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Management of Biodegradable waste by Composting

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ABSTRACT

Composting has always existed on every field and forest floor, and intuitively it makes sense to compost the organic fraction of the Municipal solid waste stream. Composting is a cornerstone of sustainable development, yet it is often neglected within integrated Municipal solid waste management programs. This informal paper argues that composting should be a more widespread practice, especially in developing countries. Composting is obviously not a panacea to today's vexing waste management problemmes, but it should be an important component within most integrated Municipal waste management strategies. Over 50 per cent of an average developing country city's Municipal solid waste stream could be readily composted. Composting is a simple process where optimization efforts are used to increase the rate of decomposition (thereby reducing costs), minimize nuisance potential and produce a clean and readily marketable finished product. Composting helps to increase the recovery rate of recyclable materials—household source separation of recyclable paper, metal and glass,already common in many developing countries.

Key words : Composting, Solid waste, Benefits of composting

INTRODUCTION

Composting has always existed on every field and forest floor, and intuitively it makes sense to compost the organic fraction of the Municipal solid waste stream. Composting is a natural process which provides several benefits: the process can be inexpensive; it addresses over 50 per cent of a city's waste stream; it reduces one of the world's largest contributors to Greenhouse gases; it enhances related recycling and incineration activities; and it can produce a beneficial end product with unlimited marketing potential. (Albrecht, 1989) It simply recycles organic material back to the topsoil from where it is mined through typical agricultural practices.

Composting is a cornerstone of sustainable development, yet it is often neglected within integrated Municipal solid waste management programmes. This informal review paper argues that composting should be a more widespread practice, especially in developing countries. However, composting can only be part of Municipal solid waste programmes if adequate recognition is given to the need and cost associated with proper waste disposal; nothing is cheaper than not collecting solid waste (Rylander *et al.*, 1993). This paper views the role of composting from the perspective of a Municipal solid waste manager; an equally relevant perspective would be that of the agriculturist.

Applicability in developing countries :

Over 50 per cent of an average city's Municipal solid waste stream in a developing country could be readily composted. Composting is a relatively simple process; the compost operator helps nature take its natural course. An optimization effort increases the rate of decomposition (thereby reducing costs), minimizes nuisance potential, and promotes a clean and readily marketable finished product. Composting is highly compatible with other types of recycling. Diverting organic material helps to increase the recovery rate of recyclable materials, while at the same time, recycling programs for glass and plastics, which are common Municipal Solid Waste (MSW) compost contaminants, improve the quality of the finished compost (Asomani *et al.*, 1996) Household source separation of recyclable paper, metal and glass is already common in many developing countries. (Selvam,1996) Many cities in developing countries are plagued with poor waste collection. While a few, more influential residents may get daily waste collection, others may never have such services. Daily waste collection in wealthy neighborhoods is usually too frequent and contributes to the lack of collection in poorer areas. In more affluent areas of a city, the use of containers and diversion of Organic waste for composting is a good way to quickly improve the cities overall waste collection service (Mazumdar, 1992). Many cities have switched from unreliable daily collection to bi-weekly organic waste collection and weekly non-organic waste collection.

Composting in Cairo (Egypt) :

Settlements of landless family groups, known as the Zabbaleen, located on the outskirts of Cairo rely on the collection and sorting of urban solid waste as a source of income. Maqattam is the largest of the Zabbaleen settlements with a population of seventeen thousand people. In the early 1980's, a community composting operation began at a former quarry in the Maqattam settlement to compost garbage from which recyclables

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have been removed and pig manure from the zeribas. (Lardinois and Vander Klundest, 1994) reported that the waste was dumped by a mechanical front-end loader through a grid onto a conveyor belt, which transfered the organic material to a hopper and finally to a rotating, cylindrical drum, where the material was sieved (Mehta, 1992). The composting time varies from only six to fifteen days since the waste has already undergone partial decomposition. Mechanical parts for the plant can be purchased in Egypt, but some electrical parts have to be imported.

Community composting in Jakarta (Indonesia) :

Cipinang Besar, a neighborhood in East Jakarta, decided to implement a community composting programme to properly dispose of household wastes being dumped into the Cipinang River. Indiscriminate dumping clogged the river and canal and caused flooding during the rainy season. Financial assistance from the United Nations Development Program (UNDP) and the government of New Zealand helped the community to establish its own composting business in 1992. The facility was built from recycled scrap steel, currently employs 12 people, and produces 3 tons of compost per month. Control of the composting business empowers the community and addresses their specific social and environmental needs (Perla, 1997).

Vermicomposting in India :

Founded in 1981, the Bhawalkar Earthworm Research Institute (BERI) has established six large scale vermicomposting projects and motivated almost 5,000 farmers to use vermicomposting applications. A system implemented by BERI at the Indian Aluminum Co. Ltd. site uses worms to treat solid waste and sewage from a colony of 500 homes and to filter the company's canteen grey water so that it can be reused in the cooling tower. Venkateshwara Hatcheries Ltd. Applies vermiculture to process almost 4 tonnes per day of poultry residues and manure. The end product is marketed as "Biogold" and sold at a much higher price than conventional compost. A vermiculture facility is successfully operated by Orient Vegetexpo Ltd. to digest 4.5 tones of onion residuals per day during a ten month processing season. The adsorptive properties of vermicomposting are able to dissipate the smell of onions within a few hours of feeding (White, 1996).

Benefits of composting :

- Increases overall waste diversion from final disposal, especially since as much as 80% of the waste stream in low- and middle- income countries is compostable
- 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
- Flexible for implementation at different levels, from household efforts to large-scale centralized facilities
- Can be started with very little capital and operating costs
- The climate of many developing countries is optimum for composting
- Addresses significant health effects 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 leaves and crop residue

Constraints on composting :

Inadequate attention to the biological process requirements with over-emphasis placed on mechanized processes rather than labour intensive operation lack of vision and marketing plans for the final compost product also poor feed stock which yields poor quality finished compost, for example heavy metal contamination 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.

- Local governments, and avoided disposal costs are not adequately addressed
- Sensible preoccupation by Municipal authorities to first concentrate on providing adequate waste collection
- Inadequate pathogen and weed seed suppression
- Nuisance potential, such as odors and rats
- Poor marketing experiences
- Poor integration with the agricultural community
- Perverse incentives such as fertilizer subsidies or over-emphasis on capital intensive projects
- Land requirements are often minimal, but can be a constraint

Design requirements :

All organic matter will eventually decompose, however, some materials are more suitable for composting than others. The raw materials which are most appropriate for composting includes:

Vegetable and fruit waste, farm waste such as coconut husks and sugarcane waste, crop residues Such as banana skins, corn stalks and husks; yard waste such as leaves, grass and trimmings; saw dust; bark; household kitchen waste; human excreta and animal manure. (Malmros and Petersen, 1988). All of these organic materials are readily found in Municipal solid waste generated in developing countries. Animal waste, such as carcasses and fish scraps, can be used as well but they are more likely to attract unwanted vermin and generate odors. Other organic matter such as wood, bones, green coconut Shells, paper and leather decompose very slowly and hinder the composting process (Lardinois and Vander Klunder, 1993).

Composting occurs whenever there is sufficient oxygen, water and ambient temperatures. Designing a composting system usually involves optimization between: transportation, land, labor, and capital costs, feedstock, and markets. There is never one "right answer" but rather several possible options. For example, combinations of community and large-scale composting facilities should encourage to reduce Municipal costs.

Residential composting :

Household composting can be a simple way to manage kitchen and garden wastes. This type of composting effectively reduces waste quantities for collection, thereby improving efficiency and reducing operating costs. Residential composting should be promoted when a significant number of homes have individual or collective yards or gardens and there is sufficient space (UNEP, 1996).Composting units can be made out of locally available materials such as wood, bamboo, clay bricks, wire mesh etc. (White,1996). The design and operation of the composters should not attract rodents, insects, or other scavenging animals. Keeping large quantities of meat, fish and fatty food out of the composter is the best way to keep pests away from the unit.

Decentralized community composting :

Decentralized composting at a neighborhood or community scale provides small groups a way to compost at a relatively low cost. Households, commercial establishments (e.g., small markets or shops), and institutions (e.g., government buildings, schools) in an area generating between five and 50 tones of organic waste per day can compost on vacant land, beside community gardens, public parks. Local governments can support the project through public education, providing land for the facility, assisting with start-up costs, transporting and disposing of rejects to local Landfills, and using the final compost in public parks (deBertoldi *et al.*, 1983). To ensure that the composting operation is environmentally and socially acceptable, UNEP (1996) recommends the following requirements for the site:

Centralized large-scale composting :

Centralized composting can range from 10 tones per day to more than 500 tones per day. Since centralized composting is on a significantly larger scale, environmental, social and technical consideration should be approached in a more formal manner and address the following requirements (UNEP, 1996) :

- Technical assessment of the area, soil, and geographic characteristics of potential sites
- Inclusion of engineering and design professionals in site selection and facility design
- Environmental assessment of the site
- Formal evaluation and site selection processes that involve all relevant stakeholders
- Programme to minimize and/or compensate for nuisance effects of traffic, odor, leachate, and noise produced by the composting operations
- Establishment of a marketing strategy for the compost
- Enforceable protocols for the quality and composition of the compostable materials delivered to the facility
- Formal agreements made between all Municipalities within the jurisdiction for sitting, design, financing, operations, maintenance, environmental compliance and billing for services and waste delivery
- Designated routes for the delivery of organic materials to the facility

Marketing compost :

Virtually any soil will benefit from the application of compost. Theoretically, there is an unlimited market for good quality compost; the organic matter is simply recycled back to where it came from. However, the cost of production, transportation and application of compost can exceed the benefits. Therefore, good marketing programs, and optimizing the use of compost, needs to be the basis of a successful Municipal compost project. The issue of compost marketing is not so much finding a use for the finished compost but rather finding cost-effective applications. The history of many failed composting projects can be attributed to poor marketing strategies and inadequate attention to long term financing.

The first step in developing a marketing strategy is to assess all existing and potential markets .This requires knowledge of the product, potential uses, limitations on use, and estimating the value of the product to the user. It is also important to adapt the marketing strategy to meet the local requirements by considering soil characteristics, agricultural practices, social customs, climate, transportation costs, seasonal variations, etc. The other critical aspect of a compost marketing strategy is to adequately include avoided collection and disposal costs that would be paid if the organic matter was not composted.

The strategy has to be flexible to accommodate market fluctuations and frequently reviewed to anticipate and make the appropriate adjustments. Marketability of the finished compost is affected by the following factors:

- Condition and fertility of local soils
- Government policies toward import substitution, such as import restrictions or subsidies on chemical fertilizers
- Availability and cost of other soil conditioners, such as animal wastes and crop residues
- Reliability and quantity of compost production
- availability and cost of other agricultural inputs, including chemical fertilizers
- Seasonal agricultural patterns
- Compost quality, such as the nutrients, particle size and maturity

Compost quality :

The high organic content in the MSW stream of developing countries is ideal for composting. However, the Municipal waste stream also contains increasing quantities of glass, plastics, metals and hazardous materials which can contaminate the finished compost. Separating contaminants from the raw material at the compost site is inefficient since it requires additional effort, space, and time, and it is likely that much of the contamination has already affected the organic fraction. Source separating the waste before collection is usually an environmentally and technically better way to improve the quality of the final compost. In addition to ensuring a safe product, compost standards provide a valuable marketing tool. The consumer can be satisfied with the knowledge that the product quality is consistent and suitable for the desired application. This is important for commercial and agricultural operations where a relationship exists between predictable results and repeated sales. The supply of compost must also be reliable since inability to meet market commitments affects customer relations and reflects poorly upon the credibility of the program (Albrecht, 1989). Table 1 presents indicative heavy metal concentrations in different MSW composts and demonstrates that source separated Municipal wastes produce a higher quality end product compared ton on-source separated Municipal solid waste. Source separation simply means putting waste out for collection in separate containers.

Table 1 : Concentration of heavy metals in different composts

Heavy metal	Source separated MSW compost: Europe and North America	Source separated MSW compost: Java, Indonesia	Non-source separated MSW compost: Netherlands	Proposed standards for MSW compost in developing countries
Arsenic	-	0.5	-	10
Cadmium	1.2	0.9	7.3	3
Chromium	27.0	20.0	164.0	50
Copper	59.0	54.0	608.0	80
Lead	86.0	99.0	835.0	150
Mercury	0.9	0.9	2.9	1
Nickel	17.0	50.0	173.0	50
Zinc	287.0	236.0	1567.0	300

The proposed compost guidelines for Indonesia were created to meet all environmental regulations throughout the country and to assure the public that the compost is safe for use. The guidelines do not propose a stringent and expensive testing regime, rather they have been developed to encourage "clean" composting that will maximize market development and minimize future process changes. Assumptions and factors used to set high quality compost standards for unlimited applications include:

- Heavy metals should be safe for use under all soil conditions
- Compost product has to be of quality such that no leaching, or plant uptake, of heavy metals will occur even under acidic soil conditions
- Prevent the accumulation of heavy metals even after repeated applications, which could occur on horticultural lands proximate to cities
- Guarantee all future land use options with sufficient standards so that site-specific controls, even after many years of application, are unnecessary
- Limited to only one class since laboratory testing facilities are usually too limited to ensure the quality of two compost classes
- Prevent the gradual pollution of relatively clean lands
- Conservative since testing costs tend to reduce testing frequency to an absolute minimum

- Sufficiently stringent to promote development of composting procedures and systems design that can be exported to other countries
- Encompass all soil amendments, such as worm castings from vermicomposting operations

It is also suggested that the standards be re-evaluated after five years of experience with MSW composting in different communities. If the standards cannot be achieved continuously at different locations, the reasons for exceeding the limits should be identified and, if possible, mitigated. Heavy metal standards may not be needed if the compost is going to be used in non-agricultural land uses, e.g., rehabilitation of mine sites or landfill cover. However, it is prudent to design a waste management system that has the potential to produce good quality compost with unlimited marketing potential. With proper attention to source separation and compost process control, these standards can readily be achieved in most cities. In developing countries, where reliance on laboratory tests and restrictions on compost use should be minimized, waste management authorities should focus on the provision of a sound compost process, with quality and temperature control

Environmental issues :

The emission of landfill gases (LGs) produced by the anaerobic and aerobic decomposition of organic matter is a major source of Greenhouse gases (GHG) which are responsible for global warming and ozone depletion. There is significant variation in the amount of carbon present in different Municipal solid waste streams. However, it is reasonable to assume that one million tones (Mt) of unsorted MSW contain approximately 0.3 Mt of carbon in various forms. Experimental research and process modeling demonstrate that about 0.2 Mt would be converted to landfill gases (LGs) consisting of 0.09 Mt carbon dioxide and 0.09 Mt methane and other trace constituents. LG emissions from landfills account for nearly half of the world's total anthropogenic sources of methane. Furthermore, methane is between 19 and 21 times more potent as a GHG than is carbon dioxide.

Composting is one of the simplest ways to prevent emissions of methane because the organic fraction of the waste stream is diverted from landfill. While composting does release carbon dioxide, it is currently considered to be a neutral process since the removal of carbon dioxide from the atmosphere by photosynthesis to produce organic matter is also not considered.

In developing countries, organic matter constitutes a significant portion of Municipal solid waste. Diversion of organic materials from landfilling extends the life of the landfill by reducing the amount of waste to be disposed. Odors are produced when conditions inside the compost pile become anaerobic through a lack of oxygen. Well operated composting facilities should produce minimal objectionable odors. The final compost product can be beneficially used as a soil amendment. Recycling organic matter back into agricultural applications improves overall soil conditions by:

- Developing and maintaining structure,
- Improving physical properties,
- Decreasing susceptibility to erosion,
- Encouraging microbial activity,
- Providing potentially available plant nutrients.

The effects of chemical fertilizers compared to compost are often misunderstood. The main difference between the two is that the nutrients contained in the chemical fertilizer are used rapidly but in completely, whereas the nutrients supplied by the compost are used slowly and stored in the soil over an extended period (Epstein *et al.*, 1996)Chemical fertilizers are generally preferred over compost because they are easy to handle, store, and apply, and because they often receive economic subsidies from governments. (Pahren, 1987)However, a synergistic relationship exists between compost and chemical fertilizers, and greater fertilizer efficiency can be established through the use of compost in conjunction with chemical fertilizers

Application of compost to agricultural soils may also help to suppress certain plant pathogens and reduce the incidence of disease. The Institute Pertanian Bogor in Indonesia found that compost significantly reduced the occurrence of certain plant root diseases of economic importance, namely seedling disease of chili peppers, tomatoes, and sweet corn, and wilt disease of soybean.

Cost of composting :

Composting rarely generates profits on its own. However, when viewed as a component of an integrated solid waste management programme, composting can provide economic benefits on a much larger scale. The costs of composting includes raw materials, production, marketing, and hidden environmental costs whereas the benefits involve the market value of the compost, savings from avoided waste disposal costs, as well as various positive environmental impacts. When considering the large quantities of organic matter generated in developing countries, government scan save money by reducing the amount of waste requiring collection, transport, and disposal. The extent of these savings are dependent on how the waste management system incorporates composting initiatives, including the elimination of temporary dumping sites, rerouting of collection vehicles, and the redirection of labour. Traditional cost accounting systems usually do not include the hidden costs and benefits of environmental and social externalities since they are difficult to quantify.

Costs benefits :

- Potential odor emissions n reduced landfill space
- Improper disposal of rejects n reduced surface and groundwater contamination
- Reduced methane gas emissions
- More flexible overall waste management system
- Reduced transportation costs
- Enhanced recycling of materials such as paper, metal and glass
- Reduced erosion and improved efficiency of synthetic fertilizers
- Reduced air pollution from burning waste

There are other benefits which may not directly impact the operation of the composting facility but do affect the overall health and well being of society. Water contamination can occur from leachate infiltration or from disposing of waste into open water bodies. Poor water quality has been linked to various human infections and diseases. Residents often burn their waste, contributing significantly to urban air pollution which can lead to respiratory illnesses such as chronic bronchitis. A 1991 emissions inventory prepared by the Indonesian Environmental Control Agency (BAPEDAL) estimated the share of total air pollutants attributed to solid waste burning. In Jakarta about 8 per cent of particulate matter and 8 per cent of hydrocarbons originated from solid waste. Bandung experienced even higher levels of 20 and 17percent, respectively (Kozak and Sudarmo, 1992)

Conclusion :

Composting is all too often implemented for the wrong reasons. It will not make large profits, nor will it solve all solid waste management problems. Incentives, such as the availability of Government subsidies and soft loans, are frequently used to set up composting projects which cannot be sustained on a long-term basis. Composting should be considered as part of an integrated solid waste management strategy with appropriate processing technologies selected based on market opportunities, economic feasibility and social acceptance.

To enhance Municipal composting efforts the following are required: mproved policies, capacity building-technical and managerial, increased public education, proper full cost accounting, integration with agricultural and horticultural activities and more focus on Implementation and day-to-day operations. Governments should support and encourage community based, private sector, and Municipal composting initiatives by:

- providing technical assistance on composting techniques
- Developing guidelines for the implementation of low-cost facilities
- Evaluating loans and other financial support
- Allocating land for compost facilities on a long term lease basis
- Promoting the use of compost through public awareness campaigns
- Using compost in its own departments, such as public works and agriculture
- Reducing subsidies on chemical fertilizers

Recommendations :

Composting do's :

- Source separate compostable materials from the waste stream
- Encourage small-scale decentralized composting projects
- Use labour intensive composting processes first
- Conduct an in-depth market study for the compost end product
- Study existing and past composting projects
- Establish compost quality standards
- Provide incentives to encourage implementation and operation of composting projects
- Integrate composting within the existing solid waste management system
- Involve community based and nongovernmental organizations
- Encourage public participation and input
- Assess public needs and willingness to participate
- Educate all stakeholders about the benefits of composting

Composting dont's :

- Do not initially establish large-scale composting facilities
- Do not rely on highly mechanized composting processes
- Do not assume that the compost end product will have an immediate use
- Do not choose technology which is unreliable and not replicable
- Do not assume that international compost standards are appropriate for the end use
- Do not provide funding without monitoring the implementation and performance of the composting project

- Do not assess composting success solely on a Municipal financial basis
- Do not rely on enzymes or "special" inoculates to enhance the process

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