The public health and economic aspects of composting night soil with municipal refuse in tropical Africa

C. PEEL

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Africa is a world in perpetual transition, a world of endless possibilities where predictions are often false. How could it be otherwise for history has never moved more rapidly than here.
C H Favrod

INTRODUCTION

The continent of Africa has a total area of 30.3 million square kilometres of which some 23.3 million square kilometres lie within the tropics, a far higher proportion of tropical territory than any other continent. Tropical Africa, in current jargon 'Africa South of the Sahara', is bounded in the North by the Sahara and in the South by the Kalahari. Because of the barrier of these great deserts, lack of navigable rivers along the coast line and the virulence of its endemic and epidemic diseases, this vast land mass remained in isolation from the rest of the world almost until the present century. Indeed the modern era of exploration and development is not much more than seventy five years old; prior to this period little was known of the true nature of the African environment.

Within the many independent countries forming the region there is found a range of environmental conditions which does not exist anywhere else in the world, including great differences in climate, a wide variety of flora and fauna and of tropical disease. There are also tremendous differences in languages, religions, customs and, above all, in political patterns. Whilst the principal feature of tropical Africa may well be its diversity there is one common denominator in the fact that agriculture forms the basic economy of almost every territory and farming of one type or another absorbs the energies of around 80% of the total populations. Although there are many large modern cities throughout the continent, the peasant farming communities pass their lives in rural surroundings in family groups and for this reason Africa has been called a 'continent of villages'.

The post-war years since 1945 have seen tremendous developments in the field of public health. This has been the era of the residual insecticides and antibiotic therapy which have made possible the control or elimination of many of the diseases which in the past have involved tremendous mortality particularly among children. Modern techniques of death control have been applied on a massive scale as a result of which human numbers are increasing at an accelerating rate in almost every territory and each government is faced with the grim task of providing the extra food necessary to keep their people alive.

It is not generally realised that the dramatic results achieved by the use of these disease-control measures have not been matched by corresponding improvements in the general health level of rural populations. More people stay alive and their life span is extended but they continue to suffer from a range of chronic debilitating diseases, the transmission of which is related to poor environmental conditions and insanitary habits particularly with regard to the disposal of human and animal excrement and community wastes.

The treatment of this material by properly organised sanitary composting methods can be of significant help in controlling these infections which apart from causing untold misery are of tremendous economic importance. Furthermore, the end product of the composting process when applied to the land provides a most valuable soil conditioner and fertiliser since it contains most of the plant nutrients originally present in the wastes.

AFRICAN AGRICULTURE

African agriculture developed within a traditional pattern of peasant farming based on subsistence crops. Land was plentiful and each family practised the notorious 'shifting cultivation': a patch of bush was cleared initially by burning and the resulting ash was dug into the soil; tree stumps were left in the ground and crops were planted and harvested season by season until the soil lost its fertility. The farm was then abandoned and left fallow, secondary bush established itself, humus was formed and this helped to regenerate the soil. In the meantime the family had cleared an alternative farm and the whole process of planting and harvesting was repeated until lack of fertility forced another move. Even today the clearing of new farms by burning is a familiar sight over most of tropical Africa in the weeks preceding the wet season and dense clouds of smoke are to be seen in most of the rural areas. The burned debris, when added to the top soil, provides much needed phosphates and potash.

This system worked reasonably well under former African conditions of a subsistence economy where there was ample land and each family only cultivated enough to provide themselves with food. The ravages of disease kept human numbers within the limits of available resources and there was no pressure of population upon land. In the post-war years, however, the scope of agriculture has changed. Lucrative overseas markets have been created for tropical crops such as ground nuts, coffee, cacao, beniseed, ginger etc and the old subsistence farming is giving way to a cash crop economy which is encouraged by the increasing availability of consumer goods imported from the developed countries.

The past thirty years have also produced radical changes in the field of public health, which have resulted in ever-increasing populations.

Thus, as agriculture advances in Africa more and more calls are made on the land and the maintenance of soil fertility becomes of paramount importance, the food required for vast and increasing populations together with the ever-expanding cultivation of cash crops are making enormous demands on primitive farming systems. Shifting cultivation is still widely practised but much larger areas of land are annually under crops and in many areas the balance between land actually under cultivation and that available for crop production when loss of fertility enforces a move has become seriously affected.

The casual traveller in rural areas in Africa is apt to obtain a false impression of the fertility of the local soil from the rich growth of vegetation of many kinds always to be seen in the primary bush (forest areas which have never been under cultivation). In fact the bush makes its own humus and to some extent its own climate. Once the forest cover has been removed for cultivation the soil begins to degenerate and becomes eroded by winds and rain. Soil erosion is a major problem in peasant agriculture throughout Africa, primitive farming practices being the main contributing factor. All governments are making strenuous efforts to teach their rural populations modern ideas of land conservation and improvement. A further factor affecting soil quality is the fact that rainfall over most of the region is confined to a short wet season followed by a long annual dry period and most of the natural soils are lacking in any form of humus to retain moisture. An ominous development in recent years has been the increasing occurrence of drought in certain areas and the tragic famines in Ethiopia and the territories of the Sahelia on the Southern fringe of the Sahara underline the absolute dependence of indigenous African peoples on their land. It is an inescapable fact that when local food crops fail large numbers of people die of starvation in spite of relief operations mounted by the developed nations. Many other countries of the so-called 'Third World' have this same dependence on the land.

The governments of all the African territories are aware of the need for massive agricultural development upon which the nutritional level and, in certain areas, the very survival of their people depend. However there are many obstacles to be overcome - for example the complex system of land tenure inhibits the introduction of mechanisation. In many parts the ownership of all land is vested in the traditional native authorities who allocate small parcels to families in perpetuity, and the inevitable result is fragmentation. The development of mixed farming would greatly enrich the land but in most districts the farmer is not a cattle owner. Cattle are the traditional monopoly of one or two nomadic pastoral tribes such as the Masai in East Africa and the Fulani in the West. In addition many parts of the continent where crop farming is carried on are closed to cattle by the presence of the tsetse fly (vector of bovine trypanosomiasis) and in others any sort of pasture is non-existent.

A further problem is the difficulty of maintaining and improving soil fertility in the face of increasing demands upon the land. Large quantities of chemical fertilisers are imported annually but in spite of various subsidies the cost is often prohibitively high when related to the income of the average peasant farmer. In the primary bush in Africa all organic wastes are turned into humus and nature adjusts the delicate balance between growth and decay, nutrients taken from the soil are returned to it, and erosion is prevented. It is therefore of vital importance to agricultural extension that human, animal or other organic wastes are utilised on the land by methods which are as near as possible to those of nature. That is by the composting treatment of these wastes using techniques which are not dangerous to the public health and which produce an end product of immense value to the peasant farmer.

THE COMPOSTING TREATMENT OF WASTE MATTER

The animal body retains only a very small proportion of nitrogen, phosphorus and potash ingested in the diet and the balance is excreted. Therefore both human and animal excrement are rich in these valuable plant nutrients. Vegetable garbage and most organic litter also contain minerals originally taken from the soil. Wherever there are human or animal communities the output of these wastes is relentless and a completely adequate sanitary disposal system is therefore a matter of critical importance to the health of the community.

Organic wastes have been associated since the earliest times with soil fertility and also with the transmission of human disease. The Chinese, for example, have maintained a high level of agricultural production for over forty centuries by using human excreta on the land but at an appalling cost in sickness and debility. Because of this historical relationship between faecal wastes and disease many tropical sanitarians have strong reservations regarding composting and are reluctant to introduce the system into any territories in which they have responsibility.

The process may be defined as the biological decomposition of organic waste material in aerobic conditions and without offensive odours as opposed to the anaerobic process of putrefaction with which smell nuisances are invariably associated. In a composting mass bacteria, fungi, moulds and other saprophytic organisms feed upon organic matter and convert this into relatively stable humus. Although the system is fairly simple to operate the biological processes involved are extremely complex and a good deal of energy is released in the form of heat, a most important factor when the public health aspects are considered.

The end product, called 'compost', whilst retaining most of the plant nutrients and minerals contained in the original ingredients also has a physical effect on the soil structure; fertility depends upon structure as well as on available plant nourishment. The water-retention capacity of soil is critical in arid climates and this is influenced primarily by the degree of aggregation of the particles. The denser the aggregation the greater the soil's ability to absorb and retain moisture. Retention is encouraged by bacterial metabolism and the presence of a good compost induces the process. Any improvement in the moisture-retention quality of the local soils is of vital importance to African agriculture since rainfall in the main is ill-spaced throughout the year.

Primitive forms of composting have been practised by farmers in many parts of the world for centuries. All manner of human and animal wastes were dumped in pits or stacked in heaps and allowed to decompose prior to being used as fertiliser. The whole operation was generally uncontrolled and took place under anaerobic conditions accompanied by objectionable odours. The first important advance towards scientific composting was made by Howard(1) working in India, who systemised the traditional procedures of the peasant farmers into a method which became known as the 'Indore' process, so called because of the locality in which it was developed.

Howard's original technique involved the use of animal manure only but was later modified to include both night soil and municipal refuse. Alternate layers of refuse, night soil and animal manure were stacked in heaps on the open ground. The heaps were called 'windrows' and the contents were turned over at intervals of a few days. This operation was repeated until biological breakdown was complete. Howard demonstrated that the turning routine oxygenated the material, accelerated decomposition and generated enough heat to kill off pathogenic bacteria together with the ova and larvae of flies and intestinal parasites present in the wastes.

The development of the Indore process established the system as a safe and hygienic method for the disposal of dangerous wastes which had the added advantage of producing a valuable end-product for use in agriculture. Howard initially was faced with a good deal of prejudice in India before compost was accepted by the local farming community but his methods have since been used in many parts of the world and adapted to a variety of local conditions. Experience has shown that almost any organic wastes can be treated and materials such as sewage sludge, cesspool contents and abattoir wastes are now regularly dealt with.

The operation can be effected in pits, stacks, heaps or in silos. It may be a simple manual process suitable for rural communities in underdeveloped countries or a partly or wholly mechanised operation used in larger urban agglomerations. There are a number of patented mechanical systems on the market today; the earliest of these was developed by Beccari(2) in Florence, Italy in 1920. In most mechanical systems the municipal refuse is fed into the plant on an endless belt and all metallic material is separated by a magnetic extractor. The material is then shredded to a standard small particle size which renders it more susceptible to bacterial invasion through exposing a greater surface area to attack. The dosage of other ingredients such as sewage sludge etc is controlled and mixing of the whole mass is much more thorough than is possible in a manual operation. Thus the quality of the end-product is standardised, particularly with regard to the vital carbon/nitrogen relationship.

PUBLIC HEALTH ASPECTS OF THE PROCESS

Most sanitarians working in under-developed territories agree that the production of compost is an important contribution to the agricultural economy of these territories but many question the wisdom of using the technique when human excreta is to be an ingredient; they feel that the danger of large scale disease transmission outweighs the undoubted value of the end-product. It would be idle to suggest that the process is free from hazard to the public health. The strictest skilled supervision is required at all stages of the operation. Without this both the workers at the composting depots and the farmers using the product are exposed to considerable risk. The experiences of the writer in West Africa(3) however, and other researchers have shown that where this supervision is available and the composting procedures are sound there is less danger in disposing of night soil and other community wastes by this method than there is in the alternatives of trenching, tipping etc.

The diseases of which the causal organisms may be found in the faecal wastes of infected persons can be classified as follows:

Bacterial infections - typhoid and para-typhoid fevers, cholera, bacillary dysentery, the brucella organisms causing undulant fever may also be present in certain animal faeces.

Protozoan diseases - amoebic dysentery and various diarrhoeas.

Helminth infestations - bilharziasis, fascioliasis, clonorchiasis, paragonomiasis, ankylostomiasis, trichuriasis, oxyuriasis.

Virus infections - research into the transmission of poliomylitis has shown that the faeces of infected persons provide a rich source of virus(4).

Were it possible to give a complete picture of the ravages of faecal-borne disease in Africa it would indeed be a sombre one. With the exception of cholera almost all of the diseases listed above are present to a greater or lesser degree. Whilst the highest mortality is found in babies and young children, they cause ill health and debility in all age groups. Associated with faecal-borne disease is almost invariably the problem of malnutrition. These two appear to go hand in hand and this is particularly apparent in helminth infestation. Hyde(5) has shown that certain intestinal helminths metabolise a substantial fraction of the food ingested by their human hosts. Thus it is said that in Africa part of the labours of sick peasant farmers go into the cultivation of food for the worms which make them sick. The economic significance of this group of infections is almost incalculable. While relatively few adults die of the diseases *per se* enormous numbers are debilitated to a greater or lesser degree. Work hours on the land are lost, physical capacity for work is lowered, mental capacity impaired and the vigour and vitality of the whole rural community is diminished. The continuing transmission of the infections is due mainly to the low sanitary standards prevailing, particularly with regard to the handling of human excreta and community wastes.

Since the organisms of any or all of the diseases listed above may be present in night soil brought to composting depots in tropical Africa it follows that the process must be effected under conditions which will ensure that pathogenic bacteria and parasitic ova are destroyed. Municipal refuse can also contain undesirable weed seeds and the ovae larvae and pupae of various flies, and for the destruction of all of this material high temperatures are essential.

The aerobic composting process generates a considerable amount of heat and, as refuse and night soil have relatively good insulation properties when properly compacted, much of this heat can be retained within the mass and high temperatures developed. There are differences of opinion as to the most suitable operating temperatures but most experienced sanitarians aver that the range 60° - 70°C is most satisfactory with the optimum around 65°C. Reference to Table 1 shows that all of the organisms of the diseases listed would be destroyed by exposure to this temperature.

Table 1: Temperature and time of exposure required for destruction of some common pathogens and parasites *

Organism	Observations
Salmonella typhosa	No growth beyond 46°C; death within 30 minutes at 55°-60°C and within 20 minutes at 60°C; destroyed in a short time in compost environment.
Salmonella sp.	Death within 1 hour at 55°C and within 15-20 minutes at 60°C.
Shigella sp.	Death within 1 hour at 55°C.
Escherichia coli	Most die within 1 hour at 55°C and within 15-20 minutes at 60°C.
Entamoeba histolytica cysts	Death within a few minutes at 45°C and within a few seconds at 55°C.
Taenia saginata	Death within a few minutes at 55°C.
Trichinella spiralis larvae	Quickly killed at 55°C; instantly killed at 60°C.
Brucella abortus or Br. suis	Death within 3 minutes at 62°-63°C and within 1 hour at 55°C.
Micrococcus pyogenes var. aureus	Death within 10 minutes at 50°C.
Streptococcus pyogenes	Death within 10 minutes at 54°C.
Mycobacterium tuberculosis var. hominis	Death within 15-20 minutes at 66°C or after momentary heating at 67°C.
Corynebacterium diphtheriae	Death within 45 minutes at 55°C.
Necator americanus	Death within 50 minutes at 45°C.
Ascaris lumbricoides eggs	Death in less than 1 hour at temperatures over 50°C.

* *Harold B GOTAAS: 'Composting'. WHO monograph series No 31, Geneva, 1956*

One of the major public health problems associated with this form of waste treatment in the tropics is the control of flies as night soil, organic refuse and abattoir wastes are all excellent media for the breeding of a large fly population. If adequate and completely efficient control measures are not practised the operational areas will rapidly become health hazards as dangerous as uncontrolled refuse dumps.

Fly larvae may originate from ova deposited in the material at the point of collection (insanitary bucket latrines and public dustbins), or they may be laid during the handling of the material at the depot. As the ova hatch in the composting mass the larvae migrate to the outer layers of the material to avoid the heat. The life cycle from ova to imago varies with ambient temperatures and other factors, but in the case of Musca domestica (the main problem) the average times may be considered as follows:- ova 1 to 2 days, larva 3 to 5 days, pupa 3 to 5 days. Thus if a strict turning routine is followed larvae which have moved to the outer layers of material will be deposited in the inside of the mass and destroyed by heat before the life cycle is completed.

In Northern Nigeria one form of fly breeding went unnoticed for several years and was only observed by accident(3). The operating chambers were originally earth bottomed. One chamber had been emptied in order to carry out repairs to the walls, and a few adult flies were noted on the soil surface at the base. A number of plugs were taken at depths of six, twelve, eighteen inches and two feet into the bottom of the chamber and large numbers of viable pupae were found in each sample down to eighteen inches. The larvae had migrated downwards into the soil to avoid the heat in the composting material, pupated and the imagoes were able to emerge from the soil when the mass was turned.

COMPOSTING OPERATIONS IN NORTHERN NIGERIA

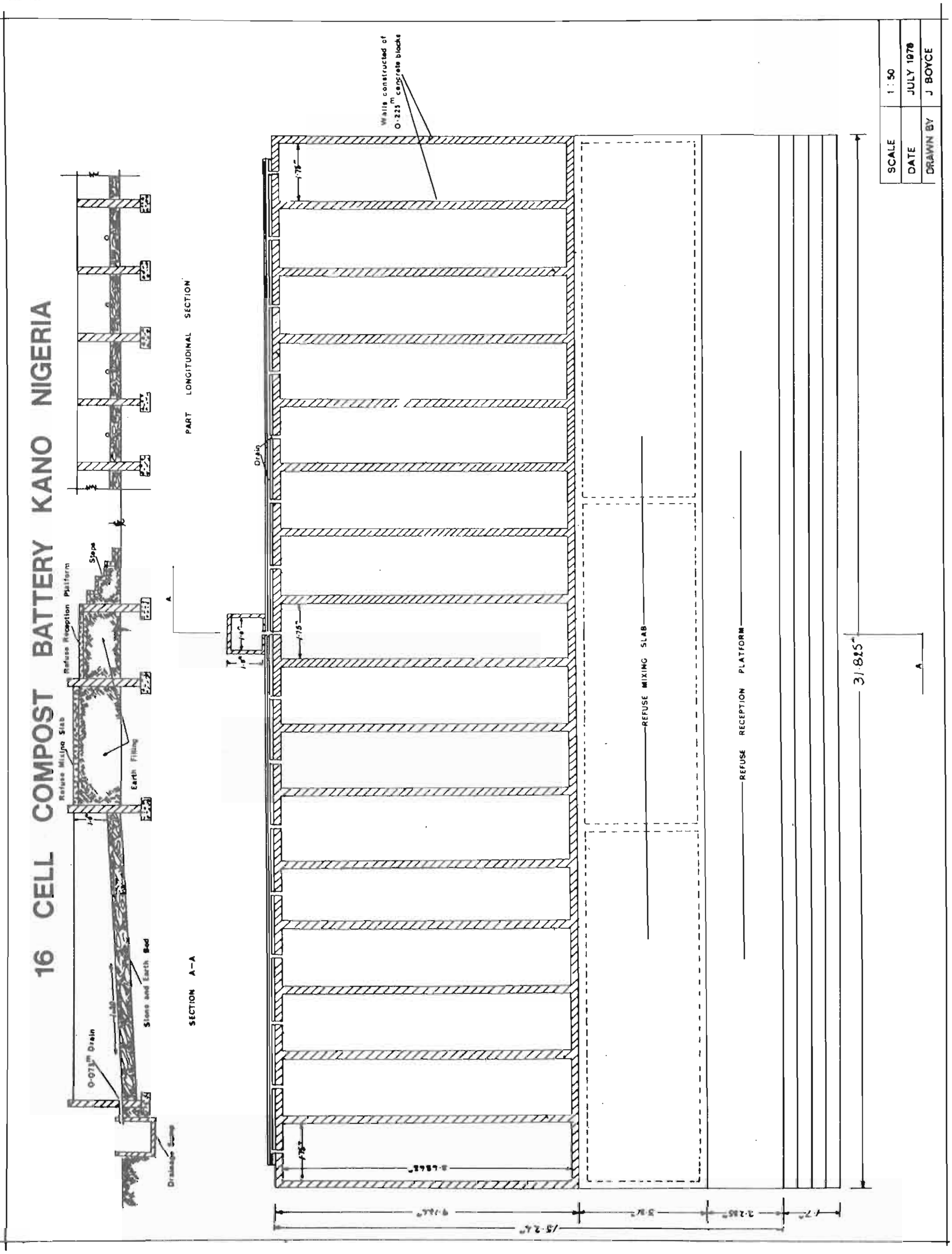
Composting operations have been carried on in various parts of Africa for a number of years and Van Vuren in South Africa(6) and Wilson(7) in the East have both reported consistent success using variations of Howard's original methods. The process was introduced into Nigeria by Gillis(8) in 1941, the first depot being opened in Kano. After a trial period the system was extended to most larger townships in Northern Nigeria.

The historic walled city of Kano had a population of around 130 000 people in the period 1950-1960 and at that time five large composting depots were working continuously. Night soil from some 3000 bucket latrines was treated daily together with most of the city's garbage and litter. The ruminal contents of all cattle, sheep and goats slaughtered in Kano's two abattoirs was also disposed of in the same manner, the average weekly kill being of the order of 700 cattle and 2000 small animals.

The techniques used were based on the Indore system, appropriate quantities of night soil being thoroughly mixed with carefully sorted refuse. The mixture was loaded into concrete chambers and the whole mass was thoroughly turned on three successive occasions after five, fifteen and thirty days. at the end of thirty days the process was complete and the resulting compost was a dark material resembling soil with an earthy, inoffensive odour which did not attract flies.

The composting chambers were built above ground, the dimensions varied slightly in the different towns depending upon the quantities of material to be handled, in Kano each chamber was approximately 8 metres long, 1.5 metres wide and 1 metre deep (figure 1). The walls were built either of locally burned bricks rendered with cement mortar or of concrete blocks. Each chamber originally had a soil bottom as it was thought that bacteria living in the soil accelerated the biological decomposition within the composting mass. Later experience showed that this type of base allowed a certain amount of fly breeding - already described - and all chambers

FIGURE 1


16 CELL COMPOST BATTERY KANO NIGERIA
SCALE 1:50
DATE JULY 1978
DRAWN BY J BOYCE
PART LONGITUDINAL SECTION
SECTION A-A
Walls constructed of 0·225m concrete blocks
REFUSE MIXING SLAB
REFUSE RECEPTION PLATFORM
Refuse Mixing Slab
Refuse Reception Platform
Earth Filling
Stone and Earth Bed
Drainage Sump
Drain
31·825

were then concreted. There were sixteen chambers to each battery. All were adequately drained and designed to hold two days' supply of material to be treated, thus allowing a thirty-day processing period.

Municipal refuse was brought to the depot by trucks which discharged onto the refuse slabs adjoining the chambers. Here it was carefully sorted and all tins, bottles, rags and other unsuitable material picked out. The remainder was then spread evenly on the mixing platform to a depth of 150 mm. An appropriate quantity of night soil, collected in the early hours of each day, was then added to the refuse so that the proportions were approximately even, and this was distributed over the whole surface with rakes. The mass was thoroughly mixed by operators using garden type spades and dumped into one of the chambers at the end nearest the mixing platform. The process was repeated until all of the day's collection of refuse and night soil had been dealt with. On the following day the procedure was the same and the two days' material filled half of the available space, the other half of the chamber being left free. Once each chamber was charged a thick layer of very fine refuse was spread over the surface of the contents to discourage flies and to retain moisture within the mixed mass.

The composting material was left for five days at the end of which time it was completely turned and transferred to the opposite end of the chamber. For this operation the workmen used large garden type forks to break up the mass in order to obtain maximum oxygenation. The routine was repeated at the end of a further ten days when after turning the material was put back to its original position in the chamber and remained there for fifteen days to complete the process. The resulting compost was then removed and stacked in large heaps adjacent to the chambers where it was kept for one month to mature prior to use on the land.

In normal operations temperatures of over 68°C in the centre of the material mass were regularly reached in the dry season although these were slightly lower in the rains. Table 2 shows the temperatures recorded during one thirty day cycle. Readings were taken at the same point each day by means of a thermocouple linked to a potentiometer. If these are compared with the data given in Table 1, it will be seen that the thermal death points of all pathogens and parasites likely to be present in the composting wastes was exceeded at some stage in the cycle.

When composting was first introduced into Nigeria in 1951, Gillis encountered a certain amount of prejudice among the indigenous farmers who were reluctant to handle a product of which human excrement was a constituent, but by painstaking propaganda and demonstration he and his staff were able to overcome this and eventually the agricultural community developed considerable faith in the manurial value of the compost and frequently travelled long distances to the nearest depot where it was supplied to them for a nominal charge and demand frequently exceeded supply at certain depots.

Although the whole operation was most carefully supervised at all depots throughout the country and the danger to the public health was minimal, there was little control over the quality of the end-product, valuable though this was. Manual composting must always be a primitive operation in which it is extremely difficult to estimate the proportions of the various ingredients or to limit the particle size of municipal refuse content. Thus the carbon/nitrogen content of the compost could not be standardised. Mechanisation of the operation appeared to be the only method which would guarantee a standard product of high quality and in the late 1950's it was decided to organise a pilot project in the city of Kano.

Kano was chosen as being the most suitable venue to introduce mechanised composting as it was the most densely populated city in the region, had five large depots continuously operating and was the administrative centre of the groundnut cultivation areas. Groundnuts were Northern Nigeria's most important cash crop, the export of which produced a significant part of the region's revenue, and there was therefore an assured market for the compost from the plant. A specialist company in the United Kingdom prepared a provisional design and a large area of land on the outskirts of the city was selected for a central depot; all the existing depots were to be closed down. The project was overtaken, however, by tremendous administrative reorganisation following Self-government in 1960 and had to be indefinitely postponed.

Table 2: Actual temperatures recorded in normal composting operations at a Kano depot - Dry season

Days after tipping	Temperature at centre of mass ^{o}C	Remarks
1	42.2	
2	48.8	
3	48.8	
4	54.4	
5	60.0	Mass turned & oxygenated
6	54.0	
7	61.0	
8	68.0	
9	68.8	Peak temperature reached
10	68.8	
11	67.7	
12	65.0	
13	65.0	
14	63.3	
15	60.0	Mass turned & oxygenated
16	58.0	
17	60.0	
18	60.0	
19	60.0	
20	56.6	
21	57.0	
22	54.0	
23	50.0	
24	50.0	
25	46.6	
26	45.0	
27	43.0	
28	43.0	
29	43.0	
30	42.0	Process completed

CONCLUSION

There is an important relationship between sanitation and agriculture in all parts of the world. In agricultural areas the utilisation of human and animal wastes is of great importance from both the public health and agricultural point of view.
Harold B Gotaas

The writer has elsewhere discussed the public health implications of present demographic trends throughout tropical Africa(9,10,11,12,13). Short of a disaster of tremendous magnitude the populations of this continent are likely to double by the end of the present century and all the governments concerned are involved in the race between food production and expanding populations.

Health standards of the vast peasant farming communities, although slowly improving, are still low and two of the principal contributing factors to this low standard are the continuing high incidence of faecal-borne disease and widespread malnutrition. Thus measures to secure improved nutrition and to control these infections are of paramount importance in each country's public health programme. There is in addition the urgent need to plan for the food requirements of the massive increases in human numbers which are now almost inevitable.

The control of faecal-borne disease must be effected through a general improvement in sanitation particularly with regard to the disposal of organic wastes. The raising of the nutritional level of existing populations and the vast requirements of anticipated additions will require food production far in excess of present agricultural capacities. Allied to these problems will be an equal responsibility to develop cash crop farming since the economic advancement of almost all the territories concerned depends to some extent on their ability to export these products.

Agricultural extension schemes on the scale necessary will make tremendous demands on the land and thus the maintenance of soil fertility is of paramount importance. Since human and animal excreta together with community wastes can be manipulated by composting to reclaim most of the nutrients which are required to maintain and improve soil fertility it follows that sanitation and agriculture have a direct relationship in Africa.

The selection of a particular composting system will depend upon a number of local factors such as size of the community to be served, character of the local wastes, climate etc. There is no one method which can be recommended for all areas and conditions: the system chosen must ensure sanitary safeguards and the absence of nuisance. It should also be an economic proposition and completely reliable in order to cope with the relentless output of the wastes to be treated.

It is advisable when this process is being considered that a small pilot project should be mounted initially. Such a project costs little and would provide valuable information as to the operational problems likely to arise in a major scheme.

In some parts of Africa it may well be thought that the local climate is unsuitable for the introduction of composting. Whilst it is true that climate is important, experience has shown that ambient conditions of humidity, rainfall, sunshine, air temperature and winds can all be modified in their effect by the roofing or screening of the treatment chambers.

In some areas there may well be local prejudices against the use of a compost which contains human excrement. In these circumstances a vigorous campaign of education and practical demonstration by both the health and agricultural authorities may be necessary.

In the present financial climate in Africa simple manual composting schemes should be attractive since little outlay is required and the end-product has a cash value which can substantially reduce the operating costs of the project. When compared with other waste-disposal systems such as incineration, it is likely that the economics of the process will be the most favourable.

It is not claimed that composting will provide a complete solution to the massive problems of ill health and malnutrition which face governments in tropical Africa today but experience in many parts of the world (including Africa) has shown that a properly designed and supervised system will secure a substantial reduction in faecal-borne disease and will provide a valuable end-product which enables plant nutrients present in organic wastes to be returned to the soil. Thus the benefits to be obtained from the adoption of this method of waste disposal are such that they merit the most careful consideration by administrative, public health and agricultural authorities throughout this continent.

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NOTE

The writer wishes to state that the opinions expressed in this paper are entirely his own and do not necessarily reflect the views of either of the two African Governments by whom he was formerly employed.

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