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Solid Waste Management in Urban India: Issues, Challenges, and Sustainable Solutions

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Abstract- In India with high urbanization and rapid population growth, solid waste management is a matter of concern due to generation of large amount of waste, improper management and associated problems of environmental pollution, health issues and economic impacts. Based on online survey among different groups of people from major towns and cities of India and review of literature, this paper attempts to highlight issues, concerns and promising options for solid waste management in urban India. It is revealed that public awareness on reduce and reuse, waste segregation at source, available dustbins in proper places, sufficient man-power with equipments for regular collection and disposal with advanced technologies and strict rules are need of the hour. Generated waste can be converted into a potential resource if treated properly with effective waste management technologies.

Keywords— Solid waste management, Landfill, Composting

I. INTRODUCTION

Solid Waste Management Rules, 2016 defines solid waste as solid or semi-solid domestic waste, sanitary waste, commercial waste, institutional waste, catering and market waste and other non residential wastes, street sweepings, silt removed or collected from the surface drains, horticulture waste, agriculture and dairy waste, treated bio-medical waste excluding industrial waste, bio-medical waste and e-waste, battery waste, radio-active waste generated in the area under the local authorities and other entities (CPCB, 2021).

The generated volume of waste from different urban centers around the world is 2.24 billion tonnes (0.79 kg/person/day) and is expected to increase to by 73% from 2020 levels to 3.88 billion tonnes in 2050 (World Bank, 2020). About 114,576 tons per day of MSW was generated by urban population in the year 1996 and the number would amplify to four fold to 440,460 tons per day by the year 2026 (Hoornweg and Laura, 1999).

The generation of MSW in developed countries differ from the developing countries in terms of quantity and composition which depends widely on income and lifestyle of the population and the geographic generated waste in different countries based on their income level can be categorised according to the four classifications as given by World Bank (2020-2021) based on Gross National Income (GNI): 2.1 kg/capita/day for high income countries like America, 1.2 kg/capita/day for upper middle income countries like South Africa, 0.79 kg/capita/day for lower middle income countries like India and 0.60 kg/capita/day for low income countries like Afghanistan (Rodseth et al.,2020).

The setting up of clusters of urban centers in India led to the generation of 1.3 billion tonnes of MSW every year and is expected to rise to 2.2 billion tonnes of waste by the year 2025 (Choudhury and Dutta, 2017), thus, creating a major concern related to human and the overall ecosystem health. Population growth is the main cause of increasing solid waste in India.

Based on primary survey and review of literature, this paper attempts to discuss major issues and concerns related to solid waste management in towns and cities in India.

II. PROBLEMS FROM SOLID WASTE IN THE TOWNS AND CITIES OF INDIA

Online survey was conducted using Google form with open and closed-ended questions to understand various issues related to solid waste in different towns and cities of the country. Total 450 persons from different towns and cities of Delhi, Maharashtra, Uttar Pradesh, Odisha, West Bengal, Karnataka, Tamil Nadu, Chhattisgarh, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Manipur and Mizoram responded in the survey. 86% respondents have revealed that solid waste is a major problem in their towns or cities with following issues (Figure 1):

Drainage congestion

- Flash flood
- Air pollution
- Aesthetically displeasing
- Water pollution
- Soil pollution

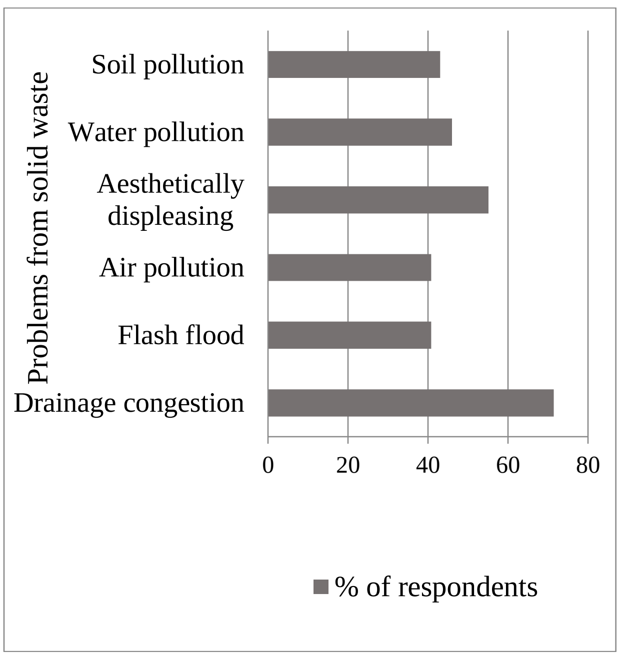

Figure 1. Problems from solid wastes in urban areas, Source: Primary survey

In developing countries like India, the challenges start with managing the MSW, for which Tchobanoglous et al. (1993) identified six functional elements that constitutes the solid waste management (SWM) practices: waste generation, storage and handling of waste at the source, collection, transfer and transport, treatment and transformation, and at last disposal. In our survey, 72% respondent expressed dissatisfaction in overall SWM in respective towns or cities. Causes of problems from solid waste were

- Lack of sufficient number of dustbin
- No regular collection of waste by authority
- Habit of people to throw waste material here and there
- No hard and fast rules related to waste disposal
- No proper disposal of waste due to large amount from large population

Only 35% respondents have practiced waste segregation in their homes. 36% respondents occasionally segregate waste on the basis of waste type and amount. More than half of the respondents (52%) don't use dustbin at household level. They dispose waste materials just outside their home or nearby drain/ river or nearby vacant areas or on road (Figure 2).

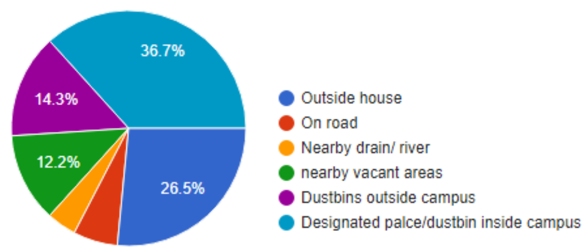

Figure 2. Immediate site of household waste disposal
Source: Primary survey

In the online survey, all respondents were moderately or highly educated with highest education level from higher secondary to PhD. Hence the real picture of solid waste management in the country is more pathetic.

About 80,000 metric tons of solid waste is estimated to be generated from the urban centres in India of which about 60% of the solid wastes finds its way to disposal site following an unscientific way and the remaining uncollected wastes finds its way to open drains and water bodies.

Major landfills in the urban metropolises are exhausted and overburdened by the daily disposal of waste. Landfills in India pose numerous threats due to their unscientific design and indiscriminate disposal of waste. One of the major threats landfills pose is the emission of methane due to the decomposition of waste. Methane is the leading cause of fires at landfills, resulting in garbage burning which causes severe air pollution. Landfills also pose tremendous health hazards due to them being a storehouse of virus and bacteria, causing cardiovascular and lung diseases.

Uncollected solid waste obstruct storm water runoff, resulting in the forming of stagnant water bodies that become the breeding ground of diseases such as Malaria, chest pains, Diarrhea and Cholera (Sankoh et al., 2013). Direct dumping of untreated waste in water bodies cause accumulation of toxic substances in the food chain through the plants and animals that feed on it (Derraik, 2002). Different workers detected higher levels of organic and inorganic pollutants and heavy metals in surface and underground water and water in the vicinity of solid waste landfills (Namasivayam and Sangeetha, 2006). Drainage congestion due to improper waste management is one major cause of urban floods which are on an increasing trend and have slowly become a regular phenomenon especially after 2000 in most of the fast-growing cities of India (Vazhuthi and Kumar, 2020). Unscientific disposal of the untreated wastes at landfill sites contributes to global warming by green house gases emissions from decomposition of organic matter. The landfill gas mainly consists of about CH_4 and CO_2 together with small amount of volatile organic compounds and other trace gases. Being Green House Gases (GHGs) both CH_4 and CO_2 have global warming potential, which is 25 times higher in CH_4 than global warming potential of CO_2 with atmospheric residence time of 12 ± 3 years (IPCC, 2007). Landfill sites currently are considered as the largest contributor of GHG emissions in the waste sectors that are emitted not only while the waste is managed but also when it is left to decay in dumpsites. Depending on the generated wastes volume and composition, and how the waste is managed, it is estimated that from the treatment and disposal of the generated waste in 2016 about 1.6 billion ton of carbon dioxide were generated representing about 5 percent of global emissions.

Solid wastes are potential problem to human health from improper handling. Health problems arise from the breeding of disease causing vectors, primarily flies and rats. The household waste along with industrial effluents creates specific danger of concentration of heavy metals in the food chain. Due to soil absorption, uptake, ventilation, leaching, solid waste may come in contact with living organism and generate various problems such as cancer, low birth weight, neurological diseases, nausea, vomiting and long term irritation in daily life.

III. ISSUES RELATED TO MUNICIPAL SOLID WASTE MANAGEMENT IN INDIA

Solid waste management is a major challenge in cities with high population density as the per capita generation of municipal solid waste has also increased tremendously with improved life style and social status of the populations in urban centers (Sharholy et al., 2007). Despite significant development in social, economic and environmental areas, solid waste management systems in India have remained relatively unchanged (Narayan, 2008). Current solid waste management systems are inefficient, with waste having a negative impact on public health, the environment and the economy (Biswas et al., 2010).

Although SWM Rules 2016 says, 'No person should throw, burn, or bury the solid waste generated by him, on streets, open public spaces outside his premises, or in the drain, or water bodies', it is ineffective due to ignorance, negligence and very weak surveillance with no strict penalty for defaulters.

45 million of India's 62 million tonnes of annual garbage remain untreated, a dangerous statistic that would lead India to severe garbage crisis by 2030. With the current trend of unscientific and untreated dumping of MSW in open areas, about 88 km squares of area would be required by the country in the future, such as almost the size of the New Delhi as dumping ground by the year 2050 (Dutta and Jinsart, 2020).

The five recognised mega-cities of India like Delhi, Mumbai, Chennai, Bangalore and Kolkata has high population density and floating population like household, offices, trade & commercial activities, industries and health care centres and are also figured in the world's 101 largest cities ranked by Global Cities Institute (Hoornweg and Pope, 2014). The per capita waste generation rate is high in states like Gujarat, Delhi, Tamil Nadu, Uttar Pradesh, Tamil Nadu due to rapid urbanization and comparatively high living standard. Low per capita waste generation is observed in states like Meghalaya, Manipur, Assam, Tripura due to less urbanization and cities like Pune, Nagpur and Indore (Sharholy et al., 2008) due to better waste management strategies. Per capita waste generation rate is higher in larger cities with population ranging from 1 lakh to over 50 lakhs in which waste generated per capita per day ranges from 200 gms to 500 gms, respectively (Priyadarshi et al., 2020).

It is estimated that by 2025 the composition of Indian garbage will change leading to increase in the components of the wastes like the organic waste which is now at 40% will go up to 60 percent ; Plastic waste will go up from 4% to 6% ; Metals will rise from 1% to 4%; Glass will go up to 3% from 2% ; Paper will increase from 5% to 15% and other components like ash, sand, grit will go from 47% to 12% (Keisham and Paul, 2015). The composition of municipal solid waste is rapidly changing in India by the wide use of materials like paper and plastics due to rapid population growth and urbanization, thus, increasing its volume which is expected to be around 125 million tonnes by the year 2031 from almost 72 millions at present (Ahluwalia and Patel, 2018).

Wastes generated in developing countries is estimated to have higher moisture and organic content as a result of which the wastes generally becomes unsuitable for the energy recovery process. In comparison to the calorific value of the wastes of high income countries with 2197.38 kcal/kg, the calorific value of the wastes generated from most of the Indian cities is just 800.13 kcal/kg which is very low for incineration process (Satishkumar et al., 2000).

IV. PROMISING TECHNOLOGIES FOR SOLID WASTE MANAGEMENT

Indian wastes with higher organic matter content becomes suitable for processes such as Composting, Vermicomposting and Anaerobic Digestion as the C/N ratio ranges between 20 and 30 (Eiland et al., 2001). Waste containing plant and animal origin can be decomposed by living organisms like microorganisms or worms and can be used for composting as they can undergo aerobic decomposition in which the organic matter breaks down into simpler compounds with the release of CO_2 and water, thus producing compost providing nourishment to the soil. But due to high volume and low quality of compost there is poor demand for compost. Also the quality of city compost is compromised due to the possibility of heavy metal contamination further putting a impact on the demand. However, anaerobic decomposition of the waste changes the organic matter that is present in the waste into methane that is useful as biofuel and liquid slurry which is useful as manure (Ahluwalia and Patel, 2018).

Non recyclable, non hazardous and having high calorific value wastes can be used as a source of energy through the process of combustion. High calorie and non recyclable dry waste can be converted into 'refuse derived fuel' by shredding, drying or compressing the dry waste into pellets or briquettes which can be then used in place of coal for heat generation (Ahluwalia and Patel, 2018). In 1999 a waste to energy plant was started in Hyderabad to produce refuse derived fuel (RDF) pellets with an installed capacity of 1000 tonnes/day that can manufacture 200-250 tonnes/day of fuel pellets (Talyan et al., 2008). The SWM Rules, 2016 mandates the use of RDF with atleast 5% as their fuel consumption to all the industries that is located within 100 km distance from an RDF plant but still the demand for utilising RDF is low owing to issues like high price, high volume, and excess residual ash which makes the fuel undesirable for utilisation. For non-segregated waste to become suitable for use as RDF, extensive manual and mechanical screening is required prior to processing. The SWM Rules, 2016 specifies the use of waste with high calorific value of

1500 kcal/kg or more in waste to energy (WtE) plant for generating energy instead of disposing it in a landfill. To carry out the incineration process in WtE plants, the plants must adhere to strict emission norms that has been set and should regulate all the harmful gases before releasing with an installed pollution control filters. Non biodegradable waste having sufficiently high calorific value can be processed or converted to energy but the Indian MSW has high biodegradable content and high recycling thus falling short for the threshold calorific value (Ahluwalia and Patel, 2018).

Gasification is another process of conversion of high calorie dry waste usually the carbon content of the material into useful gaseous forms such as ethanol and bio-char, etc. in the controlled presence of oxygen and at temperature ranging between 480 to 1650 degree Celsius. The gas thus obtained is used to generate electricity. Another process of conversion technology is pyrolysis which is carried out at low temperature (300 to 760 degree Celsius) and in absence of oxygen. The resulted products are liquid fuel, char and gases like methane, CO and hydrogen. Owing to the segregation of waste beforehand, the level of toxic pollutants released is low as compared to normal incineration (Ahluwalia and Patel, 2018).

Biomethanation is the biochemical conversion of biodegradable waste anaerobically in which the microbes break down the organic matter in the absence of oxygen resulting in the release of biogas that contains methane (Ahluwalia and Patel, 2018) commonly used for agriculture and livestock products, but has not achieved the same level of reliability for the treatment of MSW (Talyan et al., 2008).

Incineration is an effective method to reduce the volume of the waste and its demand for getting dumped at open landfills (Keisham and Paul, 2015). It is the practice of burning the pre-processed mixed wastes that generates heat and reduces the volume but it has the risk of releasing toxic gases into the atmosphere depending on the composition of the wastes. Although mass incineration of unsegregated MSW is banned in India by the National Green Tribuanal since Decemeber 2016, a controlled combustion of MSW is carried out in a furnace by segregating the wastes and drying them to increase the energy content.

V. EMERGING STRATEGIES IN WASTE MANAGEMENT

A key component in waste management is the ability of the generated wastes to get recycled and in this regard the European countries leads the way. The number of landfills in Germany was 50,000 back in the year 1950, which has now come down to 300 as the country stoped accepting unsorted waste for disposal in the landfills. They have also adopted a Green Dot System which facilitates the businesses to reduce packaging and encourages recycling. It is found that green dot scheme has reduced the amount of waste generated to 1 million tonnes per year (Greentumble, 2016).A small country like Austria has developed a high-tech method to recycle wastes specifically PET (Polyethylene terephthalate) with the help of fungal enzymes. They have also employed the use of incentives and taxes to reduce landfill disposal (Greentumble, 2016). To reduce the overall waste generation Belgium has come up with the best waste diversion rate in which 75% of their waste is reused, recycled or composted (Greentumble, 2016). Currently, over 55% of all municipal solid waste that is created in the United States is disposed of in sanitary landfills. Sanitary landfill is a method of waste disposal where the waste is buried either underground or in large piles.

Italy has come up with the solution of waste management by implementing web based Geographic Information System (GIS) technology aiding in the waste collection method (Saleem et al., 2016). Another emerging technology is the use of Global System of Mobile (GSM) to detect a certain optimum level of wastes in garbage bins so as to give indication for emptying of the bins as they reach the threshold level. Multi compartment garbage bins are used in Sweden for source segregation of the wastes. In the recent years optical sorting of wastes has emerged in which the different components of the wastes are sorted with the help of color sensitive cameras and UV sensors. Another kind of sensor based sorting method is used widely in Japan to reduce the waste volume (Saleem et al., 2016).

VI. CONCLUSION

The process of solid waste management and treatment is still at its nascent stage in India and yet to develop into full fledged form. With the rising population and ongoing urbanization in India, the immediate task in managing the huge amount of municipal solid waste is to carry out the habit of sorting the wastes at source to reduce the volume and load that is to be disposed at the landfill sites and also to utilize the potential wastes to convert them as energy. Public awareness on reduce and reuse, waste segregation at source, provision of dustbins in proper places, sufficient man-power with equipments for regular collection and waste disposal with advanced technologies like sanitary landfill are promising ways. Strict rules with penalties for dumping of waste in open areas/ drains are needed for waste management in the populous country India. If treated properly with adequate infrastructure and effective waste management technologies, the generated wastes can be converted into a potential resource. Support from the government and funding agencies, wide spread public awareness and mass participation as a whole are fundamental to successful waste management system in India.

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