Environmental Practices of Yard Waste Management in Bangkok

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Abstract

Yard waste generation is unavoidable in every society, and it is evident that rapid urbanization has led to more yard waste generation than before. At present, most of the yard waste in Bangkok is illegally dumped into abandoned waste lands. Some of these wastes are being incinerated, thus releasing poisonous gases into the air. Increasingly, stringent air and water pollution regulations and many waste disposal requirements, coupled with the anticipated shortage of available landfills have accelerated the development of yard waste composting as a viable waste management option.
The purpose of this study is to examine the technical and economic feasibility of processing yard wastes. Likewise, discussion on a market survey was carried out to evaluate the potential areas for compost application. In addition, reviews on policies and community involvement were outlined to find out the potential mechanisms for maximizing the necessary disposal controls in yard waste disposal. The information obtained from this survey will serve as reference on selection of the optimum yard waste treatment process.

Keyword: Bangkok, composting process, incineration, landfilling, organic fertilizer, yard waste management.

1. Introduction

Thailand is located in a tropical climate zone, where tropical plants grow and prosper all year round. Thus, frequent gardening takes place in the community or rural areas, creating abandoned garden wastes such as leaves, wood clips and grass clippings. This creates environmental problems for yard waste management and disposal in the community. In normal cases, the Public Cleansing Service, Department of Public Cleansing (DPC) under the Bangkok Metropolitan Administration (BMA) collects small volumes of yard waste along with municipal solid waste (MSW). In most of the cases, bulky yard waste such as stumps, logs, leaves, grass clipping were always refused for collection because they were not considered as MSW. Due to the weight/volume problem, normally this waste was small in weight but takes more volume for transporting. Therefore, it is not economical to transport this waste to the site. Often a BMA waste collector charges fees for yard wastes collection. Thus, yard wastes from both private and public places in many cases encounter difficulty in disposal. Frequently an owner hires yard waste collection staff to collect and transport yard waste. Due to rapid population growth and economic expansion, the Bangkok Metropolitan Administration (BMA) needs a comprehensive solution to overcome yard waste and disposal problems in the city. This research study aims to use existing data of yard waste to provide the most effective and reasonable yard waste management to solve the problem in the near future.

Table 1 : Future yard waste generation in Bangkok Metropolitan Region

Year	**Population** (persons)	**Rate** (g/p/d)	**Solid waste** (tons/day)	**Yard waste*** (tons/day)
2000	5,868,000	1.614	9,469	960
2005	6,334,600	1.715	10,865	1,075
2010	6,838,300	1.817	12,424	1,235
2015	7,382,000	1.918	14,162	1,430
2017	7,611,400	1.959	14,911	1,500
2019	7,847,900	2.000	15,696	1,600

Source : Master Planning Study for Waste Management of Bangkok Metropolis, Team Consulting Engineers & Quality Company, financed by BMA, 1999.

Notes : (*) : Rough estimation based on 10.1 percent of solid waste generation.
g/p/d : generation rate per person per day.

Municipal solid waste collection and disposal in Bangkok

In the Bangkok Metropolitan region, solid wastes generated from community and public area is currently collected by the Department of Public Cleansing (DPC), Bangkok Metropolitan Administration. DPC [1] reported that the amount of waste collected from 50 districts was 3,102,500 tons (8,500 tons/day). The Bangkok Metropolitan Administration [2] has three transfer stations, namely On-Nooch (3500 ton/day), Nong-Khaem (3000 tons/day) and Tha-Rang (2000 tons/day). The refuse was then transported from transfer stations to landfill sites at Lat Krabang and Kampang Saen, respectively. About 20 tons per day of hospital hazardous waste is incinerated at the On-Nooch disposal site.

Current status of yard waste management in Bangkok

In Bangkok, yard wastes are generated from park lands, community gardens, golf courses and other sources (Figure 1). Yard waste from parks and golf courses represent the largest and relatively uniform source in term of quantity and quality. Figure 2 shows yard waste disposal in the Bangkok Metropolitan Region. The finding revealed that 76% of the yard waste was improperly disposed of, which led to a number of environmental and human health concerns. Table 1 shows the future generation of yard waste in Bangkok. In 2000, Bangkok generated 960 tons per day of yard waste and the projection of yard waste generation will reach 1,600 tons per day by 2019. The Bangkok Metropolitan Region is facing a serious problem in yard waste collection.

In practice, there are two types of yard waste collection processes:

a. Local refuse collection service

In most cases, yard waste is picked up by municipal collection crews, as mixed solid waste and transported to nearby transfer station before disposal at landfill site. However, with growing trends in yard waste volume (Figure 3), There are serious concerns with disposal. Often, bulky yard waste such as stumps, logs, leaves and grass clipping were not collected by the local municipal collection crews. In these instances, fees were charged for bulky yard waste collection.

b. Private refuse collection service

Due to the large volume of uncollected yard waste, the Department of Public Cleansing (DPC) can not efficiently fulfill such a

challenge. BMA pays private contractors to collect the yard waste in the assigned areas and transport to the disposal site for treatment. There are several private organizations that participate[133k45] in yard waste management practices. These small companies account for approximately 60% of the yard waste collection in Bangkok.

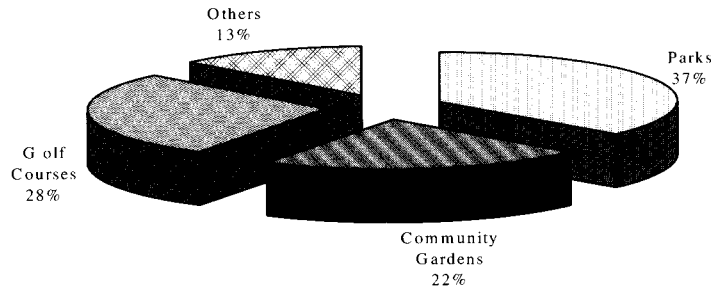

Figure 1. Yard waste generation sources in Bangkok Metropolitan Region

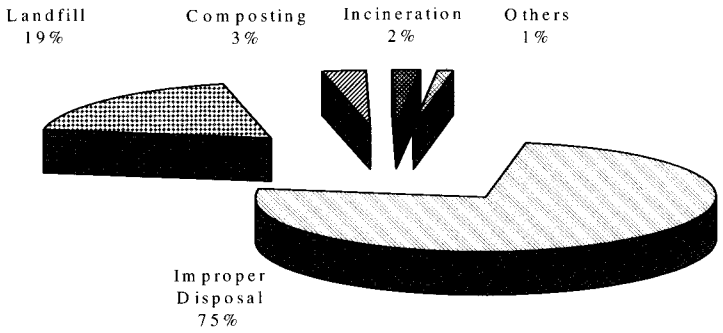

Figure 2. Modes of yard waste disposal in Bangkok

Potential Treatment Technologies

The existing yard waste disposal in Bangkok may be generally summarized as follows:

- Landfilling (with or without separation from mixed solid waste)
- Incineration (without heat recovery)
- Composting process
- Others

All methods of yard waste disposal, in the final choice rest in selecting the level of capital cost, pollution risk, and environmental impact of the various options available to a waste disposal authority. In general, every one of these alternatives requires land for its residual disposal. Thus, new strategies provided attempt to reuse yard waste rather than throw it away.

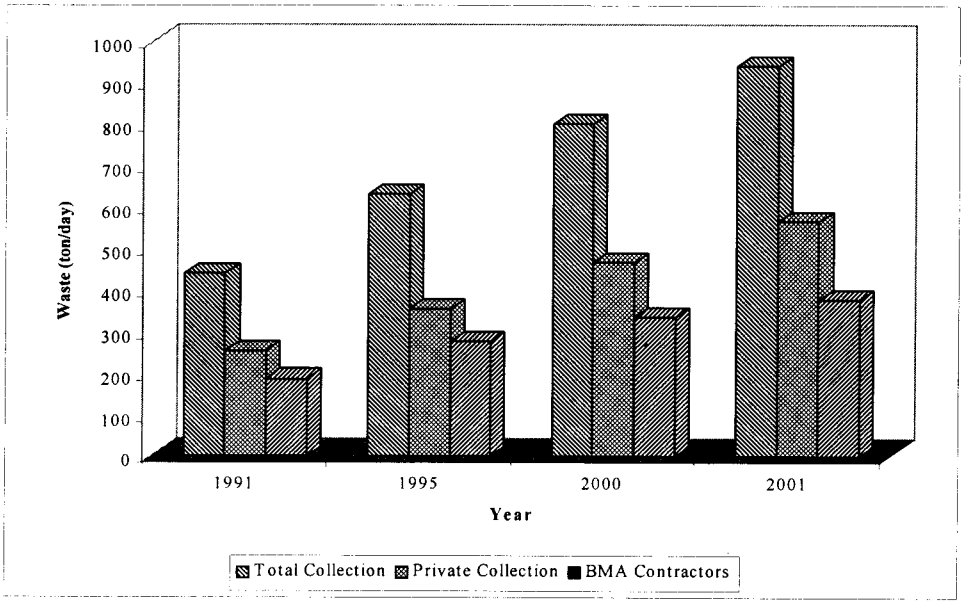

Figure 3. Statistical collection of yard waste in Bangkok (1991-1999)

Sanitary Landfill

Sanitary landfilling may be considered as the cheapest method of yard waste disposal in Bangkok. However, yard wastes or bio-solids not only occupy valuable space in landfills, but they also decompose, which can result in the production of methane gas and leachates that pollute the environment. Also, collection and transportation of yard waste to landfill sites is expensive.

Incineration

Yard waste has combustible components with high calorific value giving an overall heat content of around 6 MJ/kg [3]. The released heat can be recovered to provide a source of energy. The recovered energy can be sold in the form of steam, electricity or both (Cogeneration). Cogeneration plants can reach 90% efficiency and saves 15 to 40% energy as compared to conventional power plants. The sale of recovered energy can generate revenues that help to offset the operation and maintenance costs of such a facility. However, the drawbacks of incineration are the production of disposable waste as well as noxious gaseous pollutants. In addition, the energy produced also can't be easily stored for later.

Composting

Many schemes have recently been started in Bangkok by local authorities or voluntary organizations to reclaim yard waste and transform it into valuable materials before it becomes part of a mixed waste stream. The marketing of yard waste is emerging as the real challenge, and there is a future trend of becoming a commercial waste. According to municipal solid waste composition, yard waste ranked fourth in the decomposed waste percentage and seems to have composting potential comparable to other non decomposed waste (Figure 4). Composting is a means of recycling organic wastes, such as leaves, grass clippings, and fruit and vegetable scraps by combining them in an open pile or a container, so that they decompose through microbial action to produce a dark-brown substance referred to as compost, that can be utilized as a soil conditioner. This may reduce waste up to 85% [4]. Composting can be effective when the yard waste is collected separately at household level.

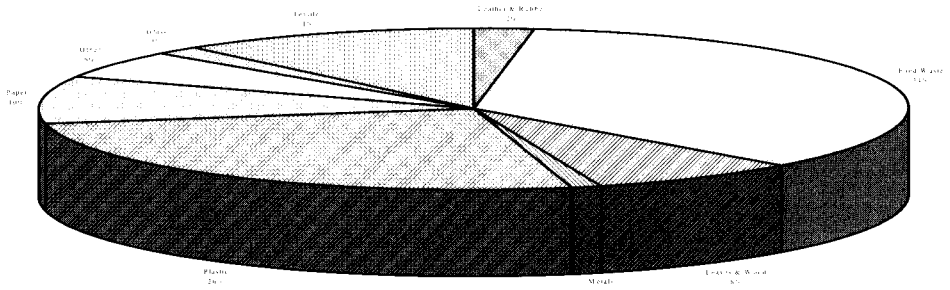

Figure 4. Composition of municipal solid waste in Bangkok

The main advantage of separate collection as a method of initial recovery, is that yard waste can be efficiently separated from mixed waste. In addition, separate collection may be quickly implemented and requires small capital expenditure.

Other applications for yard waste usage

Mushroom cultivation

In Thailand, farmers use wood waste such as sawdust, tree pruning, and yard clippings to grow mushrooms. Mushrooms are first picked 20 days after spawning and can be daily harvested for one month. Based on the information supplied by mushroom farmers, about 145 kg of mushrooms can be harvested from one ton of wood waste. The market price of mushrooms is 30 to 40 Baht per kg while the cost of wood waste is 100 Baht per ton. After mushroom harvesting, the composting waste can be used as a soil conditioner. The project is sustainable because it can provide a better living for the urban poor.

Charcoal production

Yard waste residue, especially stumps and logs when burned (charcoal), can be used as domestic fuel for cooking stoves in rural areas. From an environmental point of view, yard waste charcoal recovery is an efficient method of waste reduction and may also lead to an economic gain. The major advantage of charcoal recovery is that it reduces the need for yard waste disposal and leads to a significant resource saving. The significant reduction that results from recycling of used material not only provides a cheaper product but also benefits the environment through smaller energy demands, thus, less potential pollution.

Technical and Economic Feasibility of composting

The most important technical issue about composting lies primarily in that, it improves the structure of the soil by introducing humus, promotes microbial activities, and can help to retain fertilizers and moisture in the soil. Recycling organic wastes as compost benefits the environment. Financial returns from the sale of municipal composts can help offset the costs of collection and processing.

It is worth noting that the BMA started composting waste 40 years ago. Static sales volume and staff salaries made constant financial losses to the composting plant and required heavy subsidies from BMA. They were therefore closed down, and all responsibilities for marketing were passed over to the private sector. In the past, the main market for compost had been limited to vegetable farms and orchards within a 30-km radius of the

composting plants at On-Nooch and Nong-Khaem. For example, the latest On-Nooch composting plant was designed for 1,000 tons/ day capacity with a daily output of 300 tons of compost. It is now closed down, due to contractual and poor compost quality problems. The On-Nooch composting plant can be made productive again, if the quality of compost is improved to the quality demanded by the customers, and if the plant can be kept in operating conditions.

Under favorable circumstances, composting of yard wastes in Thailand can be competitive with incineration and sanitary landfill methods of disposal. Unless farmers are familiar with the composting products, they are unwilling to use yard waste compost as an organic fertilizer or soil conditioner. Initially, large quantities of yard waste compost must be sold to farmers at the cost price of production, in order to develop better markets later on. Sales distribution of yard waste compost is best carried out by private enterprise rather than by the traditional municipal organization, preferably by commercial fertilizer by companies. An initial arrangement is made to promote the advantageous use of enriched yard waste compost that uses an environmental friendly organic base over an inert inorganic base.

2. Methods of composting

There are two approaches currently used in the composting of yard waste. The first approach is the typical window system (piling on the ground), and the second approach utilizes mechanical equipment to facilitate a high rate of composting.

2.1. Aerated Static Pile System

This method involves placing a mixture of sludge and wood chip over the base of an aerated piping system. This pipe is connected to a centrifugal blower to draw air through the pile according to pre-determined aeration requirements. Typically, the bulking agent consists of wood chips, which are mixed with a de-watered sludge by a pug mill type or rotating drum mixer, or by movable equipment such as a front-end loader. The entire pile is covered with a layer of screening, in order to minimize odors and to maintain high temperatures in the compost pile. Material is composted for 21-28 days and is typically cured for another 30 days or longer. Screening of cured compost is usually done to reduce the end-product requiring ultimate disposal and to recover the bulking agent.

2.2 Window System

In the windrow system, the mixing and screening operations are similar to those for the aerated static pile operation. The rows are then turned and mixed periodically during the composting period, for a minimum of five times. These turnings of windows are often accompanied by the release of offensive odors. Forced aeration composting ensures temperatures in the upper thermophilic range (45°C-75°C) and are effective in the activation of pathogens. The temperature will rise to within 60-80°C in 3 days. After 5 days, the products are transported to a maturing area. The storage area also serves a secondary purpose as a maturing stage. The optimum conditions composting comprise the following:

a. 40-60% moisture content in the waste;
b. carbon-to-nitrogen ratio of 25-35 to 1;
c. sufficient amount of oxygen supply to the compost pile, either by frequent turning, forced air, or chipping the waste.

Screening, grinding or a combination of similar processes should be done to remove other materials from the compost that might be objectionable in its usage. For some usages, such as landfilling and land reclamation, compost need not be finished or processed further. For general agriculture, a coarse grind is satisfactory, whereas for horticulture and luxury gardening, the compost product must be finer. For high quality compost product, particular attention should be given to exclude the potential hazardous materials in the compost [5]. The matured compost to be used as fertilizer or soil conditioner is usually mixed with chemical fertilizers to make its nutrient content suitable for crop growth. Table 2 shows the characteristics of compost produced by a typical forced aeration composting process.

Table 2 Characteristics of compost produced by Ministry of Agricultural and Cooperatives

Item	Requirement
Chemical additive	Not involved
Content of organic matter	$\geq$ 60% by weight
C/N ratio	$\leq$ 25:1
Electrical conductivity	$\leq$ 3.5 ds/cm
pH	5.5 $\leq$ pH $\leq$ 8.5
Nitrogen (N), Phosphorus (P), Potassium (K)	N, P, K, not less than 1.0%,1.0%,0.5% By weight, respectively
Moisture content	$\leq$ 35% by weight
Particle size	Pass through sieve at 10.0 mm
Contamination (rock, plastics, Gravel etc.)	$\leq$ 10% by weight
Hazardous or harmful (glass, metal)	Not involved

Source : Ministry of Agricultural and Cooperatives (MOAC, 1992)

Difference between the two methods

It is important to decide how to promote fermentation. In other words, how to reduce the fermentation period, as composting facilities ferment organic materials aerobically. Therefore, as for the method of producing compost, the mechanical turning methods are far better than the pile-up method, for the following reasons:

The period of primary fermentation is about 10 days for mechanical turning methods and one to several months for the pile-up method. Both processes have similar modes of operation, but mechanical mixing and forced aeration are usually applied to high rate composting and have been proven to be adaptable in composting yard wastes. If the pile-up method is used for the yard waste composting system, it is important to take into account the seasonal or fluctuating demand for the compost. Consequently, there may be insufficient supply for the finished product, at the peak season. Later, the pile-up method may not produce enough compost to meet demand. Immature compost is released onto the market, resulting in a negative impact on the demand for yard waste compost. Even though, capital and operating costs for mechanical turning methods are usually higher than the pile-up method, however, shorter fermentation periods and better quality compost can be produced by mechanical mixing and forced aeration. Therefore, higher revenue from the sale of end product can reduce the costs.

Previous Market for Compost and Fertilizer

The compost market is largely controlled by governmental organizations such as the Ministry of Agriculture and Cooperatives, and the Agriculture and Cooperative Bank, as well as the Rubber Replanting Aid Fund, the Agricultural Extension Department, and the Marketing Organization for Farmers. Annually, the government has tendered 800,000 tons of organic compost, at a distributed price of Baht 1,200.00 per ton. However, farmers often bought their organic fertilizers through a bank loan arrangement, which are of higher price at Baht 2,950.00 per ton. This is a deterrent to the farmers who wish to purchase their organic compost at a lower alternative price. Thus, many farmers have turned to use the cheaper inorganic fertilizers and the most popular fertilizer formulas are: 15-15-15 and 40-00-00. In Thailand, the market is under political control, and it is difficult to market compost without political support. It is also noted that few fertilizer companies are making money, and several are insolvent.

Development of yard waste treatment system

The proposed yard waste compost plant would be constructed at the existing Tha- Rang transfer station. The proposed compost plant is

of 300 tons/day with land area of 50 Rai (1 rai = 1,600 m^2). The system would consist of receiving hopper, aerated window type fermentation system and bulk storage and bagging facilities, as shown in Figure 5. Waste is sorted out before entering into the fermentation tubes, in a sorting room that is equipped with three conveyors. The plant itself is made of three rotating drums designed for a 48-hour fermentation treatment, then followed by the separation of the rejects and of the organic matter through a 60-mm mesh trommel. The fermentation and maturation areas of static type are made of concrete platforms. Aerobic conditions are needed for composting in a 42-days fermentation and maturation period of time. After maturation, the compost is mechanically treated for a further separation of light or heavy rejects such as glass, pebbles, metals, and others, using the ballistic machine. Finally, a conveyor will carry the organic compost of 7mm or smaller in size to indoor piles, to be bagged by machine.

The typical installation of the proposed composting plant is similar to the On-Nooch composting plant. There is also an annual gross operation and maintenance cost for the proposed composting plant, which has to be invested on operation expenditure, heavy equipment, staff salaries, etc. The heavy equipment required to operate the compost plant consists of front-end loaders, dump trucks and window turning machines. The estimated operating staff requirement include 6 employees for general site work, 5 maintenance workers, and 40 employees to operate the composting and bagging plant facilities. In addition, administrative and compost sale staff of approximately 5 people would be located at the site to administer the proposed new plants.

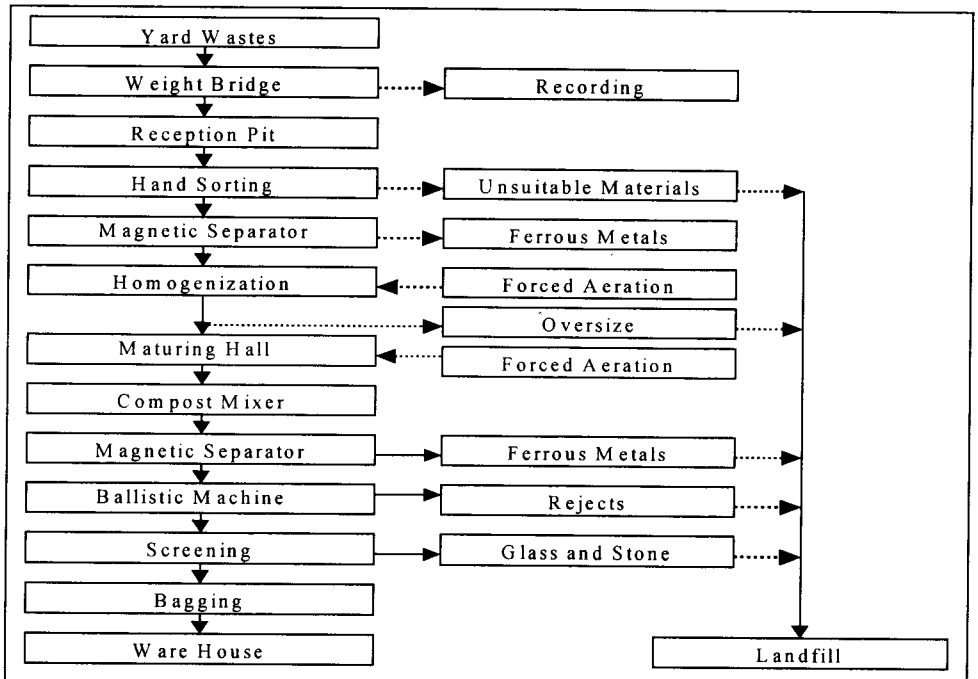

Figure 5. Proposed yard waste processing plant.

Table 3 Estimated demand of compost in Bangkok Metropolitan Region

	Parks	Recreational areas	Golf courses	Ornamental gardens
Target area (ha)	218,077	133,270	175,674	78,750
Annual demand (1,000 tons/year)	268.67	164.18	216.43	97.02
Annual cost (Baht, million)	403.00	246.27	324.65	145.53

Source: Department of Social Welfare, BMA, March 2000

Note: 1 U.S.Dollar = 42 Baht, Application rate = 1,232 kg/ha/yr, 1 ha = 10^3 m^2.

Applicability of Yard Waste Compost for Bangkok Metropolis

In the past, a few large compost plants successfully operated in the city. Closure of these plants is presumably due to the production of low quality composts with large amounts of heavy metal contaminants. If the organic wastes are still collected as part of a mixed waste stream, BMA will not be able to solve the problem of heavy metal contaminants in the produced compost. Provisions must be made to separate food and yard waste from components that cannot be composted, such as metals, tires, glasses and etc. The kitchen waste consists of garbage like, peels from fruits, vegetables, bone, shells and other food scraps. Food waste encourages breeding of flies and rats. In addition, it is odorous. It must be buried or composted by mixing with leaves or garden wastes. On the other hand, yard waste in Bangkok Metropolis contains a high percentage of organic matter and is less odorous, and is therefore more suitable for production of good quality organic compost. If high quality organic compost is required, carbonaceous matter such as sawdust, logs, straw and leaves may be mixed with high nitrogenous sewage sludge. Table 3 show estimated demand of organic fertilizer in Bangkok Metropolitan Region.

Potential Areas for Compost Application

In Thailand, compost has value as an organic fertilizer and soil conditioner. As an organic fertilizer it contains valuable nutrients such as nitrogen, phosphorus and potassium [6]. As a soil conditioner, compost lightens the bulk density of the soil, thus enabling seeds to germinate more easily and retain better soil moisture, Furthermore, compost helps to neutralize acidic soils. However, the recommended application dose of the compost is very difficult to convey to farmers because compost is bulky and difficult to transport. Likewise, many research activities have shown that a combined application of chemical and organic fertilizer should be appropriately carried out in the agricultural areas. In Thailand, the appropriate amount of compost for application is between 12.5 – 25.0 ton/ha (1 ha = 10^3 m^2), mixed with chemical fertilizer or equivalent to half of the compost amount. The application of both compost, and chemical fertilizer was observed to bring about a 30% increase in the yield.

In the Seventh National Economic and Social Development Plan (1992-1996), the Ministry of Agriculture and Cooperatives [7] established policy to promote more usage of organic fertilizer than chemical fertilizer in areas within a 100 km.- radius from Bangkok. Therefore, the garden lands in Bangkok and its surrounding vicinity should be given priorities in terms of compost application.

(a) Agricultural land

Most of the potential areas for compost application are located in the southern plains of Thailand where acid sulphate soils (wetlands) predominate, and are exploited mainly for rice cultivation. In Thailand, acid sulphate soils are divided into two groups: sulfaquepts and sulphic troaquepts. The former is common, and found

scattered along coastal areas with mangrove vegetation accompanied by sticky consistency that makes ploughing difficult. The latter develops at brackish water deposits which can possibly become cultivateable by suitable application of compost.

(b) Public Parks

There are approximately 218,077 hectares of park lands in the Bangkok Metropolis. These park lands have been used for public recreation which is covered with a variety of flowers, garden trees, grass and potted plants. Compost is used in the parks as an organic fertilizer and soil conditioner or combined application of chemical and organic fertilizer. The approximate amount of organic fertilizer applied to these green areas is reported to be 14.78 kg/m^2/month.

(c) Golf Courses

It is estimated that there are more than 150 golf courses in Thailand, and half of them are located in the greater Bangkok perimeter. It is also estimated that these golf courses consume 216,430 tons of compost, annually. The compost for golf courses is made from crop residues, manure and garden trimmings. It was observed that, compost or organic fertilizer is used in all golf courses. All golf courses apply compost as organic fertilizer for the greens, big trees, etc [8].

(d) Curbside green zone

The curbside green zone is another possible area for sludge compost application, particularly in the initial experimental stage. According to the BMA land use plan, the curbside green zone occupies around 213.0 hectares, which needs sludge compost for soil conditioning.

Compatibility and resource requirements

Successful implementation of composting requires the following major actions:

• Market evaluation and survey

Whenever a compost system is being planned, it is important to evaluate the market. Compost value depends on external demand for soil improvement, perceptions of its value, quality and accessibility to potential users in the immediate vicinity. It also depends on what alternatives to compost are available to farmers and cultivators in the region, and on the cost of those alternatives, from animal manure to chemical fertilizers.

• Review for transportation cost

The key factor that should be taken into account for a successful compost market establishment is the transportation cost. It is believed that compost production could generate revenue and a wider market, but it may not be able to cover the cost for the collection of raw materials, processing and transportation of the finished product.

• Policies and regulations governing waste composting.

Yard waste management in Bangkok is an important topic that has not received sufficient attention to date and is not widely developed due-to insufficient support on technical, incentives, laws and regulations, etc. In Thailand, there are no rules or laws governing waste composting but there are many composting programs emerging nationwide. Yard waste management is only effective where government commitment is strong and private initiative is given sufficient freedom to look for new strategies in approach and implementation. Awareness of the public with regard to yard waste management should be strengthened by public awareness campaigns organized by local authorities and NGO's. In an overall view, waste treatment technology, legislative measures and general public participation would be essential for success in yard waste management in the Bangkok Metropolitan Region.

• Community involvement and participation

Community involvement is an essential component of any successful composting programs. Community participation in yard waste separation at household level can greatly improve the quality of the finished compost products. Likewise, the most important success factor to introduce compost into the agricultural sector, is the involvement and participation of farmers for which appropriate guidance and education have to be developed, possibly by the BMA. In addition, revenues generated from the sale of compost materials can be used to improve community facilities.

3. Conclusion

Yard waste management problems can be tackled by processing yard waste more efficiently and by collection and composting. The management of yard waste involves the control of management, collection, transport, processing and disposal of yard waste in accordance with environmental considerations and can help in preventing health and other environmental consequences. Yard waste management in Bangkok is an important topic that has not received sufficient attention to date and is not widely developed due-to insufficient support on technical, incentives, laws and regulations, etc. Composting is a cost effective and environmentally sound alternative for ultimate yard waste disposal. Recycling yard wastes as compost benefits the environment, and financial returns from the sale of composts can help offset the costs of collection and processing. Recycling the composts back to city parks, in local gardens, on farms, or for any other vegetation of disturbed lands can also make them more sustainable.

Yard waste composting programs are currently initiated in many communities as a means to achieve sustainable development. The programs also aim to produce more chemical-free fertilizer for agricultural land, thereby minimizing the negative impacts of leachate in the environment.

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