Municipal Solid Waste Management in India – A Critical Assessment

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1. Driving factors for municipal solid waste management in India

In the ongoing phase of the overall economic development of India, which is witnessing a good progress in manufacturing and service sector in addition to the well established Information technology sector, sustainability issue has come to the forefront specifically with respect to resource management and waste management. The most significant resource management problem is related to the drinking water while very prominent waste management issue is that of municipal solid waste (MSW) management. It is a foregone conclusion that India needs to implement efficient MSW management throughout to cope up the sustainability challenges. MSW management in India is responsibility of democratically elected local governments, and associated bureaucracy. However, the major driving factors are political, social, and technical issues as represented in the following Figure.

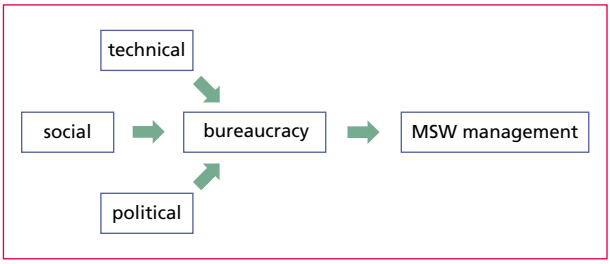

Figure 1:

Driving factors for MSW management in India

Approach adapted here is to describe the MSW management issue in the framework of the driving forces rather than routine approach delineating the data and case studies etc.

1.1. Social factors

India has 29 States and 7 Union Territories, with significant cultural, climatic, territorial, and linguistic variations. In addition there are certain religion related factors that may impact MSW generation and variation in characteristic. For example, many places in India, in a particular period of year, non-vegetarian food is avoided and when the period is over, there is sudden surge in protein content of the food waste. In addition, dietary habits vary significantly throughout India from one climatic zone to another. Dietary habits of peninsular India are entirely different from North India or Eastern parts of India and so on. This has significant impact on MSW generation, characteristics, processing technologies to be adopted. Cultural variations are related to different festivals throughout the year and allied pilgrimages, extreme variations in floating population leading to significant impact on the MSW generation, characteristics, and organic loads going on to the processing units.

Unless these social factors are properly addressed, an efficient MSW management system cannot be developed in Indian context. Many, otherwise effective technologies like biomethanation and composting have failed simply because of lack of understanding of prevalent social factors in the concerned area. This is particularly true for the technologies directly imported from developed countries in Europe and USA, where social and cultural practices are entirely different, specifically with respect to dietary habits and variations, number of festivals and social habits etc.

1.2. Political factors

Political factor is, in fact, being used here as a collective term. In Indian context, under democratic atmosphere, many factors dictating implementation of MSW management systems are influenced directly or indirectly by the politics and political Will. These factors include

- policies and regulations,
- creation of funds,
- taxation, and
- space allocation.

1.2.1. Policies and regulations

The very first regulation for MSW management was forced in Year 2000, with the title *Municipal Solid Waste-Handling and Management Rules* more commonly referred as MSW 2000 Rules. In a nutshell, the regulation had the following provisions.

- it described segregation, collection, transportation, processing, and disposal,
- it recommended composting, bio-methanation, energy recovery etc. but restricted landfilling of organic fraction of MSW,
- it described leachate management, discharge and emission norms,
- it described site selection criteria,
- it described responsibilities of municipalities/local governments, and
- it excluded hazardous and bio-medical wastes, plastic waste, e-waste, C&D waste.

It further dictated implementation schedule, which expected all the municipal corporations to fully implement the scientific MSW management systems by the year 2003. However, by the year 2013 compliance to segregation at source was around 10 %, collection and transportation around 70 %, and processing around 15 %.

In order to improve the waste management situation in the country, central government has put in force more comprehensive and stringent regulation as Solid Waste Management Rules in year 2016 and these rules are applicable to every urban local body, outgrowths in urban agglomerations, census towns as declared by the Registrar General and Census Commissioner of India, notified areas, notified industrial townships, areas under the control of Indian Railways, airports, airbases, ports and harbours, defence establishments, special economic zones, state and central government organisations, places of pilgrims, religious and historical importance as may be notified by respective state government from time to time and to every domestic, institutional, commercial and any other non residential solid waste generator situated in the areas except industrial waste, hazardous waste, hazardous chemicals, bio medical wastes, e-waste, lead acid batteries and radio-active waste, that are covered under separate rules framed under the Environment (Protection) Act, 1986. This rule, in addition to the provisions of earlier regulation, define more stringent and inclusive norms and emphasizes strict segregation at source, resource recovery in terms of energy and material, more accommodative technologies, and more responsibilities to local governments and individuals or group of individuals. It strictly prohibits C&D waste and plastic waste to be included in MSW processing. [4]

1.2.2 Creation of funds

The requirement of huge funding to local governments to deal with MSW management as per regulation was realized by central government and initially Jawaharlal Nehru National Urban Renewal Mission (JNNURM) was launched as a massive city-modernisation scheme. It envisaged a total investment of over 20 billion USD over seven years. It was launched in 2005 for a seven-year period (up to March 2012) to

encourage cities to initiate steps for bringing phased improvements in their civic service levels. Further, central government launched Atal Mission for Rejuvenation and Urban Transformation (AMRUT) in 2014. The scheme is dependent with public private partnership (PPP) model. If required, various other schemes like Swachh Bharat Mission (in English: Clean India Mission), Housing for All along with the local state schemes like that related to water supply and sewerage and other infrastructure related schemes can be linked to AMRUT. About 1 lakh crore INR (about 15 billion USD) investment on urban development under Smart Cities Mission and the AMRUT of 500 cities has already been approved by the government. All these schemes can actively fund the MSW management implementation, not only in urban areas, but also in rural areas. [1]

1.2.3. Taxation

Surprisingly, there was not (and still it is not) any specific exclusive taxation towards MSW management in India. Most of the housing taxes included only charges for water supply and sewerage systems. However, since 2015 central government has levied a very small tax on most of the commodities as Swacha Bharat Cess, which is exclusively used for sanitation and allied waste management. However, as compared to the developed countries India needs better and exclusive taxation for MSW management.

1.2.4. Space allocation

Space allocation for MSW processing has become a major issue for the implementation of efficient MSW management systems in urban areas in wake rapid economic development, increasing urbanization, and land scarcity. Availability of site complying to the criteria mentioned the regulation, exorbitant land costs, and scarcity force MSW processing sites to be located far off from the city and mostly near to some satellite village. There is increasing opposition to such sites from the villagers supported by civil societies, environmentalists, and local politicians. Getting environmental clearances and other statutory clearances has become extremely complicated.

To facilitate appropriate positioning of the MSW processing plants government needs to ensure appropriate technologies with required environmental protection measures, give incentives to the nearby villages in terms of tax sops and rebate on power and water bills etc., take up public awareness drives frequently.

1.3. Technical factors

Technical issues include following essential factors, especially in Indian context.

- MSW generation,
- MSW characteristics and variations thereof (seasonal and regional),
- MSW collection and transportation
- climatic and geographic conditions, and
- technology selection.

Typical issues related to these factors, especially in Indian scenario, are discussed here.

1.3.1. MSW generation

It is very difficult to arrive at exact MSW generation figures as per capita MSW generation varies from 0.1 to 0.55 kg/day depending on the economic and urban/semi-urban/rural status. Affluent sections in the city may generate around 0.45 to 0.55 kg/day per capita whereas in the poor sections MSW generation is often less than 0.15 kg/day per capita. Therefore, estimation of MSW generation using average per capita generation can be quite misleading and has resulted in under or over designs of the MSW processing plants in the past. According to the latest available estimates (2017), India generates about 157,478 tonnes of solid waste per day. These figures slightly vary from other information sources, nevertheless these were presented to the parliament. Against this, it has capacity to treat less than 30 % of the waste generated. The remaining 70 % is disposed of untreated. [5]

It is worthwhile to mention here that a quick exercise of obtaining actual data on MSW generation specific to the city concerned can be extremely helpful for efficient design of the MSW processing plant. All reputed technology providers do this to good research institutions or universities.

1.3.2. MSW characteristics

There are numerous reports and published articles on MSW characteristics in India. However, these are mostly specific to the site selected for sampling and time of sampling. Often the averaging and extrapolation is done to represent the Indian scenario, which is very misleading. Also, in all these reports/papers sampling technique used may not be uniform or even properly addressed leading to utterly confusing variations in the characteristics. This is very important as solid waste is a very non-homogenous kind of matrix. On the other hand, one needs reliable MSW characteristics to arrive at the appropriate processing technology and effective design.

The single most important characteristic in MSW is moisture content and its variation. As compared to the developed countries moisture content in average Indian situation is quite high 35 % being minimum value. This may exceed even one hundred percent in monsoon season which extends over three months. Moisture content critically influences composting and incineration processes. It also dictates the energy requirement for the MSW processing. In addition, it also dictates off gas composition if, gasification technologies are employed.

Calorific value (CV) is another important parameter, which needs a careful examination. Many reports do not address whether the reported value is LCV (low CV) or HCV (high CV). Also CV can show extreme variation if sampling is not done properly. Many incineration plants have failed technically and economically due to wrong assumption for CV. On an average, HCV values rarely exceed 1,800 kcal/kg. Conservative assumption should be around 1,200 kcal/kg LCV while under worst scenario it can be around 800 kcal/kg. The major reason for this is the removal of CV contributing components like wood, hard boards, and paper etc. from MSW by waste pickers. In addition, variation in moisture content is another factor influencing CV.

Presence of heavy metals in MSW is another issue in Indian MSW, which is mostly related to poor segregation at source. The metals are contributed by waste cans, boxes, scrap, and sometimes due to waste electronic and electrical gadgets or components. Heavy metals influence quality of product like compost, residues from bio-methanation, incineration ash etc. This has significant impact on the projected economics due additional disposal costs incurred and unacceptable product quality. With the increased awareness and stringent implementation of rules, this problem would minimize in near future, however, at present, a due consideration must be given to heavy metal before designing MSW processing.

Presence of inert in the form of soil/dust is unavoidable in tropical climate of India. Soil can come from street sweepings and MSW collection equipment such as JCB. This is the most neglected yet significant issue as it has direct influence on residual management and contractual obligations thereof, often leading to penalties from the corporations.

1.3.3. Climatic and geographical conditions

In India, climatic and geographical conditions vary to a very large extent from place to place and success of MSW processing, both economic model and efficiency, would largely depend upon proper selection of the technology. There cannot be any generalization in this regard.

1.3.4. MSW processing technologies

MSW technologies are classified as bio-chemical technologies and thermal technologies.

Bio-chemical technologies are those technologies which essentially involve biochemical processes involving microorganisms such as bacteria, fungi etc. These technologies can be further classified as anaerobic or aerobic depending upon whether air is supplied or not. However, from practical point of view, only two technologies emerge, composting and biomethanation. Compost produced from the composting can be used as a soil conditioner. Biogas produced from the biomethanation can be used for heating or power generation.

Thermal technologies are those technologies which essentially involve high temperature processing of MSW leading to many chemical reactions. Here, no bio-chemical process can be adopted. These processes can be further classified on the basis of extent of air supply during the treatment. Accordingly, three basic technologies emerge as follows:

- pyrolysis, where no air is supplied,
- gasification, wherein partial air supply is given, and
- incineration, wherein full or excess air supply is given.

Refuse derived fuel (RDF) often referred as treatment technology is a kind of pretreatment wherein the combustible dry fraction of solid waste is compacted to pellets that are to be essentially used for thermal processing. The thermal processes yield heat that can be used for power generation, or syngas that can be used as chemical feed

stock, or oily products that can be used as fuel oils. These technologies are depicted in Figure 2 systematically and technology essentials for successful implementation under Indian scenario are delineated thereafter.

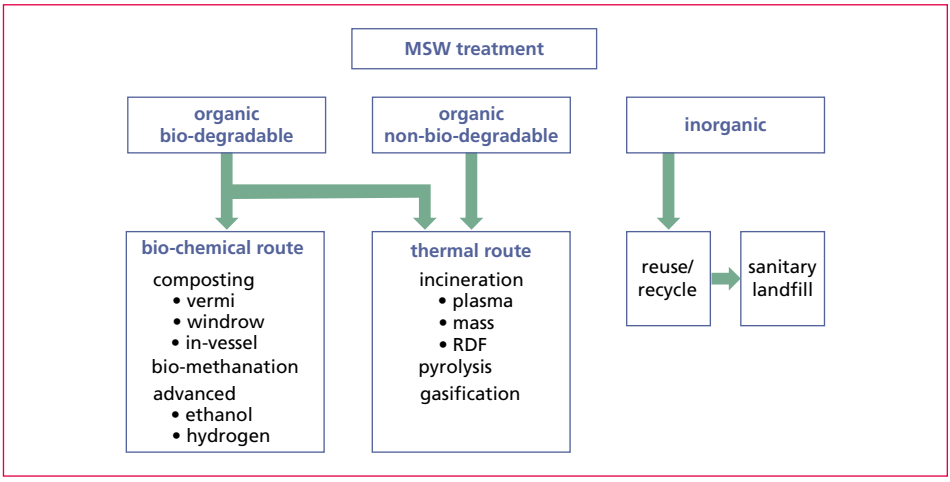

Figure 2: MSW processing technologies

Biochemical Technologies

Composting Technology

Technology essentials:

- It is a slow process and has a large footprint.
- The compost quality must match Fertilizer Control Order (FCO) norms.
- The utility of compost in nearby area must be given.
- A compost selling mechanism must be in place.

Biomethanation Technology

Technology essentials:

- The segregation of organic fraction of MSW is a must.
- The methane content in biogas should be minimum 55 % (v/v)
- For heating purposes, the utility should be in near vicinity or else a compressor is needed, which is an additional cost.
- Size reduction, maintenance of pH, and a solid concentration are a must.
- Biogas purification, generator and power distribution systems are essential components, if biogas is to be used for power generation. This needs engineering expertise and cause high costs.

Thermal Technologies

Incineration

Technology essentials:

- MSW should have a minimum NCV (net CV) of 1,200 kcal/kg and a moderate moisture content to reach an efficient incineration system.
- All air pollution control systems, including that for dioxins and furans, must be provided and the final emissions should conform to CPCB norms.
- The system should have proper residue disposal (bottom ash, fly ash etc.) mechanism as per the prevailing rules.
- The technology provider should specify the feed requirements.
- May not be available for less than 300 tonnes per day MSW.

Gasification Technology

Technology essentials:

- The calorific value of the MSW feed should be more than 1,200 kcal/kg.
- Small gasifiers are not commercially available and scale can be an issue.
- Tar formation and separation are a big problem.
- The essential for power generation and pollution control are similar to that for Incinerators.

RDF Technology

Technology essentials:

- RDF should have a minimum NCV of 2,500 kcal/kg.
- RDF should not be stored at site for more than a month.
- RDF plants should have a tie up with the cement industry and should make RDF to match the requirements of the cement industry.
- The sale of RDF should be under intimation to regulatory agencies.
- RDF plants should be vetted by reputed organizations such as Indian Institutes of Technology (IITs) or research institutes.

Pyrolysis Technology

Technology essentials:

- The technology supplier must specify the quality of the entire products viz. solid residue, oil etc.
- The quality of the oil should match the market requirements.

- Air pollution control systems are a must.
- The segregation of MSW is a must.
- The technology provider must have tie up with the purchaser for oil, residue etc.
- It is a cost intensive process and needs high quality maintenance.
- A temperatures lower than 300 °C is not advisable.
- Chlorinated plastics are to be avoided as feed material.
- The scale of operation can be a problem.

1.4. Bureaucracy

Bureaucracy is the most important component playing a pivotal role for the implementation of MSW management in India. All the basic groundwork on social issues, political will, funding avenues, technology selection, contracting, etc. is actually done by bureaucracy. It is also responsible for execution, operation and maintenance, and compliance to the statutory regulations. However, it needs substantial improvement in dealing with political interferences, technology selection, contracting and supervision. Many failures in the past can be attributed to poor contracting and selection of technology.

However, in the recent past, technology selection is being facilitated through standardization of technologies, manuals, selection guides prepared by experts. However, contracting still needs better technical inputs.

2. Existing scenario in India

Salient points of the existing situation are delineated as follows [2, 3, 7]:

- Based on the information collected by CPCB from time-to-time, the reported/estimated waste generation in the country is 141,064 t/d and out of which, 127,531 t/d (90 %) is collected and 34,752 t/d (27 %) processed.
- Segregation of MSW at source or at household level is rarely observed. Partial waste segregation practice is observed in a few cities/towns where public is aware.
- Door-to-door collection of waste is not practiced in the majority of cities/towns; however, significant efforts are being made in this direction.
- Bio-medical, slaughter house and other wastes get mixed with MSW at dust bins and finally reach landfill sites.
- Most of cities/towns covered transportation of wastes is not seen.
- There are unaccounted generation of recyclable materials collected by waste pickers at source. These recyclable materials reach custody of informal sectors leaving behind the waste of less calorific value that cannot be utilized in waste-to-energy projects.

- Many cities/towns have set up waste processing plants, but they are not self-sustaining due to inappropriate technical and economic models. Many corporations are facing contractual litigations in this regard.
- The local governments are finding it increasingly difficult to identify appropriate sites for MSW processing. Each town/city has two to three open dumping grounds, which have already been exhausted. Almost, entire waste collected is dumped and only in selected cities, waste is processed biologically or thermally.
- There are very few, probably less than twenty, sanitary landfills in country. Dumpsites therefore, are a potential threat to environment.
- Over the last few years, the scope for PPPs in MSW management has expanded it has huge commercial potential provided justified technical and economic model is proposed.
- As of November 2016, 33 waste to energy (WTE) plants with a cumulative installed capacity of 275 MW were reported to be operational in the country. However, most of them are small and biogas based. There are hardly three to four incinerator based WTE plants. All these plants are struggling with technical and economic problems. There is a serious environmental concerns raised by civil societies about such plants.

These observations are directly correlated to the various factors discussed in earlier sections.

3. Future plan and way forward

Central government has proposed active and proactive role of local governments in MSW management. Under this plan, all these local bodies are expected to plan and execute MSW management rigorously in a time bound manner. All the steps involved including detailed project report (DPR) preparation shall be monitored by the authorities. [6]

The concept of a regional/cluster–based approach is being proposed to discourage setting up of individual based waste processing or disposal facilities for small towns and villages as far as possible. Common facility should consider giving some value back in terms of end-product and also to be sustainable. Common facility is supposed to handle minimum 3,000 tonnes of MSW per day depending upon number of towns/villages covered and corresponding to waste generation. Common facility should be *integrated* with facilities for sorting, compost, RDF and energy plant and followed by inert recycling/re-use. Only a fraction of inert waste should go for land-filling. Bigger cities are expected to set up their own facilities to avoid long distance transportation of garbage. These facilities are proposed to adopt combination of waste processing technologies such as composting, RDF, waste-to-energy. Such facilities should meet existing environmental standards and even be designed with latest state-of-the-art technologies to meet stricter norms. However, state government should provide proper incentives so that such plants can be sustained and techno-economically viable.

The plan also envisages different MSW processing technologies for different scale of MSW generation suitable to Metros, big cities, towns and villages.

The major improvements needed for successful implementation of this plan are:

- Appropriate selection of technology, increasing the technology fitness by site specific modifications, and comprehensive DPR preparation and evaluation by third party experts.
- Training to bureaucrats for technical aspects of MSW management and tender preparation.
- Realistic and viable economic model to sustain the MSW management. Payments should be linked to product quality and environmental preservation rather than tonnage of raw MSW processed.
- Thorough evaluation of tenders and economic models.
- Proper and logically robust contracts.
- Rigorous monitoring and evaluation by reputed Institutions.
- Reasonable taxation to comply with *polluter pays* principle.

4. References

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