MUNICIPAL SOLID WASTE MANAGEMENT IN INDIA – AN OVERVIEW

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ABSTRACT

Solid Waste Management has become an issue of increasing global concern as urban populations continue to rise; rapid economic development & urbanization have led to an increase in the generation of solid waste. Municipal Solid Waste has been produced since the establishment of man –kind and unavoidable by product. Municipal Solid Waste Management has remained one of the most neglected areas of the municipal systems in India. About 70-80% of generated Municipal Solid Waste is collected & the rest remains unattended on streets or in small open dumps. The lack of infrastructure for collection, transportation, treatment and disposal of solid waste, proper solid waste management planning, insufficient financial resources, technical expertise and public attitude have made the situation exasperating due to which several environmental and health related problems are increasing. The study describes and evaluates the present state of Municipal Solid Waste Management in India.

Introduction:

Rapid Industrialization, population explosion, urbanization and economic growth in India led to the migration of rural people to cities, a trend of significant increase in municipal solid waste generation has been recorded around the whole country. Solid waste generation is natural phenomenon of human life. Municipal solid waste generation shows a positive correlation with the economic growth of people in terms if kg/capita/day as a consequence of improved life style and social status (Pradeep Kumar and Rajender Kumar Kaushal, 2015). The ever rising population, along with rapid urbanization and industrialization directly affects the amount of urban and Municipal Solid Waste generated (Singh and Sharma 2002: Minghua et al. 2009). Presently waste is generated faster than other environmental pollutants, including green house gases (GHGs) (Hoornweg et al. 2013). Being the world’s second most populous country the level of urbanization in India, has increases from 27.81% in 2001 to 31.16% in 2011. Th eever rising population is putting immense pressure on demand for food, shelter and on other natural resources (Manser and Keeling 1996; Cointreau 2006a, b; Kathiravale and Muhd Yunus 2008).

Municipal solid waste management (MSWM) is one of the most overlooked basic services provided by the Government of India. Generation and characteristics of MSW may vary at the level of country, state, city as well as within different areas of the same city. MSW generation rates range between 0.3 and 0.6 kg/capita/day in Indian cities and annual increase in MSW generation (volume)
is estimated as 1.33% per capita (Pattnaik and Reddy 2010). Municipalities, usually responsible for managing MSW in developing countries like India are facing a challenge in providing an effective and dynamic system to the society. They usually fail to attain this due to lack of appropriate collection system, lack of technical expertise and insufficient financial resources (Sujauddin et al. 2008; Guerrero et al. 2013). The municipalities use major chunk of their financial resources on MSW collection (primary and secondary) from different locations in municipal areas and very little is left thereafter for its management (Collivignarelli et al. 2004). In developing countries, the cities barely spend 0.5% of their per capita gross national productivity (GNP) on services for managing MSW (What a waste 1999). Moreover, political, legal, socio-cultural and institutional factors greatly influence MSWM plan.

Generally in India MSW is disposed off in low lying areas or open dumps without necessary precautions. Therefore, MSWM is one of the most challenging environmental issues in Indian megacities. In India the current urban MSW production rate is 109,598 tonnes per day (or 0.34 kg/capita/day) and is assumed to reach to 376,639 tonnes per day (or 0.7 kg/capita/day) by 2025 (Hoornweg and Bhada-Tada 2012).

The survey of 59 Indian cities, conducted by Central Pollution Control Board (CPCB) (through NEERI) has suggested that about 35,401 tonnes per day MSW was generated from 59 cities during 2004–2005. Thereafter, a survey conducted by the Central Institute of Plastic Engineering and Technology (CIPET) has reported that about 50,592 tonnes per day MSW was generated during 2010–2011 in the same 59 cities. MSW generation in selected Indian cities during 2004–2005 and 2010–2011.

**Municipal solid waste generation in Indian cities (CPCB 2012)**

<table>
<thead>
<tr>
<th>City</th>
<th>Municipal solid waste generation (tonnes per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmedabad</td>
<td>1,302</td>
</tr>
<tr>
<td>Bangalore</td>
<td>1,699</td>
</tr>
<tr>
<td>Bhopal</td>
<td>574</td>
</tr>
<tr>
<td>Bhubaneswar</td>
<td>234</td>
</tr>
<tr>
<td>Chandigarh</td>
<td>326</td>
</tr>
<tr>
<td>Chennai</td>
<td>3,036</td>
</tr>
<tr>
<td>Dehradun</td>
<td>131</td>
</tr>
<tr>
<td>Delhi</td>
<td>5,922</td>
</tr>
<tr>
<td>Guwahati</td>
<td>166</td>
</tr>
<tr>
<td>Indore</td>
<td>557</td>
</tr>
<tr>
<td>Jammu</td>
<td>215</td>
</tr>
<tr>
<td>Kanpur</td>
<td>1,100</td>
</tr>
<tr>
<td>Kolkata</td>
<td>2,653</td>
</tr>
<tr>
<td>Lucknow</td>
<td>475</td>
</tr>
<tr>
<td>Mumbai</td>
<td>5,320</td>
</tr>
<tr>
<td>Patna</td>
<td>511</td>
</tr>
<tr>
<td>Pune</td>
<td>1,175</td>
</tr>
<tr>
<td>Shillong</td>
<td>45</td>
</tr>
<tr>
<td>Srinagar</td>
<td>428</td>
</tr>
<tr>
<td>Varanasi</td>
<td>425</td>
</tr>
</tbody>
</table>

b. CIPET (2010-2011)

Generation: of Solid Waste Global and Indian Scenario:

The rapid pace of urbanization (migration of people from rural to urban areas) and growing economy have greatly accelerated the MSW generation rate in developing countries (Hassan 2000; Minghua et al. 2009; Singh et al. 2011b). Presently, the volume of waste generated from urban centers of the world is around 1,300 million tonnes per year (1.2 kg/capita/day) which is expected to rise.
to 2,200 million tonnes per year by 2025 (World Bank 2012). The Gross national income (GNI) per capita of a country greatly influences MSW generation rate (What a waste 1999).

India, the second most populous country aiming to attain an industrialized nation status by 2020 has experienced rapid urbanization and industrialization during the last few decades (Sharma and Shah 2005). India has a population of over 1.2 billion which accounts for 17.5 % of the world population (http://censusindia.gov.in). About 31.16 % of the country’s population lives in urban areas (Census of India 2011; Sudhir and Gururaja 2012). The continuous population expansion as well as migration from rural to urban areas has resulted in rapid boost in waste generation.

In India, although more than 90 % of municipality’s total budget is spent on collection of waste, yet collection efficiency is very poor about 70–72 % (Nema2004; CPCB 2012).

Composition:
The composition and characteristics of MSW is greatly influenced by the economic status, living standards, food habits, rituals, literacy rate, type of energy source, climatic and topographical conditions (Jin et al. 2006). The characteristics of waste in India show great variation in respect to composition and hazardous nature, when compared to western part of the world (Gupta et al. 1998; Sharholy et al. 2008). The organic waste contributes as major fraction in all cases. The highest amount of organic waste was reported in Mumbai (62 %), which was followed by Chandigarh (57 %). Besides this, moisture content was also high in all cases (except Ahmedabad) ranging between 41 and 64 %. The CV is very low ranging between 742 and 2,632 kcal/kg and the C/N ratio ranging between 18 and 37.

### Physical composition of MSW in Indian cities

<table>
<thead>
<tr>
<th>City</th>
<th>Organic (%)</th>
<th>Recyclables (%)</th>
<th>Others (%)</th>
<th>Moisture content (%)</th>
<th>C/N ratio</th>
<th>HCV (kcal/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmadabad</td>
<td>41</td>
<td>12</td>
<td>47</td>
<td>32</td>
<td>30</td>
<td>1,180</td>
</tr>
<tr>
<td>Bengaluru</td>
<td>52</td>
<td>22</td>
<td>26</td>
<td>55</td>
<td>35</td>
<td>2,386</td>
</tr>
<tr>
<td>Bhopal</td>
<td>52</td>
<td>22</td>
<td>26</td>
<td>43</td>
<td>22</td>
<td>1,421</td>
</tr>
<tr>
<td>Bhubaneswar</td>
<td>50</td>
<td>13</td>
<td>37</td>
<td>59</td>
<td>21</td>
<td>742</td>
</tr>
<tr>
<td>Chandigarh</td>
<td>57</td>
<td>11</td>
<td>32</td>
<td>64</td>
<td>21</td>
<td>1,408</td>
</tr>
<tr>
<td>Chennai</td>
<td>41</td>
<td>16</td>
<td>43</td>
<td>47</td>
<td>29</td>
<td>2,594</td>
</tr>
<tr>
<td>Delhi</td>
<td>54</td>
<td>16</td>
<td>30</td>
<td>49</td>
<td>35</td>
<td>1,802</td>
</tr>
<tr>
<td>Guwahati</td>
<td>54</td>
<td>23</td>
<td>61</td>
<td>18</td>
<td>1,519</td>
<td></td>
</tr>
<tr>
<td>Indore</td>
<td>49</td>
<td>13</td>
<td>38</td>
<td>31</td>
<td>29</td>
<td>1,437</td>
</tr>
<tr>
<td>Kanpur</td>
<td>48</td>
<td>12</td>
<td>40</td>
<td>46</td>
<td>28</td>
<td>1,571</td>
</tr>
<tr>
<td>Kolkata</td>
<td>51</td>
<td>11</td>
<td>38</td>
<td>46</td>
<td>32</td>
<td>1,201</td>
</tr>
<tr>
<td>Lucknow</td>
<td>47</td>
<td>16</td>
<td>37</td>
<td>60</td>
<td>21</td>
<td>1,557</td>
</tr>
<tr>
<td>Mumbai</td>
<td>62</td>
<td>17</td>
<td>21</td>
<td>54</td>
<td>39</td>
<td>1,786</td>
</tr>
<tr>
<td>Nagpur</td>
<td>47</td>
<td>16</td>
<td>37</td>
<td>41</td>
<td>26</td>
<td>2,632</td>
</tr>
<tr>
<td>Puducherry</td>
<td>50</td>
<td>24</td>
<td>26</td>
<td>54</td>
<td>37</td>
<td>1,846</td>
</tr>
</tbody>
</table>

Source: Status report on municipal solid waste management, CPCB 2004–2005

Health Impacts:
Due to continuous increase in solid waste generation, its ever-changing composition, mismanagement and poor public attitude, people are directly exposed to health risks. According to Giusti (2009), there is direct and indirect association of health impacts with each step of the handling, treatment and disposal methods of waste. In developing countries, the poor attitude of waste generators has made the situation exasperating. They commonly throw their wastes on the roads, which is further scattered by rag pickers in search of recyclables, and animals (cows, dogs, pigs, etc.) looking for food. Hence, waste generated by them clog the drains, creating stagnant water condition which is favorable for insects and mosquitoes breeding responsible for malaria, lymphatic filariasis and other diseases, thus posing risks to human health (Castro et al. 2010). However, according to the WorldHealth Organization
Environmental Impacts:

Each and every kind of waste generated needs to be managed in an appropriate manner. In India, the landfill site selection is done on the basis of convenience without prior consideration of environmental impact. The mismanaged and unscientific disposal of waste deteriorates the nearby environment causing severe imply cations on air, soil and water pollution.

Soil:

Soil is “a dynamic natural body on the surface of the earth in which plants grow, composed of mineral and organic materials and living forms” (Brady 1974). Additionally, it also acts as a protecting filtering layer laid over the ground water that mitigates the impact of several harmful pollutants (Venkatesan and Swami-Nathan 2009). The urbanization and industrialization have increased the burden of MSW on land which is adversely affecting soil properties (both biotic and abiotic) and its yield. This situation is very common in cities of developing countries. Rawat et al. (2009), has reported increased concentration of heavy metals (Mn, Zn, Cu, Cd, Ni, Pb and Cr) in soil and road dust samples from Kanpur city, this might be due to the deposition of dust from industries.

Water:

Water is the basic element of life, livelihood, food security and sustainable development. On one side the world is facing fresh water scarcity, on the other hand whatever the remaining ground water resources are available, is facing critical stress in quality due to improper urbanization and industrialization. Besides this, inadequate maintenance of distribution system also pollutes drinking water. Nagarajan et al. (2012) has compared different physic-chemical parameters of ground water quality in Erode city, Tamil Nadu, India with Bureau of Indian Standards (BIS) and World Health Organization standards (WHO), and had observed increased concentration of constituents like total dissolved solids (TDS), total hardness (TH), total alkalinity (TA), sodium (Na⁺), magnesium (Mg²⁺), chloride (Cl⁻), fluoride (F⁻) and nitrate (NO³⁻) above the upper permissible limit for drinking purpose making the water not potable.

Air:

In developing countries MSW is mainly characterized by high density that emulates high degree of biodegradable organic matter and moisture content, which when undergoes anaerobic decomposition in landfills, leading to production of landfill gas. The landfill gas mainly consists of about CH4 and CO 2 together with small amount of volatile organic compounds and other trace gases (Hegde et al. 2003 ). Being GHGs both CH4and CO2 have global warming potential, which is 25 times higher in CH4 than global warming potential of CO2 with atmospheric residence time of 12 ± 3 years (IPCC 2007).

Waste Management Practices:

Incineration:

is a thermal waste management process. In incineration combustion of raw or unprocessed waste takes place under controlled condition at 850° C in the presence of air (DEFRA 2007 ). It takes place in an enclosed structure. The byproducts are carbon dioxide, sulphur dioxide, carbon monoxide, particulate matter, dioxins, furans, water vapor, ash, heat and non-combustible material. The ash produced is termed as incinerator bottom ash (IBA) which contains residual carbon in little amount. Incineration provides maximum volume reduction of waste but employ second last priority in an ISWM approach due to environmental concerns. It is highly an exothermic process, generating heat which could be utilized in the production of steam and electricity. For high level of efficiency, solid waste should have low moisture content (<50 %) and high heating value(5MJ/kg) (Vergara and Tchobanoglous 2012).

However, the potential inimical effect of waste incinerators on human health is always being a matter of concern. Elliott et al. (1996) reported that the people residing in the close vicinity of municipal incinerators are more prone towards liver cancer in Great Britain.
Pyrolysis and Gasification:

Both pyrolysis and gasification are endothermic processes. In both the processes the end products are gas (termed as syngas), liquid (containing acetic acid, acetone and methanol) and char (containing carbon with inert material).

Composting:

Composting is referred as the process of aerobic biological decomposition of organic material under controlled conditions like temperature, humidity and pH. The indigenous microorganisms (thermophile and mesophile) mold organic material to a stabilized product i.e. compost (Hashemimajd et al. 2004). The compost thus produced acts as soil conditioner and can be used in agricultural and horticultural or landscaping applications (Singh et al. 2011; Neher et al. 2013). The quality of compost from MSW depends on many factors like source and nature of waste, the composting design, maturation length and composting procedures which have been followed during composting (Hargreaves et al. 2008).

Composting of MSW is one of the most promising and cost effective option for MSWM. It was encouraged earlier 1960s by the Government of India (GOI) which was blocked in 4th 5 year plan (1969–1974). In 1974, GOI launched a modified scheme to revive

MSW composting once again, particularly in cities with a population greater than 0.3 million. In India, composting of MSW is taking place in large scale as well as at decentralized level. The first large scale composting plant was established in Mumbai which process 500 tonnes/day of MSW by Excel Industries Ltd. Another plant has been operated in Vijaywada which handle 150 tonnes/day. About 9 % of MSW is treated by composting (Kansal 2002; Sharholy 2006; Sharholy et al. 2008). About 700 tonnes/day of MSW is composted by Kolkata Municipal Corporation (KMC) in collaboration with M/S Eastern Organic Fertilizers (India) Private Limited. The selling price of end MSW compost is 3.50 INR (Chattopadhyay 2003, 2009).

Vermicomposting:

Vermicomposting is an eco-friendly, eco-biotechnological and bio-oxidative process which stabilizes organic solid waste into valuable bio-product, i.e. vermicompost. It involves inter-mutual action of earthworms and microorganisms. In addition to the feedstock, the microbial biomass present in the earthworm’s gut is also responsible for the biochemical decomposition of organic matter. Earthworms act as important mediators which increase accessible surface area to microorganisms, thereby improving enzymatic actions and responsible for alteration of physical status of organic waste directly and chemical status indirectly (Malley et al. 2006; Fornes et al. 2012). Besides this the faecal matter produced by earthworms provides suitable organic substrate to colonize surrounding microbes supporting microbial growth and action (Williams et al. 2006).

As earthworms are considered as the biological indicators of soil health (Ismail 1997) thus they have a major role in solid waste management plus soil management. They decrease the stabilization time of household waste and sewage sludge by vermicomposting and turned them into valuable end product i.e. vermicompost that can be further utilized in agricultural and horticultural practices (Kale et al. 1982; Ismail 1993; Edwards and Bohlen 1996; Ismail 2005; Ansari and Ismail 2008), thus improving the productivity and fertility of soil (Edwards et al. 1995).

Landfilling:

Landfill is a vacated land area onto or into which waste is disposed. It is an integral part of any planned MSW management system. They are the final depot of any city’s MSW after pertinence of all available management options. Open dumping is the most common, lucid and economical practice implemented in most of the developing countries. In Asia 51 % open dumping takes place among all available management practices (World Bank 2012).

A landfill is an area of land onto or into which waste is deposited. The aim is to avoid any contact between the waste and the surrounding environment, particularly the groundwater. Landfills can be classified into three categories, which are:

1. Open dumps or open landfills, which are the most common in all developing countries, involve the refuse simply being dumped haphazardly into low lying areas of open land.
Semi-controlled or operated landfills are designated sites where the dumped refuse is compacted and a topsoil cover is provided daily to prevent nuisances. All kinds of municipal, industrial, and clinical hospital wastes are dumped without segregation. This type of landfill is not engineered to manage the leachate discharge or emissions of landfill gases.

Sanitary landfills are used in developed countries and have facilities for interception and treatment of the leachate using a series of ponds. This type of landfill also has arrangements for the control of gases from waste decomposition (Tchobanoglous et al., 1993).

Conclusions:

1. Waste management involves a large number of different stakeholders, with different fields of interest. They all play a role in shaping the system of a city, but often it is seen only as a responsibility of the local authorities. In the best of the cases, the citizens are considered co-responsible together with the municipality. Detailed understandings on who the stakeholders are and the responsibilities they have in the structure are important steps in order to establish an efficient and effective system. Communication transfer between the different stakeholders is of high importance in order to get a well functioning waste management system in the cities in developing countries.

2. Solid waste management is a multi-dimensional issue. Municipalities in general seek for equipment as a path to find solutions to the diversity of problems they face. This study shows that an effective system is not only based in technological solutions but also environmental, socio cultural, legal, institutional and economic linkages that should be present to enable the overall system to function.

3. Solid waste services have a cost as any other services provided but in general the expenditures are not recovered. Resources are required with the objective of having skilled personnel, equipment, right infrastructure, proper maintenance and operation. The financial support of the central government, the interest of the municipal leaders in waste management issues, the participation of the service users and the proper administration of the funds are essential for a modernized sustainable system.

4. Fundamental is to produce reliable data and to create proper information channels within and between municipalities. Decision makers, responsible for planning and policy making, need to be well informed about the situation of the cities in order to make positive changes, developing integrated waste management strategies adapted to the needs of the citizens considering their ability to pay for the services.

5. The information provided about the factors influencing solid waste management systems is very useful for any individual or organization interested in planning, changing or implementing a waste management system in a city.

References:


4. Chattopadhyay S (203) A study on a compost plant based on Kolkata Municipal solid waste. Master of engineering thesis paper, Bengal Engineering and Science University, Shibpur, Howrah, India


