only slightly by existing treatment processes, and methods are currently being developed to improve the efficiency of removal of many such pollutants.

Studies have shown that newly developed treatment methods can remove 97% to 99% of suspended solids, surface-active agents, and total phosphate, and can reduce BOD and COD by the same amount, but can remove only about 75% of total nitrogen. However, many of the methods have not yet been proved in full-scale operation. Total dissolved solids can also be removed from wastes to any desired degree by demineralization techniques.

Whether or not such high levels of treatment are justifiable from an economic point of view depends on the type of water re-use being considered or on the value and importance of the natural water source being protected.

An additional problem that must be considered is the possible diversion of pulverized domestic and industrial solid wastes to the waste-water collection system. Although this may provide a desirable convenience, it should be considered in the light of the over-all waste disposal problem ; adequate treatment plants would be required to meet the additional solids carried by the waste water.

### 3.3 Simplified waste-water collection and treatment

In developing countries, the availability of land, labour, equipment, and funds is often significantly different from that in more developed countries. If full consideration is given to these varying local conditions, different engineering solutions to similar problems are frequently found. Too often, design standards used in industrial countries are applied indiscriminately to developing countries, resulting in over-investment in equipment. The purchase, operation, and maintenance of such equipment may be difficult and may needlessly use up scarce foreign funds. There is, therefore, a need for the development of engineering programmes that take into account the general availability of land and labour in developing countries. Stabilization ponds and manually-operated sludge-removal devices are examples of solutions suitable for these countries, and such approaches should be developed further.

### 3.4 Toxic and persistent wastes

Industry has usually not considered the effect that the wastes from new products or new industrial processes may have on the water environment. Governments also rarely consider the possible long-term effect of such products and processes on the environment when industrial projects are conceived. Highly persistent detergents, pesticides, and other toxic wastes are becoming an ever-increasing problem in developed countries and in time will present a similar challenge to developing countries.

Particularly persistent and toxic chemicals should not be disposed of by way of the public liquid-waste disposal system. Consideration must be given to the possibility of establishing regional " burial grounds " for such wastes. There is, furthermore, a need for industry to pre-treat wastes so that they will damage neither the waste-water conveyance and treatment system nor the receiving waters.

Many pollutants formerly discharged into the air are now being discharged into the waste-water system. As previously noted, wastes should not be transferred from one part of the environment to another without adequate study of their effect upon the environment as a whole.

### 3.5 Re-use of waste water

Although the re-use of waste water has been practised for many years, particularly in agriculture, it has been given increased importance in recent years, both as a means of water pollution control and as a possible way of increasing water supplies for agricultural, industrial, and municipal purposes. However, the purification of waste water for human consumption involves great health hazards, which must be carefully studied as the technology for carrying out the necessary high degree of treatment becomes available. For example, not enough is known of the long-term effect of certain of the trace chemicals found in waste water, and there is still much to be learned concerning the removal of the more persistent forms of microbiological pollution such as some of the enteroviruses. In view of the high potential public health risk that would be involved in even a brief failure of water processing equipment, engineering safeguards must be developed to provide such installations with very high margins of safety.

However, it must be pointed out that in reality the re-use of waste water for drinking is currently very widely practised in the world, although not always by design. Communities treating polluted surface water for drinking purposes are in effect re-using waste water diluted to a lesser or greater extent. In such programmes, not enough consideration has been given to the possibility of using reclaimed waste water for many municipal and domestic purposes other than drinking water. For example, higher-grade water could be reserved for drinking, while water of lower quality could be used for secondary purposes, after adequate provisions had been made to make it biologically safe and to prevent its misuse as drinking water.

### 3.6 New materials and processes

New engineering technology as well as newly developed materials provide a basis for entirely new approaches to the collection and treatment of waste water. There is a need for studies of the applicability of new materials, such as plastic pipes, and of the possibility of entirely different waste transportation methods, such as the use of vacuum or pressure systems. In addition, not enough effort has been devoted to the development of new low-cost waste-water processes that might make it possible to speed up the improvement of sewage treatment facilities in both the developed and developing countries.

The building of pilot plants and the carrying out of demonstration programmes would make it possible to evaluate the engineering, economic, and health aspects of such much-needed innovations.

### 3.7 Plants and equipment

There is an ever-increasing gap between civilization's production of domestic and industrial wastes that increase the pollution of the water environment, and the rate at which new plants to reduce such pollution are constructed. This has already reached a critical stage in industrially-developed countries but is also a growing problem in the rapidly expanding urban centres of developing countries. The rate of construction of plants, under the best of circumstances, still lags behind the needs. It has been estimated that even if construction continues at its present rate, water will not be improved in quality, but only protected from further pollution. In the developing countries the rate of urbanization is so great that present programmes of waste-water disposal and treatment lag far behind community needs, and in many areas the waste-disposal problem, where currently marginal, will soon become highly critical. Unless a greater effort is made in developing countries to provide the necessary equipment for the disposal and treatment of waste water, normal development of the urban centres may be limited. The lack of adequate waste-water disposal equipment may very well have a much broader economic implication than those generally associated with the health aspects of the problem alone, particularly with regard to industrial growth and development and tourism.

## 4. SOLID WASTES

### 4.1 Data

Solid wastes include domestic refuse and other discarded solid materials, such as those from commercial, industrial, and agricultural operations.

Domestic refuse includes paper, cardboard, metals, glass, food matter, ashes, plastics, wood, and other substances discarded from homes. It also includes old furniture, household appliances, and other items.

Increasing amounts of paper, cardboard, plastics, glass, and other types of packing are concomitants of improved standards of living. At the same time, the increasing use of gas, oil, and electricity for heating and cooking has resulted in a decline in the ash content of solid wastes. Thus, the proportion of paper and paper products in domestic refuse has already reached more than 50% in some countries, and this trend will continue.

Commercial refuse includes the wastes discarded by markets, shops, restaurants, offices, and similar businesses. Such refuse is growing in importance not only as a result of increasing business activity, but also because there are few opportunities to deal with it on-site.

Industrial refuse comprises a very wide variety of wastes ranging from completely inert materials such as calcium carbonate to highly toxic and explosive compounds. Other examples are trimmings and scrap from manufacture, sludges and slag from industrial processes, and wastes from the food processing industry. Wastes produced in large quantities by mining and some other operations are usually treated by the respective industries themselves. The natural growth and diversity of industry generally, together with rapid technological developments, have resulted in substantial increases not only in the volume of industrial wastes, but also in their complexity.

Agricultural wastes include wastes arising from the production and processing of food and other crops and from the raising and slaughtering of livestock. In many areas the practice of agriculture near urban areas is resulting in the need to consider this type of waste, which is growing in volume, as part of the general urban waste-disposal problem.

General community waste includes demolition and construction debris, street refuse, discarded motor vehicles, and refuse arising from community services such as hospitals, abattoirs, transport systems, parks, canals, and harbours. Special handling is required for potentially dangerous wastes such as those from hospitals, international ports and airports, and firms using radioactive materials. As in the other classifications the volume of material arising from these sources is increasing.

It is safe to say that everywhere the amounts of solid wastes produced each day per person are increasing as a result of social, economic, and technological changes. In addition, better quantitative data are now becoming available as a result of improved surveys. For example, the initiation about 20 years ago of scientific surveys in a few cities, encompassing all types of solid wastes, revealed a surprising discrepancy between earlier " guess estimates " and actual production of wastes. Prior to about 1945, the production of solid wastes was assumed to be 350 to 400 kg *per capita* per year. Subsequent careful samplings and actual weighings in representative areas revealed that the actual values for all urban solid wastes ranged up to about 600 kg *per capita* annually.

Improved standards of living, the building boom, the growth of packaging of consumer goods, and vast increases in the use of paper, paper products, and synthetics have all contributed to an increase in the amount of urban wastes, so that the present average in the industrialized countries is probably at least 700 kg *per capita* per year. The annual increase is currently between 1% and 2% per year. Furthermore, the density of refuse has been dropping, resulting in even greater increases in volume, with annual values of up to 5 $m^3$ *per capita* not uncommon.

The above data show representative waste contributions in highly developed urban centres in industrialized countries with relatively high standards of living. Although the figures for other areas are now smaller, they can be expected to approach these figures in time. In developing countries, the amounts of solid wastes may well be very small percentages of the figures given.

However, the data do not adequately reflect the additional solid wastes produced by agricultural and large industrial operations, nor do they take into account the solid pollutants increasingly being separated from gaseous and liquid wastes by improved treatment processes developed to comply with stricter environmental standards.

### 4.2 Technology

The great increase in the production of wastes is causing storage, collection, and transport difficulties as well as problems of treatment and final disposal. Existing houses and apartments do not usually provide satisfactory storage for the volume and type of wastes now being produced. Furthermore, in many countries it is difficult to recruit adequate staff for the collection of refuse, and increasing traffic congestion creates difficulties and delays in transport. Inadequate storage and collection arrangements can create health and safety hazards and neighbourhood blight.

On-site disposal systems can to some extent overcome these difficulties, although they can create—and have created—other problems. For example, on-site incinerators, which can substantially reduce refuse volume, can also cause an unacceptable degree of air pollution unless they are properly designed and operated. Unfortunately, experience in some countries has revealed poor design, operation, and performance of such incinerators. To be acceptable they must serve a community large enough to justify investment in adequate equipment and supervision.

Kitchen grinders help to reduce the volume of putrescible refuse to be collected, but still leave up to 85% or more of the total volume to be collected, treated, and disposed of.

Present methods of refuse disposal are generally dumping, controlled tipping or sanitary land-fill, incineration, composting, and discharge into the sea ; in some cases refuse is mechanically reduced in volume before being deposited in a tip or land-fill.

Dumping, which is widely practised, is a most insanitary method that creates public health hazards, nuisance, and severe pollution of the environment. It should be outlawed and replaced by sound procedures.

Sanitary land-fill or controlled tipping is an acceptable method in suitable locations, if the possibility of pollution of surface water and ground water is eliminated. Under certain circumstances land can be reclaimed for valuable urban uses by means of land-fill. However, in most cases it is difficult to find suitable land in or near urban areas. In congested areas the absence of the substantial areas of land required for this operation has forced the adoption of other systems.

Incineration is used successfully in several of the industrialized countries, particularly in larger cities. This method reduces the volume of domestic refuse eventually to be disposed of, usually by tipping, to about 15-20% of the original. In many older plants, however, devices for removing pollutants from the exhaust gases are inadequate to comply with present air pollution standards or those likely to be established.

The increasing quantities of bulky waste such as old furniture and other household equipment also create problems in most existing incinerators. A few installations have incorporated special equipment for breaking up such large items before incineration.

Composting of domestic refuse, sometimes together with sewage sludge and other organic wastes such as market refuse and agricultural waste, has been adopted in a few towns and cities in several countries. The value of compost is as a humus or soil conditioner, its content of plant nutrients generally being not very significant. In many cases the fraction of domestic refuse that can be suitably incorporated in compost is decreasing, resulting in increasing quantities of material (up to 50% in some cases) that must be dealt with in other ways. The changing character of domestic refuse resulting from the increasing use of paper and plastic products will accelerate this trend. In addition, there is some anxiety that municipal compost might have certain toxic properties. This question needs further investigation.

Experience indicates that compost is becoming more and more difficult to get rid of except perhaps in countries with a subtropical climate, where refuse contains a higher proportion of food and vegetable wastes and where compost may be helpful in controlling soil erosion. In the developed countries, however, experience indicates that municipal compost now has little attraction in agriculture ; where it can be disposed of it is used for horticulture, silviculture, vineyards, parks, private gardens, and in some cases for restoration of derelict land. In a number of composting plants incinerators have been installed to deal with bulky items and with waste that is unsuitable for compost.

Mechanical size-reduction (pulverization, maceration, grinding, etc.), which is also sometimes a feature of composting plants, is now being practised in some places to help promote good tipping or sanitary land-fill practices. This is particularly true of smaller districts and of areas where otherwise suitable sites are located fairly close to land undergoing development. Pulverized refuse, after stabilization in a tip or fill, can be used for covering freshly deposited refuse, thereby making it unnecessary to provide other suitable covering material.

Provided that the equipment is properly designed and that it is correctly used in satisfactory locations, controlled tipping or sanitary land-fill, incineration, and composting are hygienically acceptable.

Disposal of refuse at sea, some distance from shore, is practised by some large seaside communities. The sea may offer a suitable receptacle for solid wastes, but investigations are necessary in each instance to ensure that on-shore currents and winds will not carry such wastes to land, destroying beaches and causing nuisance. On the other hand, the disposal of incinerator residues at sea is unlikely to cause problems.

### 4.3 Plants and equipment

As standards of living improve, the output of urban wastes continues to grow and to change in character, and at the same time it becomes increasingly difficult to obtain sufficient labourers. Furthermore, the increasing congestion of vehicular traffic necessitates better methods of storage and collection of wastes. For all these reasons, there is a need for a radical improvement in refuse treatment and disposal methods to prevent or substantially reduce pollution of the environment.

Storage and collection of refuse are being improved by the use of plastic and paper refuse containers in houses and other dwellings with one or two storeys, and bulk storage containers in multi-storey blocks of flats. The use of kitchen grinders, proper on-site incinerators, and compression devices in conjunction with dry chutes also alleviates the problem of refuse management.

However, further research and technological development are required in most, if not all, these areas to ensure that health hazards are avoided and pollution control standards met. Modern conditions, particularly in densely populated urban areas, have forced consideration of new methods of handling wastes, such as hydraulically or pneumatically operated pipe systems to transport wastes from their source to an intermediate treatment or transfer point, or to the place of final disposal.

Problems of refuse disposal must be considered in relation to local conditions, and methods appropriate for the latter must be employed. Although some countries may still use composting in certain areas, the continuing increase in volume of urban wastes, and their increasing content of packaging materials and diminishing quantities of food wastes, makes it probable that more cities, particularly in the developed countries, will turn to incineration. Further research and development is required on the design of refractory lined or wet-walled furnaces and on methods for dealing with bulky refuse, cooling and cleaning flue gases, and utilizing waste heat.

In some areas, particularly the developing countries, sanitary land-fill is—and will continue to be—the system adopted because of the lack of capital and skilled manpower necessary to provide and operate mechanical plants.

Generally, there is a lack of reliable information on which to assess costs of the various methods of refuse disposal. Sanitary land-fill is usually the least expensive. However, the lack of data sometimes makes it difficult to assess when it might be more economical to build an incinerator, which would reduce the volume to be tipped, than to use controlled tipping, which would involve the transport of refuse over increasing distances to the disposal site (and possibly also the construction of a transfer station).

There is also considerable lack of information about the comparative costs of incineration and composting. Much depends on the design of the various types of plant, the degree of complexity adopted, and the quality of the buildings. There are cases where the capital and operating costs of incineration are higher than those of composting, others where the costs are similar, and yet others where composting is more expensive than incineration. Generally, the cost of simple grinding is less than that of any other method of mechanical treatment, but here again there are wide differences in cost, depending upon the type of equipment and other associated factors.

There is need for a common standard for evaluation of costs, not only of the various mechanical methods of refuse disposal, but also of different installations of the same type erected in different areas in different countries. There is no single best method of refuse disposal. In each case, decisions must be made in relation to local factors such as cost and availability of labour and land.

## 5. ADMINISTRATION AND MANAGEMENT

### 5.1 Operations research

As already noted, wastes originate from many different sources, and travel through many different channels for disposal in the land, the air, or the water. Furthermore, management of wastes and control of pollution require substantial expenditures for the construction and operation of plants, and such expenditures must be justified in relation to other necessary investments for economic and social development. Thus, an evaluation of the best method of handling wastes, including control at their source, requires the study of an almost limitless number of alternatives. A new field of " operations research " or " systems analysis " has been developed to provide a framework for the study of complex inter-relationships of a wide variety of problems, with the computer providing a tool that makes analysis possible. However, these new techniques are only now beginning to be applied to the problem of wastes, and increased efforts in this area are necessary.

The key elements of this approach include : (1) systematic evaluation of the importance and inter-relationship of all relevant aspects of the problem, such as technical, economic, social, political, and cultural factors ; (2) assessment of alternative courses of action ; and (3) analysis of benefits and costs, on the basis of which policies can be determined and decisions made.

Basic to the systems analysis approach is the concept of the " cost-benefit " analysis. Application of such analysis is hindered by the difficulty of ascribing values to such important factors as health, aesthetics, recreational opportunities, nuisance, and convenience. For example, can an assessment be made of the benefit of having naturally clean water for drinking as contrasted with reclaimed waste water of apparently equal quality? How does one assess the benefit of a clean stream flowing through town, even if it serves only to beautify the environment? As discussed elsewhere in this report, there is a serious lack of the basic data necessary for evaluation of the benefits and costs of alternative courses of action.

The inter-relationships of " waste flows " not only demand that they be treated as a system, but also clearly necessitate the establishment of co-ordinated environmental quality standards.

## 5.2 Regional management of wastes

The management of wastes is at present handled by many different agencies. Such an approach has inherent limitations. The financial, and therefore technical and managerial, resources of a given community are often inadequate to solve the complex problems imposed by urbanization. Adjacent communities may each pollute the other's environment by the disposal of wastes. For these and other related reasons, it is necessary to adopt a regional concept of waste management. The advantages of integrated management of all types of wastes—including collection, treatment, and disposal—are evident.

Capital, administrative, and operating costs can be minimized by the introduction of regional services and by incorporating industrial wastes in the system, wherever technically feasible. The economic advantages of large-scale operation are highly significant in the collection, transport, treatment, and discharge of wastes.

Equally important advantages of regional operation are the ability to employ more competent technical and administrative staff, and the management of a significantly large, self-contained geographic area as a whole rather than individual small political units.

Despite the obvious advantages and necessity of a regional approach to the disposal of wastes, the solution of certain problems is a prerequisite for its success. The various local political subdivisions must agree to co-operate or to relinquish their activities in this area to a higher level of government. This necessitates a clear analysis of the inherent advantages and disadvantages of the regional approach. Furthermore, since urbanization is a dynamic process, the determination of appropriate boundaries for a waste-management region is closely related to economic and other development plans for the area. To some extent, technical considerations are also a limiting factor, although a regional organization is not limited to a single plant or single system. Normally topography, communications and transport, and major economic factors will be dominant in determining the regional boundaries.

Environmental pollution does not stop at arbitrary political boundaries, including those of nations. In such cases the political, legal, and administrative aspects of the problem must of course be taken into consideration.

It is gratifying to note, in the industrialized areas, an increasing trend towards the integration of public services on a regional level, particularly in the fields of water supply and waste management. Similar administrative changes are even more important in the conservation of resources in developing areas.

### 5.3 Economic management

Until now, the cost of management and control of wastes has fallen upon local and provincial government. When the problem was small the cost of such services could be absorbed by government and incentives for economical solutions were absent. Now, however, the magnitude of the problem requires sound economic analysis to rectify the neglect of the past and to provide for the needs of the future. Since the magnitude of a country's waste problem generally reflects its economic capacity, the financial ability to manage the problem is usually ensured. However, neither the administrative institutions nor the political initiative to undertake the required investment is necessarily ensured.

Methods are needed for the assessment of charges upon those who are responsible for and who benefit from the creation of wastes. A system for charging those who create solid wastes in the manufacture, use, or packaging of products is necessary. Such administrative measures are beginning to appear in the waste-water field. They provide incentives to manufacturers and other producers of wastes to reduce wastes at the source, and they avoid the slow and expensive legal controls that are otherwise necessary. However, the threat of legal regulation does have a salutary effect on an industry that prefers to police itself rather than to submit to government regulation.

There is a need for analysis of the effectiveness of various types of economic control, for the wider application of such controls, and for their introduction into the more complex field of solid waste disposal.

Sound solutions must take into account the realities of current political life and the processes of modern urban and economic planning. Absorption of small administrative units into adequately-sized operational units requires political and economic sagacity of a high order.

### 5.4 Public education

Most people have very little interest in cleanliness outside their homes. Many public authorities pay little attention to sanitation and usually look for the cheapest solutions, especially of refuse-disposal problems. This is one of the main reasons for the deteriorating cleanliness of cities, recreational grounds, etc. However, some sanitation departments have begun to educate the public, although with indifferent results, by several means, including pamphlets, advertisements, newspaper articles, television broadcasts, and talks in schools and elsewhere, often with the use of films or slides. Police enforcement of the laws seems to have more effect.

No study has been made of ways to improve public interest and co-operation. Thorough social and psychological research would be of interest to gain a better insight into the attitude of man in relation to the cleanliness of his surroundings. Studies of such attitudes might reveal approaches to a sounder public policy in the disposal of wastes.

It may be that only a small percentage of the population is responsible for most of the indiscriminate disposal of refuse over the countryside. A similar situation has been revealed by studies of motor-vehicle accidents.

In many cases, the population has to be educated to feel sufficient respect for the work of sanitation personnel, and to avoid anything that might adversely affect their self-respect. In this connexion, an investigation of the feelings of sanitation personnel about their jobs would be of value.

## 5.5 Manpower

### 5.5.1 *Professional and managerial*

The engineering problem of waste disposal must be evaluated in the same way as any other important engineering project, and disposal systems must be designed and operated similarly. The management of wastes requires intensive study, and industry, consulting engineers, universities, and governments have major roles to play. In many places the disposal and treatment of wastes is not handled by engineers or other professionally qualified personnel. A great effort is necessary towards better education and training of those professionals already engaged in the field as well as towards recruiting others to study and work in it.

The greatest advances in the management of wastes have taken place in those countries that have made a special effort to give graduate and post-graduate training to engineers already in the field as well as to professionals of other disciplines. There is a need for further training programmes in all countries, but particularly in those that are developing.

The greatest lack of trained professional personnel in the field exists in the management of solid wastes, and an effort to train academically qualified personnel is desirable in this area. Only a very few schools throughout the world offer courses for the training of engineers and managers in the disposal of solid wastes. This situation has resulted in both a lack of qualified personnel and a lack of scientific interest in carrying out the necessary research.

In the developing countries, too much dependence is still being placed on sending young engineers and scientists abroad to industrialized countries for specialized training in water supply and waste-water management. Local and regional educational programmes are required if the necessary number and quality of personnel are to be made available.

5.5.2 *Technical personnel*

In addition to managerial and engineering personnel, installations for the collection and disposal of wastes require well-trained technicians and operational and auxiliary personnel. Such skilled personnel are essential to the efficient operation and maintenance of these services and there is an ever-growing need of training programmes for them. Full utilization should be made of short-term courses, in-service training, and regular academic courses for such technicians.

5.5.3 *Labour*

In the more highly developed countries the employment of manual labourers for the disposal of wastes is becoming more difficult and in time may prove a major obstacle to the efficient operation of such services unless new labour-saving techniques are introduced. This is particularly true of solid wastes, where collection systems have been almost universally based on manual labour. Modern technology has provided possible solutions to this problem that must be evaluated from the standpoints of engineering, economics, and public health. However, manual labour will continue to be required by most such systems for many years to come and ways must be found to provide adequate incentives to employment, including improved working conditions and higher wages.

On the other hand, there are many countries where manual labour is plentiful. Such countries should use manual labour rather than overinvest in expensive and difficult-to-maintain equipment which is not economically justified in light of local circumstances.

**5.6 Collection and dissemination of information**

Different countries, in attempting to deal with their wastes and pollutants, frequently arrive at a wide variety of solutions. Only by analysis can it be shown whether or not such solutions are suitable for local conditions of geography, climate, administration, economics, etc.

In many cases, the methods devised and research results obtained by a country are of general interest to all countries. However, poor communication between countries, particularly where language barriers exist, has been an obstacle to the application of research findings from one part of the world to another. Of equal importance has been a lack of communication between disciplines. For example, waste-water management can profit from developments in the chemical and biological industries. Engineers and scientists in such fields must be encouraged to apply their knowledge to the problems of the disposal of wastes and those in the latter field must be encouraged to search out publications in a wide range of technologies. Information-retrieval systems must be established, both nationally and internationally, if full use is to be made of research accomplishments without an unconscionably long lag. Some such systems are already in use.

In each country it is very important to set up, as soon as possible, a procedure for the collection of information, and to have exchanges of views on research work that has been carried out and on the practices of other countries.[1] Such procedures make it possible to avoid unnecessary duplication of research, to apply research results to the benefit of all the countries concerned, to assess fully and comprehensively the techniques proposed or actually used, and finally to elaborate well-founded criteria to be applied by the administrative organizations concerned with planning, design, and construction.

Publication of research results depends too often on the initiative of individual specialists, as scientific organizations are not obligated to publish such information even within a single country, not to mention at the international level.

The collection of information from the whole field of wastes disposal should be continued by governments, municipalities, technical and scientific staff, specialized institutes, and laboratories. Such information should be made available to WHO for distribution to its Member States. WHO is in a unique position to stimulate research and to disseminate the results of such research. The Scientific Group also recommended that the Organization should continue to obtain the advice of consultants on various scientific and technical problems related to wastes disposal, and to make these experts available for special consultation in developing countries.

## 6. RESEARCH NEEDS

Research into the physical, chemical, and biological principles involved in waste-water collection, treatment, and disposal, and into the application of these principles, should be intensified. Similar research efforts in the field of solid wastes, which has received considerably less attention, are particularly necessary, as are studies of the administrative and economic management of waste waters and solid wastes.

Considering the size of the public and private investments that are daily being made in wastes management, and the considerable capital

[1] A bibliography of relevant publications will be found in the Annex on page 27.

investments that will be required in the future, the present research effort is indeed minuscule. Even in highly industrialized countries, research in the area of public services is often neglected. This has resulted in a relatively slow technological development in the disposal of wastes as contrasted with the very rapid technological change taking place in industry. Large industrial firms, whether private or public, find it necessary to dedicate a portion of their earnings to research, but research in the disposal of wastes is undertaken only after routine responsibilities have been discharged. Seldom does one find that a commitment to research is a primary obligation of any agency concerned with the management of waste water, and research in solid wastes is almost entirely absent. Research can be stimulated ; it can be conducted at existing institutions and through the use of pilot plants. Regulatory agencies should be sufficiently flexible to permit innovation and research as waste-management programmes are undertaken. Research should also be supported by governments and universities, as well as specialized laboratories. The funds necessary for such research should be an integral part of those provided for construction and operation of plants for the management of wastes.

Among the almost unlimited areas requiring investigation, the Scientific Group has selected the following as being of greatest importance :

### 6.1 Basic data

(*a*) Basic design data, from different parts of the world, including *per capita* contributions of wastes of all types, and their composition and characteristics, to permit the assessment of rates of change in quantity and quality. Consideration might be given to the possibility of reducing the ratio of wastes produced to goods used.

(*b*) The measurement of the quality of wastes and the development of more rapid methods of sampling and analysis and more sensitive techniques for measuring trace pollutants. The development of standard methods of analysis should be emphasized.

(*c*) Improved methods of automatic monitoring of the quality of wastes and use of appropriate data processing equipment.

(*d*) Criteria for determining the quality of natural waters, including physical, chemical, and biological indicators of pollution.

(*e*) The development of better indicators of the presence of pathogenic bacteria or viruses in water.

(*f*) Epidemiological studies of the effects of long-term exposure to trace levels of contaminants in the environment, including food as well as air, water, and land.

(*g*) Determination of the minimum infectious dose of enteric viruses.

### 6.2 Technology

(*a*) Comparative research on construction, operation, and costs of waste-management plants.

(*b*) Simplified systems for the collection, treatment, and disposal of wastes designed to make optimum use of local resources of men, materials, land, and funds.

(*c*) Laboratory and field studies of new materials and methods of handling wastes.

(*d*) Improved equipment, instruments, and controls for the replacement of manpower in areas where labour is scarce.

(*e*) Advanced processes for waste-water treatment so as to improve the quality of effluents. Such processes should remove nutrients, and other organic and inorganic substances, with high efficiency.

(*f*) The prevention and reversal of eutrophication.

(*g*) The hazards of the re-use of waste water and solids removed from it, with special emphasis on health aspects.

(*h*) The compatibility of industrial wastes from manufacturing processes, and of wastes from product use, with domestic waste-water plants and with the environment.

(*i*) The management of waste-water solids, and their integration with community and industrial solid wastes.

(*j*) Economic studies, by systems analysis techniques, of various combinations of unit processes for the collection, treatment, and disposal of wastes, of their incorporation into other waste systems, and of the eventual discharge of wastes to the land, sea, or air. Due consideration should be given to the effect of reclamation and/or disposal of the liquid, gaseous, and solid residues, and of waste heat produced by treatment plants on the environment.

(*k*) The use of wastes and residues, and of waste heat, for agricultural, horticultural, and other purposes.

(*l*) Improvement of equipment for reduction in size of solid wastes.

(*m*) Improvement in the removal of pollutants from the waste gases given off by solid-waste handling installations.

(*n*) Management of individual waste constituents at their source by collection, treatment, and re-use or disposal, rather than disposal by mixing such wastes with heterogeneous refuse.

### 6.3 Installations

(*a*) The use of existing plants for studying the effect of loading and other variables on treatment efficiency.

(*b*) Studies of plants that have performed poorly or failed, and publication of the results of such studies.

(*c*) Comparative technical and cost studies of properly designed and operating solid-waste plants throughout the world.

(*d*) Studies of the optimum size of plants and of their component units.

(*e*) Development of new processes and of pilot plants to demonstrate their utility, particularly for the handling of wastes that are continuously changing in quality.

(*f*) The future period for which a plant should be designed to be adequate. This is particularly important in developing countries.

(*g*) Methods of on-site management of wastes, including: design and operation of on-site incinerators, with attention to control of air pollution; methods of compressing refuse to reduce bulk; and methods of conveying it hydraulically and pneumatically in pipes.

### 6.4 Administration and management

(*a*) Methods for making the disposal of wastes amenable to systems analysis. Such research should cover the costs and benefits of so-called intangibles, such as health, recreation, aesthetics, nuisance, and convenience.

(*b*) The kinds of administrative and political institutions necessary to promote the efficient management of wastes, particularly on a regional basis.

(*c*) Economic methods of improving the management of wastes, including effluent charges, taxes, and financial incentives.

(*d*) Administrative, legal, and educational aspects of waste management, including the control of public and private despoiling of the environment by littering.

## 7. RECOMMENDATIONS

The Group is unanimous in its belief that the magnitude of the wastes problem facing all countries of the world, and particularly metropolitan areas, is such that WHO should give the necessary leadership in approaches to the problem.

A recurring theme during the meeting was the lack of comparative information on all aspects of the management of wastes. Another was deficiencies in the application of knowledge of existing processes and techniques under widely differing circumstances. Results of world-wide experience in the management of wastes should be collected from all sources and made available to Member States of WHO. The Group recommends that further attention be given to the collection of data on the management of wastes, taking into account the different local conditions in developing and developed countries, related to local resources of men, materials, land, and funds. In particular, further study is urgently needed in the following areas:

(*a*) The application of waste-water and solid-waste technology to specific situations that are characteristic of urban areas in developing countries;

(*b*) the status of modern technology for the collection, treatment, and disposal of solid wastes;

(*c*) the application of operations research, including cost-benefit analyses, to the disposal of wastes;

(*d*) the standardization of terminology, including units of expression, in the wastes field.

## Annex

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