*Engineering Ecological Security*

# TECHNOLOGICAL CHALLENGES IN MUNICIPAL SOLID WASTE TREATMENT

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There are close to 5100 odd municipalities across India wherein the problem of treatment and safe disposal of municipal solid waste has become extremely challenging and reaching critical dimensions. It is estimated that the 285 million strong urban population (≈ 28% of the total population) is generating almost 120,000 MT/d of MSW. A number of municipalities in the country have gone about setting up treatment plants in the past and many more are planning to establish similar facilities in the near future under the ongoing centrally sponsored programmes. The technologies that have been attempted during last 3 decades are windrow composting, mass burn, combustion of refuse derived fuel (RDF), biomethanation, and couple of large scale and several small scale vermicomposting initiatives. Because the plants apparently produce a value added output (compost, biogas, electricity), they were perceived to be like typical industrial enterprises which could sustain themselves through revenue from sale of the output. However, time and again it has been seen that the purely technology driven treatment initiatives close down in a rather short to medium term due to a combination of technical and institutional risk factors and perforce do not bring the desired environmental and public health benefits, least of all the financial benefits. In mid seventies, the Ministry of Agriculture, Govt. of India had extended a subsidy of Rs. 50 Lakh per plant for 13 plants of 300 MT/d capacity each. Apparently only one plant could survive, and the scheme had to be discontinued due to, among others, frequent equipment break down and inadequate production and marketing systems. Several compost plants since then have closed down due to a variety of reasons.

Our experimentation with advanced treatment technologies started with Timarpur mass burn plant in 1987 in Delhi which had to be closed down within 1 year of commissioning. In late nineties, biomethanation and RDF technologies were piloted under the programme for developing non-conventional energy sources. Under this, the Lucknow biomethanation plant closed down within 6 months of commissioning, the Chennai biomethanation plant closed down in couple of years, the Vijayawada RDF plant closed down in 5-6 years and the Hyderabad RDF plant is experiencing difficulties on several fronts.

Above all technology options, the constraints in initial segregation and separation system itself are rather challenging when it comes to mixed municipal solid waste. Given the diversity in socio-economic and educational background of different strata of the society across the country, it has been

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realised that source segregation is an extremely challenging task. Besides general awareness, it requires a high degree of discipline and commitment on the part of the citizens which is not easy to get. Secondly, at the plant level the available processing systems are unable to handle large daily and seasonal variations in quality and quantity of waste and are therefore unable to produce a consistent quality of feedstock (like iron ore in a steel plant) for subsequent processing in the downstream units. Presence of abrasives e.g., ash, dust, drain silt, stones, construction debris, and corrosive materials e.g., leachate from rotting organics result in high wear and tear and corrosion of the equipment which compel operators to replace plant and equipment once every 5-6 years. This is a worldwide feature of all solid waste treatment plants which entails a high replacement cost and that typically emerges as one of the major risk factors in the overall scheme.

Generally it is now believed that the conventional ‘low cost’ technology of windrow composting is the ‘most appropriate’ option under Indian conditions. However, this being a low energy input system, it runs a profound risk of odour nuisance leading to psychosomatic health impacts on the nearby communities. It is primarily for this reason that the Thane plant had to be completely dismantled in 2004 while Trivendrum and Vijayawad plants among others, encountered severe resistance from the affected communities. Secondly, with mixed municipal waste there are quality concerns related to toxic heavy metals, pathogens, weed seeds, glass pieces, sharps, needles etc. Thirdly, the nutrient value of MSW derived compost is very low and its shelf life is found to be less than three months. Due to poor quality of compost, farmers are not prepared to pay a premium and thus eventually the plants do not see a positive revenue flow.

Vermicomposting is an altogether different story. First of all it is not an appropriate solution for large scale application e.g., 100-300 MT/d capacity plants. Secondly, the indigenous species of earth worms are not found to be very effective, while the exotic species are found to be costing anywhere between Rs. 500-1000/kg. Thirdly, the worms can not be fed raw waste but only pre-digested waste thus pre-processing of waste is essential to avoid toxicity. Fourthly, the worms are very sensitive to temperature (ideally between 20-28°C) and die off due to intrinsic heat build-up in the rotting pile or during summer when a major part of the country experiences temperature above 42°C. In order to prevent heat build-up the waste needs to be stacked in shallow ‘vermibeds’. This together with the pre-processing requirement translates into a large foot print of the facility. Finally the worms also need to be protected from predators such as centipedes, snakes, rodents, birds, hens, and red ants. Because of these reasons, they require great care almost at the personal level. In view of these constraining factors, it is found that sooner or later most well intentioned vermincomposting initiatives come to a close. One large scale initiative for 400 MT/d capacity was attempted at the Deonar disposal site in Mumbai during mid nineties and was abandoned within a very short period of time.

For the mass-burn and RDF technology options, the major constraining factor is low calorific value of the feedstock. Open disposal on street corners, scavenging of combustible recyclables, high moisture content (especially during monsoon) high presence of inert, etc. are the contributing factors. The waste therefore does not burn on its own and perforce requires supplementary fuel e.g., diesel, rice husk, wood chips etc. This translates into high operating costs, which is not sustainable if not accompanied by adequate ‘gate fee’ corresponding to entire quantity of the waste delivered at the plant.

Unlike the cold climate countries where the waste heat (from cogeneration systems of waste-to-energy plants) is utilised for district heating, there is virtually very little scope for its utilisation in almost the entire country which is characterised by warm climatic conditions. As a result the net energy utilisation efficiency is merely 22-25% and thereby the revenue model remains weak. Issues related to toxic emissions and capital and operating costs for pollution control mechanisms either through maximum achievable control technology (MACT), or best available practicable technology, (BAPT) are other constraining factors which do not create encouraging situation. Furthermore, in case of RDF the overall system efficiency can be as low as 12-15% considering that the first step of fluff or briquette making can have efficiency of 50-60% while the second step of power generation (without cogeneration) can at best given an efficiency of 25%. For such a low overall efficiency, an investment of Rs. 45-50 Crore (for a 200 MT/d plant) is not justified and no businessman would be interested unless substantial fiscal and financial incentives are available.

In case of biomethanation reactors, their sensitivity to temperature variations and the need for mixing large quantity of water for ‘low dry solids’ systems are seldom perceived to be critical risk factors but they turn out to be of profound importance. The former factor exhibits itself through disruption in biological process in non-insulated reactors in winters (a major part of the country is characterised by wide variations in seasonal temperatures) and the latter entails very large reactor size as well as adversely affects its heat balance. Bio-methanation reactors are also very sensitive to toxicity from mixed waste, blockage, overloading, under loading. The biogas so produced is found to be corrosive and odorous which together make an adverse impact on the equipment, structures and the health of the community in the vicinity.  Appropriate odour control systems are not incorporated due to cost consideration which eventually turns out to be a major risk factor. Next, the biogas engines are not available indigenously and those brought from overseas are found to be expensive in terms of both the capital and repairs and maintenance costs. Finally, the waste-to-energy and the biomethanation plants experience difficulty in selling their electricity to the grid because of their relatively small size, uncertainty in realising revenue from state electricity distribution agencies, inadequate premium on renewable energy, etc., and thereby the revenue model encounters a major road block.

Finally it all boils down to a fundamental law of science which is called the **Second Law of Thermodynamics.** According to this law the feedstock with high degree of entropy (disorder) requires a fairly high input of energy and resources, and if the output is not fetching revenue well in excess of the inputs, it is not a financially viable proposition. In recognition of this basic feature only a set of fiscal and financial incentives have been evolved in some of the developed economies in the form of 'tipping fee', 'gate fee', 'green energy premium', etc. In absence of such incentives, it is understandable that the initiatives with private sector participation would not be sustained. Current project developments in India have now started considering 'tipping fee', but that is not sufficient as it only corresponds to about 20-30% of the total quantity of waste which is going to be disposed of in accompanying sanitary landfill.

Treatment of municipal solid waste is only a means to an end. The end objective of an integrated operation is **safeguarding public health** which is to be achieved through a combination of waste reduction, collection, removal, processing and safe disposal in sanitary landfills. However, due to a variety of reasons e.g., desire to recover part of the operating costs, make the initiative attractive for private sector participation, promotion of particular technology solutions, etc. the component of solid waste treatment has in general been projected to be an end in itself under the apparently attractive paradigms of 'waste to energy' and 'waste to wealth'. These paradigms need to be challenged and reappraised objectively in the light of our own cumulative experience of last three decades and the international experiences. In this regard the option of sanitary landfill operated as a bio-reactor offers a sustainable solution whereby one can harness landfill gas as energy source without making any investment in processing plant and sensitive reactor.

If the argument of paucity of land and the spiralling land prices is too strong, then looking at the growing quantity of waste and intrinsic technical unviability of any of the above technology options, it is time that we start exploring the option of mass-burn assisted by supplementary fuel and accompanied by maximum achievable emission control technology. In terms of overall system performance, this option offers highest efficiency, requires least land, reduces waste volumes by 95% and can be tailored to minimise toxic emissions. This might sound radical but its time that we draw lessons from past experience and keep all option open. It is paramount to emphasise that this option also needs to be offered commensurate genuine fiscal and financial incentives to be financially sustainable and of interest for serious private sector participation.