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Solid Waste Disposal and Utilization in Developing Countries

R.M. Schelhaas (Editor)

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SOLID WASTE DISPOSAL AND UTILIZATION
IN DEVELOPING COUNTRIES

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INTRODUCTION

On the occasion of its 50th anniversary VAM Waste Disposal Company, Stadhouderskade 40, Amsterdam took the initiative to make available its experience and know-how in solid waste disposal and utilization (particularly by means of composting) to interested developing countries. Together with the Royal Tropical Institute (KIT), the idea was born to jointly organize a workshop on "Solid waste diposal and utilization in developing countries".

The organizers gratefully acknowledge the participation and financial support from the Netherlands' Ministries of Agriculture and Fisheries, Development Cooperation, and Health and Environment.

It was the intention of the organizers to create a possibility to transfer knowledge to and exchange opinions between experts in the so far much neglected field of waste management in developing countries. It is clear that on the one hand the level of waste management in the rural areas of these countries is insufficient and in some cases even hazardous to public health and environment; on the other hand, however, the greater part of the useful components, present in the waste, is not utilized.

The VAM/KIT - workshop, which was held from October 13 - 17, 1980, in the premises of KIT, was attended by 20 invited participants from 9 countries and by several observers from Dutch institutions.

This bulletin contains the papers, presented at the workshop in Amsterdam and at the VAM Compost and Recycling Plant in Wijster during an excursion to this plant. The country reports are presented as well.

The organizers express their gratitude to the international organizations UNEP, FAO, WHO, UNIDO and the Worldbank for their contribution by sending representatives who presented an address and who took part in the discussions. Also the contribution of a number of Dutch institutions is acknowledged.

The main conclusion from papers and country reports is that in most countries financial constraints are the limiting factor in arriving at a proper waste management. Therefore it was deemed useless to stimulate the use of expensive western techniques like total recycling or composting in a sophisticated way. Instead collection and processing should be adapted to local circumstances and factors, like quantity and quality of waste, infrastructure, climate, available knowledge and technology, and the market situation with respect to the end product to be prepared, e.g. compost. Before changing an excisting system the local situation should be carefully studied. Preferably the proposed system should first be tested on a pilote scale. Expenditures for collection and disposal, that have to be made anyway should not be incorporated in the final consumer price. Moreover a subsidy of the national government should be considered to stimulate these ecologically sound recycling activities.
Although solutions developed in a certain area cannot be simply applied elsewhere, it is considered useful to learn about such solutions. Therefore the workshop was concluded with the formulation of a resolution, in which the necessity was expressed to create an informal information network for the exchange of relevant information.
This resolution is included in the bulletin as an appendix.

I. PAPERS READ AT THE WORKSHOP, AMSTERDAM

Paper 1 Opening address by dr. W.M. Otto, Director-General for Landdevelopment and Forestry, on behalf of the Minister of Agriculture and Fisheries, The Hague, The Netherlands

It is not the Dutch Minister of Agriculture and Fisheries whom you see before you. An unexpected meeting of the Farm Ministers of the European Community requires his presence elsewhere. In this way those of you who have come from afar are confronted with the European agricultural policy.

My minister has requested me to offer you his apologies for his absence and to welcome you here on his behalf.

In the opening address I have the pleasure to deliver on his behalf I would like to discuss in some detail two subjects, i.e.:

- the limits of our existence, and
- how this workshop can further the effort to remain within these limits

We all know that life and death alternate continually. That applies to every living organism on earth. A random example: under the influence of the sun and by utilizing nutrients the grass grows and is eaten by herbivores, which in their turn are fed on by carnivores. In the grass and under the ground live insects and worms, which are eaten by the birds. In my example the grass is on the one hand a source of food, and on the other an environment in which other organisms can thrive. The grass in its turn profits from that, if only because grazing prevents it being overgrown by other plants. The elements of this complicated whole interact constantly, and thereby perpetuate each other. Not in the last place because the wastes produced by one component are staple- and luxury foods to another component, such as dung to the grass and carcases to birds of prey and carrion eaters. Then comes man. He sees a good tract of grassland and grazes his cattle on it. His inventiveness, creativity and expertise enable him to utilize its productive potential. Fertilizers, irrigation and drainage, and, if necessary, herbicides, help to transform the grassland into highly productive pasture with a high production of milk or meat.

Production has, however, been increased at the expense of what there was before. That is regrettable, but there is no other way to keep ourselves, our children and grandchildren alive. As a result of human interference, a highly productive system has been created which requires care to remain highly productive permanently. The moment that care decreases or productive capacity is exceeded the danger is very real that something results that no one wanted, i.e. an arid, infertile and trampled area, in other words a desert. A minor catastrophe has taken place with all its consequences for the people who had to live from it.

Such minor catastrophes are taking place continually. All these minor catastrophes together constitute an enormous loss of, very often, the best pasture and farmland.
All in all 5 - 7 million hectares are lost every year, due to wrong farming methods, but also to the building of towns and roads. If no action is taken nearly one third of the world's cultivable land will, by the end of the century, have been lost due to some destructive influence.

The very basic of man's existence is thereby seriously impaired. Certain natural laws are violated. When I say natural laws I do not mean laws laid down by human beings nor matters that can be measured with a ruler. I mean matters understood by anyone living off and in nature, namely that any careless use of natural resources will have to be repaid in one way or another at some time in the future.

Having to some extent explored the boundaries of our existence I now come to the field of the Workshop's activities. On mixed stock and cropping farms organic residues are used on the farm as fertilizers, animal feed and sources of energy. In large-scale agriculture, including agro-industry, the sheer quantity of those residues and the fact that the farms are specialized constitute organizational impediments to the utilization of residues. The search for practical solutions to these problems only started a few years ago, its object being better use of natural resources, increase of food production and reduction of damage to the environment caused by untreated residues being dumped in that environment.

UNEP and FAO for instance, jointly organized a seminar "Residue Utilization-Management of Agricultural and Agro-Industrial Wastes" in 1977. At that seminar experts from all over the world exchanged experiences on the utilization of residues for the production of energy, and of food for humans and animals, as fertilizers and as construction materials. UNEP and FAO then proceeded on their courses of popularizing residue utilization.

In 1978, the FAO published a "World Directory of Institutions concerned with Residues of Agriculture, Fisheries, Forestry and Related Industries" and a "Compendium of Technologies used in the Treatment of Residues of Agriculture, Fisheries, Forestry and Related Industries".

Another example in a broader field than agriculture is the WHO's "Manual on Solid Waste Management", which is already nearing completion.

These are but a few instances of what is happening internationally in the field of residue utilization. However, these projects have no real significance unless ways and means of practical application are studied.

The Dutch Government has given wholehearted moral and financial support to the initiative taken by the Waste Disposal Company VAM, and the Royal Tropical Institute to organize this Workshop. It regards this as one of the occasions on which experiences with residue utilization can be exchanged on a practical level. The organizers have focussed attention on a field that has so far been somewhat neglected. The Workshop will direct its attention mainly to methods of using city wastes as soil improvement products for agriculture. If this gap can be bridged a cycle can be created where before there was only a dead-end road. In addition to the organizational and social obstacles to this type of city waste utilization, I can also envisage objections from the point of view of environmental health as the heavy metals in city wastes may in the long run affect soil fertility.

Finally, I would like to emphasize that with respect to residue utilization there can never be one optimum solution. The solution to be chosen depends wholly on local circumstances. To enable the right choice to be made between alternative possibilities, there should be an adequate exchange of information. UNEP, FAO and WHO are aware of that. But I think it is fair to ask if those in the field can find their way to these sources of information and, if not, whether this workshop should not consider whether an additional, informal information circuit needs to be created.

To end this address, in which I have dealt with problems that concern all of us, and which may in part be solved by this Workshop, whose field of activity I have outlined, I would like to wish all those taking part in this Workshop an extremely fruitful week of study.

ENVIRONMENTALLY SOUND MANAGEMENT OF SOLID WASTES

Paper 2 keynote address by Dr. A. Khosla, United Nations Environment Programme, Nairobi, Kenya

It is a privilege for me to be here with you today at this Workshop. The subject of our discussions is clearly of great interest to those concerned with development and environment everywhere. It is also central to many programmes of the organization for which I work, the United Nations Environment Programme (UNEP).

I am particularly pleased to have this opportunity to get to know a little more about the distinguished work of the Royal Tropical Institute and to be able to celebrate with you the Golden Jubilee of the Netherlands State Waste Disposal Company, VAM.

Among all the environmental problems faced by mankind, management of the ever increasing quantities of wastes produced by society is certainly one of the most urgent. This Workshop therefore provides a timely occasion to share more widely new knowledge on progress in this area. The subject of the Workshop, "Solid Waste Disposal and Utilization in Developing Countries", is doubly appropriate because of its focus on the needs of the Third World. The problems of waste management differ, of course, from society to society and their solution must be specific to each context. The processes of waste generation, disposal and utilization in developing countries are wholly different from those in the developed world; they have become significant in recent years, and yet they are generally not well understood.

Within the Third World itself, the nature of waste management problems varies considerably from country to country and from cities and towns to rural communities. The types of waste to be disposed of, the financial constraints under which public agencies must work, and the institutional machineries and infrastructure available, all affect the approaches that we must take.

However, everywhere the problem of waste disposal must be looked at from a resource management point of view, which is of course important in the developed world - but crucial in poor societies.

We have before us a full week of discussions covering the whole range of technical and scientific concerns relating to waste management. There can be no question that progress in the waste management activities of human settlements must come from specific technical developments and the establishment of appropriate institutions. From the programme of this Workshop, I see that we will be discussing these in considerable detail.

At the same time, we at UNEP believe that such discussions must be firmly placed in the wider context of the relationships between the development process and the environment. Even our early work on the environment shows that every development activity entails a variety of socio-economic consequences and only very thorough and rational planning can lead to an actual improvement in the quality of life. Because of this, it is most important that we use the lessons we learn from working on various aspects of the environment and to apply the systems perspectives we have gained to each specific aspect of development.

During the short time I have available to me, I would therefore like to present a brief overview of the considerations which I believe we must all keep in mind in our future work in this area. I will try to describe some of the fundamental relationships between environment and development as we see them in our work at UNEP. I will then briefly mention a few of the management tools needed to ensure that our development activities are ever more environmentally sound.

While I will try not to pre-empt the more technical discussions which will follow, I will also attempt to show with reference to specific aspects of waste disposal and utilization, some of the environmental considerations which must be kept in mind if waste management systems are to be designed to fulfil not only their own particular mission and goals, but also to provide other direct and indirect environmental benefits. During the course of this discussion, I will also take the opportunity to give you a brief glimpse into some of the work of UNEP relevant to this area.

Human Settlements

There are various estimates of the increase in the population of the already overburdened towns and cities of the Third World that can be expected in the coming decades. Even the most optimistic estimate is frightening when viewed in the context of the additional demands on food, clothing, housing, jobs, waste disposal, sanitation, education, medical care communication and transportation. The burden on the urban environment of this expansion will test the strenght of our economic and political systems as very few processes have done before.

Whether it will be worth living in the settlements of the future will depend upon the kind of growth they follow. One may allow them to develop by themselves, responding to their own internal forces, without any guidance or design. The case has often been made that a city is like a human being - an organic entity - sustained by an intrinsic vitality and consistency, and subject to a pattern of growth with a dynamic of its own. Since, however, a large number of decisions concerning the location and choice of facilities within a settlement are made by individuals, without reference to the effects of these decisions on others, past experience shows that such a laissez faire approach does not necessarily create a satisfactory environment for the majority of people who live in the city.

Waste management facilities may be publicly or privately owned. A conflict arises between individual preferences and planning requirements for a waste disposal system from the fact that there is a divergence between 'private costs' and 'social costs'. What may prove to be convenient for one person may cause a great deal of inconvenience for many others.

There is, secondly, an indivisibility in the investments required for public infrastructural systems - a threshold below which expenditure cannot yield any returns - and this leads to constraints on the number of choices available. Waste management problems must, for these two reasons also, be viewed in the wider context of their economic and environmental implications.

Moreover, the costs can be very great of making changes in existing infrastructure such as water supply, sanitation and waste disposal systems, power transmission, roads and transportation systems after a city is already well established. Thus it is important at an early stage to consider and allow for the type of capital investment which will be needed as a city is born and grows. In the particular case of waste management systems, not only the economic but also the social and environmental impact of various alternatives must be explored in detail to avoid incurring economic and social costs which might offset the benefits which the systems are designed to provide.

Such considerations form a part of the wider concerns which underlie the relationship between development and environment.

Development

In the 1980s and beyond, societies everywhere will increasingly have to deal with environmental factors. Some environmental concerns are already of critical importance in the efforts of countries to satisfy the basic requirements and improve the quality of life of their people, to use rationally and effectively their resource base, and to develop and expand their economies. Desertification; soil loss and degradation; deforestation, flooding and siltation; pollution, waste disposal, resource depletion, noise and congestion; modification of climate and changes in stratospheric ozone levels; inadequate shelter and water supply; environment related diseases; etc., there are only some of the environmental problems confronting mankind today as governments strive, with varying degrees of commitment and success, to pursue the elusive goals of development.

The last few years have brought about a thorough re-evaluation of the concept of development. Even before the First Development Decade (1961-1970) was over, ideas concerning the objectives and strategies of a desirable form of development were undergoing rapid evolution. New visions, and the knowledge gained from actual experience, national and international, have since reinforced the general feeling that the existing models of development have often been inappropriate, too limited and therefore unsatisfactory.

Among the key changes relevant to an understanding of the "new development" is the recognition:

- that there are many models of development, that the path followed by the highly industrialized countries is not necessarily the best, and that each country should determine its own choices by engaging in more self-reliant and endogenous approaches to development;
- that a greater stress must be placed on the quality of development (in contrast to the pervasive concentration on its quantitative indicators), and on the distribution of its benefits and costs, at present and in the future;
- that societal problems and their causes are closely interrelated, that development is a compex and integral process, and that lasting solutions require intelligent planning at all levels;
- that planning for true development requires broad public awareness of the major issues raised by it and the closest possible participation of those who are affected by it.

Another important factor was that the 1970s saw the first signs of a breakdown in the historically established patterns of economic dependence of the developing countries and in the international economic structures. We are gradually beginning to emerge from these relationships between countries. This interdependence has become more visible because of the rapid growth of global communications. It is made more viable as a consequence of the global distribution of certain key natural resources, especially energy and minerals and the increasing importance of the markets offered by developing countries in absorbing the excess production from the industrialized north. However, in the long run, perhaps the strongest links between countries will be forged through the need to maintain a healthy global environment.

Environment

Important changes in the understanding of the environmental problems have also taken place in parallel with the changes in the concept of development. Indeed, it is perhaps no coincidence that the United Nations Conference on the Human Environment (Stockholm, June 1972) was the first, in a long series of international efforts, which led the way in expanding both the concepts of development and environment.

The primary objective of environmentally-sound development is the rational use and management of natural resources and of the biosphere in general as a means of enhancing development at present, while providing a base for sustainable development in the future, and avoiding situations in which certain desirable development options might be foreclosed. The attempt to fulfil this objective has led to a number of consequences.

First, the scope of the problem has been considerably broadened. The early definitions of environment were confined essentially to questions of pollution and resource depletion, that is environmental problems associated with the side effects of the development process. This definition has been expanded to encompass also those environmental problems whose underlying causes are poverty and lack of development, and which have to be resolved through the process of development.

Secondly, the solution of environmental problems is now seen to require more comprehensive and flexible approaches. For instance, while many environmental problems are amenable to remedial, sectoral or short-term i.e. "technocratic" responses, solution of others, and especially those of a long-term nature, requires more fundamental ("structural") approaches which deal with their underlying socio-economic causes.

The effectiveness of technocratic solutions may be limited and, in the long run, they may also be more costly. On the other hand, structural change as a means of attacking the underlying causes of environmental problems requires time; it in turn, often necessitates the establishment of new institutions and possible changes in lifestyles and patterns of development, in social organization and in socio-economic relationships. Thus environmental solutions must be a judicious mix of the immediate and the sustainable.

Thirdly, it has become clear and widely accepted that the environment, with its wealth of natural resources and ecological processes, is itself a resource of great value and thus a base for development. Its constituents provide raw materials needed for development; its self-cleansing and regenerating capacity are fundamental to life itself.

Thus, from the reactive and restrictive concept of protecting and preserving the environment as a specific entity, or seeing it as a constraint on development, the emphasis has shifted towards using and improving (i.e. "conserving") the environment in the process of development and economic growth. Consequently, there is growing agreement that environmental considerations should be on par with other social and economic goals, and should form an integral part of the development process and strategies.

In other words, the attainment of development goals and of a better quality of life should be sought in an environmentally-sound development framework. Conversely, the fact that development is an integral process also means that achievement of many key environmental goals is tightly linked with social and economic progress.

Thus, the problems associated with environmentally-sound development and their possible solutions stretch over a whole spectrum of concerns:

- from the short-term to the long-term;
- from the neighbouring to the global;
- from those of a minor nuisance value to the fatal;

- from those which require simple technological or *post facto* solutions to those which need deeper, institutional changes.

It should be clear that no panacea can be prescribed for all environmental problems. The appropriate solution for a given problem will depend on both the resources available and the goals of the society. Given the wide range of choices available, the relative merits of each possible course of action, and its consequences, need to be understood and therefore must be made as explicit as possible to allow the calculus of planning, in each context, to take them fully into account.

Environmental management is understood to be the process which, by taking account of the overall ecological, cultural, economic, social, technological and other factors, attempts to ensure that the human condition is improved in an integrated and systematic manner. It aims at the best use of the existing and potential resource base in such a way as to maintain, for now and in the long term, an ecologically sustainable and productive relationship between man and the biosphere.

Contrary to common opinion, the concepts of environmental management are as applicable to the problems of poor societies as to those of affluent ones. They are also relevant in the immediate present, no less than for the distant future. They are, indeed, simply an approach to rational economic and social development.

Lack of such essentials as clean drinking water, shelter, sanitation and waste disposal; insecurity in the face of natural hazards; and the loss of valuable resources such as clean water, forests, soils and wildlife are most important environmental problems of a developing country. The costs associated with these are no less than those of industrial pollution in highly industrialized countries. These problems must, therefore, be attacked with similar urgency and vigour.

To summarize, in both developed and developing societies, the ultimate objectives of environmental management are to provide greater personal and social opportunities and to improve overall human wellbeing for present as well as future generations.

Achievement of these broad objectives is a complex endeavour. The approaches to be developed, the types of solutions to be sought and the kinds of techniques to be applied will,by definition, vary with time and from country to country. They will be influenced by many factors, including societal goals and patterns of development, and the means and resources available. And they will depend, above all, on the quality and relevance of the information available.

The knowledge needed for achieving environmentally-sound development is inter-disciplinary and cross-sectoral. It is complex, wide-ranging in scope, and rapidly evolving. Moreover, much of it already exists, often known to those who need it, accumulated in a vast store of development experience all over the world.

Specific Examples

I have, in necessarily general term, tried to draw for you the broad background against which we must pursue our more specific concerns here. It would, perhaps, be worthwhile for me to give you some examples of how we at UNEP see these general concepts translate into specific activities.

The first example concerns the establishment of an information system to improve the flow of knowledge on all matters relating to environmental management, including, of course the management of wastes.

All development efforts rely heavily on the process of communication. As defined above, environmentally-sound development, by its very participatory nature, inherently depends on communication.

Environmental action requires close public participation for two reasons. First, environmental factors are typically redistributive, and the impacts are often widely separated from their causes, both in space and time. They are also usually ill-defined and subjective. Therefore, the informed views of those whom the development is for have to be closely incorporated throughout the decision-making process.

Secondly, implementation of any action aimed at improved environmental management must necessarily rely on the commitment of the people affected and is consequently contigent upon the existence of a well-informed and interested public.

The role of communications in generating an awareness of environmental issues and in making available technical and socio-economic information on the basis of which well-argued and sound positions can be taken is therefore fundamental to the attainment of environmentally-sound development. The communications channels must therefore serve both as tools for education and for improving the access of all (decision-makers, technical experts, the lay public) to specific information. A well-conceived information policy has to be developed as an important and integral component of the structures established to promote socio-economic development and can serve as a powerful tool towards its implementation.

The rapid emergence and multiplication of complex scientific, technological, and social problems outpaces the ability of any nation, however rich and determined, to seek all the requisite solutions to these problems and to explore all the alternative options open to it. A global co-operative effort is the only logical response to the issues challenging humanity. It is for this reason that nations seek to share knowledge and experience pertaining to their common problems and for the attainment of common goals.

In response to the need for a mechanism to facilitate rapid access to this information, UNEP has established a network for the exchange of environmental information - INFOTERRA, the International Referral System for Sources of Environmental Information.

INFOTERRA

INFOTERRA is a component of EARTHWATCH, UNEP's programme for the critical assessment of the global environment. INFOTERRA was established to facilitate the exchange of environmental information within and between nations, and has been operational since January 1977.

INFOTERRA activities are financed at the global level as a project from the Fund of UNEP and at the national level by each partner country.

INFOTERRA is a decentralized network of environmental information systems; its operation relies on a grid of national, regional and sectoral focal points.

Thus far, 110 countries have agreed to participate in INFOTERRA by designating an office within the national government structure to serve as the contact or national focal point of this network.

The decentralized structure of INFOTERRA, one of its most important features, has been chosen for good reasons. It is the least costly way of gathering information on sources, it provides the speediest response by the widely dispersed community of sources, and it brings the information machinery as close as possible to the user. But perhaps the most important consequences of decentralization is the self-reliance it promotes. In order to participate actively, countries must develop their own internal information systems; a focal point cannot be very effective without a strong system of support within the country itself. It is recognized that the success of the system depends very much on the joint efforts of its partners, and particularly on those of national focal points. Therefore, as its most basic goal, INFOTERRA encourages and assists the development of national environmental information systems.

INFOTERRA is based on the concept of referral. All INFOTERRA focal points are equipped to refer an enquirer to the sources best able to provide the information sought. In other words, they act as switchboards to connect users with appropriate sources of environmental information. The basic tools used are the National and International Directories (containing detailed information on sources), standardized terminology and the search procedures.

The subject coverage of INFOTERRA is very broad. As defined by Governments, it covers all those problems which they consider "environmental".

Examples include resource questions, nature conservation, technology, desertification, human settlements, pollution, waste disposal, etc. The concept of environment is continually evolving, and varies from place to place, from time to time and from culture to culture. INFOTERRA attempts to compile as complete as possible an inventory of information sources, in order to give adequate subject, geographical, and other coverage. Thus it must maintain close links with other national and international information systems, since they almost always have at least something of interest to potential clients of INFOTERRA.

Ultimately, however, the potential of INFOTERRA to provide access to useful information hinges on the ability of each source to respond with knowledge relevant to the needs of the user. It is here that the spirit of cooperative effort can play a valuable role in improving the transfer of information from those who need it.

Social Benefits

The second example I would like to give you is more conceptual in nature. It relates to the additional opportunities offered by imaginative and systems-based design of our technologies and institutions. Later this week, we will consider in more detail the use of biogas technologies for waste management. Biogas is a case which provides an excellent illustration of the concepts of environmental management, and can, with proper design, lead to several social and environmental benefits which go far beyond the simple disposal of wastes, and fulfil a number of development criteria.

A full social benefit/cost analysis of biogas is quite difficult to carry out, because of the large number of social and environmental impacts it can have. Moreover, many of these impacts are of second and third order and no adequate attempt has been made in the past to quantify them. Some examples of studies carried out on biogas will however, suggest the magnitude and importance of the external benefits of this technology.

Biogas technology has a considerable potential impact on hygiene and therefore on public health. Detailed epidemiological studies in Sichuan show that a biogas programme can permanently sustain the reduced incidence of intestinal infections achievéd by medical and sanitation measures. Use of biogas improves hygiene for three main reasons:

1. Since the ova of common parasites are heavier than the digester slurry, they quickly sink to the bottom. This sedimentation (i) removes pathogens from possible contact, and (ii) concentrates them for easy treatment when the slurry is taken out.
2. Pathogens have a far shorter life in the anaerobic and high temperature conditions in the digester (usually hours) than they do in free atmosphere (usually weeks or months). Thus, the biogas plant effectively is a germ-destroying machine.
3. A properly-designed biogas plant produces extremely clean fuel and fertilizer and also reduces the need for handling human and animal wastes, and therefore the possibility of contamination and exposure to infections. Cooking on a biogas burner automatically eliminates the major source of stomach infections - contaminated food.

Moreover, a host of second order causes and effects, such as the availability of additional water (pumped by a biogas-driven motor), improved environmental conditions in the kitchen, healthier diet, etc. serve to reinforce the hygienic conditions made possible by the above factors.

The public health impact of biogas is contingent on the setting up of a critical mass (threshold number) of biogas plants in each locality to sustain a minimum level of hygiene and to prevent recontamination. It also requires the use of human excreta for biogas production.

Such conditions exist in Sichuan. Even a conservative interpretation of the Sichuan data, which show a very large improvement in the incidence of stomach infections suggests the economic, social and environmental impact possible with well-designed and appropriate technologies. The presence of parasites in the stomach reduces the absorption of food eaten. This is essentially because the zoo of parasites inside the stomach requires feeding, reducing the food available for human metabolism. Estimates for this loss of food vary between 10% and 25% per infected individual. Thus, the direct public health consequences (even in purely financial terms) of the introduction of biogas technology are very considerable and in fact greater in real economic value to society than the value of the fuel and fertilizer produced by the plant. For instance, if the level of health improvement sustained by a biogas programme reported for some production brigades in Sichuan were to spread throughout the province, the value of food saved because of this factor alone, calculated at world prices, can easily be shown to exceed $200,000,000 per year.

The Chinese experience has also shown that by removing wastes, biogas installations reduce the presence of flies and mosquitos and consequently lessen the risk for infectious diseases such as dysentery and malaria. Other diseases which have been reduced by the implementation of biogas in China are said to include typhoid, liverluke, infectious hepatitis, schistosomiasis and poliomyelitis. The economic value of such public public health benefits are incalculable, but clearly significant.

Several benefit/cost studies in India have shown that the environmental benefits of using biogas-produced fertilizer are considerable. Mainly because of the cow dung saved from burning, users of biogas have reported crop yield increases of up to 75%. Biogas also has a considerable economic value in substituting for commercial fuels such as coal, kerosene and charcoal. The value of this technology is partially reduced, however, because of social and class factors. The community plants now under study may circumvent these problems, but it is also possible that they could accentuate class differences.

A Korean study has shown that, with the introduction of biogas, the time required to collect firewood has typically been reduced from 3 hours per family per day to 1 hour. The value of the extra time available, used for productive work, study or leisure has not been calculated. Nor have the other, second order, improvements this extra time brings to the lives or the poor - especially women and children. Even more difficult is the evaluation of environmental effects due to reduced deforestation, soil erosion and siltation or improved microclimates and water management.

One economic externality which can be calculated is the value of imported fuels and fertilizer saved. For a family-size plant, this exceeds $40 per year, all in valuable foreign exchange.

Thus, while the fuel and fertilizer produced by the biogas plant provide sufficient return on investment for the owner to justify the capital outlay needed, the economic, social and environmental benefits are even greater and accrue to society as a whole. Indeed, the public health benefits to society are, alone, greater than the direct return to the investor.

Conclusions

I have tried to show, with a couple of examples, how the general considerations of environmental management open opportunities for specific action in each development sector, such as the management of wastes. The general concepts, on which I have deliberately spent a little time, can only be translated into specific and beneficial action if the local conditions and constraints are fully taken into account.

Not withstanding the basic convergence between the requirements of environment and development, each real situation involves difficult choices and potential societal conflicts. There is only one pie, of limited size - and governments and municipal authorities must take trade-offs between many different possible expenditures. It is, therefore, a special responsibility of scientists and engineers to develop methods for waste disposal and recycling which are both effective and financially feasible. When a local authority cannot even afford a truck to carry away domestic refuse, what use are sophisticated solutions involving much larger expenses?

Waste recycling and reuse are areas needing extensive research and development effort. Here is an area of work where developing countries can contribute greatly to knowledge, and one for which there need be no permanent gap between developed and developing countries. Research in this area does, however, require considerable resources and it is time for commonplace observations about the "Spaceship Earth" and "common responsibility to the planet" to lead to real resource transfers.

The international community can play an important role in this sphere. The New International Economic Order for which we are now striving provides an excellent framework for the exchange of international experience on all aspects of environmental management. I have already described the possibilities offered by information systems such as INFOTERRA for the exchange of R and D results. An even more fundamental need is for building up research capacity in developing countries. Moreover, access to new technologies must not be hampered by the high costs of inappropriateness in their application to new conditions. Among possible measures, such technologies and processess should be declared a common heritage of mankind and be made freely available to all who need them.

The Government of the Netherlands has been at the forefront of the movement to include environmental considerations in development cooperation activities, and is exploring the possibility of putting in its development assistance programme an environmental increment in the cost of various project feasibility studies and even for the capital costs. We can only encourage such approaches by donor countries and agencies.

Ultimately, the possibility for implementation of waste management hinges on the whole question of lifestyles.

The consumer society is also a waste generating society. Neither developing countries nor the developed ones can hope in the future to continue to use nature's resources in the manner that they have aspired to in the past. Patterns and levels of production and consumption will have to be modified if life on this planet is to continue to be meaningful and worthwhile. All that we do and discuss during the coming week must be seen in this light.

WHO ACTIVITIES IN THE FIELD OF SOLID WASTE MANAGEMENT

Paper 3 by P.K. Patrick, World Health Organization, Geneva, Switzerland

Summary

The development of good practice in all aspects of solid waste management is a well-established component of WHO activities. These include literature on the subject, seminars, training programmes and country projects.

A current project is being undertaken in Turkey for Istanbul Metropolitan Area and is discussed in the paper.

Methods of waste disposal are reviewed, particularly in their relevance to developing countries.

Recovery and utilization of solid wastes is of growing significance in solid waste management. In western countries the high cost of labour and energy militate against economic recovery; in developing countries comparatively simple and labour-intensive methods are generally preferable to highly mechanized processes.

The production of compost from waste can often be beneficially adopted in developing countries, where the waste has a high organic content. However, numerous problems, discussed in the paper, may arise in marketing the product.

Landfill will remain an essential and basic method of solid waste disposal and techniques should be improved.

1 Introduction

Wastes are produced in all human habitations and as a result of human activities. These wastes must somehow be disposed of, and in a manner which has the minimum impact on the environment. Solid wastes is a general term used to define waste material other than liquids, produced as a result of domestic, commercial, industrial or agricultural activities. By definition, liquid and gaseous wastes are excluded but no hard and fast line can be drawn in the case of sludges from some industrial processes, which are part liquid and part solid. As an extension of solid wastes, the expression "solid waste management" is now used to embrace all activities involved in the storage, collection, transport, treatment and disposal of solid wastes.

In small agricultural communities solid wastes may readily be absorbed into the natural cycle - organic waste can be put to land, and animals may consume food residues. However, in towns and cities the management and disposal of solid wastes create problems which in many areas have become critical. Not only does the quantity of waste increase with urbanization, but the tremendous development of technology and change in life styles in the last 30 years have given rise to an extremely wide range of materials discarded as waste, ranging from innocuous inert material to complex chemical substances requiring special measures in handling and disposal because of their toxic or potentially hazardous nature.

There is also a much greater public awareness of the need to safeguard the environment, and methods of waste handling and disposal commonplace in former years are no longer acceptable.

2 WHO activities in solid wastes management

The development of good practice in solid wastes management has been recognized by World Health Organization as an essential component of its environmental pollution control programmes. WHO activities in this field are carried out through the Organization's Regional Offices. The writer has been involved in recent years in activities of the European Regional Office, which are summarized below.

2.1 Development of a solid waste programme

In 1971 a working group was convened at Bilthoven, in collaboration with the Netherlands Government, to advise the Regional Office on the development of the solid wastes component of the long-term programme in environmental pollution control. The report(1) of the working group contained conclusions and recommendations on:

- Trends and developments in solid wastes technology
- Recovery and re-use of solid wastes
- Preparation of model European Code of practice for land disposal of solid wastes
- Dissemination of information on modern technology in solid wastes management
- Feasibility of use of legislation and taxation to restrict quantities and types of waste and facilitate disposal

2.2 Code of practice for disposal of solid waste on land

As part of the implementation of the afore-mentioned programme, Regional Office prepared a code of practice[2] for land disposal of solid wastes ("controlled tipping" or "sanitary landfill"). This has been translated into several languages. The object of the code was to give guidance on procedures to be adopted for the safe and hygienic disposal of solid waste on land and to establish guidelines for the technique of controlled tipping.

2.3 Solid wastes manual

A manual dealing with various aspects of waste disposal is under preparation at the European Regional Office. An excellent manual[3] on solid waste management in developing countries has been produced by South-East Asia Regional Office, New Delhi.

2.4 Glossary

A glossary[4] of more than 900 terms relevant to solid waste management has recently been published.

2.5 Training

Training in the techniques of solid waste management is carried out by means of fellowships, seminars and workshops.

2.6 Country projects

A fundamental part of WHO activities, of course, is the provision of technical asstance in country projects. In conjunction with the national government concerned, WHO Regional Office prepares a detailed project programme, setting out the objectives, activities, consultant programme, equipment, training requirement and budget for the project. Technical assistance, depending on the scope of the project, is provided by a full-time senior technical adviser and short term expert consultants. Country projects, in which there has been a solid wastes component, have been undertaken by the European Regional Office in Poland, Greece, Yugoslavia, Algeria and Turkey. Information on the projects in Turkey, in which the writer is currently involved, is given below.

3 WHO/UNDP Projects in Turkey

A comprehensive project for solid wastes management in Istanbul Metropolitan Area is at present under way, financed by UNDP with contributions by the Turkish Government and Istanbul Municipality. A similar project for Ankara has just been approved.

The Istanbul project is one of the largest solid wastes projects undertaken by WHO. The project covers an area comprised of 30 municipalities with a present population of more than 4 million. This is projected to grow to 7.5 million by 1995. The project itself is a feasibility study to determine the most suitable methods of refuse storage, collection, materials or energy recovery and re-use, transport and disposal in the metropolitan area. A project team of Turkish personnel with a Turkish project manager was set up and a full-time WHO senior technical adviser and bi-lingual secretary appointed. The programmed duration of the project is 20 months. Visiting international expert consultants are recruited as required for particular aspects of the project.

In a country such as Turkey where there is no tradition of solid wastes management as known in western countries, one of the difficulties in a large-scale project is the collection of reliable data. This generally is a time-consuming process and is only obtainable by staff visits and personal enquiries. Instanbul contains about 40% of the industry of Turkey, so information on quantities and types of industrial wastes was essential. With the assistance of an expert consultant an extensive programme for an industrial wastes survey was carried out, covering 300 of the largest industrial premises employing some 25% of all industrial employees in the area. A questionnaire was drawn up and visits made to all the premises concerned to obtain the required information. An extensive survey of hospital wastes, including the methods of handling and collection, was also made. This entailed visits to some 80 hospitals, nursing homes and clinics.

Essential to any solid wastes management study is knowledge of the composition of the wastes. A programme of waste sampling was carried out. Samples of refuse were collected from groups of premises in various categories and physical separation and classification was made by project staff. Chemical analyses were undertaken by Istanbul Technical University.

With the assistance of a consultant hydrogeologist and in co-operation with the State Water Authority, a widespread search for potential landfill sites was made. Despite difficulties in finding suitable and acceptable sites for landfill, these are essential in any waste disposal plan, as there is no practical alternative technology to dispose of all types of solid wastes.

Because of the precarious economic situation in Turkey, particular attention is being paid to the scope for materials or energy recovery. Markets for recovered materials have been identified. The prices paid for recovered material of all kinds, particularly plastics and paper, are very high by western standards, so the potential for materials recovery is good. However, there already exists a thriving private enterprise industry in this field. Scavengers sort out material from refuse receptacles on the streets. At tips, unofficial scavengers extract material from the refuse as it is deposited. These activities pose social problems. It is easy to say that the practice is unhygienic and should be stopped. In practice this is difficult and it can be argued that this unofficial scavenging contributes to the economy at minimum cost. In many cases also, this activity may be the principal means of livelihood for the people engaged in it. Certainly the activities of scavengers should be brought under some control, e.g.

by allowing some sorting at landfill sites under contract, with specified conditions.

The World Bank is involved in the Istanbul project and if the final conclusions and recommendations in the project report are approved, some financial assistance will be available from this source for implementation of the recommendations.

An important aspect of this and similar WHO projects is the training of national professional and technical staff in the techniques of solid waste management. In the Istanbul project, full use has been made of the presence of visiting consultants for this purpose, by sending project staff members into the field to work with them.

4 Waste management

It is not within the scope of this paper to discuss in detail all aspects of and technologies involved in solid waste management, but it is pertinent to consider what is meant by the term. Waste management might be described as a system incorporating all the measures necessary to ensure the safe and most economic methods of disposing of wastes. We know, of course, that wastes cannot be wholly destroyed; they can only be converted to substances which eventually reach the air, soil or water. The aim of waste management must be to minimize the environmental effects of converting or utilizing wastes.

5 Recovery and utilization of solid wastes

With increasing industrialization in developing countries, the demand for and cost of raw materials will continue to grow, while their long term availability can no longer be taken for granted.

Commercial and industrial solid wastes represent potential sources of re-usable material and energy, and much research is being carried out in Europe and USA to determine the most practicable and economic methods of materials and energy recovery from solid wastes. Materials which can be recovered fall into two main groups: those which can be directly re-used without further processing; and those which require processing before they can be re-used as a secondary raw material. Within industry, a considerable amount of waste material from manufacturing processes is directly recycled; glass and plastics are notable examples. On the other hand, materials recovered from domestic wastes may require considerable processing before they can be re-used as raw materials. For example, newspapers removed from solid wastes, whether collected separately from other wastes or not, have to be re-pulped and de-inked before being used as raw material in a paper mill.

Generally, materials recovered from wastes and recycled for industrial purposes are of a lower grade and value than virgin raw materials. Very often, the cost of recovery and processing is less than their market value in a free economy. Nevertheless, other considerations must be taken into account: the recovery and recycling of materials reduces the quantity of solid waste to be disposed of by other means; as the cost of virgin raw materials increases, the recovery and recycling of wastes is likely to become more economic; in countries where national economic considerations seriously restrict the import of virgin raw material, waste recycling can make a valuable contribution to the economy.

However, enthusiasm for recovery and recycling should not blind one to the practical difficulties and limitations. It is something of a paradox that in the wealthier nations where saleable constituents may comprise 40-50% of the wastes, the high cost of wages and energy often make recovery uneconomic. Conversely, in poorer countries, there is less paper, plastics, metals, etc. to be recovered and much of this is extracted from the waste stream by private scavengers.

In developing countries, the relatively complex and sophisticated recovery plants being developed in western countries are generally not appropriate, at least in the present stage of technical development. Such equipment as air classifiers, ballistic separators, pulverizers, pelletizers, etc. require considerable amounts of energy and are often not appropriate for the type of waste generated. A combination of screening and hand-sorting will generally be adequate and cost-effective in countries where labour is plentiful and wages low.

6 Waste disposal methods

The aim of solid wastes disposal practice is to absorb the wastes into the environment in such a way as to cause the minimum adverse environmental impact.

The disposal of solid wastes from human habitation and industrial activity is generally a more severe problem than collection, which is principally a matter of financial resources and organization. Disposal gives rise to environmental problems, whichever method is used. The proposed location of a disposal facility in any neighbourhood is likely to give rise to objection by local residents, who may take a lot of convincing that good disposal practice will not create unpleasant conditions in the neighbourhood. Very often, the views of citizens are coloured by evidence of unsatisfactory procedures and activities in other areas.

The disposal methods commonly used are: landfill, incineration and composting. The establishment of any of these facilities requires careful site selection, knowledgeable engineering and good management. Very often the last-named is the key factor.

6.1 Landfill

"Landfill" is now the accepted term for the deposit of solid waste by "sanitary landfill" or "controlled tipping". This method is not to be confused with crude dumping, which is hygienically and aesthetically objectionable.

The landfill method involves depositing the waste in layers not exceeding 3 m in depth, compacting the waste during formation of the layers by bulldozer or special compaction machine, and covering exposed waste with soil daily as work proceeds. Heating up and decomposition of the waste takes place in the landfill; compaction and covering of the waste prevents the breeding of flies or other vermin.

Planning a landfill operation requires careful site selection; drainage and other protective measures may be necessary to prevent risk of pollution of surface and underground water. If buildings are in the vicinity, measures should be taken to prevent the migration of gases generated in the landfill. Methane gas, which is explosive in combination with air in certain proportions can be a particular hazard. Technology has been developed to "de-gas" landfills and in certain cases it is possible to collect the gas for use as a fuel.

Sites suitable for landfill operations include land made derelict by mineral extraction - e.g. sand and gravel pits, clay pits; low-grade land which may be improved and put to useful purpose by filling, levelling or contouring.

6.2 Incineration

The purpose of incineration of solid wastes is to reduce the waste to the smallest practicable volume and to produce a sterile residue which can readily be disposed of on land.

Modern incineration plants operate on a continuous flow basis. The furnace grates are mechanically operated to move the burning material continuously through the furnace; the clinker and ash produced are cooled in a water trough. Ferrous metals are extracted from the clinker to be sold as scrap for iron-making. The clinker itself may find use as fill material for road or other construction works.

The combustion gases have to be cleaned to remove solid particles before being passed to the atmosphere. In most western countries there are now stringent regulations imposing standards for chimney emissions from incinerators. To meet these standards, expensive gas-cleaning processes are required. It is necessary to reduce the temperature of combustion gases before they enter the gas cleaning equipment. This may be done by means of a waterspray cooling tower, by air cooling or by incorporating steam-raising boilers in the furnace plant.

Incineration plants are expensive in capital cost and in maintenance. Many problems can arise in the operation of high-pressure boilers in waste incineration plant. The gases given off in combustion of the waste are often highly corrosive, particularly if there is a high PVC content in plastics contained in the waste. Corrosion of boiler tubes can therefore be a serious problem. Solid waste is also a highly variable fuel and plant operation acquires skilled management. Solid waste incinerators are not flexible in meeting heat demands; a certain amount of waste has to be received and burned every day and the boiler output cannot meet widely fluctuating demand.

Incineration is not likely to be a solution to waste disposal problems in developing countries. In many areas the very high moisture content and low caloric value of the waste makes heat utilization impracticable and in some cases the C.V. may be too low to sustain combustion of the waste without the addition of supplementary fuel.

6.3 Composting

The wastes in developing countries are often very suitable for conversion to organic humus, as they contain a high proportion of organic material (60% or more). The composting of wastes is an age-old process, of course; modern techniques reduce the time required for production of matured compost.

Compost produced from solid wastes is a peat-like material, the main constituent of which is humus. It also contains the important plant nutrients, nitrogen, phosphate and potassium. Applied to the land, compost can have the following benefits:

- Lightening of heavy soil
- Improvement of the texture of sandy soil
- Increased water retention

Compost produced from organic wastes cannot compete in economic terms with artificial fertilizers, the nutrient content of which is controlled within known limits. Although compost may be regarded as complementary to artificial fertilizers, there is often resistance by farmers to its use. Before a decision is made to adopt composting on a large-scale as a waste disposal method it is essential to ascertain market potential in terms of quantities and price. It is also necessary to satisfy potential customers that the quality of the compost produced will be acceptable. This can best be tested by a pilot project, which is the only safe approach.

The production and marketing of compost in large cities poses numerous problems. Some of the problems were listed in a report[5] prepared by the Ministry of Works and Housing of the Government of India, as follows:

1) Lack of a rural market
   Farmers in both Thailand and Japan showed little interest in urban compost, even when the price was reduced to one-third the cost of production. Progressive farmers preferred chemical fertilizer, while less affluent ones relied upon the cheaper locally produced manure.
2) Inadequate road systems
   In cities such as Bangkok, the roads were so crowded or inadequate that vehicles transporting refuse to the compost plants and compost to farmers were not able to make many rounds.
3) Low quality
   In Bangkok, the percentage of plastic materials in the end product was high enough to significantly diminish the compost's value. In Japan, the manurial value of the compost was also found to be very low.
4) Social unacceptability
   The production and use of compost was considered obnoxious in the countries visited and, therefore, rejected by many potential users. This seemed to be a most serious obstacle in Bangkok, where private contractors refused to lend their vehicles for this purpose.
5) Storage difficulties
   Because of the difficulty of selling compost, storage space was inadequate in a number of countries, thereby damaging the environment.

The technology of composting is well known and need not be described in this paper, but systems most suited to developing countries are generally simple in construction and operation. A typical small compost plant would be based on the "windrow" method, with pre-screening if necessary, and final grading of the matured product to meet market requirements.

Fully mechanized plants, of which there are many variations on the market, are only justified where there is a large and dependable outlet for the material.

7 Conclusion

The overall objectives of solid wastes management are to minimize the environmental impact resulting from the collection and disposal of such wastes, and to protect health. Improvement in solid wastes management practice will create better environmental conditions for people living in urban and rural communities.

The technologies and systems outlined in this article deal with the wastes produced; the longer term aim should be to reduce the amount of waste produced, both from domestic and industrial sources. There must be limits to growth in waste production as in other aspects of human development. Achievement of a reduction in waste may require a combination of approaches - modification of industrial processes, elimination of certain hazardous substances, governmental influence by legislative or fiscal methods. There will certainly be an increasing rate of development in reclamation and recycling technology, along with improvement in the performance and reliability of existing processes.

The real problem will lie in reconciling the economic and political pressures which at times beset all nations with the need and demand for better environmental standards, but the protection of the environment and need to conserve resource are now matters of concern throughout the world.

References

1) WHO Regional Office for Europe (1971) Long-term programme in environmental pollution control in Europe - Development of solid wastes programme (EURO 3402)
2) WHO Regional Office for South-East Asia (1976) Management of Solid Wastes in Developing Countries

3) WHO Regional Office for Europe (1973) Model Code of Practice for the Disposal of Solid Waste on Land (EURO 3402(2))

4) WHO Regional Office for Europe (1980) Glossary on Solid Waste

5) Report of Committee on Urban Wastes (1975) New Delhi, Ministry of Works and Housing

HEALTH ASPECTS OF THE ELIMINATION OF REFUSE AND WASTE FROM SOCIETY

Paper 4 by Dr. H.L. Wolff, Institute of Tropical Medicine, Leyden, The Netherlands

Continual changes in the composition of waste and refuse do not only raise new problems for the processes of elimination, but also pose new medical (health) problems. Toxic substances like heavy metals (mercury and cadmium from batteries and lamps), which did not figure formerly to any noticeable amount in household garbage, are now even present in remote places of this world.

In the elimination process we should be aware, that the end products may not be dangerous to man and environment. During the processing itself the labourers have to be protected from possible dangers. Therefore, we must know what dangers exist and to what extent. The whole problem is both a qualitative and a quantitative one. Pathogenic microbes may be harmless in the concentration present in some end product, but cannot be tolerated because of the possibility of multiplication to high numbers elsewhere.

Some special problems arise from refuse produced by hospitals and mental institutions. This may contain drugs, radioactive material, harmful viruses, pathogenic bacteria, etc. Refuse from these places, therefore, should be excluded from the normal elimentation process. The same holds good for some industrial wastes; but exclusion does not solve the problem. Hospital refuse and industrial waste have to be disposed of in a safe way. Pathogenic organisms and microbial substances can be destroyed by burning. The main problem then becomes: how to collect and transport such material in a safe way.

Radioactive substances used for (medical) diagnosis mostly have a short halflife (hours or days) and the end products are more or less harmless. The substances used for the irradiation of tumors and such (radium, cobalt) should not be discarded in the environment. They are part of one of the many major problems of modern society.

Most of the pathogenic organisms: bacteria, fungi, parasites are killed at a temperature of 60°C. Most of the viruses do not withstand this temperature either. Composting, therefore, is a good means to make these pathogens harmless. One must be sure, however, that all pathogens are killed. The leachwaters should not contain such pathogens any more, or have to be treated before being evacuated into other water systems. A regular bacteriological check of the leachwaters is therefore necessary. Spores of *Bacilli* (anthrax) form a special problem; they are resistant to high temperatures. The same holds true for some viruses.

Neither parasites, nor their eggs, form a major problem. They are killed at composting temperature. In developing countries, especially in tropical and subtropical regions, the refuse itself forms a danger. On the one hand cockroaches, flies and other arthropods may live and multiply to enormous numbers on refuse; on the other hand mosquitoes and other disease vectors may breed in or on the composting materials. Among the pests attracted by refuse and waste material are rats, mice and many other rodents. They may harbour pathogenic organisms like *Pasteurella pestis* (plague), *Yersinia multocida* and others, causing fatal disease in many animals, Mycobacteria causing tuberculosis in animals and man, etc. The battle against these pests is difficult, the more so as also harmless animals and birds feed on refuse. The use of poison for this purpose is limited as the end product must not contain dangerous components as it may be used for hog feed or the cultivation of vegetables. Also one has to consider the leachwater, that may not contain dangerous chemicals.

Little or nearly nothing at all is known about toxic products, that may be formed during the composting process. Theoretical possibilities exist, such as the toxins from *Clostridium perfringens*, which cause diarrhea in man and animal. The first article on this subject has still got to be published.

One has to be alert in order to prevent new threats, that may arise from garbage that is offered for treatment.

We already know that some viruses are not "killed" by temperature treatment. As viruses cannot multiply without host and the number of virus particles in the end product is relatively low, they will not create any danger at all. We do not know much about the presence of spores (e.g. anthrax) in compost. In developing countries the presence of such spores should be investigated. Just as with drinking water we will have to give strict instructions, however small the dangers may be.

A special health problem form the labourers working in waste - and garbage processing plants. In some of these industries the household refuse is still sorted out by hand, this should not be tolerated. Even if gauntlets are used, injuries may occur (glass); such wounds become easily infected. Statistics show a high number of accidents among the labour force in refuse processing industries. Whether this is due to the type of work, the indifference of the workers, or the liberation of toxic fumes is not known. Here again is a point for investigation.

All labourers coming down with any kind of disease or injury should be traced and followed. A check for contageous diseases should regularely be made. A possible correlation with the work, the treated material and the working circumstances should be kept in mind.

ANNEX

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THE EFFECT OF SOLID WASTES ON HEALTH AND WELFARE

Health aspects

Solid wastes vary throughout the world because both the quantity and the constituents are determined by social customs and living standards. As a society becomes industrialized the traditional domestic solid wastes are augmented by industrial, commercial, and agricultural wastes, each of which adds a new potential for nuisance and sometimes a new threat to the health and welfare of human beings.

Most wastes are heterogeneous and may vary seasonally; thus there can be no uniform approach to the problem they present. However, two main categories exist universally : fermentable organic wastes, which will decomposite rapidly, and non-fermentable wastes, which resist decomposition or decompose very slowly. Wastes in the first of these two groups arise primarily from the preparation of food for human consumption. They are closely linked with the pattern of food consumption, and vary with the way of life and with living standards. In summer the volume of these wastes increases because of the abundant supply of fruits and vegetables and in winter it may decline if some of the wastes are burned on fires. However, the importation of fresh foodstuffs out of season tends to modify the traditional composition of household wastes.

Ideally, solid wastes should not contain any faecal matter or urine, and the mixture of the latter wastes with household wastes should, as is the case in some developed countries, be prohibited by law. Difficulties of enforcement, however, and variations in way of life mean that some tolerance has to be accepted in this matter. Where it occurs, such mixing makes it more difficult to undertake the collection of solid wastes in a manner satisfactory from the point of view of environmental health. The handling of pathological wastes, slaughterhouse wastes, and similar materials in association with household wastes should also be prohibited. But pathogenic organisms will continue to be present in wastes in spite of all possible precautions.

Harm from waste products can arise from other causes : inflammability because of paper content or by spontaneous combustion when in heaps; production of smoke; disgusting or nauseating smells and liquids during exposed fermentation in the open; the scattering of paper, plastic, and dust by wind; and the breeding of flies and rodents, the role of which is still of great importance in the spread of disease.

It is necessary to concentrate attention on certain of these immediate problems : insects, rodents, polluted water and air, contact contamination, and accidents. There are also some long-term problems of man's food chain that have to be examined.

Insects

Various flies, particularly the housefly and the blowfly, breed near houses when there are waste products in the vicinity. They are also to be found at solid wastes disposal sites at which good standards of operation are not observed. Of course, it is relatively easy in temperate zones to avoid fly proliferation near human dwellings, but control is much more difficult in countries with high temperatures and high humidity and where the rate of decomposition of wastes is faster. Flies have a very great power of dispersion, with a flight range over land of about 10 km in radius.

Improper discharge of solid wastes in open drains or rivers may result in the creation of breeding places, as may the improper disposal of tin cans and automobile tires that hold water.

Rodents

Rodents proliferate very rapidly in uncontrolled deposits of refuse, which provide their main sources of food. Throughout the world there are periodic campaigns to exterminate rats and mice, but the presence of food wastes permits rats to persist and to migrate from dumps to human dwellings in the vicinity. This creates a serious health problem because the rat may be a reservoir of plague, murine typhus, leptospirosis, histoplasmosis, rat-bite fever, salmonellosis, tularaemia, trichinosis, and many other diseases.

Solid wastes and air pollution

Uncontrolled and incomplete combustion of solid waste materials can result in the release into the atmosphere of a number of undesirable pollutants, including particulate matter, sulfur dioxide, nitrogen oxide, various hydrocarbons, and other noxious gases that may have deleterious effects on the health of those who inhale them.

The main source of air pollution from this cause is the deliberate, accidental, or spontaneous combustion of waste deposits in the open, which gives rise to large volumes of smoke and offensive odours. When rubber is present in the burning material the problem becomes especially serious.

Another source of pollution is the old or inefficient incinerator plant. Combustion causes a large amount of dust to be suspended in flue gases, and if dust eliminators are not installed it may be very unpleasant to live in the immediate environment of the plant. Some incineration plants have installed equipment to limit the generation or emission of dust, but only the newer plants are equipped with electrostatic precipitators.

The burning of plastics, particularly polyvinyl chloride, gives rise to hydrochloric acid, which not only causes corrosion in the plant but may also produce unacceptable aerial pollution in the vicinity. For this reason consideration is being given to the possibility of replacing polyvinyl chloride by other synthetic products that do not have the same disadvantages. A warning is necessary with regard to the possible future marketing of even more dangerous plastics, for example, those based on fluorine.

Small (household or institutional) incinerators, which usually lack dust extraction equipment, should be subjected to stringent controls, especially in urban communities. Well-designed incinerators are, however, a preferred method of destruction of pathological refuse for hospitals.

Solid wastes and water pollution

Rainwater that passes through a deposit of fermenting solid wastes emerges as a leachate, which contains a very high proportion of fermenting organic matter. While the possibility exists that pathogenic organisms may be carried some distance, studies have shown that in normal permeable soils the bacterial penetration does not exceed a dozen metres. But where the deposit is sited on fissured rock distant water sources may be contaminated. Hence, a geological and hydrological investigation by specialists is a necessary prerequisite to the use of a site for the deposit of solid wastes. When fermentable solid wastes are deposited in water-filled sites in impervious ground the damage is of a different nature and is due rather to the sulfite-reducing organisms, which may produce obnoxious odours over a considerable area.

Large quantities of industrial solid wastes are deposited in landfills and some of these are toxic. Certain highly toxic wastes are dumped at sea. Leachate from industrial solid wastes may contain dissolved chemicals, particularly heavy metals, which are poisonous. It has been demonstrated that such materials may be concentrated in nature by some organisms in man's food chain.

Epidemiological studies

A study in India of stool specimens from refuse workers indicated that 94% of this group were infected with selected parasites as against slightly more than 4% in the control group[1]. The same study indicated that the infection rate with worms and related organisms was 3 times that in the control group. Contamination of this kind is liable to occur at all points where waste is handled. However, although it is certain that vector insects and rodents can transmit various pathogenic agents of diseases (amoebic and bacillary dysenteries, typhoid fever and salmonellosis, various parasitoses, cholera, yellow fever, plague, leptospirosis, etc.), it is often difficult to demonstrate the precise relationship between the sources of infection and the health of the population affected.

Another danger to refuse workers is the high accident rate attributable to heavy lifting and mechanized equipment. Although no study has been completed specifically identifying the types of accident and permitting an accurate comparison of this rate with that in other occupations, it is believed that - at least in some countries - the rate is much higher among this group than among any other comparable working group.

Some evidence suggests that certain population groups may also be particularly influenced by improper solid wastes handling or disposal practices. In this connexion, it would be desirable to investigate the influence on the mental and physical health of the aged, the infirm and the very young as well as on that of people living in the vicinity of treatment or disposal sites.

The importance of such studies cannot be overestimated because all the evidence suggests that a thorough clean-up of the environment is followed by a significant reduction in disease and a fall in the death rate.

MAIN CONCLUSIONS AND RECOMMENDATIONS

Health and welfare

Although only limited study has been made of the direct effects of solid wastes handling, available evidence shows that improper handling adversely affects health and property values and hampers the recycling of natural resources, besides being aesthetically undesirable. It may also lead to dangerous concentrations of toxic substances in food chain organisms through physical and biological processes.

It is recommended that international agencies and research institutions should investigate these phenomena, seeking in particular to develop appropriate means for epidemiological studies and for monitoring the hazards of toxic industrial solid wastes. It is further recommended that national health agencies should be closely involved in policy making with respect to solid wastes disposal and should promulgate codes of practice for sanitary disposal, emphasizing the control of insects and rodents, faecal matter, and pahtological wastes, and the pollution of natural waters.

References

Abd-El-Malek, Y, M. Monib, S.G. Risk & M. Shebata : Biological activities during ripening of composts. Zentralbl. Bakt. (Naturwiss.) 1976 Vol 131-744.

Anonymus : Solid Wastes Disposal and Control. WHO Technical Reportseries no 484 d.d. 1971

Anonymus : Human viruses in water, waste water and soil. WHO Technical Reportseries no 639 d.d. 1979

Anonymus : Solid Wastes Disposal and Control. WHO chronicle 1972 Vol 26 p. 147.

Anonymus : Wastes Disposal. WHO chronicle 1976 Vol 30 p. 24.

Bräuer, S , G. Burger, P. Czerney & U. Eichler : Untersuchungen zur Menge und Beschaffenheit von Mullsickerwassern aus einer geordneter Deponieanlage. Z. Gesamte Hygiëne 1978 Vol 24 p. 916.

Craig, R.H. : Waste disposal - how are the new authorities coping? The local authority viewpoint. Royal Society of Health J. 1977 Vol 97 p. 225.

Czerny, P., G. Langner & A. Kegel : Gröszenordnung und Variabilität analytischer Kennwerte von Haushaltmüll der Stadt Dresden. Z. Ges. Hyg. 1977 Vol 23 p. 109.

Editoral : The national filth. Brit. Med. J. 1979/2 Oct. 20, p. 952.

Eyl, T.B. : Organic mercury food poisening. New Eng. J. Med. 1971 Vol 284 p. 706.

Fürmaier, B. : Schadlose Beseitigung von Pflanzen Behandlungs-mittel. Schriftenr. Ver. Wassr, Boden, Lufthyg. 1975 Vol 46 p. 135.

Gaddusek, D.C., C.J. Gibbs Jr, D.M. Asher, P. Brown, A. Dinan, P. Hoffman, G. Nemo, P. Rohwer : Precautions in medical care of and in handling materials from patients with transmissible virus dementia (Creuzfeld-Jacob disease). N. Eng. Med. J. 1977 Vol 297 p. 1253.

Groszman, G. & P. Sopadjier : Müllbehalter und deren hygiënische Behandlung. Zeitschr. Ges. Hyg. 1976 Vol 22 p. 200.

Hook Jr, R.I. van, B.C. Blaylock, E.A. Bondietti, C.W. Francis, J.W. Huckabee, D.E. Reichle, F.H. Sweeton & J.P. Witherspoon: Radioisotop techniques in delineation of the environmental behaviour of cadmium. Environmental quality 6 Safety, 1976 Vol 5 p. 167.

Hurst, C.J. & C.P. Gerba : Development of a quantitative method for the detection of enteroviruses in soil. Applied & environmental microbiol. 1979 Vol 37 p. 626.

James, S.C. : Metals in municipal landfill leachate and their health effects. Am. J. Publ. Health 1977 Vol 67 p. 429.

Jansen, J.D. : Medical and toxicological research on Dieldrin and related compounds. Environmental Quality & Safety 1976 Vol 5 p. 208.

Johnson, C.J. : Toxic soluble waste disposal in the sanitary landfill site draining to an urban water supply. Am. J. Publ. Health 1977 Vol 67 p. 468.

Kofler, W. & H. Schorat : Vorschlag zur einbringung von Testkiemen in Rottemiten bei Grosztechnische Versuchen. Zentr. Blatt Bakt. Orig. B. 1976 Vol 162 p. 389.

Krogstad, O. & R. Gudding : The survival of some pathogenic microorganisms during reactor composting. Acta Agri. Scandinavica 1975 Vol 25 p. 281.

Martin, C., H. Frauendorf, U. Erdmann, G. Kühn-Seyr : Arbeitsphysiologische Untersuchungen beim Transport von Müllgroszbehälter in de Hausmüllberäumung. Z. Ges. Hyg. 1979 Vol 25 p. 283.

Maugh, T.H. 2d : Toxic waste disposal a growing problem. Science 1979 Vol 204 p. 819.

Miersch, K. & D. Strauch : Hygiënische Ueberprüfung der Kompostierung von Siedlungsabfallen in stationären Rottezellen mit Belüftung. Müll & Abfall 1978/4, p. 115.

Möller, F, K. Krannich, H. Engelbrecht & K. Isserstedt : Untersuchungen zur Entseuchung und Hygiënisierung von Siedlungsabfällen durch Mieten Kompostierung so wie Schloszfolgerungen zur Standardisierung der Kontrollverfahren. Zentr. Blatt Bakter (Naturw.) 1976 Vol 131 p. 222.

Müller, W.P. & F. Korte : Ecological-chemical evaluation of waste treatment procedures : the behaviour of xenobiotics in waste composting. Environmental Qual. & Safety 1976/5 p. 21.

Patrick, P.K. : Model code of practice for disposal of solid waste on land. WHO Chronicle 1973 Vol 27 p. 439.

Powell, T.W. : Converting garbage (foodwaste) into safe animal feed ingredient. Proc. Ann. Meet. US Animal Health Ass. 1975 Vol 79 p. 278.

Schröder, C.D., et al : Survey of rodent populations associated with an urban landfill. Am. J. Public Health 1979 Vol 69 p. 713.

Smalley, D.L. : Detection of enteric virus in solid waste landfill leachates. Am. J. Public Health 1979 Vol 69 p. 389.

Sobsey, M.D. : Field survey of enteric viruses in solid waste landfill leachates. Am. J. Public Health 1978 Vol 68 p. 858 .

Sogonuga, O. : Health factors in solid waste management. Nigerian Med. J. 1979 Vol 9 p. 619.

Wachendorff, R. : Bisherige Ergebnisse bei Aktionen zur Beseitigung von Pflanzenschutzmittel resten in Nord-Rheingebiet. Schriftenr. Ver. Wasser, Boden, Luft, Hyg. 1975 Vol 46 p. 139.

Walker, E.A., et al : Disposal of carcinogens. Nature 1980 - 20/3-284 p. 210.

Wands, R.C. : Solid waste disposal a long standing public health problem comes of age. Amer. J. Public Health 1977 Vol 67 p. 419.

SOLID WASTE DISPOSAL OF FOUR CITIES IN INDONESIA
REPORT ON A PROJECT FOR TECHNICAL COOPERATION

Paper 5 by Ir. B.G. Kreiter, Institute for Waste Disposal (SVA), Amersfoort, The Netherlands

1 Introduction

This paper reports on a project for technical cooperation on the improvement of waste collection in four Indonesian cities: Bandung, Medan, Pontianak and Ujung Pandang. This project was initiated by both the Ministry of Public Works (Republic of Indonesia) and the Ministry of Foreign Affairs, Directorate of International Technical Assistance (Kingdom of the Netherlands).

In preparation of the implementation of the project an identification mission visited Indonesia in the fall of 1974. The result of this visit was a draft plan of operations for the implementation of the project.

The objective of this proposed project was to obtain basic information with repect to:

- the quality and the quantity of solid wastes in the four cities,
- the most suitable equipment for collection and transportation of solid wastes in specific Indonesian circumstances.

The project as such was approved by the two Governments and regarded as a first phase of a "Master Plan for the Improvement of Solid Wastes Management".

In accordance with the approved proposal SVA drafted a detailed schedule of operations in which the necessary equipment, the weighing and measuring programme, instruction for operation and maintenance as well as the activities of Indonesian and Dutch participants were described.

The equipment was shipped to the four cities in 1976. Construction of weighing bridges took place early 1977. The systems were put into operation during September-October 1977 under the supervision of SVA.
As a result of an interim evaluation some additional equipment was sent to Indonesia in September 1978.
The project was evaluated and concluded during a Workshop in Jakarta (1-3 May, 1979).

2 General observations

One of the most important aspects with repect to solid wastes is the specific relationship between wastes and hygiene. Diseases are often transmitted by vectors like flies and rodents. When community or personal practices permit accumulations of fly-breeding media the potential for human infections via fly-borne pathogenics is increased. Such media are generally found in waste. As far as rodents are concerned, the commensal rat is a known source of diseases transmissable to man. The rat thrives where-ever carelessness in waste handling and disposal is found.
In particular it appeared that wastes accumulated at market-places. At these places most of the food for the inhabitants will be sold.
The heaped waste is always attended by vermin (flies,rats) so the possibility for infection of human beings through bought food is not imaginary.
In addition a lot of waste is simply dumped in ditches and canals. This result in stagnation of water flow as well as in water pollution. This water is often used for domestic purposes so there is another possibility for the generation of diseases. Furthermore during the wet (tropical) season restricted flow in ditches and canals will cause flooding of residential areas.
In conclusion: The first priority should be devoted to an adequate waste collection system in order to remove wastes from concentrations of human beings.
The treatment and disposal of wastes can mostly be regarded as matters with a more secondary priority.

In particular in those cases where available budgets are limited priorities are to be formulated. Within the context of the described project and according to the foregoing aspects emphasis was put on waste collection.

3 Aim and scope of the project

In the course of the identification mission as mentioned in the introductory paragraph it became clear that both living conditions of the population in the four cities as well as the working conditions of the refuse collectors could be improved through better solid waste management.
The project offered the opportunity to test under practical conditions more or less sophisticated means of collection and transportation. In addition basic data on quantitative aspects should be obtained.
The equipment used for the implementation of the project could, on a small scale, contribute to the immediate improvement of the situation.
It was decided to apply four different means for waste collection and transportation.
The equipment was not experimental in itself but has been very well tested under European conditions. Most of the problems in the four cities are more or less similar.
This means that the results of the use of the equipment are comparable and some general conclusions or guidelines could be formulated. In order to obtain quantitative and qualitative data on solid waste and on the efficiency and capacity of the four systems a measuring programme has been developed for a period of one year.
In order to execute this programme the four cities were provided with mechanically operated weighbridges.

4 Some practical experiences

In this paragraph a number of relevant experiences will be listed. One should bear in mind however that the organization of a cleansing department is of course not totally focused on one single collection system.
Large scale application of new collection equipment requires adaptation of the cleansing operation as a whole. In particular items as training and instruction of personnel, sufficient possibilities for an adequate maintenance programme as well as adaptation of the waste treatment operation to some extent to the respective vehicular means can be mentioned.

4.1 Trucks

Sophisticated vehicular means require adequate maintenance. Often lubrication oil or spare parts were not available mostly because of lack of sufficient budget. Moreover the drivers were in some cases not careful in truck handling resulting in excessive wear of for instance tires, clutches and gearboxes.
In nearly all cases the collected wastes are dumped at distances to the cities of 11 up to 27 kms. The dumping sites however show generally a very bad accessibility (particularly during the wet season) for heavy loaded collection trucks. This resulted also in excessive wear as already mentioned. In addition the unloading procedure took to much time which of course reduced the truck efficiency sharply.
On the dumping site near the city of Medan movable wooden rails were successfully used in order to improve the accessibility. Finally it can be remarked, that the trucks were often overloaded. Moreover the use of a bulldozer on the landfill site was very helpful.

4.2 Containers

A distinction can be made between the steel containers and the plastic wheel containers.
Some large steel containers suffered rather heavy corosion effects due to inadequate surface finishing (painting) and steelplate thickness.

Moreover it is, particularly in the wet season, necessary to drain the large open containers through bottom holes, in order to remove the excess of water. In this way at least a part of the mentioned corrosion effects can be avoided. The plastic wheel containers suffered from damaged hinges and wheels. The hinges were reinforced whereas the wheels were enlarged. The damage to the wheels was mainly caused by the bad condition of the pavement in a number of the residential areas combined with refuse with a high specific weight. It is recommended that at least the transfer locations are provided with an adequate pavement.

5 Principal findings

In order to obtain sufficient information from the project several forms (9 in total) were used. During the project implementation the completed forms were sent regularly to the SVA-office.

Furthermore a specific questionnaire has been drafted to be completed by the respective Cleansing Departments. In this questionnaire a number of items were listed with regard to organizational, technical and economical aspects of the cleansing operations.

It was difficult however to obtain information on items as the actual collected waste quantity particularly in relation with the number of inhabitants. It has been tried, of course with certain assumptions, to compare the existing with the new equipment. These assumptions were, among others, related to the following aspects:

- new equipment has to be imported in Indonesia from Europe. Locally produced or assembled equipment however could probably reduce the investments,
- the rate of interest,
- the average life span of the equipment,
- number of working days per week,
- wages of collectors and drivers.

The annex 1 shows per specific equipment the principal numerical results for the situation of the city of Bandung.

The financial aspects are expressed in the local currency (Rupiah, Rp.).
As far as the total operational costs are concerned the new system is more efficient compared to the existing equipment. The same is the case for the cities of Medan and Pontianak. In the case of the city of Ujung Pandang the new system is more expensive.
More detailed information on the efficiencies can be found in the final report on the project (Volume I and Volume II) SVA/3226/224.

6 Conclusions

During a "Workshop on Solid Waste Management" held in Jakarta 1-3 May 1979 the project and its results were discussed in detail. These discussions formed the basis for the formulation of conclusions.
These conclusions with a number of recommendations are very well formulated in Volume II of the already mentioned report SVA/3226/224.
However it seems fruitfull to list the following, more general, items:

- In order to improve solid waste management in a country a so called "Master Plan", covering a long term period, is necessary.
- A proper planning enables to predict in particular budgetary needs necessary to fulfil a plan.
- The formulation of a Master Plan needs reliable basic information. Therefore certain "Pilot Projects" are necessary. The described project can be regarded as such. Annex 2 indicates a rough outline of such a Master Plan.
- The above mentioned basic information should cover the whole field of waste management with important aspects related to:
  * the organizational structure of cleansing departments (it was often observed that staffing was inadequate both qualitatively as well as quantitively due to budgetary problems),

* the collection and transportation of wastes preferably for the full 100% (often only 40 or 50% of the wastes are collected),
* the improvement of the waste treatment operations; waste treatment often consists of badly organized landfill operations, resulting in bad performances of the collecting and transportation equipment.

- Improvement of solid waste collection will improve often the functioning of drainage systems. In particular during the wet season these improvements can be noticed.
- In those localities where soil erosion appears as a problem composting of wastes might be an attractive option because compost is able to improve the soil condition.
- A programme should be developed in order to stimulate public participation during a solid waste management improvement operation. This participation should be of a financial as well of a physical nature. A more or less educational effort should be organized through schools and the press.

Finally the author wishes to acknowledge the excellent cooperation with the Directorate General of Cipta Karya, the respective municipal authorities as well as the heads of the respective cleansing departments during the implementation of the described project. Furthermore the services of the local representative of DHV-Consulting Engineers, who acted as an observer-rapporteur, were highly appreciated.

Principal numerical results

Bandung:

According to the weighing and measuring programme the following average data could be calculated:

	present system	new system
- specific weight	210 kg/m^3	240 kg/m^3
- time per trip per car theoretical optium	106 min.	174 min.
- capacity per car per trip	1179 kg	7243 kg
- capacity per car per hour	683 kg/h	2516 kg/h
- personnel per car (incl. driver)	6	4
- total weekly transported wastes (all available vehicles)	1300 tonnes	66 tonnes

The costs of waste collection and transportation were as follows:

	Existing system	DAF-Kliko
Price flatbottom truck	Rp 11.25 x 10^6	
ditto for DAF-Kliko (excluding containers)	-	Rp 44.1 x 10^6
transshipment	-	7.5 x 10^6
custom duty	-	p.m.
Total investment	Rp 11.25 x 10^6	Rp 51.6 x 10^6
- Depreciation 10 resp.6 year at 10% interest.	Rp 1.83 x 10^6	Rp 11.85 x 10^6
- maintenance	1.13 -	4.41 -
- insurance	0.17 -	0.66 -
- running costs (tyres, fuel etc.)	1.17 -	1.09 -
- truck personnel (including 20% overhead)	1.85 -	1.23
Yearly costs per car, excluding collection and containers	Rp 6.15 x 10^6	Rp 19.24 x 10^6

Counting 20% reserve for the maintenance of the trucks, the yearly capacity per car can be determined.

existing system : $\frac{52 \times 38 \times 0.683}{1.2} = 1125$ tonnes

DAF-Kliko system: $\frac{52 \times 38 \times 2.516}{1.2} = 4150$ tonnes

This results in operational costs per tonne <u>transported</u> waste of:

existing system ca Rp 5470/tonne
DAF-Kliko system ca Rp 4650/tonne

The <u>collection</u> costs are calculated to be Rp 3900/tonne for the existing system and Rp 4350/tonne for the new system. In order to make systems comparable collection and transportation costs were combined to one figure:

existing system:	transportation	Rp 5470/tonne
	collection	Rp 3900/tonne
		Rp 9370/tonne
DAF-Kliko system:	transportation	Rp 4650/tonne
	collection	Rp 4350/tonne
		Rp 9000/tonne

For implementation of the DAF-Kliko system the following numbers of equipment and labourers can be estimated per 100.000 inhabitants:

DAF-Kliko combination:	3
plastic wheel container:	1800
drivers, loaders, collectors	3,9,48

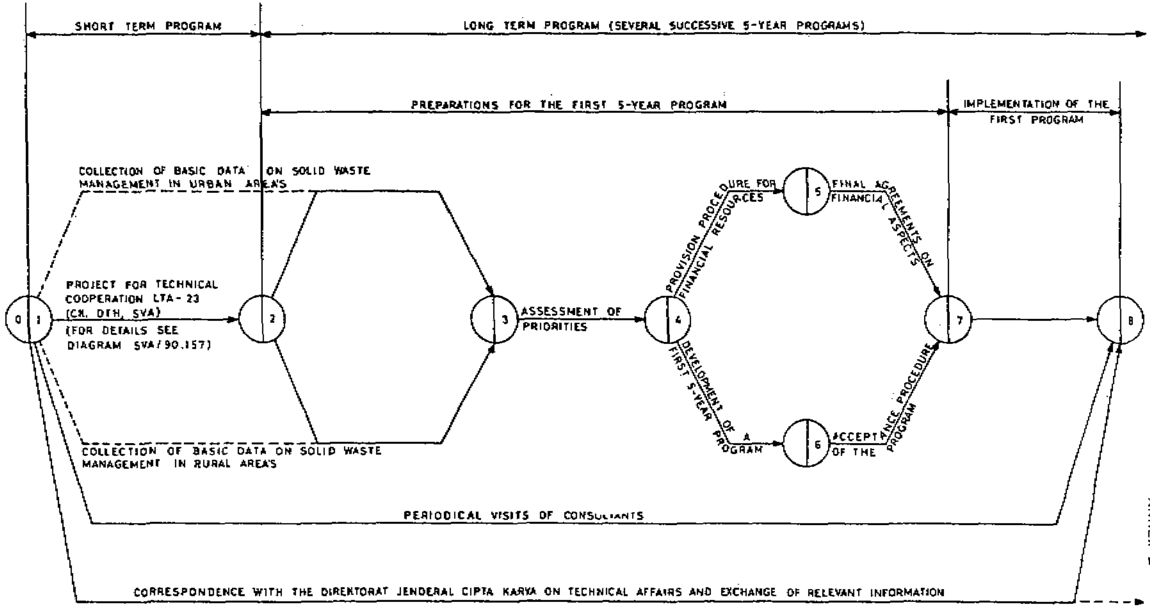
DIAGRAM SHOWING AN OUTLINE FOR A MASTER PLAN FOR IMPROVEMENT OF SOLID WASTE MANAGEMENT

EXPLANATION: TIME IN WEEKS —⊕— NUMBER

D.T.H.: DIREKTIE INTERNATIONALE TECHNISCHE HULP (DIRECTORATE OF INTERNATIONAL TECHNICAL ASSISTANCE)

C.K.: DIREKTORAT JENDERAL CIPTA KARYA

S.V.A.: STICHTING VERWIJDERING AFVALSTOFFEN (INSTITUTE FOR WASTE DISPOSAL)



ANNEX 2

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ORGANIC RECYCLING IN AGRICULTURE IN DEVELOPING COUNTRIES

Paper 6 by F.W. Hauck and C.S. Ofori, Food and Agricultural Organization, Rome, Italy

Introduction

Prior to the advent of mineral fertilizers the fertility of soils was maintained through the use of organic materials. Farmyard manure and composts were the main nutrient sources for maintaining soil productivity. In some countries in Asia, for example China, Korea and few cities in Japan, additional nutrient sources such as human faeces were widely used. Crop rotations with legumes were practised to provide nitrogen to the succeeding crops even though systematic inoculation of the legumes seeds was not extensively applied.

Large-scale development and intensification of agriculture have resulted in the availability of crop and animal residues which in a number of the developed countries are referred to as agricultural wastes. In the developing countries, however, these organic material sources should necessarily be regarded as resources and as such be recycled for the purpose of increasing soil productivity.

The impact of chemical fertilizers has relegated the importance of organic material as nutrient sources to the background. The beneficial effects of chemical fertilizers are widely recognized, but with the increase in the price of energy the majority of small farmers in developing countries still lack the financial resources to afford their use.

The need to improve and maintain soil productivity is now more crucial than ever before since available lands are limited in many countries, particularly in Asia, and the population pressure on these limited arable land areas is increasing.

The energy crisis in 1973/74 has necessitated the reassessing of the role of organic materials in improving soil productivity and generating interest in encouraging their use.

In this respect, however, it should be stressed that use of organic materials to improve soil fertility must not substitute for the use of chemical fertilizers but should complement it.

1 Potential for Organic Manure in Developing Countries

In most developed countries today soil fertility maintenance is largely through the application of chemical fertilizers. Farmyard manure in livestock farms is becoming a burden to farmers as an agricultural waste requiring its safe disposal to avoid its pollutory effect upon the environment. Organic manures which are in limited supply in developing countries, are agricultural resources which are both essential in the maintenance of soil fertility as well as a source of energy in some of these countries. It is estimated that about half of the farmyard manure produced in India is used as energy source (Sathianathan 1975).

Reliable estimates on potential quantity of organic manure in the developing countries are unavailable. Data based on the Indian estimates have, therefore, been used in many cases to project available plant nutrients from organic sources (Table 1).

The figures in the Table may not only be grossly over-estimated, but have assumed adoption of practices, for example the use of night soil, which has strong social barriers in many countries. Nevertheless, other sources such as cattle manure and compost could contribute greatly in areas where their development is possible.

Table 1

TOTAL ANNUAL PRODUCTION OF PLANT NUTRIENTS (N,P,K) THROUGH ORGANIC WASTES IN THE DEVELOPING WORLD, 1971 (ACTUAL) AND 1980 (ESTIMATED)*

		(million metric tons of nutrients)		
Source		N	P	K
Human:	1971	12.25	2.87	2.61
	1980	15.26	3.57	3.25
Cattle:	1971	17.80	4.91	14.12
	1980	22.25	6.14	17.65
Farm Compost:	1971	9.54	3.34	9.54
	1980	11.93	4.18	11.93
Urban Compost:	1971	0.48	0.38	0.57
	1980	0.60	0.48	0.71
Urban Sewage:	1971	1.43	0.29	0.86
	1980	1.79	0.36	1.08
Other:**	1971	6.63	4.44	11.35
	1980	8.29	5.55	14.19
Total:	1971	48.13	16.23	39.05
	1980	60.12	20.28	48.81

* Excludes Central America and Oceania; includes Socialist Asia.

** Bone meal, poultry litter, bagasse, sheep/goat litter, oil cake, press mud (several). Other sources were not included due to small potential for all developing world.

Based on data in Garg et al (1971) ICAR (Indian Council of Agric. Research), Technical Bulletin No. 32, FAO Production Yearbook (1971) and IBRD's Trends in Developing Countries (1973).

Assumed data human excrement: 0.0047 metric tons N/person/year
0.0011 metric tons P_2O_5/person/year
0.0010 metric tons K/person/year

Cattle: 8.6 metric tons/cow/year
N,P and K of 0.0029, 0.0008 and 0.0023 metric/tons/cow/year.

Large quantities of straw are available in cereal-based farming systems. The total rice straw production in Asia (excluding China) in 1974 for example, was estimated at 227 million tons (Tanaka 1973) corresponding to 1.134 million tons N, 0.149 million tons P and 3.392 million tons K. Much of this straw, however, is either burned, used as feed, animal bedding or fuel and a relatively small fraction is used in making compost. Some of the constraints include the high labour costs, time involved and transportation to the site of application.

2 Urban Compost and Sewage Sludge

Properly processed urban compost and sewage sludge contain valuable nutrients that could contribute to soil fertility maintenance and increase crop production. But one of the limitations to their use is the transportation costs which have often offset their economic advantages as nutrient sources.

Sewage and urban compost are applied at rates several times those of farmyard manure. The trace element content in urban compost is reported to be ten to hundred times higher than in stable manure (Kick 1971). Heavy land application of urban compost, therefore, could be injurious to crop growth. Likewise, high levels of heavy metals in sewage sludge are deleterious to crop growth.

Another problem associated with heavy application rates of sewage sludge and poultry manure is the higher levels of N they contain which may be released as inorganic N, possible as ammonia, soon after application to the soil. Excessive application rates, therefore, could lead to pollution of surface and ground waters by nitrate-N, through runoff and leaching (Parr 1975).

There is an urgent need for establishing maximum allowable safe limits of heavy metals in sewage sludge for crop production, testing these materials and matching the results with the proposed standards.

Many countries outside Asia are unfamiliar with extensive use of organic materials for crop production. Education and extension work have major roles to play in the promotion and adoption of these practices by the small farmers.

3 Cropping System

Organic recycling in agriculture is necessarily closely connected with farming and cropping systems practised in various agro-ecological zones. Under mixed farming, animal manure and other agricultural wastes are available and could be used in the various cropping systems practised. It is, however, to be recognized that quantity as well quality of dung are important considerations in achieving the desired effects with regard to increasing soil productivity. In some cases in Asia and Africa fuel requirements often necessitate the use of these resources for energy supply instead of direct agricultural use.

The prevalence of pests such as the Tsetse fly (*Glossina* sp.) and the nomadic system of animal husbandry in parts of Africa impose limitations to the production and collection of organic manures. The adoption of mixed farming practices in areas free of diseases is one of the effective means of promoting the use of organic manures. The "Compound farming" system as practised in the savannah areas of Africa makes use of all organic manures and composts from the household and these are applied to the immediate compound farms to maintain soil fertility and increase crop yield.

3.1 Green manures

The use of green manures in the farming system was widely practised in the past in Asia. Singh (1965,1975) aportioned the gain from green manuring into "legume effect" and "green matter effect" and indicated that the former was more important. The contribution of green manures to the build-up of organic matter in the soils of the tropics and sub-tropics does not seem to be substantial. In their reviews, Scherbatoff (1949) and Joffe (1945) indicate that under the tropical climatic conditions, the main contribution of green manures is through the release of plant nutrients after decomposition.

Promotion of green manures as a part of organic recycling in agriculture must be based on such legumes as beans, cowpeas and pigeon peas which not only enrich the soil through N fixation, but give a direct cash benefit to the farmer. Due consideration must also be given to agro-ecological zones. since moisture deficit resulting from the growth of the green manure crop could adversely affect the main crop.

3.2 Crop residues

Mulching with crop residues contributes directly to soil erosion control, promotion of microbial activities through temperature moderation and direct nutrient release on decomposition. Incorporation of crop residues ensures the return of plant nutrients to the soil. Favourable C/N ratio must be maintained through supplementary N so as to prevent any temporary immobilization of soil N which is already a limiting factor to the productivity potential of the soils of the savannah and dry tropical areas.

Lack of draught - animals or tractor - in rural areas seriously limits the incorporation of crop residues into the soil. More than half of the rice straw produced in Asia (est. 227 million tons) is burned in the fields and the rest used as animal feed or fuel with only a small percentage being directly incorporated into the soil. Development of farm technology suitable to alleviating the drudgery of the small farmer's work will go a long way to promoting the incorporation of crop residue into the soil.

4 Promotion of Programmes on Organic Recycling

The impact of the 1973 energy crises resulted in a renewed interest both at the national and international level in a more systematic and intensive use of organic fertilizers. FAO initiated programmes with the immediate objective of updating and accumulating information on the subject. Some of the activities include:

4.1 Workshops

A series of workshops on regional basis in Asia, Africa, Near East and Latin America were organized with financial support from SIDA (Swedish International Development Authority) on organic materials as fertilizers with the main objective of defining the scope and potentialities in the various regions and to work out guidelines for national programmes. The need for adjusting such programmes to the requirements of the various regions and countries is well recognized.

4.2 Regional programmes

The lack of information, technical know-how and education are some of the main constraints to the wide application of organic recycling techniques. Many countries in Asia have had the tradition of recycling organic wastes. Programmes initiated in Asia, therefore, are aimed at strengthening national institutions and training of extension staff.

Rural energy supply has for a long time been a major problem to farmers. Cattle manure has been extensively used as fuel instead of direct application to soils. The introduction of biogas technology and its wide application should therefore be regarded as a breakthrough. The by-product could be available for the improvement of soil fertility. More than 40 000 biogas plants are presently in operation in India, whilst in China such units number more than one million.

One of the advantages in addition to gas production from cowdung is the reduction of loss of organic matter and nitrogen thereby increasing the quality of the dung. Data in Table 2 show results of comperative studies by Garg, A.C. et al (1971).

Table 2 MANURE OBTAINED WHEN ONE TONE OF FRESH DUNG IS PROCESSED BY THE TRADITIONAL INDIAN METHODS AND THROUGH A GAS PLANT (FRESH DUNG) 1 000 KG AT 0.25% NITROGEN

	Traditional method	Obtained through gas plant
(a) Organic matter - loss by decomposition	500 kg	270 kg
(b) Nitrogen - loss by decomposition	1.25 kg	NIL
(c) Final manure quantity	500 kg	750 kg
Quality - N% on dry basis	1.0 kg	1.3 kg
(d) Additional advantage	-	2 000 cu. ft. gas for cooking

The on-going FAO/UNDP Regional Project on Organic Recycling in Asia aims at an integrated approach of promoting biogas technology, the use of biogas by-product to improve soil fertility, promotion of N fixation through the development of biofertilizers (Azolla and Bluegreen algae) and training of staff.

4.2.1 Biofertilizers

Biofertilizers are gaining importance as a source of N supply to supplement mineral N applied to rice crop. The potential contribution of N from Blue-green algae is under intensive investigation while work on the promotion of Azolla as a source of N is being encouraged in many rice growing countries in Asia, and of recent in Africa.

Azolla programme in Thailand is expanding rapidly with the recent development of over 100 ha demonstration sites (RAS/75/004). About 3 kg of Azolla have been found adequate to seed one ha of land covering the area in 10 days. Much higher rates are used in China. Other Asian countries with Azolla programmes include China, Korea, Bangladesh, Nepal, Indonesia and India.

Research support is urgently needed for large-scale application of the Azolla technology. The level of N fixed in different countries varies widely depending on climate, ecology and fertility status of soils. But even with a modest amount of N fixed, the technology offers a great potential to the small farmer.

4.2.2 Training

An important component of FAO programme on organic recycling is the training of extension officers. Most of this activity is organized as national training courses and seminars in cooperation with the respective governments. Subjects covered include composting, use of Azolla and Blue-green algae in rice cultivation, crop residue management and recently biogas technology.

Extension materials and technical manuals are prepared for such training courses. Presently under preparation are technical manuals on Blue-green algae technology, biogas technology, a document on proposed standards for metal additions to soil from organic wastes, particularly sewage sludge.

Consultancies are undertaken in response to requests from various governments for project formulation on the use of organic wastes including composting and biogas technology. So far, a number of governments in Asia, Africa, Near East, and Latin America have taken advantage of this programme.

5 Conclusions

The present economic trend in many developing countries has placed a great strain on the wide application of mineral fertilizers to maintain the fertility of the soil even though there is the awareness of the role these inputs play in increasing crop yield. Population growth has increased the exploitation of the land thereby making it more urgent than ever to utilize other available sources in maintaining soil productivity. Full exploitation of organic material resources such as farmyard manure, composts, sewage sludge, crop residues, green manuring and biofertilizers offer a great potential in supplementing the chemical fertilizer inputs that the farmer can afford.

There are, however, many constraints to the rational and economic use of these resources. The economics of organic recycling in agriculture is a neglected field and there is an urgent need to strengthen research on this. Similarly, there is need to collect reliable data in the developing countries on the potential available organic material that could be profitably recycled for crop production. The rapid development of urban areas in many developing countries offers opportunities for the production of composts and sewage sludge. Research should be strengthened in testing these materials with regard to safe limits of the heavy and toxic metals, as well as their effectiveness in increasing crop yields.

Cooperative programmes on both national and international levels must be strengthened with much emphasis on education and extension so as to assist the small farmer to fully utilize the local resources as a supplement to other inputs.

References

Anon. (1973). Trends in Developing Countries. IBRD, New York.

FAO. (1971). Production Yearbook.

FAO. (1980). RAS/75/004 Reports (Coord. P. Hess).

Garg, A.C. et al. (1971). Organic Manures, Indian Council of Agricultural Research, New Delhi. Tech. Bull. (Agric.) No. 32.

Joffe, J.S. (1945). Advances in Agronomy 7, 142.

Parr, J.F. (1975). Chemical and Biological Consideration for Land Application of Agric. and Municipal Wastes. FAO Soils Bulletin 27, Rome.

Sathianathan, M.A. (1975). BIO-GAS: Achievements and Challenges, New Delhi.

Scherbatoff, H. (1949). Soils and Fertilizers 12, 155.

Singh, A. (1965). Exp. Agric. I, 209.

Singh, A. (1975). The use of Organic Materials and Green Manures as Fertilizers in Developing Countries. FAO Soils Bulletin 27, Rome.

Tanaka, A. (1973). IRC. Newsletter 22, No.2.

Kick, H. (1971). Die Anwendung von Mullkomposten und Mullklarschlammkomposten in der Landwirtschaft. Hdb. Mull- und Abfallbeseitigung.

COMPOST AS FERTILIZER AND SOIL AMENDMENT

Paper 7 by Ir. R.M. Schelhaas, Royal Tropical Institute (KIT), Amsterdam, The Netherlands

Composting can be considered from different angles. Workers in different disciplines have different goals in mind when dealing with composting. Municipal authorities are worried about the continuous flow of waste, that is produced daily by the inhabitants in their houses, their gardens, in offices, stores, schools, workshops, slaughterhouses, factories etc. Their main interest is to get rid of all this waste in an efficient way and to keep the cities clean. If the waste can be disposed of by composting it, it is allright to them, provided it is not too expensive. Moreover the compostplant should be able to accept continuously all the waste that is offered by the city and the processing itself should not create pollution within the city.

Public health authorities consider the waste as a potential source of all kinds of diseases, so they promote a hygienic way of waste disposal, which might be composting. Farmers, look upon compost as a possible fertilizer or soil amendment and if the product comes up to their expectations they are willing to pay a certain price for it, particularly if the costs of chemical fertilizers go up.

Ecologists are aware of the infinity of raw materials and energy sources and are concerned about the quality of our environment. They oppose methods of waste disposal by which valuable components get lost. They consider waste as a resource that should be exploited effectively and composting is to them a valuable way of waste utilization.

Soil scientists and particularly soil fertility workers have to ensure that our soils produce enough food for the world's growing population. The most promising way to achieve this is increasing the productivity of soils already used for agriculture. This is particularly so in the developing world, where most people live and where current yields are still generally low. How do these soils people qualify composting and compost? This paper pays attention to their point of view.

Soil organic matter synthesis and break down

Compost is an organic fertilizer. It supplies the soil with organic matter and it contains several macro- and micronutrients, which are essential for crop production.

In nearly all handbooks on soil science there is a section on organic matter, on the importance it has on soil properties and soil productivity and on the measures to maintain or obtain a certain level of soil organic matter.

The reason that soil organic matter receives so much attention is its great importance in soil forming processes and soil fertility. As a matter of fact the formation of organic matter is the beginning of soil genesis and the presence of organic matter is what soil distinguishes from rock.

Soil organic matter has been the subject of research for almost two centuries and theories on its formation and decay and its importance for plant growth have changed considerably during this period. In the first decade of the 19th century De Saussure and Thaer developed the theory of humus nutrition, which said that humus substances were directly assimilated by the plant root. This theory was widely accepted for several decades until Liebig and Boussingault (1840) developed the theory of the mineral nutrition of plants. Liebig stated that the plants need N, P, K and Ca for their nutrition.
He proved that humus is almost insoluble in water, from which he concluded that it can not be the source from which the plant takes its carbon. From that time humus was mainly studied from a chemical standpoint. Humus was regarded as an oxydation and dehydration product of plant materials. After the discoveries of Pasteur in the field of biochemistry of microbes it was discovered that humus formation was not a chemical or physical process, but a biological one, resulting from the diverse activities of micro-organisms. It was shown that humus was a source of nutrients for the plant, but that it first had to be converted into plant available forms.

There are in fact two reciprocal processes, one of decomposition and one of syntheses. It is a continuous proces of recycling. In a simplified form this is shown in Figure 1. There are in fact many intermediate steps and side reactions.

Most organic residues in soils originate from plants. This can be leaves, roots, or whole plants, including trees, as for instance in a tropical forest. These residues are different in nanature and have a different resistance against microbial attack. Readily decomposable are carbohydrates as sugars, starches, celluloses, and proteins, aminoacids. Most of these components are sythesized into the microbial bodies, which sooner or later die and become part of the organic residues again. Lignins, fats, oils and waxes are much more resistant, so that the break down of these components is much slower. The greater part is transformed into what is generally called humus and the process humification. Humus is not only made up of resistant plant residues, but also by components newly synthesized by micro organisms. Also N and S are incorporated in the humus complex. Humus is very important in maintaining the soil fertility. It is difficult to mention a soil property, which is not affected by the presence of organic matter. The chemical composition of the humus is fairly constant. Half of it is C, the N-content fluctuates around 5%, and P and S are in the order of 0.5%. These elements are released when eventually the humus breaks down into the mineral compounds. This proces, the mineralization is a very slow proces, because humus is very stable and resistant.

The rate of mineralization is not the same in all circumstances. It depends on factors like mean annual temperature, rainfall, aeration, kind of vegetaion, etc. The more favourable the conditions are for the growth of the micro organisms, the faster the breakdown. For this reason mineralization proceeds faster in the tropics than in temperate regions and faster in cultivated fields than in soils under forest. From experiments it has been foumd that in the tropics mineralization is in the order of 3-5% per year. This means that in a 20 cm topsoil, containing 2% organic matter 100-150 kg of N and 10-15 kg of P and S are released in one year. The minerals are soluble and from the soil solution they are again available for a new generation of plants.

Properties of soil organic matter

The effect of soil organic matter on soil properties and soil productivity are widely recognized. The content of organic matter in most soils is low, it commonly ranges from 0.1-5%, but its importance is out of proportion.

a. Retention of cations

Due to its large surface area and the presences of specific functional groups the capacity of organic matter to adsorb cations is much greater than it is for clay. The cation exchange capacity of organic matter is in the order of 150-300 me/100 gr, for clay it is at most 100, but for the most common clay mineral in tropical soil, kaolinite it is even lower than 10. So particularly in soils with a low buffer capacity, like sandy soils and latosols, the organic matter may account for most of the exchange sites. A sufficiently high buffering capacity of soils is very important, as it prevents cations from leaching and it holds them in an available form.

b. Water retention

Because of its collodial nature soil organic matter has a high capacity to absorb water. Its water holding capacity is at least 4 times higher than that of clay. So an increase of the organic matter content in a soil results in an increase of the water retention. This is particularly important for sandy soils under rainfed conditions, but also under irrigation, as the frequency of irrigation can be lower as the available water capacity is higher.

c. Soil structure

Organic materials have an important role in the formation and stabilization of soil structure, thus lowering a possible risk of erosion. Organic matter makes heavy soils more friable, easier to work, and promotes a crumbly structure.

Also the aeration, which might be low in heavy clay soils is improved by organic matter.

Investigations in India showed a positive correlation between the degree of aggregation and the organic matter content. In Africa it was shown that improved structural stability and permeability were closely linked to organic matter (Kanwar, 1978).

d. Supply of nutrients
Soil organic matter is a store house of various nutrients, that are essential to plant growth. Organic matter mainly consists of C, H, and O (these elements account for more than 90%), but also N, S, P and other elements, including microelements, are present. These nutrients are gradually released in a mineral, that is in a plant-available form.

Of the above functions of soil organic matter, the first 3 are mainly to be ascribed to the stable humus, the part that is remaining in the soil, but the value of the last factor wholly depends on its break down. The higher the rate of mineralization, the more nutrients will become available for the plant within a certain period, but the lower the content of organic matter in the soil will fall. So it will be clear that if we want the full profit of all these functions, it is necessary to supply the soil with organic matter regularly.

In a natural environment this is no problem. All plants die sooner or later and decompose on the spot. No organic materials and nutrients are removed, except for some leaching. A state of equilibrium will be achieved here between humus formation and decomposition. Humus content will be maintained at a fairly constant level, a level that is characteristic for a particular set of conditions like climate, vegetation, topography etc.

But as soon as agriculture starts the cycle is broken. The purpose of agriculture is to grow crops, that can be consumed by man or cattle. So the greater part of what is grown in the field is removed. What is remaining after harvesting are the roots, stubbles and may be the leaves, depending on the kind of crop.

Fertilization

If we don't compensate for these losses, the soil will deteriorate, resulting in lower yield of the next crop, so that less plant residues remain, etc. Soil fertility of agricultural soils can only be maintained by fertilization. During centuries the farmers have been using farm manure for this purpose. Since the work of Liebig on mineral nutrition, more and more attention was given to the use of artificial manure or as we call it now chemical or mineral fertilizer. Also in the developing countries these fertilizers were introduced, particularly after the Second World War. And they have helped a lot in increasing agricultural production there. Chemical fertilizers have many advantages compared to organic fertilizers. They have a high concentration of the required nutrients, there chemical composition is exactly known and is not variable, which makes it easy to give a balanced fertilization corresponding to the need of a certain crop, they are easy to handle and are rather cheap. At least they were.

For these reasons the use of chemical fertilizers has increased enormously during the last decades and less attention was paid to organic fertilizers even in countries that have developed efficient methods of conserving organic residues like cattle dung or human faeces.

But chemical fertilizers are not always the answer to the problem of low yields. They do supply the soil with nutrients but not with organic matter, anyhow not directly. Indirectly they do to some extent, because when crop production is increased, also the amount of crop residues will be higher. But this only works when the soil is in a good physical condition. If not, the response of mineral fertilizers will be low. Therefore the farmer should pay much attention to the organic matter husbandry of his soil, particularly if low-residue-crops are grown. If the amount of crop residues is too low to maintain a required level of organic matter, organic fertilizers should be used for this purpose. The most common ones are farm manure and green manure. But also compost is a suitable organic fertilizer.

Compost may be home made from all kind of farm wastes or may be obtained from an industrial compost-plant. Application of compost has two functions. It provides the soil with organic matter, so that at least temporary the content of soil organic matter increases and, as soon as mineralization starts, plant nutrients become available for the crop. So it acts at the same time as a soil amendment and as a fertilizer. Both functions have to be accounted for when evaluating the benefit of compost.

Compost as a fertilizer

The manurial value of compost depends on its chemical composition and on the rate of mineralization. The chemical composition varies greatly, depending on the kind of the initial refuse (town waste, agricultural or industrial waste) and on the origin, season, etc. and also on the method of composting. In Table 1 a range is given of the most important elements present in compost. In the left column the data are given as presented by Kehren (1962/63). In the second column the values as obtained by the Soils and Agro-chemistry Division of the Royal Tropical Institute (KIT) in 12 samples of compost and fresh town refuse, originating from 4 countries. It should be kept in mind that these are total values obtained by a complete destruction of the samples.

As you may see from the table there is a wide range in the concentrations of all elements. Concentrations of the main elements are generally below 1%. An exception is Ca. The high content of this element is important for application on acid soils, not in the first place for feeding the plant, but for increasing the pH. Compared to chemical fertilizers the concentrations of macro-elements are low. Therefore the dressings of compost should be much higher. Usual applications of compost are between 10 and 50 ton, whereas for chemical fertilizers they are in the order of some hundreds of kg/ha.

Also the presence of micro-nutrients as Mn, Zn and Cu is favourable as long as their concentration is not too high. A possible contamination of Cd, Hg, Cr, Ni and As should be avoided, because these elements are toxic even in a low concentration. This may occur when industrial waste and sewage sludge are used for composting. With these products we have to be careful to avoid soil pollution and harmful effects on plant growth. Which concentrations can be tolerated under certain conditions is still a point of research. Hazard of heavy metal pollution seems to be more a problem of developed than of developing countries. As said before the data shown in Table 1 refer to total amounts. Only a part of it will become available during the first year or growing season. Which part depends on the rate of mineralization and on the form in which a certain element occurs in the compost. Elements like K and Mg probably occur mainly in an inorganic form and can be released without depending on a micro biological decomposition. Some research on the recovery and residual effects of different elements has been reported in literature, but most studies refer to manure and to temperate regions. According to Brady (1974) the recovery in manure for N = 50%, for P 20% and for K 50%. For compost these values are probably lower.

It is important that more research is carried out on this matter. If the farmer does not know the amount of nutrients he is applying to his soil, he will not be able to adjust the fertilization to the needs of his crops.

This year we started a research project to get some more data on this subject under greenhouse conditions. To this end we grew Amaranth, a tropical leaf vegetable in compost, mixed with perlite, in 2 liter pots. To the pots a complete nutrient solution was added, except for, in the different treatments, one element. This element could only be provided by the compost. The uptake of this nutrient can be calculated then from the yield and the chemical composition of the Amaranth. Given the amount and composition of the compost the recovery can be calculated. Unfortunately the results of this study are not yet available.

Another way of approaching this matter is to develop a laboratory method, that gives analytical results, comparable with the plant available amounts. This is principally another way of measuring. As said before mineralization is an microbiological process, where as here extractability was measured.

The aim of our study is to correlate the greenhouse data with the analytical results, so that possibly laboratory analyses can be interpreted in terms of availability. We applied three different extractants, namely water, NH_4-acetate and $NaHCO_3$-EDTA. The results are given in Table 2. They are expressed in % of the total amounts, given in Table 1.

Due to the different origin of the samples, there is a wide range. The extractability in water is lower than in the other extractants, which are more or less in the same order. The values for K and Na are high, which is understandable from their high solubility. The values for N are low, because they only give its concentration of NO_3. This can be used by plants on a very short term. Table 3 gives the same data again, only in NH_4-acetate but then calculated into kg of nutrient per 25 ton of dry material. Compared with the nutrient uptake of an average crop, it can be seen that these amounts are substantial for all elements. Table 4 illustrates the effect of the process of composting on the extractability of the different nutrients. Out of the 12 samples analysed 6 represented compost and 6 more or less fresh town waste. It appears that for the macro-elements the values are higher in fresh town waste than in composted material. The differences are most striking for P. Apparently during composting new, more resistant compounds have been formed. Also the method of composting may affect the extractibility as is shown by the two last columns.

Compost as a soil amendment

The second factor we have to take into account when discussing the value of compost is its effect on the soil properties. These effects are directly related to the above functions of soil organic matter. So it is quite understandable that in experiments it has been found that compost application resulted in a better soil structure and aeration, less erosion, and run-off, a higher water retention capacity and an increased buffer capacity.

This is particularly important in soils that are in an sub-optimal condition with respect to one or more of these properties.

As examples can be mentioned poor sandy soils and compact heavy clay soils, but also soils that have lost part of their top layer by deep tillage or erosion. These are the soils that in the first place need an additional application of compost. Fifty years ago the VAM composting plant was founded in Wijster in the NE part of The Netherlands, because of the presence of sandy soils with a low fertility in this area.

It should be kept in mind that soil improvements due to a compost application are non-permanent. We can not expect from the compost to release all its nutrients on a short term and at the same time to increase the soil organic matter content. The fate of all organic materials is that it is decomposed sooner or later. The rate of mineralization is high during the first year after application and decreases to the equilibrium value mentioned before with respect to the break down of soil organic matter. But this value also highly depends on the kind of the material, particularly on the C/N-ratio. Fresh leaves, having a C/N-ratio of around 10, decompose very fast. In The Netherlands Kolenbrander (1974) found that after one year only 20% of this material has remained. For farm manure (C/N = 15) this part is 50%, and for a material as peat moss it is 85% (C/N = 30).

So, if the main purpose of a fertilization is to increase the soil organic matter content, materials that are resistant to decomposition, should be used. If we aim at an enrichment of the soil with nutrients, we need a fertilizer that is rapidly decomposed. Depending on the composition and origin of compost this product can be used for both purposes. It is also possible to mix compost either with peat or with minerals.

Field trials

From the above it will be clear that it is much more difficult to assess the value of compost than that of chemical fertilizers. The effect of the former is much more complicated and of longer duration. The best way of getting an idea of the overall effect of compost on soil productivity is to carry out field trials. These trials should be aimed at getting answers to the following questions:

- which soils in a certain region are the most responsive to an application with compost? In general better results have been obtained on poor soils than on more fertile soils, in other words, yield increases depend on the fertility level, either natural or due to earlier fertilization. In Germany Tietjen (1975) reported yield increases of potatoes, rye and oats of 25% on poor soils, as against only 4% on the richer ones. Similar results and even more striking were ones obtained in Benin, W. Africa by Grubben (1976).
- which are the crops commonly grown in a certain area, that respond best to compost? It is known that the behaviour of all crops is not the same in this respect.
- what is the optimal dosage to be applied under certain conditions?
- what is the influence of the wheather and climate conditions? To measure this effect it is necessary to continue the field experiments for several years.
- what is the influence of the method of application? Compost may be given as a mulch, so that evaporation is decreased and the temperature in the toplayer will be lowered or it can be ploughed into the soil at different depths, or be applied in plant holes.
- what is the interaction with chemical fertilizer? Generally a combination of both kinds of fertilizers gives the best results. Field trials are not only useful in selecting the most suitable soils and crops for the compost and to study the most economical dosage, they can also act as demonstration objects for the farmers and officers of the Agricultural Extension Service. Too often they only believe in chemical fertilizers and forget about the benefits they may have from compost.

Economics of compost

Of major importance is the price of the compost. For the waste the farmer produces on his farm, like crop residues, farm manure, kitchen waste etc. there is no price. He simply has to handle it properly by making his own compost pile or by distributing it in his fields in a fresh condition and he will have all the benefit. To buy compost from a commercial compost plant is quite another thing. The advantages of a compost application are obvious, but whether it is economical for an individual farmer, largely depends on the price of the product. He does not want to be charged for the disposal of the city waste. If the price the farmer can afford is too low for the composting plant to work economically, a subsidy of the Government, as is often the case with mineral fertilizers should be considered. It will serve the farmer to be able to buy a good product, the composting plant to operate economically and the municipalities to have clean cities.

References

Allison, F.E. (1973) Soil organic matter, its role in crop production. Elsevier Scientific Publishing Company, Amsterdam, London, New York, 637 p.

Brady, N.C. (1974) The nature and properties of soils. MacMillan Publishing Co. Inc. New York, 639 p.

Grubben, G.J.H. (1976) The cultivation of Amaranth as a tropical leaf vegetable. Communication 67 of the Dept. of Agr. Res., Koninklijk Instituut voor de Tropen, Amsterdam, 207 p.

Kanwar, J.S. (1978) Soil fertility, theory and practice. ICAR, New Delhi.

Kehren, L, and Vaillant, J. (1962/63) Methods of household refuse processing and the importance of aerobic composting in tropical environment. Central Bureau for the Study of Equipment for Overseas, Informatory Report 23, 75 p.

Kolenbrander, G.J. (1974) Efficiency of organic manure in increasing soil organic matter content. Proceeding 10th Intern. Congr. of Soil Science. Vol 2, p. 129-135.

Tietjen, C. (1975) Principal problems of the use of city wastes for crop production and soil conservation, in: Organic materials as fertilizers, FAO Soils Bulletin 27, Rome.

Figure 1 : Formation and breakdown of humus (after Allison, 1973)

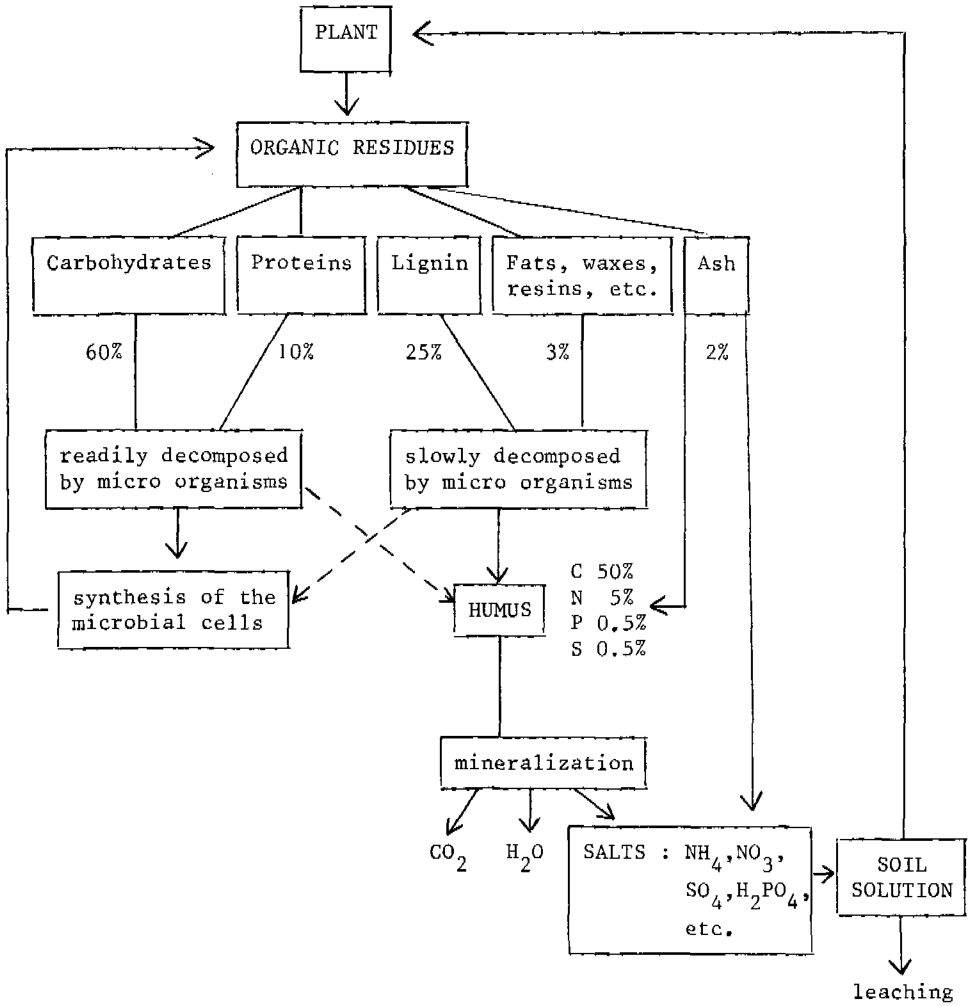

Table 1 : Chemical composition of compost

Element	Kehren (1963)	KIT-Soils Div.	kg/25 ton of dry matter
Nitrogen	0.4 - 1.5%	0.7 - 1.8%	175 - 450
Phosphorus	0.1 - 0.3%	0.2 - 0.4%	50 - 100
Potassium	0.3 - 1.0%	0.3 - 0.9%	75 - 225
Sulphur	0.1 - 0.5%		
Calcium	1.5 - 6.0%	2.0 - 11.0%	500 - 2750
Magnesium	0.1 - 0.5%	0.2 - 1.0%	50 - 250
Sodium	0.2 - 0.5%	0.2 - 0.6%	50 - 150
Iron	0.2 - 1.0%	0.4 - 8.0%	100 - 2000
Copper	10 - 800 ppm	50 - 600 ppm	1 - 15
Manganese	20 - 500 ppm	100 - 1700 ppm	2 - 42
Zinc	10 - 400 ppm	300 - 3600 ppm	7 - 90
Boron	10 - 500 ppm		
Molybdenum	1 - 50 ppm		
Cobalt	1 - 20 ppm		

Table 2 : Nutrient extractability in 12 town waste and compost samples in % of total amounts

Element	Water	NH_4-acetate	$NaHCO_3$-EDTA
Nitrogen	0 - 5	<1 - 10	
Phosphorus	<1 - 17	15 - 70	20 - 60
Potassium	60 - 90	70 - 100	70 - 100
Calcium	3 - 50	50 - 90	30 - 80
Magnesium	10 - 60	20 - 100	15 - 70
Sodium	80 - 100	90 - 100	
Iron		<1 - 9	2 - 30
Copper		5 - 30	20 - 60
Manganese		20 - 50	20 - 60
Zinc		45 - 70	50 - 65

Table 3 : Nutrients extractable in NH_4-acetate (kg/25 ton of dry matter) and nutrients uptake (kg/ha) of common crops

Element	Extractable	Uptake
Nitrogen	0.2 - 25	20 - 200
Phosphorus	10 - 40	5 - 40
Potassium	75 - 175	30 - 300
Sulphur	25 - 200	5 - 40
Calcium	250 - 2500	5 - 80
Magnesium	25 - 50	5 - 50
Iron	1 - 15	1 - 25
Copper	0.2 - 2	- 1
Manganese	1 - 18	- 1
Zinc	4 - 50	- 1

Table 4 : Nutrients extractability in NH_4-acetate in different samples

Element	Town waste (n = 6)	Compost (n=6)	VAM(n=2)	DANO(n=2)
Nitrogen	3	1	0.1	0.3
Phosphorus	52	22	16	23
Potassium	100	88	88	100
Sodium	100	95	88	100
Calcium	79	72	50	88
Magnesium	54	47	38	66
Iron	4	3	1	8
Manganese	28	28	18	28
Copper	38	42	6	26
Zinc	57	57	66	70

TOWN REFUSE FOR VEGETABLE PRODUCTION

Paper 8 by Dr. G.J.H. Grubben, Royal Tropical Institute (KIT), Amsterdam, The Netherlands

1 General situation of vegetable production in the tropics

Home production of vegetables for own consumption is much more important in the tropics than it is in economically highly developed temperate countries. Commercial production varies between 20 and 60 % of the total production and depends primarily on the degree of urbanization. This commercial vegetable growing has rapidly increased during the last few years. The vegetable farmers all have to face the same big problem: how to make their soil more fertile or how to maintain a high fertility level.

In many rural areas, it is good practice to use kitchen waste, woodash, sweepings, sometimes also nightsoil, as manure for vegetable production in the compound. The waste is thrown on heaps in the backyard and dug-in or simply spread-out as well-rotten compost or as more or less fresh material. Many market growers use the town refuse in the same way for their vegetable production. Thus helping to solve the waste problem of the urban societies is beneficial for the supply of vegetables for the citizens and a better income for the growers.

Vegetables with a short shelf-life, mainly the leafy vegetable type like spinach, amaranth, kankung, spinach beet, lettuce, celery, pakchoi and mustard are mostly grown within a short distance of the city markets. Vegetable types with a good keeping quality for storage and transport such as cucumber, gourds, onion, okra, beans, eggplant, peppers and cabbage are produced more in remote areas, often at higher altitudes.

Compared to agricultural crops (cereals, tubers, cotton etc.) vegetables require more of the chemical and physical properties of the soil, unless the grower is content with low yields, bad quality and low profit. This is especially true for the very intensive, year-round and high-yielding cultivation by market growers in the vicinity of the big city.

2 Nutritional value of vegetables

Vegetables supply vitamins and minerals to our body. These micronutrients are essential for growth and health. The staple food provides calories and proteins but is normally deficient in micronutrients. The recommended quantity of vitamins and minerals depends on the type of staple food and on other factors such as age, weight, health condition, environment, and activity. Anyway, a daily intake of at least 150 grammes of vegetables will deliver a sufficient quantity of minerals, provided that 1/3 consists of a dark-green leaf vegetable. Moreover, vegetables enrich the menu with a small quantity of good quality protein, which is important in tropical areas with a marginal protein intake.

The present vegetable consumption in the tropics varies largely with area, season, food habits and income. Per country, it is not more than 50 to 110 grammes per head per day. So public health requires an increase in vegetable production by an increase in area and productivity, in order to supply cheap and nutritive vegetables to the city markets.

Table 1 gives the composition of three popular vegetables, and an estimate for the annual production of nutrients by one hectare of these vegetables. It may be concluded that amaranth - and in general all the dark-green leaf vegetables - produces the highest quantity of nutrients. Table 2 is an estimate of the number of people whose nutrient requirements are satisfied by the year long cultivation of tomato, cucumber or amaranth, assuming that the vegetable part of the menu contributes all the vitamin A (as carotene), all the vitamin C, 1/2 of the iron, 1/3 of the calcium and 1/5 of the protein. This table illustrates the importance of vegetables, and especially the leafy vegetables, in the diet of the city dwellers.

The yield of a vegetable crop depends most of all on the soil fertility. Also the nutritional composition (content of carotene, iron, calcium, protein) fluctuates with the level of soil fertility. The better the soil, the higher is the crop yield and the better also the market yield and the nutritional value of the produce.

3 Fertilization and mineral uptake of vegetable crops

We could rephrase the statement of the last paragraph as: the higher the nutritional value and the yield of a vegetable crop, the higher is the mineral uptake of this crop from the soil.

Table 3 gives an estimate of the removal of minerals by the harvested product per cultivation and per year for some agricultural and horticultural crops. The mineral uptake and removal by leafy vegetables is strikingly high in comparison to the other crops.

Apart from the five major elements N, P, K, Mg and Ca, several other minerals are important both for plant growth and for human nutrition. Sulphur is another macro-element in plant nutrition which is found as a component of the essential animo-acids methionine, cysteine and cystine. The valuable animo-acids are present in reasonable amounts in the leaf proteins. Fresh leaf vegetables contain 0.5 to 1.0 grammes of sulphur per kg; a 20 ton crop removes 10 to 20 kg of sulphur from the soil.

Micro-elements are those elements which are essential for plant growth, but only in very small quantities. Iron is such a micro-element, which is in addition a very important micronutrient for human health. Iron deficiency in the soil is rare, but iron deficiency in human beings is a very common health problem in the tropics. Iron anaemia is often caused by malaria or other parasitic diseases, and can be cured by the consumption of food with a high iron content. Dark-green leaf vegetables score very high in iron content. They contain 10 to 60 mg of iron per kg. A crop of 20 t/ha removes 0.2 to 1.2 kg or iron from the soil, which means blood for several thousands of people.

4 Solid town refuse as organic fertilizer for vegetable crops

In the previous paragraphs, we noted that the most intensive permanent vegetable farms are concentrated in the vicinity of the great city markets. These professsional growers produce mainly leaf vegetables. They need soils with good physical and chemical properties. These soils are very rare, unless the grower gives them these properties by heavy manuring with organic matter for many years.

Apart from being a rich source of minerals, organic manure improves the water-holding capacity as well as the drainage and aeration. It retards the leaching of chemical fertilizers and the surface erosion and makes tillage easier. Perhaps the most important beneficial effect of organic manure on vegetable crops is that it hampers the break-out of soil-borne diseases, notably bacterial wilt and rootknot nematodes.

Household garbage, often referred to as municipal waste, city waste or town refuse, is used in many Asian countries for fertilization of vegetable plots. It is used pure or mixed with animal manure, nightsoil, city sludges and other organic waste material. Sometimes, it is used fresh and almost non-decayed, after only a simple removing of non-decomposable parts. Others use it after a shorter or longer period of decomposition, as compost. The habit of using town refuse for manuring vegetable fields is widespread in South-East Asia but much less popular in Asian Islamic countries, in Africa and Latin America.

Town refuse has a different composition if compared to material from temperate areas. The bulk density is higher, the C/N ratio is generally lower, the content of (toxic) heavy metals is usually low. Also the quantity of non-decomposable material (5-15%) is much smaller than in temperate areas (30%), mainly because of the limited use of plastics and metals as packing material. Is is shown in Table 4 that the mineral content is somewhat higher than in western countries.

In western countries, growers use high doses of 500 to 1000 kg chemical fertilizer per hectare, so the main function of the organic matter is to improve the physical soil properties.

However, much smaller quantities of chemical fertilizer are applied in the tropics, so at least 25 to 50 t/ha/crop of organic refuse have to be applied in order to maintain the fertility level of the soil and to replace minerals removed by the previous crops. Chemical fertilizer is too expensive and not widely available. Manure of poultry, cattle or pigs and also nightsoil is unsufficiently available, so many vegetable growers rely on town refuse.

A rule of thumb, which can be checked with Table 3, is that without chemical fertilizer, you need 1 kg of refuse for the production of 1 kg of a non-leafy vegetable and 2 kg of refuse for 1 kg of leaf vegetables.

An important constraint is the contamination of the grower or the vegetables with pathogenic orgamisms, because the garbage contains human feaces and urine. The faster the garbage is removed from the streets and the markets, the smaller this danger. Once the garbage has been put onto compost heaps or has been dug into the soil, the contamination danger is no longer present. Irrigation of vegetables with polluted water is a much greater source of contamination. Anyhow, the best control is to boil all the loose-leaved vegetables before eating, but peeled vegetables like onion, cucumber, heading cabbage, tomato, radish and carrots may be eaten raw. The cost of transport remains the main constraint to the use of town refuse as manure. Many municipal sanitary services deliver town refuse for a low price or without costs to the grower, but transport must be paid for. As a rule, the use of refuse is not economical to the grower at distances of more than 20-25 km from the garbage collecting point. But this is very variable, depending on local conditions.

5 The utilization of town refuse in Benin

Market growers around the cities Porto-Novo and Cotonou in Benin, West Africa, produce leaf vegetables (amaranth, celosia, corchorus, lettuce, leeks) and other vegetables (French beans, peppers, eggplants, carrots). They cultivate vegetables mainly on two soil types; a leached and improverished ferralitic soil called "terre de barre", and a sandy littoral soil. Between 1968 and 1974, the Horticultural Centre of Ouando carried out experimental work on town refuse as an organic fertilizer.

"Gadoue", slightly decomposed or fresh refuse collected by the municipal lorries, is a very popular manure. With high doses of refuse, poor soils are converted into a man-made horticultural soil, rich in minerals and with an excellent structure. This is illustrated by Table 5. Experiments with new plots of poor sandy soils have proved that with heavy doses of 100 to 200 tons/ha/year this process takes only a few years. Also the reversed process takes only a couple of years, if the grower ceases to apply organic fertilizer.

Amaranth, the main vegetable type, grows very well on fresh town refuse. Growers bury high doses of 25 to 100 kg per bed of about 10 m^2 (25-100 t/ha). Sometimes, they apply up to 200 kg per bed and raise 3 to 4 successive crops of amaranth before renewing the fertilization, others plant European type vegetables (cabbage, French beans) after a first amaranth crop, because these vegetables do not stand the fresh refuse too well. All these vegetables stay remarkably free from soil-borne diseases.

Amaranth is a leaf vegetable with very high mineral uptake, it is fast growing and therefore a good test plant for field experiments. Laboratory analysis of the soil, the refuse and the harvested product were combined with the field experiments. Table 6 gives an example of the removal of mineral elements by three amaranth crops of 4 weeks each on a very poor soil. It clearly shows the positive influence of town refuse on the yield of this leaf vegetable. It also shows a better effect of the NPK fertilizer if it is combined with organic fertilizer.

The experiments allowed the following conclusions:

1. fresh or partly decayed town refuse is good organic fertilizer for amaranth and other vegetables;
2. negative effects by temporary N-immobilization were not observed;
3. chemical fertilizer gives a better result if it is combined with town refuse; with very high doses of over 50-100

tons of refuse, the effect of chemical fertilizer decreases to insignigicant;

4. fresh refuse has the same or a slightly better effect on the vegetable yield than composted refuse.

The important recommendations to vegetable growers and horticultural extention officers are:

1. apply at least 25 kg of town refuse per 10 m^2 bed of a vegetable crop on a fertile soil and 50 kg per 10 m^2 on a poor soil; double these quantities for high yielding leaf vegetables (amaranth);
2. give chemical fertilizer NPK (10-10-20) about 400 g per 10 m^2 in addition to the refuse;
3. screen and remove carefully all non-decomposable material (plastics, glass, iron, stones) from the refuse in order to avoid pollution of the soil.

6 Composting

We have already noted that the growers in Benin bury the town refuse shortly after receiving it from the municipal service, without special composting, with good results. There were no symptoms of N-immobilization, probably because of the low C/N ratio of the refuse (between 10 and 20). An extension project of the Agricultural Service which attempted to teach the growers how to make a good compost out of the fresh and rough refuse was a complete failure.

We did an experiment composting fresh town refuse, exactly as described by Wilson (1948) for East Africa and known in India as the Indore system. At the start of the operation the compostable part of the refuse (about 90%) was put into 4 heaps, and some slaked lime, ammonium sulphate and soil was added. The final compost, obtained after two turnings in 7 months, had a good structure and composition, but the results in field experiments were slightly inferior to fresh refuse. See Table 7 for the characteristics of the refuse and the compost.

The positive results with the "fresh" refuse may be explained by the fact that it consists of a mixture of organic material which, after being heaped up in the streets for several days to several weeks, is partly composted, at least in the lower layers. The important fraction of 50 to 80% mould consists mainly of sweepings and has the advantage of absorbing urine, faeces and free minerals. The organic component, partly- or non-composted organic material such as leaves and peelings, gives a long lasting effect. The low C/N ratio of the refuse together with the high temperature and fast fermentation in the well sprinkled soil guarantee that N-immobilization, if it occurs, will not last longer than a few days. Koma Alimu, Soe Agnie and Jansen (1976) believe that the fine mould fraction will release sufficient minerals, notably N and P, to compensate for N- and P-immobilization by the rough organic fraction. The greatest inconvenience of composting is the high labour input, about 5 workdays per ton, making compost at least three times more expensive than town refuse. Another disadvantage of composting is a considerable loss of minerals, here calculated at 39% of N, 42% of C, and 20% of K.

As a final conclusion we may state that, at any rate in present conditions, growers in Benin are quite right in manuring with fresh town refuse instead of making compost. So before deciding in favour of compost making all the advantages and disadvantages must be weighed and calculated. Probably the hygiene aspect will lead to compost making in most cases. On the other hand, there is no proof that putting fresh refuse into the soil leads to greater health risks than putting it into heaps for composting.

Making compost by hand labour seems too costly, even for developing countries with cheap labour. The best solution seems to be found in a semi-mechanized system for sifting and handpicking all non-degrable rough material out of the refuse, and crushing and mixing the refuse to a certain degree before distribution to the growers.

References

FAO. (1968) Food Composition Table for use in Africa. Food and Agriculture Organization of the United Nations, U.S. Department of Health, Education and Welfare, Public Health Service, 306 p.

Geus, J.G. de (1973) Fertilizer guide for the tropics and subtropics. Centre d'Etude de l'Azote, Zurich, 774 p.

Grubben, G.J.H. (1976) The cultivation of amaranth as a tropical leaf vegetable. Department of Agricultural Research, Royal Tropical Institute, Amsterdam. Communication 67, 207 p.

Jacob, A., Uexküll, H.v. (1963) Fertilizer use. Nutrition and manuring of tropical crops. Verlagsgesellschaft für Ackerbau, Hannover, 617 p.

Knott, J.E. (1966) Handbook for vegetable growers. John Wiley & Sons, New York, London, Sydney, 245 p.

Koma Alimu, F.X., Soe Agnie, J.E., Janssen, B.H. (1976) Evaluation of town refuse from Dahomey as an organic manure. International Symposium on Soil Organic Matter Studies, Braunschweig, 21 p.

Schelhaas, R.M. (1978) Les sols à vocation horticole du Sud-Est Bénin et leur fumure à la gadoue. Department of Agricultural Research, Royal Tropical Institute, Amsterdam, 77 p.

Wilson, F.B. (1948) A system of composting farm and village waste. E. Afr. agric. J. 14 p. 82-85.

Table 1 : Content of essential nutrients in 100 g of edible product of tomato, cucumber, and amaranth leaves (FAO, 1968) and total annual nutrient production in kg per ha, based on 80 tons/ha of edible product per year

	Tomato		Cucumber		Amaranth	
	content	kg/ha	content	kg/ha	content	kg/ha
Dry matter	6.5 g	5200	4.9 g	3920	16.0 g	12,800
Carotene	0.5 mg	0.4	trace	trace	5.7 mg	4.6
Iron	0.6 mg	0.5	0.5 mg	0.4	8.9 mg	7.1
Calcium	10 mg	8	13 mg	10	410 mg	330
Vitamin C	26 mg	21	16 mg	13	64 mg	51
Protein	1.0 g	800	0.8 g	640	4.6 g	3,680

Table 2 : Number of consumers whose nutrient requirements to be contributed by the vegetable part of the diet may be satisfied with one ha of vegetable cropping during one year

	FAO/WHO requirements*)		Contribution of vegetables	Number of consumers/ha/year		
	per day	per year	per year	Tomato	Cucumber	Amaranth
Carotene	1.5 mg	0.5 g	0.5 g	800	100	9200
Iron	9 mg	3.3 g	1.7 g	290	240	4180
Calcium	500 mg	183 g	61.0 g	130	160	5410
Vitamin C	30 mg	11.0 g	11.0 g	1910	1180	4640
Protein	37 mg	13.5 g	2.7 kg	300	240	1360

*) Reference man 65 kg

Table 3 : Removal of minerals from the soil by different crops and mineral supply by 50 tons of town refuse.
Source : 1. De Geus, 1973; 2. Jacob & Von Uexküll, 1963; 3-6. Knott, 1966; 7-8. Grubben, 1976

Crop	Removed products	Period months	Edible yield t/ha		REMOVAL OF MINERALS kg/ha				
					N	P	K	Ca	Mg
1. Rice	panicle with grain	4	4		40	11	9	10	8
				per year	*120*	*33*	*27*	*30*	*24*
2. Cassava	tubers	9	40		146	16	176	24	6
				per year	*195*	*21*	*235*	*32*	*8*
3. Beans	pods with ripe seed	4	4		166*	2	9	2	2
				per year	*498**	*6*	*27*	*6*	*6*
4. Tomato	fruits	5	30		104	12	121	6	9
				per year	*250*	*29*	*290*	*14*	*22*
5. Cabbage	heads	4	20		67	10	74	14	3
				per year	*201*	*30*	*222*	*42*	*9*
6. Spinach	leaves and stems	2	18		101	15	42	22	10
				per year	*606*	*90*	*252*	*132*	*60*
7. Amaranth	leaves and stems	2	25		124	23	291	76	41
				per year	*744*	*138*	*1746*	*456*	*246*
8. Fertilization with 50 t of town refuse SUPPLY OF MINERALS					164	27	135	312	42

*Mainly atmospheric nitrogen

Table 4 : Macro-elements in town refuse of The Netherlands (mean of 4 samples) and in partly decayed refuse of tropical countries (North and West Africa, mean of 8 samples) in % of dry matter and kg per fertilization with 50 t per ha, dry matter content 70%.
Source : Division of Soils and Agrochemistry, Royal Tropical Institute, Amsterdam.

Elements	Compost Netherlands		Refuse tropics	
	%	kg per 50 t	%	kg per 50 t
N	1.11	389	1.18	413
P	0.23	81	0.34	119
K	0.50	175	0.68	238
Ca	2.11	739	4.60	1610
Mg	0.20	70	0.40	140
S (from SO_4)	0.13	46	0.28	98

Table 5 : Analyses of a poor sandy soil (0-15 cm) used for agricultural cropping and a nearby vegetable plot, improved by town refuse (Schelhaas, 1976)

		Sandy soil	Soil improved by town refuse
pH H_2O		5.4	7.5
CEC		2.6	26.9
Exchangeable bases : (meq/100 g)	K	0.08	0.63
	Ca	1.00	18.80
	Mg	0.13	3.97
	Na	0.02	0.02
	Total	1.23	23.42
P_2O_5-Olsen (ppm)		6	554
% C (Walkley & Black)		0.38	3.03
% N (Kjeldahl)		0.03	0.43

Table 6 : Removal of mineral elements in kg/ha from a degraded ferrallitic soil manured with fertilizer NPK (10-10-20) and with town refuse. Source : Grubben, 1976

Treatments		DM	Removal				
town refuse t/ha	fertilizer kg/ha	yield kg/ha	N	P	K	Ca	Mg
0	0	419	8.3	0.50	11.2	4.7	3.7
0	400	762	17.5	1.37	21.2	10.4	4.3
0	800	733	17.7	1.18	26.1	8.3	4.5
50	0	1,176	25.2	3.57	55.0	18.5	12.1
50	400	1,613	42.2	4.27	62.3	26.7	15.2
50	800	1,827	43.8	3.81	68.3	29.2	15.5
100	0	1,758	40.2	3.23	74.3	28.2	19.2
100	400	1,941	43.0	5.44	85.1	33.6	19.2
100	800	2,519	55.2	7.91	114.1	36.1	23.4
mean		1,416	32.6	3.48	57.5	21.7	13.1
in percentage		100	2.30	0.25	4.06	1.54	0.93

Table 7 : Chemical and physical characteristics of town refuse and compost.
Source : Grubben, 1976

		Town refuse n = 4	First turning n=4	Second turning n=1	Compost n=2
Specific density	$t.m^3$	0.33	0.50	0.75	1.13
Humidity	%	25	25	20	20
Dry weight	t	11.5	13.0	13.6	13.6
Fractions	%				
1. mould < 2 mm		49.5	49.5	61.4	73.6
2. org. matter, degradable		43.6	42.1	35.4	20.7
3. org. matter, hard		3.7	5.0	2.1	2.0
4. stones, iron, plastic, etc.		3.2	3.3	1.0	3.7
Chemical composition					
pH - H_2O		7.8	7.7	8.0	7.5
% N (Kjeldahl)		1.11	1.25	0.97	0.73
% C (Walkley & Black)		11.59	12.45	9.44	5.79
C/N		10.4	10.0	9.7	7.9
P (ppm)		1,520	1,790	1,596	1,146
K (ppm)		6,310	6,115	3,727	4,232
Ca (ppm)		16,531	13,801	15,728	14,054
Mg (ppm)		1,668	2,022	1,927	1,416

COMPOSTING OF URBAN WASTES IN DEVELOPING COUNTRIES

Paper 9 by M. Maung, United Nations Industrial Development Organization, Vienna, Austria

Summary

Based on UNIDO's experience in assisting developing countries in the production of compost from urban wastes, the paper discusses the problems and suggests the approach that developing countries might take in planning to utilize their urban wastes for soil improvement.

1 UNIDO's activities

Since 1969 UNIDO has provided technical assistance to several developing countries in the production of compost from municipal wastes. Feasibility studies have been carried out for Aden, Bamako, Bujumbura, Conakry, Cotonou, Damascus, Freetown, Kuwait and Ouagadougou. Whilst in Morocco, assistance was provided to rehabilitate and improve the efficiency of existing compost plants at Rabat, Meknes, Tetouan and Marrakech, and to train Moroccan personnel in the operation, maintenance and repair of compost plants. Advice was also given on the marketing and application of compost. In addition, UNIDO has assisted in rationalizing and improving the efficiency of garbage collection in Casablanca and Damascus in order to ensure a regular supply of raw material for composting. Currently, UNIDO is assisting the Government of Indonesia in setting up a compost plant near Jakarta and in improving the efficiency of the plants at Medan and Surabaya. Thus, UNIDO's activities in the composting field cover pre-feasibility studies, feasibility studies, trouble-shooting, pilot composting operations and technical advisory services for preparation of tender specifications, evaluation of bids, etc. Proposals have been made for the establishment of pilot compost plants (10 tonnes of garbage per hour) at some of the cities where UNIDO has carried out studies, and it is hoped that some of these pilot plants may materialize.

2. Main problems

Despite the growing awareness in developing countries of the benefits that might accrue from composting urban wastes, there are many problems which hinder the establishment of composting facilities in these countries. The major problems are related to high costs, lack of infrastructure (both physical and organizational), and the attitude of the authorities concerned towards composting and wastes management.

First, as regards capital and production costs, most patented systems of composting are prohibitively expensive, particularly for developing countries. The high costs are related to the unnecessarily sophisticated designs of most patented composting systems, and yet despite their sophistication they do not produce better compost than that which can be produced by much simpler equipment.

Secondly, many cities in developing countries do not have an adequate system of wastes collection, which itself requires considerable capital investments and operating funds. Older parts of cities often have narrow and cramped road networks which make efficient wastes collection impossible. Expanding urban areas with their rapidly changing perimeters make site selection difficult for wastes disposal. Further, there is frequently a lack of co-operation among public health, municipal, commercial and agricultural organizations in order to stimulate efforts to secure the greater recycling of organic wastes.

Finally, there is the restrictive attitude of municipal and other authorities who see community wastes merely as wastes that should be disposed of as quickly and cheaply as possible. The resource value of wastes is generally not fully recognized. This attitude is passed on to the potential buyers of compost who are therefore reluctant to pay a fair price for what they consider to be the city's "filth". There is also the attitude that environmental quality is a luxury which developing countries cannot afford to give a high priority. What is often forgotten is the fact that the more the environment is allowed to deteriorate, the harder and costlier it is to remedy.

Next, many developing countries have started composting operations with varying degrees of succes. Let us therefore examine the causes of failure of compost installations in these countries.

Many compost plants have been built and are operating either unsatisfactorily or not all. In a few developing countries there are instances where plants have been bought but not properly installed, or shut down soon after commissioning. The main reason behind this state of affairs is hasty planning and the resultant inability to cope with the problems discussed above.

Again the cost factor is the dominant one among the causes for deterioration of these plants. With the turn-key projects installing over-designed plants that require huge capital and operating expenditures, it is not possible to produce compost at a price which is competitive with mineral fertilizers, especially when in some countries mineral fertilizers are subsidized by the government.

However, there is another important factor: inappropriate process and plant design. Currently available turn-key technologies are not the best adapted to developing countries whose wastes composition and climate conditions are different from those of the developed countries where these technologies originated.

Other factors are wrong choice of plant site and plant capacity, inadequate management and provision of operating budget, inadequate market development and lack of interest of agricultural organizations, and the relatively high costs of transport and application of compost when compared with those for the use of mineral fertilizers.

3 Some thoughts for developing countries

Conditions in developing countries vary tremendously, not only between different countries, but also between different localities within the same country.

Therefore it is not possible to establish detailed guidelines which can be universally applied. However, the following thoughts epressed by a number of UNIDO experts might be useful to developing countries planning to embark upon composting of urban wastes.

3.1 Assessment of the viability of commercial processing

There are a number of basic factors which must be carefully considered in every case. These include:

- production costs;
- product evaluation;
- supply of raw material;
- marketing of the product;
- organization.

a) Production costs

Cost is the real key to success in composting. The cost must be kept as low as possible in order to make composting competitive with other methods of soil improvement.

Delivery costs are important and therefore the compost plant should be located as near as possible to the marketing area.

Part of the processing cost should be chargeable to the municipality as a direct waste disposal cost. In fact, many compost plants, particularly those in developed countries, receive payment from municipality for accepting to process the garbage which is delivered free to the plant.

b) Product evaluation

The value of locally produced compost should always be ascertained before a commercial scale of processing is adopted. This should be determined by means of a full economic and agricultural evaluation, using compost which has been produced from a simple pilot installation. This will require proper agricultural tests consisting of plot and field trials. Chemical analyses of the compost will enable an economic comparison to be made with mineral fertilizers on the basis of nutrient content, (N.P.K.).

c) Supply of raw material

Local circumstances and economic conditions will determine the size of the catchment area in which the wastes are geerated, but the main regulating factors are the facilities for collection, transportation and delivery of the wastes on a regular basis. The costs of collection and transportation should be a community charge and should not be borne by the compost plant.

d) Marketing of the product.

There should be a reliable local market which will consistently use the total production from the compost plant. The extent of the marketing area around the plant will be determined by delivery costs.

For successful marketing it is important that reasonable user requirements are consistently satisfied. These are usually:

- The compost should be of the highest quality, fully matured and cured, free from foreign material, and graded to a size suitable for the user's purpose.
- It should be available in adequate amounts at the time when it can be most conveniently used.
- The total cost to the user (purchase, delivery, application) should be as low as possible, and should not exceed the cost of other methods of soil improvement.

For economic operation, a plant must produce compost on a regular basis throughout the year, but the agricultural demand for the compost is seasonal. Successful marketing will enable compost as it is produced to be delivered and stored at the users' premises. This has several operational advantages:

- It reduces the need for extensive storage facilities at the plant.
- It eliminates double handling of the material.
- It reduces the problems of satisfying the users' delivery demands at the seasonal peak periods.

- It enables delivery vehicles to be operated to their full productive capacity, and by so doing reduces the cost of delivery.

e) Organization

The establishment and operation of a plant can be done as a private commercial operation, or as a public service. In most cases, for success, it requires the authority and powers of an official public body. Whatever the form of organization involved, whether it be commercial, municipal or governmental, it is essential for success that there should be the fullest co-operation and participation of all affected parties, and especially of agricultural organizations. This co-operation should be generated from the earliest planning stages of a scheme.

3.2 Weather influences on plant design

It is most important that, in addition to other criteria such as quantity and composition of wastes, due consideration be given to climatic conditions in the selection of plant design.

Weather conditions in many developing countries are such that systems of composting which are successful in temperate climates, will require modification, before they can be used under different conditions.

The climatic conditions which give rise to problems are either singly or in combination:

- High ambient temperatures
- Strong and persistent winds
- High intensity of rainfall
- Widely variable or high relative humidity

High temperatures, strong winds and low humidity can cause excessive evaporation of moisture from the windrows. Such conditions, unless remedied, will seriously disturb the fermentation process.

Tower silos and other structures absorb and retain heat, and unless adequate thermal insulation or other remedial measures are provided, serious problems can arise with the fermentation process.

Heat and humidity play a vital part in the propagation of flies and insects.

Sandstorms are particularly hazardous to exposed electrical and mechanical equipment, and windrows need protection against contamination by wind-blown sand, especially if this has a high saline content.

Rainfall is important not only in relation to its total volume but also in relation to intensity of precipitation. It can have a significant effect on the moisture content of incoming wastes, which will necessitate careful control of the water-balance in the composting process. Under monsoon conditions windrows will require protection to prevent water-logging especially of the outer layers. The site and all working areas will need to be properly surfaced to prevent or minimize the accumulation of rainwater.

3.3 Environmental impact of a compost plant

All composting plants, despite the greatest care in their design and operation, will produce some environmental problems, which must be considered when the location of a plant is under consideration.

In hot countries these problems are of greater magnitude than would apply in a temperate climate.

The principle problems are:

- Concentration of vehicular traffic
- Emission of dust, odour and noise
- Concentration (and transmission) of flies, insects, rodents and scavenger birds

Despite the most competent design a compost plant can never be a good neighbour to other nearby development. Ideally therefore it should be sited so that its environmental impact will be as small as possible.

3.4 Outlines of tropical composting systems

a) Manual windrow composting

This has two applications:

- as a method of composting for populations of up to 10000
- as a pilot project to ascertain the quality and usability of locally produced compost

The capacity is restricted to an input of about 3 tonnes per day of wastes and a production of about 1.5 tonnes of compost per day. The wastes would be delivered to a windrowing area where they would be spread in a layer about 50 cm deep. Tests would be carried out to determine the amount of additional moisture required. The requisite amount of water be applied to the refuse, and after a period of one hour (to permit absorption of the liquid, and the drainage away of any surplus) the material would then be stacked into a windrow.

Each windrow would be dismantled and restacked on the 7th and the 14th day after it is formed and any additional moisture added at each turn. On the 21st day the windrow would be broken and passed through a manually operated rotary screen of about 25 mm mesh to remove oversized materials. The screened material would be stored for at least 30 days in a maturation heap.

The land needed would be about 500 sq metres. The work would require three men.

The approximate capital costs would be about $ 1.200 and the approximate cost of compost would be about $ 7 per tonne of compost.

The costs are given here for comparative purposes only between different composting systems and are assessed on the basis of experience in a number of Middle Eastern countries.

b) Windrow composting plant using the minimum of machinery

The capacity is limited to an input of 150 tonnes per day and a production of about 100 tonnes of compost per day.

The plant consists of a reception house in which wastes are desposited on the floor and are fed by means of a loading shovel. The process consists of shredding the wastes through a vertical hammer mill, the magnetic extraction of ferrous metals, and the mixing and moisture adjustment in a homogeniser rotary drum. The prepared wastes are then removed by tractor and trailer to the paved windrow area where individual windrows are made from each day's production. The scheme of turning is the same as for the manual system above.

A seperate screening and grading plant is provided adjoining the maturation area. This consists of an elevating feed conveyor to a rotary screen which discharges the fine material to a ballistic separator and the oversized material into a trailer for ultimate disposal.

The land needed for the scheme would be 1.6 hectares. The plant would require 16 workers.

The approximate capital cost would be $ 2.4 million and the approximate cost to produce 1 tonne of compost would be $ 10.

The estimated cost of a pilot plant designed along the lines described above and having a capacity to process 10 tonnes of garbage per hour is of the order of $ 1.2 - 1.4 million, of which $ 0.5 - 0.6 million will be for civil works.

c) Typical patented composting system using windrows

This system provides:

- Offices and weighbridge
- Enclosed reception house with deep bunker and grab crane
- Elevating feed conveyor to hammer mill
- Hammer mill
- Magnetic extraction of ferrous metals
- Homogeniser/mixer drumm (with liquid controls)
- Conveyor discharge to windrows
- Enclosed windrow hangar with special windrow turning machine
- Maturation hangar
- Fine garding and cleaning line (to include screening, fine milling, ballistic separation and bagging)

The cost will vary according to capacity as follows:

Land Ha	Input t/day	Hrs	Staff	Total cost	Compost t/day	Gross cost of compost per tonne
1.2	100	8	12	$ 6.2 m	60	$ 38
2.0	200	8	15	$ 8.9 m	120	$ 31
3.0	600	8	21	$16.8 m	360	$ 21

The above costs are given for purely comparative purposes to enable an assessment to be made of one system from another. Actual costs are affected by many influences, not the least being the comparative rates of exchange of the currencies between the supplying country and the purchasing country. Local costs also vary between country and country in relation to the erection of buildings and structures, the supply of energy, and the rate of wages.

The gross costs given above for the cost of production of a tonne of compost, includes all elements including that of amortization of the capital cost of the plant. It is assumed that there would be no payment for wastes delivered for processing. If the public authority accepted a fair share of the treatment costs as a proper community charge for waste disposal, the true cost of the compost will be about 33% less than the figures given above.

The reliability of energy supply and the level of energy costs are of extreme importance to composting. The provision of adequate facilities can be costly and site location must take this seriously into account. Energy reliability should be as near as 100% as possible. The greater the energy demand the greater are the problems of maintaing a supply. Where energy is scarce or costs are high, steps must be taken at the design stage to minimize power consumption.

3.4 Planning a compost plant

Great care is needed in the design of a compost plant to obtain the system and the simplicity which is desired. Most manufactures of patented systems attempt to supply on a turn-key basis and purchasers have usually little opportunity of securing amendments or modifications to the system. With care at various stages there is a greater opportunity of influencing the final design in the manner which is desired. The various steps are:

a) Careful feasibility study to obtain reliable design data
b) Selection of a site which satisfies all the requirements. including:

- Good provision of services (power, water and sewage)
- Good highway access
- Environmentally satisfactory
- Good access from collection area for wastes
- Convenient to the marketing area for the compost

c) Pilot tests to be carried out to produce local compost for testing and evaluation.

d) A thorough economic and agricultural evaluation of the compost and its potential use and market.

e) Prescription of plant parameters and restrictions, including extent of mechanization, and provision for duplication and extension.

f) Decision on capacity of the plant to be provided.

g) Pre-qualification of manufacturers of composting plants. They should be required to submit outline schemes for the size of the plant required, and budget estimates of the capital and operational costs. These should then be evaluated.

h) Preparation of contract documents having regard to the most favoured schemes submitted at the pre-qualification stage. The contract documents must emphasize any major modifications which are desired. The performance specification and guarantee requirements should be based NOT on the design data obtained in the feasibility study, but the contractor should be required to satisfy themselves regarding the nature, composition, condition and quantity of the wastes which are to be treated. Any data contained in the contract documents should be quoted without any guarantee of its accuracy and should be included as INDICATIVE only of the wastes which have to be treated. No two loads of waste are of the same composition and although general analyses can be compiled, it is almost impossible to provide wastes of this actual composition. If performance requirements are based on a precise composition of wastes, and such wastes cannot be supplied for the tests, the manufactures are in a strong position to evade their obligations.

i) Final tender submissions should be carefully evaluated in respect of:

- Compost processing and engineering
- Structural engineering
- Electrical engineering
- Mechanical engineering

Careful analysis of many composting installations indicates that the most successful are those of relatively straightforward design and serving moderate populations (50,000 to 250,000). Very large plants are not so successful. Many have been built to provide a central processing complex, and the logistics of waste delivery and compost marketing are very complicated. For very large city areas the concept of relatively small satellite composting plants, sited just outside the built-up area will be more successful and operationally much more efficient.

4 Conclusion

Unless carefully planned to reduce capital and operating expenditures and to overcome the many problems of infrastructure, organization and marketing, compost plants will not become viable ventures in developing countries. Therefore, before embarking on a huge capital expenditure for a full-scale plant, these countries should establish pilot-scale facilities for work on process adaptation, ranging from labour intensive methods to mechanical systems, market development, and local fabrication of compost plant machinery. This development work will also ensure that the wastes are processed according to established methods and standards, so that the product is environmentally safe, hygienic, and beneficial for land application. The results of this development work should be used in a national programme for waste management and organic recycling, involving standardized plants largely of local fabrication.

SOLID WASTE DISPOSAL AND UTILIZATION, FINANCIAL CONSIDERATIONS

Paper 10 by Joseph Freedman, World Bank, Washington, U.S.A.

Introduction

The bank is very interested in the problems of solid waste disposal and utilization in developing countries. We have been increasing our financing of these projects in our urban development projects and our water supply and sanitation projects. In some (as in Onitsha, Nigeria and Jakarta, Indonesia) we are helping with pilot projects; and in others we are financing feasibility studies. We have also undertaken a research project in Appropiate Technology for Water Supply and Waste Disposal and will begin begin the new one which I will describe at the end of this talk: Planning for Applied Research and Development in Integrated Resource Recovery. My attendance at this seminar is due to the Bank's interest in assisting in trying to resolve these problems and I wish to thank VAM and the Institute for inviting the Bank to this stimulating seminar.

Briefly, I am an engineer from the part of the Bank known as the Central Projects Staff, Water and Wastes Division. Our division has the responsibility of advising the six water supply and waste divisions that are at an operating level and deal directly with institutions in member countries, preparing projects for Bank loans and then supervising the carrying out of these projects.

Projects

What do I mean by a project. It is always a little difficult trying to describe what the Bank means by a project, but I will do my best, and if there are any questions I will try to answer them as clearly as I can.

Bank Project

In my mind there are three main types of projects in which the Bank is participating - or be more precise - for which the Bank makes specific loans.

The most well-known type is a major facility such as a water supply system for a city. The works could include a dam, intake works, transmission main, distribution network, and even house connections and standpipes. Generally, detailed engineering plans and bidding documents will need to be prepared and so the project provides for this also - either by the borrowers staff or the staff assisted by consultants. Frequently it is considered necessary to train members of the institution that will operate and maintain the service - from professionals to labourers - and provision is made for this. The financial and institutional aspects are not neglected, since these may be the most difficult aspects to resolve for a variety of reasons. Urban water supply systems should be able to pay for themselves so it is necessary to have efficient management that provides good service at a cost that the consumer can pay; and it is necessary to have a willingness on the part of the consumer to pay, a tariff structure that takes into consideration the different social levels in the community. I would like to return to the question of finance later and so will summarize the elements of this type of project.

Final Engineering Design and Supervision
Administration
Construction of Facilities
Training
Technical Assistance for Financial, Management and Tariff Studies.

There is also another type of project which of course precedes the "construction of the works" project. In Bank jargon this could be called a "feasibility study". These studies in the past were generally funded by the interested governments with their own funds or assisted by funds from bilateral agencies. Sometimes, however, additional funds would be added to a Bank loan for some other type of works such as an electric power project say, to pay for a "feasibility study" for a water supply system in the same city. Now what do these feasibility studies comprise?

Well it not only examines the existing facilities and future needs of the community involved (which is an art in itself) but it evaluates the various options to determine the least costly one from the point of view of capital and operation and maintenance costs. Of course the operation and maintenance costs must take into account the level of professional and technical people that can be attracted and held by the possible salary scales, the materials and spare parts that are available within the country, the energy costs and the durability of materials.

To pay for these costs a study of the past revenue of the enterprise and a forecast of its future revenues is made. Many times the proposed project needs to be revised and scaled down or the financial analysis needs additional work.

Therefore, in order to accelerate the process the Bank now has loans for the preparation of projects. There are in a manner of speaking "interim or bridge loans" which can be used to refine the studies to satisfy Bank requirements, train personnel in advance to help carry out the project, drill wells to define the source of water, make tariff studies, prepare legislation and in short advance the project.

The other method I would like to mention is the utilization of the UNDP funds for these preliminary studies. It is a Bank policy to indicate to the prospective borrower that the UNDP should first be consulted for funding preliminary studies and when government agrees, the Bank is willing to participate in the discussions with the UNDP. Now whilst UNDP can provide the funds it is not an executing agency, so another agency must work with the government and assist them in carrying out the studies with their staff and consultants. In some cases WHO acts as the executing agency, as in the Istanbul Solid Wastes Study which Dr. Patrick has so well described for you, and cited two points so dear to the heart of an engineer Banker - institutions and finance. In other cases, the World Bank may act as the executing agency. One advantage of the UNDP funds are that they are grant funds, however, your requests must compete with other government priorities.

Now what has all this to do with your problems of solid waste collection and disposal? Simply put - the Bank is interested in helping by financing the necessary facilities and improvements in services but requires:

a) Sound institutions;
b) Financial viability;
c) Least cost solutions;
d) Technology adapted to the local conditions and needs; and that is sound and durable;
e) a solution that is environmentally sound.

The previous speakers have emphasized much of these very eloquently and we have seen slides and films which give detailed examples of what we are talking about. To complement this, I would like to give some information on how the Bank and other international leading agencies may view the problems of

a) Institutions
b) Finance

Institutions

Now let us look at the municipality as an institution or public enterprise responsible for the cleaning of the streets; the collection, removal and disposition of the solid wastes; and in some cities the emptying of privy vaults and septic tanks of human excreta and its final disposition. Not all communities have complete sewer systems, examples are Tokyo and communities in the U.S. - even close to my home in Washington, D.C.

There are of course some cities in which semi-autonomous agencies or contracted private companies do the collection and disposal, but the majority of cities attempt to do it themselves.

The cities have a mayor, council, administrative services, and then several service departments depending on their size and complexity. The salaries and operating expenses of these cities come from various taxes, rates, charges, fees etc. These sources of income have been decreed by the central government or some branch of the government and many times have not kept pace with recent explosive growth of the cities. Frequently, the income of the cities is not enough to meet their day-to-day expenses and funds must be obtained from the national government. The accounting and budgeting systems of the cities are generally old and antiquated; property registration is deficient; property taxes are low or not even collected.

The picture is gloomy indeed.

Now within this municipal institution there is our special interest - the department responsible for solid waste management. Frequently this has developed in an unplanned fashion, with an erratic budget, many untrained people, inadequate equipment, and poor salaries. And yet, (if we can rely on the bookkeeping of many cities,) sometimes about 20% of the city's budget is spent on this department. What can we do here? I am sure you, who live with this problem are more able to examine this problem from more aspects than we at the Bank and devise some proposals for remedying them. In any case, when we examine a proposed project, we evaluate the existing institutional arrangements that there will be for managing the services we hope to improve.

Financial aspects

Now we come to the financial aspects of these projects. One of the major problems of providing adequate service to the community is the generation of sufficient funds to pay the daily costs, salaries and other expenses. There seem to be two major sources of funds - general municipal revenue of specific charges. But specific charges for the urban poor are probably not feasible and in fact as one of our colleagues suggested it may be advisable to reward these people in some way by reduced taxes or even cash payment. Thus with some motivation for strong community participation the overall cost of collection in these neighbourhoods could be reduced.

The other source of funds in many countries is from property taxes. But as I previously mentioned in many rapidly growing cities, property is not registered, property values have not been properly assessed, and the tax structure needs to be revised. Property registration and assessments, as you know are frequently used as a basis for storm and sanitary sewer charges. Therefore, the amount of revenue that the municipality can assign to the streetcleaning and solid wastes management must be determined.

What does this mean?

To the Bank it means how large a project can be undertaken, and then that funds will be available to operate and maintain the facilities and equipment.

Project Financing

The Bank and other international agencies do not provide loans to finance 100% of the "study projects" or the Construction projects. Generally speaking the Bank will finance all the foreign costs - imported goods and services and training costs, and recently a portion of local costs, in some cases, interest during construction; the Bank does not make grants.

There are two types of funds: The regular Bank funds which now are close to 8% for a total of up to 20 years including a grace period of up to 4 years. There are also the softer funds IDA Credits which are lent first to the government at a service charge of 3/4% for 50 years and may be relent to the respective institutions at shorter terms and higher rates of interest. These IDA Credits are limited, and apply only to countries with an average per capita income that recently was the equivalent of about $ 375.

The project preparation funds have a limit of US $ 1 million and are lent at the usual rate of interest for periods of up to 7 years. If followed by a construction loan, the amount would be added to the loan and be given the same amortization period.

So here I present two more problems for project financing. The first one is the source and amount of local financing that is needed. In our case (the cities) it may have to come from the national government.

The second one is debt service. Can the municipality pay the interest and amortization or will the national government? The day-to-day operation and maintenance, I believe should be paid by the municipality or the entity responsible for managing the service. This I believe is a minimum financial requirement.

Appropriate Technology

And so we come full circle to what is appropriate for the country and its communities.

I believe you are tackling one of the most difficult problems - that involves paying for a service to take something away after it has been discarded.

So if something useful can be recovered even to obtaining a partial benefit, the problem can also be alleviated to some extent.

The lecture was concluded with reference to the project, summarized by Mr. Charles G. Gunnerson.

PLANNING FOR APPLIED RESEARCH AND DEVELOPMENT INTEGRATED RESOURCE RECOVERY

by Charles G. Gunnerson, World Bank, Washington, U.S.A.

Increasing competition for resources and decreasing margin for error in allocating them require new approaches and reexamination of traditional ones for conservation, recycling, and waste disposal. The problem is particularly acute in developing countries where in many cities an estimated 1 to 2 percent of the population is supported by entrepreneurial manual recovery and secondary utilization of materials discarded by the upper 10 to 20 percent. These systems provide entering level employment to new arrivals and household incomes ranging from bare survival to almost three times the average urban income in at least one city. Meanwhile, costs of refuse disposal are rising above 20 percent of some municipal budgets.

Preliminary planning is underway for World Bank research and development in integrated resource recovery. Long-term objectives are to achieve replicable health, environmental, energy, employment, and economic benefits through integrated resource recovery projects in developing countries. The approach will be similar to that of the recently completed World Bank research project on appropriate technology for water supply and waste disposal in developing countries. Here emphasis was directed toward the technological and economic interactions between water and sanitation service levels and the potentials for water, fertilizer, and energy recovery.

The plan provides for participation by developing country consultants and agencies in comparing capital and labour intensive operations, designs, and demonstration projects for (1) direct recovery of energy through combustion or methane production, (2) conservation of equivalent energy through recycling metals, glass, paper, and plastics, (3) conversion of fertilizer values to protein or firewood, and (4) improved occupational health and municipal sanitation.

Research products will include a state-of-the-art review of historical practices in industrial countries and current practices in developing ones, documentation and dissemination of research and development findings, design and operation of integrated projects in six developing countries, a manual of practice, and policy options and planning guidelines for single-purpose and integrated resource recovery systems. Mr. Freedman invited participants of the VAM/KIT workshop to join this project.

PRODUCTION OF BIOGAS ON FARM SCALE IN THE NETHERLANDS, STATE OF AFFAIRS AND PERSPECTIVES

Paper 11 by Ir. A.A. Jongebreur, Institute of Agricultural Engineering, (IMAG), Wageningen, The Netherlands

Summary

Production of biogas is becoming more interesting since energy prices have increased very much. Besides that there is quite a considerable reduction of malodours by anaerobic digestion of liquid slurry. The conditions for the anaerobic fermentation are given a.o. temperature, loading rate of the digestion tank and detention time. Practical possibilities for the biogas installations are described and the perspectives are mentioned. Moreover, the research and development activities for the next years are pointed out.

1 Introduction

In The Netherlands the basic research of the anaerobic digestion of pig slurry is carried out by Van Velsen (1977, 1979). The important factors which influence the biogas production are temperature, retention time, loading rate and the dry matter content of the slurry. The practical research on farm scale started in 1978 on a livestock farm with 2500 fattening pigs. At the moment about 10 biogas installations are functioning on a practical scale.

2 Biogas-installations

Complete biogas-installations consist of the following parts:

- slurry storage
- digestion tank
- biogas storage
- tank for the digested slurry.

It is clear that the digestion tank has a center function in the installation. Important criteria for the dimensioning of the digestion tank are the temperature, retention time, the method of loading and the method of mixing. For the anaerobic digestion of pig slurry a temperature of 27^{o}-$35^{o}C$

a retention time of 15 days and a loading rate of 4 kg TS/m^3 digestion tank/day is optimal (Van Velsen, 1977 and 1979). The fundamental research of the anaerobic digestion of dairy cow slurry has started in 1980.

All over the world there is a large variety in the construction and the appearance of digestion tanks. In connection with this it is interesting to mention the plug-flow system, where in the digestion tank no mixing takes place (Jewell a.o.,1976). A review of the digestion types and systems for animal manure is given by Baader and Dohne (1978) and Wellinger (1979). The form of the digestion tank can be cylindrical, rectangular, horizontal or as an underground canal. There are practical installations where the normal storage system is used as digestion tank. In this case the retention time of the manure is relatively long.

It is necessary to have a gas storage to equalize the peaks in the production and the consumption of the biogas. Application of storage under high pressure is too expensive at the moment.

3 Farm scale installations

The capacity of the digestion tanks on the 10 installations which are running in the Netherlands, vary from 75-300 m^3. From 8 installations the digestion tank is made of enamelled steel plates. These tanks are insulated with 60-70 mm PUR-foam which is covered with aluminum plates. One of the tanks is built as a ground pit of concrete. Three installations have a floating gas cap for storage of the biogas. Some other installations have a synthetic bag with a capacity of 70-100 m^3 for the storage of the biogas.

Mixing and heating

Almost all installations have a mixing system. Small installations have a pump which agitates on the top or on the bottom of the tank. The mechanical mixing system can also be combined with the heating system by bringing a double walled warm water system round the mixer. Another possibility is the application of a blower system and pipes with small openings to return the flow of the biogas. With the last mentioned system special attention must be paid to the safety of the blower and the foam formation on the top of the slurry. The heating of the slurry can be carried out by means of a central heating system with warm water pipes in the digestion tank. In the plug-flow system there is the risk of floating layers on sedimentation. Therefore, it may be better to load such a system with slurry which is handled in a separation machine.

4 Experience

Careful management is very essential to reach a good biogas-production. Gas-production is an important indication for the success of the process. At the moment there are especially on the livestock farms with pigs low to very low gas-productions measured. An intensive research after the causes of these low gas productions is running now. May be the biodegrability of the manure is one of the critical points behind this history. Some dates of the farm-scale installations are given in Table 1.

Table 1 : Global gas productions on 8 livestock farms in m^3 biogas per m^3 manure

	Dry matter in %	NH_3 in mg/l	Volatile fatty acids meq/l	m^3 biogas per m^3 slurry	Number of farms
Dairy cows	4.8 - 10	1500-3600	16 - 100	12 - 18	3
Pigs (fattening and breeding)	4.0 - 11.3	1900-6300	15 - 222	2 - 24	5

The following remarks can be made:

- After starting the digestion tank it may one or two months before the biogas production reaches a satisfactory level. Seeding takes place mostly with material from a running installation.
- A low dry matter content of the slurry gives disappointing results because of the relative high part of the process energy in relation with the produced biogas.

- At a concentration of 5000 mg/l NH_3 the digestion is inhibited. This is mostly the case with pig slurry. Therefore the dry-matter of pig slurry must not be higher than 8 à 9 %.
- The greater part of the slurry is digested during the winter-period for reasons of gasconsumption. Starting-up the digestion process in good time before the cold period is beginning, is important because increasing of the loading rate must be done step by step.
- On the dairy farms with the help of a gasmotor electricity is generated. From 1 m^3 biogas 1.3 - 1.7 Kwh is produced. Besides that the heat of the cooling water and the exhaust gas is used for the heating of the slurry.
- On the pig farms the produced biogas is used for heating of the houses. Special attention must be paid to adapt the central heating system to the lower pressure (50-70 mm) and the cleanliness of the burner. The burning of the biogas in kitchens or pig houses is from the point of view of safety not advisable. Because traces of sulphur components are present in the biogas it may be wise to applicate a purification system for the sulphur components.
- To prevent floating layers in a plug-flow digestion system it may be essential to separate the fibrous materials out of the slurry.

5 *Economical perspectives*

Application of biogas-production in the Netherlands can be economically feasible - in comparison with natural gas - at a scale of about 2000 pig fattening places and 150 dairy cows. It must, however, be stressed that the investment costs, the utilization of the biogas and the price of the energy sources effect the economic feasibility strongly. In the case of the use of oil or propane gas - 70-100 % higher costs - the production of biogas is economically attractive at a smaller scale.

References

Baader, W., E. Dohne, M. Brenndörfer (1978), Biogas in Theorie und Praxis. KTBL-Schrift 229. Kuratorium für Technik und Bauwesen in der Landwirtschaft e.v.

Velsen, A.F.M. Van (1977), Anaerobic digestion of piggery wastes. 1. The influence of detention time and manure concentration. Neth. Journ. of Agric. Sci. 25, 151-169.

Velsen, A.F.M. Van (1979), Anaerobic digestion of piggery waste. 3. Influence of temperature, Neth. Journ. of Agric. Sci. 27, 255-267.

Wellinger, A. (1979), Landwirtschaftlicher Biogasanlagen in der Schweiz. Blätter für Landtechnik, Eidgen. Forsch. anstalt für Betriebwirtsch. u. Landtechn., Tänikon.

UPGRADING OF ORGANIC RESIDUES IN RURAL AREAS

Paper 12 by C.A. Shacklady, Centre for Animal Nutrition Research (ILOB), Wageningen, The Netherlands

Introduction

The title of this paper lends itself to a variety of interpretations of which several are covered in other papers that have been presented here. But though the title may be rather general, I propose to make the content more specific. It will deal mainly with the potential value of agricultural residues as sources of feed for animals, to a lesser extent, food for humans and, very briefly, as sources of energy. I shall confine my observations to methods of treating these residues that are, or may become, feasible in rural communities of developing countries. In other words I shall try to differentiate between what is practicable and what is practical.

This is not merely a semantic difference. According to Weseen, quoted by Gowers in his book "The Complete Words": that which is practicable is often not practical. Anything that is possible of accomplishment by available means may be called practicable. Only that which can be accomplished successfully or profitably under given circumstances may be called practical.

So although it is evidently practicable to put men on the moon, few communities would regard it as practical to do so. We should bear this difference in mind in developing technology intended to be applied in circumstances far removed from those to which many of us are accustomed.

Nature and extent of the residues

Agricultural residues fall into three general categories. These are characterized by either the dominant features of their composition or the nature of their origin. They are the fibrous, that is to say lignocellulosic, residues, carbohydrate residues and animal manures. It is difficult to be precise about the extent to which these exist but an idea may be gained from the folllowing figures.

Of the major agricultural crops a surprisingly low precentage is consumed directly by man. The uneaten residues are 40% for roots and tubers, 60% of the grain crop, 85% of the oilseed crop, 90% of the cane sugar crop and 100% of the grass and timber produced.

Some indication of the quantities involved are suggested by the following estimates. In 1974, cereal straw production in Asia alone amounted to 607 million tons. When to this is added a further 207 million tons from Africa and Latin America the total represents almost half the world's production of straw.

The residues in Africa, Latin America and Asia from cassava, bananas, citrus fruits and coffee have been estimated at 124 million tons, almost 95% of the world's total of residues from these crops, while 72% of the residues from sugarcane amounting to 83 million tons is found in these regions. So not only are the proportions impressive, but the absolute quantities are very considerable.

In addition, but even more difficult to estimate, is the enormous quantity of manure from the world's 9,500 million head of domesticated livestock of all types. Approximately 40% of these animals are in Africa, Asia, Latin America and the Near East. The significance of these figures, approximate though they may be, lies in the fact that most - if not all - of these residues represent potentially valuable and renewable sources of raw materials for processing into more useful products, that is for upgrading from wastes to resources.

Processing

The processes by which organic residues may be upgraded can be physical, chemical, biological or a combination of any of these. This is a somewhat arbitrary division. It could be argued that biological processes depend upon enzymic action on materials in a particular state and so are basically chemical and physical reactions. It is, however, convenient to retain the generally accepted differentiation between these methods.

In almost every case the processing of residues for animal feed or human food involves a biological stage if they are to be used to the best advantage. In the present state of the art and because of man's attitude to his food there is little doubt that the indirect route to food production, that is by increasing livestock production, is the one that is likely to predominate. There are, of course, exceptions to this generalization, some which are mentioned later.

Materials

The residues that occur in the greatest quantity are the fibrous ones and, within this category, the most important are the cereal straws. The straws themselves may come from rice, wheat, barley or maize but they are all characterized by the presence of greater or lesser amounts of lignin and cellulose some of which is present as complex lignocellulosic compounds.

In many developing countries straw is the staple - sometimes the only - feed of the ruminant animals, that is to say cattle, sheep, goats and buffalo. In these countries too, the ruminant animal plays a central part in the rural economy providing food, a source of power and an investment.

The unique feature of the ruminant is its ability to digest fibrous materials that are virtually indigestible by simple stomached animals like the pig, the fowl or man. There is, however, a limit to what even the ruminant can digest and its ability to digest lignin is very limited indeed. In contrast to this, it is quite efficient in its ability to digest cellulose. This is achieved by the action of the micro organisms in the rumen which is, in effect, a mobile anaerobic fermentation chamber.

The action of the rumen micro organisms is retarded by the physical shielding of the cellulose by lignin molecules and by the chemical bonding of lignin to cellulose. This reduces the digestibility of the straw to an extent that may leave as much as 65% of its organic matter undigested.

It would be logical to assume that this figure could be made significantly lower if a way could be found of opening up the cellulose to the attack of the micro organisms.

This can be done by chemical treatments, by microbial treatments or by a combination of these. All are practicable but, in my view, at present the only practical treatment that could be used in rural areas of developing countries is a chemical one.

The chemical treatments involve the use of mineral acids, high pressure steam or alkalis. Neither mineral acid treatment nor the use of superheated steam can be recommended on the grounds of safety or cost of equipment to apply them, though both methods have been used to a limited extent in industrialized countries. This leaves alkali treatment.

Various alkalis have been used and there is no doubt that the most effective is sodium hydroxide at a concentration of about 4 to 5% in water. Application can be very simple, virtually any sprinkling device will serve, the action is reasonably quick and, according to the published work, the digestibility of the straw can be increased from around 35% to as much as 55% or more. This is comparable to the figure for medium quality hay. There are commercial plants in Western Europe, Scandinavia and elsewhere for treating cereal straws by this method.

However, the negative aspects of this treatment have caused some misgivings in developing countries and prevented its adoption on any significant scale. Sodium hydroxide is expensive in terms of both money to buy and energy to produce. It is also corrosive as might be inferred from its common name - caustic soda - and the farmers are unused to handling it. Unless special equipment is available for washing the treated straw, making up the wash water to the required concentration with more alkali and recycling it, most of the sodium hydroxide is retained in the straw and eaten by the animal. This amount far exceeds its physiological requirement and most is excreted. The effect of the deposition of large quantities of sodium in the soil over a period of years is a source of concern to soil scientists and environmentalists. Consequently, in spite of the effectiveness of sodium hydroxide, other alkali treatments are being investigated more intensively even though they may be less effective in increasing the digestibility of straw.

Calcium hydroxide has been tried but without much success. Not only is it a much weaker alkali than sodium hydroxide but is not very soluble in water and this limits the concentration that can be applied.

Anhydrous ammonia is quite effective and has been used succesfully on a field scale in the Netherlands and elsewhere but the cost, the expertise and equipment needed for handling liquefied gas rule it out for rural community application. However, a very promising method is to use an aqueous solution of fertilizer grade urea at a concentration of about 4% by weight.

This is basically an ensiling process. The straw is chopped, packed in a container, moistened with the urea solution and the container sealed. All of this can be done with a very simple equipment. The container can be made from polythene sheeting or can be a pit dug in the ground and covered over. Ammonia is evolved from the urea and it is this that acts upon the straw, hence the need for an airtight container.

At the ambient temperature found in tropical and subtropical countries, the action of the alkali is complete in about 2 - 3 weeks though there is no harm in leaving the straw for longer periods. Before the material is fed, the container should be opened for 2 - 3 hours to allow any free ammonia to escape.

There is now considerable interest in this process and it is being investigated further in several projects in India, Sri Lanka and Indonesia. If it is as successful as early results indicate, it will have a number of advantages over the sodium hydroxide treatment.

Urea is cheaper to make than sodium hydroxide and needs only about 60% of the energy to produce an equal weight. It has the added advantage that it is not an environmental pollutant and any residue left in the straw can be used by the ruminant as a source of nitrogen for protein synthesis in the rumen. Sodium hydroxide adds no nitrogen to the feed.

This could well be a practical method of upgrading a substantial quantity of the most abundant organic residue in developing countries and one that could have a significant impact on livestock production.

It is an example of a chemical treatment external to the animal followed by a bioconversion process within the animal itself. As such it raises the question as to whether or not it would be possible to carry out both the chemical and biological treatments outside the animal so as to present it with a biomass product having both a greater digestibility and higher protein content than the original straw.

The microbial degradation of lignocellulosic materials is receiving increasing attention both as a research project and as being potentially useful in industrial processes. In general the aim is to release the cellulose for use as such, or as a substrate for the production of simpler organic compounds like short chain fatty acids and power alcohols.

There is quite a wide variety of organisms, certain fungi, yeasts and bacteria that can degrade lignocelluloses, the problem is to find a process that is practical. The difficulty of devising such a process is increased enormously if it is designed to be applied in the uncontrolled environment of villages in developing countries.

Of the organisms with lignocellulotytic activity the white-rot fungi seem to be the current favourites. Eriksson in Sweden has produced cellulase-less mutants of *Sporotrichum pulverulentum* that attack only the lignin; most other active organisms use at least some of the cellulose as a source of carbon and energy for their growth. In the wood pulp and paper industry it is important to minimize the loss of cellulose.

Unfortunately even these organisms have a fairly slow rate of growth. Unless the conditions are under careful control this presents the danger of contamination of the biomass by undesirable extraneous organisms that can produce toxins. A well known example of this is aflatoxin production by *Aspergillus flavus*.

The risk of contamination can be almost eliminated in an industrial process by sterilization of the substrate, filtration of the air used in the fermentation and control of pH and temperature. However, both the expense of the equipment for this and the degree of expertise needed to operate it are far beyond the resources of rural communities. Indeed at present even industry does not find it an attractive proposition other than in a few rather special circumstances.

Any aerobic fermentation carried out in uncontrolled conditions is subject to the danger of contamination to at least some extent. In most circumstances it is reasonable to assume that the danger is increased the longer the fermentation proceeds. Unfortunately, even at high ambient temperatures, the action of the lignolytic fungi is not very rapid. Lignin is a complex polyphenolic compound and the ability of any organism to degrade it will depend on the organism's producing, among other enzymes, phenol oxidases. Eriksson has shown that phenol oxidase-less mutants of *S. pulverulentum* have no lignocellulolytic activity. It is interesting to speculate what would be the effect of transferring the gene coding for phenol oxidase synthesis in *S. pulverulentum* to a non-pathogenic aerobic bacterium capable of very rapid growth. Presumably this is at least theoretically possible with the recombinant DNA techniques now available.

However, it must be said that at present there is no process for the microbial upgrading of straw as an animal feed material that would be technically or economically feasible in rural communities. That is not to say that a practical process may not emerge in the future but it may require a different approach to that represented by the present line of thought.

In most of the research directed to upgrading ligno-cellulosic materials for animal feeding the object seems to be to maximize microbial growth so as to increase the protein content of the biomass. Inevitably this leads to long fermentation times because the only way the organism can grow is by degrading the substrate and this is a slow process.

As has been said already, the ruminant animal could itself ferment the cellulosic material if the rumen micro organisms could get to it. So perhaps, the aim should be to allow the external fermentation to proceed for only the minimum length of time needed to open up the lignocellulose to the action of the rumen flora. In my view it would be worthwhile carrying out some small scale *in vitro* studies or nylon bag digestibility studies in fistulated cattle to get an idea of the shortest fermentation period needed with various organisms at ambient temperatures around 30^{o}C to give a significant increase in the digestibility of different straws.

Most people will be aware of the use of straw as a compost for mushroom growth. Volvariella and other tropical mushrooms can be - and are being - grown quite successfully on straw substrates in Taiwan, the Phillippines, central Java and probably elsewhere as well. Whether or not this can properly be regarded as a method of upgrading straw is perhaps a matter of opinion. Certainly it is a way of using straw to produce something more valuable and moreover, that can be used directly for human nutrition.

The spent compost has been used as a fertilizer or soil conditioner for other crops but there is now the awakening of an interest in its potential as a feed for ruminant animals. Very little work has been done on this so far, certainly not enough to allow any critical evaluation to be made.

At first sight it would seem reasonable to expect the protein content of the used compost to be higher than that of the original straw because of the mushroom spores that would remain in it. On the other hand if the growth of the mushrooms was at the expense of the cellulosic rather than the lignin component of the straw, the residue would have a higher lignin to cellulose ratio than the undergraded straw.

These factors could vary with different straws and varieties of mushroom but should not be difficult to determine. It is unlikely that this particular use of straw would have a significant effect on the total amount that is available in developing countries. Nevertheless it could be of importance in certain areas particularly as, according to Alicbusan in the Philippines, it is readily adaptable to the small scale.

Quantitatively the next most abundant residues with a potential for upgrading to feed materials are those that are predominantly carbohydrate in nature. These include solid wastes such as rejected fruits, citrus wastes, coffee pulp etc. and liquid effluents from various processes like the milling of cassava, oil palm etc. and the refining of cane sugar.

Some of these materials can be - and sometimes are - used directly for animal feeding but in many instances are environmental pollutants rather than feed materials. I do not propose to say anything about the fermented food products common to many of the developing countries because, by definition, these are not residues. However, the processes that have developed over the years in the production of these traditional foods do have a bearing on those that might be applied to the treatment of some of the residues.

The methods that are being investigated are almost entirely fermentations or processes in which a fermentation stage is involved. Carbohydrate-rich residues are generally more easily attacked, and by a wider range of organisms, than are the lignocellulosic ones. This apparent advantage is not an unmixed blessing because it means that they are also more susceptible to dangerous contaminating organisms. This is probably the most serious problem and the one most difficult to overcome among those confronting workers in this field.

That they can be overcome is evident from the handful of industrial processes that have been developed to, at least, the pilot plant scale. But, once again, the means of doing so appear at present to be out of the reach of rural communities. Nevertheless attempts are being made to find technologies that can be applied in those conditions.

One line of attack is the fermentation of the solid or semi solid substrate to produce what is now being termed "Microbial Biomass Product" (MBP). This differs from the processes for the so-called Single-cell Protein (SCP) manufacture in that no attempt is made to isolate and harvest the organism as a final product. Instead the organism and any unfermented substrate are harvested together and fed together in either the moist state or are co-dried, preferably in solar driers, in which case they can be stored for some time.

This type of treatment is being investigated by Senez using cassava as the substrate and *Aspergillus niger* as the organism. In the Philippines, Uyenco and her co-workers are trying a similar technique using a mixed culture of *Aspergillus niger* and *Aspergillus foetidus* on banana rejects. In Bangkok a Microbiological Resource Centre (MIRCEN) has been established under the sponsorship of UNEP/UNESCO. Its functions include the conservations of micro organisms of economic and environmental importance and the dissemination of information on fermentation technology. Various projects are now in hand among which may be mentioned the microbial preservation of bagasse for pulp production, the protein enrichment of cassava as already mentioned and MBP from pineapple waste.

In South East Asia in particular there is a long history of the use of fermentation in the production and preservation of food. What is now needed is the transfer of available technology - modified if necessary - to the rural areas and its application to the agricultural residues that are there.

A number of the carbohydrate-rich residues, such as coffee-pulp, are suitable for ensiling. This is essentially an anaerobic fermentation in which the formation of short chain organic acids preserves the ensiled material. It must be borne in mind, however, that silage is neither marketable nor easily transportable so it has to be used at, or very near, the point of production. In general it is more suited to the feeding of ruminant animals than to non-ruminants like pigs or poultry so it is only worth considering in places where there is livestock to eat it.

Mention of livestock brings me to the third major residue, animal manure. Its use as a fertilizer is, of course, well established and most people will be aware of its use as a fuel in the dried form and now as a source of energy as biogas after its anaerobic fermentation. Perhaps less well known may be its use for feed purposes.

In certain circumstances manure from one animal species may be fed directly to another or dried and incorporated in its mixed feed. An interesting use is made of this by a feed factory in Thailand. The manure from poultry is fed by gravity to pigs as a supplement to their normal feed. The pig manure, in turn goes into a lagoon stocked with fish. Algal growth in the lagoon is stimulated and the fish feed on this and directly on the pig manure. On the commercial scale this has been quite successful and attempts are now being made to scale it down for application on the small farm.

In an integrated scheme for village self sufficiency, Seshadri in Madras is feeding the liquid effluent from biogas generators into algal/fish ponds with the same aim in view.

I have said nothing about the upgrading of liquid effluents but this is, perhaps, excusable in a conference devoted to the treatment of solid wastes. It is a problem, however, that is commanding a great deal of attention on the grounds of environmental protection as well as those of the use of renewable resources, so it has not escaped notice.

The possibility of using these effluents as substrates for the growth of single-cell proteins, i.e. yeasts, bacteria and fungi is often mentioned, frequently, I regret to say, by those who have had no experience of the problems associated with this type of process. I am not aware of any system of SCP production on effluents that may be of practical application other than, possibly, by industrial plants.

It must be borne in mind also that before any fermentation process can be considered as suitable for recommendation the toxicological and nutritional acceptability of the product must be established. This is an issue that, in itself, has been and still is the subject of numerous conferences but time does not permit anything other than a reference to the need for such an evaluation.

In summary therefore it would seem that the alkali treatment of lignocellulosic materials is already at the stage where it could be considered as a practical method of increasing their feeding value and one that can be applied in rural areas of developing countries. This alone is quite significant in view of the enormous amount of these residues that is available.

With the exception of mushroom production, fermentation processes are generally not yet sufficiently developed for either lignocellulosic or carbohydrate rich residues to be transferred to the village with much hope of success.

The use of animal manures may be mainly for energy, either directly or through biogas production, and as fertilizer. Nevertheless there are ways in which they can be used directly and indirectly in animal feeding.

We have seen the main difficulty in bioconversion with micro organisms is that of avoiding undesirable and possibly toxic contamination by extraneaous organisms. This is a particular danger in the uncontrolled conditions that would exist in open fermentations in villages and on farms.

Looking some way into the future it is tempting to speculate how this might be overcome. The action of the micro organisms is the product of enzyme systems, each with a specific part to play in attaining the final result. Is it beyond the ingenuity of the molecular biologists and biochemists to identify those systems from the organisms of choice, for the geneticists to enhance their production by strain selection or gene transfer and the bioengineers to isolate the pure enzymes? These could then be used to effect the fermentation reactions much more rapidly and quite as specifically as the entire orgamism. Can this de done, ultimately, at a cost that would bring the enzyme preparations within the reach of village communities? Could we also use immobilized enzyme or cell systems to clean up liquid effluents? If the answer to some or all of these questions should be "yes", an enormous step forward will have been made.

Inevitably this paper is a very superficial treatment of the subject but this is not surprising in view of its immensity. It has concentrated almost entirely on technological consideration and has not mentioned the other factors involved if the problems are be solved. Equally important are the economical, social and political factors. The mere listing of these makes it clear that a multidisciplinary approach is essential if there is to be any hope of success in developing and transferring the technologies that are needed. Development alone is not enough. If it gets no further than the confines of a research institute or a university department there is a distinct possibility that it will provide only food for thought. I suspect that those who are hungry would prefer a more substantial diet.

II. PAPERS READ AT VAM COMPOST AND RECYCLING PLANT, WIJSTER

Paper 13 Address by Ing. P.J. Houter, Waste Disposal Company, (VAM), Amsterdam, The Netherlands

As acting director of the VAM it is a great honour for me to say a hearty welcome to you at our plant at Wijster.

At first I like to tell you some facts. In this plant we receive the garbage of about 2.5 millions of inhabitants, with an annual production of 1,000,000 tons of garbage of 120 cities, big and small. Most of the garbage is transported by train in specially built rail-road waggons, about 75%. 25% is road transport, of which 15% in trailers and containers and 10% in collection-vehicles (the last especially in the neighbourhood of the plant here).

As you have already heard VAM is founded in 1929. It is a company with shares owned mainly by the Dutch government. As usual, there is a board of directors. But because VAM is a governmental organization the board consists of representatives of the Ministry of Agriculture and Fisheries, Ministry of the Interior, Ministry of Finance, Ministry of Health and Environmental Control, Ministry of Commerce and Industries,a representative of the society of Dutch municipalities, a representative of the Dutch farmers organizations and the Mayor of Beilen, the city, to which Wijster belongs. As far as I know there is no country in the world which has a refuse-disposal-organization of this type. A second VAM-plant is in the southern part in our country in the village of Mierlo in the neighbourhood of the city of Eindhoven; a smaller plant than the one in Wijster with an annual capacity of about 130,000 tons refuse.

Our headquarters is in Amsterdam and our Department of Research and of Public Relations is in Wageningen, the city with the famous agricultural university. Totally we have 175 employees of whom 115 in Wijster.

How does the VAM-system work? What we do not do, is to collect the refuse in the cities. This is mostly done by the cities themselves. Our company makes contracts with municipalities or with regional authorities for transport of the collected waste to our plants, to compost it there, to dump it or to recycle it in our new recycling-plant. These contracts are for either 10 years, 15 years or up till 30 years.

If the transport is done by train VAM takes care of the transport in its own 200 railroad cars. Each railroad car has a capacity of 100 m^3 (with a weight-capacity of refuse of the present compositions of 25 metric tons). The railroad cars are filled at transloading stations and at the end of the day cars from these 15 stations are combined to 5 trains, which are unloaded on 500 m long viaducts on the VAM-plant. This is done at night. The unloading is all done with a hydraulic system and takes just about half an hour per train of 30 railroad cars. When the train is empty, it returns the same night to the 15 transloading stations and the daily amount of cars is delivered again. This needs a close cooperation with the Dutch Railroad Company, but such a disposal system means for the municipalities an important service, as you can imagine. Namely at the end of each day the refuse has been removed from the towns, but the problem has moved to the VAM. What do we do with it? On an annual basis 400,000 ton is put in the compost plant, the same amount is dumped on a land-fill and 125,000 tons clean household refuse is treated in the recycling plant. You will hear more about the various systems in the following papers of Mr Oosthoek and Mr Bruinsma.

We mainly handle the refuse which is collected by the municipalities. We do not handle chemical waste and other hazardous waste like hospital waste, sludge, animal waste, car wrecks etc. I have to say better not yet, because perhaps we will do in the future. Nowadays in The Netherlands the garbage picture is as follows: 30% is burnt, 20% goes to the VAM and 50% is dumped, more or less as a sanitary landfill or as a controlled-tip.

Space in this country - with the highest population density in the world - is becoming very scarce. Therefore space for dumping garbage is not available anymore in a few years. On the other hand people are against dumping, because they think it is hazardous for the environment and besides it may mean waste of valuable components like paper, plastics, iron, organic matter for composting and glass.

For this reason we started a new recycling-plant in Wijster with an annual capacity of 125,000 tons of clean garbage. You will hear more about this plant from Mr Bruinsma in his paper. I will conclude my short introduction with wishing you a valuable course and a fruitful stay at our plant. If there are any questions do not hesitate to ask them.

Thank you for your attention.

COMPOSTING IN THE NETHERLANDS, REFUSE COMPOSITION AND COMPOST

Paper 14 by J. Oosthoek, Waste Disposal Company (VAM),
Amsterdam, The Netherlands

The use of city refuse for agricultural purposes in The Netherlands dates back to the Middle Ages, when the first towns developed. At that time there were no public cleansing services and the garbage which accumulated in the streets was simply removed once in a while by the farmers when they needed it for their fields. The farmers remained using refuse up till around 1900, and this prolonged application of refuse is probably one of the main reasons why, in spite of intensive exploitation, the degree of fertility of the arable land in The Netherlands was maintained during the centuries.

This is not so difficult to explain, because this method of soil exploitation closely resembles the cycle of nature, where all plant nutrients extracted from the soil by vegetation are returned in the form of the residues of vegetable and animal life.

The soil capital (plant nutrients and humus) could be maintained on a certain level, but could not be increased by this method of soil exploitation.

Most of the sandy soils with a poor vegetation could not be cultivated at that time. Only the richest soils could be cultivated. Agricultural practices changed when about 1900 artificial fertilizer came into general use. The "poor" sandy soils could be reclaimed and good crops could be grown on then with the aid of artificial fertilizers.

Generally, crop yields showed a considerable increase with some 25 to 50%. The production capacity of the soil was no longer dependent on the amount of plant nutrients.

The great success achieved with artificial fertilizers caused a revolution in the farming methods in The Netherlands. From that time refuse compost, prepared in the towns and used for centuries by the farmers, became virtually unsaleable in The Netherlands and therefore the towns were forced to find other methods to get rid of their refuse.

The mistake was made, however, that after 1900 the use of artificial fertilizers became too exclusive. After all, the presence of sufficient avaiable plant nutrients is only one aspect of the soil fertility problem, the
chemical aspect;
The other and by no means less important aspect is the physical aspect. A good soil is fertile both from a chemical and a physical point of view. Good physical soil fertility is only obtainable and maintainable if sufficient quantities of organic manure are applied periodically, because it is based on biological activities in the soil and on the presence of humus.

It is evident now, that after 1900, when artificial fertilizers were used too exclusively the physical soil fertility gradually declined. After some 30 to 40 years this became noticeable in several arable soils. This is the main reason that in The Netherlands composting of city refuse became popular again. Now we are composting for two reasons:
First and most important is to get rid of the refuse and second to make the refuse useful by making compost and saving organic material. Still, there is in The Netherlands a need for organic matter.

In 1929 we had a refuse of a very different composition, than we have now. In this country in winter, we have to heat our houses. In the past, till 1960-'65 we used for heating mainly coal and also wood. By burning coal and wood the remainder is ash. The ashes were in that time an important part of the refuse. Especially in winter the refuse consists for the bigger part of ashes (60-80%). In those years plastics weren't yet invented. There was less paper in the garbage too. But they made a lot of compost in spite of a low content of organic matter. Ashes are fine and through sifting they came into the so-called compost. Technically seen compost is only the fermented organic material. Only materials of organic origin can be composted.

But 70 - 80% of the refuse became part of the compost. At that time the compost was very poor, with in winter a low organic matter content of 7 - 10%, and in summer of 10 - 15% (of the wet material). Nevertheless this compost worked wonderfully. Especially in arable farming where the physical condition of the soil was very bad. But, probably, most important was that this compost contained various trace elements.

In the beginning of the operation of the VAM composting was easy. The refuse was unsorted put on windrows, water was added and after a few months (2/3) sifting followed. The sieve had big holes. The result was a very rough, coarse compost. A gift of 40 metric tons a hectare in the first year on "waste land" (very poor sandy soils), land that was not cultivated sofar, together with artificial fertilizers, was sufficient to give a good harvest. After that every 3 years 25 tons per hectare gave a good result. Later on attention was paid to the fact that only a part of the refuse could be converted into compost. The conditions for composting were bad in a part of the windrow, because there was an oxygen deficiency. Therefore, it was decided to turn over the windrows.

It is to be expected that there are germs and weed seeds in the refuse. These aspects were noticed later on, resulting in turning over twice, fulfilling the condition that all material is exposed to the temperatures of 70 - 90^{o}. As a consequence all germs and weedseeds were killed.

In the fifties and the years before, the only treatment after composting was sifting. As I said, the result was a very coarse compost. In those years they called our salesman: "Merchants in glass and china". But the farmers bought this compost, because they knew that it was necessary for a good crop.

In the sixties compost became in interest by other consumers. Especially in horticulture. A good market for compost. This group of customers was able to pay better pirces, but wanted a better quality. So we had to do a lot of crushing, milling to reduce and remove glass, china. Later on the recreation has been our most important market. And so it is now, in 1980.

At this moment the garbage composition in The Netherlands is as follows:

Paper	20 - 25%	
Organics	45 - 50%	(kitchen garbage, plantrests)
Glass	12%	
Plastics	6%	
Metals	3%	(especially in tins)
Rest	7%	

Composting by the Van Maanen system means that the refuse without any pretreatment will be put on windrows. Only water is added. Moistening of this refuse is very difficult because there is a lot of runoff. The reason for this are the plastics. Moistening can be done most efficiently during turning over the windrows. Nowadays turning over takes place two or three times.

This creates a big pore-space because the refuse is not shredded at all. But still the oxygen is used very rapidly. In a few days there is no oxygen available anymore in the bigger part of the 8 meter high windrows. In the beginning of the fermentation there is a lot of easy decomposable matter; as a consequence oxygen consumption is high. That is the reason why especially in the beginning of the fermentation period anaerobic conditions soon occur.

Anaerobic decomposition means that fatty acids are accumulating. The pH goes down. If the acidification goes too far there is no question of decomposition anymore, but of conservation. Before this stage is reached turning over must be effected. Turning over has various aims:

- for air-supply (oxygen);
- homogenizing, to mix the different zones; some parts are wet (at the bottom), some parts are dry (at sites where high temperatures are developed and as a consequence evaporation is high);
- to have the good condition for adding water;
- to take care that all material is exposed to the same high temperatures, fulfilling the condition that weedseeds and germs are killed.

Composting is done to convert the refuse into a material that can be applied as a soil improver. Meaning:

- To reach such a C/N ratio that there is no nitrogen immobilization anymore. The C/N rato of The Netherlands refuse is high. That means that by applying this refuse to the soil the available nitrogen in the soil is used by the micro-organisms for their growth. At a C/N ratio of about 20 there is a balance and there is not any immobilization of nitrogen. This is one reason for composting. During composting there is a loss of carbon, CO_2 disappears. Composting is a relative enrichment of nitrogen.
- With the Van Maanen system the material is reduced into smaller particles by the micro-organisms so that sufficient compost can be separated by sifting. For both reasons the composting period for the present refuse has to be long; at this moment 10 - 12 months.

Looking at the refuse composition one is inclined to think that much compost will become available. The refuse consists of 70% organic matter; 20% paper and nearly 50% other organics as plantrests and kitchen garbage. But only 30% of the refuse is turned into compost; 20% disappears as CO_2 (fermentation loss) in the air. The remainder, the residue, of about 50% must be dumped. This residue consists of plastic, wood, stones, glass and still a lot of organic matter. Sifting is not for 100% effective and a part of the organics is hard to decompose. It is clear that we can produce more compost out of the refuse if the composting period is longer. But if we make the fermentation period longer, there will be a nitrogen loss, while the C/N ratio reaches a low level. In fact, compost is considered as a soil improver, but also the nutrient content is important. The importance of the nutrients will increase certainly. In future, prices for artificial fertilizers will go up under influence of the oil prices.

The analyses of the compost from the past (from the fifties) and the compost we have today are as follows (all figures are on dry base):

	1950	1980
Organic matter	10 - 20%	30%
Nitrogen	0.4 - 0.6%	1.0%
Phosphate (P_2O_5)	0.3 - 0.6%	0.8%
Potassium (K_2O)	0.15 - 0.4%	0.3%
Lime (CaO)	3.0 - 5.0%	2.5%

The compost from 1950 contained less organic matter and nutrients, only the lime content was higher. For both kinds of compost the efficiency index for nitrogen is low (this means the availability in terms of equivalent amounts of inorganic fertilizer). About 15% of the nitrogen will be available in the first year.

Especially the organic matter content has increased. We can say that the present compost is much more valuable. But out of the viewpoint of elimination of garbage, composting was much more effective in the fifties. There was only a residue of about 20%, 70 - 80% was sold as compost. Nowadays, we have 30% compost and still 50% residue. And...... the quantity of the garbage produced by one person has strongly increased. We had to dump an increasing quantity of refuse especially in the last decades. That is one of the reasons we have decided to look for other possibilities for refuse-treatment.

You have heard that at this moment the refuse contains 20 - 25% paper and about 50% plantrests. The organic part contains 30% paper and 70% other organics. Talking about composting of urban refuse means talking about this organic part. The C/N ratio is high because of the paper. For the Dutch refuse this ratio is 40 - 50.

Refuse in other countries may have a lower C/N ratio. In that case the fermentation period will be shorter. Biological reduction may be not sufficient there. If, however, the composting period is longer, then the C/N falls below 20 and nitrogen will be lost. So, the Van Maanen system is not suitable under these circumstances.

For some kinds of city refuse e.g. in those countries where the paper content of the garbage is very low, the C/N ratio might be below 20. Fermentation is not necessary then.

When using non composted garbage as a soil improver, the oxygen demand is high. The organic matter is easily decomposable and because no fermentation has taken place the organic matter has not stabilized. As a consequence this so-called compost never may worked deeply into the soil.

At this moment VAM has besides the totally unsorted, unshredded garbage (treated by Van Maanen system) another basic material for composting. This week you have heard several times about our recycling plant. Besides other fractions as paper, plastic, iron, there is also a so-called organic fraction. This fraction can be composted or digested anaerobically. We decided to compost because there is no need for more methane. We have more than we need for our total plant in the control tip. It is clear that this fraction is a totally different basic material because it is only a part of our refuse. The important specifications of this fraction for composting are:

- all particles are smaller than 15 mm; 70% is smaller than 7 mm and 35% is smaller than 3.5 mm;
- easily decomposable; it mainly consists of plantrests and kitchen garbage;
- it contains less paper;
- C/N ratio between 25 and 30;
- nitrogen content 1.2 to 1.4% on dry base.

For this material the required fermentation period is much shorter. But there may be problems because of the fineness of the material. There is a high oxygen demand, especially in the beginning of the fermentation. Anaerobic conditions could be expected soon. Experiments and experiences have learnt that turning over must be effected after a week. The concentration of easily decomposable organic matter is so high that a second turning is necessary after another week. After these two turnings the oxygen demand decreases. Two more turnings with wider time intervals are needed. A mature compost is produced after 8 - 10 weeks.

It will be clear that the result is a very different type of compost in comparison with the Van Maanen compost. The chemical analyse is as follows: (all figures on dry base)

Organic matter	40%
Nitrogen	2.0%
Phosphate (P_2O_5)	0.8%
Potassium (K_2O)	1.0%
Lime (CaO)	5.0%

As a matter of fact I must say that these figures are tentative. Of this kind of compost we have only a few analyses. For this compost the nitrogen efficiency index is about 40%; it depends on the circumstances. That means that 40% of the nitrogen is available in the first year.

When in arable farming 25 tons/ha of this compost is given, equal to 12.5 tons of dry matter, the result is a total N-gift of 250 kg of which 100 kg becomes available in the first year. In terms of energy it means: saving of more than 200 m^3 natural gas per hectare. Further there is a saving on phosphate and potassium gifts.

Heavy metals probably are not important, not yet in discussion, in the countries you come from. But in Holland it is quite a problem, especially when dealing with sewage-sludge. But also Van Maanen compost contains heavy metals. The percentages are much higher than in sewage sludge from household waste water. So VAM decided not to advise this Van Maanen compost for greengrowing anymore.

In comparison with the Van Maanen compost the percentages for heavy metals in the compost after separation are strongly decreased. The main reason for this is that by separating the refuse in the recycling plant a lot of these metals are removed at the first step.

So, you have seen that different kinds of refuse need different treatment, and that the compost quality depends on the refuse composition.

Which treatment you need depends on the kind of refuse. Of course, this is only one of the aspects. But when you want to go into composting you have, besides other information, to know the garbage composition. Starting point has always to be the specifications of the refuse.

RECYCLING TECHNICS IN INDUSTRIAL AREAS

Paper 15 by Ir R.F. Bruinsma, Waste Disposal Company (VAM), Amsterdam, The Netherlands

1) Why recycling?

Recycling is a popular word for the technical concept of urban waste separation. This is the separation along mechanical ways of urban waste into valuable components. The need for recycling arises firstly from an expected scarcity of resources. The second reason is energy conservation. Recycling of resources requires far less energy than the extraction and reprocessing of raw materials. The third incentive to recycling is an economic one: it is far cheaper than incineration or other means of modern waste handling.

2) By whom?

A government owned company like VAM, secured of income and a constant flow of waste and thus income, is in a position to take more risks than any other institution. Recycling, being highly experimental, therefore poses a risk to the investor. VAM has chosen for a recycling capacity of 125,000 tons of urban waste per year, delivery 20,000 tons of paper, 2,500 tons of iron and steel cans, 4,500 tons of plastic and 40,000 tons of compost. The present capacity can be extended. The total waste delivery in Wijster is a million tons per year.

3) Criteria

Why did we choose for this system? The following conditions were considered important:

a. the plant should be delivered as a turn-key project by one company. Only Fläkt could do so.

b. the plant should have a favourable energy-balance. Only the so called dry separation does indeed suit this purpose. Other systems have a wet separation process, which converts the waste into a wet pulp. This pulp has to be dehydrated again, before being traded. Dehydration requires (a lot of) energy.

c. the plant should be composed of standard equipment.
d. adjustment to specific regional waste handling must be possible: in every region or country the composition of urban waste is different.
e. a doubling of existing industries should be excluded. The recycling plant may not become a paper or steelfactory.
f. extension of the plant should be possible, including possible glass, aluminium and other separation facilities.
g. the environment should be protected as much as possible. Dry separation has no waste water. Through the applied total energy and purification of emissions the environment is hardly affected and the available energy resources are optimally utilized.

4) Technology

In short the technique of the plant works as follows:

- a shredder controls the waste input and opens the household bags
- mechanical sieves separate the waste into particles of various sizes
- air separation in vertical classifiers causes the lightweight parts to lift, and the heavy particles to fall down
- magnetic materials are extracted by magnets
- materials with an electrostatic load are separated electrostatically
- shrinkdrying through heat injection causes plastic to become heavier than paper, thus separating these components.

5) Energy

Power for the plant is generated by gas turbines. These produce electricity. The waste heat is used for the shrinkdryer. This combination leads to an efficient use of energy of 93%, so we can speak of Total Energy. The huge hills of residue contain enormous amounts of methane gas, far outreaching the need to operate the plant. So, the Wijster recycling plant will become 100% selfsupporting for its energy consumption.

6) Environment

The plant does not use any water. As a consequence there will be no waste water. Air from the air separators is recirculated. A central exhaust system and slight underpressure prevent dust to escape in the outdoors.

7) Sales

a. Plastics

Because of the rapidly increasing oil process plastic has become the most profitable of all recycled components. Plastic is, by contract, delivered to the chemical industry.

b. Iron

Steelcans are delivered to a detinning factory to extract the highly priced tin, the ferro-metals return to the steel-recuperation industry.

c. Paper

So far, the paper industry has not yet accepted the paper fraction. Experiments, technical adjustments and investments are necessary. A provisional solution can be found in using paper as a RDF, refuse derived fuel, for electricity generation in power plants.

d. Putrescribles

The compost is of high quality, containing only a fraction of the heavy metals which lately limited the application of compost. Now, recycling compost might be applied to horticulture and agriculture again.

e. Residue

For the moment, the residue (about 25% in weight) is dumped on the landfill. Extracting a glass fraction will be considered at the end of 1981.

8) Costs

The smallest possible industrial scale in The Netherlands turns out to be a capacity of 125,000 tons per year. Costs of a recycling factory per unit are most favourable at a capacity of 400,000 tons/year. Dependent on the expected increase of oil prices and acute scarcity of paper (pulp), the financial results of the plant will improve simultaneously.

III. COUNTRY REPORTS

WASTE DISPOSAL PROBLEMS IN THE NETHERLANDS ANTILLES

Paper 16 by Ing. R. Winkel, Department of Agriculture,
Willemstad, Curaçao

1 GENERAL CHARACTERISTICS

The Netherlands Antilles, which consist of the islands of Curaçao, Aruba and Bonaire a few miles off the Venezuelan coast and the islands of St. Martin, Saba and St. Eustatius near Puerto Rico, has a total area of 993 km^2 and a population of approximately 250,000. Thus, the islands have a relatively high population density of 250 persons per square kilometer.

Of the three leeward islands Aruba is the most densely populated and has about 65,000 inhabitants; then comes Curaçao with 160,000 and the least populated is Bonaire with 10,000 inhabitants.

A small part of the population is active in agriculture, and even then mostly only during the rainy season.

Aruba is the smallest island (19,300 ha); the next in size is Bonaire (28,100 ha), and the largest is Curaçao (44,400 ha).

The temperature shows practically no variation during the year; neither do the strong north-eastern trade-winds. Of the three islands Aruba is the most windswept.

Mean annual rainfall as measured at various stations on the islands, is for Aruba from 400 to 430 mm, for Bonaire 385 to 540 mm and for Curaçao from 500 to 600 mm. Monthly rainfall varies considerably.

2 ENVIRONMENTAL PROBLEMS

Most industrial activities take place on the island of Curaçao. Apart from incidental noise problems, there is an enormous waste problem. The necessity to attack these problems is also based on economic motives; pollution of the island may on the long run be a drag on an important source of income, namely tourism.

Irrigation and salinization of the soil

Mean rainfall in Curaçao is 570 mm a year, more than half of which falls in the three rainy months : October, November and December. It is therefore understandable that every kind of agriculture depends on irrigation. Sources of irrigation water are : groundwater, surface water, treated sewage water or destilled seawater. In Curaçao mainly groundwater is used.

The layman perhaps would expect that well-water which is pumped for irrigation purposes would repenetrate into the soil; however, this is not the case because evaporation is considerable. Open water evaporation amounts to about 9 mm a day. Conclusion : the growing of vegetables and other crops demands much irrigation water.

Excessive pumping in the coastal areas causes seawater penetration into the soil, increasing the salt content of the soil, an extremely troublesome form of pollution.

The conductivity of the groundwater virtually always lies between 1200 and 5000 micromhos. (For comparison : seawater has a conductivity of ± 70,000 micromhos.)

To raise the level of the groundwater, the surface runoff of rainwater to the sea should be prevented; in other words, infiltration should be improved. There are countless possibilities for doing this; from simple ripping of the soil to building costly reservoirs.

Another possibility for keeping the water table up to level is, to use treated sewage water. At present Curaçao is giving much attention to this possibility.

3 WATER POLLUTION

Discharges into surface waters

On the island most open rainwater drainage systems as well as many sewers discharge into the sea. Such points of sewage disposal cause foul smell and attract vermin. From a health as well from an environmental point of view, this is an unacceptable situation, making control measures obligatory.

There is a need for sewage disposal systems which are economical and/or methods of recycling water on the more arid islands; water could be recycled for agricultural purposes.

Treated sewage water resources

The utilization of treated sewage water for agricultural purposes, especially in semi-arid regions where water resources are limited, is practised in more and more countries. As long as certain provisions are made to check regularly on the chemical composition and biological condition of the treated effluent, the use of this water for irrigation is feasible.

The main feature of treated sewage water as a supply for agricultural purposes is its independence from rainfall and therefore the regularity of its supply. Evidently, in order to use it for agriculture, a regular demand throughout the year is required. If variations in demand cannot be avoided, storage or buffer tanks are required.

Another feature of treated sewage water is that it is not pure. The monitoring of its chemical composition concerns in particular certain elements such as nitrogen and chlorine.

Present situation and future possibilities

At present there is a primary treatment plant on the west side of Willemstad. Other effluents are discharged untreated into the sea, causing pollution of the shore and the beaches. This is becoming more and more unacceptable as the discharges quantities increase whereas the use of the beaches for tourism and recreation intensifies.

A new treatment plant will be built within the next two years to serve the eastern part of the island.

Considerations regarding the re-use of sewage water

Of all water resources on Curaçao the only one which still shows development potential is treated sewage water. Groundwater extraction has already reached or surpassed its limits in all areas. Surface water in the form of collected runoff is too scarce and much too unreliable to be of practical value. There are certain limitations, however, to the use of sewage water.

Health aspects

With higher degrees of purification, limitations on crop choice become less. In Curaçao we consider mainly fruits and vegetables which would almost certainly demand desinfection of the effluent.

Total salt content

Analysis of sewage water showed on the average EC values of 1000 - 2000 micromhos/cm. Very large sudden increases in salt content indicate dumping of industrial waste products. This makes it necessary to check all units connected to the sewer to avoid illegal dumping which would have desastrous effects on the treatment process and would render the water unsuitable for irrigation. In some parts of Curaçao sewers (e.g. Willemstad) are at or under sealevel. Needless to say that water from these sewers is unsuitable for irrigation.

Specific salts

SAR and RSC values of untreated sewage water show values which are acceptable (below 8, resp. below 1.25 mg/l). No data exist on heavy metals but these are not expected to cause a problem.

Other water quality problems

pH values of the sewage water are rather on the high side (7 - 8). Also bicarbonates are high but as no sprinkler irrigation is envisaged, this should not cause major problems.

4 SOLID WASTE

The waste problem

In Curaçao there is a great waste problem. Over the whole island all possible kinds of waste are found, varying from household refuse and bottles, to scrap-iron and auto carcasses; not only on the roadsides, but also in the country and along the shore. From esthetical, environmental and economical considerations, this form of pollution requires immediate attention.

Public authorities will have to take the lead, by taking care that the refuse be collected regularly.

The collection of garbage in the urban areas functions fairly well. The Sanitary Department has approximately 450 employees and rather modern equipment.

With regard to the processing of waste, the following remarks can be made. The island has a sanitary landfill; this functions pretty well, although the method of compressing the waste may be improved.

The problem of the auto carcasses will hopely be solved with the future installation of a ship-breaking yard and a scrap-iron processing industry.

A solution to the solid waste disposal problem by incineration and energy generation connected to the factories for desalinization of seawater is considered.

RECAPITULATION

Both on the Windward and the Leeward Islands of the Netherlands Antilles the following matters should be taken up soon as possible :

a) pollution as a consequence of arbitrary dumping of waste, and the system of waste processing;
b) pollution of the surface water on and around the islands due to discharge of untreated sewage water and industry effluent.

These problems have been pointed out in the report : "Research on the Environmental Problems in Aruba, Bonaire and Curaçao" of April 13, 1978 by Ir H.S. Buijtenhek and Mr P. Verfaille, and the necessity for granting priority to the same has been clearly shown.

Particularly Aruba, Curaçao and St. Martin urgently need an efficient regulation of the problems mentioned above.

Waste processing

On all the islands waste is presently disposed of by dumping it on land and in sea. These methods of waste disposal are not justified from an environmental point of view.
Disadvantages : pollution of the shore;
pollution of the soil and groundwater (minimum);
vermin;
stench;
esthetics.

Especially on Curaçao and St. Martin the negative effects are very evident. For these reasons and because the dumping capacity of these islands is not unlimited, other processing methods must be developed. The research to find solutions for the waste disposal problem was assigned to a governmental commission. The incineration of refuse should be given priority; if possible it should be connected to a factory for desalinization of seawater, which will be run on the energy from the incineration.

Treatment of sewage and effluent

On all the islands untreated sewage water and effluent water of industrial and domestic origin are being discharged into the sea and into the bays. This course of matters calls for urgent correction. In many places along the coasts of the islands the seawater is so extremely polluted, that measures are imperative. As far as it is not the case, an adequately functioning sewage system should be set up.

It is urgent to change the construction of sewage systems which are also connected to treatment plants. The effluents which are now being discharged into the sea can then be re-cycled and used for irrigation purposes. Also the sludge can be used for soil improvement.

REFUSE DISPOSAL AND UTILIZATION IN CAIRO

Paper 17 by Dr M.A. Sherif, Health Department Cairo Governorate, Cairo, Egypt

INTRODUCTION

Cairo is the capital of Egypt; population is around 6 million; total population of Egypt is 40 million.
Cairo is divided into seven districts; in each district there is a local health department responsible for all health services including environmental sanitation. Besides the chief of the district is responsible for refuse disposal.
The major problem in Cairo city is the overcrowding due to internal immigration from other governorates because of better work prospects.

REFUSE COLLECTION AND DISPOSAL

Total amount of refuse in Cairo is around 5000 tons daily from all sources i.e. 0.75 kg/capita/day.
It is divided as follows :

- 1300 tons from houses and big buildings;
- 3700 tons from streets.

Refuse from big buildings

This type of refuse is collected by the private sector from houses of higher and middle class inhabitants.
It is collected from house to house and from different appartments in the same house early in the morning.
After collection, it is transported in primitive cars to specific places outside the city and separated into different types such as :

- paper materials sent to paper mills;
- broken glass sent to glass mills;
- remnants of food materials sent to big breeding farms.

Total number of scavengers in the city of Cairo is around 5000 men and about the same number works officially in the same field (i.e. separation, reclamation, drivers and animal breeding).

Refuse from streets

This amounts to about 3700 tons daily of which 1200 tons true street refuse and 2500 tons of remnants of construction activities.

It is daily collected by the municipal employees in 5000 refuse containers which are distributed in selected places in every district.

These containers are emptied in 350 special big trucks which are designed for this work.

Then the refuse is transported to special places outside city borders where it is disposed of by different methods including incineration, dumping and controlled dumping.

Parts of the refuse collected from the northern districts of the city is disposed of by fermentation in a factory for the production of organic fertilizers.

The new trend in refuse collecting and disposal in Cairo governorate is :

- provision of adequate numbers of licensed personnel and motor cars for the collection and transportation of refuse;
- distribution of a large number of refuse baskets all over the city;
- distribution of refuse containers for all shops and trade establishments;
- doubling the circulation of the trucks for immediate transportation of the collected refuse, and
- erection of new refuse factories in different parts of the city for justified utilization of refuse.

INDIA

Paper 18 by A.D. Bhide, National Environmental Engineering Research Institute (NEERI), Nagpur, India

The urban population of 110 million (1971 census) generates approximately 15 x 10^6 tons of solid wastes every year in India. Municipal agencies spend as an average 10% of their total budget on solid waste management. An estimated US $ 70 - 100 million was being spent annually on solid waste management in urban areas in India during the period 1971-1973.

The collection and disposal is labour intensive. The manpower provision for collection, transport and disposal of solid waste per million inhabitants served is about 1000 - 3000 persons.

Community bin system is the most widely used in India. Storage bins are provided at frequent points on the roadside. They are owned and maintained by the civic authorities. A variety of bins ranging from simple cut pipe sections to parked trailers or tractor trailer combinations or containers of the container carrier system are provided. For very large collection sites, masonry structures known as Vats, chambers etc. are used.

The solid waste from individual premises as well as from roads is brought to these sites from where it is collected and taken away by municipal vehicles. The collection of waste from these bins is done at least twice a week and in the case of market areas daily or even twice a day.

The municipal solid wastes are transported to the disposal sites by vehicles mostly owned by civic authorities, though in the case of shortage of vehicles, private agencies are also hired for this purpose. In most Indian cities the common methods of processing and disposal consists of composting and landfilling. Incineration is only done in case of hospital waste.

Composting up till now was mainly done by the anaerobic pit method. In the case of towns which do not have a water carriage system night soil was composted along with it.

In 1975, a scheme on "Solid Waste Disposal" was jointly launched by the Ministry of Agriculture and the Ministry of Works and Housing. Under this scheme the Ministry of Agriculture gave one third of the capital costs as subsidy for the plant. Realizing that the infrastructure will have to be strengthened to ensure that the required quantity and quality of waste reaches the compost plant, the Ministry of Works and Housing provided subsidy to the extent of 50% of the capital expenditures required for facilities such as cleansing equipment, vehicles, garages and workshops. Up till now a total of 7 such plants have been put into operation and two more will be ready soon.

At this stage NEERI was entrusted with the task of evaluating the performance of these mechanical composting plants with a view to arrive at a system best suitable for Indian conditions. The work is going on and is expected to be completed by 1981. Most plants have capacities of 150 to 200 tons per day and the costs range from Rp 4 to 10 million (8 rupees equal about US $ 1) depending on the degree of mechanization. The operating costs of these plants range from Rp 35 to 80 per ton. The plants are fabricated completely in India. However, the individual manufacturers have collaboration with some foreign counterparts in the case of specific equipment.

For areas not having water carriage systems, and generating night-soil, anaerobic digestion to produce biogas and to utilize digested sewage as manure is being recommended. Processes for anaerobic digestion of the organic fraction of city waste have been developed and are expected to go on for full scale testing soon.

Biogas from cattledung can supply a major part of rural energy and fertilizer requirement of India. Hence a crash programme has been started in the country. The biogas generated can be used for cooking gas and lightning as well as for obtaining irrigation water from tube wells. The digested slurry can be used as a manure on the fields. Cooking gas has prevented the cutting of trees for firewood, besides providing a better and more efficient method of heating. The tube wells operated on biogas can supply protected drinking water besides supplying water for irrigation of farms. Flour mills and other plants have been operated on the biogas produced.

The extensive use of biogas sludge as manure has resulted in improved crop yields. The experience till now has also shown an improvement in sanitary conditions.

The operating costs of the community biogas plant are met by contributions from individual families and such experiments have been successful in a number of rural communities. So far 82,000 biogas plants are operating in rural India and it is the intention to increase this amount with 20,000 per year or even more.

City sewage has been quite commonly used on sewage farms for the growing of crops. Normally treated or at least partly treated sewage is used for growing crops which are not likely to come into contact with the sewage.

Oxidation pond is a very commonly used method of sewage treatment; it utilizes the abundant sunshine available in India. The effluent from oxidation ponds is used for pisciculture and the effluent is led to farms where crops are grown. This method of total recycling is being propagated and popularized in India.

SOLID WASTE DISPOSAL, THE INDONESIAN EXPERIENCE

Paper 19 by N. Makarim, Ministry of Development Supervision and Environment for Industry, Mining and Energy, Jakarta, Indonesia

As already stated by a speaker in this workshop, the aim of solid waste disposal practice is to absorb waste into the environment in such a way as to cause minimum adverse environmental impact. To achieve the aim, especially in a present day more complex society, a multidimensional approach is required. Not only technological and financial approaches are required but also institutional, legal and social economic considerations must be taken into account in planning, execution and control of waste management.

At present, collection, transporation and disposal of waste in cities and towns in Indonesia, are carried out by Municipal Public Cleansing Services. The head of the service is directly responsible to the Governor. Each district/town/city provides dumping sites for collection of waste, which later on is transported to a controlled dump. There are few exceptions as in Surabaya, East Java, where private entrepreneurs have a role in collection and transportation of waste and are paid by the Municipal Cleansing Service on the basis of volume of waste collected and transported. In Surabaya and Medan, two composting plants owned by private companies are in operation.

However, most of the present practices in solid waste management are developed on the basis of past experiences where human settlements were mostly rural or semi-rural. As those human settlements grow into metropolises, management of solid waste disposal remains on the same priciples.
The problems faced hence are :

- short term :
  with increase of population, requirement for disposal sites is increasing sharply. However, this demand has to compete with other consequences of rapid increase of population e.g. more space for infrastructure, human settle-

ments, etc. Disposal methods which require area proportional to volume of waste especially in high density populated area thus must be abandoned;

- long term :
  with the present situation on the island of Java where towns and cities merge, it was projected that in the year 2000 Java will be an "island city". This fact demands a new approach in waste management.

Facing the short term problems, municipalities in Jakarta, Bandung and Surabaya are improving their methods and equipment for collection and transport, especially in the low income areas through integrated projects such as "kampong improvement projects". In waste disposal the Government of Indonesia is placing high priority upon programmes of organic recycling in order to enhance environmental control, to improve soil conditions and fertility and to reduce wastage of non-renewable forms of energy.

Effective disposal of city wastes is a major problem and the Government wishes to convert the waste organic material into compost which has a big potential for agricultural purposes. Currently city waste is used for vegetables and horticultural crops to a limited extent only, in an unhygienic and inefficient manner. In agriculture compost is used as a complement to mineral fertilizers and to improve efficiency of fertilizers used.

Coping with long term problems as stated above is far more complicated, since a 20 year planning based on the island as a system is required. Perhaps the most difficult stage in the planning is the change of attitude toward waste itself so that the need for integrated efforts in long range planning is considered necessary. The plan would consist among other aspects of institutional building, application of appropriate technology, developing the necessary regulation/incentives and public awareness.

In the field of biogas, we consider biogas as a substitute source of energy in the rural areas. It can help to reduce the consumption of fuel wood and hence reduce the degradation of forest area, and also to reduce the consumption of kerosine. The biogas technology and composting have also the benefit such as indirectly eliminate the parasitic organisms, which can cause diseases. Therefore the utilization of biogas technology and organic recycling will also help to reduce environmental pollution and improve sanitation systems.

To give a better picture of present undertaking in waste management in project level, the following is the highlight description of solid waste management approach in the city of Bandung, West Java. The city of Bandung is the provincial capital of West Java, located at a distance of 120 km from Jakarta. Known before as "Paris of Java", today the degradation of urban conditions and services cause environmental problems and health problems as a whole.

Solid waste programme in Bandung is incorporated in "Bandung Urban Development Project", a project which consists of :

- Kampong Improvement Project
- Solid Waste Sector
- Sewarage Sector
- Drainage Sector
- Site and Services and Core Housing Sectors.

The objective of the solid waste sectorial programme is to improve quality of environment, esthetic values, pollution control and public health, and also to prevent people disposing their wastes to drainage canals, which will cause local flooding. The training and upgrading of personnel responsible for future operation of the system are also included in the programme.

In formulating the plan, decisions are required in all the elements comprising the plan. A number of decisions may be called for in each element. Some of the criteria used in this decision making process include :

1) costs - capital, operating and maintenance;
2) environmental factors;
3) resource conservation;

4) institutional - political acceptability, legal constraints, administrative capacity and social aspects.

Based on those criteria, the decisions made are among others :

- collection system recommended consists of manually operated handcarts fitted with containers to eliminate handling of waste;
- for resource recovery licencing of scavengers to operate at the fill site may result in better control over type of materials recovered as well as the control of health of scavengers;
- at present sanitary landfill is the least costly acceptable method of solid waste disposal available at Bandung due to present availability of land; for long term purposes a composting method is being studied and considered.

SOLID WASTE COLLECTION, DISPOSAL AND UTILIZATION IN KENYA

Paper 20 by J. Nguiguti, Nairobi City Council, Nairobi, Kenya

1 INTRODUCTION

Collection and disposal of solid waste does not become a problem in very small communities e.g. households in rural areas or in small villages, as the producers can dispose of it very easily either by burrying or by simply leaving it to dry followed by burning. However, in towns where the population may be large the disposal of refuse may pose problems and special attention must be paid to it. The responsibility of the solid waste collection and disposal then falls under the town authority who should look into the most economical and hygienic possibility of solid waste collection and disposal.

The responsibility of solid waste collection and disposal in Kenya falls under the medical officer of Health of the relevant municipality, urban council, town council, etc. In Nairobi, the capital of Kenya, with a population of 835,000 (August 1979), the responsibility of refuse collection and disposal falls under the Public Health Department. However, the Water and Sewerage Department was responsible in supervising some studies on solid waste disposal carried out in 1974 by SWECO as part of the Master Plan for sewerage and groundwater survey. The Department is also partly responsible in ensuring that the water courses in Nairobi are not unnecessarily polluted by either liquid or solid wastes. In this connection the disposal of solid wastes in quarries along rivers in Nairobi becomes a concern for the Department as this can greatly pollute the river water.

Some information on solid waste collection and disposal is available for Nairobi (studies on solid waste disposal by SWECO in 1974) and also for Mombasa but very little information is available from other urban areas.

As the writer is more acquainted with the Nairobi solid waste disposal system more will be written on the Nairobi system and Nairobi will be treated separately from the rest of the urban areas. The information on Nairobi is based on the 1974 SWECO report and also on some studies carried out by the writer. Information on the rest of the country is based on materials gathered by the writer while on visits to the towns.

2 POSITION IN NAIROBI

2.1 Organization

The collection of refuse and disposal as well as the cleansing of the city are the responsibilities of the cleansing section of the Public Health Department. As mentioned above the important duty of ensuring that river water are not polluted as they pass through the city, falls under the Public Health Department and Water Sewerage Department.

For refuse collection purposes the city is divided into 5 Districts each under a District inspector.

2.2 Content of refuse

Refuse in Nairobi like other industrialized towns consists of domestic,industrial and commercial solid wastes. In the first category vegetable and fruit wastes, food remains, broken glassware, papers, dilapidated furniture, bones, ashes, flower and hedge cuttings and rags predominate. The industrial and commercial wastes consist of papers, food remains from restaurants, husks from coffee factories, wastes from laboratories and petro chemical industries, wrecked vehicles, old and useless tyres, expired drugs, etc.

Analyses carried out by the cleansing section in 1973 on domestic refuse gave out the following results :

Table I

Content	Percent
1. Fine dust and small cinder (less than 1.27 cm)	9.9 - 13.5
2. Cinder (1.27 - 5.08 cm)	21.4 - 29.8
3. Vegetable and putridity	18.2 - 29.2
4. Paper	14.6 - 9.7
5. Metal (ferrous and non-ferrous)	14.4 - 2.0

Content	Percent
6. Rag (including bagging and textiles)	1.3 - 2.3
7. Glass	7.1 - 1.5
8. Rubber, plastic	2.5 - 1.4
9. Unclassified debris	10.6 - 10.7

The density of the uncompressed refuse was about 0.14.

2.3 Collection system

Refuse is collected in :

a) 70 and 90 litres metal dustbins in domestic and commercial areas;

b) 900 litres containers in commercial and industrial areas;

c) 12 m^3 containers for bulk collection.

The programme for refuse collection is as follows :

- city centre : 6 times a week
- all other areas : 2 times a week
- bulk containers : 2 - 6 times, depending on the type of refuse.

The quantities of refuse collected between 1970 and 1970 are shown in Table 2 :

Table 2

Year	Tons/day
1970	450
1971	550
1972	375
1973	445
1974	475
1975	525
1976	510
1977	550
1978	540
1979	375

The table shows clearly that despite the tremendous growth of the city the amount of solid waste has not shown that sharp increase. This is due to the fact that the number of refuse vehicles has not increased at all and instead has decreased without any replacements. The high refuse collections in 1971 and 1977 were a result of demolitions of illegal buildings and clean up campaigns organized to combat cholera during these years. The decreasing amount of refuse may also be explained by the increased sporadic burning carried out by the plot owners or the cleansing personnel when refuse has remained uncollected longer than necessary and has dried. A comparison of the refuse quantities in Table 2 above and the expected projected figures carried out by SWECO in 1974 (see Table 3) explains how the unavailability of transport can affect a solid wastes disposal system.

Table 3 : Projected refuse quantities in 1974

	Amount of solid tons/days			
Year	1972	1975	1980	2000
Domestic refuse	300	560	1000	4500
Industrial solid wastes	70	120	200	1200
Earth	100	110	130	200
TOTAL	470	790	1330	5900

2.4 Transport system

Various types of vehicles are used to transport the solid wastes (see Table 4). The refuse vehicles are allocated to the five districts according to the number available each day and these then move from household to household or area to area collecting all the refuse. When the vehicle is full the refuse is transported to the nearest tipping site.

Table 4 : Types of vehicles used to transport refuse

Type of Vehicle	Capacity	Available Feb. 1974	No. Available Feb. 1980
1. Refuse Super Compactors	15	15	6
2. Refuse Compactors (side loaders)	14	17	4
3. Refuse side loaders	7.5	20	4
4. Standard bin vehicles	7.5	12	2
5. Bulk bin vehicles	11	2	1
6. Dumpers	5 tons	7	1
7. Bulldozers	N/A	2	0
8. Tractor Shovers			
9. Lorries	5 tons	2	2

According to some studies on the collection distances and times carried out in 1974 it was found that the high density areas (250 persons per hectare) subsidize for the low density areas. The results are summarized in Table 5.

Toxic solid waste from hospitals, laboratories, industries is collected in special vehicles and is then burried at the tipping sites immediately. Collected dead animals are also burried immediately.

Table 5 : Refuse collection distances and times

District	Average collection		Average to tip	
	Travel time (hours)	Distance (miles)	Distance (miles)	Travel time (hours)
Eastern	1.25 - 1.90	2.4 - 4.3	1.1 - 5.7	0.22 - 0.33
Southern	1.53 - 2.21	7.1 - 7.8	6.5 - 7.9	0.27 - 0.37
Central	2.63	4.1	5.2	0.18 - 0.26
Western	2.45 - 4.76	6.7 - 17.9	9.6 - 12.5	0.46 - 1.03
Northern	1.88 - 4.46	4.2 - 32.9	5.8 - 10.9	0.50 - 0.70

2.5 Solid waste disposal system

The present practice used for disposing of refuse is by controlled tipping in abandoned quarries which are filled with the solids. The refuse is spread and compressed with bull-dozers into 2.5 m thick layers. The wastes are then gradually covered with a layer of soil of about 30 cm. There are currently three tipping sites being used : Dandora, Githurai and Kawangware. Tipping at the Dandora site commenced about 2 months ago and according to some rough calculations it may take about 2 years to fill the quarry. The Kawangware and Githurai tipping sites are almost filled up and new sites in these areas must be located soon if long travelling distances by the refuse vehicles are to be avoided.

Hundreds of marabou birds were observed at the Githurai sites. During a visit at the three sites on 9/10/80 strong stenches emanating from the sites were noticed. Animal and bird scavengers were noted at the Githurai site while people scavengers were present at the Dandora site. The more than 50 people at Dandora including women, men and children were salvaging metal scrap, dilapidated furniture, papers, pieces of leather, etc. These are believed to be sold later.

Three previously filled quarries namely Industrial area along Ngong river, Kariobangi and Dandora have been completely reclaimed and some factories including a three storied building have been constructed at the Industrial area site. Plans are already in hand to convert the Kariobangi site into a recreational area.

2.6 Air pollution in areas with tipping sites

For miles around tipping sites where the refuse has not been covered for some time due to the unavailability of transport strong stenches will be noticed. Fires at the Kariobangi tipping site burned for many months. Investigations showed that methane gas was coming from the filled quarry.

2.7 Pollution of water courses

Nobody has so far done any study on the pollution of the water in rivers passing near old quarries or on groundwater in areas near the refuse dumping areas. This, however, is not to say that the disposal od refuse does not cause pollution of water. As part of the industrial survey which has already been started by the Sewerage Section water samples will be taken from points downstream and upstream of the old filled quarries along Nairobi Ngong and Mathare rivers and these will be analysed to determine if the disposal of waste solids has caused any pollution.

3 POSITION OUTSIDE NAIROBI

3.1 General

Unlike Nairobi where a study has been conducted on solid wastes collection and disposal very little information is available from other urban centres. Some information, however, is available from Mombasa and from a few other towns. Due to the shortage of finance in most of the urban centres very little attention is paid especially to the disposal of the solid wastes. Various means of transport are used for the collection but after that nobody cares very much whatever happens to the refuse.

3.2 Composition of the refuse

The contents of domestic solid wastes may vary from town to town depending on the habits of the different type of people, standard of living, etc. but basically will be similar to that found in Nairobi. The industrial wastes will also differ depending on the type of industry. In towns where there are very few industries e.g. Nakuru the greatest percentage of wastes will be domestic and commercial. Other towns such as Thika with quite a number of industries will of course have more industrial solid wastes.

3.3 Collection system

The collection of solid wastes in many towns in Kenya is carried out in a similar manner as it is done in Nairobi e.g. in Mombasa, Kisumu and Nakuru but on a smaller scale. Open vehicles are used in some towns while tractors with trailers and tippers are used in others.

3.4 Disposal system

Most of the towns use uncontrolled tipping in quarries, murram pits, creeks (for example in Mombasa) while other towns just dump the wastes in open areas. Scavenging by people, animals and birds is a common sight in many of the refuse disposal sites and it is not uncommon to find some people eating food remains. Any article of value is salvaged and may find its way back to where it came from e.g. papers, bottles, cans, etc. Burning of the refuse is carried out frequently, so in places where the refuse dumping is too close to public roads or residential areas e.g. in Mombasa, Limuru and Thika, the stench from the burning is often unbearable. In other areas papers and other light materials are blown by the wind for miles around.

4 SHORTCOMINGS IN THE PRESENT COLLECTION AND DISPOSAL METHODS

Frequently we read in the papers complaints on uncontrolled garbage which has commenced to decompose and has become a nuisance to the public.

In more than 90% of the cases the reasons given for the failure by the local authority has been the unavailability of vehicles due to breakdowns. In towns like Nairobi the situation has been very critical and it was common to see refuse uncollected for 2 weeks where the collection whould have been 4 times in that period. The collection has however improved in the recent weeks. Lack of finances for buying new vehicles has been the main cause of the inadequate services. The other causes of unsatisfactory collection and disposal of wastes have been identified as :

a) provision of irregular transport due to unavailability of spare parts for repairs;
b) unavailability of economical refuse dumping sites;

c) lack of any tipping sites;
d) discarding of refuse by hawkers and squatters in crowded areas or pavements where access roads are not available.

5 THE FUTURE OF THE CURRENT METHODS OF SOLID WASTE DISPOSAL

Considering the rate at which refuse is increasing (see figures for Nairobi - SWECO - 1974 - Table 3) it will be almost impossible in the near future to get rid of it in the big towns by the current disposal method. Nairobi is lucky in that the existing tipping sites and others will take some time to fill. Consideration must however be given to the pollution of the waters in Nairobi rivers by the leachates from the quarries. Air pollution in the estates around the tipping sites must also be considered.

In other towns where the only method has been the uncontrolled tipping or dumping in the open land and then burning, studies need to be carried out with a view to finding the most hygienic and economical methods.

In the survey carried out in 1974 for Nairobi several methods such as open composting, accelerated composting, incineration, etc. were considered.

The open composting method was recommended and it is understood that proposals have already been invited with a view to instal a compost manure plant for Nairobi.

SOLID WASTE DISPOSAL AND UTILIZATION IN SRI LANKA

Paper 21 by C.M. Kulasekera, Deputy Municipal Commissioner,
Colombo, Sri Lanka

Area : 24,959 sq. miles
Population : 14 million
Capital city : Colombo - area = 35 sq. miles
population = 700,000
floating population = 1.2 million

Solid waste disposal in Sri Lanka has not been a serious problem in its past except in its urban areas and in particular in its municipal towns of Colombo, Kandy, Galle, Jaffna, Batticaloa, Dehiwala, Mount Lavinia, Ratnapura, Badulla, Matale, Negombo, Kurunegala and Nuwara Eliya where concentrations of population has been heavy due to employment, schooling and trade.

Waste disposal in other local authority areas has not posed any serious problem as yet due to availability of land, deserted quarries, etc. for disposal of garbage and night-soil (small percentage composting being also done by individual land owners in the rural areas).

Seventy five percent of the rural population are farmers and they use the waste in the rural areas as manures : also tiny unsophisticated incinerators have been built by small local authorities for burning of waste. The rapid conversion of dog earth or bucket latrines to watersealed type latrine has also reduced the necessity for disposal of night-soil. A major portion of the city of Colombo is served by sewage.

Problems of waste disposal in the Colombo municipal area

We would like to focus some attention on the growing problem of waste disposal in Colombo. The quantity of waste collected by the municipal council is in the range of 250 ton per day. There are three municipal dumps in the city and they are fast reaching saturation point : the 2 old fashioned incinerators which were installed in the northern and eastern areas of the city over 50 years ago have outlived their period of usefulness. Very little use is made of the incinerator in the eastern area and the one in the north has been demolished.

Sources of solid waste

The main sources of solid waste are domestic, commercial, street cleansing and industrial waste. Domestic waste contributes the greater percentage, with street sweepings coming next.

Constituents of the waste

The major constituents of the domestic and street cleansing waste are food remnants, house sweepings, waste papers, empty containers and debris. Commercial waste is composed mainly of the waste produced by shops, offices, hotels, eating houses and hospitals. Industrial waste includes demolished materials from building sites (considerable at the moment because of the building boom), packaging materials, lefts-overs of metal, wood or hard board, textiles, glass and leather. Fortunately most of the few industries in the city arrange their own methods of waste disposal.

The major constituents of industrial waste are paper, wood, little metal and fermentable organic matter.

Collection and transport

The collection and transportation of solid waste is the most costly phase. The city of Colombo is served by 50 vehicles which consist of garbage lorries and tractor trailers. The city is divided into 47 areas, each having a technically qualified area officer.

The vehicles are deployed by a central transport officer to each of the 47 areas, but to highly commercial areas like Colombo port and Pettah area additional vehicles are given daily. From these areas waste is removed both by day and by night. The narrow streets and lanes are served by 47 mini tractors and trailers, one for each area.

Residents are required to place their refuse in bins and place such bins outside. The content of these bins are emptied into the collection vehicles, each of which is manned by six labourers.

The municipal council employs some 3000 persons and spends about 20% of its budget on waste management.

Every effort is being made to remove the waste of each area daily, but this may not be possible if vehicles break down or if there is heavy rainfall. The backlog of waste not collected tends to promote problems including severe criticism and additional vehicles have to be deployed.

Problems faced by city administration of Colombo

1. Collection - non availability of vehicles.
   Most of the vehicles break down daily as they are 20 years old and spare parts are not available. Purchase of new vehicles is not possible due to severe financial constraints in the city budget.
2. Non availability of suitable temporary dumps, which would be used by mini tractors and hand carts to bring lane refuse for removal.
3. Disposal.
   There is an inadequacy of land suitable for sanitary fill as well as insufficient machinery for levelling and compacting the waste.

Solutions

1. Purchase of a fleet of vehicles on the basis of one large modern waste removal truck, one small lane lorry and two mini tractors for each area.
2. Purchase of additional 30 containers, which could be used as temporary dumps, to be placed in the commercial areas of the city close to markets, etc. These containers have to be removed by tractors and be emptied at the dumps.

3. It is suggested that six small and simple compost plants be installed in each of the six districts, into which the city of Colombo has been divided. The compost produced could be sold to the Agricultural Department and to the State Plantations Corporation.

BOMBAY

Paper 22 by F.A. Attarwala, Municipal Corporation of Greater Bombay, Bombay, India

In addition to what Dr Bhide has said on the rural areas of India, I have some remarks on the waste situation in Bombay.

Bombay is one of the largest cities of India, having a population of 8 million people, spread over an area of 437 km^2. As it is situated on an island it is difficult to find waste disposal sites. So far low lying marshy lands were used for this purpose.

Daily waste production is over 3000 ton (450 gram per head). The waste is collected from the houses or from the community dumps and transported daily by 350 vehicles, working in 2 shifts, over a distance of some 30 km to the various dump sites. Road sweeping is done manually.

Originally the dumping sites were outside the city, but as the city is growing rapidly these sites become part of the city, so that the nearby population objects against the practice of waste dumping. That is why we had to look for other solutions.

Incineration was tried on a small scale. It appeared that it was not a suitable method. Due to the high moisture content (50-60% in the monsoon) the oil consumption was very high. The costs of incineration were calculated to be 150 - 280 Rp/ton against 6 - 8 Rp/ton for landfill. Last November a 300 ton capacity composting plant was commissioned and it will be completed shortly. So far 8000 ton of compost has been produced, which could be easily sold. At the moment the content of glass particles in the compost is still too high, but we hope to overcome this problem rapidly.

In Bombay it is not possible to plan for a period beyond 5 -10 years because of the rapidly changing circumstances : waste composition (which also differs from place to place and from season to season), population explosion, industrialization explosion, etc. Moreover no one single solution is possible for the entire city.

Special solutions are also necessary for the hospital waste. This waste may not be handled manually and dumped. Therefore special incineration plants have been built to burn this hazardous waste.

IV. SUMMARY OF DISCUSSIONS

I Hygienic aspects

Q Is hand sorting of refuse on landfill sites and in recovery plants acceptable from the standpoint of health?

A Common practice is that hand picking takes place, although there is a danger for the people involved. Particularly glass splinters may cause infections. For hygienic reasons feeding of nightsoil to a composting plant is not recommended.

C In India it was noticed that workers in refuse processing plants have a higher risk in getting diseases than other industrial workers, partly because they do not strictly follow the regulations (use of gloves etc.).

II Waste collection

Q In the Indonesian study the use of newly imported vehicles was recommended. Several speakers question this recommendation. Generally it is difficult to obtain spare parts so that maintenance is not possible for a long time. In Istanbul 40% of all vehicles is out of service, which makes a regular waste collection impossible.

A Locally made equipment is to be preferred, but is not available everywhere.

C In connection with this it is regrettable that the World Bank provides only loans for imported equipment. The main reason of the frequent break down of imported vehicles is that they were not designed for the prevailing working conditions. In many cases they are not constructed for waste collection at all. New vehicles are commonly used for transport of building materials etc. and only when become too old for this purpose, they are put into use for waste collection. That's why it is suggested as is done in India, to standardize the vehicle park. Another reason for the difficulty in obtaining spare parts is that the automobile industry too frequently changes its models.

Q How can people be persuaded to participate in a project, aiming at improving the waste collection system? How can people be prevented from continuing the easiest way of waste disposal, that is to discard the garbage in the nearby river? Regulations can be made, but they are hard to control.

A The following suggestions were mentioned:
- through a pilote project people can see how living conditions are improved
- education at school
- extention through newspapers, radio and television
- the use of cultural and folkloristic facilities to bring the message to the people
- strict legislation
- study the possibilities to purchase the waste from the people to give them a financial incentive.

C When setting up a new collection system a good coordination with the public work authorities is necessary.

A Yes, containers should not obstruct the traffic.

Q Are plastic bags being used for waste collection in Instanbul?

A No, they are too expensive in Turkey to be used for this purpose. The best solution would be some kind of dust bin.

III Methods of waste disposal

Q It was mentioned that in London sanitary landfill as well as incineration is applied. Why was not the same method of waste disposal chosen for the whole city?

A For a city of London with 7.5 million inhabitants there is not just one solution, which suits all conditions. All depends on the circumstances and available facilities. In London excisting mineral extraction pits could be used as landfill sites. Composting was not feasible because of the high transport costs.

Q What criteria should be used in selecting the proper method of disposal?

A The first criteria is to find the lowest cost solution, which is environmentally acceptable.

C For decisionmakers a feasibility study is not sufficient. What is certainly required is a cost/benefit analysis.

C To carry out a cost/benefit analysis is a good exercise, but if e.g. no land is available composting is the only remaining method, and then it is automatically economical.

C Composting is not the cheapest way of waste disposal. Controlled tipping is cheaper, but incineration is more expensive and not without problems.

Q What is the best way of utilizing waste from slaugther houses? Can it be composted?

A It is admitted that this is an important source of material to be recycled. FAO will study this subject in the near future.

Q What is the use of shredders in waste disposal?

A They do not solve a problem, so their use in developing countries is not recommended.

Q What is the best method to train professional and technical staff in solid waste disposal methods?

A Sending people to western countries for training is of limited use, as the technique required is different. It is better to train people in their own country even if experience in waste disposal does not yet exist. Together with experienced people from abroad the problems have to be studied and possibilities evaluated.

IV Sanitary landfill

C The experience with sanitary landfill in India is that no bulldozers or other expensive equipment for compaction is needed. The initial density of the waste is already pretty high (500-600 kg/m^3). The vehicles unloading the waste and moving over the sites cause a further increase in density to values of 1000-1100 kg/m^3, which is much higher than obtained at sites in developed countries.

C Leachates from landfill sites are highly polluting, so that contamination of grondwater or waterways must be prevented.

The use of plastic liners as suggested is beautiful for developed countries but too costly for most developing countries. Sufficient protection can be achieved when using unpermeable soil layers. Sanitary landfill must be as cheap as possible, otherwise municipalities will never adopt this method, but continue uncontrolled dumping.

Q In the Indonesian study no attention was paid to an improvement of the crude dumping system. Why did not you suggest to start controlled tipping?

A There was no budget for that. The improvement of the waste collection had the first priority.

Q Sanitary landfill is a good system of waste disposal, but what if no land is available?

A Then other possibilities must be studied. Initially people looked for depressions to be used as landfill sites, but there are many examples where the waste is dumped above ground, so that hills are created. This can be done safely if leaching to open water is prevented.

Q How to manage landfill sites under conditions of heavy rainfall?

A The sites should be properly chosen and the access roads should be well maintained. The latter is not an engineering but a budget problem.

V Composting

C The problems mentioned on setting up composting plants are dealt with in India as follows:
- the Ministry of Agriculture subsidizes 1% of the capital costs
- The Ministry of Housing supplies 50% of the infrastructure
- commonly the local government provides the land.

Remaining problems are mainly with the equipment. The marketing is done through an Agro Industry Corporation, which has professional experience in this field.

C The set-up of a mechanical composting plant in Bombay with a capacity of 300 ton compost per day is as follows:

- 1/3 of the plant is owned by the civic authorities
- 1/3 by the manufacturer
- 1/3 by the marketing organization.

This formula guarantees that all important aspects, the supply of raw material, the construction and the marketing, are involved. Nowadys 8 mechanical composting plants have been set up in India. These plants will be evaluated now to study which type of plant is most suitable for future projects. The Indian experience is that turn key projects may be two times more expensive than less mechanized ones and do not yield better compost. It is of major importance to keep the production costs as low as possible as the price of the compost determines whether a compost project will fail or succeed.

A Sophisticated machinery plays a little role in producing a good quality compost, because composting is essentially a microbiological process. Nevertheless there is a necessity of mechanization if dealing with vast quantities of waste, but the degree of mechanization must always be kept to a minimum. Developing countries can learn from each other in this respect, because composting is a field where there is no competition.

C There is a United Nations programme, called TCDC, Technical Cooperation among Developing Countries, to which countries can apply for assistance in formulating their problems.

C The necessity of marketing is usually underestimated. Too often marketing starts when the plant has already been built, so that it may appear that the production cost is higher than the price the consumer wants to pay. That's why it is preferable to do it other way around. First the market has to be studied to determine the maximum price the user can afford. Accordingly the plant has to be designed as well as the fee the municipality has to pay for disposing its waste through the composting plant.

Q But how can a reasonable comsumer's price be set, if the consumers do not know the product?

A Prior to the construction of a full scale plant a small pilote plant with a capacity of around 3 tons/day should be set up. This plants feeds its product to demonstration plots for a period of 2-3 years. In this period the farmers can become convinced of the value of the compost and the price be set.

Q What is the price the farmers can pay for compost in India?

A 50-85 rupee per ton. For the low quality untreated material the farmers took from the dumping sites before the composting plants were started, they paid 30 rupees per ton.

VI Utilization of waste and waste products in agriculture

Q In Benin is was shown that fresh town waste could be applied in horticulture succesfully without composting. Is it possible to apply the Benin method in other countries?

A The circumstances in Benin might be rather exceptional with respect to the low C/N ratio and the very high organic fraction (90% or more).

C In Conakry comparable conditions were met with.

C In India the experience is that compost gives better results than non composted materials probably because of the rise in temperature in the soil when applying the latter.

C If the initial C/N ratio of the waste to be composted is as low as it was in Benin (around 10) no ammonium sulphate should be added, because this would result in losses of nutrients and in an increased time needed for composting. It would have been better to add sawdust.

C Because of the existing objections against the use of nightsoil as a manure, it is suggested to utilize this material for the production of biogas.

C Sewage sludge in developed countries may contain an unacceptable high level of heavy metals due to the presence of industrial wastes. It is the Indian experience that in developing countries, where industrialization is much lower, the concentration of heavy metals is low, so that this product can safely be used in agriculture.

C The mentioned favourable effect of sewage sludge on crop yield in India might be explained by its pretty high Zn content. Several soils are known to be deficient in this element.

C The necessity of recycling of organic matter is stressed as well as the major role agriculture plays in this activity. Proper technology has to be developed to promote recycling under different cropping systems.

C Nitrate content in compost is lower than in the initial material.

Q Is it possible to increase the organic matter content in tropical soils?

A The effect of an organic fertilizer can not be permanently because sooner or later it will decompose. Because of the higher mineralization rate in the tropics applications of organic fertilizers must be higher or more frequent than in temperate areas to maintain the required level of organic matter in soils.

VII Biogas

Q Is the biogas system, developed by IMAG, based on continuous use?

A The system is based on daily feeding, but as in summer the energy need is low, the loading rate is lowered then, which decreases the efficiency.

Q Does this system contribute in pollution control?

A To a certain extent, but it is not the first aim.

Q What is the reduction in BOD?

A No exact figure can be given as it depends on:
- concentration of the influent
- type of manure
- retention time.

Q What is being done with the digested manure?

A It is used as a fertilizer, but in certain areas it is difficult to find sufficient land to apply to.

C In Bombay a complete recycling system has been developed on a pilote scale dairy farm.

The gas orginating from the animal manure is used to generate electricity to run the laboratory for testing milk quality and to operate the pumps, which distribute the urine and stable wash water over the fields. The food remnants are mixed with the digested slurry to yield a fertilizer.

Q What is your experience with the use of a floating gas cap?

A It is difficult to keep a floating gas cap in balance, so a fixed type is preferred.

Q What is your gas storage system?

A The storage tank is made of a synthetic material. The capacity is 100-150 m^3. The investment costs are around 2500 US $, which is much cheaper than using compression or storage under pressure.

Q Do you use a gas turbine for the generation of electricity?

A A normal car motor rebuilt for gas utilization is applied.

VIII Financing and organization

Q What is the relation between waste collection and disposal and income?

A In many big cities the poor people do not receive any municipal service, like water supply and garbage collection, because they can not pay their tax or they are not even registered. So the budget of the municipality is very low. In many cities it is physically impossible to manage the waste problem because of the rapid growth of the city and the insufficient budget.

C If in a region several municipalities cooperate with respect to waste disposal it is necessary to create an authority to supervise this activity, otherwise the World Bank can not finance such projects.

APPENDIX I : RESOLUTION

The participants in the VAM/KIT Workshop on "Solid Waste Disposal and Utilization", held at Amsterdam, The Netherlands, from 13 - 17 October 1980

1. aware of the need to utilize refuse as a resource
   - for the production of energy;
   - for the production of food and fodder;
   - as organic fertilizer;
   - as construction materials;
2. bearing in mind that the recycling and the utilization of refuse could be a very important source of employment generation;
3. aware of the environmental and health risks in connection with solid waste disposal;
4. aware of a huge amount of scientific knowledge on the subject available at scientific institutions in the developed as well as the developing countries on solid waste disposal and utilization;
5. aware of the several information exchange services as there are:
   - UNEP-Infoterra
   - FAO
   - UNIDO
   - WHO;
6. realizing that there is a need for knowledge and for exchange of information on planning, design, management, operation and maintenance of disposal and utilization of solid wastes in developing countries;
7. realizing that in practice there are limited possibilities in obtaining information through the above mentioned information exchange networks of the several international organizations;
8. express the need
   - to improve the exchange of scientific knowledge, the exchange of information on feasibility studies of residue

utilization and the exchange of applications of knowledge and techniques on the disposal and utilization of solid waste within the social economic context of developing countries;

- to organize meeting points of technicians in the field of application from developing countries;

9. request the Government of The Netherlands to organize a follow-up of this workshop in about two years time somewhere in the world;
10. and also request the Government of The Netherlands:
    a) to assist in the above mentioned needs by establishing as a starting point an informal information network between the participants of this workshop and others interested cooperating closely with Infoterra, etc.;
    b) a coordination role of VAM/KIT, amongst others to issue a newsletter.

Such an initiative would highly contribute to the solution of a sofar widely neglected major problem, the disposal of solid waste and the related conservation or deprivation of the soils.

This resolution, having been accepted by the participants, is brought to the attention of the Government of The Netherlands on October 17, 1980.

Names

Ing. Marco Correa, Jefe de Empresa de Saneamiento Ambiental, Quito, Ecuador

Dr Mounir Sherif, General Director for Waste Disposal, Cairo Governate, Egypt

Mr F.A. Attarwala, Director Solid Waste Management of Greater Bombay, Municipal Corporation of Greater Bombay, India

Mr Shri A.D. Bhide, Scientist and Head Solid Waste Division, National Environmental Engineering Research Institute, Nagpur, Maharashtra, India

Dr Dilip Biswas, Principal Scientific Officer, Department of Science and Technology, New Delhi, India

Dr K.K. Singh, Senior Research Officer, State Planning Institute, Lucknow, India

Dr D. Muljadi, Director Soil Research Institute, Bogor, Indonesia

Ir P. Sidabutar, Project Manager, Bandung Urban Development Project, Indonesia

Mr R.M. Dipokusomo, Sector Manager, Bandung Urban Development Project, Indonesia

Mr Nabiel Makarim, Deputy Assistant to the Minister, Ministry of Development, Supervision and Environment for Industry, Mining and Energy, Jakarta, Indonesia

Mr Josph Nguiguti, Civil Engineer, Nairobi City Council, Kenya

Mr Paul Ewagata, Producer Environmental Radio Programmes, Voice of Kenya, Nairobi, Kenya

Mr M.G. Fowler, Bonaire, Head of L.V.V., Bonaire, Netherlands' Antilles

Ing. R. Winkel, Head Department of Agriculture, Animal Husbandry and Fisheries, Curaçou, Netherlands' Antilles

Mr J. Francisco, Director Sanitation Department, Curaçao, Netherlands' Antilles

Mr Abdullah Kassem Ghleb, General Manager, Refuse Disposal and Collecting Service, Sanaa, Yemen

Mr C.M. Kulasekera, Deputy Municipal Commissioner, Colombo, Sri Lanka

Mr T. Kanagasingham, Engineer Colombo Municipal Council, Colombo, Sri Lanka

Mr Imad El Din Sabri, General Secretary of Damascus Governate, Municipality Damascus, Syria

Dr Adib Talib, Director Health Department, Municipality Damascus, Syria

APPENDIX II : PROGRAMME OF THE WORKSHOP

Koninklijk Instituut voor de Tropen
Mauritskade 63, Amsterdam

<u>Monday, October 13, 1980</u>

10.00 - 11.00 hrs	Registration
11.00 - 12.00 hrs	Informal introduction and meeting of participants
12.30 - 13.30 hrs	Luncheon
	Day-chairman : Ir F. Deeleman, President KIT
14.00 - 14.15 hrs	Welcome address by Mr Th. Laan, President of the Board of Directors of VAM
14.15 - 14.30 hrs	Opening of the Workshop by Dr W.M. Otto, Ministry of Agriculture and Fisheries
14.30 - 15.15 hrs	Keynote address by Dr Ashok Khosla, UNEP "Environmentally Sound Management of Solid Wastes"
15.50 - 16.00 hrs	"The Organic Cycle", a VAM-documentary on Urban Waste Disposal Practices in Kenya and India
16.00 - 17.30 hrs	Reception, offered by the Director-General Land Development and Forestry, Ministry of Agriculture and Fisheries

<u>Tuesday, October 14, 1980</u>

	<u>Disposal of City Waste - Sanitary Aspects</u>
	Day-chairman : Jhr Mr D.J. de Geer, Ministry of Public Health and Environment
09.00 - 10.00 hrs	Mr P.T. Patrick, WHO, Copenhagen "WHO-activities in the Field of Solid Waste Management"
10.00 - 11.00 hrs	Prof.dr H.L. Wolff, Institute of Tropical Medicine, Leyden, "Health Aspects of the Elimination of Refuse and Solid Waste from Society"
11.00 - 11.30 hrs	Coffee break

Tuesday, October 14, 1980 (cont.)

11.30 - 12.30 hrs	Ir B.G. Kreiter, SVA. "Solid Waste Disposal of four Cities in Indonesia. Report on a project for technical cooperation"
12.30 - 13.15 hrs	Luncheon
	Collection of City Waste
	Excursion to the Municipal Incineration Plant of Amsterdam
13.15 hrs	Departure from KIT to Incineration Plant by boat
13.45 hrs	Arrival Incineration Plant
13.45 - 14.00 hrs	Welcome/coffee
14.00 - 14.45 hrs	Introduction to the incineration process
14.45 - 16.45 hrs	Excursion in two groups
16.45 - 17.00 hrs	Questions/drinks
17.00 hrs	Departure to KIT by boat

Wednesday, October 15, 1980

	Waste Utilization - Compost
	Day-chairman : Prof. dr ir A. van Diest, Agricultural University, Wageningen
09.00 - 10.00 hrs	Dr C.S. Ofori, Soil Resources, Management and Conservation Service, FAO. "Organic Recycling in Agriculture in Developing Countries"
10.00 - 11.00 hrs	Ir R.M. Schelhaas, KIT. "Compost as Fertilizer and Soil Amendment"
11.00 - 11.30 hrs	Coffee break
11.30 - 12.30 hrs	Dr ir G.J.H. Grubben, KIT. "Town Refuse for Vegetable Production"
12.30 - 13.30 hrs	Luncheon
	Waste Utilization - Energy and other products
14.00 - 15.00 hrs	Dr M. Maung, UNIDO. "UNIDO-activities in Composting of Municipal Solid Waste"
15.00 - 15.30 hrs	Mr J. Freedman, World Bank. "Solid Waste Disposal, Financial Considerations"
15.30 - 16.00 hrs	Prof. ir A.A. Jongebreur, IMAG. "Production of Biogas on Farm Scale in The Netherlands"

Wednesday, October 15, 1980 *(cont.)*

16.00 - 16.30 hrs	Tea break
16.30 - 17.30 hrs	Mr C.A. Shacklady, ILOB. "Upgrading of Organic Residues in Rural Areas"

Thursday, October 16, 1980

	Excursion to the VAM Compost and Recycling Plant at Wijster
08.00 hrs	Departure from KIT
10.00 - 10.30 hrs	Arrival Wijster/coffee
10.30 - 10.45 hrs	Welcome address by Ing. P.J. Houter, Acting Director
10.45 - 11.05 hrs	VAM-film
11.05 - 11.30 hrs	Mr J. Oosthoek. "Composting in The Netherlands, Refuse Composition and Compost"
11.30 - 12.00 hrs	Ir R.F. Bruinsma. "Recycling Technics in Industrial Areas"
12.00 - 12.30 hrs	Evaluation : questions
12.30 - 13.30 hrs	Aperatif/luncheon
13.30 - 15.00 hrs	Excursion Compost Plant and Recycling Plant
15.00 - 15.15 hrs	Coffee
15.15 - 15.45 hrs	Ing. C.J.W. Mora. "Marketing of Compost"
15.45 - 16.00 hrs	Evaluation
16.15 hrs	Departure
18.00 hrs	Arrival Amsterdam

Friday, October 17, 1980

	Day-chairman : Ir H.Ph. Huffnagel, Director Department of Agricultural Research KIT
09.00 - 11.00 hrs	Contributions by participants on alternative solutions of waste disposal and utilization in participants' countries (5-10 min. talk)
11.00 - 11.30 hrs	Coffee break
11.30 - 12.30 hrs	Continuation morning programma
12.30 - 13.30 hrs	Luncheon
14.00 - 16.00 hrs	Discussion on conclusions and follow-up
16.00 - 16.30 hrs	Tea break
16.30 - 17.30 hrs	Continuation afternoon programme
19.00 - 21.00 hrs	Farewell dinner

APPENDIX III

Explanation of abbreviations of international organizations

UNEP - United Nations Environment Programme

WHO - World Health Organization

FAO - Food and Agriculture Organization

UNIDO - United Nations Industrial Development Organization

WB - World Bank

Translation of abbreviations of Dutch Institutions

VAM - Waste Disposal Company

KIT - Royal Tropical Institute

SVA - Institute for Waste Disposal

ILOB - Centre for Animal Nutrition Research

IMAG - Institute of Agricultural Engineering