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Organic Solid Waste Management in a Framework of Millennium Development Goals and Clean Development Mechanism – How Can Research Contribute?

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Abstract
The present paper underlines opportunities available for use in improving organic waste management in light of the Millennium Development Goals (MDGs) and the Clean Development Mechanism (CDM, a mechanism of the Kyoto Protocol). Initiatives and commitments for improving waste management in developing countries have gained momentum with the formulation of the MDGs and CDM. The Millennium Development Goals form a blueprint agreed on by all nations and leading development institutions of the world and have stimulated unprecedented efforts to meet the needs of the world's poor. Although solid waste management – in contrast to water supply or sanitation – is not specifically mentioned in the targets, many of these can only be achieved by also improving municipal organic waste management. Organic waste management, for instance, is the key to improving hygienic conditions on household, community and city level thus contributing to targets 5, 6, and 11 all related to improving health and reducing disease burden. Recycling and use of treated organic waste in agriculture furthermore contributes to target 9 (reverse the loss of environmental resources and reducing carbon dioxide emissions) as well as target 2 (improving food security). Focusing in addition on innovative management and organizational models for solid waste service contributes to target 1 (combating poverty) as decentralized collection and organic waste treatment schemes provide income opportunities, and thus contribute towards alleviating poverty. In contrast, the Clean Development Mechanisms focus less directly on the wellbeing of individuals but rather tackle the global issue of reducing greenhouse gas emissions at lowest cost and in a sustainable way. CDM supports aerobic composting as it avoids methane production in disposal sites. In this framework, research has an important role to play in providing scientific basis for quantifying the wide range of impacts of different future waste management scenarios, as well as managing to include research results in policy and practice and thus contributing towards informed decision making and wide spatial replication.

1 Introduction

1.1 The Millennium Development Goals

The Millennium Development Goals (MDGs) were adopted by 189 nations during the UN Millennium Summit in September 2000 (United Nations, 2006). Their objective is to act as a blueprint for the building of a better world in the 21st century and comprises many of the most important commitments made separately at the international conferences and summits of the 1990s. They are constituted by eight goals corresponding to the world's main development challenges. The 8 goals break down into 18 quantifiable time-bound targets.

- Goal 1: Eradicate extreme poverty and hunger
- Goal 2: Achieve universal primary education
- Goal 3: Promote gender equality and empower women
- Goal 4: Reduce child mortality
- Goal 5: Improve maternal health
- Goal 6: Combat HIV/AIDS, malaria and other diseases
- Goal 7: Ensure environmental sustainability
  - Target 9: Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources
  - Target 10: Halve by 2015 the proportion of people without sustainable access to safe drinking-water and sanitation
  - Target 11: By 2020 to have achieved a significant improvement in the lives of at least 100 million slum dwellers
- Goal 8: Develop a Global Partnership for Development

Crucial for solid waste management are the targets attributed to goal no. 7 as listed above. Although solid waste management is directly linked to the sanitation targets as well as the targets related to slum improvement, it is also indirectly but intricately linked to the issues of poverty and the many targets related to health improvements (goal 4, 5, 6).

The Millennium Project, commissioned by the United Nations Secretary-General in 2002, was mandated to develop a concrete action plan to achieve the Millennium Development Goals. Individual thematic task forces developed recommendations on concrete strategies for scaling-up throughout the developing world, outlining how donor country aid commitments could be of help in achieving the goals and targets. In the thematic field of water and sanitation, in which also solid waste management plays a key role, the task force stated the importance of working with local communities in developing countries to provide hygiene education, teaching proper use of facilities, and to focus on service delivery, in addition to upgrading or building new infrastructures. Two recommendations must be highlighted: 1) Increase of financing for infrastructures, operations and maintenance, and, 2) Decentralization of responsibilities to local authorities and communities. Given the limited financial resources of local authorities it is critical

to analyze the possibilities of obtaining funding for the improvement of waste management services.

1.2 The Clean Development Mechanism (CDM)

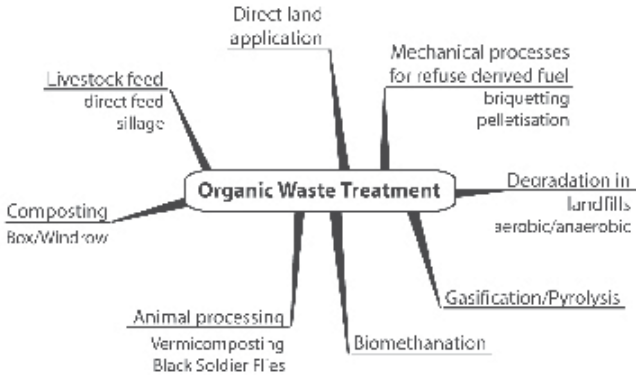
The 1997 Kyoto Protocol, a global effort to protect the environment and achieve sustainable development by reducing greenhouse gas emissions, includes cooperative mechanisms aimed at cutting the cost of curbing emissions. Thus it is of no importance to the climate where emission reductions are achieved and economics argue for achieving them where they are least costly. The CDM, contained in Article 12 of the Kyoto Protocol, allows governments or private entities in industrialized countries to implement emission reduction projects in developing countries and receive credit in the form of "certified emission reductions," or CERs, to be balanced against their national reduction targets. The CDM strives to promote sustainable development in developing countries, while allowing developed countries to contribute towards the goal of reducing atmospheric concentrations of greenhouse gases. Waste management and handling are key areas for implementation of CDM projects. Currently, of the 477 registered projects, 25 % cover the scope of waste handling and disposal (while 47 % concern renewable energy projects, 11 % agriculture, 8.5 % fugitive emissions for fuels and 5 % manufacturing industries).

The process of registering a project however is time consuming and expensive. Projects which do not yet have an established methodology for assessing the baseline and emission reduction face an even more severe hindrance as at first an appropriate methodology needs to be developed, established and accepted by the executive board of the UNFCCC prior to registration. Currently waste projects in CDM are dominated by landfill gas collection projects providing for flaring or electricity generation for which methodologies are well established. Recently the methodologies for "biomethanation of organic wastes" (AM12) and "avoiding methane emissions through alternative waste treatment processes" (AM25) have been endorsed by the UNFCCC executive board. This last mentioned methodology, originally developed for composting and now expanded to include other technologies and approaches, forms the basis for obtaining certificates for composting or other organic waste treatment approaches.

1.3 Urban Solid Waste Management

Local governments and urban authorities are in desperate need for strategic decisions to improve recycling, collection, treatment and disposal approaches while taking into account the costs involved and the local financial possibilities, and finally the consideration of impact of wastes on the local and global environment. The paradigm, focusing on end-of-pipe high energy/high technology treatment and disposal, is moving more towards waste processing and waste recycling with consideration of public-private partnerships, small and medium enterprises and community based involvement using low energy/low technology

resources. Some of the key criteria for future solid waste approaches will have to include increasing community participation, understanding of economic benefits of waste recovery, establishing finance mechanisms for investments and operation, focus on life cycles and closed loop systems, decentralized administration and management of solid waste, while retaining minimal environmental impact. In cities of most developing countries, more than 50 % of the municipal solid waste (MSW) in weight consists of biodegradable organic matter (Diaz et al., 1996; Rytz, 2001). Given this significant proportion in the municipal waste stream, it is thus of great interest to the local authorities responsible for waste management



to identify ways of recycling the organic fraction in order to alleviate the waste burden not only by total volume to be disposed of in landfills, but also allowing recovery of nutrients, organic matter and energy contained in the waste. Figure 1 shows various approaches for managing and recycling organic solid wastes.

Fig. 1: Schematic overview of organic waste management technologies.

Aerobic composting represents just one of the potential approaches. Although an ancient agricultural practice, in the context of increasing urbanization this traditional recycling process has been somewhat lost. Since the 1970s, composting has experienced a renaissance. However, due to inappropriate technical and managerial approaches, composting gained a questionable if not negative reputation. Large-scale, highly mechanized solid waste composting plants turned out to be failures with serious financial consequences (Dulac, 2001). The hope that composting could be a money making business solving the city's waste as well as financial problems was rapidly shattered. A study carried out in India (UNDP/WB RWSG-SA, 1991), concluded that out of eleven heavily subsidized mechanical municipal compost plants constructed between 1975 and 1985, in 1991 only three were in operating condition and that these plants were operating at much lower capacities than initially scheduled. The study recommended: *"Instead of setting up one single large mechanical compost plant, it will be beneficial to set up several small manual composting plants."*

2 Decentralized Approaches in Organic Waste Composting

Since the 1990's, with the aim of counteracting the negative experiences, many small-scale composting initiatives have been initiated by NGOs or community groups often receiving international assistance. Some continue to exist, although many disappeared after a few project years due to managerial mistakes similar to those occurring in centralized plants. Two major barriers can be identified. 1) Many of the initiatives focused on the treatment of waste and neglected the need for marketing of the product compost. The lack of a sufficient and constant market led to income losses which could not be compensated by collection fees. 2) Often, these initiatives lacked a link or cooperation with the municipal solid waste management system. Almost none of the schemes had obtained official approval from the municipal authority. Once the seed money provided by the funding agency was used up or the initiator had withdrawn from the project, the management was significantly weakened and the project often terminated operation soon afterwards.

Despite these discouraging experiences, many organizations all over the world are still putting efforts into composting with special focus on decentralized composting. In Europe, where the legal framework prohibits disposal of organic waste and promotes resource recovery and recycling, composting has become an interesting income opportunity for farmers, and municipalities are promoting decentralized composting (Commission, 1999). Furthermore, a diverse market for various compost products has been established over the past few years. Hoornweg et al. (1999) states that "*the issue of compost marketing is not so much finding a use for the finished compost but rather finding cost-effective applications*."

The department Sandec at Eawag conducted research on composting in developing countries, analyzing the factors of success and failure from different perspectives in order to bring together experiences characterizing successful decentralized composting. Several general features can be highlighted when comparing centralized versus decentralized schemes. Centralized schemes are large-scale, highly mechanized composting plants mostly located outside a city, often close to a dump site. The incoming waste is either separately collected market waste or mixed household waste which needs (but often lacks) a separation process prior to composting. Depending on the population size of a city, such plants are designed for 50 to 600 tons of waste per day (Hoornweg et al., 1999). The handling of large amounts of waste requires mechanical equipment like conveyor belts, turning equipment and rotating drum sieves. In contrast, decentralized composting schemes are located inside the city, close to neighborhoods where waste is generated. The smallest unit of a decentralized composting scheme is backyard composting. Community-based decentralized schemes handle waste from one neighborhood resulting in plant capacities scarcely exceeding 10 tons of waste per day. These low amounts of waste still allow manual handling with little mechanical support, keeping investment costs down. In small and medium

scale plants two composting techniques are most popular: windrow composting and box composting. The choice of a composting technology is mainly dependent on space availability, the availability of laborers, and initial funds. Box composting units are suitable for limited space and can be placed even along roadsides, whereas windrow composting schemes need sufficient space for a proper setup. Table 1 shows a selection of assessed composting schemes in India and Bangladesh.

Tab. 1: Overview of community based initiatives in India and Bangladesh, sorted by the number of households served

Name of Site/ Company	City	Composting Technique	Space available (m^2)	No. of households served	Amount of waste composted (kg/day)
Sandu Lane ALM	Mumbai	Bin-composting	16	120	no records
Diamond Garden Residents Forum (DGRF ALM)	Mumbai	Bin-composting	100	125	60
Scientific Handling of Waste Society (SHOW)	Bangalore	Bin-composting with active aeration	190	180	50
Sindh Colony	Pune	Shallow windrows	150	264	200
Pammal	Chennai	Vermi-composting in bins	300	476	100
CEE Kalyana Nagar Residence Association	Bangalore	Bin-composting	500	980	122
Residents Initiative for a Safe Environment (RISE)	Bangalore	Bin-composting	290	1200	300
Mirpur Composting Site	Dhaka	Windrow composting	800	1300	2000-3000
Green Road Composting Plant	Dhaka	Box Composting	1000	2000	4000

Composting schemes can be characterized into typical organizational set-ups:

- Neighborhood initiatives and community-based waste collection and composting schemes
- Initiatives of companies and institutions composting on their premises
- Medium-scale private sector composting enterprises
- Public-private partnerships in large scale composting schemes

Municipalities themselves are seldom initiators of such schemes. One example worth mentioning is Mumbai's Advanced Locality Management Initiative (ALM). These are formed streetwise or within small areas with municipal support. Support consists of exchange of information and communication between ALM representatives and municipal authorities, technical advice and organizational assistance. Waste collection is often considered the main priority and composting

activities usually follow at a later stage. Key common features of community-based schemes are their small scale of operation and the high degree of public participation. They are initiated by residents as a response to a crisis in local hygiene and poor waste management, often in areas lacking satisfactory services. In all schemes observed, composting was included as an activity to reduce waste amounts for further transport, a problem often persisting due to the unreliable secondary collection service of the municipal authorities. House-to-house collection is the core activity of many initiatives for which residents can be motivated to pay additional fees. It is this financial contribution of the residents which usually guarantees the financial viability of the whole scheme, including the composting activities, rather than income from compost sales. Payment of fees is often voluntary and initiators must invest a lot of effort to convince people to pay. Many households are not willing to pay fees in addition to the taxes they already pay, and which in principle should cover the provision of a proper municipal solid waste management service. The unofficial status as well as the lack of cooperation with the municipal waste management department has forced many decentralized schemes to stop.

3 Organic waste management opportunities - the role of research

3.1 The MDGs - a justification for prioritizing organic waste management?

It is obvious that organic waste management - as part of the city's solid waste management strategy - has significant benefits towards a wide range of social, economic, institutional, and environmental factors. Nevertheless these benefits are rarely taken into account or quantified. Often the organic waste treatment plant - be it composting, biomethanation or another treatment or reuse approach – is evaluated as a singular activity. Rather, organic waste management needs to be considered as one building block of the overall solid waste management system, taking into account its enormous positive contribution to the city's waste services, highlighting its contribution to the MDGs on the local level as well as national and global levels.

On a research level, in recent decades several models have been developed to support decision making in municipal solid waste management (Hung et al., 2007). These models often focus on environmental impact and life cycle assessment and to a lesser degree take into account financial and economic factors (system cost and system benefit), and have hardly been applied to the developing country context. Extending financial and environmental valuation of composting by including health, social and institutional aspects and related spin-off effects towards other MDG targets are crucial towards giving a holistic picture of the organic waste management strategic alternatives and integrating them into an international debate regarding poverty reduction strategies and sustainable development. This aspect was also raised by the task force of the UN Millennium Project (2005), that has published priority actions for research organizations to:

- Better document and communicate the *economic benefits* of improved

services,
- Develop a conceptual framework for defining and *measuring the contribution of improvements to the Millennium Development Goals*.
- Support the development of appropriate technical standards,
- Conduct research on appropriate, affordable approaches and technologies as well as institutional innovations.

Decentralized composting, as an example, contributes to a wide range of MDG targets as it significantly improves hygienic conditions within the service area thus contributing to Targets 10 and 11 of the MDGs. Composting schemes also provide employment in the neighborhood/community as labor-intensive technology is applied, thus offering new and safer income opportunities particularly for poor and underprivileged people of the informal sector, (MDG target 1). With reuse of compost, its high organic matter content can help to re-establish the natural soil structure, leading to improved crop production when supported by the careful use of artificial fertilizers. In this context urban agriculture plays an exceptional role in the provision of fresh food for urban centers, constituting an excellent market potential for compost (Target 2 "Food security"). Target 9 stipulates the integration of sustainability in country policies and the reversal of the loss of environmental resources. The reuse of organic waste in agriculture does not represent an overall solution but may certainly contribute towards achieving such targets in a sustainable way.

Finally, decentralized composting activities and interaction between residents in issues of waste handling, hygiene, cleanliness and environment can significantly enhance environmental awareness in a community and enhance social cohesion. While all these benefits are obvious, there is need for more research evidence which quantifies these impacts.

3.2 CDM - a new driving force for organic waste management?

Recently, increasing attention has been focused on organic waste treatment in a global context. Indicator 28 under Target 9 of the MDGs specifically addresses the carbon dioxide (CO_2) emissions per capita. One incentive measure for reducing greenhouse gas emissions at lowest cost and in a sustainable way in developing countries is the clean development mechanism (CDM), an initiative of the United Nations (UN). In October 2005, the Dutch company World Wide Recycling together with the NGO Waste Concern succeeded in registering composting as greenhouse gas abating measure under the *United Nations Framework Convention on Climate Change* (UNFCCC) (World Wide Recycling and Waste Concern, 2005). Composting falls under the category of greenhouse gas avoiding measures due to the fact that organic waste composted under aerobic conditions produces less CO_2 equivalents than organic waste incorporated in typically anaerobic landfills without landfill gas collection. This pioneering effort in developing an appropriate baseline methodology "AM0025" has opened up opportunities for com-

posting schemes in many developing countries which have ratified the Kyoto Protocol. Furthermore the methodology has meanwhile been revised (version 5) to include various "alternative waste treatment processes" which include: aerobic composting, gasification, anaerobic digestion with biogas collection, and mechanical processes to produce refuse derived fuel (e.g. pelletization, briquetting) (UNFCCC, 2006a). Furthermore an adapted methodology has also been endorsed for small scale projects resulting in emission reduction of less than 25,000 ton CO_2 equivalent per year (UNFCCC, 2006b). However, until now only one composting project has been officially registered. Another six have been submitted and are currently awaiting comments. This comprises the "Wuzhou Organic Waste Composting Project, Guangxi Province China" and 5 small scale composting projects in Malaysia. As transaction costs for obtaining registration are still high, there is a risk that CDM may promote large scale centralized composting plants similar to those constructed in the 1970's. Being blinded by the new financing options there is the danger that investors may forget both their past mistakes and the continuing institutional and technical problems in relation to solid waste management.

Research can contribute on one hand towards improving baseline assessment and monitoring methodologies, by simplifying procedures and establishing evidence based results on potential project emission reductions as well as project greenhouse gas emissions. Furthermore conceptual development and research should also involve other solid waste related greenhouse gas avoiding measures.

4 Conclusions

Evidence based research results together with incentive schemes provided by international and national policies play a fundamental role in enhancing and supporting organic waste management initiatives. Whatever organic waste management strategy is implemented, its success is determined by the scope of municipal support, integration into the solid waste management scheme, and the national and local enabling environment promoting sustainable resource management.

Research must show quantifiable evidence of the impacts of organic waste management schemes towards the MDGs. To achieve the millennium development goals additional financial resources must be made available. Many of these resources will have to be found within each single country, but international incentive schemes such as CDM provides opportunities to advance the development goals especially in the solid waste sector. Composting schemes can now count on significant revenues from selling CO_2 certificates in addition to the revenues from compost sales. These revenues can be used to support the start-up phase, particularly in developing and establishing the still weak market and distribution networks for compost products. The full extent of potential benefits from CDM for organic waste management in developing countries is difficult to forecast. However there is enormous potential to promote sustainable approaches and increase foreign investment flows. Increasing possibilities for small

scale projects and reducing the burden of complicated, time intensive and costly registration procedures are crucial steps towards enhancing the opportunities of local communities, or small and medium enterprises to engage and benefit for the emission certificate trading.
Research has the responsibility in providing scientific evidence and getting research results into policy and practice and thus contributing to informed decision making and wide spatial replication.

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