RECYCLING ORGANIC WASTE

Introduction
Organic waste is produced wherever there is human habitation. The main forms of organic waste are household food waste, agricultural waste, human and animal waste. In industrialised countries the amount of organic waste produced is increasing dramatically each year. Although many gardening enthusiasts 'compost' some of their kitchen and garden waste, much of the household waste goes into landfill sites and is often the most hazardous waste. The organic waste component of landfill is broken down by micro-organisms to form a liquid 'leachate' which contains bacteria, rotting matter and maybe chemical contaminants from the landfill. This leachate can present a serious hazard if it reaches a watercourse or enters the water table. Digesting organic matter in landfills also generates methane, which is a harmful greenhouse gas, in large quantity. Human organic waste is usually pumped to a treatment plant where it is treated, and then the effluent enters a watercourse, or it is deposited directly into the sea. Little effort is made to reclaim the valuable nutrient or energy content of this waste.

In developing countries, there is a different approach to dealing with organic waste. In fact, the word 'waste' is often an inappropriate term for organic matter, which is often put to good use. The economies of most developing countries dictates that materials and resources must be used to their full potential, and this has propagated a culture of reuse, repair and recycling. In many developing countries there exists a whole sector of recyclers, scavengers and collectors, whose business is to salvage 'waste' material and reclaim it for further use.

Where large quantities of waste are created, usually in the major cities, there are inadequate facilities for dealing with it, and much of this waste is either left to rot in the streets, or is collected and dumped on open land near the city limits. There are few environmental controls in these countries to prevent such practices.

There are a variety of ways of using organic waste and in this technical brief we hope to outline a few of the principle methods used for putting it to good use. The three main ways of using organic waste that we will look at are for soil improvement, for animal raising and to provide a source of energy.

Organic waste – types, sources and uses
As mentioned earlier, there a number of types of organic waste which are commonly discarded. Below we will look at the types and sources of organic waste and some examples of common uses for this waste.

Domestic or household waste
This type of waste is usually made up of food scraps, either cooked or uncooked, and garden waste such as grass cuttings or trimmings from bushes and hedges. Domestic kitchen waste is often mixed with non-organic materials such as plastic packaging, which cannot be composted. It is beneficial if this type of waste can be separated at source – this makes recycling of both types of waste far easier. Domestic or household waste is usually produced in relatively small quantities. In developing countries, there is a much higher organic content in domestic waste. From Figure 1 we can see that up to 60% (or more in some cases) of all municipal waste is organic matter, much higher than the figure for an industrialised country. It is therefore well worth intercepting this supply of useful material where it can be used effectively.

Practical Action, The Schumacher Centre for Technology & Development
Bourton Hall, Bourton-on-Dunsmore, Rugby, Warwickshire CV23 9QZ, UK
Tel: +44 (0)1926 634400 Fax: +44 (0)1926 634401 E-mail: infoserv@practicalaction.org.uk Web: www.practicalaction.org

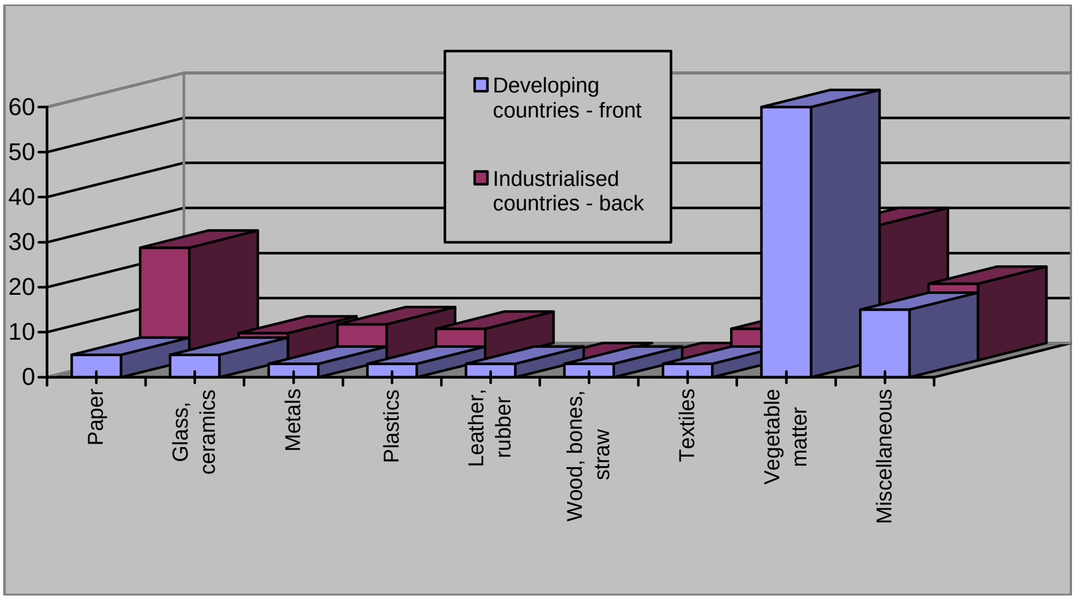

Figure 1: Composition of municipal waste in a typical developing and industrialised country (actual figures vary significantly – this figure is only an example).

Commercially produced organic waste.

By this, we mean waste generated at institutional buildings, such as schools, hotels and restaurants. The quantities of waste here are much higher and the potential for use in conjunction with small-scale enterprise is good (see box 2).

Animal and human waste.

It is worth mentioning at the start of this section that there are serious health risks involved with handling sewage. Raw sewage contains bacteria and pathogens that cause serious illness and disease. It should be stressed that health and safety procedures should be followed when dealing with sewage and that people involved with its handling should have a clear understanding of the health risks involved. Raw sewage should never be applied to crops which are for consumption by humans or animals.

- *Human faecal residue* is produced in large quantities in urban areas and is dealt with in a variety of ways. In the worst cases, little is done to remove or treat the waste and it can present enormous health risks. This is often the case in the slum districts or poor areas of some large cities. Sewage is often dealt with crudely and is pumped into the nearest water body with little or no treatment. There are methods for large-scale treatment and use of sewage as a fertiliser and a source of energy. The most commonly used method is anaerobic digestion to produce biogas and liquid fertiliser. Composting toilets (see later section) facilitate the conversion of human faecal waste into rich compost.

- *Animal residue* is rarely wasted. This fertile residue is commonly used as a source of fertiliser, being applied directly to the land, or as a source of energy, either through direct combustion (after drying) or through digestion to produce methane gas.

Agricultural residue

This is the 'waste' which remains after the processing of crops (e.g. maize stalks, rice husks, foliage, etc.). There are a wide variety of applications for this residue, ranging from simple combustion on an open fire to complex energy production processes that use this waste as a fuel stock. It is not within the scope of this paper to deal with the many and varied uses of agricultural residues.

Methods of processing organic waste

As mentioned in the introduction, there are three main ways in which organic waste can be used:

- soil improvement
- animal raising and
- to provide a source of energy

Differing levels of processing are required for achieving the above and in this section we will take a brief look at just some of the common approaches to using organic waste. Figure 2 below, shows some of the options in the form of a flow diagram.

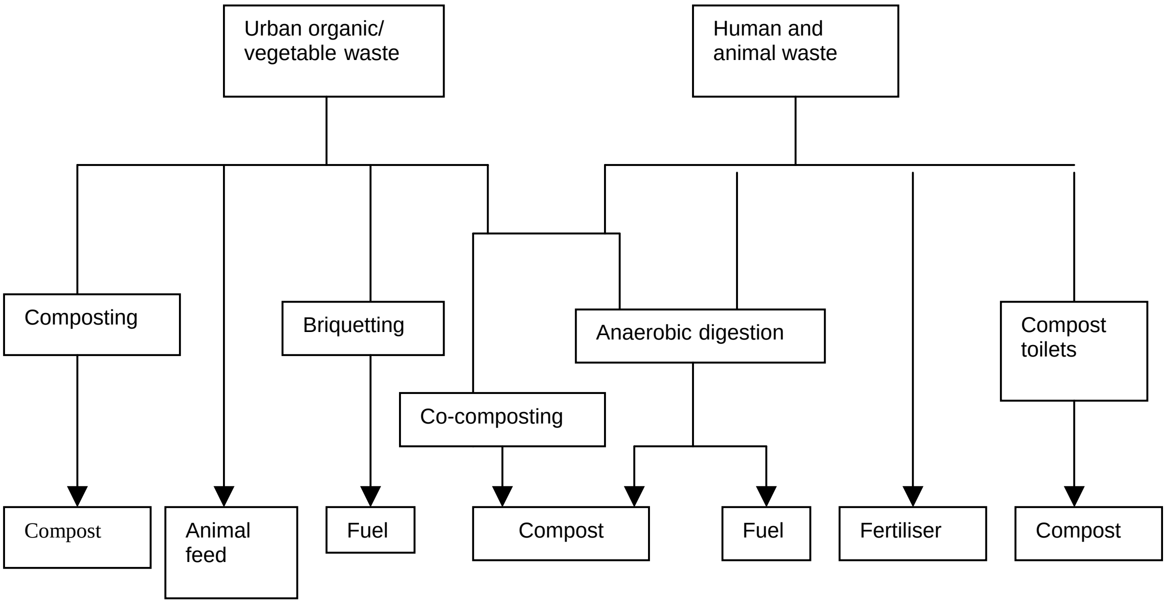

Figure 2: Processes and products from organic waste

Composting

Composting is simply the method of breaking down organic materials in a large container or heap. The decomposition occurs because of the action of naturally occurring micro-organisms such as bacteria and fungi. Small invertebrates, such as earthworms and millipedes, help to complete the process. Composting can convert organic waste into rich, dark coloured compost, or humus, in a matter of a few weeks or months. There is nothing mysterious or complicated about composting. Natural composting, or decomposition, occurs all the time in the natural world. Organic material, the remains of dead animals and plants, is broken down and consumed by micro-organisms and eaten by small invertebrates. Under controlled conditions, however, the process can be speeded up.

Composting has many benefits;

- It provides a useful way of reclaiming nutrients from organic refuse
- Saves valuable landfill space and possible contamination of land and water due to landfill 'leachate'
- Can be used as fertiliser on farmland or in the garden
- Improves the condition of soils

In composting, provided the right conditions are present, the natural process of decay is speeded up. This involves controlling the composting environment and obtaining the following conditions:

- The correct ratio of carbon to nitrogen. The correct ratio is in the range of 25 to 30 parts carbon to 1 part nitrogen (25:1 to 30:1). This is because the bacteria which carry out the composting process digest carbon twenty five to thirty times faster than they digest nitrogen. This is often seen as being a roughly equal amounts of "greens" and "browns". Carbon to nitrogen ratio will be referred to hereafter as the C:N ratio. The C:N ratio can be adjusted by mixing together organic materials with suitable contents.
- The correct amount of water. Plants have a liquid rather than a solid diet and therefore the compost pile should be kept moist at all times. On the other hand, a wet compost pile will produce only a soggy, smelly mess.
- Sufficient oxygen. A compost pile should be turned often to allow all parts of the pile to receive oxygen.
- The optimum pH level of the compost is between 5.5 and 8.

In these conditions, bacteria and fungi feed and multiply, giving off a great deal of heat. In well managed heaps, this temperature can reach as high as 60 C, which is sufficient to kill weed seeds and organisms that cause disease in plants and animals. While the temperature remains high, invertebrates are not present in compost heaps, but when the temperature drops, the invertebrates enter the heap from the surrounding soil and complete the process of decomposition.

Forms of decomposition

Anaerobic. In anaerobic decomposition, the breakdown of the organic material is caused by bacteria and fungi that thrive in low or no-oxygen conditions. It is the type of decomposition that takes place in closed containers. This type of system is more complex and difficult to control and requires complex equipment for larger scale composting (see Box 4).

Aerobic. In aerobic decomposition, bacteria and fungi which thrive in high oxygen conditions are responsible for the decomposition. This form of decomposition occurs in open heaps and containers that allow air to enter. With open heaps and more ventilated containers, compost can be formed in a matter of a few months, and even faster if the organic material is turned regularly. In heaps or bins where aerobic decomposition is occurring, there should be no unpleasant odours.

Some methods of composting

Composting systems can be opened or closed, that is the organic matter will either be placed in open piles or rows or in a closed container or reactor. The open system is rarely used in low-income countries due to its technical complexity, so we look at some of the open systems in use.

Backyard composting at the household level is a simple technique. It requires only suitable organic waste, space to construct the heap and time to carry out the necessary work. The waste can be placed in a pit (say 2m x 2m x 1m deep) and left to decompose for 2 – 3 months. Alternatively, the waste can be piled up within an enclosure of 4 poles and surrounded by boards or chicken wire and left for a similar period. This produces a rich compost which can be used as a fertiliser on fields or gardens.

Neighbourhood composting. A commonly used technique for neighbourhood composting is the use of windrows. Here waste is simply laid out in long rows and turned occasionally. Another method is the rotating bin method which uses a series of closed, aerated bins (see Lardinois[3]).

Co-composting is technique whereby organic food waste is mixed with human or animal excreta and composted Similar techniques are used to those described above. See Box 3 for an example of co-composting. There are many examples of successful co-composting systems throughout the world (see Lardinois[3]).

Large-scale, centralised composting has tended to be unsuccessful in developing countries for a number of technical and organisational reasons. It is not dealt with in this paper.

Medium scale biogas and compost production from market garbage in Colombo, Sri Lanka

A pilot project being implemented by the Colombo Municipal Council uses organic waste from local city vegetable markets to produce biogas and compost. The digesters were developed by the National Energy Research and Development Centre and accept dry batches of organic waste. There are four 20 foot diameter floating dome digesters (see figure 3) each with a capacity of 40 tonnes dry waste. The residence time for the organic matter is 4 months and thus the four tanks are able to deal with a total of 480 tonnes of market waste each year.

The waste produces approximately 1 cubic metre of biogas per tonne per day and this translates to a total of 7500 kilowatt hours of electricity each year. The system also yields 300 tonnes of saleable fertiliser each year. Before this, all the waste had to be landfilled outside the city.

The digester is made from concrete with a floating fibreglass cover. The gas is piped from the digester and is used to power a 220 volt, 5 kilowatt converted engine. There is also a baker's oven and a catering size gas burner at the site to demonstrate the uses of the gas.

Now we will look at an example of animal rearing using organic food scraps. This is a typical example of waste being put to good use and benefiting a number of groups.

Pig-feeding in Metro Manila

In the outlying urban areas of Manila, backyard pig- rearing has long been a traditional source of income. Commercially produced feed for this activity is expensive and pig raisers often turn to organic scraps to supplement or replace the commercial product. A network of collectors has developed that collects organic waste from restaurants in the city centre, and then distribute it amongst the backyard farmers. The farmers can purchase the scrap at about half the price of the commercial feed. A cost comparison carried out under the WAREN project (cited in a report titled 'Recycling activities in Metro Manila') shows that profit is more than doubled by feeding the pigs on organic scraps, even after all other costs, such as veterinary costs, transport, fuel, etc., are taken into consideration.

Such ventures are beneficial not only to the pig raisers, but also to the municipality who would otherwise have to dispose of the waste in a landfill.

Biogas production

Biogas is produced by means of a process known as anaerobic digestion. It is a process whereby organic matter is broken down by microbiological activity and takes place in the absence of air (anaerobic means 'in the absence of air'). It is a phenomenon that occurs naturally at the bottom of ponds and marshes and gives rise to 'marsh gas' or methane, which is a combustible gas. It also takes place naturally in landfill sites and contributes to harmful greenhouse gases. Biogas can be produced by digesting human, animal or vegetable waste in specially designed digesters (see Box 2). Animal waste is particularly suitable for biogas production because it is often available is large quantities and also has a suitable C:N ratio. The scale of simple biogas plants can vary from a small 'household' system to large commercial plants of several thousand cubic metres. The process is sensitive to both temperature and feedstock (the correct C:N ratio is required as with composting) and both need to be controlled carefully for digestion to take place. Digestion time varies from a couple of weeks to a couple of months.

The digestion of waste yields several benefits:

- the production of methane for use as a fuel.
- the waste is reduced to slurry which has a high nutrient content which makes an

ideal fertiliser; in some cases this fertiliser is the main product from the digester and the biogas is merely a by-product.

- during the digestion process pathogens in the manure are killed, which is a great benefit to environmental health.

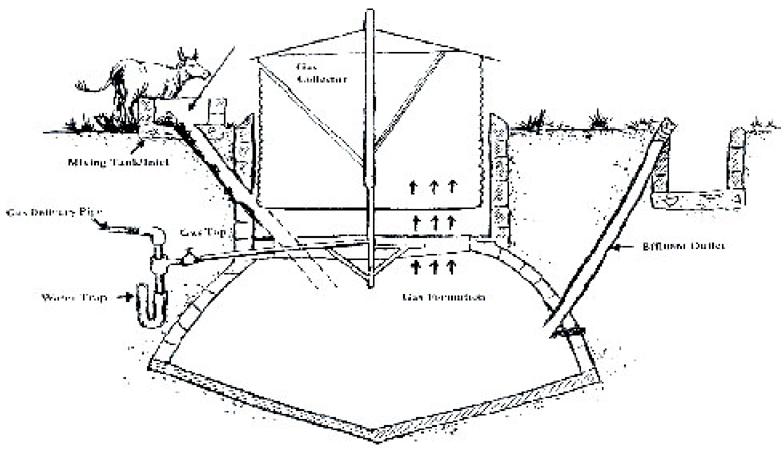

Figure 3: a typical floating cover biogas digester

Two popular simple designs of digester have been developed for use in developing countries; the Indian 'floating cover' biogas digester (see figure 3 above) and the Chinese fixed dome digester. Both operate in the same way but the storage chambers have a slightly different design.

The residual slurry is removed at the outlet and can be used as a fertiliser. Biogas can be used for a number of applications, including lighting, cooking, electricity generation and as a replacement for diesel in diesel engines. Some countries have initiated large-scale biogas programmes, Tanzania being an example. The Tanzanian model is based on integrated resource recovery from municipal and industrial waste for grid-based electricity and fertiliser production (Karekezi 1997).

Waste Material	**C:N Ratio**	**Gas yield (litres per kg)**
Human excreta	6 – 10	-
Cow dung (up to 12kg per cow per day)	18	90 – 300
Pig manure (up to 2.5kg per pig per day)	-	370 – 500
Chicken manure	7	300
Grass (hay)	12	Not suitable alone
Grass with chicken manure	-	350
Paper	-	Not suitable alone
Paper with chicken manure	-	400 – 500
Sewage sludge	-	600
Wheat straw	150	Not suitable alone
Bagasse (sugar cane waste)	150	Not suitable alone
Sawdust	200 – 500	Not suitable alone
A gas-cooking burner needs 300 – 600 litres of gas per hour. A peasant family uses 4000 – 5000 litres per month per person. The ideal C:N ratio is between 25:1 and 30:1.		

Table 1: Ability of waste to produce methane (Source: Vogler, Work from Waste)

Composting toilet
There are a number of methods commonly used for home composting (or small-scale community composting) of human excreta. The simplest and most elegant solution is the composting toilet. Usually the design of such a toilet incorporates two chambers, each capable of holding at least one years deposit of excreta for the proposed site. No water is added to the chamber, but sawdust or ash can be added to improve the Carbon:Nitrogen ratio. When the first chamber is full it is sealed off and allowed to aerobically compost. The process produces a rich, pathogen-free compost. When the second chamber is full, the first chamber is emptied and the cycle begins again. For a single dwelling, the structure need be no bigger than that of a typical pit latrine. Other methods of home composting of excreta include co-composting with vegetable matter or anaerobic digestion in a biogas reactor (see later) or in a septic tank, which yield a rich slurry compost. For more information on these techniques see Franceys[3].

Health, environment, and social aspects of waste reclamation
Waste collection and disposal is often seen as being the responsibility of the government or municipality. In many cases the municipality is unable to fulfil this role either due to financial constraints, lack of will or lack of organisational skills. In many cities, collection and separation of waste by the private or informal sector is seen as being too time consuming because of the content of the waste, often a mixture of organic and non-organic substances, such as plastic film. For there to emerge a successful organic waste reclamation process, it has been noted that it is of great help if the organic and non-organic waste is separated at source. It is here that the responsibility is thrown back onto the generator of the waste, the public. Many successful schemes are only successful because of community participation in the activities on a day-to-day basis. Where waste is separated at source, this lessens the risk of contamination from such items as batteries, means that the organic waste is cleaner (and will therefore fetch a higher price), it is easier to sort and the incidence of injury and disease related to sorting is decreased. There are a number of good examples of community recycling or resource recovery schemes in developing countries. Two such schemes are outlined below.

Accra, Ghana
In the Ghanaian capital, Accra, small-scale composting of domestic waste has been introduced to help ease the waste situation. The project has been running since 1985 with 3 collection points in low-income districts. As soon as it arrives at the collection points (delivered by workers from the city's waste management department) the waste is pre-sorted – immediately reusable material is separated from organic waste. More solid waste is removed after the compost has been turned over for the first time. The waste is sorted a further two times during the composting process and finally sieved before being sold by the container-load to local farmers. (GATE Questions and Answers No3/89).

Mérida, Mexico
In early 1978 a new drainage and recycling system was commissioned as part of a new low-cost housing project in Mérida, a city in south-eastern Mexico. The system is known as SIRDO (Sistema Integrada para la Reciclaje de Derecho Organico - Integrated System for Organic Waste Recycling). Each house is connected to a drainage system that distinguishes between grey (washing) and black (toilet) water. The grey water is filtered and used for irrigation, and the solids in the black water are settled out and used in a co-composting process (with household waste) to produce a nutrient rich, dry-powder fertiliser. The dual chamber system yields compost every 6 months. The treated black water is also used for irrigation.

The system was designed to be managed by the community. In the early days there was considerable opposition to the system, not only from the community but also from the local council and private companies, but this soon dissipated as it became clear that the system improved the communities sanitation and yielded a good quality saleable compost.

The system is maintained by community members on a voluntary basis and revenue from the sale of compost (usually to middle class residents for garden use) is reinvested in micro-enterprises or used to pay for larger maintenance jobs.

Where the informal sector carries out reclamation activities there is also a direct benefit to the municipality. A reduction in the quantity of refuse to be collected means a proportional reduction in the collection costs. Some progressive authorities actually encourage collection by members of the informal sector and will provide facilities to aid community recycling, as it is realised that it is cheaper than collection and disposal of waste. The municipality also often realise the value of contracting the work of collection and disposal to private companies. In Bogota, a city of 4 million people in Colombia with a waste generation level of 0.5kg per capita per day, it has been estimated that the cost of public waste collection is approximately US$35 per tonne whereas the private sector can make the collection for US$17 per tonne, less than half the cost.

There is often a health benefit when the municipality supports the local informal sector in recycling activities. With proper facilities for collection and processing of waste, many of the health hazards associated with this work can be removed or reduced.

Where the refuse collection activities are carried out by members of the informal sector, this is usually characterised by a complex network of interrelated activities. There is usually a hierarchy of scavengers, collectors, middlemen, dealers, small-scale recycling activities, micro-enterprise, etc. One of the most institutionalised scavenging systems in the world exists in Cairo, Egypt. There, a group of former oasis dwellers, called Wahis, have controlled garbage collection for the last 100 years. Another group, the Zabaleen, pay a fee to the Wahi for the right to collect garbage. The Zabaleen, with less than one third of the staff of the municipal sanitation department, collect 1,600 tons of trash each day to the cities 1,450 tons. Even so, 15% of the cities rubbish piles up in the streets. The Zabaleen haul home the day's receipts in donkey carts. Later, in residential courtyards, the women and children of the household sort the trash. Organic materials feed the pigs – their primary income earners – while glass, paper, plastics, metal and cloth are sold. A report has suggested that systematic garbage collection by the city would cost more than the entire municipal budget. Without the Zabaleen, much of the city's waste would simply not be collected (Worldwatch Paper 76).

References and further reading

1. McHarry, Jan, *Reuse Repair Recycle,* Gaia Books Ltd. 1993. A valuable source book aimed at reducing wastage by thrift. Aimed mainly at a western audience but with many references applicable to the developing world.
2. Lardinois, I., and Klundert, A van de, *Organic Waste – Options for Small-scale Resource Recovery,* Urban Solid Waste Series, TOOL / WASTE Consultants, 1993. The focus of this book is on the recovery of urban organic waste, in developing countries, through activities such as animal raising, composting, the production of biogas and briquetting.
3. Franceys, R., *A guide to the development of on-site sanitation.* WHO 1992. Provides in-depth technical information about the design, construction, operation and maintenance of on-site sanitation facilities, with numerous practical design examples.
4. Karekezi, S. and Ranja, T., *Renewable Energy Technologies in Africa,* AFREPEN, 1997.
5. Vogler, Jon, *Work from Waste – Recycling Wastes to Create Employment,* Intermediate Technology Publications, 1981. A classic text full of practical ideas for recycling and re-use of waste.
6. Pollock, Cynthia, *Worldwatch paper – Mining Urban Wastes: The Potential for Recycling,* Worldwatch Institute 1987.
7. *GATE – questions, answers, information*, No 3/89, GTZ 1989

Book: Guttentag, Robert M., *Recycling and waste management guide to the internet,* Government Institutes, 4 Research Place Suite 200, Rockville, MD 20850, USA. Email giinfo@govinst.com ISBN 0-86587-582-0.

Internet addresses

http://www.acr.be/default.htm Association of Cities for Recycling (ACR). The aim of ACR (an international non-profit organisation based in Brussels) is to exchange technical and educational information on the subject of waste management.

http://www.chiron-s.demon.co.uk/ccn/ Home page of the Community Composting Network

http://gate.gtz.de/biogas/AT_biogas.html GTZ Information and Advisory Service on Appropriate Technology – Biogas Page

http://www.biogas.ch/ Web Site for the Swiss Biogas Forum

techical brief

Useful addresses

Environmental Development Action in the Third World,
Head Office: PO Box 3370,
Dakar, Senegal.
Tel: +221 (22) 42 29 / 21 60 27
Fax: +221 (22) 26 95
Regional offices in Colombia, Bolivia and Zimbabwe. Database, library, publications and advice. Quarterly magazine 'African Environment'.

International Labour Organisation,
4 Route des Morillons,
CH-1211 Geneva, Switzerland.
Tel; +41 (22) 799 83 19
Fax: +41 (22) 798 86 85
Database on products and processes and socio-economic aspects of waste, Solid Waste Management and employment generation.

Small Industries Research Institute (SIRI),
PO Box 2106, 4/43 Roop Nagar,
Delhi 110 007, India.
Tel: +91 11291 81 17
Consultants specialising in small business and Intermediate Technology's.

WASTE Consultants
Nieuwehaven 201,
2801 VW Gouda, The Netherlands.
Tel: +31 (0)182 522 625
Fax: +31 (0)182 550313
email: office@waste.nl
http://www.waste.nl
Co-ordinators of the Urban Waste Expertise Programme (a programme with partners in Africa, Asia and Latin America)
Edit newsletter – UWEP News and regular UWEP email Bulletins.
Many publications, very active in many areas of waste management.
Contact: Anne-leis Risseeuw

CAPS
Room 8, Maya Building, 678 EDSA, Cubao,
Quezon City, Metro Manila,
The Philippines.
Contact: Mr. Dan Lapid
Tel: +63 (2) 912 36 08
Fax: +63 (2) 912 34 79
Consultants with on-line enquiries, training, info and education.

GTZ - German Agency for Technical Co-operation,
Post Box 5180,
Dag-Hammarskjold-Weg 1,
D-6236 Eschborn, Germany
Tel: +44 (6196) 790
Fax: +44 (6196) 791115
Database, library and publications.
Free quarterly publication 'GATE: questions, answers, information'

International Reference centre for waste Disposal,
Uberlandstrasse 133,
CH-8600 Dubendorf, Switzerland.
Tel: +41 (1) 823 50 18 / 17
Fax: +41 (1) 823 53 89
Research, library and advice.

UNDP / World Bank
Integrated Resource Recovery Programme,
1818 H. Street NW,
Washington DC, USA.
Tel: +1 (202) 477 1254
Fax: +1 (202) 477 1052
Publications on policy and case studies.