Chapter 8

Recycling of Urban Organic Waste for Urban Agriculture

Sustainable management of solid waste is a major challenge being faced by municipal authorities across the world, both in the North and the South. In developing countries, urban waste remains a serious problem that causes contamination of soil and water bodies and endangers human health and the environment. Much of the solid waste consists of organic matter that can be recycled into a profitable input (compost) for urban agriculture. Composting the large quantities of organic matter provides a win-win strategy by reducing waste flows, enhancing soil properties, recycling valuable soil nutrients and creating livelihoods, but there remain several constraints that explain why this opportunity is seldom exploited. This chapter discusses the benefits of constraints to composting and presents a framework for analysis and planning of composting interventions. The arguments and models contained in the chapter are supported with case study material from Ghana, Philippines and Kenya.

Recycling of Urban Organic Waste for Urban Agriculture

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The Urban Waste Challenge

The accelerated growth of the global urban population implies an increasing demand for public services. Yet, urban centres in developing countries are unable to meet such demand – services such as sanitation are poor or inadequate to cope with the increasing rates of urbanisation and the associated higher standards of living. According to the UN 2002 Human Development Report, 2.4 billion people in the developing world lack access to basic sanitation. In Africa, Asia and Latin America, the sustainable management of waste is a major challenge for municipal authorities. Waste is a product or material that does not have a value anymore for the first user and is therefore thrown away; however, it could have value for another person in a different circumstance or even in a different culture (van de Klundert and Anschutz, 2001). Municipal authorities have insufficient financial, technical, and institutional capacities to collect, transport, and safely treat and dispose of municipal wastes, consequently waste management remains one of the major urban problems (Drechsel and Kunze, 2001). In Ghana for example, 58 percent of the solid waste (SW) generated is dumped by households in designated dumping sites, 25 percent is dumped elsewhere in non-designated sites, and only 5 percent is actually collected. The quantity uncollected varies from place to place and could be as high as 20 percent as in the two largest cities of Accra and Kumasi. (GSS, 2000). The situation in other African cities is hardly different. In many cities household waste collection is restricted to wealthy neighbourhoods, while in the remaining areas waste is dumped along road sides, in illegal dumps and in storm water drains (Mbuyi, 1989). The city authorities in Tanzania collect only 24 percent of the refuse (Kulaba, 1989) while in Nigeria, 35 percent of Ibadan's households, 33 percent of Kaduna's, and 44 percent of Enugu's do not have access to waste collection. (Asomani-Boateng and Haight). In Ougadougou, Burkina Faso, about 23 percent of household wastes are deposited in small drains (Ousseynou, 2000). In India, about 50 percent of the refuse generated is collected. As much as 90 percent of the Municipal Solid Waste (MSW) collected in Asian cities end up in open dumps. (Medina, 2002). The failure of city authorities to collect waste leads to unpleasant conditions and decomposing wastes constitute a serious health and environmental hazard (Ali, 2004)


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Block-built triple chamber compost bin being used at Apeadu Junior Secondary School, Kumasi

Urban waste could be solid or liquid, organic or inorganic, recyclable or non-recyclable. A considerable quantity of urban waste is biodegradable and hence of immediate interest in recycling (see Box 8.1).

Very large quantities of SW are generated in urban areas; the average SW generation is 0.6 kg per person per day. Based on the composition of solid waste of cities of low- and middle income countries (from Algiers, Alexandria, Cairo, Sao Paolo, Obeng and Wright, 1987), easily bio-degradable fractions range between 44 percent and 87 percent in weight (see Figure 8.1). Similar ranges (40-85 percent) are also reported by Cointreau et al. (1985) for low-income countries. Levels of urbanisation and modernisation have a profound effect on the production and composition of municipal waste; however, some general trends such as the high content of organic matter (50-90 percent) provide an opportunity for exploitation through composting processes (Allison et al., 1998; Asomani-Boateng and Haight, 1999). The percentages of organic matter in municipal solid waste in selected African cities were recorded as 56 percent in Ibadan, 75 percent in Kampala, 85 percent in Accra, 94 percent in Kigali and 51 percent in Nairobi (Asomani-Boateng and Haight, 1999). The volume and composition may however be subject to large seasonal variations (GFA-Umwelt, 1999). A detailed report on the organic waste flow in integrated sustainable waste management has been written by Dulac (2001). In short, the waste stream is not a homogenous mass but a collection of different materials (organic material, plastics, metal, textiles etc.) that can be handled in different ways to maximise recovery. The organic waste fraction remains the largest proportion to be recovered.

Box 8.1 *Common forms of organic waste*

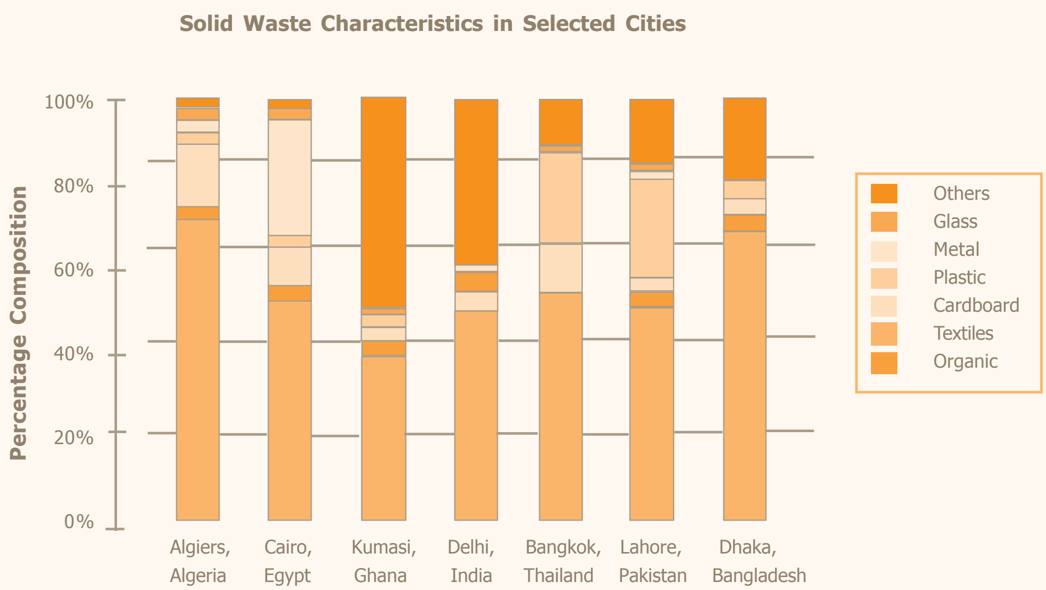
Solid waste: domestic and market wastes, food waste including vegetable and fruit peelings, charcoal ash. This also includes waste from institutions and commercial centres.

Horticultural and agricultural waste: garden refuse**,** leaf litter, cut grass, tree prunings, weeds, animal dung, crop residues, waste from public parks etc. Manure: poultry, pig, cow.

Agro-industrial waste: waste generated by abattoirs, breweries, processing and agro-based industries

Sludge and bio-solid: human faecal matter from septic tanks and treatment plants

Figure 8.1 *Solid Waste characteristics in selected cities (Drawn using data from: Hughes, 1986; Obeng and Wright, 1987; WASTE 1997; Zurbrügg, 2003; Ali, 2004)*



Urban Waste Management Strategy

Many approaches to waste management exist. Generally, solid waste is managed through landfills, incineration and recycling or reuse. However in developing countries, properly engineered landfills are not common while the cost of modern incineration is too exorbitant to bear. Hence, the most common method of waste disposal is some form of landfill, including variants such as uncontrolled dumping in undefined areas, collection and disposal on unmanaged open dumps, collection/disposal on controlled dumpsites (UNEP, 2004). It is common to find scavengers moving from door to door or sorting through communal bins to pick dry recyclable materials. However, these pickers are more interested in inorganic recyclable materials such as plastics and glass, but not in organic wastes.

Agenda 21, adopted in Rio in 1992, states that environmentally sound waste management should include safer disposal or recovery of waste and changes to a more sustainable pattern introducing integrated life cycle management concepts (UNEP, 2004). It introduced a step-wise approach to waste management in order of environmental priority. The general principle of the waste management hierarchy consists of the following steps:

- Minimising wastes;
- Maximising environmentally sound waste reuse and recycling;
- Promoting environmentally sound waste disposal and treatment;
- Extending waste service coverage.

After Rio most countries have generally accepted this hierarchy as a strategy towards an environmentally sound waste management system. In the last ten years the concept of Integrated Waste Management (IWM) has evolved and is slowly becoming accepted by decision makers (UNEP 2004). IWM relies on a number of approaches to manage waste, including all aspects of waste management, from generation to disposal, and all stages in between with proper consideration of technical, cultural, social, economic and environmental factors. Resource recovery is critical and is embedded in this strategy.

Recycling of Urban Organic Waste

Current urban organic waste recycling practices include the following:

- The use of fresh waste from vegetable markets, restaurants and hotels, as well as food processing industries as feed for urban livestock (Allison et al. 1998);
- Direct application of solid waste on and into the soil;
- Mining of old waste dumps for application as fertiliser on farmland (Lardinois and van de Klundert, 1993);
- Application of animal manure such as poultry/pig manure and cow dung;
- Direct application or human excreta or bio-solids to the soil (Cofie et al., 2005)
- Organised composting of SW or co-composting of SW with animal manure or human excreta.

Whichever method is used, a process of microbial degradation releases the useful nutrients in organic waste for soil improvement and plant growth. Composting is the process of decomposing or breaking down organic waste materials (by micro-organisms such as bacteria, protozoans, fungi, invertebrates) into a valuable resource called compost. Composting is done at different scales (large, medium, small) by various people (municipalities, NGOs, communities, individuals) and for various purposes (gardening, landscaping, farming) in the urban areas. In the 1970s, large scale centralised composting was prominent especially in the Western world. However, this has proved to be a failure (Onibokun, 1999). The collection and transportation of organic waste to centrally managed sites is expensive, time consuming and energy intensive; these processes are also dependent on fossil fuel inputs that are often heavily subsidised in order to enable maintenance of fuel inputs, therefore extending economic inefficiency at the macro-level. In situations where funding is secured from donor agencies, the conditions accompanying such funds are often disincentives to good practice. Technological know-how on financial analysis, engineering design of composting facilities and transport schedule modelling has been very limited in developing countries (Cointreau-Levine, 1997). In addition, technological transfers of composting processes and equipment from developed countries were often done in the past without considering local constraints (Hoornweg et al., 1999; Etuah-Jackson et al., 2001) and the technologies transferred were often not applicable in the receiving country. Also comprehensively planned composting stations, based on a demand-supply analysis, are not common. In fact, waste management authorities in many developing countries hardly have the "luxury" of planning for recycling; instead they focus their limited resources on the priority needs of "waste collection" and "safe disposal" which consume an immense share of the municipal budgets in low-income countries as cost recovery is low (Drechsel et al., 2004). The irony is that if well planned, the costs of waste disposal could be reduced through composting. However, what appears to be a logical win-win- situation for city authorities and farmers, is seldom a reality in the developing world (see the case study by Duran et al on Marilao, Philippines, for an example of an innovative win-win solution). This is due to several factors such as lack of affordable equipment, technical personnel, frequent mechanical breakdowns, and financial restrictions (Drechsel et al., 2004; Asomani-Boateng et al., 1996).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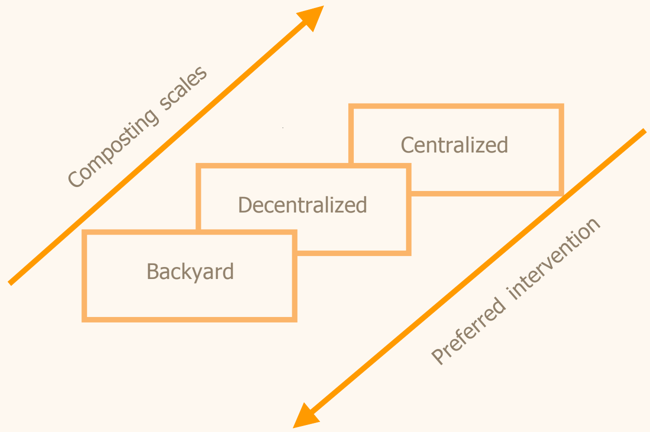
Waste ready for collection

In the 1990s, small to medium scale decentralised composting based initiatives evolved (eg. see GFA-Umwelt, 1999). However, a transition from centralised composting to decentralised composting approaches is often compounded by the lack of inter-sectoral planning (waste/planning/agriculture) in waste management. Ecological approaches to waste management have only been adopted where predominant conventional waste management approaches are not challenged. Consequently, small-scale decentralised approaches are yet to receive extensive government support at national levels. Cuba is a marked exception to this general pattern in urban planning and management. In the very different geopolitical and social conditions of Havana, Cuba, substantial progress has been made in recycling urban organic waste, as nutrient recycling principles have been implemented in practice and have proven to be very successful (Cruz and Medina, 2003; Díaz and Harris, 2005; Viljoen and Howe, 2005). But generally on a global scale, at the lowest intervention level, backyard composting is practised by few individuals.

By far, the better composting options are those that are decentralised and use organic waste as close to the source as possible. Decentralised on-site (for commercial organic waste) and on-plot (for domestic organic waste) are the preferred levels of intervention with each individual intervention requiring the appropriate technology at the appropriate scale In essence, the primary function is all about getting the nutrients and organic matter in waste back into the soil in the most efficient and effective manner; hence the priority order of backyard composting (household) and decentralised (community) approaches (see Figure 8.2). Centralised municipal approaches do not have a good track record and the potential scale-of-economy advantages have not materialised due to operational and marketing constraints.

Figure 8.2 *Composting scales of intervention*



Source: Bradford, 2005

Use of Urban Organic Waste for Urban Agriculture

The provision of sufficient food and the provision of basic sanitation services, two major challenges in (mega-)cities, are inter-linked as the urban food supply contributes significantly to the generation of urban waste (Drechsel and Kunze, 2001). In principle, therefore, recycling organic waste through composting could be a win-win situation for municipalities and farmers (for example see the Marilao, Philippines case study by Duran et al.). The interests of urban waste recycling go well with the promotion of urban agriculture since urban and peri-urban farmers are in need of organic matter as a soil conditioner. Cities and towns, on the other hand, wish to conserve disposal space and reduce the costs of landfills as well as municipal solid waste management. Also important is the need to incorporate informal waste collectors and the private sector that contribute to urban waste management into this process (see Box 8.2 and the Nairobi, Kenya case study by Njenga and Karanja).

Benefits and constraints

Zurbrugg and Drescher (2002) report that the potential benefits of organic waste recycling are particularly in reducing the environmental impact of disposal sites, in extending existing landfill capacity, in replenishing the soil humus layer and in minimising waste quantity. Other benefits adapted and summarised from Hoornweg et al. (1999) with particular reference to organic waste composting are that it:

- increases overall waste diversion from final disposal, especially since as much as 80 percent of the waste stream in low- and middle-income countries can be composted;
- enhances recycling and incineration operations by removing organic matter from the waste stream;
- produces a valuable soil amendment - integral to sustainable agriculture;
- promotes environmentally-sound practices, such as the reduction of methane generation at landfills;
- enhances the effectiveness of fertilizer application;
- can reduce waste transportation requirements;
- is flexible for implementation at different levels, from household efforts to large-scale centralised facilities;

- can be started with very little capital and operating costs;
- the climate of many developing countries is optimum for composting;
- addresses significant health impacts resulting from organic waste such as reducing Dengue Fever;
- provides an excellent opportunity to improve a city's overall waste collection programme;
- accommodates seasonal waste fluctuations such as leaf litter and crop residues;
- can integrate existing informal sectors involved in the collection, separation and recycling of wastes.

Box 8.2 *Solid waste and urban and peri-urban agriculture in Bamako, Mali*

Urban waste produced in Sahelian cities has been providing a source of nutrients and organic material for farmers in the peri-urban interface for quite some time. In Bamako, current developments present interesting opportunities for ensuring a safer and more sustainable recycling of solid urban waste.

In the peri-urban zone of Bamako, farmers involved in mixed cereal and horticultural crop farming prefer to use the solid waste primarily on their staple crops and are prepared to pay for it. The form and manner in which waste is applied is also more appropriate for cereal crops than for the relatively intensive cultivation methods used for vegetables and strawberries, particularly with respect to soil management. In this sense, urban waste is a second-choice product as a soil improver/fertilizer for horticulturalists. But given the relative scarcity of the preferred animal manure, there remains a demand from this group of farmers.

Cultivation on degraded soils has even been revived in some cases due to this readily available resource. However, uncertain land tenure means that farmers have little incentive to ensure the safe disposal of dangerous elements in solid waste. Current plans would eliminate this recycling practice and promote large-scale composting, but the cost for farmers will be too high, leaving them with an incentive to make their own illicit arrangements for acquiring waste material. Furthermore, small enterprises and associations that have come to play a complementary and innovative role in waste management would be forced out.

The key challenge for policy is to regard urban waste not as a dangerous nuisance but as a source of nutrients and organic matter in agriculture, provided that a system for separating dangerous wastes is in place. The master plan is not yet finalised in Bamako, and local actors seem convinced that pilot initiatives as undertaken in the peri-urban areas will be integrated in the plan. The experience in Bamako indicates the value of some form of new stakeholder platform that addresses these linkages in a more concrete manner by working at the more local level of the communes rather than that of the entire municipality (district of Bamako).

Source: Eaton and Hillhorst, 2003

Although composting seems an attractive option in many respects, it is also constrained (Hoornweg et al., 1999) by the following factors:

- Inadequate attention to the biological process requirements;
- Over-emphasis placed on mechanised processes rather than labour-intensive operations;
- Lack of vision and marketing plans for the final product - compost;
- Poor feed stock which yields poor quality finished compost, for example when contaminated by heavy metals;
- Poor accounting practices which neglect that the economics of composting rely on externalities, such as reduced soil erosion, water contamination, climate change, and avoided disposal costs;
- Difficulties in securing finances since the revenue generated from the sale of compost will rarely cover processing, transportation and application costs.

An evaluation of composting projects in West Africa pointed out that apart from being too expensive, a common problem leading to project failure is poor *co-ordination* among institutions and stakeholders due to weak institutional linkages and the lack of an enabling institutional framework, including clear legislation and policies. Experiences from six composting stations of different scales of production in five countries in West-Africa (see the overview in table 8.1 in the Annex) showed that compost stations in the sub-region suffer from a number of omissions (Drechsel et al., 2005). Lack of thorough market analysis including consideration of alternative soil inputs; transport costs; user's demand as well as willingness and ability to pay for compost prior to station set-up; lack of supportive legal frameworks and institutional arrangement to implement composting initiatives are some of these. In many cases, important stakeholders (land owners, waste collectors etc) were often not involved in planning which then constrained successful implementation. Apart from these, most composting projects are not financially viable, especially when outside funding available for the initial set up is exhausted. These points confirm the need for a comprehensive feasibility study before setting up any composting project.

Framework for Analysis and Planning of Composting

Planning is necessary to ensure a well functioning composting system. Analyses of the various segments - from waste generation, recycling to re-use - is necessary. The nutrient recycling loop concept is very helpful in this process (see Figure 8.3). The recycling loop is represented in this figure by various segments: urban consumption and waste generation, waste processing, compost demand for agriculture, along with an economic feedback mechanism and finally the legal, institutional and communal settings throughout the loop. (Drechsel et al., 2002)

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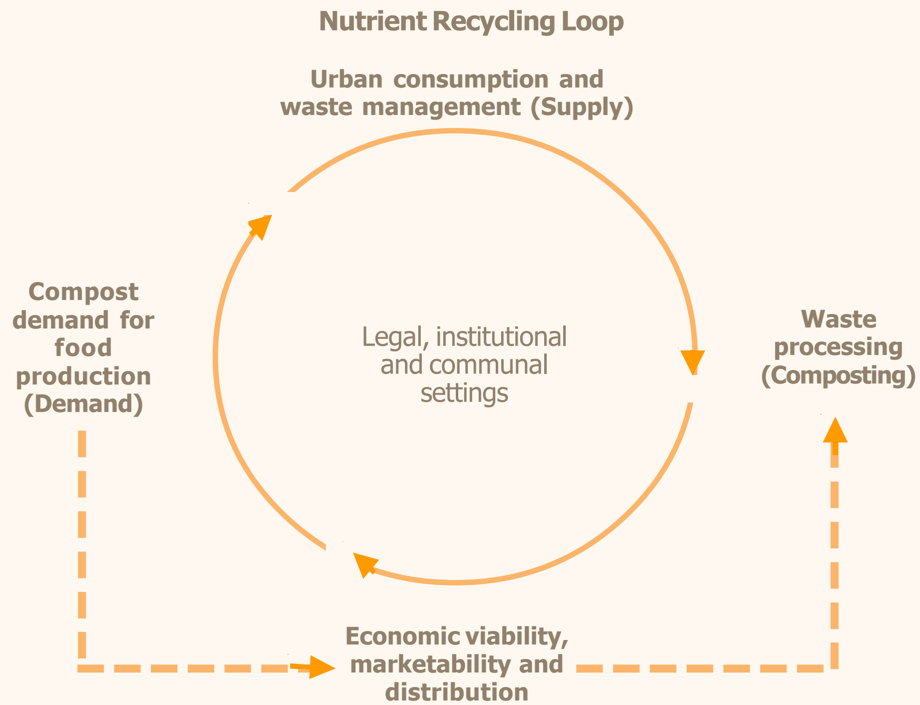
Community involvement in waste collection

The first segment of the loop, *urban consumption and waste generation,* addresses the supply dimensions of urban waste. It raises questions regarding organic waste production, location, ownership, quality, quantity, time, availability, value, health & safety constraints, etc. This is followed by the second segment *waste processing*, where questions are raised on (possibility of) organic waste transportation, appropriate processing methods (i.e. composting), production capacity, operation costs, sustainability, subsidies etc). The third segment deals with *compost demand* and address questions on users' demand, application, experiences, ability and willingness to pay, cultural constraints, etc. In addition to these three segments, there is an economic analysis linking the demand and composting segments that addresses economic viability, marketability and distribution. The final element looks at the *legal, institutional and communal setting,* in which the issues of planning, regulations, by-laws, policy constraints or support, land availability, local stakeholder participation, monitoring & evaluation, inter/intra-sectoral corporations, etc. are addressed, throughout the cycle of analysis.

This nutrient recycling loop is used to scope and assess all the processes involved in recycling organic waste into a valuable resource at municipal (centralised), community (decentralised) and/or household (backyard) levels for use in urban agriculture. The model provides a diagrammatic illustration of the systematic processes that are involved in selecting an appropriate organic waste recycling technology at the appropriate scale of intervention. For an urban farmer this process may take the form of a rapid appraisal or scribbles on the back of an envelope, whereas for a community-based organisation or a municipal authority it will form a logical guide to a more detailed and rigorous assessment study.

The recycling loop gives the required framework and potential best practice for planning composting for urban agriculture (Cofie et al., 2001, Drechsel et al., 2002, 2004, Danso et al., 2005). The questions which should be addressed at each moment in this cycle are summarised in Figure 8.3. The effectiveness and usefulness of this framework was tested in Ghana (Drechsel et al., 2004) using specific methods in the analysis of each segment of the recycling loop. It is important to note however that the analysis can have various degree of sophistication depending on the specific location, scale of the intended composting project, available funds, etc.

Figure 8.3 *The Nutrient Recycling Loop (modified from Drechsel et al., 2002).*



Application of the Nutrient Loop

The supply of organic waste

The key question in the waste supply context is: *Where* is *which* amount of waste of *what* kind of quality and *when* is it available for composting? This will allow identification of recycling needs in terms of design and capacity. Supply studies should focus on the various types, amounts, quality, present and potential uses, current value and availability of organic municipal waste for composting. The analysis of waste supply in West Africa showed that the availability of organic waste is not the limiting factor for compost production, although, not every form of waste is always available as there are often alternative uses (fodder, fuel etc) and seasonal variations. A comparison of waste generation and availability along a south to north gradient from Accra, Ghana to Ouagadougou in Burkina Faso showed that with decreasing biomass production, the amount of organic waste and related nutrient availability per capita decreases progressively as dryer eco-zones are encountered (Danso et al., 2005)

A result of waste surveys in Ouagadougou (Eaton, 2003) indicated that 80,000 tons of organic waste is produced each year in the form of solid household waste with a nitrogen content of 26 tons. It was estimated that about 25,000 tons of organic material per year could be composted and sold to farmers for application on a relatively modest estimate of 200 ha of intensive urban horticulture plots. This would correspond to an estimated 8 tons of nitrogen. This leaves approximately 55,000 tons of organic material per year that could be spread over an area of 8,500 hectares of peri-urban staple crop fields, a flow of approximately 18 tons of nitrogen. In other words, the supply of organic material is much more than can be realistically absorbed in agriculture, at least given current economic circumstances (Tessier, A. 2004).

The demand for waste-derived compost

The demand assessment includes the characterisation of all potential clients under consideration of their willingness (and ability) to pay (WTP). It is expected that a major demand for compost in rapidly expanding cities will come from landscape designers (horticulturists, parks and gardens) and real estate developers, so this sector must not be left out in the analysis. The demand analysis should also consider socio-cultural aspects, farm economics, attitudes/perceptions of users of waste compost and actual demand projections. Danso et al., (2005) reported for Ghana that many urban farmers have positive perceptions and are willing to use compost although not all have the necessary experience. Farmers' interest in compost was both for its plant-growth enhancing (fertility) effect and soil amelioration. Variations in WTP were recorded between farmers with and without compost experience, different farming systems, urban and peri-urban farms, as well as between different cities with different compost alternatives. The WTP expressed by farmers who already used compost was in several cases lower than among non-users. This was due to past experience with poor quality compost (in Accra) which resulted in poor crop performance and the negligible market demand for "organically" produced crops in Kumasi.

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Waste collection in Lomé

The study further revealed that estate developers were willing to pay higher prices for compost than urban and peri-urban farmers. In comparison to agriculture, the real estate sector has much lower qualitative requirements as compost will mostly be used for lawns and ornamentals. Thus the real estate sector could be the "favourite" customer group with options for private-public partnerships with the municipality. The financial strength of the real estate sector could subsidise parts of the compost production for agriculture.

The process of waste composting

The process of waste composting includes the determination of the type of facility, optimal number, capacity, and location of compost stations per city. Most critical in this assessment is to include possible ways of composting and determine the number of potential compost stations and station capacity with due consideration of waste supply and compost demand. Composting is best achieved by providing optimal conditions for the micro-organisms through the best combination of air, moisture, temperature and organic materials (Agromisa, 1999). Composting processes can be aerobic (with oxygen) or anaerobic (without oxygen) and even alternate between the two during the decomposition process. Anaerobic composting is a low-temperature process that is not recommended for urban agriculture due to the strong odours and the inability to destroy harmful pathogens that may be present in urban organic waste. Conversely, aerobic composting is a high-temperature process due to the development of microbes that generate higher temperatures in the compost pile. The key factors affecting the biological decomposition processes and/or the resulting compost quality are listed in box 8.3

Box 8.3 *Factors affecting biological decomposition*

- Carbon to nitrogen ratio
- Moisture content
- Oxygen supply, aeration
- Particle size
- pH
- Temperature
- Turning frequency
- Micro-organisms and invertebrates
- Control of pathogens
- Degree of decomposition
- Nitrogen conservation

The choice of a technology for aerobic composting will depend on the location of the facility, the capital available and the amount and type of waste delivered to the site. The two main types of systems generally distinguished are: 1) open systems such as windrows and static piles and 2) closed "in-vessel" systems. These "in-vessel" or "reactor" systems can be static or movable closed structures where aeration and moisture is controlled by mechanical means and often requires an external energy supply. (see the Kumasi, Ghana case study by Adam-Bradford). Such systems are usually investment intensive and also more expensive to operate and maintain. "Open" systems are the ones most frequently used in developing countries. They can be classified as:

Windrow, heap or pile composting: The material is piled up in heaps or elongated heaps (called windrows).

Olufunke Cofie

Compost heaps at Kumasi co-composting plant

Bin composting: Compared to windrow systems, bin systems are contained by a constructed structure on three or all four sides of the pile. The advantage here is a more efficient use of space. (for illustrations see the Kumasi, Ghana case study).

Trench and pit composting: Trench and pit systems are characterised by heaps which are partly or fully contained under the soil surface. Structuring the heap with bulky material or turning is usually the choice for best aeration. Control of leaching is difficult in trench or pit composting. In some cases, composting materials are completely buried in the trench which then serves as a planting bed, for example Mtshepo's home gardening in South Africa.

The aerobic composting process can last from a few weeks to 3-4 months, depending on the type of composting feedstock and the method of composting.


Olufunke Cofie

Mtshepo's home gardening in South Africa

Locally made composting pits in Tamale, Ghana

Emerging trends include the practice of vermiculture and the use of effective micro-organisms (EM) to accelerate the composting process. *Vermiculture* is the use of worms to digest organic waste into rich humus, similar to compost, that can then be applied in urban agriculture. Local varieties of both surface and burrowing earthworms can be used, although the latter are particularly suited as they not only digest organic matter but also modify the soil structure. Vermiculture is particularly suited to urban agriculture because it can be applied in a variety of settings and at different scales. The practice is also used very often as part of integrated gardening in community building urban agriculture (see chapter 6). Indeed, broad-scale vermiculture is widespread in India, Indonesia and the Philippines (GFA-Umwelt, 1999), while the practice has recently been gaining ground in Cuba and Argentina (Dubbeling and Santandreu, 2003; Viljoen and Howe, 2005). In broad-scale vermiculture, the earthworms are introduced to organic waste piled in elongated rows that are covered with some form of vegetative protection to prevent water logging (Ismail, 1997).

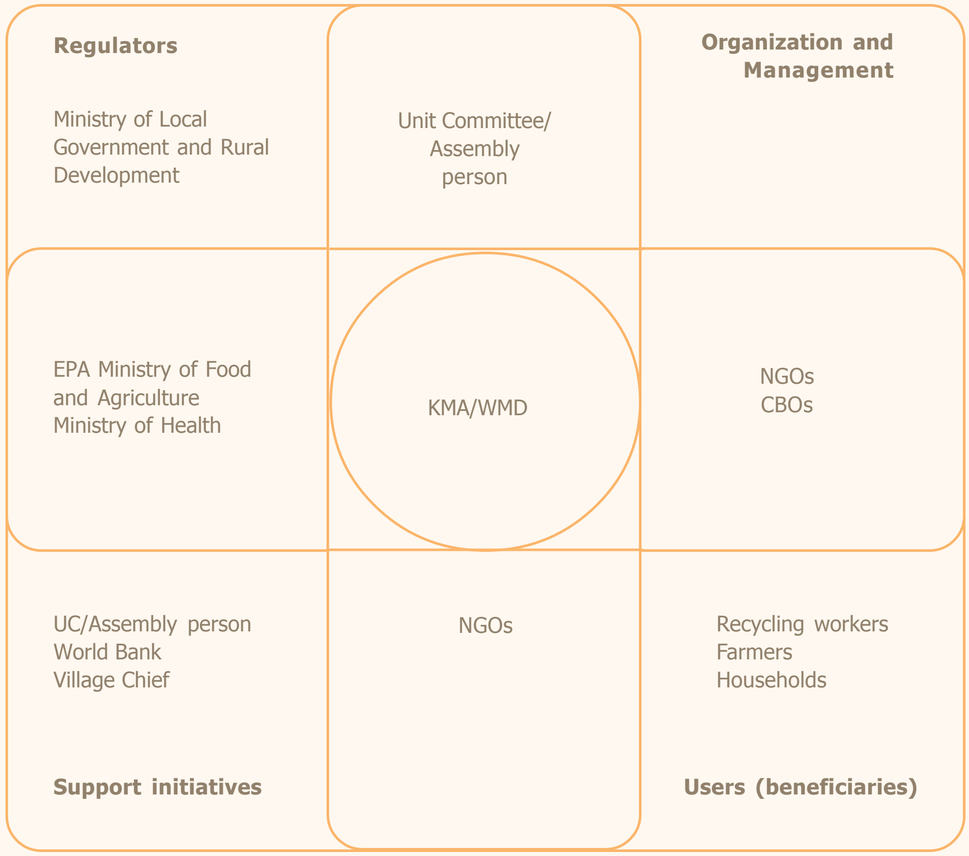
Economics of waste composting

The economic analysis links the supply, demand and process segments. This refers to consideration of the viability of the proposed compost station. GTZ-GFA (1999) has developed a model to assess the economic feasibility of compost stations. Analytical scenarios need to address different levels of technical sophistication and the actual and potential (but realistic) transport capacity of the city-specific waste collection system including profitability and investment analysis for constructing and operating compost facilities in the specific city. Such an analysis was done for Accra (Drechsel et al., 2004) and the results show that the overall cost of building and operating composting facilities in the Accra-Tema Metropolitan area is much lower than for incineration and land filling. Further more, using land fills is about 95 percent cheaper than incineration under prevailing Ghanaian conditions. The unavailability of land for landfills, incinerators and their transfer stations, and the requirements for meeting environmental quality standards are the major causes of the high capital cost of land-filling and incineration in the area. Composting urban solid waste appears to have the highest total economic benefits especially through labour-absorption.

Legal, institutional and communal settings

Legal, institutional and communal factors affect the set-up and sustainable management of compost stations. The legal, institutional and administrative context within which composting and the use of compost could be feasible concerns the environmental and sanitation by-laws and policies as well as public awareness and the roles and perceptions of authorities and other interest groups, especially CBOs and NGOs in composting. Various stakeholder institutions could play the role of regulator, manager, supporter of initiatives or beneficiary. Through stakeholder analysis and role clustering, it is possible to identify which institutions play a central role or a secondary role (See Figure 8.4). These institutions in two or more role clusters also play an important role inter-linking other institutions

Figure 8.4 *Institutional Platform for recycling of organic waste in Kumasi, Ghana (Source: Vázquez,, 2002)*



Vasquez et al., 2003 reported related work done in Kumasi, Ghana and observed that the Waste Management Department (WMD) of Kumasi Metropolitan Assembly (KMA) is the central institution to provide assistance on, or to facilitate the regulation, support (financial, technical, human resource), as well as organisation and management of organic waste recycling. Dissemination of information and services from the platform (in the centre) to the beneficiaries (in the nutrient loop) together with feedback from the beneficiaries to the platform provides a mechanism for system improvements and sustainability.

Health Implications of Organic Waste Recycling

A considerable amount of research has been done on the health implications of organic waste recycling (eg. Cairncross and Feachem, 1993; Birley and Lock, 1999; Furedy et al., 1999; Furedy, 2001). Health implications are a major constraint to recycling organic waste in urban agriculture (Asomani-Boateng and Haight, 1999), in addition to the issues of economic viability and attitude and behaviour (especially of officials). Due to the close connection of organic waste recycling with the food chain, the issue of health is crucial, not just for farmers engaged in urban agriculture, but also for consumers of the products that are derived from recycled organic waste (Asomani-Boateng and Haight, 1999). The often negative perception held by municipal authorities is associated with the use of recycled organic waste in urban agriculture as a "detriment to modern urbanity and a health hazard" (Asomani-Boateng and Haight, 1999). Furedy identifies the principal health hazards as: "survival of pathogenic organisms in residues; Zoonoses associated with animal wastes; increase of disease vectors; respiratory problems from dust and gases; injuries from sharp fragments; and contamination of crops from heavy metal take-up and agrochemical residues via wastes and their leachates" (Furedy, 2001).

Indeed, when urban solid waste contains high levels of human excreta, the application of such wastes in agriculture requires careful management (Asomani-Boateng and Haight, 1999). In addition, when compost piles are badly managed, pathogens such as nematodes and parasite eggs that may be present in the organic waste could survive the decomposition process and be carried to farmers' fields and plots when composts are applied to soils (Birley and Lock, 1999).

Simple health and safety protection measures can be taken to mitigate many of these health hazards by reducing the possible transmission pathways through the use of protective clothing. Compost workers should be equipped with rubber boots, work gloves, and mouth & nose masks to ensure protection. Training and education in the safe handling of wastes and in basic first aid should be given to compost workers and on-site washing facilities and a first aid point should be provided at the workstation. In composting plants, particularly where co-composting techniques are utilised, the regular monitoring of the final compost product is required to ensure that any pathogens present are inactivated during the decomposition process.


Almitra Patel

Mysore Compost Plant

Of course, there are many situations when a trade-off has to be made. For many poor and subsistence urban farmers, curtailing any hazardous agricultural practice is simply not a viable option. Urban agriculture is a lifeline for many of the world's urban poor, and therefore in most cases attempting to balance the health trade-off will be the preferred solution. Consequently, educating farmers in risk minimisation may well be the most appropriate option. For example, improving waste separation and collection at the organic waste set-out point is one method that can minimise the contamination of organic wastes.

Chemical contamination is another potential risk associated with re-use of organic waste. As organic solid waste is often stored and collected together with other waste fractions, contamination of the organic fraction is easily possible by chemical constituents, especially heavy metals. When applying contaminated compost, these constituents can accumulate in soils. The contamination of soils by chemicals, the potential uptake by crops, and the possible chronic and long-term toxic effects in humans are discussed by Chang et al., (1995) and by Birley and Lock (1997). Plant uptake of heavy metals depends significantly on the metal itself as well as compost and soil conditions. Similarly, the presence of a given metal can be harmful in one soil and harmless in another. A number of other parameters have to be known before any risk assessment related to heavy metals is possible. Metals in municipal waste come from a variety of sources. Batteries, consumer electronics, ceramics, light bulbs, house dust and paint chips, used motor oils, plastics, and some inks and glass can all introduce metal contaminants into the solid waste stream. Even after most contaminants have been removed through sorting, the compost may still contain these elements, although in very low concentrations.

In small amounts, many of these trace elements (eg. boron, zinc, copper, and nickel) are essential for plant growth. However, in higher concentrations they may decrease plant growth. Other trace elements (eg. arsenic, cadmium, lead, and mercury) are of greater concern primarily because of their potential to harm soil organisms or plants and possible entry into the food chain. The impact of these metals on plants grown in compost-amended or wastewater-irrigated soils depends not only on the concentration of metals and soil/ compost properties as mentioned above, but also on the type of crop grown. Different types of plants can absorb and tolerate metals differently. For instance mushrooms should not be cultivated on soil ameliorated with mercury- or cadmium-rich compost. In general, however, there is little evidence of crop contamination through compost. The application of municipal solid waste composts might, however, increase the metal content of uncontaminated soils. This may pose a risk to animals or children in the area who could ingest the composted soil directly.

A. Adam-Bradford

Organic rich compost produced from domestic waste

Further risks arise from impurities of non-biodegradable origin such as glass splinters or other sharp objects contained in the compost product. Such impurities can be a result of insufficiently sorted municipal solid waste before or after the composting process.

There are also indirect health risks caused by the attraction and proliferation of rodents and other disease carrying vectors (Furedy and Chowdhury, 1996).

Challenges Ahead

Composting raises issues not only of the technological approach used, but also of the necessary organisational set-up for operation and management of the composting, delivery of feedstock (raw material) and distribution of the compost product as well as proper extension or education. Hoornweg et al. (1999) list several reasons why the use of organic waste and composting in particular are not widely or successfully practisd in cities of developing countries.

- Insufficient knowledge and care in carrying out composting operations leading to inadequate compost quality and resulting in odours and rodent attraction that is deemed a nuisance.
- Lack of markets for the product and lack of appropriate compost marketing strategies and skills.
- Neglect of the economics of composting which relies on externalities, such as reduced soil erosion, reduced water pollution and avoided disposal costs.
- Limited support by municipal authorities who tend to prioritise centralised waste collection services rather than promote and support recycling activities and decentralised composting schemes.

In addition, the following issues related to organic waste recycling require applied research:

- Appropriate methods of segregation at source or sorting procedures to allow delivery or utilisation of pure organic solid waste for the co-composting process and to limit risks of compost contamination by impurities and chemical constituents;
- Marketing strategies and institutional framework
- Regulatory frameworks and realistic standards for compost use.

The recycling of urban organic waste brings several ecological advantages that can enhance energy efficiency through carbon, nutrient and water conservation in urban and peri-urban landscapes (Holmgren, 2002). These advantages can be categorised as the micro-environment benefits as they relate directly to soil amelioration measures, but in addition, energy efficiency should also be considered in the broader sense to encapsulate the wider advantages that can be accrued at national, regional and international scales. For example, recycling organic waste through composting in urban agriculture reduces the need to import chemical fertilizers and food stuffs. Furthermore, when urban organic waste recycling is decentralised there is reduced need for external inputs such as equipment, fuel and transportation.

Many urban and peri-urban areas are vast nutrient sinks as the recyclable nutrient potential from organic waste is seldom exploited and thus lost. This is compounded by the combination of soil nutrient mining in rural and peri-urban production areas and the accumulation of urban organic waste in the disposal sites. In these sites the mined nutrients accumulate in the peri-urban areas, largely through informal waste disposal due to the inefficiency of formal waste disposal structures (Drechsel and Kunze, 2001; Cofie, 2002).

Reversing these trends and patterns requires the adoption of holistic and integrated approaches to organic waste recycling that seek to optimise the use of a combination of methods at appropriate scales of intervention to manage organic waste in urban agriculture is a sustainable way. This means closing the nutrient recycling loop by reversing the negative impact of urban and peri-urban nutrient sinks through maximising nutrient exploitation of urban organic wastes. Furthermore, such interventions can be designed to generate livelihoods and thus contribute to urban food security. The combination of methods at appropriate scales allows for the design of interventions that are geographically applicable to the prevailing urban conditions, while exploiting urban organic waste for urban agriculture also enhances environmental protection by reducing organic waste quantities, as well as reducing the need for inorganic fertilizers in urban agriculture.


Pay Drechsel

Community based compost station in Accra.

References

Ali, M. 2004 (ed). Sustainable Composting: Case studies and guidelines for developing countries. WEDC. Loughborough University, UK. 124pp

Allison, M., Harris, P.J.C., Hofny-Collins, A.H. and Stevens, W. 1998. A Review of the Use of Urban Waste in Peri-Urban Interface Production Systems. Henry Doubleday Research Association, Coventry, UK.

Asomani-Boateng, R. and Haight, M. No date. Reusing organic solid waste in urban farming in African cities: a challenge for urban planners, http://www.idrc.ca/en/ev-33948-201-1-DO_TOPIC.html (accessed 31st March, 2006).

Asomani-Boateng, R. and Haight, M. 1999. Reusing organic solid waste in urban farming in African cities: A challenge for urban planners. Third World Planning Review, 21 (4): 411- 428.

Asomani-Boateng, R., Haight M. and C. Furedy. (1996). Community Composting in West Africa. Biocycle 1/1996, pp. 70-71.

Birley, M.H. and Lock, K. 1999. The Health Impacts of Peri-urban Natural Resource Development. Liverpool School of Tropical Medicine, Liverpool, UK.

Bradford, A. 2005. 'Solid Waste Management and Urban Agriculture'. In *Feeding cities in Anglophone Africa with urban agriculture: Concepts, tools and case studies for practitioners, planners and policy makers*. CD-Rom. International Potato Centre – Urban Harvest, Lima, Peru.

Caincross, S. and Feachem, R. 1993. Environmental Health Engineering in the Tropics: An Introductory Text. Second Edition. John Wiley and Sons, Chichester, UK.
Chang, A.C., Page, A.L., Asano, T. 1995. Developing Human Health-Related Chemical Guidelines for Reclaimed Wastewater and Sewage Sludge Applications in Agriculture. World Health Organisation, Geneva.
Cofie, O.O., Drechsel, P.. Amoah, P. Danso, G and Gyiele, L. 2001. Improving rural-urban nutrient flows through urban and peri-urban agriculture. In: Rural-Urban Encounters: Managing the Environment of the Peri-urban Interface, Development Planning Unit, University College London, International Conference Paper, November 2001 (http://www.ucl.ac.uk/dpu/pui/pui-abst.htm)
Cofie, O. 2002. 'A 'nutrition' cycle in Kumasi'. In Allen, A. and You, N. (eds.) Sustainable Urbanisation: Bridging the Green and Brown Agendas. The Development Planning Unit, University College London, UN-Habitat and the Department for International Development, pp. 60-61.
Cofie, O.O., Gordana Kranjac-Berisavljevic and P. Drechsel. 2005. The use of human waste for peri-agriculture in northern Ghana. Renewable Agriculture and Food Systems: 20(2); 73–80
Cointreau, S. J., Gunnerson, Ch. G., Huls, J. M., Seldman, N. N. 1985.. Integrated Resource Recovery: Recycling from Municipal Refuse: A State-of-the-Art Review and Annotated Bibliography. (UNDP Project Management Report No. 1.), The World Bank Washington & UNDP, Washington
Cointreau-Levine, S. 1997. Project Preparation: Solid Waste Management, Section IV. In: Urban Waste Management, Guidelines, Tools and Practices in Sub-Saharan Africa, World Bank, Washington DC
Cruz, M.C. and Medina, R.S. 2003. Agriculture in the City: A Key to Sustainability in Havana, Cuba. International Development Research Centre, Ottawa, Canada.
Danso, G., Drechsel, P., Fialor, S., and Giordano, M. 2005. Estimating the demand for municipal waste compost via farmers' willingness to pay in three Ghanaian Cities. International of Journal of Integrated Waste Management Science and Technology.
Danso, George, Pay Drechsel and Funke Cofie 2005.. Developing Policy Support on Closing Rural-Urban Nutrient Recycling for Urban and Peri-urban Agriculture in West Africa: Application of multi-stakeholder processes and approaches. Paper presented at the international conference on urban and peri-urban agriculture, Oct 2005. Yaoundé, Cameroon
Díaz, J.P. and Harris, P. 2005. 'Urban agriculture in Havana: opportunities for the future'. In Viljoen, A. (ed.) 2005. Continuous Productive Urban Landscapes: Designing Urban Agriculture For Sustainable Cities. Architectural Press, Elsevier, Oxford, pp. 135-145.
Drechsel, P. and Kunze, D. (eds.) 2001. Waste Composting for Urban and Peri-urban Agriculture: Closing the Rural-Urban Nutrient Cycle in Sub-Saharan Africa. International Water Management Institute, Food and Agriculture Organisation and CABI Publishing, Wallingford, UK.
Drechsel, P., Cofie, O., Fink, M., Danso, G., Zakari, F.M. and R. Vasquez 2004. Closing the Rural-Urban Nutrient Cycle. Options for Municipal Waste Composting in Ghana. Final Scientific Report submitted to IDRC (project 100376). Executive summary under: www.iwmi.cgiar.org/africa/west_africa/
Drechsel, P., Cofie, O., Fink, M., Danso, G., Zakari, F., and Vasquez, R., 2004. Closing the rural-urban nutrient cycle. Options for municipal waste composting in Ghana. Final Scientific Report on IDRC project 100376. Unpublished.
Dubbeling, M. and Santandreu, A. 2003. Recycling Organic Wastes in Urban Agriculture: Guidelines for Municipal Policymaking on Urban Agriculture No5. International Development Research Centre, Ottawa, Canada.
Dulac, N. (2*001)*. The Organic Waste Flow in Integrated Sustainable Waste Management. Tools for Decision-makers. Experiences from the Urban Waste Expertise Programme (1995-2001).
Eaton, D. and Hilhorst, T. 2003. Opportunities for managing solid waste flows in the peri-urban interface of Bamako and Ouagadougou. Environment & Urbanization, 15 (1): 53-63.
Etuah-Jackson, I., Klaassen, W.P. and Awuye, J.A. (2001) 'Turning Municipal Waste into Compost: the Case of Accra'. In Drechsel, P. and Kunze, D. (eds.) Waste Composting for Urban and Peri-urban Agriculture: Closing the Rural-Urban Nutrient Cycle in Sub-Saharan Africa. CABI Publishing, Wallingford, pp. 84-95.
Furedy, C. 2001. Reducing Health Risks of Urban Organic Solid Waste Use. Urban Agriculture Magazine, 1 (3): 23-25.
Furedy C and Chowdhury T. 1996. Solid Waste Re-use and Urban Agriculture: Dilemmas in Developing Countries: The Bad News and the Good News. Paper presented at Joint Congress of the Association of Collegiate Schools of Planning, and Association of European Schools of Planning, Toronto, www.cityfarmer.org/Furedy.html.

Furedy, C., Maclaren, V. and Whitney, J. 1999. 'Reuse of waste for food Production in Asian Cities: Health and economic Perspectives' in Koc, M., Macrae, R., Mougeot, L.J.A. and Welsh, J. (eds.) For Hunger-proof Cities. International Development Research Centre, Ottawa, Canada. pp. 136-144.

GFA-Umwelt (1999) Utilisation of Organic Waste in (Peri-) Urban Centres, GFA Infrastruktur und Umweltschutz GmbH, Bonn (GFA Umwelt), Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ), Eschborn and Ingenieurgemeinschaft Witzenhausen Fricke & Turk GmbH (IGW), Witzenhausen, Germany.

Ghana Statistical Services. 2002. 2000 Population & Housing Census. Republic of Ghana

Harris, P.J.C., Allison, M. Smith, G., Kindness, H.M. and Kelly, J. (2001) The Potential Use of Waste-stream Products for Soil Amelioration in Peri-urban Interface Agricultural Production Systems. In Drechsel, P. and Kunze, D. (eds.) Waste Composting for Urban and Peri-urban Agriculture: Closing the Rural-Urban Nutrient Cycle in Sub-Saharan Africa. CABI Publishing, Wallingford, pp. 1-28.

Holmgren, D. (2002) Permaculture: Principles and Pathways Beyond Sustainability. Holmgren Design Services, Victoria, Australia.

Hoornweg, D., Thomas, L., Otten, L. 1999. Composting and Its Applicability in Developing Countries, Urban Waste Management, Working Paper Series No. 8. The World Bank, Washington DC.

Hughes, E.G. (1986). Solid Waste Composting in Egypt. BioCycle, 27(2), pp. 26-27

Ismail, S.A. 1997. *Vermicology: The Biology of Earthworms*. Orient Longman: Hyderabad.=

Kulaba, S. 1989. Local Government and Management of Urban Services in Tanzania. In Stren, R.E.; White, R.R.; ed., African Cities in Crisis: Managing Rapid Urban Growth. Westview Press, Boulder, CO, USA. pp. 205-245.

Lardinois, I. and van de Klundert A. (eds.) (1993) Organic Waste. Urban Solid Waste Series 1: Options for small-scale resource recovery. Waste, Gouda, the Netherlands.

Mbuyi, K. 1989. 'Kinshasa: Problems of Land Management, Infrastructure and Food Supply'. In Stren, R.E. and White, R.R. (eds.) African Cities in Crisis: Managing Rapid Urban Growth. Westview Press, Boulder, CO, USA, pp. 149-175.

Medina, M. 2002. Globalization, Development, and Municipal Solid Waste Management. Paper presented at the Global Development Network, www.gdnet.org/pdf/2002AwardsMedalsWinners/ (accessed 31st March, 2006).

Obeng, LA and Wright, FW. (1987) The Co-composting of Domestic Solid and Human Wastes. World Bank Technical Paper No. 57. World Bank, Washington, DC, USA.

Onibokun, A.G. (ed.) 1999. Managing the Monster: Urban Waste and Governance in Africa. International Development Research Centre, Ottawa, Canada.

Ousseynou, 2000 and Tessier, A. 2004. The possibilities of reuse organic waste in urban agriculture. Case study of Ouagadougou city in Burkina Faso. MSc thesis, Wageningen University

UNEP (2004) Waste Management Planning, an Environmentally Sound Approach for Sustainable Urban Waste Management - An Introductory Guide for Decision-makers. International Environmental Technology Center (IETC), United Nations Environment Programme, Division of Technology, Industry and Economics.

UN (2002) Human Development Report

Van de Klundert, A. and J.Anschutz, 2001. Integrated Sustainable Waste Management Tools for Decision-makers WASTE Publication

Vázquez, R. (2001). Municipal Waste Management in Kumasi: The Prospects of Building and Operating Small-Scale Community-Based Composting Plants in Kumasi. Faculty of Environmental and Development Studies. Kwame-Nkrumah University of Science and Technology. Kumasi, Ghana; pp 4, 18-19, 35-52, 60. 2001.

Vázquez, R., Cofie, O.O., Drechsel, P. and I.F. Mensa-Bonsu, 2002. Linking urban agriculture with urban management: A challenge for policy makers and planners. In: C.A. Brebbia et al. (eds.): The Sustainable City II. Urban Regeneration and Sustainability, WIT Press, 925- 934

Viljoen, A. (ed.) 2005. Continuous Productive Urban Landscapes: Designing Urban Agriculture For Sustainable Cities. Architectural Press, Elsevier, Oxford.

Viljoen, A. and Howe, J. 2005. 'Cuba: laboratory for urban agriculture'. In Viljoen, A. (ed.) (2005) Continuous Productive Urban Landscapes: Designing Urban Agriculture For Sustainable Cities. Architectural Press, Elsevier, Oxford, pp. 146-191.

Zurbrugg, C. and Drescher, S. 2002. Solid Waste Management – biological treatment of municipal solid waste. SANDEC News No. 5, Duebendorf, Switzerland

Zurbrügg, C, 2003, Urban Solid Waste Management in Low-Income Countries of Asia How to Cope with the Garbage Crisis http://www.sandec.ch/SolidWaste/Documents/04-SW-Management/USWM-Asia.pdf

Figure 8.5 *Questions to be addressed for an appropriate establishment of municipal compost stations for (peri)urban agriculture and other uses (modified from Harris et al., 2001)*

Supply

What organic wastes are produced?
Where are they produced /disposed?
Is the waste treated? How?
What are the current disposal costs and/or environmental/social externalities?
What is the quality (potential soil fertility value) of the material and is the material contaminated or phytotoxic?
Are there seasonal variations in its availability or quality?
Who owns the waste?
What is the current use of the waste? (Are there competing uses in comparison with composting, for example untreated fertilizer, livestock feed, fuel, or recycled for other manufacture or use?)
What is the related market demand and economic waste value?
How much/which waste is unused and the de facto available for composting?
Are there waste use/collection constraints related to health, handling, safety and environment which could be addressed?

Institutional, legal and communal framework

Are there constraints/support related to official plans, programmes, regulations, by-laws or policies and how could we make best use of them?
Are there constraints to the set-up of compost stations related to land availability?
What are the official attitudes and recommendations eg. at institutional/ municipal/communal level?
Could inter/intra-sectoral cooperation be improved (platform building)?
How can local key groups/stakeholders become involved (community based stations)?
What are the implications of composting for these groups and what kind of commitment/input would be necessary from them?
What management settings and instruments (M&E, accounting, O&M, etc.) would be most appropriate?

Demand

Who is interested in compost (urban and peri-urban farming systems, real estate, landscape design, horticulture, etc.)?
What is their experience and/or perception of the product?
What are their requirements on the product?
What is their ability and willingness to pay for the product?
Are there special constraints to compost use related to cultural aspects (taboos), gender, compost marketing, handling?
How high is the likely demand and how does it vary over the year?

Processing

Is composting the most appropriate method to treat the waste for soil improvement?
What should be the capacity of the compost production (comparing supply and demand)?
Which technologies appear appropriate (which technologies have been applied successfully in the sub-region)?
Are these technologies locally available?
Is appropriate maintenance of these technologies likely/possible?
Are there technical waste-use constraints related to separation/collection/transport and how could we address them?
What is the transport capacity of the waste collectors?
What is the public perception towards source separation or composting?
What is the location of the waste sources and of the potential compost users?
How many compost stations are needed to keep transport costs low?

Economics

What would be the total establishment and running costs?
Which (economic) benefits for the society at large are possible?
Can these justify municipal subsidies?
What is the best mixture of waste from different sources?
How to realise co-composting?

Table 8.1 *Some compost facilities compared in West Africa (Dreschsel et., 2004)*

Name and Location of Compost Facility	**Teshie-Nungua, Accra, Ghana**	**Zogbo and Houeyiho Cotonou, Benin**	**Hèvié Compost Plan Benin**
Year of Establishment	1980	1994	1998
Realistic production capacity (tons compost)	up to 11,000	360	1200-2000
Access to Sources of Organic Material	Easy Access to Organic Waste	No easy access to MSW	Easy access to MSW waste, and slaughterhouse Waste
Method of Waste Collection	House-to-house collection system *Communal*	House-to-house collection system	Curb-side collection system
Technology Employed	Capital intensive Mixed MSW Composting	Labour-intensive. Waste separated before composting	Labour-intensive. Manually separated waste composting
Problems facing Compost Facility	- Lack of spare parts, water, training and public education programmes, and reliable energy sources.	- Poor quality of Compost	- Complaints about bad odour. facility
	- Poor funding of maintenance	- Low priced competing products such as poultry droppings, 'black soil', animal anure, raw waste, etc.	- Cheaper priced competing products such as black soil, poultry droppngs, animal manure, etc.
	-No clearly defined marketing strategies	- Lower market prices of compos than production cost	- Poor marketing strategies
	- Persistent public complaints about location	- Lack of training programmes of operator	- Located far from farmers and other compost users.
	- No collaboration & networking amongst stakeholders	- Difficulty in accepting the value of compost	

Hèvié Compost Plant, Benin	Bodija Plant, Ibadan, Nigeria	Lome and Tsévié ,Togo	Wogodogo,Ouagadougou, Burkina-Faso
1998	1985	1998	1998
1200-2000	3000	900	3000
Easy access to MSW waste, and slaughterhouse Waste	Easy access to Bodija market	Easy access to MSW	Easy access to MSW
Curb-side collection system	Curb-side collection system (communal) *containers)*	House-to-house source separated waste collection system & communal containers.	House-to-house collection system & Curb-side system
Labour-intensive. Manually separated waste composting	Labour-intensive. Manually separated waste composting	Labour-intensive, source separated composting	Labour-intensive, manually separated composting
- Complaints about bad odour. facility	- Political bickering over ownership of Togo.	- Problem of replicating technology elsewhere in	- Cheaper priced competing products.
- Cheaper priced competing products such as black soil, poultry droppngs, animal manure, etc.	- Inadequate working capital.	- Inadequate funding.	- Lack of public education on the benefits of compost and source separation
- Poor marketing strategies	- Poor quality of compost	- Poor marketing strategies	- Poor marketing strategies
- Located far from farmers and other compost users.	- Lack of skilled personnel to manage the plant.	- Poor quality of compost	

Planning in a Changing Environment: The Case of Marilao in the Philippines

Leoncio Duran Jr.
Joseph Batac
Pay Drechsel

Marilao is a municipality with approximately 15,000 households located on the fringe of Manila in the Philippines. At the end of the nineties, Marilao's authorities faced a typical peri-urban dilemma. With only 2,625 hectares of land area, just five kilometres away from Metro Manila, Marilao's mayor could not find affordable land for a new waste disposal site. There were more than 850 business firms and housing projects that competed for the use of municipal land. The problem was not just where to bring the waste. What to do with the recycled waste and what changes in policy and urban management needed to be made were also issues to be tackled.

Breaking with Traditional Planning Habits

The answers to the challenging question, "Where do we bring our waste?" posed in 1995 by the mayor, involved complex concepts high in capital investment requirements, but no affordable or practicable ideas. The precarious situation was emphasised during a series of community planning workshops in 1997 in search of reducing waste by getting all major stakeholders involved. With the gigantic waste problems of Metro Manila in mind, Marilao's authorities decided to go a different way, and involving the community instead.

Joseph Batac

Vegetables grown in pots

The problem, however, was that the anticipated involvement of the community had to be tested in a country where the style of municipal governance is predominantly administrative-oriented rather than participatory. Planning has been a purely technical matter guided by a corresponding manual. However, the preparation of the development plan with community involvement, required interactive consultations with different sectors of the community. Most of the planning officers found it difficult to organise such multi-sectoral consultations. The tools and methodologies required for participatory processes had to be adopted from the NGO community. It was even more challenging to apply them in an environment, which was used to a regulatory style of management. Moreover, experience has shown that a regulatory framework alone is hardly effective, even in the Philippines, which has one of the most stringent environmental laws in Southeast Asia.

Thus, a new style of local governance was required. The basis for this new style was given in 1992, when municipal local government units (MLGUs) were mandated by law to be autonomous with specific powers, functions and revenue. The mandate was anchored in certain principles, among which is the pursuit of an ecological balance and participatory processes of managing development. Each of the 1,525 units in the Philippines can have their own interpretation of these two principles, given their actual conditions and the management capacity to change them. Within this favourable atmosphere for near autonomous local governance, the municipal authority of Marilao together with NGOs, started in 1996 to brainstorm on appropriate solutions, more stakeholder participation and on investment programmes to overcome the waste crisis. It was estimated that the existing landfill would be full in about 3-5 years. Another study revealed that almost 50 percent of the current content was biodegradable waste; 30 percent could be recycled and only 20 percent consisted of non-usable materials.

The leaders of the municipal local government units and of the NGOs decided to look for ways to recover the major portion of the waste. Four months later, a proposal was finalised for the municipality to establish a composting facility, while the NGO community was to address the necessary change in behaviour of the main waste generator: the households in the municipality.

This solution was in fact supported by the Integrated Solid Waste System Framework (Presidential Task Force on Solid Waste Management 1993), which addressed the separation and processing of biodegradable waste into compost. Composting had been promoted by the national government under a specific programme since 1990 (Anonymous 1990), but like the Framework, it was more wishful thinking than implementation. To improve the situation, the national government provided a model ordinance in 1996 (Anonymous 1996) to implement an integrated solid waste management system in municipalities. Thus, Marilao was probably the first municipality actively implementing this policy.

To ensure the stable supply of organic household waste, source separation was initiated at the household level in late 1997, followed by a series of campaigns in the next two years. The activities in these campaigns involved workshops, cross visits, seminars, training, video films (on community cable TV), the playing of jingles during collection, providing the collection crew with a uniform, heralding the message of waste segregation, printing of calendars and community newsletters, and periodic letters from the mayor. The costs of these activities were shared between the NGOs and the municipality.

In general, principles of marketing were utilised for all activities, starting with an analysis of the clientele to ascertain their existing knowledge, attitude and practices (KAP). The ideal profile of potential clients was formulated and its 'appeal' determined. Distribution channels as well as promotional activities were then set up. NGOs drove the process of product development for community change. The process utilised participatory planning techniques that were designed by the NGOs. The planning interfaces again involved both the NGO leaders and the municipal staff, and were placed within the Municipal Development Planning Council (MDPC). Each year, a work plan was agreed upon and translated into investment by the municipality. The agreement only took effect after a series of consultations with community stakeholders and the mapping of internal strengths and weaknesses as well as of external threats and opportunities. This was followed by the identification of strategies, consensus on the preferred strategy, translation of this consensus into activities, and the contribution of municipal investments as well as NGO counterpart activities to implement the strategy. These investments included developing models on urban agriculture and improvements on the collection system for solid waste management. From 1995 to 2000, a total of USD 10,000 was allocated for developing models on urban agriculture. The investment for the collection system reached USD 15,000.

Reaching Households

The adoption of the practice of waste segregation was initially slow but accelerated over time. The municipality offered a predictable and reliable collection of *segregated* waste as an incentive, and this meant a lot in Marilao. Within three weeks, the 500 households in the first area adopted the practice, seeing that the waste collection really was predictable and more frequent. After three months, an adjoining area with 400 households decided to adopt the practice. Another 2,000 households from the contiguous area followed six months later, and the municipality had to buy more collection vehicles to maintain the promised collection frequency. Today, almost all the 15,000 households of Marilao benefit from the system by providing source separation.

The Nurture Plan

This regular supply of biodegradable waste allowed the municipality to produce compost at a rate of approximately one ton per day by using a compost fungus activator to reduce the composting time from three months to one month. The set-up of the technology needs both waste from urban households and a market, which are the urban farmers of Marilao. Initially, the compost was given to urban farmers together with seeds and tools. When the municipality realised that the compost supply could not cope with the demand, and farmers also asked for application guidelines of the compost and related information, the NURTURE plan (*Networking for Urban Renewal Through Urban Ecology)* was established.

The NURTURE plan identified the farmers who practise solid waste segregation and have open spaces within their yards and/or in contiguous areas. Three strategies were identified based on the crops grown: (i) food security, (ii) recreation and aesthetics, and (iii) livelihood. The farmers targeted for "food security" are the urban poor who cultivate high nutritive crops that supplement micro-nutrient deficiency, especially among children. The target group for "recreation and aesthetics" is middle class households who grow ornamentals and plants with fragrant flowers; and the "livelihood" strategy addresses farmers growing potted crops/flowers mainly during the off-season.

All three groups encountered the problem of access to land. The NURTURE plan addressed this by developing compact gardens with a standard soil composition. At first, the plan targeted guidelines for compost application, but it had to struggle with large inner-urban variations in soil quality, and some urban areas even had no soil at all but only concrete. Yet they faced a demand from farmers using pots and other containers to grow vegetables or flowers. To address this situation, the municipality carried out a series of practical experiments in 1999, which resulted in a standard substrate with compost as the predominant material for pot cultures and raised beds with rain shelters.

The farmers were organised under the umbrella of the Marilao Federation of Service Organisation (MAFESO). The MAFESO is a network of 75 community-based housing associations, church/religious groups, sectoral groups like women and transport workers, and civic clubs. In each of these organisations, there are many members who have been actively involved in the activities of solid waste recycling and urban agriculture. These members periodically plan and discuss their activities within a working committee under the MAFESO and the Municipal Development Planning Council (MDPC). The members are critical in technology applications and testing, land access arrangements and implementing the investment plan as approved in the MDPC.

The Message Spread

After a meeting with Mayor Duran of Marilao, the chairman of the Government of Metro Manila instructed his senior staff to study the Marilao model via one-day cross visits. Several more local government representatives went to Marilao on cross visits to learn about the project. In addition, national government as well as donor agencies published articles on the project, and in April 2000, the wife of President Estrada visited Marilao to learn about urban agriculture. Officials from the largest NGO in Metro Manila working on solid waste management and recycling accompanied her.

All of these interested groups and institutions had one common question – how did the programme start? The Marilao experience showed that the way to success is a stony one, which challenges old structures and planning habits. The required shift in mindset of officials and style of governance to manage development with community change can only happen when there is a strong political will. This is necessary to motivate the NGOs as well as the communities. Once there is political will, the technical aspects can be modified with a greater degree of tolerance for correction in the context of improvement. The Marilao experience has also shown that municipal planning can serve as a focus of development, as long as more participatory style of management is followed. This commitment then easily translates into investment for community mobilisation and logistics for both short and long term.

References

Anonymous. 1990. National Composting Program. Manila: Department of Science and Technology.

Anonymous. 1996. Memorandum Circular 96-119. Manila: Department of the Interior and Local Government.

Presidential Task Force on Solid Waste Management. 1993. Integrated Solid Waste System Framework. Manila: Office of the President.

Container Composting in Peri-urban Kumasi, Ghana

A. Adam-Bradford

This case study reports on the experimental implementation of container composting methods in Ghana's second largest city, Kumasi [1]. Container composting can be simply defined as the use of a receptacle or structure in which organic waste matter is composted. Using a container for composting bestows several advantages that make the practice particularly suitable for urban and peri-urban agriculture (UPA), where close proximity to human settlements becomes a consideration. Composting domestic organic waste in an urban environment may create breeding sites for disease vectors (eg. flies, mosquitoes, cockroaches, rats), attract snakes that feed on the vermin and give rise to unpleasant odours. Using composting containers can not only mitigate many of these problems, but also protect the compost pile from being adulterated with contaminated wastes, and furthermore, when good handling skills are applied, allow for extremely efficient decomposition rates. Composting then remains safe, hygienic and acceptable to local residents and, more importantly, conforms to local environmental sanitation by-laws.

Andrew Bradford

Easy to operate 'Suame' compost tumbler

Table 8.2 *Advantages and disadvantages of container composting*

Advantages	Disadvantages
Closed container	Requires drainage
Small space required	Requires regular handling
Low odour emissions	Requires aerating manually
Protection against water logging	Requires education and training of the user
Protection against moisture loss	Prevalence of anaerobic conditions
Use of recycled materials for construction of containers	Emission of odours when handled inappropriately
Control and monitoring of waste inputs	Requires motivation
Handling of small organic waste quantities	Purpose-built containers - cost intensive
Protection against pests, vermin and snakes	Thermophilic microbes may not develop
Prevents domestic organic waste at source from entering urban waste stream	

Source: field observations, 1999-2005 and modified from GFA-Umwelt, 1999.

Decomposition Process

Compost containers can be used to easily obtain the optimal decomposition conditions for organic waste by regulating the air, humidity and temperature during the composting process and thus create the ideal environment for micro-organism development (bacteria, protozoans, fungi, invertebrates). Good handling of the compost pile accelerates the decomposition rate while also minimising the nutrient loss. Good practices include cutting up and shredding the organic waste, turning the pile to increase aeration, sprinkling water on the pile if it becomes too dry (dusty with ants), and keeping the container closed during heavy rains to prevent (the pile from) water logging.

Maintaining the optimal C/N ratio of 25-30/1 may require careful monitoring and appropriate handling, as nitrogen levels are often quite high when composting domestic organic waste in containers due to the concentration of nitrogen-rich matter and limited aeration. Under such conditions the compost becomes putrid, acidic and compacts, and its quality deteriorates. This then leads to high odour emissions and the prevalence of anaerobic conditions. Turning the pile and adding dry porous materials (carbon rich), such as leaves, sawdust, or straw, can easily rectify this problem. It should be noted that if anaerobic conditions prevail thermophilic microbes may not develop, and consequently, thermophilic temperatures may not be achieved. However, in container composting this is not so crucial as only domestic organic waste is used, rather than waste from unknown sources that may contain unwanted (i.e. human) pathogens and/or agricultural residues that may contain crop diseases and/or weed seeds.


Andrew Bradford

Block-built double chamber compost bin in Esereso, Kumasi

Container Design and Use

Containers can be purpose built (eg. from bricks, blocks, plastic barrels, wicker baskets) or constructed from recycled materials (eg. oil drums, plastic barrels, building materials). The space required for a composting site is approximately 1.5-2m^2 per household (in peri-urban Kumasi an average traditional household consists of 10 adults and 8 children). This allocated area allows enough space to place two containers side by side, or to build two chambers if using bricks or blocks (height 1m); sufficient working space should be maintained around the front of the containers. The chambers are filled sequentially, so that when the second chamber is full the compost in the first chamber can be emptied and the mature compost stored until ready for use. In designing containers, consideration has to be made for aeration vents, drainage, ground soil contact and overhead protection.

In Kumasi, the main container-composting method demonstrated was block-built compost bins chosen mainly because of the wide availability of building blocks. Cement was used in the construction of the double-chamber bins although gaps were left between the blocks in the bottom to facilitate aeration (left without mortar for temporary use), and then each chamber was covered with a wooden lid. In some locations and in six schools larger versions consisting of three high-capacity chambers were also built and demonstrated. But regardless of the type of container selected, some fundamental design principles need to be considered including:

- Pile compost directly on ground soil thus ensuring drainage and allowing contact with soil micro-organisms (in sealed containers provide drainage holes and add fresh compost in each cycle to ensure micro-organisms are present).
- Provide means of aeration in container walls (holes in drums or gaps between blocks).
- Use covers to close containers at night and regulate compost pile during day.

Performance and Problems

Container composting proved to be highly effective for decomposing organic waste, particularly when good composting practices were followed, specifically where organic materials were shredded and the compost pile frequently aerated. Problems encountered included compost compaction and putrefaction, low participant motivation and loss of the actual composting site. During the earlier phases, some project participants eager to fill their containers with organic waste invited their neighbours and friends to also use them. As the containers were designed for individual household use they were rapidly filled, which resulted in compost compaction and putrefaction. Removing the top layers and increasing aeration of the remaining compost pile remedied this. In places where the larger capacity triple-chamber containers were used this problem did not occur.

Despite the immediate benefit for women and children of not having to make the routine early morning trip carrying daily domestic waste to the local refuse dump, the participants' motivation decreased overtime. This largely stemmed from the programme's failure to incorporate sufficient training and support in entrepreneurial skills related to compost demand and marketing. When such training was provided, participants became extremely motivated in compost production. The success of composting programmes is not dependent on the composting method or container, but principally on 'intensive care and know-how of the individual' (GFA-Umwelt, 1999), including marketing knowledge and alternative compost uses. Finally, two compost sites were actually lost due to the extension of adjacent houses. Hence, where possible, composting interventions need to be planned around future developments, although in peri-urban areas where urbanisation is rapid and spontaneous, this becomes a challenge.

Policy Implications

In the six peri-urban locations 20 demonstrations were implemented and after 3-months 17 additional micro-projects had been taken up. Early spontaneous uptake of the technology was encouraging, with the number of installations almost doubling within three months of project initiation. However, the main obstacle to further uptake was financial constraints as the average construction cost of a block built double-chamber container was approximately 13 Euro, and exceeded the purchasing power of most peri-urban farmers. In two sites where the larger triple-chamber containers were constructed, several households shared the construction costs, although this then required a much greater level of self-monitoring and household coordination.

Separating and composting domestic waste at the household level can lead to substantial decreases in waste stream outputs and thus contribute to a cleaner environment, particularly in peri-urban areas that are plagued by unmanaged open waste dumps. However, in this activity, there is a time lag before the compost is produced and the subsequent benefits are gained, so the intervention must be well planned and sustainable, with project participants actively engaged in all stages of the planning and implementation process. Failure to adopt such an approach may result in the implementation of inappropriate technologies (see Hamdi, 2004). Furthermore, the successful implementation of container composting programmes requires substantial educational and training inputs across a range of topics including establishing compost sites, constructing compost containers, appropriate compost handling, compost use and compost marketing. In Kumasi, successful implementation was enhanced through the provision of demonstrations and information leaflets and the running of composting workshops. The latter became even more effective in time when the local project participants became proficient in demonstrating composting principles. Finally regular monitoring of the composting process is also required to enable problems to be addressed as and when they arise.

Conclusions

Container composting has the potential for creating a classical win-win situation by increasing urban and peri-urban agricultural production through appropriate soil fertility management, protecting the environment through the recycling of organic waste, and income and livelihood generation, which enhance urban and peri-urban food security (Drechsel and Kunze, 2001; Leitzinger, 2001). In the context of decentralised composting of urban waste at the household level, there exist a variety of interventions that meet low-cost requirements and that are appropriate in peri-urban areas. In Kumasi, interest in the introduced low-cost technologies has been high within the selected communities. Although several households have spontaneously adopted the techniques, supplying their own materials to construct compost containers, if such programmes are to be implemented on a wider and systematic scale, then financial assistance (or purpose-built compost containers) will be required.

Note

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References

Adam, M (2001) Definition and Boundaries of the Peri-urban Interface: Patterns in the Patchwork, in Drechsel, P and Kunze, D (eds.) *Waste Composting for Urban and Peri-urban Agriculture: Closing the Rural-Urban Nutrient Cycle in Sub-Saharan Africa*. IWMI, FAO, CABI Publishing, Wallingford, pp. 193-208.

Adam-Bradford, A. McGregor, D. and Simon, D. (2006) 'Community-based waste management strategies: peri-urban interface, Kumasi, Ghana'. In McGregor, D. Simon, D. and Thompson, D. (eds.) *Peri-Urban Interface: Approaches to Sustainable Natural and Human Resource Use*. Earthscan, London, pp. 231-245.

Bradford, A. McGregor, D. and Simon, D. (2003) Container Composting in Peri-Urban Kumasi, Ghana. *Urban Agriculture Magazine*, 10: 30-31.

Drechsel, P. and Kunze, D. (eds) (2001) *Waste Composting for Urban and Peri-urban Agriculture: Closing the Rural-Urban Nutrient Cycle in Sub-Saharan Africa*, International Water Management Institute, Food and Agriculture Organisation and CABI Publishing, Wallingford, UK.

Hamdi, N. (2004) *Small Change: About the art of practice and the limits of planning in cities*. Earthscan, London.

GFA-Umwelt (1999) *Utilisation of Organic Waste in (Peri-) Urban Centres*, GFA Infrastruktur und Umweltschutz GmbH, Bonn (GFA Umwelt), Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ), Eschborn and Ingenieurgemeinschaft Witzenhausen Fricke & Turk GmbH (IGW), Witzenhausen, Germany.

Leitzinger, C (2001) The potential of co-composting in Kumasi - quantification of the urban and peri-urban nutrient balance, in Drechsel, P and Kunze, D (eds.) *Waste Composting for Urban and Peri-urban Agriculture: Closing the Rural-Urban Nutrient Cycle in Sub-Saharan Africa.* IWMI, FAO and CABI Publishing, Wallingford, pp150-162.

Community-Based Compost Production for Urban Agriculture in Nairobi

Mary Njenga
Nancy Karanja

Population growth in Kenya is given as 5 percent in the past five years, while it is estimated that 20-40 percent of its inhabitants live in absolute poverty (MoPND, 2003). The poor in Nairobi seek food security and income through crop and animal keeping on small and insecure plots. Estimates by Foeken and Mwangi (2000) indicated that about 150,000 people or 30 percent of the households in Nairobi practice farming and that 80-85 percent of the cultivators are women.

Nairobi's urbanites produce about 2000 tons of solid waste daily of which 60 percent is organic (JICA, 1997). Of the total waste produced in Nairobi, only 40 percent is collectively disposed of at dump sites (ITDG-EA, 2003). Heaps of garbage is found along roadsides and in residential estates. Despite the urban waste disposal problem, a well planned and regulated organic waste resource recovery is yet to be realised in many cities. This study illustrates that composting organic waste for reuse in urban agriculture is a way to alleviate urban poverty while contributing to solving the waste problem (with youth involvement) in Nairobi. Although the study did not primarily investigate the impact of composting schemes on poor urban dwellers, the results obtained nevertheless give interesting insights into these aspects.


Andy Bradford
Transporting household waste to a sorting site.

The survey among CBOs

Low-income communities produce compost in the urban and peri-urban area in order to generate income and secure self-employment. A survey was conducted in 2003-2004 on the management of organic waste and livestock manure for enhancing agricultural productivity in urban and peri-urban Nairobi. Interviews were held with ten community-based organisations (CBOs)/self-help groups in Nairobi and with a CBO from the neighbouring town of Ruiru, specialised in compost production from dump site mining. These CBOs were identified from secondary data (Ishani et al., 2002; ITDG-EA, 2003). Individual and group interviews were done with a set of semi-structured questionnaires and checklists. The survey covered group dynamics, compost and manure production, use and marketing of the products. The CBOs were analysed on their environmental management and potential to alleviate poverty.

Results of interviews

The eleven CBOs compost about 0.6 percent or 2,500 tons of the total organic waste produced in Nairobi daily. All of them aimed at generating income and tried to contribute to environmental management. Some of them in addition were involved in raising health awareness and rehabilitating of street children. The groups had been formed between 1978 and 2001, and their members generally belong to the poor section of the population and included both men and women. In Ruiru town, the CBO was made up of young school leavers of the lowest social level with diverse backgrounds. Four of the interviewed groups are located in informal settlements, two in middle class residential estates, three in retail and wholesale small to medium agriculture produce markets and two in waste dump sites (one in the City Council of Nairobi and the other at the Ruiru dump site). All the groups are located within a radius of 25kms from the city centre, except for the Ruiru group which is 40 km away. All the groups surveyed were officially registered as self-help groups.

Different types of organic waste such as household waste, market refuse, food waste from canteens and hotels, as well as agro-industrial waste (i.e. coffee husks) are collected and used as raw material for composting. Two of the CBOs only used a single type of raw material, i.e. either market or dump site waste, whereas the other CBOs composted a mixture of different waste materials. Six groups transported waste to the composting sites using wheelbarrows, donkeys and carts. Those who did not transport the waste to another location carried out composting at the source – the dump site or the market. The compost produced by the CBOs was of lower quality to the commonly used cattle manure.

Nancy Karanja and Mary Njenga

Composting organic waste from the market

Different practices and materials used in composting resulted in a high variability in compost characteristics. Waste contamination at source was likely to be responsible for the high zinc and copper contents in the compost samples, particularly those taken from the dump sites. Two groups generated income by charging households for waste collection. Six groups had received formal training in compost making from development organisation such as UN-Habitat and Intermediate Technology Development Group (ITDG-EA), while others applied local knowledge which they had acquired in the rural areas. However, most of the formally-trained groups were reluctant to apply the acquired skills because they found the new/improved composting techniques labour-intensive and time consuming. Lack of space was the main challenge faced by the CBOs since composting was done either on rented or leased public land, or illegally on open spaces adjoining markets.

The study was undertaken by several different institutions that were working in partnership. The market survey identified plant nursery operators, residents of the high income estates for their ornamental gardens, and landscapers or estate developers as the main compost buyers, including a small number of small-scale and large-scale horticultural farmers from the city environs. The urban and peri-urban farmers who purchased and/or used compost were mainly those who were also members of the composting CBOs. Compost was transported by hired vehicles for distances of up to 50 km. For shorter distances, bicycles, wheelbarrows or carts were used. About 253 tons or 30 percent of the compost produced was sold at USD 67 – 133 per ton (compared to USD 14 – 24 per ton of cattle manure) which was thought to be too high considering the quality and the fact that most of the farmers still prefer chemical fertilisers.

The study revealed that compost production as a business venture is a challenge for the producer due to limited production knowledge leading to poor quality of compost. The demand for compost was very low due to lack of information on the origin of the compost and hence the fear of potential risks associated with urban waste such as heavy metal and pathogen contamination. It appeared that farmers and policy makers were largely unaware of the soil fertility and environmental management benefits of compost making.

Discussion of findings

High compost prices seem to be a major drawback to the success of this activity in uplifting the livelihoods of the youth and the poor in Nairobi in general. The high prices were not attractive to the poor urban farmers with limited resources coupled with insecure land tenure. It is not surprising that only 30 percent of the compost produced was sold, and that clients for compost were primarily business enterprises and large horticultural farms in the rural areas. These enterprises have a much better bargaining position as they can purchase large quantities of compost whereas the poor urban farmers with little land are forced to pay high prices. Farmers are interested in using organic fertilisers if the quality and price of the products are comparable to other sources of plant nutrients which include inorganic fertilisers and animal manure, and untreated waste water which is used on 36 percent of irrigated land in Nairobi (Hide and Kimani,2000). Compost production and urban agriculture are not necessarily linked to each other but efforts through the office of the Nairobi Provincial Agriculture will be rekindled so as to enhance nutrient recovery from the large mountains of organic waste especially around the wholesale markets. In Nairobi, the only urban farmers who used compost were those who had actively participated in the CBOs or who were given compost free. Therefore, besides information on product quality and price, awareness should also be raised among compost producers and users (for instance through media) how to obtain access to the compost.

Nancy Karanja and Mary Njenga

Storage and marketing of compost by City Park Environmental Group in Nairobi

Conclusion

Organic waste recovery for compost making offers numerous advantages, particularly to the urban poor, as it helps to improve food security through urban cultivation and to generate income through composting. The municipal councils of Nairobi and other towns in Kenya are unable to cope with the heaps of garbage that are found all over the place. Recycling of the organic material through compost making would not only generate highly needed soil amendment fertiliser and improved community incomes, but would also result in a cleaner and healthier environment.

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References

Foeken, D. and Mwangi, A. M. (2000) ' Increasing Food Security Through Urban Farming in Nairobi'. In Bakker, N., Dubbeling, M., Gundel S. Koschella-Sabel, U. and De Zeeuw H. (2000) (eds) Growing Cities, Growing Food. Urban Agriculture on The Policy Agenda. DSE pp 303

ITDG-EA, 2003, 'Nairobi solid waste management network' [Online], Available by WasteNet http://www.wastenet.or.ke/ (posted 09.05.04; verified 11.02.04)

JICA (1997) Master Plan Study of Nairobi

Maxwell, D.G., 1998, 'Does urban agriculture help prevent malnutrition? Evidence from Kampala', Food Policy, Vol. 23, No. 5, pp. 411-424.

Njenga, M., Gathuru , K., Kimani, K., Frost, W., Carsan, C., Lee-Smith, D., Romney D. and Karanja, N. (2004) 'Management of Organic Waste and Livestock Manure for Enhancing Agricultural Productivity in Urban and Peri–Urban Nairobi'. Project Report.

Ministry of Planning and National Development, Kenya (2003), Economic Survey.

UN-Habitat, 2003, ' The challenge of slums: Global report on human settlements', United Nations Human Settlements Programme (UN-Habitat), pp. 310.

WB, 1997, 'The use of compost in Indonesia: Proposed compost quality standards', World Bank, Washington, D.C.

Resources

Waste Composting for Urban and Periurban Agriculture: Closing the Rural-Urban Nutrient Cycle in Sub-Saharan Africa
Drechsel, P.; Kunze, Dagmar (eds). 2001. 200 p. ISBN 0-85199-548-9. CABI, Wallingford, UK; IBSRAM Regional Office for Africa, Ghana; FAO Regional Office for Africa, Ghana
This CABI hardcover publication provides an African perspective on the potentials and constraints of urban waste recycling for soil amelioration (and integrated pest management) as well as for urban and periurban farming systems. Most of the papers here are derived from an IBSRAM - FAO International Workshop on Urban and Periurban Agriculture held in Ghana in August 1999

Reuse of Waste for Food Production in Asian Cities: Health and Economic Perspectives In: For *hunger-proof cities: sustainable urban food systems / Mustafa Koc, Rod Waste Recycling MacRae, Luc JA Mougeot and Jennifer .Welsh (eds), p. 136-144. ISBN 0.88936.882.1.*
This paper discusses health and economic aspects of the reuse of municipal waste in South and Southeast Asia. Recent research in Bangkok, Bandung, Bangalore, Hanoi, Ho Chi Minh City, Jakarta, and Manila is used to suggest the potential for linking organic waste reuse with urban agri-aquaculture.

A Review of Waste Recycling the use of Urban Waste in Periurban Interface Production Systems
Allison, M., Harris, P.J.C.., Hofny-Collins, A.H. and Stephens, W. 1998. HDRA, Ryton Organic Gardens, Coventry, UK.P.34
This publication is an output of a research project funded by the Natural
Resources Systems Programme of the UK Department for International Development (DFID). It is a review of urban waste and its potential use in periurban agriculture.

Municipal solid waste management, involving micro and small enterprises: guidelines for municipal managers.
Haan, Hans Christiaan; Coad, Adrian; Lardinois, Inge 1998. 154 p. ISBN 92-9049-365-8 ; USD 20. Publications Department, International Training Centre of the ILO, Viale Maestri del Lavoro 10, I-10127 Turin, Italy.
The focus of this publication is on micro- and small enterprises (MSEs) which have the advantage of appropriate technologies that can provide low-cost services at places where larger scale operations are either too expensive or make use of inappropriate equipment. At the same time, a number of restricting conditions that concern the extent to which SMEs can be involved in waste management operations is given. The current trend, the authors argue, is a mixed system of small and larger enterprises working together with municipalities.

Integrated Sustainable Waste Management: A Set of Five Tools for Decision-Makers. Experiences from the Urban Waste Expertise Programme (1995-2001).
Klundert, A. van der, M. Muller, A. Scheinberg, N. Dulac, J. Anschutz and L. Hoffman. 2001.WASTE Advisers on Urban Environment and Development, Gouda, The Netherlands
This series of Tools for Decision-makers on Integrated Sustainable Waste
Waste Recycling Management (ISWM) presents a unique approach to municipal waste management. Integrated Sustainable Waste Management is a concept, an analytic framework and an assessment that pays attention to aspects often neglected in conventional municipal waste management. The series is based on lessons learnt in the Urban Waste Expertise Programme, a six-year research and pilot project programme (1995-2001) on urban waste in Africa, Asia and Latin America.

Further Key Readings

UNEP, IETC (2004), Waste Management Planning, an Environmentally Sound Approach for Sustainable Urban Waste Management - An Introductory Guide for Decision-makers. International Environmental Technology Center (IETC), United Nations Environment Programme, Division of Technology, Industry and Economics.

UNEP, IETC (1996), International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management. International Environmental Technology Centre Japan. SMI (Distribution Services) Limited, Stevenage, Hertfordshire SG1 4TP, England [B].

Klundert, A van de., Anschütz, J. (2001). Integrated Sustainable Waste Management - the Concept. Tools for Decision-makers. Experiences from the Urban Waste Expertise Programme (1995-2001)
Wilson, D., Whiteman, A., Tormin, A. (2001), Strategic Planning Guide For Municipal Solid Waste Management; CD-ROM, DFID and The World Bank.
Dulac, N. (2001). The Organic Waste Flow in Integrated Sustainable Waste Management. Tools for Decision-makers. Experiences from the Urban Waste Expertise Programme (1995-2001)
Cooperband, L. (2002). The Art and Science of Composting - A resource for farmers and compost producers. University of Wisconsin-Madison, Center for Integrated Agricultural Systems

Hoornweg, D., Thomas, L., Otten, L. (1999), Composting and Its Applicability in Developing Countries, Urban Waste Management, Working Paper Series #8. The World Bank, Washington DC.
Obeng, LA and Wright, FW. (1987). "The Co-composting of Domestic Solid and Human Wastes." World Bank Technical Paper No 57, World Bank, Washington, DC, USA 1987.

Nas, P.J.M., Jaffe, R. (2004). Informal waste management - Shifting the focus from problem to potential. Environment, Development and Sustainability 6: 337–353, 2004.

Coad, A. (1998), Solid Waste Management: Directory of English-Language Publications and Organisation for Low- and Middle-Income Countries. SKAT, St. Gallen, Schweiz, Distributor IT.
Lagerkvist A. (1997). Landfill Dictionary. ISWA International

Skitt, J. (1992). 1000 Terms in Solid Waste Management. ISWA International

www.sandec.ch
SANDEC is part of the Swiss Federal Institute for Environmental Science and Technology (EAWAG), Switzerland. Its activities centre on problems of sustainable development in economically less developed countries. Its mandate is to assist in developing appropriate and sustainable water and sanitation concepts and technologies adapted to the different physical and socio-economic conditions prevailing in developing countries.

www.waste.nl/uwep.htm
WASTE works towards sustainable improvement of the urban poor's living conditions and the urban environment in general. Its multi-year, multi-country programmes and projects have a focus on bottom-up development in relation to recycling, solid waste management, ecological sanitation and knowledge sharing. WASTE, located in the Netherlands, teams up with like-minded organisations in Africa, Asia, Latin America and Eastern Europe in implementing its activities.

www.ecosan.nl
This is an important new site focusing on ecological sanitation. The site provides information on the technical, financial, environmental, health, socio-cultural, institutional, political and legal aspects important for the success of (ecological) sanitation. The site also offers practical examples of sanitation systems from around the world and provides further links to sites, publications and experts.

www.wastekeysheets.net
This site assists in making a Municipal Waste Management Plan, flexible and sustainable, by applying strategic planning and Integrated Sustainable Waste Management. The key-sheets are products of the project "Building Municipal Capacity for ISWM Planning" funded by DFID's KAR programme in which three municipalities were assisted in starting up the planning process for a municipal waste plan. The activities undertaken have been reworked into key-sheets offering hands-on support and information for planners in other municipalities.