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Future Perspective for Utilization of Municipal Solid Waste (MSW) in India: A Review

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Abstract | **Review Article**

Presently urban areas are reported for supporting 56% of the total world population, accountable for generating significant amount of municipal solid waste (MSW). Seventy percent of which ends into landfills, 19% is recycled and 11% is employed for energy generation. Generation of municipal solid waste in India is increasing day by day. The average per capita generation of waste was about 500 g/day in 2007 and it will increase to 925 g/day by 2047. Municipal solid waste (MSW) is one of the key components of India's prominent mission 'Swachh Bharat Abhiyan'. Rising urbanization, faster economic growth and lifestyle changes all contribute to higher waste generation in India. Unscientific treatment, improper collection and low use of technology based solutions for handling MSW lead to hazards like environmental degradation, water pollution, air pollution and soil pollution. The most important step to be used for management of this waste would be minimising its generation but this is not really possible. Then to manage waste sustainably, the waste to wealth route remains a viable solution although in India it is not common practice. Maximum recycling, composting with organic municipal solid waste and waste to energy generation should be utilised for MSW management. This approach of sustainable waste management can solve the problem of land required for waste disposal and resulting pollution problems of air, ground, surface water, soil etc.

Keywords: Population, Landfills, Municipal Solid Waste, Recycling, Composting, Pollution.

INTRODUCTION

Due to rapid population expansion, industry, monetary development, urbanisation and an increase in human lifestyles, the amount of municipal solid trash generated in India has increased. India with the second largest population in the world (16.7 per cent of the world population.) accounts for a meagre 2.4 percent of the world surface area. With the changing life style and consumer economy waste generation is increasing rapidly in India and the annual municipal waste generation. (MSW) is 48 million tons/year (5 million tons/year is hazardous waste) already. This will increase to approximately 300 million tons annually by 2047 (Table 1).

Table 1: Increase in Municipal Solid Waste in India [1]

Years	Urban Population (Millions)	Daily Per Capita waste Generation (Grams)	Total waste Generated (Million tonnes)	Area under Landfills (Thousand of ha)	Annual Methane Emissions (Million Tonnes)
1947	56.9	295	6	0.12	0.87
1997	247	490	48	20.2	7.1
2047 (Projected)	-	925	300	140	39

Significant increase in waste generation, lack of both the sustainable waste management plans and their implementation policies, are accountable for causing environmental damages like soil, water and air pollution, plant and animal contamination and generation of odors. Waste ending in landfills causes littering and emission of

greenhouse gases responsible for causing health related problems along with environmental damages Worldwide, the developing economies have witnessed the trend of rural population migrating to urban areas for employment, better facilities and convenience. This has led to a significant increase in the generation of municipal solid waste (MSW) [10, 11].

With a population of approximately 1210 million, the urban population in the country is more than 377 million constituting 31.16% of its total population. The municipalities with such rapid rate of urbanisation, facing an extra burden on the socio-economic and environmental prospects owing to migration and depletion of natural resources. As per the central pollution control board (CPCB) of India, the per capita waste generation has increased at an exponential rate (0.26 kg/day to 0.85 kg/day). It is estimated that approximately 80% to 90% of the municipal waste is disposed-off in landfills without proper management practices and open burning, leading to air, water, soil pollution. The citizens are not much aware of waste management related issues, and their careless attitude towards their waste creates challenges for the municipalities. The potential threat about MSW at landfill sites which emits harmful greenhouse gases eventually leading towards environmental pollution subsequently contaminates the groundwater with the formation of leachates. The sound & micro-dust is another issue during transportation causes nuisance for the elderly and newborns [13, 17]. The uncollected garbage pollutes open drains, waterways and other bodies of water in the vicinity, harming human health and posing an environmental hazard. Residents can be exposed through a variety of channels including inhaling toxins emitted by garbage, direct contact with polluted water or soil, or consuming items or contaminated water. Moreover the population living near waste disposal landfills and incinerators is often more deprived and possible health effects are cancers, birth outcomes and lung, skin and abdominal discomfort or illnesses.

Increased industrialization in the wake of green revolution coupled with population explosion has paved its way to enormous solid waste generation. Inadequate techniques and paucity of technical expertise have led to generation of heterogenous categories of waste. The per capita waste generation is escalating, continuously challenging the global sustainability. Most of the waste produced in India is directly disposed of to the landfills without any proper sorting and segregation, which later produces greenhouse gases, posing risk to human health and environment. Thus, there is a need to implement strict laws, increase awareness and utilize innovative as well as latest techniques in order to cope up with the growing threat of solid waste [14].

Integrated solid waste management is a critical aspect of environmental hygiene which can be incorporated into environmental planning. Environment friendliness, cost effectiveness and social acceptability are major attributes which sum up to achieve efficient waste management system. Moving toward ‘zero waste production’ and ‘waste prevention’ aims at reduction of gaseous emissions, solid residues and pollution contributing to the protection of climate and environment. Green technology approach is the stepping stone to waste management that seeks solutions that are environmentally and ecologically benign. Recycling and composting are the easy to go techniques which are helpful in minimising the volume of the waste generated and producing valuable products with multipurpose utility. Waste valorisation is an attractive concept gaining increased popularity due to the rapid increase in waste residues generation [14].

Municipal solid waste (MSW) generation is around 500 g/day/person. This is estimated to further increase to 925 g/capita/day by 2047 [1]. The MSW contains largely food/organic waste, papers, plastics, textiles, rubber, leather, wood, glasses, batteries, ferrous and nonferrous metals containing components etc. Indian MSW has 40-60% of compostable material or organic material with high moisture contents (Tables 2 and 3). The rising income levels and in turn greater purchasing power of individuals especially in big cities have given rise to consumer preferences that make goods obsolete quickly and this has led to a sharp rise in generation of wastes. Wastes pose a severe challenge for Municipal Authorities for its sound disposal and the problem has been agitating the minds of policy makers, regulators and concerned citizenry. One recent example of tragic impact of improper management of municipal solid waste was seen as epidemic in Surat, Gujarat in 1994. Land scarcity in the cities has made waste disposal more difficult. The use of landfill is no longer considered to be a satisfactory environmental solution due to many health hazards linked with it. Therefore, new methods have to be found to produce wealth from the waste [2]. Obviously, the impact on environment can be reduced by reducing waste generation itself and failing this, waste should be either recycled or reused. When these options are unsuitable, waste must be incinerated for energy recovery. The last resort should be used in landfills because it requires space and run the risk of leakage [10, 12, 13].

Table 2: Physical Characteristics of MSW in Indian Cities. All value in % and are calculated on dry weight basis

Population Range (in million)	Number of cities surveyed	Paper	Rubber, Leather and synthetics	Glass	Metals	Total Compostable metals	Inert
0.1 to 0.5	12	2.91	0.78	0.56	0.33	44.57	43.59
0.5 to 1.0	15	2.95	0.73	0.35	0.32	40.04	48.38
1.0 to 2.0	9	4.71	0.71	0.46	0.49	38.95	44.73
2.0 to 5.0	3	3.18	0.48	0.48	0.59	56.67	49.07
>5	4	6.43	0.28	0.98	0.80	30.84	53.90

Source: Manual on MSW management for GOI, Urban Development Ministry, 2000

Table 3: Chemical Characteristics of MSW in Indian Cities. All values except moisture are on dry weight basis

Population Range (in million)	No. of cities surveyed	Moisture %	Organic Matter	N as (TN)	P as P_2O_5	K as K_2O	C/N Ratio	Calorific Value in K cal/Kg
0.1 to 0.5	12	25.18	37.09	0.71	0.63	0.82	30.94	1009.89
0.5 to 1.0	15	19.52	25.14	0.66	0.56	0.69	21.13	900.61
1.0 to 2.0	9	26.98	26.89	0.64	0.82	0.72	23.68	980.05
2.0 to 5.0	3	21.03	25.06	0.56	0.69	0.78	22.45	907.45
>5	4	38.72	39.07	0.56	0.52	0.52	30.11	800.70

Source: Manual on MSW management for GOI, Urban Development Ministry, 2000

ADVERSE IMPACTS BY UNPLANNED DUMPING OF MSW

Some adverse impacts are ground water contamination through leachate generation, surface water contamination by run-off from waste dumps, fire menace, bird menace, bad odours from dumping sites, epidemic through stray animals, global warming due to release of greenhouse gases (methane and CO_2), acidification of surrounding soils, stratospheric ozone deletion, photo-oxidant formation, etc. These can be eliminated if MSW is put to some use [3, 9, 12]. It should be noted that much of MSW may be rich in nutrients. Thus, there is need to bring technological interventions for achieving waste reduction and its utilisation. Waste should be taken as resource/ wealth lying at a wrong place. Thus, in view that it has immense potential for resource recovery, it is required that MSW is looked from cradle to grave, properly collected, stored, transported segregated and made ready for final disposal. Only those wastes should be sent for dumping which cannot be reused or recycled. The organic waste can be used as compost. The approach in waste management should be such that maximum possible waste generated could be used in one way or other. Proper MSW management requires sensitizing the community about the importance of environmentally sound waste management practices, as well as concerted efforts and adoption of a scientific approach by the concerned authorities. The biggest challenge is to ensure that different kinds of wastes are kept segregated from the very beginning when individuals or families discard them [10-13].

WASTE TO WEALTH POTENTIAL

Reduction in waste generation should be the first priority in MSW management hierarchy and then comes its maximum recycling possibilities. The 3R principle Reduce, Reuse and Recycle should be used to minimize waste generation. Now there is a 4th and 5th R which implies Rebuy and Repair [5, 9]. Thus, encouraging to rebuy the products made from the recycling of MSW, recycling industries can be promoted. There is no process in the world which has zero or no waste generation. Some of the steps that can be taken for waste to generate 'wealth' from MSW are as follows:

1. Composting from Municipal Solid Waste

Composting of MSW is recognized as a costeffective method for waste management that results in an end product that can be used as a soil conditioner with beneficial effects on soil productivity. The MSW in India has 40-60% (or sometime more) of compostable material with high moisture contents. The high moisture contents and low calorific value makes it unsuitable for incineration. Biomethanation and composting are perhaps better alternatives for treatment of wastes.

2. Waste to Energy Generation Option

In the waste management hierarchy, waste to energy (WTE) has been considered as a mode for the recovery of resources that must be considered before ultimate disposal of the final inert materials. It is true that incineration plants are expensive. Because of this reason burning technologies are considered as inappropriate method of waste management by environmentalists. Several incineration plants that were installed in Delhi and Lucknow have failed to deliver rated energy outputs and have since been closed. However, there have been success stories elsewhere and the Govt of India provides subsidy for installation of incinerators which not only generate power but reduce the bulk of wastes to a small volume of ash [5].

3. Anaerobic digestion or Biomethanation

Methane is produced by anaerobic decomposition of landfill solid waste and it contributes towards global warming. Methane is 21 times more potent greenhouse gas (GHG) than CO_2. Calorific value of landfill gases is app. 4500 Kcal/m3. Biomethanation technique of using methane gas for combustion or electricity generation could also provide compost for soil conditioning. This technique can be effectively used in a developing country like India. The methane value estimated for wastes generated in six selected metropolitan cities in India is 2 million tons/annum [6] to several times more. It is expected to increase to 39 million tons/annum by 2047 (Table 1).

4. Refuse Derived Fuel (RDF)/Palletisation

This proven and tested technology has been widely implemented in Europe for disposal of MSW and this RDF is suitable for Indian cities. The pellets are a good coal substitute. The NOX and SO2 emissions are less than what are emitted from coal burning and the calorific value of these pellets are 2500–3000 Kcal/Kg. A 6.6 MW electricity generation plant from incinerated pellets is satisfactorily running at Mahbobnagar, Hyderabad.

5. Incineration

Calorific value of MSW in India ranges from 600-1100 kcal/m3 and 100 tons of raw solid waste can potentially produce 1-1.5 megawatt power. In Malaysia, where 80% of MSW contains food, papers and plastics with 55% of moisture contents incineration plants operate successfully. By incinerating 1500 tons of MSW/ day with an average of calorific value of 2200 kcal/kg one can produce 640kW/day [7]. In Delhi, Muncipal Corporation of Delhi (MCD) has planned to produce 16-20 MW of electricity by first converting MSW to RDF and then incinerating it to produce electricity [8].

6. Pyrolysis/Gasification

This is a process of destructive distillation. In this process, MSW is heated to 900-1000ºC so that pyroligenous liquid/water gas can be used in internal combustion engine to produce electricity. This is a bit expensive technique but can be used in more effective manner in small scale production of electricity.

EARNING OF CARBON EMISSION REDUCTION (CER'S)

One can earn carbon credits under CDM (Clean Development mechanism) of Kyoto Protocol n or m by preventing generation of methane and carbon dioxide gases as landfill gas recovery and utilization by composting/biodigestion, efficient collection and recycling, closing and capping of the existing dumping grounds. The possibility of availing carbon credit in these projects not only ensures that the best of technology will be used for sound disposal but projects will also be financially remunerative.

SOLID WASTE MANAGEMENT IN JAMMU & KASHMIR

Solid Waste Management is one of the biggest global issues facing humankind as a result of rapid urbanization and an everincreasing global population. The issue puts pressure on the limited resources available such as land, thus making it mandatory to seek new alternative methods for disposing of waste. Jammu and Kashmir is no exception [13]. As per the Draft Policy of 2018, with 1.04% population of India, on an average, J&K generates 3,134 tons of solid waste a day that constitutes organic fraction 40-45%, 20-30% inert fraction, rest plastic rags and other components. The two landfills in Bhagwati Nagar in Jammu division and Achan in Kashmir division are overflowing as both the landfills have already exceeded their capacity. Due to the fertile nature of the land, mountainous terrain, and rapid urbanization, it is difficult to find more land in J&K for waste disposal. The two models of Solid Waste Management that have proven successful in the states, where they have been implemented, and are recognized worldwide for their effectiveness offer some important insights for efficient and effective management of waste in Jammu and Kashmir namely:

1. Alappuzha: The Venice of the East

Alappuzha was recognized by the United Nations Environment Programme (UNEP) in December 2017 amongst five cities in the world for its decentralized sustainable solid waste management project. The project was started in 2012 and has been replicated in Thiruvanthapuram whereas Meghalaya is on its way to implement it. Pipe compost units and biogas plants were set up in households depending on the amount of organic waste that was generated at a subsidized rate; a pipe compost unit cost only Rs.150 instead of Rs.960 and a biogas plant only Rs.3375 instead of Rs.13500. Households who couldn't adopt these measures were provided with the facility of aerobic compost units located within walking distance. They consist of 4ft by 4ft concrete bins with each having the capacity to convert 2 tons of waste into compost within three days. The number of bins depends upon the locality and the number of households. The walls of the units have been painted to make them attractive and it has turned out to be a 'tourist attraction'. People can deposit waste two times a day, from 6 am to 11 am and from 6 pm to 10 pm [15]. For treating non-biodegradable waste, material collection facilities are available in public spots that have separate sections for various kinds of waste like e-waste, hard plastic and carry bags. Further, a team of volunteers called 'Green Task Force' has also been assigned to collect this waste from households on a monthly basis. Hotels, vegetable markets, wedding halls are mandated to have their own plants or make arrangements to entrust their waste to recognized private service providers. Assorted plastic waste is handed over without paying fees to contractors for recycling at specified dates and at specified points [16]. The model has been financially beneficial, as the numbers reveal

money saved on diesel, the cost for transporting waste to Sarvodayapuram (dumping site) is Rs.70, 27, 762, cost of biogas produced through 1164 biogas plants is equivalent to 4992 LPG cylinders i.e., Rs.70 lakhs, and manure produced from compost - 225 tons priced at Rs.34 lakhs [16]. The model couldn't have been a success without constant efforts by the local bodies and support from the community. Efforts were supplemented with an extensive IEC programme. NGOs were roped in and they went from door-to-door to spread awareness. Clubs were started in schools, households adopting measures were praised to build the confidence of people. The decentralized model ensured the participation of people by giving them ownership. The slogan of the program says it all, the 'garbage I produce is my responsibility'.

2. Indore: The Cleanest City

Indore was ranked the cleanest city on the Government's Swachhata Sarvekshan, 2017. Since 2016, it has achieved 100% door-todoor collection and segregation of waste at household levels. Households pay between Rs. 60 and 150 a month based on the waste they generate, and commercial facilities pay Rs. 3 per kg of waste. Dividing in wards, the administration carried out an 'Identification Study' to figure out the amount of waste generation in each ward and developed a detailed route plan to ensure that it covers all wards. It further helped in implementing a staff deployment plan to meet the requirement of the workforce. Even research has shown that waste collection efficiency is low in India, due to non-uniformity in the collection system. Waste collection efficiency is 100 percent only in those areas where private contractors and non-governmental organizations are actively involved. Realizing this strategy, the administration contracted private corporations to undertake operations such as transportation, collection and disposal of waste. Besides this, it partnered with NGOs to spread awareness, monitoring, and segregation of waste. People were made aware using various practices and in case of repeated violation, they were penalized. A massive Information Education Communication (IEC) programme was held that consisted of street plays, wall paintings, radio messages and utilizing cultural events such as Ganesh festival and Gandhi Jayanti. It also roped in religious leaders to read out from texts and give sermons on cleanliness. Oath taking and cleanliness drives were organized in schools. The most interesting aspect was the incorporation of monitoring (verification) activities in the IEC. The verification process took place through different means: An app named 311 has been developed to register complaints and ensures redressal within 48 hours, surprise checks through online site visits, and monitoring staff attendance through biometrics. Commissioners were appointed for each area. They are held accountable for their work and this helped to ensure regular visits. While certain IEC media, such as nukkad nataks, rallies connected citizens with service providers (community association, NGOs, volunteers) – on the other hand, technologies such as 311 App- helped in directly connecting with the IMC official machinery.

Together the aforementioned models of Solid Waste Management could help develop a strategy for the newly carved out Union Territory. Based on the cross-learning from other best practices that have already yielded results in other states, this paper provides some recommendations that are tailored to suit the specific needs of Solid Waste Management in Jammu and Kashmir. These recommendations attempt to offer solutions to the other major challenges that the erstwhile state is facing to deal with SWM. They are interlinked in nature and require simultaneous consideration. Nonetheless, what lies beneath all this is undeterred political will, appropriate funds and support from the community. By increasing the participation of people, a sense of ownership should be developed among the citizens to make sure they take responsibility for their actions.

CONCLUSION

With population growth and changing preferences of people, more and more waste comes for disposal. Land scarcity has further aggravated the problem of environmental friendly disposal. The way left for sound waste management is utilization in one form or other. Some of the utilization techniques are recycling, compost formation, biomethanation, WTE, bio-fuels etc. Composting and biomethanation are considered as most suitable. Moreover, municipalities, along with the involvement of informal sectors, private agencies are required to focus on creating potential opportunities and achieves the long term goal of the MSWM sustainability for Indian cities.

Declaration of competing Interest

There are no conflicts of interest among the authors, and also declare that no funding has been received for this research.

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