12

Decentralized Solid Waste Management in India: A Perspective on Technological Options

Satpal Singh
National Institute of Urban Affairs, New Delhi
Email: satpal61sociologist@gmail.com

Abstract

In most Indian cities, the problem of solid waste management is acute. Solid waste management is a critical service for the urban local bodies since many public health issues are connected with it. The situation is particularly bad in the unauthorized settlements and slums in urban areas where municipal solid waste management is virtually absent. Inadequate waste disposal may cause severe environmental and health problems. These problems may be attributed to the partial segregation of recyclable waste, absence of waste collection at source, unavailability of suitable infrastructure to treat and dispose the huge amount of waste generated. In order to meet these challenges, the present paper advocates decentralized solid waste management to minimize the problems of solid waste management in urban areas. The main purpose of the paper is to provide a comprehensive view of the decentralized approach to solid waste management along with the appropriate technologies to solve the problem of processing and treatment of waste. The paper also summarizes the major findings of the study and suggests policy relevant avenues for future research.

Keywords: door to door waste collection, waste minimization, zero waste, segregation of waste, recycling of waste

Introduction

India is the second largest country in the world with a population of over 1.21 billion accounting for 17.5 percent of the world population (Census of India, 2011). As per the latest population Census-2011, the urban population grew at a rate of 31.16 percent during the last decade 2001-2011. The increase in population has not only changed the physical size of the cities due to large scale of migration but is also exerting significant additional pressure on the basic services and infrastructure across the Indian cities.

Many Indian cities face the serious problem of solid waste management (SWM) due to rapid urbanization and are struggling to find effective responses to improve the living standard of people. Currently, the Indian cities generates over 1,70,000 metric tons i.e. about 62 million tonnes of municipal solid waste per day. It is assumed that urban India will generate 2,76,342 tonnes per day (TDP) by 2021, 4,50,132 tpd by 2031 and 11,95,000 tpd by 2050 (Plaaning Commission, 2014). The quantity and physical composition of solid waste is continuously changing with population redistribution, changing life styles, income and consumption patterns in Indian cities. While, the share of paper, plastics, rubber, glass and metals is constantly increasing that of the biodegradable organic materials still remains significant in our cities. Out of the total waste generated in India, more than 50 percent waste is organic, 31 percent inert waste and 18 percent is recyclable waste (Earth Engineering Centre, 2012). It is observed that a large part of India's waste is compostable waste. The per capita municipal solid waste generation rate is 200-300 gms/capita for small towns, 300-400 gms/capita for medium cities and between 400-600 gms/capita for large cities (Planing Commision, 2014).

Urban Local Bodies (ULBs) responsible for the solid waste management rarely have sufficient funds, infrastructure and appropriate strategies for the improved SWM. It leads to low collection efficiency and uncontrolled disposal. About 70-90 percent waste is collected in larger cities and less than 50 percent in smaller cities (MoUD, 2000). Rest lies outside the bins in most of the urban areas due to inappropriate design, capacity and location of community bins. The situation is particularly alarming in the unauthorized settlements and slums in urban areas, where the SWM is virtually absent.

Solid waste is transported inadequately as many cities lack proper transport facilities and its disposal is also not done in a scientific manner. The trucks used for transportation of waste are generally opened and uncovered which tends to spill waste onto the road resulting in unhygienic conditions. More than 80 percent of waste is disposed of indiscriminately at dump yards in an unhygienic manner by the municipal authorities leading to problems of health and environmental degradation (Planning Commision, 2014). Dumping grounds are not sustainable landfills as these dumping grounds have no foundations, liners, leveling, cover soil, leachate managements and treatment facility (Jha et al., 2011). Majority of cities dispose their waste in low lying areas outside the city without taking precautions or operational control. Cities are facing the problem of the limited availability of land for waste disposal especially big cities. Finding new landfill sites is major constraints including the 'not in backyard (NIMBY) phenomenon. People want a good facility for municipal solid waste but not near the vicinity of their households. The NIMBY attitude of the people has made the task difficult for the ULBs with respect to SWM.

With regard to finances of ULBs, literature show that ULBs are in a dire financial position and are barely able to discharge their duty of SWM. Except few progressive ULBs, all others are heavily dependent on the Central and State Governments' grant that are often inadequate. There is a wide financial gap between the revenue income and expenditure. A significant proportion of revenue expenditure is incurred on establishment cost i.e. salaries of the conservancy staff and transportation of waste. Very little expenditure is incurred on the treatment and disposal of waste. User charges and revenue from waste recovery are largely non-existent in most ULBs. The income and expenditure profile of municipalities clearly indicates that the requirement of fund for SWM cannot be met fully by internal sources.

Considering the graveness of the problems, it is imperative to undertake the decentralized solid waste management since the existing centralized system is not suitable for waste with high organic content and is also not cost effective. It does not allow integration of informal waste workers (Karthykeyan, et al., 2012). Wastes are not collected in efficient manner under this system. As a result, overflowing garbage bins at the public collection sites, scattered waste

all over is common scenario prevailing in most of the cities (ACCCRN, n.a.). In addition, centralized system has a limited scope for community participation, livelihood generation and innovation whereas, the decentralized system do not suffer from these limitations. Decentralized system is more appropriate as it encourages civic responsibilities and provides effective SWM by engaging the local people in the waste management and helps in changing the mindset of people towards the waste management. The system is based on door to door waste collection and sensitizing residents for segregation of waste. The technologies like waste recycling, vermi-composting and small scale bio-gas for this system are very simple, cost effective and labour intensive.

The present paper is an attempt to provide a comprehensive review of the decentralized approach for SWM along with appropriate technologies to solve the problem of processing and treatment of waste. Furthermore, the paper summarizes the major findings of the study to suggest policy relevant avenues for future research.

Decentralized Solid Waste Management

The Decentralized Solid Waste Management (DSWM) is a system to provide a clean environment and hygienic living condition by reducing the quantity of waste at source. It involves the management of municipal solid waste by various small waste management centres within the locality. Such centres are called Integrated Resource Recovery Centres (IRRC) which can be either profit making or not-for-profit organizations engaged in collecting, transporting and processing around 2 to 20 metric tons of waste from the locality (Karthykeyan et al., 2012). The decentralized system is not only sustainable and financially viable but also helps to improve the quality of life and working conditions of the waste pickers. Decentralized or at source segregation and treatment of waste has become the most practical and acceptable solution to the menace of garbage. Many bulk waste generators such as large industries, hotels, IT companies and some forward looking municipal corporations have started adopting various decentralized waste management solutions as a part of their overall waste management strategies. Decentralized organic Solid Waste (SW) composting promotes green growth, reduces GHG emissions and also reduces transportation of organic SW to waste

disposal site. In order to encourage innovation and adoption of decentralized waste recycling solutions, government may consider fiscal and financial incentives for setting up and operation of 'Garbage to Garden' and 'Garbage to Gas' decentralized models with waste generating communities' engagement (The Economic Times, 23rd October 2013, p10). The Municipal Solid Wastes (Management and Handling) Rules 2000 provides legal support to the community based waste management. According to the Rules, the ULBs should promote and implement the waste segregation at source. Compliance with these Rules requires that ULBs set up an appropriate systems and infrastructure facilities for undertaking scientific collection, transportation, processing and disposal of SW. However, ULBs to manage solid waste in the city has defeated the goal of MSWM Rules. Systematic weaknesses at the ULB level exist due to resource, capacity and financial constraints and these have resulted in poor collection, transportation, treatment and safe disposal of solid waste.

Research documents show that not many cities have adopted the decentralized approach but there are few cities namely Chennai, Bengaluru, Purdilpur ward of Gorakhpur city and Saharanpur which have experimented with the decentralized system. Chennai had a decentralized waste collection and transportation in 1989 where EXNORA International (NGO) set up small waste management units in different areas of cities which were managed by the local people. EXNORA roped in the informal waste workers for primary collection and transportation of waste from households to the municipal waste bins. The community contributes a nominal amount towards this service which along with revenue from sale of recyclables covered the operational expenditure (salary of the workers and other administrative expenses) of the project. The Chennai Municipal Corporation supported the initiative by transporting the waste from the municipal bins to the dump sites (Karthykenyan et al., 2012).

The authorities of Golden Temple popularly known as "Narayani Peedam" adopted a comprehensive decentralized solid waste management plan. EXNORA is focusing on environmental services. All recyclable waste is collected daily by women workers called "Temple Beautifiers". There are 150 workers, most of them are women who sorted, dried, processed and segregated the waste collected into 45 different varieties before it is packed and sold. The

bio-degradable waste is taken to composting centre to convert into organic manure through vermi composting process. The natural manure is used for enhancing the green cover in the campus while segregated fruit and vegetable peels are used for making cleaning powder (Thangaraj, 2013).

A ward in Bengaluru has initiated the decentralized solid waste management by utilizing the community participation fund under the Jawaharlal Nehru National Urban Renewal Mission (JnNURM). The implementing agency namely, Vijayanagara Nagarikara Vedike (VNV) has been working in association with the Health Department of Bruhat Bangalore Mahangara Palike (BBMP) and the local community. The scope of the work includes road sweeping, collection, segregation, transportation and disposal (through bio-mechanical composting) of the waste. In Sharanpur city, the solid waste is being managed by a joint initiative of a large corporate house (ITC Ltd.), Muskhan Jyoti Samiti (NGO), municipal corporation and the district administration. The NGO is engaged in the door-to-door collection, transportation and processing of waste. It has set up a small composting unit in the locality for converting organic waste into manure. The operational expenditure of the initiative is covered by sale of recyclables, manure and collection of user charges from the waste generators (Chatri et. al., 2012).

Another initiative is observed from Purdilpur ward of Gorakhpur where the Gorakhpur Environmental Action Group in collaboration with M.G. Post Graduate College, Gorakhpur has taken up pilot initiative towards community based solid waste management in Purdilpur ward. This initiative is supported by Rockefeller Foundation under the Asian Cities Climate Change Resilience Network (ACCCRN). The initiative was to comply with MSW handling rules 2000 in decentralized way through participation of the community to bring sustainability to solid waste management in the city. Initially 120 households of Purdilpur ward responded positively, but later, the number has gone up to 200 households. This initiative aims at setting up a model of solid waste management before the local government and creates awareness among the community towards community based solid waste management.

Technological Options for DSWM Treatment

There are a number of technologies such as recycling of waste, pit composting, vermi-composting and small scale anaerobic digestion (Bio-Gas) available for decentralized solid waste management. The selection of suitable technologies in the Indian context depends on various factors such as climate, techno-economic viability and size of the cities. The important parameters which are generally considered for suitability are quantity of waste generation, land availability, environmental sensitivity to locations, capital investment, cost-recovery, etc. The high moisture content, low calorific value, substantially high contents of nitrogen, phosphorous and potassium in Solid Waste samples indicate that the vegetative fractions of waste are more suitable for composting to organic manure after separating the reusable and recyclable fractions. The inert, non-biogradable residue left after composting could be disposed of using sanitary landfill (Varma, n.a). These technologies are discussed in detail in the following paragraphs.

Recycling of waste

Recyling of waste is mostly undertaken by the informal sector which includes waste pickers, *kabariwala*, scrap dealer and recycling units. It can also be done by residents themselves or with the assistance of voluntary agencies. Recycling materials are still collected by rag-pickers and passed into the recycling stream. Segregation of waste is an important activity for the recycling of waste but it is generally not carried out in India. Mixed waste can neither be recycled nor composted. Recycling of waste saves space in landfills and reduces pollution.

Recycling of used materials is another major productive area in which considerable quantity can be utilized for manufacturing new products. Paper, plastics, card board, and metal can be converted into useful products. Paper can be made from waste paper and even from other waste materials such as old clothes, rags and crop leftovers and can be converted to shopping bags, shoulder bags, tiffin carrier bags, jhola bags, mats etc. Shopping bags can be converted to eco-friendly recycled products. Cloth bags may prove ecologically sustainable alternatives to plastic bags. The Coorg Municipality in Karnataka has been recycling the plastic carry bags with poly looms.

The product is designed keeping in view with the present trend of the market. It creates new business opportunities with minimum investments and space requirement. The technology has led to increase job opportunities among women due to its easy and user friendly process. Centre for Environment Education (CEE) has been awarded the 'Plasticon 2005 Award' on 1st October 2005 in Mumbai by the PlastIndia Foundation in category of 'Innovation in Recycling Technology' for its innovation of a 'polyloom'. Polyloom is a plastic weaving handloom that helps reuse and recycling of discarded plastic bags. The first CEE-ERU was established in Coorg, Karnataka and subsequently, through various CEE Offices in Ahmedabad, Coimbatore, Delhi, Goa, Patna and Tirupathi (World Bank Institute, IPE and CEE, n.a).

Data shows that there are 1777 known plastic recycling units in India. Most of these units are located in Tamil Nadu (588), Gujarat (365), Karnataka (302), Kerala (193) and Madhya Pradesh (179). The total number of plastic recycling units and the capacity of each of these units are unknown (Annepu, 2012). The economics of recycling units encompasses a medley issues which includes collection costs for disposed materials, market demand for recycled product, landfill costs saved as a result of recycling the product and industrial infrastructure and technology available. From an economic perspective recycling pays only when additional costs of collection materials, sorting them for recycling and finally recycling and marketing them is substantially recovered from the value of the recycled product.

However, *kabadiwalas* and ragpickers in Delhi have found themselves sidelined by the draft municipal solid waste rules, 2013 which does not recognized their contribution to the city's waste management. There is need to give them proper recognition in the society (Nandi, 2013). Despite playing a major role in collection and recycling of waste in cities, their work is mentioned only once in the draft rules which say the municipal body can engage agencies and groups 'including ragpickers' in collection of waste from homes, leaving it to the will of the corporation to decide whether or not they will avail their service at all (Nandi, 2013). Due to absence of segregation of waste at source, the quality of recycled products are generally poor and incapable of finding markets which is occupied by virgin materials based products. In addition to this, recycled

products are largely neglected because of the absence of policy for recyclable products.

Decentralized Composting

Decentralized composting can be operated by an appropriate technology and implemented at reduced investment and operating costs. Manual composting in small, decentralized plants is more easily integrated in the prevailing Indian level of development and socio-economic background, as it requires labour intensive processes. It also offers new employment opportunities and a source of income to the under privileged in the Indian society. Considering these benefits, various small scale decentralized composting schemes are initiated by Non-Governmental Organizations (NGOs), Community-based Organizations (CBOs) often receiving some international assistance. The schemes can be seen as promising management and treatment options for urban areas as they enhance environmental awareness in a community allowing close quality surveillance of the service and product (Zurbrugg, et al., 2004). Cities like Bangaluru, Chennai, Mumbai and Pune have very active community based and decentralized composting schemes by which separated waste is turned into high quality compost (World Bank, 2008). Research documents reveals that the community based decentralized composting can generally process about 2 to 50 tons of waste per day depending on the community size and volume of compostable materials, while composting facilities are capable of receiving 10 to 200 tons of waste per day. However, composting is still not officially accepted as manure or soil conditioner and is rarely financially competitive to heavily subsidized chemical fertilizers and traditional cow dung or poultry manure. Farmers generally use urea for agricultural purposes without taking care of fertility of soil. The market for compost is still underdevelopment despite its potential (Zurbrugg, et al., 2004). Marketing of compost is a major problem in India.

Pit Composting

The basic structure of the above ground pit has small horizontal air pipe on the walls. These pipes act as air holes allowing air to get into

the garbage heap. This supplements the air circulation in the pit and thereby hastens compositing. Each pit has a dimension of 9x4x3 ft (Figure 1), (World Bank Institute, IPE, CEE, n.a). It generally takes one month time to prepare compost (Mani, 2013).

Figure 1: Above Ground Pit for Composting

Source: World Bank Institute, IPE and CEE, n.d.

The underground composting proceeds are more slowly than above ground setup because it doesn't have access to as much fresh oxygen as above ground piles. Cities like Pune and Goa are using pit compositing at the household level. The Pune Municipal Corporation has made pit compositing mandatory for all housing societies constructed after year 2000 to build their own composting pits and process wet waste within the premises. The Corporation has established a mechanism through citizens' committee in each neighbourhood to get periodic updates on the functioning of compost pit once they are build, create a pool of 'certified or approved' service providers who could take care of the maintenance and operation of compost pits. Pit composting reduces the demand for future landfill space to serve the city as it grows.

Vermi Composting

Vermi composting is a simple and effective process that can be done at the household level as it requires little space. Domestic wastes are mostly organic. It is estimated that each household produces not less than 200 kg of organic solid waste per year (Rajendran, 2008). Household composting involves waste preparation, waste degradation and finishing of waste. Waste needs to be sorted and prepared for rapid degradation. Once the waste is converted in to

raw material for composting, the waste can be degraded. The degradation process should be controlled by maintaining adequate temperature, moisture and aeration. It is an effective method for treating pathogen rich wastes (MoUD, 2000) and has been adopted by many cities namely, Suryapet, Hyderabad, Bangaluru, Mumbai and Faridabad. It is pertinent to note that in any composting method, due to loss of moisture, recovery of compost from waste is only 25-30 percent of wet waste composted (Mani, 2013).

Small Scale Anaerobic Digestion (Bio-Gas)

Small scale bio-gas is a decentralized technology and the most environmentally friendly technology to recover energy from organic wastes (Figure 2). It serves as a waste disposal technology and help to solve solid waste environmental problems. It is extremely appropriate to ecological and economic demands of the future as it provide pollution free environment, efficient energy for cooking and lighting. Bio-gas is generated when bacteria degrade biological material in the absence of oxygen in a process known as anaerobic digestion. It mainly constitutes methane and carbon dioxide and the

Figure 2: Small Scale Anaerobic Digestion (Bio Gas)

Source: Annepu, 2012

unit can be connected directly to a cooking stove. Since it is mixture of methane and carbon dioxide, it is a renewable fuel produced from waste treatment. It provides a clean, easily controlled source of renewable energy from organic waste materials. It has been very successful technology in India. Many households have installed such bio gas units in their houses. Total number of units installed in cities is unknown due to numerous companies offering this technology. A private company known as **BIO-TECH** alone installed 20,000 units of small scale Bio Gas in Thiruvananthapuram and Kochi. A single household in Thiruvananthapuram and Kochi produce 0.5-0.85 kg per day and 1.1-2 kg per day respectively (depending on the number of persons in the house) (Annepu, 2012). The potential use of this gas is for cooking purposes and to produce electricity in a dual fuel biogas-diesel engine. The manure generated is high quality and can be used for gardening and agricultural purposes (World Bank Institute, IPE and CEE, n.a.).

Figure 3: ARTI Bio Gas

Source: www.arti-india.org

Another company known as **ARTI** has developed a compact bio gas plant which uses waste food rather than dung/manure as feedstock to supply bio gas for cooking (Figure 3). About 2000 plants are currently in use both in urban and rural households in Maharashtra.

The company has won the 'Ashden Award for Sustainable Energy 2006' in the Food Security category that makes it the only company in the world to win the prestigious Ashden Award twice. ARTI won its first Ashden Award in 2002 for its chain of technologies for converting agricultural waste into charcoal. The benefit of compact bio gas plant is savings in cost as compared to the use of kerosene or LPG for cooking. This technology offers a solution not only for domestic waste disposal but also for collective disposal of community waste. People can avail this technology to convert starchy waste into clean useful energy (www.arti-india.org/..accessed on 10-07-2013).

The analysis of the technologies for decentralized waste management indicates that no technology is perfect. All of them have advantages and disadvantages as well. The selection of suitable technology lies on the extent of waste segregation at source which is not in practice as yet in India. Appropriate segregation of wastes can improve the quality of the compost and recycled materials that can solve the problem of marketing of these products.

Conclusion and Way Forward

The preceding discussion thus concludes that the solid waste management is a critical issue in India. Most of the challenges of the solid waste management and environmental sustainability are still unanswered. The condition is even worse for the unauthorized settlements and slums in urban areas where municipal solid waste management is virtually absent. It is pertinent to note that the improvement in the solid waste management is the greatest challenge being faced by the municipal authorities. The decentralized approach could be one of the effective methods to solve the problems of waste management in India as it has potential to reduce the quantity of waste by changing the mindset of the people and reduces the transportation cost, reduces the traffic congestion, reduces the amount of air pollution, road maintenance cost, and contamination of ground water through the seepage of leachates. More important, it reduces the amount of waste in landfill sites as the land is a major constraint of the solid waste management system. Finding new landfill sites around cities is nearly impossible because of various constraints like lack of space for locally unwanted land uses, population density and

the scale of India's increasing urban sprawl. Decentralized approach is not only sustainable and financially viable but also helps to improve the quality of life and working condition of the waste pickers. It could bring about citizen participation, and contribute to environmental sustainability and economic efficiency.

An analysis of various technological options indicates that due to lack of segregation of waste at source, the recycled products are mostly of poor quality and low cost, incapable of finding markets occupied by virgin materials based products. As a result, both the people involved in the trade as well as the products produced from recycled waste are a largely neglected a lot. In addition, the recycling industries face a number of problems such as (i) reuse and recycling of waste is labour oriented and inadequate, (ii) the processing of waste by small scale industries is not compliance with regulatory requirements. Also, there is no policy for recyclable products. Compost is rarely financially competitive to heavily subsidized chemical fertilizers and traditional cow dung or poultry manure. Therefore, there are fewer buyers available in the market for the compost. The market for compost is still underdeveloped despite its potential. The analysis further indicates that no technology is perfect. All of them have advantages and disadvantages as well.

In order to overcome the above cited problems of solid waste management, community based decentralized solid waste management should be promoted with the community participation but with municipal support. In this regard, the policy paper or action plan should be prepared to promote the community based decentralized waste management system. Zero waste approach should be introduced to minimize the waste and change the consumption habits of people. Government should prepare the plan for recycling products which encompasses the quality of products, guidelines to the recycling industries including the compliance with regulatory requirements and marketing policy for recycled materials and compost.

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