Environmental effect concluded

Environment and Health

The most important environmental and health hazards are due to pathogens and heavy metals. Other environmental effects include water, soil and air pollution. In this chapter, the environmental and health effects of the recovery of organic waste are discussed. They refer mainly to those arising from the biological treatment of waste through processes such as composting.

Waste: a potential health threat

Over the last decade, public awareness of environmental issues has grown considerably, especially in the industrialized countries of Western Europe and North America. Measures to clean up water, soil and air pollution have become so expensive, however, that priority is now being given to the minimization and avoidance of pollution. Rising transport and disposal costs,

as well as the lack of land for waste dumps, have clearly demonstrated the need to minimize the amount of waste generated, and to develop alternative treatment systems. The prevention of waste is the ultimate aim, but this is only possible in a few areas. Although the importance of environmental protection has now been recognized, the implementation of legislation is often rather slow due to economic constraints, the lack of political will, and because the change to cleaner production processes needs time.

In many economically less developed countries awareness of the environment is also increasing, especially within government institutions and non-governmental organizations. However, in these countries it is even more difficult to change policies and to take appropriate measures than in industrialized countries. Protection of the environment is not a priority in these countries, where survival economics dominate and where foreign currency is badly needed.

Waste treatment systems themselves may also pollute the environment. Assessments of both the environmental and health effects of a system should therefore be integrated in any choice of technology. Although ideally the same standards and criteria used in Western Europe and North America should be applied in less developed countries, the health and pollution risks should also be seen in relation to the exposure to and contamination from other sources. Environmental impact assessments are not easy to carry out. For example, it is often difficult to determine the exact cause of a human health problem, since this is likely to be influenced by a number of factors, and disease transmission routes may be long and complex. However, since it is known that waste collection and recovery activities also pose environmental and health risks, ways should be sought to minimize these dangers as far as possible.

Pathogens

Urban solid waste may contain large quantities of pathogenic micro-organisms. This is especially important when organic waste is used as compost or animal feed. The sewage sludge or human excreta that is sometimes added to increase the nutrient value of the compost generally contains more pathogens (particularly of faecal origin) than solid waste.

There are two groups of micro-organisms that may cause disease.42 ***Primary pathogens,*** which are normally present in raw waste and can cause infections in healthy individuals, include bacteria, viruses, protozoa and helminths eggs. Most of the infections they cause (such as diarrhoea and dysentery) are spread via faecal-oral transmission routes. The micro-organisms that are the causative agents of these diseases pass from infected persons in excreta, eventually reaching other people either orally (by drinking water contaminated with faeces) or through the skin. The micro-organisms (fungi and acid-producing bacteria) that grow during biological decomposition are called ***secondary pathogens***. These pathogens are less important than the first group, however, they can cause primary infections or respiratory diseases, usually in people with weakened immune systems. Contact with or inhalation of air containing a high density of secondary pathogens (which may occur when a compost heap is being turned, for example) may cause health problems for both compost workers and users. Examples of some common primary and secondary pathogens are listed in Table 4-1.

Waste can also encourage rats, and the diseases they carry, such as plague, endemic typhus and rat-bite fever. Flies and other insects are also responsible for the transmission of pathogens.

Table 4-1: Examples of pathogens spread during the composting of sewage sludge, and the associated human diseases.

Group	*Example*	*Disease*
Primary pathogens		
Bacteria	*Salmonella enteritidis*	Salmonellosis (food poisoning)
Protozoa	*Entamoeba histolytica*	Amoebic dysenetry (bloody diarrhea)
Helminths	*Ascaris lumbricoides*	Ascariasis (worms infecting the intestines)
Viruses	*Hepatitis* virus	Infectious hepatitis (jaundice)
Secondary pathogens		
Fungi	*Aspergillus fumigatus*	Aspergillosis (growth in lungs and other organs)
Actinomycetes	*Micromonospora* spp	Farmer's lung (allergic response in lung tissue)

Positive effects of waste treatment

The treatment of waste using methods such as biological degradation can greatly reduce the numbers of pathogenic organisms and should result in hygienically safe products such as compost, or in hygienic methods of disposing of non-reusable waste. One of the major benefits of waste treatment is its positive effects on public health. Biologically degraded waste does not attract insects as is the case with fresh waste, and it is free of odour.

The spread of disease caused by pathogens depends on a variety of factors, including the number of pathogens present, transmission routes, level of immunity, multiplication rate and the infective dose. The key conditions that determine the survival of pathogens are temperature and time. The higher the temperature, the shorter is the time required to destroy the pathogens, and vice versa. High temperature is the most effective method of killing pathogens, since these organisms consist of proteins that are usually denatured at temperatures of 50 - 70 °C. Each group of pathogens has a different ability for survival. The following recommended timetemperature interactions will destroy practically all pathogens: heating for 1 hour at more than 62 °C, 1 day at more than 50 °C, or 1 week at less than 46 °C. These conditions should also deactivate weed seeds and pests. In a system of windrow composting (see Chapter 7), where the piles of compost are regularly turned, heat treatment at 55 °C for an extended period (18 - 21 days) is necessary. If temperatures are increased to 60 - 70 °C, the pathogens will be destroyed more rapidly.

Since human and animal waste may be used in co-composting or anaerobic digestion systems, the effects of treatment are briefly described here. Faecal material normally contains higher concentrations of pathogens than other organic waste material. Anaerobic treatment of sewage sludge or human excreta also reduces pathogens, but since the temperatures reached are normally lower than during aerobic processes, pathogen dieoff is not complete. Digested sludge should be handled with care, since it may still contain some pathogens, especially helminth eggs. Further treatment of the sludge (by air drying or co-composting, for example) reduces the pathogen content still further and in the latter case, if properly operated, it produces a pathogen-free product. Dried sludge may still contain some pathogens, but if it is applied properly (by being ploughed under, for example) they present no health risks.

Before being applied to the land, excreta should be stored for at least a year at ambient temperatures. This period of storage refers to the entire time interval between excretion and application, and includes any time spent in a pit latrine or in a treatment process such as an anaerobic digester or a composting plant. However, since there is no way of differentiating between freshly added and already digested excreta within a sanitation system, the entire contents of single-pit latrines, septic tanks, single-vault compost toilets and wastewater sludge should be stored for at least a year after removal. This storage period should only be reduced if the material is treated by aerobic composting at higher temperatures or co-composting.

The complete deactivation of pathogens in a compost heap is rarely achieved, for a number of reasons:46

1. Due to the heterogenous nature of the compost materials, clumps may form with the pathogens and protect them from being fully exposed to high temperatures.
2. The temperature distribution within a compost heap is usually uneven; unless the heap is completely and continuously mixed, the temperature near the outer surface will remain lower than on the inside, reducing the overall efficiency of pathogen die-off throughout the heap.
3. Many pathogens (such as spore-producing bacteria, cysts and helminth eggs) are only partially deactivated during composting. They can regrow and may become infective again if exposed to a favourable environment, such as the moist conditions in crop fields.

Heavy metals

Small amounts of metals such as zinc and manganese are necessary elements for the growth of living organisms. However, when inhaled or when present in excessive amounts, they may cause acute and sometimes chronic effects. Other metals, like mercury and cadmium, are non-essential and toxic elements. The presence of these heavy metals may affect the quality and suitability of the end products of organic waste recovery processes such as compost and meat from animals fed on contaminated material. They present a high pollution risk for the environment. When present at or above specific concentrations, heavy metals interfere with processes in the soil and in plants, and if they enter the food chain, they may form a health hazard for human beings and animals. The health effects of the various metals differ, and depend upon the concentrations34.

Many countries have established legal maximum levels for individual metals; as an example, Table 4-2 gives the currently accepted levels of metals in compost in the Netherlands. Because the criteria used to determine safe levels have been tightened, a number of grades of compost are distinguished, i.e. 'compost', 'clean compost' and 'very clean compost'. To achieve these stricter criteria, the Dutch government is now actively promoting the separation of all waste at source (see Chapter 2). By 1994, in principle all Dutch households will be required to separate the organic from other waste fractions.

The amounts of metals that remain in end products can fluctuate strongly, depending on the origin of the raw material. Organic waste material may contain high concentrations of heavy metals due to contact with, for example, batteries or newspaper ink, during storage and transportation. If they are not biodegradable, other hazardous chemicals that are present in organic waste, such as pesticides, may also appear in the end products.

Table 4-2: The maximum allowed amounts of metals in the three grades of compost in the Netherlands. *Source:* Van Lierop *etal.35*

	Compost		*Clean compost*	*Very clean compost from 1991*
	A	*B*	*A*	*B*
Organic material (% d.s.)	. > = 20	. > = 20	. > = 20	. > = 20
Cd (cadmium)	< = 2	< = 1	< = 1	< =0.7
Cr (chromium)	< = 200	< = 50	< = 70	< = 50
Cu (copper)	< = 300	< = 60	< = 90	< = 25
Hg (mercury)	< = 2	< = 0.3	< = 0.7	< = 0.2
Ni (nickel)	< = 50	< = 20	< = 20	< = 10
Pb (lead)	< = 200	< = 100	< = 120	< = 65
Zn (zinc)	< = 900	< = 200	< = 280	< = 75
As (arsenic)	< = 25	< = 15	< = 15	< = 5

1 until December 1994
2 with effect from January 1995

Precautions

A number of precautionary measures can be taken to improve general standards of hygiene and safety in waste treatment systems. These measures are strongly recommended for use in all composting and co-composting systems:

1. Workers should be encouraged to maintain high standards of personal hygiene. Washing facilities should be provided.
2. During hot, dry weather the composting area should be periodically sprinkled with water in order to reduce dust dispersal.
3. Workers should protect themselves by wearing gloves, masks and boots during processes such as sieving or (mechanical) turning, when the spores can be dispersed.
4. During bad weather, workers should be encouraged to wear masks, respirators or some other material to cover mouths and noses in order to avoid dust inhalation.
5. Skin contact with biologically degrading materials should be avoided.
6. Waste treatment plants should be located well away from hospitals and residential areas. The distances will vary from plant to plant, but in general should be at least 1 km.

Composting processes that do not require the piles to be turned, such as the Chinese composting system and the forced aeration system (see Box 7.1), pose fewer health risks to workers.

Before applying compost to the land, its quality should be checked by measuring the amounts of metals and pathogens. Livestock fed on organic waste should also be kept in accordance with local health and safety regulations to ensure the production of good quality meat (see section 5.3).

Other environmental effects of waste treatment

Odour

In general, the anaerobic conversion of organic waste produces far more odour than aerobic processes. If a closed system is used, the inconvenience of odours is also limited. However, the aerobic process in an open system should be odourless if carried out correctly. This method can this be used as an index of the efficiency of the composting process. Odour affects public acceptance of treatment systems, especially in densely populated areas. There are various

effective methods of controlling or removing foul odours from composting materials unless the process is completely anaerobic. One method is to use some previously composted material as a filter. The organisms in the compost readily absorb and decompose the malodorous compounds. Simple filters consist of a small pile of compost through which air is blown.

Emissions into water

Aerobic treatment systems release less liquid than anaerobic treatment systems because most of the moisture evaporates into the air. However, leachate water may pollute the soil and eventually may threaten groundwater supplies. The amount of water that will leach from the system depends on a number of factors, including weather conditions. When large amounts of leachate are discharged, the water should be collected. Part of the leachate water may be used to dampen the composting material during processing.

Air pollution

Air pollution caused by biological treatment systems such as composting is usually limited, but when organic waste is burned as a fuel (see Chapter 10) the levels of air pollution caused by the smoke could be considerable. The composition of the waste is important; it should be processed and burned in such a way that smoke is avoided as far as possible. Organic waste that is burned should not contain materials such as plastics, because the smoke may contain hazardous chemical compounds. The smoke may also affect human health, especially if the organic fuel is used for cooking indoors. Some of the additives, for example the ones that are used to improve the binding characteristics of briquettes, may cause considerable levels of pollution, and so should be avoided. Suitable binders include starch and molasses.

Animal Raising

One of the simplest ways of recovering the value of domestic and some industrial wastes is to feed it to animals. In situations where it is culturally acceptable, such use of organic waste can increase nutrient levels, and reduce dependence on imported feed.

Backyard animal raising is a common practice in many cities in low- and middle- income countries, and provides a source of income for many small-scale enterpreneurs. Goats, hens, cows, donkeys and especially pigs can be raised on garbage. The two most common types of pig are the heat-tolerant breeds kept in cities such as Cairo and Calcutta, and the less heat-tolerant Western breeds raised in Manila, which need to be cooled down on hot days. The manure of Southern breeds tends to be solid, while that of the Western breeds is more liquid, so that more water is needed to keep the pens of Western breeds clean.

Organic waste as animal feed

Organic household waste provides a cheap source of animal feed, since it is usually abundant, freely available, and transportation costs can be kept low. Markets also provide useful organic materials such as fruit and vegetable waste. Only completely rotten items cannot be used and are thrown away. In Nairobi, for example, market traders have organized the collection of waste for their own use or for sale as animal feed. While awaiting collection, the waste is generally stored in sisal bags and straw baskets. Many hotels and restaurants have arrangements with traders to collect food remains for use as poultry and pig feed. Stale bread from bakeries is sold to livestock farmers and to animal feed companies. Industries are also important sources of organic waste. Breweries, for example, produce substantial amounts of organic waste by-products (wet malting, sieving), which are sold either as animal feed or as raw materials for animal feed manufacturers.

Animal feed should contain:65

- carbohydrates for energy to keep the animal alive and to increase its weight;
- protein for energy and amino acids necessary for survival and growth;
- minerals, vitamins and other essential nutrients for a healthy condition of the blood, bones, teeth, etc.,
- fibre or roughage to assist the animal's digestion;
- fats to provide energy and increase weight; and
- water, which may also be provided separately.

Free-range animals obtain these elements independently, but penned animals must be fed carefully blended diets that include all the necessary nutrients. Organic wastes usually provide most of the bulk feed elements, but additives are sometimes necessary. Pig fodder, for example, is often supplemented with an iron preparation.

In Manila, pigs are not fed on a constant diet of organic waste. One month before delivery, pregnant sows are given commercial feed instead of organic waste, since experience has shown that this helps to build the sow's resistance to infection and increases the likelihood of a healthy litter. Commercial feed is continued for 45 days after delivery, when the piglets are weaned from their mothers. Feeding organic waste to the sows or piglets before that time will result in diarrhoea.

Some animals such as cows have complex digestive systems that can digest materials containing mainly cellulose, such as straw, whereas pigs have simple systems that cannot digest straw or low-quality fodder. However, pigs have powerful appetites and eat almost any food waste materials. All organic waste used as animal feed should be carefully examined to ensure that it contains no harmful or poisonous substances. In general, the taste of meat and diary products such as milk and eggs is not affected.

Pretreatment

Some organic waste needs to be treated before use. Crop residues such as rice straw or bran can provide the necessary nutrients for livestock without processing, but if 1 "5 soaked in an alkali bath, the digestibility of these materials can be almost doubled. This can greatly increase the nutrient availability, enabling the animals to produce more milk or to gain weight more quickly.

In Manila, as soon as the organic waste is obtained, it is fed directly to the pigs; uncooked waste is preferred because the pigs grow better. Cooking is needed only if there are enough leftovers for the following day, by which time micro-organisms in the o material will have multiplied rapidly, giving it a sour taste. The leftovers are heated to kill the harmful micro-organisms, although in the process the beneficial micro-organisms are also eradicated.

Health problems

Animals are sometimes fed on urban refuse that contains slaughterhouse waste. This practice can pose grave dangers. Waste products containing meat or other animal products may help to transmit serious diseases to other animals (e.g. swine fever), as well as to humans (e.g. salmonellosis), and should not be used. Food waste that contains meat, or has been in contact with meat or any part of an animal carcass, should always be batch-sterilized by boiling in water for at least an hour. Sterile and raw waste should always be handled and transported separately, preferably using different containers and vehicles. High standards of cleanliness are required throughout the operation. Eggs produced by hens raised on garbage should be cooked for at least six minutes to kill all pathogens.

In urban areas, livestock rearing presents a number of health risks, however, not only because human diseases can be spread through the waste, but also because of the unsanitary conditions created within residential areas. For these reasons, and because of the foul odours that are often generated, the practice of animal raising is sometimes forbidden in city centres. In Manila, for example, backyard pig raising was once widespread, but as the population grew and space became scarcer, the practice was prohibited. [8] The activity has now been displaced from the centre to surrounding neighbourhoods, and the number of backyard pig breeders increases with distance from the centre of Manila.

Resources and References

Ali, S.M., Cotton, A.P., and Westlake, K. 1999. Down to Earth: Solid Waste Disposal for Low-Income Countries, WEDC, Loughborough University, UK.

Ogawa, H. 1989. Selection of Appropriate Technology for Solid Waste Management in Asian Metropolises, An International Journal of Regional

Development Dialogue, UNCRD, Nagoya, Japan, Vol. 10 No.3, Autumn.

Tchobanoglous, G., Theisen, H., and Eliassan, R. 1977. Solid Wastes Engineering Principles and Management Issues, McGraw-Hill Book Company,

New York.

US Environmental Protection Agency. 1989. Decision-Maker's Guide to Solid Waste Management, Vol 1, Washington.

US Environmental Protection Agency. 1995. Decision-Maker's Guide to Solid Waste Management, Vol II, Washington.

Vagale, L. R. 1997. Environment of Urban Areas in India Case Study: Bangalore, ENVIS Journal of Human Settlements, Centre for Environmental Studies, School

of Planning and Architecture, New Delhi, India, November 1997.

Diaz, L.F. and C.G. Golueke, “Solid Waste Management in Developing Countries”, BioCycle, 26:46-52, September 1985.

Japan International Cooperation Agency, Master Plan and Feasibility Study on Seoul Municipal Solid Waste Management System in the Republic of Korea, Draft Final Report,

Tokyo, Japan, 1985.

Scharff, C. and G. Vogel, “A Comparison of Collection Systems in European Cities”, Waste Management & Research, 12(5), October 1994.

CalRecovery, Inc., Criterio de Diseño - Planta de Selección y Recuperación de Subproductos de los Residuos Sólidos Municipales, prepared for Mexico City, Mexico,

December 1992.

CalRecovery, Inc., Handbook of Solid Waste Properties, Governmental Advisory Associates, Inc., New York, New York, USA, 1993.

Morwood, R., “Australian Waste Management - Towards 2000”, Proceedings of 32nd Annual International Solid Waste Exposition, SWANA, San Antonio, Texas, USA, August

1994.

Cal Recovery Systems, Inc., Norconsult A.S., and Engineering-Science, Metro Manila Solid Waste Management Study - Review of Existing Conditions, May 1982.

Cointreau, S. Environmental management of urban solid wastes in developing countries. A project guide. Urban Development Technical Paper No. 5. World Bank, Washington, DC,

1982.

Diaz, L.F., G.M. Savage, and C.G. Golueke, Resource Recovery from Municipal Solid Wastes: Vol. I, Primary Processing, CRC Publishers, Inc., Boca Raton, Florida, USA, 1992.

Moeller, D. W. (2005). Environmental Health (3rd ed.). Cambridge, MA:Harvard University Press

Diaz, L.F., G.M. Savage, L.L. Eggerth, and C.G. Golueke, Composting and Recycling Municipal Solid Waste, Lewis Publishers, Ann Arbor, Michigan, USA, 1993.

Diaz, L.F. and C.G. Golueke, “Solid Waste Management in Developing Countries”, BioCycle, 26:46-52, September 1985.

CalRecovery, Inc., Metro Manila Solid Waste Management Study - Waste Stream Characterization, prepared for Ad Hoc Committee, Republic of the Philippines, May 1982.

Nath, K.J., “Solid Waste Management in the Present Indian Perspective”, proceedings of ISWA 1993 Annual Conference, Jönköping, Sweden, September 1993.

Japan International Cooperation Agency, Master Plan and Feasibility Study on Seoul Municipal Solid Waste Management System in the Republic of Korea, Draft Final Report, Tokyo, Japan, August 1985.

CalRecovery, Inc., Handbook of Solid Waste Properties, Governmental Advisory Associates, Inc., New York, New York, USA, 1993.

World Health Organization, Regional Office for Europe, Urban Solid Waste Management, edited by Institute for the Promotion of International Health Actions (IRIS), Copenhagen, Denmark, 1991.

Morwood, R., “Australian Waste Management - Towards 2000”, Proceedings of 32nd Annual International Solid Waste Exposition, SWANA, San Antonio, Texas, USA, August 1994.