RISK FACTORS ASSOCIATED WITH SOLID WASTE TREATMENT

TECHNOLOGY OPTIONS IN THE INDIAN CONTEXT

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ABSTRACT

There are close to 5100 odd municipalities across India wherein the problem of municipal solid waste (MSW) management has reached critical dimensions. It is estimated that 285 million urban population in India (≈ 28% of the total population) is generating almost 120,000 MT/d of MSW. The urban local bodies (ULBs) in their efforts to safeguard public health are incurring between Rs. 800-1500/MT of solid waste for collection, treatment and disposal and this activity alone accounts for almost 30- 50% of a typical municipal budget. There are significant issues related to primary collection, transportation, treatment and safe disposal which impact sustainability and viability of the entire chain of operations. A number of ULBs have gone about setting up treatment plants under the paradigm of 'waste to energy' and 'waste to wealth' with the presumption of that being an end in itself. The paradigm of 'safeguarding environment and public health' is often found to be relegated to a secondary level. In most cases, decisions to set up a particular technology solution also appear to have been influenced by other factors. The technologies that have been attempted in India during last 3 decades are windrow composting, mass burn, combustion of refuse derived fuel, biomethanation, and at a small scale numerous vermicomposting initiatives. However, time and again it is seen that the technology driven initiatives run into rough terrain and perforce do not bring the desired environmental and public health benefits, least of all the financial benefits. A number of institutional, technical and financial risk factors are associated with almost all the resource recovery technologies mentioned above which lead to closure of the facilities within a rather short period after commissioning.

Key Words

MSW treatment, waste to energy/wealth, entropy, risk factors, landfill.

INTRODUCTION

A case study of 11 municipal solid waste treatment plants and one disposal facility from across India was carried out with the objective of assessing the sustainability dimension, i.e., the effect of diverse risk factors associated with various treatment technologies. The need for such a study was felt in the light of the cumulative experience of unsuccessful interventions over last 2-3 decades as well as that from the recent past and the impetus on construction of more such facilities under the ongoing programmes of various agencies from across the country. The study covered nine cities viz., Lucknow, Surat, Mumbai, Thane, Bangalore, Hyderabad, Vijayawada, Trivendrum, and Suryapet representing a fairly wide range of treatment technology options. These comprised four composting plants, three biomethanation plants, two refuse derived fuel (RDF) plants, two vermicomposting initiatives, and one sanitary landfill facility. Among the composting plants three were running at varying levels of capacity utilisation under difficult circumstances while one was completely dismantled due to odour related litigation. Among the biomethanation plants, one large scale (300 MT/d) plant was completely closed down indefinitely due to a host of technical and financial issues while two small scale (5 - 20 MT/d) plants were running reasonably well. Out of the two RDF plants, only one plant at Vijayawada could be visited whereas the operator at

Hyderabad was not willing to arrange a visit apparently for confidentiality related to operational status and technical issues. The pilot RDF plant at Mumbai (not covered in the study) which served as a model for these two full scale commercial plants had been by then completely dismantled for technical and financial reasons. The vermicomposting plant with an ambitious 400 MT/d capacity set up in Mumbai back in early 1990s was found to have been closed down within two years of commissioning, again for a host of technical and institutional reasons. The small scale vermicomposting initiatives found operational at couple of locations were found to be more in the nature of demonstration rather then a response to address the entire large quantity of waste generated in those particular towns or localities.

Among the 11 plants covered in the study 6 were set up under public private partnership while for the remaining 5 the concerned urban local bodies made the investments. On the whole, 7 plants were operational and 4 had closed down. At the outset of this study an appraisal of an available data base of 200 existing and planned plants as in year 2000 (Kirti Devi and Satyanarayana, S., 2001) was also carried out. It was found that by 2005 only 31% plants could materialise or were operational, 19% plants had closed down and 50% plants did not materialise at all.

The study has helped in identifying a very wide range of risk factors which undermine sustainability of solid waste treatment plants under Indian conditions. These risk factors could be classified under fourteen broad categories viz. (1) project development, (2) political aspects, (3) administrative aspects (4) contractual agreement (5) promoter background (6) location of plant (7) collection and transport system (8) waste quality (9) waste quantity (10) plant design (11) operation and maintenance, (12) climatic factors, (13) market and (14) environmental and social impacts. The subsequent sections of the paper bring out these risk factors, first the cross cutting issues followed by technology specific issues. The paper attempts to define the paradigm of developing sanitary landfill - the most forgiving and least risky option for reliable and safe method of treatment and disposal of municipal solid waste, which is discussed in the concluding section.

CROSS CUTTING RISK FACTORS

A set of risk factors which are cross cutting all technologies pertain to due diligence and transparency at the time of initial project development, selection of plant location and conducting environmental and social impact assessment. Several plants in the country and across the world have closed down when the above aspects are not addressed appropriately at the right stage of project evolution.

Project development

Solid waste treatment and disposal projects if planned and implemented on a fast track run the risk of closure as adequate consultation with all stakeholders is not carried out and neither is the public participation factored in. The concerns of the host community require full addressing and the beneficiary city population also need to be fully informed about the new individual and family responsibilities with regard to waste generation, segregation, storage, collection, transport and the associated user charges, if any. The public must be made to perceive and recognise genesis of the project as an intervention for safeguarding its health rather the ULB’s ulterior motives of making ‘wealth from waste’. If the public perceives utilisation of available subsidy as the motive behind the project, its long term cooperation can not be guaranteed. At this stage it would be pragmatic to proactively inform local media about the short and long term objectives of the project rather than letting it interpret the evolving situation which would not serve the purpose of the local body. Therefore the project development must be accompanied by a well planned information and communication campaign to convey the right messages on behalf of the ULB.

Development of almost all MSW treatment plants in the country has not be supported with environmental and social due diligence under the prevailing rules of the Environment Protection Act. However, considering the nature of the projects it is absolutely necessary to carry out these pre-project obligatory activities to identify and address concerns of the host community and the receiving environment. Overlooking this good project planning and development practice could emerge as a risk in the short to medium term as has been experienced in the case of the compost plant at Thane (near Mumbai) where due to odour related complaints from the community, the entire plant had to be dismantled after court intervention.

Political risk factors

Considering the nature of the projects, political factors may not be perceived to be major risk posers, however they have a very strong potential to affect sustainability of MSW treatment plant related projects. For instance in case of Trivendrum compost plant the different political set up at the ULB and state level and changes after the general elections created a new set of constraints for the city planners and the operator. The assurances given by the city government/previous government were not honoured by the state/new government. Likewise the assurances on fiscal incentives and preferential treatment given by the urban development department could not be honoured by the agriculture department. The plant operator is unable to address evolving situation and faces several unmanageable risks.

Administrative risk factors

Change of a Mayor or a municipal Chief Executive Officer/Commissioner can create a set of risk factors which perhaps are not envisaged and factored in the agreement at the outset of the project. For instance operations at the compost plant at Mysore (location not part of the study) came to a stand still after one such change and the operator’s inability to meet the emerging exigencies.

A major risk factor which the Manual on Municipal Solid Waste Management has also attempted to address pertains to the countrywide practice of entrusting the responsibility of MSW management to public health professionals who by training are clinical professionals. They are expected to manage the curative facilities and measure indicators of public health rather than get involved in logistics of collection, transport, treatment and disposal of solid waste, management of fleet of dumper, loaders and earth moving machinery etc. The latter set of tasks typically require engineering knowledge and skill which are best left for the engineering departments. Because of this mismatch, it is no wonder that the solid waste operations are in a rather poor shape across the country. In this context, it is encouraging to note the decision of the Andhra Pradesh High Court which disallowed petition of the health professionals to prevent transfer the responsibility to the engineering staff at the Municipal Corporation of Hyderabad. As a consequence of this positive change the improvements in the city of Hyderabad in terms of manpower and fleet planning, contractual arrangements, work allocation, demarcation of responsibilities etc. are highly commendable.

Promoter background and contractual agreement

Some of the projects which came up in early stages of evolution of the sector witnessed entry of inexperienced players with limited technical, financial and organisational strengths. Their commitment was not towards long term sustainability rather in availing short benefits which made them pursue the ‘waste to wealth' paradigm. Integrated solid waste management requires technical and logistical capabilities akin to mining operations with commensurate financial resources. Lack of such capabilities has been demonstrated in many projects across the country to have emerged as a major risk for short and medium term sustainability.

It is understandable that with the above kind of players and lack of appreciation on the part of the urban local bodies on required expertise/resources, the contractual agreements were slanted by the promoters towards availing capital subsidy and compensation in the event of deficit in delivery of assured quantity of waste or closure of the plant. The fundamental premise of converting 'waste to wealth' and expectation of royalty on the part of the ULBs entailed operators to adopt short cuts to achieve operating profits. The contracts typically did not define the responsibility of collection, transport and safe disposal of rejects, which highlights the misplaced priority on the paradigm of 'waste to wealth' rather than on the paradigm of 'safeguarding the environment and public health'.

Location of the plant

No body wants a waste treatment and disposal facility in his/her back yard. As a result, there is severe protest by the affected community to any such proposals of the urban local bodies across the country. Proximity to a habitation necessitates conducting due diligence (irrespective of the size of capital investment), identification of impacts and incorporation of remedial measures in terms of higher order technology and effective and robust pollution control measures e.g., odour/emission control system, effluent treatment plant etc. On the social side, unlike a typical large scale industrial project, a MSW treatment plant does not involve considerably high capital investment and thus there is not enough budget for compensation, resettlement and rehabilitation of the project affected people. However, there is an utmost need to address real fear of the community of being ostracised, loss of property values and potential health impacts. Provision for host community fee and/or augmenting basic infrastructure/services could help in reducing the risks, however these features are still not in vogue.

FEEDSTOCK RELATED RISK FACTORS

Municipal solid waste to be treated and thereby receive value addition needs to be considered not just as waste but as 'feedstock' from the point of view of the plant operator. As in case of an industrial plant, feedstock/raw material delivery, quality and quantity become crucial from operational efficiency point of view. Any shortfall on these counts can undermine plant operations.

Delivery system

In this regard lack of a seamless integration between treatment plant and the collection and transport system emerges as a significant risk factor. Under the existing system the plant operator has no control over the municipal personnel and fleet drivers who are entrusted with the responsibility of delivery of the feedstock to its plant. The latter groups are well known for their low efficiency and lack of accountability and the operator can be held at ransom or could be a helpless observer when it comes to timely delivery of required quantity and quality of feedstock. Secondly, in the evolving system of contracting out transport of waste, while there is significant revenue for transport contractors, the plant operator does not get 'gate fee' in proportion to the quantity of waste delivered at its premises. Integration of transport and treatment systems/services will reduce such risk factors and offer higher motivation for a private operator to make a competitive and realistic bidding.

At times passage of waste laden trucks has been objected by communities due to aesthetic and odour related concerns. For instance in Trivendrum the loaded trucks are parked near transfer stations and made to ply only during night hours. This imposes severe restrictions on quantity of feedstock that can be delivered to the plant. It also affects plant operations, shift timings etc. Therefore type and size of transport fleet, its condition, servicing etc. become crucial factors in ensuring day to day operational status of the plant.

High entropy feedstock requires high inputs

The feedstock (mixed waste) typically delivered at an MSW plant is in a very high state of disorder i.e. it has 'high entropy' which is characterised by:

- Mixed up organic and inorganic waste fractions
- Mixed up combustibles and non-combustibles
- Mixed up dry and wet wastes
- Organic fractions at different stages of putrefaction
- High level of moisture, especially during monsoon as mostly waste is collected from open community bins
- Domestic waste, at times mixed up with hospital and other hazardous waste
- MSW mixed with construction and demolition debris
- Presence of abrasives i.e., sand, silt and metal fines, and
- High variation in composition of waste from season to season and city to city

On top of the above factors, the Indian reality is that whatever material that has some residual economic value is invariably taken out by rag pickers for recycling. Under this scenario, the 'disorder' is further compounded from the processor's point of view. In order to reduce this 'disorder' and bring about a change in its state and thereby do meaningful economic value addition, i.e. as compost, fuel or energy, as per **the second law of thermodynamics** the extent of resource and energy input required should be of very high order. For instance in case of composting process one needs to not only look at segregation of inorganics but also to ensure safety from pathogens, heavy metals, glass/fines, weed seeds and freedom from odour nuisance, water pollution, wear and tear etc. Similarly in case of combustion systems, besides initial segregation the external energy input is required in the form of diesel (as tried out in Timarpur plant) or biomass (as being practiced in Hyderabad and Vijayawada RDF plants). In absence of any external support (e.g., fiscal and financial incentives), the realisation from sale of the value added products can not be commensurate or in excess of the resources deployed for processing. Therefore, attempts to make stand alone commercial ventures out of a high entropy feedstock (unlike an ore beneficiation plant) fundamentally can not be financially viable.

TECHNOLOGY RELATED ISSUES

Leave aside source segregation, available systems in the country are far from perfection in pre-processing i.e., separation, size reduction, removal of plastics, metals etc. All processing plants require a consistent quality and quantity of feedstock and large variations in either of them can disrupt operations. Besides this, there are a number of technology related issues when it comes to the processing stage, some of which are discussed below.

Compost

For capital cost considerations, compost plants adopt windrow method as a norm, disregarding its inherent odour nuisance potential. This emerges as a major risk factor since the host community finds it extremely damaging for its socio-economic and psychological well being. It is time that for all subsequent projects, the next higher order technology option of 'Aerated static pile' is adopted uniformly which offers inherent feature of odour control.

Biomethanation

Bacteria involved in biomethanation reactors are highly sensitive to temperature variations. Robust and efficient systems are designed to maintain operating temperature within a range of ± 2°C. This requires insulation and efficient instrumentation for real time monitoring of operating parameters. Preference for 'low cost' systems does not allow incorporation of these features while ambient temperature in several parts of the country varies from 5°C in winter to 45°C during summer. As a result biological process gets disrupted. Secondly 'low dry solids' technology (< 10% solids, 90% water) which is adopted in the country entail addition of large quantity of water for formation of slurry. In winter this factor alone disrupts the heat balance of the reactor and thus makes an extremely adverse impact on the process. Moreover, water addition necessitates large reactor size, effluent treatment and correspondingly higher operating costs.

Lack of availability of indigenously manufactured and reliable gas engines, their spare parts and skills for repairs emerged as a debilitating factor for an otherwise safe segment of renewable energy from biomethanation of distillery effluent. The costs of bringing spares and skilled mechanic from overseas turned out to be discouraging for the investor who preferred to close down the plant and thereby defaulted on repayment of loan to the funding agency. Based on this experience the latter has stopped giving preferential treatment to such project proposals.

Mass burn / RDF

In the Indian context, fundamentally due to the waste characteristics and climatic conditions, the waste to energy preposition is technically not easy to achieve. Because of high dust, inerts and moisture content the calorific value of feedstock is between 800-1000 kCal/kg which is way below the optimum of around 2500 kCal/kg for self sustaining combustion. Therefore MSW perforce requires blending of auxiliary fuel e.g., biomass or fuel oil which add to operating costs.

Secondly whether it is direct combustion or through the biogas route, the energy utilisation efficiency in not more than 22-25%. In a typical cold climate country it is possible to achieve above 60% efficiency through the cogeneration route by way of selling the waste heat (which is about 30-35%) for space heating. In a warm climate country like India this is simply not possible and thus the revenue model of a plant is fundamentally severely weakened.

High capital and replacement costs

Because of presence of high abrasives and corrosive materials, irrespective of processing technology, all plants suffer sever wear and tear and corrosion of equipment, structurals and machinery. This entails high specifications for material of construction at the outset leading to higher capital costs. Notwithstanding this, frequent breakdown and shutdown are common sights at MSW plants which entails a very high repairs and maintenance cost. Next comes the issue of replacement of worn out equipment and machinery which entails large expenditure once every 5-6 years which could be as much as 30-40% of the original capital expenditure. If these costs are not factored in realistically, the operator can experience severe erosion of capital as demonstrated in Trivendrum, Bangalore and Vijaywada composting and RDF plants. In this regard, a life cycle cost analysis of a large scale plant based on any of the above described technology options shows that over a typical project span of 20 years invariably there are net costs to be incurred and no profits could be made through stand alone operations.

NO BACKSTOPPING BY A LANDFILL

Projects in the past have also not factored in the need for providing landfill as a backstopping facility and thus one finds accumulation of rejects at the plant site or in the vicinity of a habitation. In view of limitations of treatment plants, an operator is often confronted with large quantities of process rejects which have highly objectionable putrefying characteristics and leachate potential. Their safe disposal in a sanitary landfill site is an utmost public health exigency, however until recently this was not used to be factored in operating costs. Contracts in the past did not categorically define the responsibility and associated costs of lifting, transport, disposal, compaction and covering in a sanitary landfill. In a short time the accumulating quantities at the plants become a liability on the operators and a public health hazard. The operators dispose off the reject either indiscriminately and irresponsibility or could give up entire plant operations considering the prohibitive costs involved. Recent projects have factored in this aspect through inclusion of 'tipping fee', however the provisions are still not commensurate with the quantities and tasks involved. Here it will be important to distinguish between the 'gate fee' and the 'tipping fee' which pertain to the entire quantity of waste reaching a plant and the quantity of rejects being sent to land fill respectively. The evolving policy in the country is only providing for the tipping fee corresponding to a presumed level of rejects between 20-40% which may need to be revisited.

INSTITUTIONAL FACTORS

Besides the cross cutting risk factors described in the beginning of this paper, there are still many more issues related to (a) quality specifications for compost, size of the market and marketing of the produce (b) lack of assurances for buy back from concerned government agencies, fiscal incentives and final price etc. (c) conditions and reliability of power purchase agreement and premium available on renewable energy, if any (d) strength of agreement with municipality with regard to minimum guaranteed quantity and quality of feedstock and compensation in lieu thereof. A number of projects have experienced difficulties and failed when these issues are not addressed adequately.

CONCLUSIONS

In view of the fairly vast range of risk factors involved, there is no guarantee that one or the other risk factor would not crop up during an early stage of a project i.e., during development, designing, commissioning or early operational stage. Available evidence from closed and surviving plants points in this direction. This high degree of inherent risk actually gets summed up characteristically through the fundamental **Second Law of Thermodynamics** which governs the route and resources required for moving from a high entropy system to high enthalpy system. Mixed municipal solid waste is in highest degree of entropy and to bring it to a state of high enthalpy e.g., finished compost/biogas/electricity the costs are prohibitive. The discipline and efforts required to reduce entropy over the entire chain from the point of generation to its processing and disposal are very demanding and therefore not enforceable in a high entropy society. Secondly the outputs do not generate as much revenue that it will make commercial sense from a stand alone private operator's point of view. It is on this basis that appropriate fiscal and financial incentives have been evolved across the world to provide a viability gap funding for sustaining a 'robust' and not a 'low cost' processing facility. Finally, all waste processing facilities (with all their inherent limitations) must be considered under the paradigm of 'safeguarding public health and environment' in conjunction with a sanitary landfill or a bioreactor rather than attempting to defy the universal Second Law of Thermodynamics by chasing the paradigm of 'making wealth out of waste'.

References

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