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Lessons from Municipal Solid Waste Processing Initiatives in India

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Erfahrungen aus Abfallvorbehandlungsvorhaben in Indien

Abstract
About 40 million tonnes of municipal waste is generated in India every year. The waste management scenario continues to be grim, even though there have been some commendable initiatives by scattered municipalities, individuals, groups and NGOs. As of today, open dumps are the major mode of waste disposal. Composting, biomethanation and thermal processing are being attempted as the options for waste processing. This paper analyses the performance of such waste processing initiatives in India, identifies the key constraints and presents suggestions for improvement.

Keywords
Waste processing, Composting, Biomethanation, RDF, Waste to energy

1 Introduction

Municipal solid waste (MSW) includes household garbage and rubbish, street sweeping, construction and demolition debris, sanitation residues, trade and non hazardous industrial refuse and treated bio-medical solid waste. The management of MSW is an area of universal concern for both the developed and developing world. It is a major problem in Indian cities and towns with the urban areas of India producing about 40 million tons of solid waste from household and commercial activities every year. As the Solid Waste Management (SWM) is of local nature it is the responsibility of the State which in turn has entrusted it to local authorities who carry out the solid waste management in areas under their control using mostly their own funds, staff and equipment. The urban local bodies spend approximately Rs.500 to Rs.1500 (approx. USD 12 - 36) per tonne on solid waste for collection, transportation, treatment and disposal. About 60-70% of this amount is spent on collection, 20-30% on transportation and less than 5% on processing and final disposal. Out of the total municipal waste collected, about 94% is disposed by open dumping and the rest is composted (VISVANATHAN ET AL.,2004).

The 2001 Census has put the number of urban centres as 5144 out of which 464 centres have a population greater than 1 lakh. According to the Central Pollution Control Board (CPCB) the average waste generated for small towns is 0.1 kg per person per day; for medium towns/city is 0.3 to 0.4 kg per person per day; and for large cities around 0.5 kg per person per day (CPCB, 2000). The typical rate of increase of waste generation in Indian cities has been estimated at around 1.3% annually. The expected generation of MSW in 2025 will therefore be around 700 grams per capita per day. Considering that the urban population of India is expected to grow to 45% of total from the prevailing 28%, the magnitude of problem is likely to grow to even larger proportions (WORLD BANK, 2006).

The socio-economic structure of the Indian society not only makes per capita generation of waste much less compared to that of the western societies, it has also brought in a system of waste recycling and reusing not common in developed societies, though these systems are fast loosing ground. A substantial amount of MSW is recycled and reused through the primary intervention of ragpickers and second-hand markets, though there are problems like the health hazard to the ragpickers and the degradation and devaluation of the recyclables.

Since the experience in the towns all over India regarding waste processing has not been encouraging and since the States were not observed to take any specific initiative in this regard various committees were appointed by the Central Government and as a result of these committees various projects were initiated. The two leading methods of waste processing being adopted in India include composting (aerobic composting, anaerobic, vermicomposting, etc.) and waste-to-energy (bio-methanation, pelletisation, incineration) (CPHEEO,2000). The larger (50-60%) proportion of organic matter in Indian MSW indicates the desirability of biological processing of wastes. This paper is aimed at analyzing the performance of these waste processing plants on technical aspects (i.e. processing technology and quality of product), the type of management and performance, institutional aspects (i.e. government policies and regulations, stakeholder cooperation) and environmental health aspects. This also includes aspects such as the technology maturity, input quality/ quantity flexibility and local availability of technology and expertise.

2 Historic and Regulatory Perspective

The history of waste processing in India dates back to 1934, when Mr. Howard, a British Sanitary Engineer put garbage in the form of windrows (known as 'Indore Process') followed by 'Bangalore Process' carried out by Prof. Acharya and his team at IARI during the late 40's and early 50's (CPHEEO, 2000). Composting of municipal garbage started in a big way in the late 70's when about a dozen mechanical compost plants were set up across the country. Due to technical problems and financial losses all of them were closed down, except the Karnataka Compost Development Corporation (KCDC) in Bangalore. During 1984 a plant for processing 300 tonnes garbage to produce about 3 MW of power was set up in Delhi with technical assistance from Denmark. The plant was not successful. 1999-2000 is regarded as a land mark year so far as recovery of energy from wastes is concerned. A project for producing 105 tpd fuel pellets from MSW in Hyderabad has been installed by SELCO international Ltd. (SIL) based on technology provided by Department of Science and Technology, New Delhi. 5 MW Power Project based on high rate biomethanation of MSW to process 500-600 tonnes per day of Municipal Solid Waste of Lucknow city, was not able to operate to its full capacity due to high level of inerts in the waste(IPE, 2006).

At the national policy level, the Ministry of Environment and Forests has recently legislated the Municipal Waste Management and Handling Rules (MoEF, 2000). These Rules are applicable to every municipal authority responsible for collection, segregation, storage, transportation, processing and disposal of municipal solid wastes. The rules require that the municipal authorities shall adopt suitable technology or combination of such technologies to make use of wastes so as to minimize burden on landfill. The biodegradable wastes shall be processed by composting, vermicomposting, anaerobic digestion or any other appropriate biological processing for stabilization of wastes. It shall be ensured that compost or any other end product shall comply with specified standards. Mixed waste containing recoverable resources shall follow the route of recycling. Incineration with or without energy recovery including pelletisation can also be used for processing wastes in specific cases. Municipal authority or the operator of a facility wishing to use other state-of-the-art technologies shall approach the Central Pollution Control Board (CPCB) to get the standards laid down before applying for grant of authorisation. An April 2004 study of 128 cities by Mr P U Asnani had 50% compliance for Waste Processing in only 8 % of 128 cities.

3 Composting Plants

In the seventies the Government of India gave subsidies compost plants in the major cities, but the initiative failed and most of the plants were abandoned due to reasons such as the following.

- Technology applied was often too complicated and not adapted to local circumstances
- Over mechanization and Choice of technologies without due analysis of waste characteristics
- Financial and marketing aspects were usually ignored resulting in high operational costs
- Management and technical expertise was often not sufficiently available;
- Absence of supportive institutional environments such as the legal and policy framework or economic circumstances

- Poor quality of process outputs due to the use of mixed municipal waste with lot of inerts
- Low skill/managerial inputs reduced the operating efficiencies resulting in high cost of production; and
- Poor quality of finished compost resulting in problems in marketability

The problems were further compounded due to large distances between compost production centers and the compost utilisation centers, namely the farmlands. The resulting cost of transportation made marketing even more uneconomical.

The scenario changed radically with the entry of a private operator (Excel India Ltd.) in the early 90's. They reduced mechanization by almost eliminating the pre-processing stages while post-screening stages were introduced to improve the quality by better removal of contaminants. Bio-inoculum was sprayed over the windrows for suppressing bad odour. These plants have been successful in marketing their compost and have been able to sustain their production. A windrow based compost plant set-up by Poabs Envirotech Private Limited (POABS) of 300 TPD capacity came into operation in July 2000 is operating effectively at Thiruvananthapuram, in Kerala. on 30 acres of land on contract for 30 years with Trivandrum Corporation under Built, Operate and Transfer (BOT) scheme. It is the first and very unique plant in the whole of India having the facility to process MSW into Organic Bio Manure under one roof of 1,25,000 square feet. Though this plant is considered as a model plant the project has not addressed the issue of managing the rejects from the plant that accounted for about 50% of the waste feed. The improper disposal of such residues has raised lot of public criticism of the plant.

During the same period, several NGOs have also started promoting waste recycling through community-based/involved decentralized backyard composting plants with aerobic, vermi-composting and anaerobic / trench composting. Many of the individual and community efforts have found success not only because of the community participation but also because of the emphasis on at-source segregation, better individual responsibility and the relatively smaller scale of operation. Though, the Decentralised composting at home or neighbourhood or campus level, attempted sporadically in various cities, is successful with strong individual commitment or NGO funding, but has not really taken off as it should.

Composting is a proven technology worldwide, albeit for source segregated wastes. It is expected that segregation will improve in the coming years, with composting capacity increased and composting technology modernized. It is likely that a market for compost may take long to develop in the absence of segregated waste input, and subsidy given to fertilizers. Consequently it is recommended that strategy towards sale of compost should change. Composting should be regarded as a treatment option rather than a self supporting project. Compost may be given away to the public or to government agencies for use in horticulture or alternatively be used as landfill cover or used for closure of open dumps. The real challenge is to generate markets for the finished compost. A recent study (CPCB, 2006) has recommended that the compost plants shall be fed only source separated organic waste to ensure that the heavy metals in the compost are within limits.

Public perception and confidence in composting is generally positive and the product is well supported in the market place. The amenity impacts of open windrow composting are considerable, with such facilities generating many complaints regarding odour and dust emissions. Control of local odour dispersion is remaining as a key factor in siting of such facilities. Employment impacts are low in the composting process but moderate in product sales and indirect activities.

4 Biomethanation Plants

The Ministry of Non-conventional Energy Sources (MNES), Government of India declared a National Master Plan in 1994, which incorporates biomethanation as one of the major waste-to-energy options to be developed and adopted in the country (CPHEEO, 2000). It can generate biogas of about 250–350m3/tonne of waste and about 20% of the waste as manure. A biomethanation plant based on 16 tons of vegetable market waste and 4 tons of slaughterhouse waste generated in Vijayawada Municipal Corporation in Andhrapradesh was commissioned in February 2004 . M/s Mailhem Engineers Pvt. Ltd. (MEPL), Pune did the Engineering Company for Design, Detailed Engineering, Supply, Construction, Erection, Testing and Commissioning of the Plant on a turnkey basis. Sewage from the nearby treatment plant was also used for dilution of the mixed waste in the plant. The plant is daily generating about 1600 cu. m of biogas and 5 tonnes of organic manure. The biogas so produced is being used for generation of electricity. Another 0.3 MW power project utilising vegetable market wastes at Koyembedu Market Complex, Chennai is also in operation .

The Lucknow city producing around 1800 MT of MSW daily setup a plant to handle minimum of 300 TPD of municipal waste using the bio-methanation process for conversion of waste to energy with help of a BIMA digester, a technology that is being used in over 50 WTE plants worldwide. This project was designed as the first solid waste power project in Indian which the MNES identified as a full-scale national demonstration plant. Although the project was initiated in 1998, the project got delayed because of finalisation of land transfers, government guarantee, identification of financiers and other related formalities, which could be completed only by August 2001. The plant construction was completed in August 2003.The project was executed on a Build Operate and

Transfer (BOO) basis. While firms from Austria and Singapore were providing the technical inputs, Indian firms provided human resource for execution. The Lucknow plant has been plagued by non-availability of “acceptable waste” despite the city’s total waste generation of 1650 tons a day. The plant is currently non-operational due to the inability of the plant to receive quality waste. Most waste transported contained less than 50-70% inorganics, which rendered operations unviable. This is again because of inordinately high inerts in Indian waste, far higher than in comparable Asian countries. Hence, the “rejected” truckloads of untreated waste lie in growing hillocks around the entire plant. The failure of the plant have led to the evaluation of the waste to energy projects in the country by an Expert committee constituted under the direction of the Hon. Supreme court of India. The committee was of the opinion that the problem faced in the operation of the Lucknow plant may be attributed both to the ineffective segregation system and the quality of MSW available for the plant.

Public perception and confidence in anaerobic digestion is expected to be fair. Amenity impacts are low due to the process being enclosed. Employment impacts are moderate in process operations due to the capital intensity of the operations, but moderate in process control and asset management. However, the overall performance of the Bio-methanation Plant is greatly influenced by the input feed specification and the plant requires segregated biodegradable MSW (e.g., hotel and restaurant waste, market waste) for optimal plant performance rather than un-segregated MSW. The homogeneity of the feed material is an important parameter from the efficiency point of view. The solid waste management system needs to be modified and improved to make it compatible with the requirements of BT covering source separation collection of solid waste. Or else the applicability will be limited to highly organic and homogenous waste streams like Market wastes.

5 Thermal Processing Plants

In the early 1980s, the Indian Commission on Alternative Energy Sources (now, Department of Non-Conventional Energy Sources) with the support of the Danish Firm Volund Miljoteknik A/S set up a small (300 t/day) research and development waste incineration plant with two 150-TPD Rotary Kiln Incineration units, designed to burn waste that averaged 5,000 kJ/kg with a moisture content of approximately 15%. The system was projected to produce 3.7 MW. The plant was put into trial operation in March 1987, and operated for 8–10 hours per day during the initial start-up period and was subsequently shut down in 1990 due to mismatch of quality of incoming feed with plant design.

The waste that was available for the plant was very different in composition, moisture content, and energy content than that initially tested. These wastes turned out to have a very high percentage of inert material, in the form of dirt, sand, silt, rock, and ashes. This also resulted in a waste stream with a density of 500–1,000 kg/m3, which was far above the design parameters. The energy content of the waste was only about 50% of the design value. The plant was designed for a MSW having a calorific value of 1463 kcal/kg. But in actual operation, it was realized that the heat content of the MSW was only 660 to 750 kcal/kg. As it could not sustain combustion, there was a need of large quantities of auxiliary fuel and hence the combustion air. But the burners and the air supply arrangements could not cope up with the load. The high inert content of the MSW also caused the failure of the ash handling system.

The operational difficulties and the failures were mainly due to the difference between the design assumptions and the actual field scenario. For self-sustaining combustion, there should be a heat content of at least 2500 kcal/kg (about 5000 Btu/lb). Usually below 1500 kcal/kg, it is not recommended for incineration. Indian MSW is infamous for its low heat content (770 to 1000 kcal/kg, on dry basis, sometimes as low as 600 kcal/kg), high moisture content (30 to 55 % by weight) and high inert contents (30 to 50 % by weight). It is a fact that Indian MSW is not directly suitable for incineration. Waste preparation is a must for incinerating Indian MSW. Waste should be dried, inerts removed and heat content improved to about 2500 kcal/kg.

The perception that incinerators are very damaging to health persists. A solid waste and energy recycling facility “SWERF®” was proposed in 2003 to be setup at Perungudi dumpsite in Chennai for the conversion of 600 MTPD of municipal solid waste to 14.85 Mw electricity through the Pyrolysis and Gasification route at a project cost of Rs.180 Crores. The proposal did not materialize due to public protests.

Vijayawada, a city of one million launched a WTE plant to generate electricity from MSW. This was the first plant in the country to be set up with financial assistance from the United Nations Development Programme (UNDP) and the MNES. The capacity o the power plant is 6 MW and is aimed to process 500 MT of MSW per day (Good Governance India, 2004). The processing of MSW was earlier established only on a pilot scale at 2 MT per hour plant by TIFAC under aegis of Department of science and technology, GOI.

The twin cities of Hyderabad and Secundrabad producing around 2200 MT of waste every day Setup a WTE plant in 1999 based on the RDF Technology (IPE, 2006). Located next to the Ganghamguda municipal land dump (20 acres), which receives 1300 MT of garbage every day from Hyderabad city. It was set up by the Andhra Pradesh Technology Development & Promotion Centre (APTDC) and Selco International Ltd. The installed capacity of the plant is 1000 TPD and it can manufacture 200-250 TPD of fuel pellets. Currently, the plant is processing only 100-150 TPD of garbage. A power plant (with air cooled condenser) was setup later at Shar Nagar (about 40 km from the

RDF plant) at a cost of Rs. 28 Crores and is currently in operation. The extent of MSW processed by the Plant is still unclear as it uses lot of biomass(high-calorie paddy-husk and / or wood wastes) in addition to the MSW.

The lessons from these waste to energy plants are that in order to determine whether an thermal processing project is a feasible waste management alternative for Indian Cities, the following questions should be addressed:

- When source reduction, reuse, recycling, composting, and waste-stream growth patterns and is the characteristics of the remaining waste stream sufficient to support an energy recovery facility operating at or near capacity over the life of the project?
- Is there a buyer for the energy (RDF/electricity/steam) produced by the energy recovery facility?
- Is there strong political and public support for a WTE facility?

If the answer to any of these questions is “no,” it probably will not work, and other options should be considered.

6 Processing of Construction and Demolition Wastes

The fairly high (30- 50%) inert content of the waste stream has seen to interfere with the performance and in many cases caused the failure of the waste processing plants as had happened in Lucknow. This category of waste is mostly the result of street cleansing that removes wastes from drain cleaning, new construction, renovation, demolition and reconstruction activities comprising of sand, gravel, concrete, stone, bricks, wood, metal, glass, plastic, paper etc. Presently management of such waste from construction and demolition activities in India, comprise of the following elements:

- Re-use of materials salvaged in good condition during demolition.
- Re-melting metal items through scrap dealers.
- Disposal of other items to low lying sites or used for filling material in new construction.

Concrete and masonry constitute more than 50% of waste generated by the C&D activities and there is a huge unexplored scope of recycling of this waste by converting it to aggregate. MSW Rules requires that the construction or demolition wastes or debris shall be separately collected and disposed off. But this is rarely followed and it gets mixed with other wastes causing problems to their biological or thermal processing.

The generators of construction waste / debris must be made responsible for its separate disposal. Any mixing of construction waste with normal municipal waste should be penalized heavily. The construction waste is best collected by giving a concession or a contract to a private operator who shall, at a pre-determined rate take away the debris/ construction waste from the generator and takes care of its lawful disposal. The private operator should be allowed to collect the charges directly from the generator. The operator can “sell” such debris to other construction sites that require land filling. It can be used for developing playgrounds, etc or making bricks and tiles. Municipal bodies can also earmark certain sites where generators can dump their debris. Private operator / municipal body can rent out special bins for debris collection and storage.

7 Conclusions

The analysis of waste processing initiatives in India supports the need to develop Integrated Waste Management Plans for all major urban centres in India. Many of the failures described in this paper have less to do with technology than lack of knowledge of waste characteristics and poor shortsighted policies. Proper segregation of waste into different components and their separate collection can definitely lead to remarkable changes in the entire system. Proper segregation would lead to better options and opportunities for scientific processing and disposal of waste. This would be a long drawn exercise as it involves attitudinal changes in people and will have to be done with careful planning, in a phased manner. To start with, the municipalities must change their own habits and immediately practice the discipline of collecting inerts (road dust, drain silt, debris) in a separate trip from garbage. Appropriate provisions should be made for the ultimate disposal/utilization of the byproducts/residues from the waste processing facilities.

After segregation of inert materials, dry-organic matter and the recyclables, the organic fraction of MSW will be suitable for composting or bio-methanation. Collection system must be efficient and effective to prevent odor problems at the source and during transit. Centralized large plants for mixed waste composting may be incompatible due to the large amount of residue (up to 50%), odor nuisance and marketability of products. Thermal processing technologies such as Mass burn incineration is not a realistic option in India for technical and financial reasons since Indian MSW have low calorific value, high moisture content and high organic matter leading to high economic and environmental costs. Though RDF based plants have been reported to be technically feasible, the details needs to be carefully considered with reference to the volumes and nature of the wastes accepted and the quantity and mode of disposal of the rejects including the emission controls.

It is also to be noted that the municipal authorities often do not have properly trained personnel for managing the waste processing activity. This has often resulted in failure of the latest equipment and facilities that were introduced in the past. It has also resulted in improper decisions being taken by persons who did not have the necessary expertise. It is hence necessary that suitably trained manpower be deployed which will ensure selection and optimal utilization of various equipments, vehicles and processes. Private participation may help to address this issue to a greater extent, provided the contracts are drawn properly and executed with commitment.

Despite all that has been said above, there is countrywide a generally raised official as well as civil society consciousness about the importance of waste management which was not there a decade ago. Even better, there are two small south Indian towns, Suryapet in Andhra Pradesh (population 103,000) and Namakkal in Tamil Nadu (pop. 53,000), which are both dustbin-free “zero-garbage” towns (Good Governance India, 2004). Their highly motivated city managers and elected members, working in unison with dedication and focus to win public participation, have achieved this without any Central or State encouragement or subsidy. There lies the hope for India’s future and it would deploy more than one technology in tandem depending on the nature and the quantity of wastes.

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