THE INTEGRATION OF BIOWASTE AND URBAN AGRICULTURE: PROSPECTS AND ISSUES

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ABSTRACT

Presently, Metropolitan Manila (MM) generates about 6,000 tons of municipal solid wastes per day of which 2,800 tons is estimated to be biodegradable. Despite a legal framework and policy that aims at recycling 25% of the biodegradable wastes, presently (only) 160 tons/d of these biowastes (ca 6%) is source-separated and processed in 22 small-scale composting plants. Evaluation of the performance of 3 of these plants revealed flaws in obtaining compost with the officially required quality standards. A survey among 50 horticultural farmers showed that only 34% of them use organic fertiliser. The main impediments for increased compost application are low expectations about the yields of compost versus inorganic fertilizers, the relatively high price and cumbersome handling of the bulky product.

At 25% recycling in MM an agricultural area in the order of 20,000 ha would have to apply municipal biowaste-based compost in quantities of ca 10 tons/ha/yr, which is far more than the agricultural area within the city's boundaries.

Enhancement of the municipal biowaste reuse chain in MM would require synchronous expansion of the markets, the composting and the collection of segregated wastes. In order to develop a vision on chain enhancement a research programme covering Manila and several other South East Asian megacities is proposed.

A determined collaboration of the stakeholders involved in the chain, farmers, compost producers, waste generators, waste collectors and waste managers, is seen as a prime prerequisite in the development of this vision.

I. THE PERSPECTIVES OF SOLID WASTE MANAGEMENT IN METROPOLITAN MANILA

In developing cities solid waste management is one of the most pressing concerns. This certainly is true in Metro Manila (METROPOLITAN MANILA, MM), the prime urban center of The Philippines. In the year 2000 Metro Manila counted about 10 million inhabitants, which is 13% of the national population, living on an area of 636 km^2. The municipal solid waste (MSW) flow amounts to about 6,000 tons per day, which corresponds to about 25% of the country's MSW production and this flow is still growing fast. About 45% of the total flow consists biodegradable material (municipal biowaste or MBW). Waste collection and disposal are a task of Metro Manila Development Authority (MMDA) and the 17 local government units comprising MM. Each of these local government units is subdivided into *barangays*. A *barangay* in MM comprises a population in the range of 2,000 – 10,000 persons.

The fraction of solid wasted collected in MM is estimated at 65% (JICA and MMDA, 1998). Collected commingled municipal waste is transported to open dumpsites. Only 2% of the wastes are disposed onto sanitary landfills or controlled dumps. Uncollected wastes are either burned or dumped in vacant lots. The many dumpsites and the uncollected wastes cause severe air and water pollution as well as clogging of the drainage systems.

As new dumpsites for the soaring flow of municipal wastes are increasingly hard to find, or only at very large distances from the city, a national policy of closing of material cycles has been put into place and thus recycling and reuse have become a core issue. It was realised that huge amounts of agricultural products are taken from the land inside and surrounding MM, but that the failing re-supply of organic matter, if not of N+P+K, to these lands would eventually lead to soil degradation. A new biowaste management policy would have to help prevent this soil degradation. Here, the product resulting from the (aerobic or anaerobic) stabilisation of municipal biowastes is designated with 'compost' or 'soil conditioner'. The term fertiliser is avoided since biowaste-based compost is not a satisfactory fertiliser in it own right.

Since 2000 the Philippine Government bases its waste management on the Ecological Waste Management Act (EWMA). This law targets at a 25% reduction of the wastes to be landfilled/ dumped within 5 years (2005). The law prescribes mandatory waste segregation, waste recovery, composting and reuse of biowaste-based products in agriculture. The Department of the Environment and Natural Resources (DENR) and The Department of Agriculture (DA) are charged with respectively the technical assistance for the production of good biowaste-based 'compost' and the development of new markets for the compost (ESWMA, 2002). The EWMA stipulates that implementation of waste segregation at source and collection be further decentralized from the higher local government units such as to the *barangay* level. However, at this moment due to lack of resources at the *barangay* level in most localities the higher local government units, provinces and municipalities, are still the main actor in solid waste management.

At the same time (1998) a national program for urban agriculture was adopted. Urban agriculture is stimulated by means of the Integrated Research Development and Extension Agenda Program (IRDEAP). Urban agriculture is considered important as a livelihood especially for the low-income brackets of the population. It contributes to food security, though modestly in the case of Manila, and in addition could be a market for a certain amount of composted biowastes.

Everywhere in the developing world the problems of solid waste management are accumulating through the enormous per capita growth of the waste flow, the increasing fraction of non-biodegradable and hazardous wastes and the concomitant crisis of traditional recycling practices.

While the traditional recycling practices are dwindling, most city wastes are being dumped onto landfills. Environmental authorities in Europe and the USA have realised that biowaste recycling, especially composting and reuse, in agri- and horticulture, remained an indispensable element in waste management. Initially, mixed waste was used as input for composting. The product of this process became gradually less attractive to farmers due to the deteriorating quality of the raw waste that contradicts higher quality requirements. For better compost quality the biowastes had to be separated from the growing fractions of other wastes, either at-source or centrally after collection. At the same time, the separation of fractions enhances the calorific value of the combustable wastes, thus facilitating waste incineration with energy recovery.

The present practice in Europe and the USA, where firms at a scale of 100,000 tons/yr process source-separated urban biowastes for commercial markets, is serving as the hopeful perspective for waste managers in developing countries. This system is feasible however, by virtue of a substantial financial contribution of the households founded on the polluter-pays-principle.

In The Netherlands (www.compostnetwork.info) the costs of the production of compost from municipal biowastes amounts to about 60 EUR/ton. The market value of this compost varies with quality and application. High quality compost used for greenhouse cultures and sports turfs may yield 30-60 EUR/ton, compost used for landscaping about 25 EUR/ton, while in regular agriculture compost can be sold at 0-5 EUR/ton (1 EUR = 1.2 USD, 2003)

Table 1 Market share of compost sales in a few EU countries (Status 1999-2001)

Market share (%)	Belgium	Germany	France
Landscaping	26		19
Landfill+ restoration	2	25	
Agriculture	9	43	52
Horticulture		5	5
Earth works	35	10	15
Private gardens	19	14	
Export	5	-	
Miscellaneous	4	3	9

The data presented in Table 1show that the compost market in Europe is diversified and strongly varies across countries. The closing of the cycle of biowastes requires a continuous effort to find new markets for compost and the outcome of this marketing effort may vary from place to place.

In developing countries there are several reasons why composting still contributes insignificantly to the reduction of waste disposal onto landfills. A financial contribution from the households to biowaste processing, or any other treatment process, usually does not exist and is hard to realise in the near future. Consequently, compost buyers have to pay the full price of the composting process and subsequent transport, which renders the compost too expensive for the average farmer. In reaction, composters attempt to tap the markets of high-value crop producers. Such markets exist, but their effective demand is limited.

In order to overcome the problem of the high compost price, Furedy (2003) suggests giving farmers in developing countries access to non-contaminated urban biowastes such as market wastes. While compost would cost in the order of 50 USD/ton, this raw unprocessed waste would be sold at transfer points at a modest price of 1-2 USD/ton. Farmers would additionally pay for the cost of transport and process the waste at their own premises.

II. OBJECTIVES AND METHODOLOGY

The present study aims at elucidating the main problems of the municipal biowaste reuse chain and included the following stages.

a. The state of art of solid waste management and its related regulations and policies in The Philippines and MM.
b. A study about the operation of 3 composting enterprises by means of interviews, field observations and chemical and microbiological analysis of the produced compost. In addition managers at 13 compost producers were interviewed about compost manufacturing and marketing.
c. A questionnaire survey among 50 urban and peri-urban farmers mainly about their views on the application of organic fertilizers.
d. Scenario studies exploring the supply and demand of soil conditioner in and around MM.
e. A strengths-weaknesses analysis to appraise strategies for enhanced compost utilization.
f. Formulation of a research agenda aiming at answers about the main uncertainties.

III. RESPONSES TOWARD CLOSING CYCLES

3.1. Small-scale composting sites

The Philippine Ecological Waste Management Act stipulates that each *barangay* formulate and implement a Solid Waste Management Plan appropriate to the local conditions. As of October 2002 22 small-scale composting sites had been established in the metropolis. Together they treat an estimated 160 tons/d of separated biowastes. (6% of the total 2,700 t MBW/d generated). The activities of 3 of them, Barangay Sun Valley in Parañaque, Barangay Escopa II in Quezon City, and Smokey Mountain in Manila, are appraised here with regard to technology, product quality and cost. These sites were selected to represent different scales and systems of biowaste processing (Table 2).

3.1.1. Compost–making

Common to the 3 sites are the use of kitchen waste as feedstock, employment of eco-aides to do segregated waste collection and the use of coco dust/sawdust and inocula as additions to the wastes. The inocula or bacterial activators contain pure strains of micro-organisms or other biological factors deemed important to accelerate the decomposition and stabilisation of organic matter and to fix nitrogen. They are often termed as "enzymes," "hormones," "preserved living organisms," "activated factors," "biocatalyst," etc. Coco-dust and sawdust are applied to control the moisture content and to enhance the carbon/nitrogen (C/N) ratio. Structural materials like wood chips or yard trimmings to enhance the aeration of the biomass are not added.

Table 2 Capacity and prices of packed product at 3 studied composting sites (N.C.= not commercialised)

Biowaste Composting Plant	Capacity (tons/ month)	Compost retail Price (USD/50 kg)
Barangay Sun Valley	90	4.5
Barangay Escopa II	6	N.C
Smokey Mountain	50	N.C

At Barangay Sun Valley, raw materials are first mixed thoroughly by means of a cement mixer, put into sacks and stored for 15 days to allow decomposition. The stabilised materials are then shredded to reduce the size and sieved before packing. The compost product is sold to traders from MM and Tarlac Province The composting plant has a partnership with the municipal government of Cavite (a province just adjacent to MM) in which the efficacy of the compost is tested at a farm.

Barangay Escopa II utilizes rotating drums instead of a cement mixer to mix the materials. Wastes are mixed with inocula and sawdust, rotated daily and left open for aeration. The materials are left in the drum for 1-3 weeks to allow decomposition and are afterwards spread on the ground for drying. At Smokey Mountain, a rotating drum with a maximum load of 5 tons is utilized. The residence time in the drum amounts to only 4 days followed by a period of drying. The compost produced at Barangay Escopa II and Smokey Mountain is used for receptacle farming.

3.1.2. Quality of the produced compost

In The Philippines, a standard for compost separate from that of organic fertilizers has recently been developed. Compost producers must therefore comply with the requirements of the Fertilizer and Pesticides Authority (FPA) (see Table 3).

Table 3 Philippine quality requirements for compost (Obcemea, 2004)

Parameter	FPA requirement
Moisture content	< 35% (wet matter)
N+P+K	3-4% (dry matter)
C/N-ratio	12
Total coliforms	< 500/g
Fecal Streptococci	< 5000/g

The products from Barangay Sun Valley and Smokey Mountain comply with the moisture norm. The product from Barangay Escopa II had a moisture content of 50%, far above the requirement of 35%.

According to the FPA requirements compost should contain 3-4% N+P+K on a dry weight basis. Barangay Sun Valley compost having a total NPK content of 7.26 % more than meets the requirement. Barangay Escopa II and Smokey Mountain produce compost slightly higher (4.26%) and lower (1.84%) than the norm for N+P+K content, respectively.

The product C/N ratio of 12, as specified by FPA, is being attained at Barangay Sun Valley only. Considering the required final C/N ratio of 15-20 (Kayhanian and Tchobanoglous, 1993), the compost products from Escopa II (C/N=25) and Smokey Mountain (C/N=33) even did not come close to that range. This could be attributed to the application of a too big amount of sawdust/coco dust. A C/N ratio of the end product higher than 20 should be avoided since such a high ratio could have a negative impact on the plant growth and seed germination (Ref 5). Under these circumstances micro-organisms would continue to degrade the materials and consume available nitrogen and oxygen in the soil, thus competing with crops.

Among the 3 composting sites, Smokey Mountain exceeded the requirement set for total coliforms and fecal streptococci, while Salmonella bacteria, indicators for the possible transmission of infectious diseases, have been detected in all samples. Salmonella species can be eliminated from compost by an exposure for 15-20 minutes at 60o C or for 60 minutes at 55oC (dela Cruz, 2003).
Since the feedstock used for composting is source separated, heavy metal concentrations are low and pass the FPA requirements.

In subsection 4 the experiences with the three composting enterprises serve as a basis for an assessment of the biowaste to soil conditioner chain.

3.1.3. Survey among compost producers

The 13 compost producers reached by our questionnaire survey mainly manufacture organic fertilizers based on animal manure and other agricultural residues. Five of them were using household or market wastes as raw material. Their production capacities averaged about 90,000 bags of 50 kg per year, sold at a price ranging from 100 – 300 P/50 kg (= 2-6 USD/50 kg). The compost products were FPA registered and certified. The most important compost buyers are farmers, but also fish pond owners were mentioned. The principal problem in extending the compost market, according to the producer group, lies in the fact that farmers are not convinced about the efficacy of the compost.

3.2. Urban agriculture in metro manila

Urban and peri-urban agriculture (UPA) is thought to play a major role in helping to close the biowaste-related nutrient cycle in that it represents a potential demand for compost. In MM urban field agriculture is a marginal activity, but a significant source of income for the poor. According to data published by the Bureau of Agricultural Research the total area cultivated within the boundaries of MM in 1998 amounts to (only) 262 ha (0.04 % of MM surface) with a total annual production of various vegetables of 3,362 tons or 1.1 % of the vegetable demand of the city. The small fraction of urban agricultural land and open land available for the establishment of waste processing plants can be explained by the high need of land for more profitable purposes as reflected by increasing land prices. For comparison: in Biratnagar, a town in Nepal, 59% of the urban area is used for agricultural purposes (Karki, 2004).

The urban farmers of MM usually do not own the land they till and often are insecure about their tenure, but they depend on farming as their major source of income. For them short-term financial security is of much higher concern than long-term environmental benefit and consequently they use inorganic fertilizers to replenish and support the nutrient requirement of the crops. Most respondents to our questionnaires recognize the benefits of organic materials, but see three main drawbacks:

1. Preparation of compost is time consuming and laborious, so they rather buy compost than prepare it themselves.
2. The price is high, but they would buy it if it would be cheap(er).
3. They are uncertain about the agricultural value, but they would buy it if it is shown to be effective.

The farmers are dependent on prompt crop yield, do not like to gamble with novelties and prefer proven methods. They assess government support for urban agriculture as marginal.

Receptacle farming is common in Manila and promoted by institutions like the University of the Philippines Los Baños, Central Luzon State University and Cavite State University, where compost is utilized as growing media. The use of compost for receptacle farming is believed to increase.

IV. COMPOST SUPPLY AND DEMAND

In order to get a picture of the required compost market in and around MM, the supply was estimated for three scenarios of biowaste collection.

4.1. Three supply scenarios

The 3 scenarios are referred to as 1. Recycle- All; 2. Philippine-Law and 3. Business-as-usual. The Recycle-All scenario assumes that all compostable wastes in Metro Manila, particularly the food waste, grasses and wood trimmings fraction could be collected and transformed to soil conditioner. The Philippine-Law Scenario is based on the target set forth in the Ecological Waste Management Act. According to this law about 25% of biowaste would have to be composted. The Business-as-usual scenario departs from the present recycling rate of 6% (160 t/d) of the total biodegradable waste flow. In each scenario the same set of assumptions is applied as shown in Table 4.

Table 4 Assumptions applied in scenario analysis

Waste Input	
Municipal Solid Waste generated	5,350 t/d
Biowaste fraction of MSW (w.w.)	52 %
Municipal Biowaste generated (w.w.)	2,780 t/d
Moisture content of MBW	45%
Organic dry matter fraction in MBW	84.6%
C content in MBW	50%
N content in MBW	3.2%
P content in MBW	0.08%
K content in MBW	1.5 %
Process	
Addition of carbon-rich material (% of wet waste)	20%
Organic matter degradation rate	
C-loss to environment	34%
N-loss to environment	34%
	33%
Compost (end-product)	
Moisture content	35%
C/N ratio	15-20
Compost application rate	10 t/ha/yr

4.2. Demand within the urban area

As the available land to urban agriculture amounts to 262 ha, the demand would be 2,620 tons of soil conditioner per year based on an application rate 10 tons per hectare per year. To this amount could be added the demand for receptacle farming whose value however is unknown.

4.3. Supply of organic soil conditioner in Metro Manila as per 3 scenarios

Recycle-All

In this scenario it is assumed that all generated biowastes, equal to 2,780 tons per day, would be collected for composting. Utilizing the waste characterization in MM (JICA and MMDA, 1998), this amount of waste represents a dry matter flow of 1,530 tons and an organic matter flow of 1,294 tons per day. As indicated in Table 4 sawdust or a comparable material would be added as a carbon-rich material for adjustment of the C/N-ratio at a rate of 20% of the biowaste wet weight.

This mixture would amount to 3,338 tons/d available for composting. Assuming the quality requirements given in Table 3, this mixture would result in 2,374 tons/d of compost, containing 1,429 tons of dry matter, 34 tons/d of N, 2 tons/d of P and 33 tons/d of K. The sum of N+P+K = 5.8 %. This compost has 40% moisture: that is higher than the requirement.

During the composting process an estimated 316 tons of carbon (as CO_2) and 17 tons of nitrogen would be lost to the environment.

According to the Recycle-All scenario Metro Manila would generate 866,000 tons of municipal biowaste-based compost annually. This is 330 times the quantity of 2,620 ton/year required for urban agriculture. It shows that the theoretical compost flow of 870,000 tons/yr is enormous and could help in improving the soil quality of an area in the range of 80-90,000 ha provided this compost could be distributed to these lands.

4.4. Philippine law and business-as-usual scenarios

Similarly to the Recycle-All scenario the Philippine-Law and the Business-as-usual scenario are calculated. The results are shown in Table 5.

The calculations show that even the actual practice (Business-as-usual) where only 6% of the generated biowaste is composted leads to a supply (142/7.2 =) of ca 20 times as high as the demand of field agriculture within Metropolitan Manila. It is evident, that the chain biowaste-to-soil conditioner in Manila can be enhanced only if reliable markets for compost are developed for agriculture outside the city and for non-field applications.

Table 5 Municipal biowaste collected, compost produced, emissions and theoretical compost demand in the present 262 ha of urban agriculture within Metro Manila.

Scenario	Wastes		Compost Production		Emissions to environment		Present demand within Metro Manila	
	Biowaste Collected (%of MSW)	Biowaste Collected (w.wt) (t/d)	C-rich material added (t/d)	Compost Produced (t/d)	N+P+K (% d.m.)	C (t/d)	N (t/d)	Compost needed (t/d)
Recycle-All	100	2,780	556	2,370	5.8	316	17	7.2
Philippine-Law	25	696	139	590	5.8	79	5	7.2
Business-as-usual	6	167	33	142	5.8	19	1	7.2

V. WEAKNESSES AND STRENGTHS OF THE PRESENT PRACTICE

In the ensuing analysis of strengths and weaknesses of the existing practice a distinction is made between the municipal biowaste reuse chain as a whole and the composting activity as such.

5.1. Strengths of the chain

The main strength of the present practice in MM is the fact that municipal biowaste reuse chains are operating and continue to develop. This development is made possible by official supportive policies and by the environmental awareness and active stance of a multitude of grassroots organisations. The ratification of the Philippine Ecological Waste Management Act in 2000 reflects the strength of the organizations, which lobbied for this law. These include NGOs in education and training regarding waste management, a local private sector dealing with waste collection under government contracts and universities that promote organic and receptacle farming. These organisations together with the local government units are the backbone of the present chain.

5.2. Weaknesses of the chain

The chains exist but contribute as yet insignificantly to the reduction of the biowaste flow going to landfills. This is the pivotal weakness of the present practice. As of 2002, the biowaste reuse in MM depended on the operation of 22 small composting plants with a summed capacity of 160 tons/day, which represented about 6% of the total municipal biowaste flow. The small scale of the operation has its pros and cons as is explained below.

Evidently the municipal biowaste reuse chain depends on the strength of the three links: compost markets, compost production and segregated waste collection. At the present stage it is impossible to pinpoint something as a main weakness in this chain.

The Sta Maria, Bulacan study (Lapid *et al.*, 1996) and our own survey among farmers show in a qualitative way that the potential compost markets would be vast under the conditions that quality be guaranteed, prices lowered and farmers made aware of the importance of maintaining the soil organic matter content. This statement would suggest that chain enhancement would particularly depend on improvement of quality and price of compost. But at the same time waste segregation remains a struggle for most cities, and commingled waste collection, though discouraged by the law, is still by far most important. Where waste segregation at source runs well its success depends on the participation of the people, efficient involvement of the local private sector and on the support and political will of the national and local government. Some recent experiences have also shown the political vulnerability of the chain. Simultaneous changes of political leadership and connected administrative staff after elections have brought about the collapse of well-running biowaste reuse schemes, though these schemes themselves never were an issue at the elections.

5.3. Strength of the present small-scale composting practice

Positive features of the present small composting plants are their:

1. manageability by grassroots organisations under the present conditions of limited availability of at-source segregated biowastes and uncertain markets of the end products.
2. short transport distances of the bulky biowastes.
3. low requirement of space in crowded urban neighbourhoods close to the sources of wastes.

A basic assumption of the barangay-scale plants is that the transport distances of raw wastes and compost product to the users are small so that transport costs which amount to about 0.04 USD/ton km remain modest.

For the present size of plants the cost of transport is estimated at about 10% of the cost of processing.

If the number of these small plants would increase, markets at short distance from the processing plants could become scarce and transport costs would increase.

5.4. Weaknesses of the present composting practice

In our survey the quality of the compost of the 3 small enterprises appeared to be unreliable and in some respects deficient. NPK content was found to be too low (< 3% dry weight) in one instance and the C/N ratio and pathogen content too high. Doubts about the quality of the final product were raised in a study on the 6 tons/day composting plant at Sta Maria, Bulacan as well (Lapid *et al.*, 1996). The quality control of the compost is a task of FPA, but the regulations are not strictly enforced. The frequency of compost analysis is low (once per year) and significant quality fluctuations may occur depending of the quality of input wastes. Also it can be observed that composts in the market often lack FPA certification.

Disappointing quality is not an intrinsic consequence of small-scale composting, but operations at a bigger scale could more easily justify more skilled surveillance, a more professional plant lay-out and more frequent product analysis. In bigger composting facilities of the windrow forced-aeration type the high temperature required for fast pathogen removal could be more easily attained and controlled.

VI. FUTURE BIOWASTE REUSE CHAINS

A significant increase of municipal biowaste reuse requires a simultaneous boost of waste separation at source, compost production and application. If, in accordance to the Philippine Law 25% of the biowastes of MM would be reused in agriculture, the compost flow produced would amount to about 600 t/day and the involved agricultural area would be in the range of 20,000 ha. If we would visualize the metropolis as a rectangle of 30 * 21 km^2 with one side bordering the sea and 3 sides amenable to horticulture, the average width of the peri-urban horticultural 'rim' would be about 3 km. Even if only a part of this rim could be cultivated, this calculation shows that transport distances of compost do not have to be very long.
In terms of composting an extension of the processing capacity to 1000 tons of wastes per day would require the implementation of the following possibilities:

1. Reuse of raw biowastes by farmers.
2. Increase of home composting.
3. A high number of small-scale plants with capacities in the order of 5 – 10 tons per day
4. A small number of medium capacity plants of 10 – 100 t/d spread along the perimeters of the Metropolitan.
5. One large-scale plant with a capacity in the order of 500 t/d.

The reuse of raw at-source segregated household biowastes by farmers was suggested by C. Furedy (2003), mainly as a means to reduce the financial burden for farmers at the use of compost from municipal wastes and thereby improving the possibilities of reuse. This form of reuse is not uncommon in Asia. An important disadvantage would be a complete lack of quality control of the end product. It could lead to enhanced hygienic and chemical risks. Most likely the option could work in rural towns where the distance between waste generators and reusers is small. Some form of quality control to the raw wastes would have to be implemented.

Home composting is particularly feasible in urban areas with a modest population density (e.g. < 100 /ha) where households could cultivate vegetables or decoration plants in gardens or in receptacles close to the residences. Home composting is common e.g. in cities in Nepal (Karki, 2004)

Small-scale plants with a capacity up to 10 tons raw biowastes per day are the option embarked on in MM now. The option matches with the present institutional arrangements of waste collection at *barangay* level and with the limited market. A barangay with a population of 5,000 inhabitants would generate about 5 tons of biowastes per day.

The strength and weaknesses of this option have been discussed above on the basis of our own survey. Despite some strengths of small-scale (manageability by grassroot organisations), we believe that its weaknesses (e.g. lack of quality) plead for an increase of the scale of the plants or at least the scale of institutional collaboration so that technical surveillance, product quality control and marketing could benefit from economies of scale.

Big or medium scale composting plants do not exist yet in MM . Composting at a scale of more than 10 tons/d and especially at a scale of 100 tons/d or more would require a strong political determination at the level of municipalities and central government to solve the problems of markets, high-quality compost production and source separation in a coordinated way. This determination seems to lack at the moment.

A general challenge regarding biowaste processing is the siting on composting plants. For the same flow of wastes many small plants would take more land than a few big plants, as service buildings, storage surfaces and roads take space that does not shrink in proportion to the small size of the plant.

Since composting plants with their storage of raw wastes could generate bad odours and a considerable flow of rejects and leachate, they often are laid out at the same site as landfills. In MM such sites could probably be found only at a (long) distance from the built-up environment.

From a logistic point of view the best location of a composting plant would be close to the zone of waste generation, since due to the weight reduction at composting of about 60%, the transport of the raw biowastes contributes much more to the costs than the transport of the final compost product. This of course is true only if the compost can be utilized in the vicinity of the composting plant. Location of composting plants far from the city would considerably increase the cost of transport in the chain.

Again from the viewpoint of transport costs, it can be concluded that a number of medium-scale plants is cheaper than one big central composting plant. One or two very big plants would lead to large transport distances and consequently high costs: the bulky biowastes would have to be transported over long distances to the plants and from thereon to the widely extended areas of compost application. A higher number of smaller plants could result in considerably smaller transport costs.

The optimum number in a city would be determined by many local factors, but theoretically the decreasing cost of transport associated with smaller plants is offset by the higher cost of processing per ton of waste in small plants in comparison to big plants.

VII. TO LAND ON HIGHER GROUND

In The Philippines up to now the production of compost from MSW has primarily been viewed as a method of solid waste treatment better than landfilling. The pressing questions preceding the extension of composting capacity are however: to what extent do farmers and other potential users want biowaste-based compost from MSW? What other applications than farming could be part of the chain? What qualities of compost are needed? Up to now no adequate answers to these questions have been found.

Our research has shown that increase of the reuse of municipal biowastes is fraught with uncertainties. It is useless to start stepping up one link of the chain, e.g. the composting capacity, without simultaneously warranting a matching demand of compost product and an enhanced segregated collection. Evidently, all key players have to act in concert to make the chain In order to find mechanisms to achieve a viable and manageable biowaste reuse chain and create a supportive environment for implementation, a research and demonstration programme consisting of 4 main activities has been developed (Table 6).

Table 6 Research agenda for enhancing the biowaste reuse chain

Stakeholder dialogues
Establishment of a supportive environment through assessment of needs, constraints and strengths of stakeholders
Diagnostic research
Analysis of ongoing waste segregation at-source activities
Assessment of the technical efficiency and economic viability of existing composting ventures including regulatory framework of compost application
Agronomic, financial and demand analysis of the application of fertilizers
Demonstration activities
Farmers Field Studies to assess the efficacy of in the produced compost
Manufacturing competitive compost products from market wastes and source-separated municipal wastes
Strategies for chain management
Survey of international best practices in urban waste management and reuse in South East Asian Cities
Identifying mechanisms to achieve a viable and manageable biowaste reuse chain

The backbone of the activities is the stakeholders dialogue. The main stakeholders are users of biowaste products, compost producers, waste generators (citizens and their grass root organizations), waste collectors and waste managers. The dialogue brings stakeholders together, makes them familiar with each other's needs, constraints and possibilities and intends to create a supportive environment for coordinated expansion of activities in the chain.

Secondly diagnostic activities in each of the links: waste segregation at source, composting ventures and compost market intend to find bottlenecks and opportunities in the chain, to learn from good practices already existing and to contribute to a vision on chain management.

Thirdly, demonstration activities in biowaste treatment and application of compost in horticulture would have to result in widely agreed procedures to make competitive compost products and to have farmers build up a joint experience in the use of compost. In contrast to field studies carried out by staff of an agricultural institute, during Farmers Field Studies farmers apply the compost under their own field conditions, they themselves carry out the monitoring of the plant growth and are directly involved in the analysis of their data and those of colleagues.

The research programme will have to result in strategies for chain management applicable under Philippine conditions. The final stage of 'identifying mechanisms to achieve a viable and manageable biowaste reuse chain' is carried out on the basis of a survey of international best practices in urban waste management, especially in South East Asia, in addition to the lessons learned from stakeholder dialogues, diagnostic research and demonstration studies.

Since reuse of municipal biowaste reuse is a pressing problem, not only in The Philippines but in South East Asian cities in general, the proposed programme could integrate comparative studies, conducted by joint venture of local and international partners, in the surroundings of Bangkok (Thailand), Ho Chi Minh City (Vietnam) and Phnom Penh (Cambodja).

VIII. CONCLUSIONS

Presently, MM generates about 6,000 tons of municipal solid wastes per day of which 2,800 tons is estimated to be biodegradable. Despite a legal framework and policy that aims at recycling 25% of the biodegradable wastes, presently (only) 160 tons/d of these biowastes (ca 6%) is source-separated and processed in 22 small-scale composting plants. Evaluation of the performance of 3 of these plants revealed flaws in obtaining compost with the officially required quality standards. A survey among 50 horticultural farmers showed that only 34% of them use organic fertiliser. The main impediments for increased compost application are low expectations about the yields of compost versus inorganic fertilizers, the relatively high price and cumbersome handling of the bulky product**.**

At 25% recycling in MM an agricultural area in the order of 20,000 ha would have to apply municipal biowaste-based compost in quantities of ca 10 tons/ha/yr, which is far more than the agricultural area within the city's boundaries.

Enhancement of the municipal biowaste reuse chain in Manila would require synchronous expansion of the markets, the composting and the collection of segregated wastes. In order to develop a vision on chain enhancement a research programme covering MM and several other South East Asian megacities is proposed.

A determined collaboration of the stakeholders involved in the chain, farmers, compost producers, waste generators, waste collectors and waste managers, is seen as a prime prerequisite in the development of this vision.

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