# Exploring Methane Capture Options under the Asansol-Durgapur Urban Area Solid Waste Management Project

# Final Report

Indo-USAID Financial Institutions Reform and Expansion Project—Debt & Infrastructure Component (FIRE-D Project)

USAID-TCGI Contract No. 386-C-00-04-00119-00

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**THE FIRE-D PROJECT OF THE**

**UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID)**

**EXPLORING METHANE CAPTURE OPTIONS UNDER THE ASANSOL URBAN AREA MUNICIPAL SOLID WASTE MANAGEMENT PROJECT**

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**APPENDIX ATTACHED TO THIS REPORT**



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# 1. INTRODUCTION

1.1 The Financial Institutions Reform and Expansion (FIRE-D) project of the United States Agency for International Development (USAID) is providing technical support to the Government of West Bengal to operationalize the West Bengal Solid Waste Management Mission (WBSWMM) and develop pilot projects in select urban local bodies (ULBs). FIRE-D has prepared a detailed project report for ‘Municipal Solid Waste Management in Asansol Urban Area’. The project covers five urban local bodies comprising the municipal corporations of Asansol and Durgapur and the municipal councils of Raniganj, Kulti, and Jamuria. The project comprises, among others, collection, transport, composting and safe sanitary land filling of the municipal solid waste generated in the five cities. It is one of the uniquely structured projects in the country where the regional approach for treatment and disposal through private sector participation has been envisaged.

1.2 In this context, a study has been commissioned to explore methane capture options and appraise the proposed treatment and disposal solutions. The study commenced in the last week of March 2007 and an inception report was submitted in the second week of April 2007. The present report constitutes the consolidated submission of the subsequent four deliverables, e.g.:

A. Risk analysis of proposed treatment and disposal options, which is based on:
    a. the findings of a field visit
    b. interactions with the team of consultants, and
    c. a review of the detailed project report and the draft Concession Agreement.
B. Baseline situation of methane capture feasibility.
C. Comparison of options and determination of feasible option.
D. Draft terms of reference for engagement of an expert on design of a methane recovery landfill system.

## OBJECTIVES OF THE STUDY

1.3 This study has been commissioned with the following objectives:

- Carry out an appraisal of the present Detailed Project Report entitled ‘Municipal Solid Waste Management in Asansol Urban Area’, January 2007 to identify risk factors associated with the envisaged treatment and disposal methods.
- Develop mitigation/remedial measures to address the identified risks.

- Explore all options for methane capture and detail out a road map incorporating a set of most feasible and viable options.
- Compare and evaluate the most feasible methane capture option(s), if any, vis-à-vis the option of solid waste disposal and treatment as it stands. Lay out broad terms of reference, if appropriate, for engagement of an expert for formulation of detailed technical specifications for a feasible methane capture option, if any.

**STRUCTURE OF THE REPORT**

1.4 Chapter 2 provides an executive summary. Chapter 3 presents current understanding of the project which is based on the DPR and the Concession Agreement. Chapter 4 presents findings of the field visit and brings out diverse risk factors as per the baseline situation for the proposed treatment and disposal options. Chapter 5 brings out a set of technical risk factors related to the proposed compost plants. Chapter 6 briefly lists out comments on the technical aspects of the proposed landfill. Chapter 7 and 8 provide a set of comments on the Concession Agreement and the RFP document from the point of view of incorporating modifications in the proposed scheme/design. Chapter 9 briefly lists out the factors contributing to differences in project costs at the draft and final stages. Chapter 10 summarizes the diverse risk factors analyzed in the preceding chapters and provides contours for an alternative. Chapter 11 attempts to develop an alternate perspective for a long-term sustainable solution comprising a sanitary landfill with a bioreactor for enhanced methane capture. Finally, Chapter 12 provides comprehensive recommendations along with a brief systemic analysis for two distinct options, viz.:

- Option I: Project in its ‘current form’ with suggested modifications, and
- Option II: Modified project with enhanced methane capture involving 3 transfer stations and 1 compost plant in conjunction with the SLF

1.5 For Option I, a set of recommendations is provided for improving the proposed composting solution, if the project were to be taken forward in its current form. Option II constitutes an alternate paradigm for methane capture by adopting the long-term sustainable solution of a bioreactor.

## 2. EXECUTIVE SUMMARY

## 3. CURRENT UNDERSTANDING OF THE PROJECT

3.1 The Asansol Urban Area MSW Management Project envisages an integrated service provision for collection, transport, treatment and safe disposal of over 690 MT/day of municipal solid waste from the five cities. Both at Asansol and Durgapur it is envisaged to construct a combined segregation-composting-transfer station facility of about 200 MT/d capacity from where the rejects are proposed to be transported to the regional engineered sanitary landfill site at Mangalpur. From Kulti the waste is expected to go to the composting plant at Asansol, while from the other two smaller municipalities of Raniganj and Jamuria the mixed waste is proposed to be taken directly to the Mangalpur site where a smaller segregation cum composting facility is also proposed. The combined rejects are to be disposed of in the sanitary landfill. The waste generation nodes and their relative location with respect to the landfill site are shown in Exhibit 3.1 and in a schematic form presented in Exhibit 3.2.

### Treatment technology

3.2 Each of the compost plants is proposed to be based on the windrow technology which involves stacking of waste in long rows, about 2 m wide and 2.5-3 m high. After pre-processing of 200 MT/day of mixed municipal solid waste, about 120 MT/day of degradable waste is expected to be available for composting while the rest would be sent to the sanitary landfill. Special bacterial cultures are proposed to be used as inoculums and to suppress odor. First stage of decomposition in the windrows is estimated to take about 20 days, which will involve weekly turning of the piled up waste through mechanized windrow turners. Subsequently, the material will be stored in smaller heaps for maturing over a period of 30 days. Finally, screening and grading will yield the finished compost.

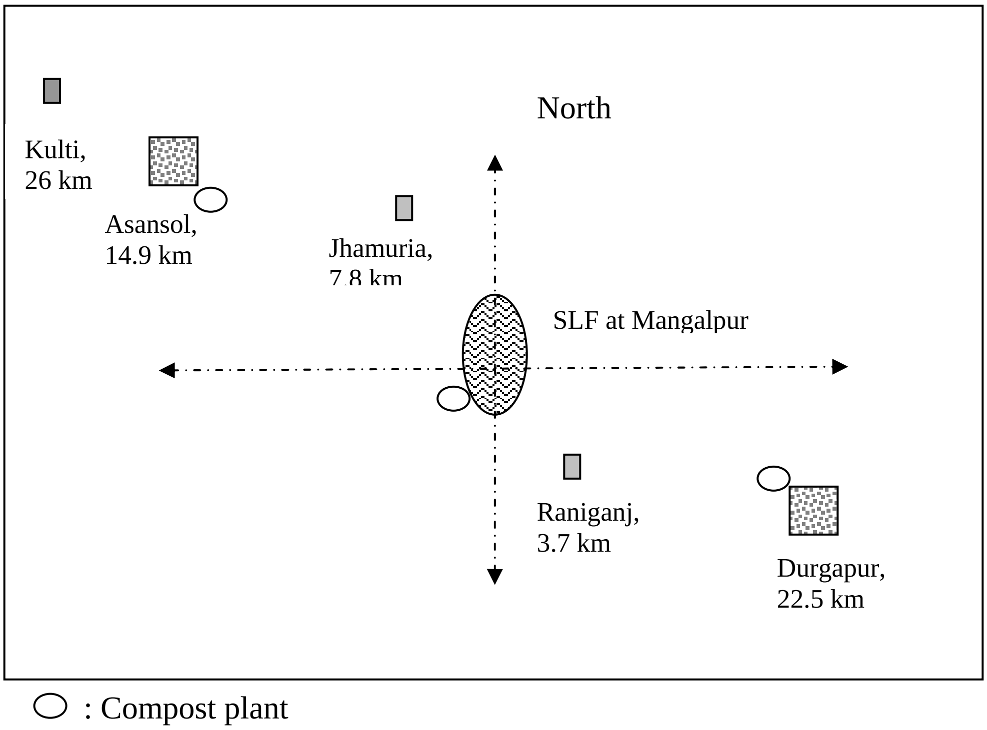
### Regional sanitary landfill

3.3 The identified site for the sanitary landfill at Mangalpur measures 167 acres. It is proposed to be developed in four phases each with a life span of 5 years. It will have provisions for leachate collection and its treatment; a small capacity compost plant (~ 50-60 MT/day) for waste from the two smaller towns and also to serve as a backstopping facility in case the plants at Asansol and Durgapur experience temporary shut down, etc; and a passive landfill gas venting system without collection, flaring or utilization components.

**EXHIBIT 3.1: NODES OF WASTE GENERATION IN ASANSOL URBAN AREA**

| Urban Local Body | Population (Lakh) | | MSW (MT/d) | | Hotel and restaurant waste, (MT/d) | Distance from SLF |
|---|---|---|---|---|---|---|
| | Yr. 2006 | Yr. 2013 | Yr. 2006 | Yr. 2013 | Yr. 2006 | Km |
| Asansol | 4.93 | 5.17 | 200 | 211 | 18 | 14.9 |
| Durgapur | 5.43 | 6.08 | 224 | 249 | 12 | 22.5 |
| Raniganj | 1.21 | 1.35 | 50 | 55 | 2 | 3.7 |
| Jamuria | 1.42 | 1.42 | 58 | 58 | 2.5 | 7.8 |
| Kulti | 3.17 | 3.37 | 130 | 138 | 5 | 26 |
| **Total** | **16.16** | **17.39** | **662** | **711** | **39.5** | |

**EXHIBIT 3.2: RELATIVE LOCATIONS OF THE PROJECT TOWNS, PROPOSED COMPOST PLANTS AND SANITARY LANDFILL SITE**



**Public private partnership**

3.4 All the three proposed treatment plants and the sanitary landfill facility are to be developed under a public private partnership. Salient features of the contract arrangement are proposed to be as follows:

- The treatment and disposal infrastructure will be developed by a single private agency under a 'Build Operate and Transfer' arrangement. The agency will be responsible for the design, engineering, financing, procuring, construction, operation and maintenance of the facilities and transfer the same at the end of post closure period.

- Collection and transportation of MSW inside the city and supply of MSW till the treatment plants, particularly in Asansol, Kulti and Durgapur, will be the responsibility of the respective ULBs. The private developer would be responsible for transport of residual inert matter to the SLF. In the case of the two smaller towns, the respective ULBs will be responsible for transport of mixed MSW to the processing plant proposed at the SLF.

- The operator would be responsible for O&M of the treatment and disposal facilities for a period of about 20 years, depending on the extent of space available in the landfill and the quantum of residual inert matter to be disposed of. In addition, as stipulated in the MSW Rules, 2000, the operator would also be responsible for post closure maintenance and monitoring of the landfill and the surrounding environment for a period of 15 years.

- With the funds available under the JNNURM program, the operator will be provided a 50% capital grant on COD (commercial operations date) and balance 50% on completion of 1 year from COD. As a result, at all points of time during the concession period the ownership of assets, viz., the treatment plant and the SLF infrastructure would rest with Asansol Durgapur Development Authority (ADDA) and the ULBs.

- The operator will be paid a 'tipping fee' (by ADDA or ULB consortium) in proportion to the quantity of rejects to be disposed of in the landfill. The tipping fee would incorporate, among others, the operating costs, part of the capital costs (less the capital grants), equipment replacement costs, etc. As a result, the 'tipping fee' becomes the crucial parameter and the bidders are required to quote this as their financial proposal.

- The bidder seeking lowest ‘tipping fee’ would stand to be awarded the contract. In this regard, it is important to emphasize that given the performance-based nature of the project, capex is not a decision parameter.

- Furthermore, the financial proposal is proposed to be the only bidding parameter, while the technical proposal is to be used for screening. This is particularly so since the broad technology (expected to be windrow based composting) and output-based specifications for facilities and processing, to the extent feasible, have been set in accordance with MSW Rules. However, it is understood that subject to adherence to the above-referred specifications, the developer has flexibility to incorporate and implement measures for efficient operation and maintenance, as well as to minimize the environmental footprint of the proposed facilities.

- In general the average level of rejects is considered to be around 40%. However, in the event of deficit in delivery of guaranteed quantity to the treatment plant, the compensation amount to be paid by the ULBs to the operator is proposed to be arrived at by considering 20% as ‘would be rejects’.

- The capex as per current estimates considers only the first phase of SLF development, which broadly corresponds with the JNNURM plan period. However the bid is offered for a much longer period involving development of 2$^{nd}$, 3$^{rd}$ and 4$^{th}$ phases of the SLF. In view of this, the tipping fee to be quoted by the bidders is expected to factor in the capital and operating costs related to the total period of landfill and post closure obligations. Furthermore, the cost of the smaller composting plant proposed at the SLF is also yet to be included in the overall project cost.

- Based on a general understanding of the region, it is perceived that the market for compost is likely to be limited. As a result likely revenue from sale of compost has not been considered in the financial analysis.

3.5 Finally it is understood that ADDA and the ULBs have finalized the bid documents and after having invited the ‘expression of interest’ from potential bidders, they are ready to issue the same in a short period of time.

## 4. FINDINGS OF THE FIELD VISIT

4.1 A short field visit to the Asansol Urban Area was organized during April 16-19, 2007 with the objective of identification of critical issues, if any, and the possible risk factors. During the visit all the five cities and the sites identified for the treatment and disposal facilities were covered. Discussions with ADDA, all ULBs and civil society organizations were held. Key issues related to the proposed treatment and disposal arrangements are described in this chapter.

### Waste quality

4.2 Reliable data on waste quality from the project area is not available. A rapid visual survey carried out during the field visit confirms the presence of high fractions of coal ash, debris, and drain silt and relatively lower levels of organic waste. Some of the pictures bringing out this aspect are presented in Exhibit 4.1. In order to have a higher degree of confidence, there is a need to generate a reliable set of data on waste characteristics for Asansol and Durgapur Municipal Corporation areas, in particular, and from Kulti, Jamuria and Raniganj municipalities in general. For the Kulti and Jamuria ULBs it is found that collection is once or twice a week because of the vast spread of the jurisdictions and the waste carrying a higher fraction of inerts.

### Waste segregation

4.3 While door-to-door collection of domestic and commercial waste has been started in selected wards of Durgapur and Asansol Municipal Corporations, the practice of waste segregation at source is yet to be initiated. Considering the diversity in the socio-economic profile of the communities in different parts of the project area, apparently this is a rather difficult and challenging task which would involve considerable social engineering inputs and may take a long time to be realized.

4.4 Waste from numerous tea shops, small eating joints, restaurants and hotels also contains higher fraction of inerts comprising earthen cups and coal ash. Vegetable or food waste is rummaged and eaten by stray cattle. Segregation of waste at numerous such commercial outlets again appears to be a very challenging task. It is learned that kitchen waste from various hostels in Durgapur is taken away by livestock farmers and thus there is limited scope for attempting localized treatment in the form of small scale biogas plants.

4.5 Silt from open drains across the project area is disposed at the same roadside collection points where the rest of the household and commercial waste is temporarily deposited. This is a widespread practice, which further compounds the problem by spoiling the quality of the waste – the feedstock for the plants.

**EXHIBIT 4.1: HIGH FRACTION OF INERTS OBSERVED AT COLLECTION POINTS**

4.6 While segregation of the above types of waste streams is rather difficult to achieve, there appears to be lack of initiative in separately handling and utilizing the rather uncontaminated horticulture waste comprising dry leaves. Apparently dry leaves constitute a sizable quantity during the fall season as the vast industrial townships have fairly good tree cover. As shown in Exhibit 4.2, current practice comprises burning of leaves on the curb-side in habitation areas. Apparently, appropriate guidelines and instructions are not issued to the municipal/contract workers and therefore such environmentally unacceptable practices continue to take place. This practice alone amply demonstrates the potential difficulties in getting the public's cooperation for source segregation, which is 'hoped' to be achieved when the project is operationalized.

**EXHIBIT 4.2: BURNING OF DRY LEAVES IN INDUSTRIAL TOWNSHIPS**

**Hospital waste management**

4.7 A hospital waste incinerator has been constructed at the Mangalpur site by M/s Ramkey of Hyderabad under a 'public private partnership' arrangement. The plant is to be commissioned some time in April-May 2007. The operator is supposed to serve the entire Asansol Urban Area and beyond. As a result of this positive development, it is expected that the municipal solid waste will generally be free of hazardous hospital waste.

**Compost plant site at Asansol**

4.8 For the compost plant at Asansol, as against the originally envisaged site on the National Highway near Kalipahari, a new site has been identified. The site is in the southwest of the city, located about 5-7 km off the highway in Mohishila/Kotaldihi Wards of the AMC (Asansol Municipal Corporation). It is a vast expanse of over 100 acres of undulating and uncultivated land. It is generally low-lying land along a small nalla, which joins the Damodar River about 3 km further to the south.

4.9 The land belongs to the Government of West Bengal and a fair-weather approach road passes through a private property belonging to one individual. There is no habitation on this site and neither are there any agriculture fields. About 1 to 1.5 km on either side of the site there are two small habitations of 400-500 inhabitants each. In the view of AMC officials, prima facie, there would be no difficulty in transfer of the land. Nonetheless it is not sure as to how long the process may take.

4.10 Three years back AMC had planted 30,000 trees in this area, which now offer fairly dense vegetation cover. The fair-weather approach road to the site passes through Mohishila habitation, which is now a part of AMC. In order to improve the access, it will be necessary to construct an additional 2-3 km-long stretch of road and convert the entire stretch into an all-weather bitumen concrete road. Apparently the Municipal Councilor of the Mohishila Ward has been instrumental in identifying the land and preliminary informal consultation with the community is said to have been carried out to get its support for the location of compost plant. However, considering the narrow carriage way, habitations on both sides, and the large number of vehicle trips expected to be made every day (estimated to be over 130 trips/day including vehicles carrying waste from Kulti), the community may find it inconvenient and may object in due course of time.

**Compost plant site at Durgapur**

4.11 The site is located on the outskirts in the northeast of the city in the Haribazar revenue area. The township of Durgapur Steel Plant is about 2-3 km to the west of the proposed site while Shankarpur and Jemua villages are about 2-3 km on its south and 7 km on its north respectively. An irrigation canal passes in the vicinity of the site, which facilitates cultivation in the area. The land is undulating and low lying, surrounded by a green belt on the north and paddy fields on the other sides. Apparently, a specific contour map for the site is yet to be developed.

4.12 From the GT Road the site is accessed through Bidhan Nagar and then passes through Sankarpur village. The approach road ends about 1.5 km before the site. DMC (Durgapur

Municipal Corporation) has started the process of alignment of road, and identification and acquisition of land for construction.

**Landfill site at Mangalpur**

4.13 The landfill site is located off the highway at Mangalpur about midway between Asansol and Durgapur. It is an abandoned open cast coal mine with contour variation from 65m to 114m. The depressions receive monsoon runoff and hold water for about 6-8 months of a year. The proposed alignment for the landfill site excludes these depressions and covers only that part which has been raised to average ground level and above, with the mine overburden. Thus the landfill site will be developed entirely on the overburden, which is of rather recent origin (about 10-15 years old). Its geotechnical and geological characteristics have not been assessed as yet. In view of the complex loading of over 15m of municipal solid waste expected to be placed on this kind of strata and possible landfill gas and leachate migration, there could be concerns related to structural stability.

4.14 In this regard it is pertinent to highlight the recent case of subsidence and cracks that have been observed on the stretch of national highway near the existing dump site at Asansol. This is attributed to underground coal mining (widespread in the project area) of the past and possibly gas migration. As a result of this, the damaged stretch of the highway is being abandoned and a new stretch is being constructed on the other side to the unaffected lane.

**Limited market for compost**

4.15 The western part of the Burdwan District, where a major part of the project is located (Asansol, Kulti, Jamuria and Raniganj), is characterized by coal mining and iron ore processing industries. Agriculture activity is further limited as there are no major sources of irrigation. Primarily one rain-fed crop is planted by the local community. On the other hand, the eastern part of the district, which benefits from the irrigation canal network of the Damodar Valley Corporation, is a very fertile area. It is characterized by intensive agriculture where farmers typically take two-three crops a year. The compost plant at Asansol would find selling the compost difficult, while the Durgapur plant could serve the fertile belt in the eastern part of the district. However, the cost of transporting over a long distance could be a deterrent.

4.16 Secondly, from the point of view of quality of the finished compost there are concerns related to its suitability for application to food crop cultivation. Generally the compost produced from unsegregated municipal solid waste contains glass pieces, sharps, needles, etc., which the farmers find difficult to work with. On top of this, there is the concern of the presence of heavy metals and toxins. Lastly, the typical windrow technology-based production process, which is proposed to be adopted, does not enable complete destruction of pathogens and weed seeds nor does it help in capturing nitrogen (the key fertilizer parameter) with the bulk. In the project area, in particular, high presence of coal ash will further contribute towards production of inferior quality compost as it is difficult to separate. Therefore, generally farmers are not prepared to use MSW based compost for food crop cultivation.

4.17 Possible afforestation on mine overburden dumps, fly ash ponds and wasteland can consume some quantity of compost in the region. However, new marketing models for sustainable forestry development would need to be created and commitment from respective PSUs (Public Sector Undertakings) needs to be secured if regular off-take of compost is to be assured.

4.18 On the whole, the market for the compost is found to be limited and sustainability of the plant operations from revenue of compost alone is doubtful. In this regard, discounting this scenario, the project has adopted a pragmatic approach by excluding the likely revenue realization from compost and provided for a fair amount of tipping fee. As a matter of fact, under such a scenario, the Concession Agreement considers the possibility of transporting finished compost to the landfill site for use as a daily covering material.

**Ballpark estimate for tipping fee**

4.19 The project involves upfront capital expenditure and prolonged operational expenditure over its lifecycle. Secondly, it also involves capital expenditure during subsequent phases of SLF development. Thirdly, it involves a significant level of replacement costs for the equipment and machinery, which are subjected to high wear and tear and corrosion. On the other hand, the project would offer two infusions of grants in its early phase for the operator. After that only the tipping fee will be given by the ULBs to take care of all the costs that the operator is expected to incur. However, at this stage the ULBs do not have a fair estimate of the range of tipping fee in which the bids could be expected.

**Kulti Municipality**

4.20 The Kulti Municipality was formed in 1993 by the amalgamation of three notified area authorities (NAA), viz. Kulti-Barakar NAA, Bisalgar NAA and Neamatpur NAA. It is spread over an area of 96 sq.km. and has a population of over 3.1 lakh. Apparently in terms of geographical area, Kulti is the largest ULB in its category in the state of West Bengal.

4.21 There are several PSUs which fall within the boundary of the Kulti Municipality, e.g., Eastern Coalfields Limited, Bharat Coaking Coal Limited, IISCO (Indian Iron and Steel Company) and a power utility. As a result about 50% of the geographical area of the Kulti ULB falls under the jurisdiction of these PSUs while for the balance 50%, the ULB provides the basic urban services. The ULB appears more as a conglomeration of a number of semi-urban habitations and the entire area is divided into 35 municipal wards which are located at quite a distance from each other.

4.22 The PSUs are understood to take care of the solid waste management within their respective township areas. It is learned that the PSUs are not paying local taxes and the ULB's financial resources are rather weak due to a variety of factors.

4.23 Solid waste management in this ULB entails collection from a very vast and thinly populated area. A number of street side collection points have been created where household waste is disposed of. A set of pictures presented earlier in Exhibit 4.1 attempts to bring out the nature of the waste. Prima facie there is less putrescible kitchen waste and more coal ash, debris, dry vegetation, tender coconut shells, etc., which do not appear to be very suitable for composting. Likewise, small-scale biogas plants as a treatment option at the local level are also ruled out.

4.24 Because of limited resources the ULB is able to lift the waste only once a week. Six trucks deployed for the work visit each ward on average once a week. Under the proposed project, disposal of the waste will entail transport from this ULB over a distance of 12-15 km to Asansol and then a further 5-7 km to the new site identified for the treatment plant. The ULB, given its weak financial position, has expressed concern on meeting the associated transport costs as well as the tipping fee. Secondly, the ULB does not appear to be up-to-date on project development and inter-municipal agreement aspects.

**Jamuria Municipality**

4.25 Jamuria Municipality was formed in 1995 by amalgamation of 22 different villages/ panchayats. As a result it also appears to be primarily an agglomeration of rural settlements, which are widely spaced. As a result the total area of the ULB is rather large at 79 sq.km. Total current population of the ULB is estimated to be over 1.41 lakh.

4.26 Given the rural setting and poor socio-economic profile of the population, door-to-door collection and source segregation are prima facie found to be rather challenging tasks. Likewise, secondary collection is weak, typically carried out once a week from the 200 odd concrete bins, which have been constructed during the last year. At these roadside bins, the presence of coal ash, inerts, and debris is generally found to be high while the compostable material is found to be low. This could be attributed to the less wasteful rural society as well as rummaging by cattle. Considering the waste characteristics and generation pattern, a decentralized small-scale biogas plant as a treatment option is not found to be feasible.

4.27 Distance from different parts of the rural agglomeration to the proposed sanitary landfill site at Mangalpur varies from 7-9 km. Apparently the municipality is rather proactive – it has initiated a public awareness campaign with the help of the municipal council chairman and councilors, ward committee members, etc., and has also adopted a resolution to send its waste to the Mangalpur SLF site.

**Raniganj Municipality**

4.28 Raniganj Municipality is the closest to the proposed SLF site at Mangalpur. Being on the railway line, it serves as a regional hub for travelers from the surrounding villages. It also appears to have a fairly thriving regional commercial and trading centre.

4.29 A set of pictures of waste collection points from Raniganj town is presented in Exhibit 4.3. They bring out the current practice of disposal of household and commercial waste along with the drain silt at the roadside collection points. It is apparent that segregation has not been attempted or was perhaps found to be rather difficult to achieve. Given the nature of the town and the socio-economic setting, source segregation is indeed a rather challenging task. Currently the mixed waste is dumped near the Mangalpur site and thus the municipality would not incur any extra cost for transporting the waste once the project is commissioned.

**EXHIBIT 4.3: DRAIN SILT MIXED WITH MSW**

**Community participation and awareness**

3.30 The concerned ULBs do not appear to have the capacity to carry out a public awareness campaign for the proposed integrated solid waste management project. In none of the ULBs has a formalized campaign been initiated. Similarly those communities which are likely to be exposed directly, e.g., due to location of the treatment plant, routing of the waste laden vehicles, etc., do not appear to be fully informed about possible benefits or implications. For instance the communities in Mohishila ward of the Asansol Corporation and Sankapur village in Durgapur, which are along the roads that will be used for transporting waste to the compost plants, are not yet aware of the likely adverse impacts it could have on their day-to-day activities. It would lead to increased traffic movement with a frequency of one vehicle every five minutes on a narrow and worn out road. This will pose a safety risk particularly to children as well as cause pollution due to vehicular emissions, dust from the roadsides and odor from the payload.

**Role of the NGOs**

4.31 Prima facie there are very few NGOs working in the project area in general and particularly on the subject of municipal solid waste management. Only one informal group, viz., 'Polluclean', has been working on a voluntary basis in one ward of Asansol on door-to-door collection of solid waste. However, its capacity to address issues related to community awareness, training of workers, mobilizing waste service providers, etc., appears to be limited and currently focused on one ward. Furthermore, the role and participation of other NGOs with the ULBs on this subject is almost non-existent.

4.32 One of the highly respected civil society organizations, viz., Ramkrishna Mission, has a branch office in Asansol where it runs a school and a vocational training institute. Preliminary interaction with the Mission brought out its interest in working on the subject of urban solid waste management, particularly on the issue of community awareness and participation. However, the Mission itself is not aware of the formulation and development of the integrated solid waste management project and its imminent implementation in the Asansol Urban Area. Likewise, there is a women's group called 'Mahila Sangha' which is located in the IISCO township of Asansol and provides training on livelihood skills to the underprivileged women. This organization also does not appear to be aware of the project and has not considered covering the issues related to solid waste collection in the township. For instance, as already shown earlier in Exhibit 4.2, the horticulture waste (dry leaves) in the IISCO township is typically burnt on the road sides, while this relatively uncontaminated feedstock can very well be collected separately and composted on a small scale decentralized level. This could as well be positioned as a livelihood generation activity wherein the leaf mould can provide sustainable income for the NGO workers.

**Stakeholder participation**

4.33 In Asansol, Durgapur and Kulti there are a number of PSUs. They have sizable employee townships, which are going to be benefited from the project as a result of improved public health conditions in respective habitations. Currently waste management and disposal in several townships is carried out by the respective PSU administration. In due course the responsibility for secondary collection, transport and disposal is likely to shift to the respective ULBs. Thus on the whole, the PSUs and their employees are going to be benefited. However, it is found that involvement of these major institutional stakeholders is not yet structured into the project planning process. Apparently they can play a constructive role and be active partners in different stages of the project.

**Solid waste workers and transporters as stakeholders**

4.34 The municipal solid waste workers and transporters play the most crucial role of delivery of the feedstock to the treatment plants and SLF. If the delivery logistics are to be streamlined and the plants or the SLF are to get assured quality and quantity of feedstock, then these groups of workers must be considered as important stakeholders. Experience from Lucknow and Trivendrum treatment initiatives shows the critical role played by these groups. They must perceive certain stakes and derive commensurate benefits, tangible or intangible, such that they extend all cooperation during the operational phase of the project. As of now, it is understood that the project has not undertaken any sensitization and awareness creation activities to address these groups of stakeholders.

**Industries in Mangalpur area**

4.35 On the same lines, there are a number of medium and large-scale industries located near the proposed SLF site at Mangalpur. Should there be significant yield of landfill gas, a few of these industries could be potential stakeholders as they can consume the gas to meet part of their energy requirements at a comparatively lower cost. However, this will depend on the quantity and quality of the landfill gas and its availability over the life of the landfill.

**Steering of the project**

4.36 As of now the project development appears to be steered through individual initiative and leadership at the ADDA and DMC levels. However, stability at these positions is not certain. Secondly, it appears that the project monitoring committee, which under the aegis of ADDA has been taking the project forward, has not been able to get adequate participation from all the municipalities. For instance AMC has not been able to provide proportionate inputs while Kulti Municipality appears to have been left behind during the project development process.

## 5. RISK FACTORS RELATED TO COMPOST PLANT

5.1 While the issues related to quality and marketing of compost have been described under the section on ‘findings of the field visit’, this section brings out a set of risk factors related to the technology of composting proposed in the DPR.

### Odor emissions from windrow processing

5.2 The project proposes to adopt the windrow composting method for treatment of mixed municipal solid waste. Windrow composting as typically practiced in India comprises a four phase process of (a) prolonged rotting of mixed solid waste, (b) separation of non-degradables, (c) curing/maturing of compost, and finally (d) grading of finished product according to particle sizes.

5.3 The first phase of rotting involves staking of mixed municipal solid waste in long rows (20-30m long) - 2m wide and 1.5-3m high. Over a period of 3-4 weeks the waste is allowed to decompose, while the process is accelerated by turning the waste once a week from the outside to the centre. The turning is essential and carried out with multiple objectives of: (a) exposing the waste in the centre to atmospheric oxygen, thereby accelerating its decomposition, and (b) bringing the outer layers to the core where temperature build-up over the next week (>55°C) enables pathogen destruction. In the second phase, the decomposed material is screened for removal of contraries, large objects, etc., which constitute the rejects and need to be safely disposed of into a sanitary landfill. This is followed by a curing phase for about 4 weeks where the partially stabilized waste is again staked in 1m wide x 1m high rows typically 20-30m long. Regular turning during this phase helps in rapid stabilization and maturing of compost. A subsequent phase involves multiple screenings for grading into typically 4 mm particle size finished compost.

<u>Odor nuisance potential</u>

5.4 There is an inherent risk of odor nuisance associated with any composting technology and more so with the windrow technology. This is particularly so because windrow technology is a low energy input technology and it does not have the feature of containing and treating the odorous gases, which are invariably emitted during the rotting of the waste. This feature of the composting plants often draws objections from the habitations in the vicinity. In the case of the Thane composting plant, because of this reason alone, it had to be completely dismantled under court intervention. Likewise there have been several cases across the world where this kind of situation has arisen. Though the proposed locations in Asansol and Durgapur are away from habitations, future trends and directions of urban growth cannot be predicted. In the case of Durgapur the location is more vulnerable as the separating distance from DSP Township and Shankarpur is not very large. Moreover, depending on the predominant wind direction, one of the habitations can be severely affected.

Limited processing period

5.5 The DPR considers a processing period of 20 days for the first phase of rotting in windrows. This may not be adequate for a typical unaccelerated process. Furthermore, in case of overloading, slow reaction rates in monsoon and winter, and under emergency situations, there would be virtually no margin to absorb the spillover. While the expected waste loads are higher than the quantities committed for delivery at the plant gate, waste from Kulti is also proposed to be sent to the Asansol plant, which will put extra load on the proposed infrastructure. Overloading may very likely lead to anaerobic conditions, which would certainly cause odor problems and may emerge as a risk factor for sustained operations of the plant.

**Likely objections to high vehicular movement**

5.6 Transport of waste to the Asansol treatment plant through Mohishila locality may invite objections from the community. Likewise, in Durgapur the compost plant would involve passage through Bidhan Nagar and Sankarpur village. Upon realizing the adverse impacts, the respective communities may start objecting to heavy movement of vehicles.

**High replacement costs of treatment plant**

5.7 Solid waste treatment plants in general are subjected to high wear and tear due to the presence of abrasives, e.g., sand, grit, ash, glass, metal objects, etc. On top of that, they are also subjected to high corrosion due to the acidic conditions created by rotting of waste in the presence of moisture. Therefore the general experience is that there is high repair and maintenance cost involved in day-to-day operations, and once in about 5-7 years the equipment needs to be replaced. On the whole this translates into high operating and life cycle costs.

5.8 In the case of Asansol Urban Area MSW management project, the probability of wear and tear and corrosion is high as the sand, ash, drain silt and stone fraction is found to be over 25% and rainfall is also reported to be fairly high at 1300 mm/annum. In the case that revenue from operation of the plants including tipping fee is not attractive enough and provision for depreciation is not adequate, there will be a tendency on the part of the operator to avoid replacement of the equipment when it is due. Under such an eventuality the plants may under-perform and mixed waste would have to be diverted to the sanitary landfill. At this stage there is a possibility of a conflict between the operator and the ULBs as the waste stream being diverted to the landfill may not pass the prescribed test for inerts.

**Lack of pre-processing operation**

5.9 Typically the treatment scheme adopted in India does not involve any form of processing of mixed municipal solid waste prior to its rotting in windrows. The large non-degradable objects and other contraries as well as potential sources of toxic compounds are not removed. Plastic bags containing biodegradable kitchen waste are also not torn open and as result a fair fraction of useful feedstock goes out of the system at the end of the treatment scheme. Size reduction and adjustment of the carbon to nitrogen ratio is also not attempted, which on the one hand leads to production of poor grade compost and on the other causes odor problems.

## 6. COMMENTS ON THE LANDFILL

6.1 There are certain issues related to the technical features of the landfill, which need to be further defined and specified in the DPR. These pertain to leachate treatment, gas collection system, flaring arrangement, etc. These are briefly listed in this section while a detailed discussion in the context of the Concession Agreement is presented in the next section.

### Leachate treatment

6.2 The DPR envisages a simple treatment scheme for landfill leachate comprising a combination of a sedimentation tank and an aerated lagoon. However, considering the complex nature of the leachate, which is characterized by high dissolved solids, toxic substances, dark brown color, high chemical oxygen demand, etc., the proposed treatment scheme may not be adequate to comply with discharge standards.

### Gas collection and flaring

6.3 The DPR considers landfill gas collection through a passive venting system. However, it does not spell out the accompanying pipe network and flares required to dispose of the gas. In view of the fact that the SLF site comprises an overburden dump of recent origin and the large-scale industries in the vicinity, risk of landfill gas migration and, consequently, probable damage to adjacent properties must be ascertained.

## 7. COMMENTS ON THE CONCESSION AGREEMENT

7.1 The Concession Agreement is a very comprehensive and well-structured document. It has covered all aspects of the project adequately and unambiguously, defining the responsibilities, powers and obligations of various parties concerned with the project. However, there are certain areas, which need to be elaborated, clarified or reviewed from the point of view of enhancing the sustainability of the entire intervention, particularly related to institutional and technical aspects. These points are briefly described in the paragraphs that follow, and the recommended modifications are also provided alongside.

### Payment to the Project Engineer

7.2 While the Project Engineer is mandated to monitor the activities and performance of the Concessionaire, as per para 4.2 (a), payment of professional fee to the former is proposed to be made by the latter. This arrangement is not in line with the true spirit of impartial monitoring and reporting of execution and O&M of the project. The Project Engineer needs to be made independent of the Concessionaire in order to be able to objectively carry out the mandated tasks of monitoring. Considering the client-consultant relationship between the municipalities and the Project Engineer, ideally the payment of professional fees to the latter must be made by the consortium of the ULBs.

### Payment to the Concessionaire

7.3 The proposed institutional structure among the ULBs and its relationship with the Concessionaire requires the latter to raise a monthly invoice for tipping fee individually to each of the five ULBs. This requires the Concessionaire to deal with five different clients for generating its regular revenue. While the perceived inherent advantage of this arrangement is higher involvement and accountability of each of the ULBs, it also has a downside from the point of view of the Concessionaire. The uncertainties involved in collection of revenue from small ULBs and the efforts required to follow up with five clients separately can serve as a disincentive for the latter. Instead, a mechanism must be evolved to create a corpus with proportional contributions from all the ULBs to an escrow account such that the payment against invoices from the Concessionaire can be released through a single window.

### Environmental compliance

7.4 As per para 5.10, the Concessionaire is supposed to comply with all relevant environmental laws for emissions, discharges, etc., arising out of the construction and operation of the waste treatment and disposal facilities. The Concessionaire is also expected to carry out an environmental impact assessment of the proposed set of interventions. However, mandating this responsibility on the Concessionaire is not in line with the true spirit of objective environmental due diligence, which should generally be carried out prior to the implementation/execution phase of any typical infrastructure project. By the time the work is awarded to the Concessionaire, the contours of the project, including the technical specifications and the financials, would have been frozen and at that stage it would be rather late to incorporate any possible remedial measures.

7.5 While the Concessionaire is required to comply with the environmental rules, etc., the technical specifications for the processing technology, viz., the 'windrow composting', do not offer any inherent odor control feature. Experience from other plants based on the same technology shows that odor nuisance is unavoidable and there is a need to opt for improved technical specifications. In this regard it would be desirable to specify for the Concessionaire the additional technical feature of external continuous aeration coupled with a bio-filter (together they are called 'static aerated pile composting', see Appendix I), which will minimize the odor emissions and make the environmental footprint of the plants more acceptable to the surrounding community.

**Processing facility**

7.6 As per clause 5.13(a), the Concessionaire is permitted to adopt 'such processes and methods as it considers necessary and expedient for processing at the project facilities subject to meeting the construction and O&M requirements as laid out in Schedule 2'. Schedule 2 suggests conventional windrow composting method, however, it does not specify installation of a pre-processing unit, external aeration system for accelerated degradation in aerobic (and therefore odor free) conditions, and bio-filter for odor control. As stated earlier, strong odor emission from windrow technology plants often leads to problems with the surrounding community.

7.7 On the same point it is pertinent to highlight the condition laid out in clause 4.1 of Schedule 4, which permits the Concessionaire to adopt any such process and/or method, which it considers necessary for processing of municipal solid waste in order to ensure that the compost thus produced is certified as being fit for sale, corresponding to a given quality criteria. This is an output-based criterion, which does not stipulate any precautionary measures for the process per se′, i.e., related to odor control. Furthermore, while the DPR and the Concession Agreement do not expect large revenue from the sale of compost anyway, specifying process performance entirely relating to the product being 'fit for sale' is not compatible with the expected environmental footprint of the plant.

7.8 In order to overcome the odor related potential risk factor, it is desirable to include the three components/features of pre-processing, external aeration system, and a bio-filter in the suggested scheme of composting of mixed municipal solid waste. As a result of these inclusions the plant would have inherent pollution control features built into its design, which would enable the operator to comply with the stipulations of the MSW Rules 2000, as well as with the relevant rules under the Environmental Protection Act. Eventually this set of improved features would make the plant more innocuous and acceptable to the surrounding community and avoid any chance of confrontation during its operational life. Accordingly, it would be desirable to make necessary modifications in section 5 of Schedule 4, which specifies the 'Mandatory Facilities' for the processing plant.

**Capacity of the processing plant**

7.9 Section 2.2 of Schedule 2 specifies minimum capacities for the three compost plants proposed under the project. In relation to the specified minimum, the average and the projected loads are summarized in Exhibit 7.1 below.

**EXHIBIT 7.1: EXPECTED WASTE LOADS AND SPECIFIED MINIMUM CAPACITY OF COMPOST PLANTS**

| Plant location | Cities served | Estimated generation in 2006 (MT/d) | Projected generation in 2013 (MT/d) | Expected arrivals on commissioning (MT/d) | Minimum specified plant capacity (MT/d) | Deficit with projected generation (MT/d) |
|---|---|---|---|---|---|---|
| Asansol | Asansol and Kulti | 200+130 = 330 | 211+138 =349 | 200 | 170 | 179 |
| Durgapur | Durgapur | 224 | 249 | 200 | 120 | 129 |
| Mangalpur SLF | Raniganj and Jamuria | 50+58 =108 | 55+58 =113 | 60 | 60 | 53 |
| | Total | 662 | 711 | 460 | 350 | 361 |

7.10 Ideally the plants' capacities need to be based on the expected average loads with scope for absorbing the peak load for the design year. However, here the approach of specifying the collective minimum capacity (350 MT/d) has been adopted in view of the uncertainty involved in collection and delivery of the full or average loads and from the point of view of minimizing the fee which the Concessionaire is eligible to claim from the ULBs in case of shortfall.

7.11 Nonetheless, there is a need to distinguish between the guaranteed minimum quantity to be delivered by respective ULBs to the compost plants and the normal and peak capacity of the plants. This is relevant and important in order to avoid: (a) overloading of the plants and, as a result, a probable breakdown of equipment, or (b) large accumulation of waste at the plant sites as a result of distress dumping, which will eventually cause unavoidable odor emissions from the rotting, accumulated and unprocessed waste. The latter can further lead to objections from the surrounding communities, if any, which can precipitate into undesirable situations.

7.12 This issue can be addressed by allocating adequate area for the receiving and windrow sections of the plants corresponding to expected average/peak loads, while the machinery section can be designed according to the average loads.

Disposal of remaining waste

7.13 It is seen from Exhibit 7.1 that the proposed treatment capacity is below the current and projected generation and expected arrivals. The combined deficit with respect to the projected generation in the year 2013 is found to be almost the same as the combined proposed treatment capacity. This quantity of waste, if collected, would continue to be disposed of either at the existing open dump sites or will accumulate at the respective treatment plants. As a result, this will undermine the expected public health benefits that are to come out of the proposed project. Ideally this remaining or surplus waste should be safely disposed of in the same sanitary landfill site and appropriate mechanism for its transport to the SLF must be spelt out.

**Waste characteristics**

7.14 While the treatment process and minimum capacitates for the plants have been specified, the Concession Agreement is missing an important aspect, which is the representative set of characteristics of the feedstock for which the plants need to be designed. The DPR has included a set of data, which is representative of the region and not specifically from the project area. In the absence of feedstock data, the bidders may find it difficult to adopt an appropriate design for the pre-processing, processing and post-processing sections of the proposed compost plants. In view of this, it would be desirable to provide a representative set of waste characteristics data including, if need be, appropriate caveats for cross checking, validation, etc.

**Compensation to the operator**

7.15 As per Article 6.1, clause (b), the ULBs are liable to pay a penalty at the rate of 20% of the tipping fee for each metric ton of shortfall of mixed MSW. This condition assumes that the rejects would in general be about 20% of the raw waste. In actual practice, however, this is found to be between 30-40%. In the event of consistent shortfall and higher average reject percentage recorded at the treatment plants, there is a possibility of likely disagreement between the operator and the ULBs emerging as a potential risk factor.

**Compost quality**

7.16 Under clause 4.2 of Schedule 4, quality of compost is specified from the point of view of its suitability for agricultural (food and non-food crop) application. In the specified criteria, the C:N ratio for the finished compost is stated to be between 20-40. However, this range corresponds to the typical raw mixed municipal solid waste (generally above 35) and is way above the generally desirable value for a matured sample of compost (generally ≅ 12-15). Accordingly a correction would be required in the specified criteria.

7.17 Likewise in the same section, the particle size of the finished compost is specified to be 14 mm, which is rather high. Typically the final product corresponds to a wire mesh of 4 mm, which is more acceptable by a wider section of the eventual end users. It would be desirable to make corrections accordingly.

**Disposal of recyclables**

7.18 As per para 5.13 (b), the ‘Concessionaire is free to dispose of the recyclables using …. such strategies as it may deem appropriate subject to meeting the O&M requirement’. This condition may offer a degree of freedom to the Concessionaire to dispose of the recyclables indiscriminately in case there are no takers/buyers for them. In such a situation, one might encounter unaesthetic and unhygienic conditions as a result of accumulation of apparently recyclable material outside the processing facilities.

7.19 In order to avoid such a situation from developing, it would be desirable to specify in the Concession Agreement that the recyclables would not be allowed to accumulate on the processing plant site beyond a certain time limit and beyond a certain quantity.

**Leachate treatment at the landfill**

7.20 Under section 2.7 of Schedule 3, while the leachate collection and removal system at the sanitary landfill is described, the component of leachate treatment is apparently not included. As per the DPR it is one of the important and essential components of the proposed SLF system and therefore needs to be included in the specifications appropriately. The leachate treatment method need not be defined (as per DPR it comprises sedimentation followed by an aerated lagoon, which may not be sufficient), instead the effluent discharge standards should be specified. The same set of specifications as provided in Table 4.3 ‘Schedule 4: O&M requirements for the waste processing facility’ should be adopted.

**Gas recovery and greenhouse gas mitigation system**

7.21 Under section 2.8 of Schedule 3, the specifications provided for the landfill gas recovery and greenhouse gas mitigation system only cover the topsoil layer of 200 mm. However, ideally this section should also categorically specify the gas collection piping network, active withdrawal system, and provisions for flaring with a standby flare. This would be required to prevent direct emissions of methane, a potent green house gas, into the atmosphere and also to prevent its migration, which has a probability of causing structural damage in adjacent properties.

7.22 Likewise under section 5.7 of Schedule 5 there is a need to specify O&M of the gas collection and flaring system to make it conform to the above-suggested modifications in the corresponding section of Schedule 3.

**Leachate and gas migration observation wells**

7.23 Over the life of the sanitary landfill, notwithstanding the leachate and gas collection systems, the leachate and landfill gas are expected to migrate beyond the site. Experience from landfills from other countries has been along these lines. In order to monitor and check the possible migration, it is desirable to provide monitoring wells around the SLF for both the leachate and the landfill gas. Accordingly, the Concessionaire must be made to evolve and follow a monitoring and sampling program during the operational and post closure stages of the SLF. Accordingly appropriate clauses need to be inserted in Schedule 3 and Schedule 5, which pertain to construction and O&M of SLF, respectively.

**Vehicle and tyre wash facility**

7.24 Vehicle and tyre washing facilities are required from several points of views. First, they help in removing corrosive substances and thereby lengthen the life of the vehicles. Secondly, a tyre washing facility will minimize the adverse footprint of the vehicles on the city roads and the National Highway on which they will ply to dispose of the waste to the SLF. Thirdly, washing will also reduce the odor problem from the empty vehicles, which is very repulsive. Finally, overall improved aesthetics will help in projecting a better image and thereby enhanced acceptance by the general public. The effluent from this section could be sent to the windrows or could be treated in the respective leachate treatment plants.

## 8. COMMENTS ON RFP DOCUMENT

8.1 The RFP document includes the Draft Concession Agreement as one of its annexures, which provides all the necessary technical information pertaining to construction and O&M of the various treatment and disposal facilities. Guidelines and formats for the technical proposal are provided for bidders to submit information in a structured way.

8.2 Considering that the 'Tipping Fee' quote, which is the singular criteria for evaluation of bids, is a function of life cycle costs of the entire project, it would be desirable to seek information on the methodology adopted for its computation. In order to maintain consistency with the specified project components and service delivery obligations, it may be desirable to provide broad guidelines to the bidders on preparation of the financial proposal as well. This will ensure that all the bids have included all the lifecycle costs (capex, opex and replacement costs of all the four phases) of the project and there are no exclusions in any apparently lower quotations. This will prevent any possibility of future disagreements with the Concessionaire.

## 9. FACTORS FOR DIFFERENCE IN PROJECT COSTS AT DRAFT AND FINAL STAGES OF DPR

9.1 It is understood that the estimated cost of the project at the final DPR stage is higher by around 20% compared to that at the draft stage. The reasons attributed for this difference are as follows:

a. The final DPR involved two compost plants of 200 MT/d rather than a single plant of 400 MT/d, which was envisaged in the draft report. Provision for two smaller plants with relatively higher unit capital costs led to an escalation of about Rs. 2.2 crore.
b. The final DPR estimates had to be developed as per the JNNURM guidelines on 'bill of quantities' basis rather than on block rates as was done in the draft report. It is understood that the unit rates as prescribed in the West Bengal Schedule of Rates of the Public Works Department are found to be generally higher as compared to other states.
c. In order to align the project implementation with the JNNURM timeframe and its specifications, it was made mandatory to include the cost of capping of the first phase (5 years) of the SLF, which was not provided for in the draft report.
d. The development of the SLF over four phases of 5 years each and the requirement for capping of each phase entailed provision of separating dykes/embankments between the phases. Construction costs of the intermediate dykes were to be revised in view of the higher design and performance specifications.

9.2 At this stage it is pertinent to mention that the final approved project cost, which stands at Rs. 43.57 crore, does not yet include the cost of: (a) the third compost plant proposed at the SLF, (b) landfill gas recovery/collection and flaring system, (c) pre-processing units for the compost plants, and (d) storage godown for the finished compost.

## 10. SUMMARY OF RISK FACTORS

10.1 Based on an analysis of various facets of the project as presented above, a summary of the risk factors is presented in Exhibit 8.1. Key issues are classified under 'technical aspects', 'Concession Agreement and RFP document', and 'other aspects of MSW management', respectively, which are listed below.

### Technical aspects

Location of the plants

10.2 Narrow passage for waste laden vehicles through some habitations and proximity of compost plants to other habitations are of concern as the communities could object to inconvenience due to increased traffic and the resulting odor nuisance.

Waste quality and quantity

10.3 The plant designs are based on limited secondary waste characteristics data. Representative quality data based on a primary field survey is apparently not available. High presence of inerts and coal ash and less organic waste could impact performance and the life of compost plants.

10.3 Wide gap of almost 350 MT/d in the estimates for generation and collection in the entire project area is an issue to be addressed appropriately. The aggregate treatment plant capacity is provided corresponding to the quantity estimated to be collected, leaving the balance to be disposed of as per current practices at the existing open dumps. This may not help in achieving the desired public health goals in the project area.

Collection and transport

10.4 Weakness in collection and transport systems would impact on the quality and quantity of the raw material reaching the compost plants and their performance. This could be related to inadequate capacity for transport of segregated waste, different agencies involved in the supply chain with differing priorities, unforeseeable restrictions on traffic movement, high wear and tear of vehicles and lack of ULB capacity for timely replacements, etc.

Plant design

10.5 Main issues pertain to lack of pre-processing, potential odor emissions from windrow technology, plant wear and tear and inadequate process monitoring system. Another major concern is the low plant capacity, which is pegged at around 50% of the estimated quantity of generation in respective catchments. This may lead to accumulation of waste, overloading of the plants, disagreement with operator in case he declines to receive excess loads (only 25%

excess loads are allowed) and distress dumping by the ULB vehicles on the outside of the plants.

<u>Plant operation and maintenance</u>

10.6 Because of high presence of abrasives and corrosive material, repairs and maintenance costs and replacement costs are of concern over the life cycle of the compost plants.

**Concession Agreement and RFP document**

10.7 In the Concession Agreement, issues that need to be addressed appropriately to minimize possibilities of disagreement with the operator are related to:

(a) proposed modes of payment to the project engineer and the operator
(b) inadequate compensation in the event of shortfall in delivery of waste
(c) inadequate gate fee/tipping fee, and
(d) difference in minimum plant capacity and the expected waste loads.

10.8 In the case of the RFP document, the issues that need to be addressed are related to lack of:

(a) guidelines for consistency in preparation of financial bids
(b) financial modeling of expenditures and revenues over the life of the project, and
(c) a reliable estimate for the tipping fee to serve as a benchmark.

**Other aspects of the project and MSW management**

<u>Project development</u>

10.9 Issues, which could be of concern, pertain to:

(a) lack of stakeholder and public participation, and
(b) project preparation apparently being accelerated by the need to comply with JNNURM deadlines and guidelines.

<u>Administrative aspects</u>

10.10 The project has benefited from strong leadership and stability provided by ADDA and the mayors of DMC and AMC. However, with frequent administrative and political changes, this level of stability may not be assured during the implementation and operational phases. Secondly, the role of smaller ULBs in steering the project forward has been limited.

Lack of environmental and social due diligence

10.11 Project development has not been backed by due diligence on environmental and social aspects. There could be hidden factors pertaining to potential adverse impacts on air and water quality, aesthetics, and social issues. In case severity of such impacts is high, these could be of concern for the operator as well as for the administration.

Capacity of the ULBs

10.12 Finally, MSW management goes beyond technical matters and requires a deft handling of diverse issues related to public relations (awareness and participation), dissemination of relevant information, stakeholder participation, managing local media, joint working in a regional format, etc. Lack of capacity within the ULBs on these matters can emerge as an issue over time.

Market for compost

10.13 It is acknowledged that the market for compost is limited in the project area. Thus the compost plants may not see positive revenue and the produced compost may accumulate. The operator may not have incentive for running the entire process.

**Insert Exhibit 10.1 (3 pages) from excel file.**

## 11. OPTIONS FOR METHANE CAPTURE

11.1 The preceding chapters have analyzed diverse issues and risk factors related to the proposed scheme of MSW treatment and disposal in the Asansol Urban Area. In view of the underlying risks emerging there-from, this chapter attempts to explore another paradigm for an alternate long-term sustainable solution, which pertains to methane capture.

11.2 Methane is a potent greenhouse gas. Decomposing solid waste (either in indiscriminate open dumps or well developed sanitary landfills) emits large quantities of this gas into the atmosphere. Because of this reason the subject of municipal solid waste has come into focus under the ongoing 'Methane to Market' program of the USEPA and the UN's 'Clean Development Mechanism' of the Kyoto Protocol to mitigate greenhouse gas emissions. As a result of these bilateral and multilateral programs, such mitigation initiatives can also take advantage of unconventional revenue streams arising from the sale of possible 'carbon credits'.

11.3 Broadly there are the following four options for methane capture under a typical solid waste treatment and disposal project:

- Centralized anaerobic digestion (biomethanation) system
- Decentralized anaerobic digestion systems
- Sanitary landfill, and
- Bioreactor type sanitary landfill.

11.4 Each of these options along with their pros and cons is analyzed in the sections that follow. Another set of options, which prevents formation of methane generating conditions, comprises mass burn and 'refuse derived fuel'. However, because of their inherent technical limitations, experience from unsuccessful pilots under Indian conditions, and subsequent restrictions imposed by the Supreme Court of India, they are not included in the current scope of analysis.

### CENTRALISED ANAEROBIC DIGESTION SYSTEM

11.5 A centralized anaerobic digestion system is typically designed for a treatment capacity of 30 to 50 MT/day or even higher corresponding to a large city or a group of smaller towns. It entails collection of a large quantity of fairly segregated organic waste and transportation to a central location, pre-processing and then digestion in a reactor under oxygen free conditions. The reactors are generally based on a 'low dry solids' (slurry as the feedstock) process, as that technology is more commonly available. However, advanced technologies based on ‘high dry solids’ content have also been developed, but they are found to be significantly higher in terms of construction specifications, operation requirements as well as capital costs. In general, anaerobic digestion offers the following advantages:

- Volume reduction
- Waste stabilization
- Production of compost/soil conditioner, and
- Possibly, net energy generation.

11.6 Anaerobic digestion reactors can be designed to operate at either of two distinct temperature ranges. The first range is called mesophilic, which is between 30-38°C and the second is called thermophilic, which is around 55-56°C. The higher temperature conditions entail higher energy input into the system, but offer the benefit of a faster process. This also means higher operating costs as well as superior specifications for the reactors on account of pre-heating and insulation requirements. Under Indian conditions, the mesophilic range has been widely adopted for field applications for cattle waste treatment. It is argued that underground reactors are adequately insulated and thus neither external energy input during pre-processing nor elaborate insulation is required. On this premise, a large number of cattle waste-based biogas plants have been constructed across the country. However, their performance with widely varying diurnal and seasonal temperatures has not been found to be reliable.

11.7 Anaerobic digestion has been commercially proven for homogeneous organic waste either in liquid or solid form, e.g., waste from distilleries, abattoirs and food processing industries. However, its application for municipal solid waste treatment has been attempted during the last 2 decades and has been found to be a highly challenging proposition.

**Technical risk factors in anaerobic digestion**

11.8 ‘Low dry solids’ process-based anaerobic digesters typically maintain a solids concentration of 8-10%, which means that feedstock preparation requires the addition of a large quantity of water at the outset to convert solids into slurry form - which is then easier to handle. However, this also means that the reactors need to be sufficiently large to accommodate the additional volume of water. Secondly, addition of cold water, especially during the winter season, adversely affects the heat balance of the reactor. Thirdly, this also entails dewatering of the digested material at the end of the treatment process. All these features translate into higher capital and operating costs and energy inputs during operations.

11.9 In order to efficiently condition the microbial process, temperature fluctuation in the reactor must not be more than ±2°C from the specified range of 35-38°C. However, 'low dry solids' mesophilic process-based uninsulated reactors invariably experience process disruptions due to wide variations in diurnal and seasonal temperatures. Resuming normal operations typically takes between two to three weeks, which a large-scale commercial facility cannot afford.

11.10 The anaerobic digestion process is also very sensitive to toxicity and, therefore, segregation of solid waste at source and care during feedstock preparation become very crucial. Secondly, pre-processing equipment is not robust enough to withstand wide vitiations in composition of the mixed municipal solid waste and is unable to consistently deliver satisfactory output of biodegradable fraction. Plastics, sand, ash, grit, construction debris, etc., cause severe problems in the functioning of the system, e.g., clogging, blockage, wear and tear, etc., of the moving machinery and reactors. Secondly, fluctuation in feedstock quantity is also known to disrupt the microbial process and, in case of large-scale plants of 200-300 MT/d capacity, there is no guarantee of consistently receiving the required quantity of specified quality of waste. Failure during the last 5-7 years of the two large-scale MSW plants at Lucknow and Chennai is prima facie attributed to, among others, the above reasons.

11.11 Other risk factors associated with large-scale anaerobic digestion facilities are odor emissions, corrosive nature of the biogas, and its inconsistent calorific value. Control of odor emissions requires a robust ventilation system and an elaborate bio-filter, however these are often excluded due to capital and operating cost considerations. The resulting adverse environmental footprint invites protests from affected communities, which often lead to closure of the plant. The biogas, which is available from an anaerobic reactor, leads to corrosion of the plant, equipment, engines and surrounding public and private properties. Appropriate treatment for biogas entails additional capital and operating costs.

11.12 When it comes to biogas utilization for electricity generation, the indigenously available duel fuel engines, which are used in this process, entail regular procurement of diesel as the auxiliary fuel – translating into higher operating costs. The gas engines brought from overseas on the one hand are found to be expensive, and on the other, necessary spares and skilled manpower required for repairs and servicing are not available indigenously. These engines offer a conversion efficiency of 22-25% without cogeneration, and around 65-70% under the cogeneration option. In most situations for MSW treatment, the option of cogeneration under the Indian context is not available and therefore the energy utilization efficiency is rather low. Considering 60% recovery at the pre-processing stage and energy utilization efficiency at 25%, the overall system efficiency comes to only 15% (0.6 x 0.25).

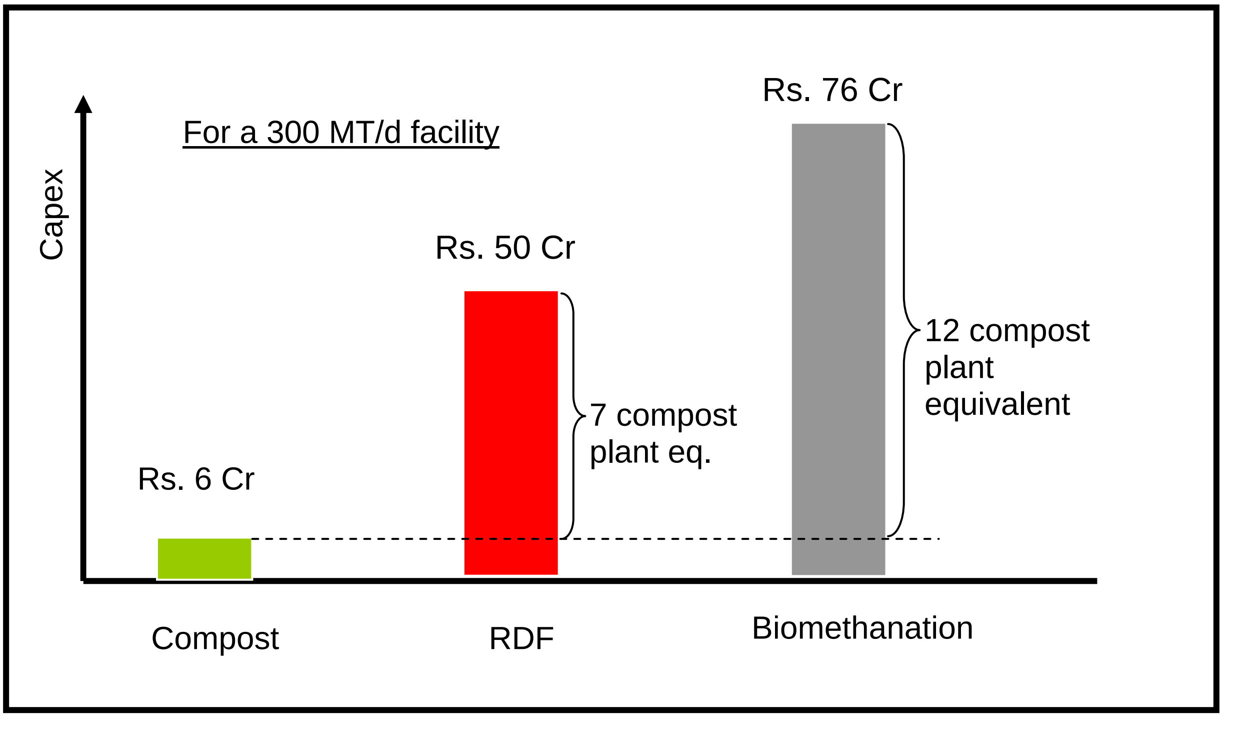
Thus, from the point of view of investment and the commensurate limited health and environmental benefits, an anaerobic digester type system is hard to justify.

**Other risk factors**

11.13 In view of a wide range of inherent technical limitations, it is understandable that the full-scale MSW biomethanation pilots at Lucknow and Chennai have failed. On top of these technical issues, there are institutional and financial issues, which further complicate these initiatives. For instance, sale of electricity and revenue realization from utilities has an element of uncertainty. Lack of an adequate premium on 'renewable energy' and an upper limit on installed aggregate capacity of renewable energy plants within a State that is eligible for fiscal/financial incentives are other constraints.

11.14 Lastly, from the point of view of capital cost, as shown in Exhibit 11.1, a biomethantion plant is found to be an order of magnitude higher than a compost plant of equivalent capacity. For instance, the Lucknow plant of 300 MT/d capacity involved capital expenditure of Rs. 76 crore (single reference value available) while a compost plant of the same capacity costs 15 times less, between Rs. 5-6 crore. The incremental benefit in the form of biogas and/or electricity would in no way be commensurate with the incremental capital expenditure of Rs. 70 crore. Therefore, from a capital investment point of view a biomethanation plant is also not found to be sustainable.

**EXHIBIT 11.1: COMPARATIVE CAPITAL COSTS OF THREE MSW TREATMENT TECHNOLOGY OPTIONS**



11.15 In light of the above discussion, it is recommended **not to consider** centralized anaerobic digestion (biomethanation) as an option for methane capture under the scope of the Asansol Urban Area Municipal Solid Waste Management Project.

**DECENTRALISED ANAEROBIC DIGESTION SYSTEMS**

11.16 Based on the plethora of limitations associated with large-scale anaerobic digestion plants, a school of thought has emerged which propagates small-scale reactors near the source of waste generation. These plants are typically of 5-10 MT/d capacity, which are located near habitations or bulk generators, e.g., hotels, hostels, vegetable markets, etc. Their capital expenditure ranges from Rs. 30 to 50 lakh for the above-stated capacity range.

11.17 It is argued that such an arrangement represents a relatively better option because it offers better control on feedstock quality and quantity, involves less cost on transport and allows use of biogas for thermal applications (higher efficiency option). However, experience from such selected initiatives in the country shows that a high degree of commitment is required from the concerned local body in terms of: (a) consistent delivery of feedstock of required quality and quantity, (b) providing a gate fee to the operator to meet the fixed operating costs, and (c) enabling arrangement for sale of biogas and manure, etc. On the part of the operator (micro-enterprises or NGOs, if any), the required commitment is in terms of providing reasonably trained manpower and acceptance of a modest profit, if any, for sustained working of the plant. It is well recognized that these operations are not profitable on their own and, perforce, need to be provided with appropriate fiscal and financial incentives.

11.18 Due to their proximity to habitations, small-scale decentralized plants also need to be carefully designed and operated to prevent odor nuisance. So far, only the 'NISARGRUNA' technology of the Bhaba Atomic Research Centre (BARC) has demonstrated its effectiveness in mitigating odor emissions. However, most other technologies have strong odor emissions and thus run the risk of being objected to by the host communities. Furthermore, as in the case of a large-scale reactor, a small-scale reactor is also sensitive to temperature variations, fluctuations in feed rate, toxicity, etc. In view of the unforgiving nature of the system, again a high degree of commitment on the part of the operator is required to prevent build-up of such undesirable situations.

11.19 Lastly, from the point of view of large-scale methane capture, small-scale anaerobic digesters do not have sufficient potential (at best 40-80 $m^3$/MT of feedstock) unless a number of them are combined under a particular project. Further, the Asansol Urban Area does not have the benefit of adequate capacity among civil society groups/NGOs who could extend the required commitment for operating such systems sustainably. In view of these factors and the fact that under the Asansol Urban Area MSW Project the feedstock quality cannot be guaranteed (characterized by presence of a high level of inerts and coal ash), the option of small-scale anaerobic digesters on a decentralized level is not considered appropriate.

**SANITARY LANDFILL**

11.20 A sanitary landfill is the most forgiving option when it comes to safe disposal of mixed municipal solid waste and achievement of the universal objective of safeguarding public health. It is not vulnerable to climatic factors, variations in waste feedstock quality and quantity, equipment malfunction, wear and tear and corrosion of critical equipment, etc. Its odor emissions are also greatly mitigated by deposition and compaction of daily soil cover and by following best operating practices. Anaerobic conditions under which the waste stabilization process takes place enable release of landfill gas at a subdued rate without deployment of any reactor, plant or equipment. Thus the landfill gas so produced can then be considered as a by-product, which may or may not be utilized for gainful application. A sanitary landfill operation does not involve any segregation, pre-processing, and then composting, but enables the waste in its 'as arrived' form to be safely deposited under a cover of soil. Based on the latest reference values available from various projects across the country, the unit capital cost of a sanitary landfill of 5-7 year life-span varies from Rs. 3-3.5 crore for a 100MT/d capacity (excluding cover and gas extraction system), while that of the Lucknow biomethnation plant for an equivalent capacity (of 100 MT/d) came close to Rs. 25 crore. Therefore, in the overall analysis, from the point of view of capital investment and resource recovery, if any, there are limited risk factors involved in a well engineered sanitary landfill as an option for methane capture. From that point of view, it can be considered as a dependable, robust and affordable option.

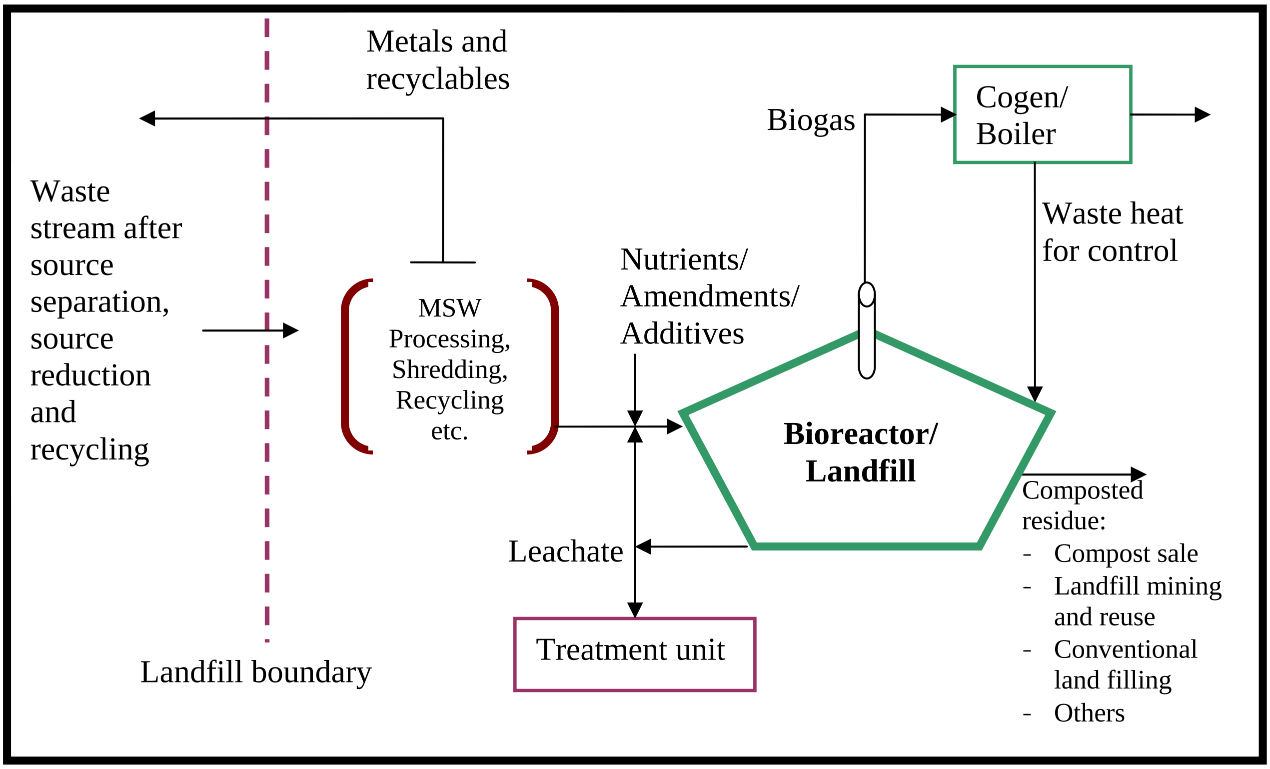
11.21 However, a sanitary landfill does not enable accelerated waste stabilization, maximum gas recovery, and possible recovery of stabilized waste as compost. From that point of view, a technology variant of a sanitary landfill has been developed, which offers enhanced benefits at incremental costs. This option is described in the section that follows.

**BIOREACTOR**

11.22 'A bioreactor landfill is a **sanitary landfill** that uses enhanced microbial processes to transform and stabilize the readily and moderately decomposable organic waste within 5 to 10 years of bioreactor process implementation' (*Pacey et.al*.). Ideally, it is preceded by some pre-processing operations, which involve separation of large non-biodegradables and inerts, shredding and blending of required nutrients/amendments, etc. Additional operations during pre-processing and the filling stage can comprise blending of MSW with readily digestible waste (e.g., sewage sludge, cattle waste, etc.), and recycling of leachate. Moisture content is the single most important factor that promotes accelerated decomposition of deposited waste and, therefore, the bioreactor technology relies on maintaining optimal moisture content in a range of 35 to 45% and, when required, the addition of water/wastewater from external sources to maintain that percentage.

11.23 Among others, these measures enable creation of optimum conditions for: (a) anaerobic digestion of the deposited waste and, as a result, significantly increased waste decomposition, (b) higher conversion to methane, and (c) process effectiveness compared to a 'dry' sanitary landfill. **The landfill gas thus produced during this process is a significant by-product, which enables maximum methane capture**. In view of these features, alternate terms used to define a bioreactor landfill system are 'controlled land filling', 'landfill methane enhancement', and of course 'anaerobic composting'. A schematic of a bioreactor system is presented in Exhibit 11.2.

**EXHIBIT 11.2: SCEMATIC OF A BIOREACTOR TYPE SLF**




11.24 Potential advantages of bioreactors include:

- Decomposition and biological stabilization in 5 to 10 years, rather than decades as in the case of 'dry' sanitary landfills

- Lower waste toxicity and mobility
- Improved leachate quality, which stabilizes within 3 to 10 years
- Reduced leachate treatment and disposal costs
- A 15 to 30 percent gain in landfill airspace due to an increase in density of waste mass
- Significantly increased LFG generation that, when captured, can be used for energy generation on-site or sold off-site
- Reduced post-closure care, and
- Possibility of early land use following closure.

11.25 Other advantages of a bioreactor are:

- It precludes the need for setting up a depreciating and potentially unviable compost plant
- It does not lead to any emissions of particulates, gases, and toxins
- It has reduced problems with odor
- It offers improved aesthetics compared to other treatment options
- A deep reactor requires a smaller foot print
- An active system for landfill gas withdrawal, collection and monitoring prevents its migration and any potential damage to adjacent properties
- It enables the operation of different phases of a large landfill in rotation as the stabilized organic waste, where required, can be mined and used as compost, and
- It helps in capturing potent greenhouse gas and provides a potential alternate energy source, as well as a possible revenue stream from carbon credits.

11.26 Significant generation of landfill gas is found to take place in 6 months to 1 year or at most 2 years, depending on waste composition and landfill/atmospheric conditions. In general a lag time of one year after commissioning of a landfill is observed. Methane production of up to 93 l/kg of processed organic waste is achievable with proper blending of green waste. At ultimate study state a well-designed bioreactor of 450-500 MT/day capacity has the potential to yield 0.04 million cum of landfill gas per day (*Augenstein et.al.*).

11.27 In this context, case study findings for a bioreactor are available from Yolo County, California, which are presented in Exhibit 11.3. Here two almost identical landfills (1093 sq.m. area and 12.2 m deep) were constructed in 1993. One was operated as a conventional dry landfill and the other was operated as a bioreactor. In both cases the base liners were installed in 1993 and filling of about 9,000 ton of MSW was completed in a period of 7 months over April-October 1995. In both cases an almost equal amount of green waste and covering material was used and both were given an equal degree of compaction. In the case of the bioreactor landfill, leachate and groundwater addition began after 1 year in October 1996 and, over the next two years, about 4.3 million liters of this mixture were introduced. Measurements carried out at the end of this two-year period, around October 1998, showed that the bioreactor landfill produced 0.81 million std. cum of landfill gas, while the dry landfill produced about half that. In the case of the former, the methane content was 57% while in the latter it was 31%. Similarly, the settlement (thereby additional air space for further filling) recorded in the case of the bioreactor was 117 cm, about four times higher than that of the dry landfill.

**EXHIBIT 11.3: BASIC FACTS OF THE BIOREACTOR AT THE YOLO COUNTY, CALIFORNIA, USA (Sept.-Oct. 1998)**

| **Construction Features** | **Control Cell** | **Enhanced Cell** |
|---|---|---|
| Footprint | 0.27 acres (1,093 sq.m) | 0.27 acres (1,093 sq.m) |
| Average depth | 40 feet (12.2 m) | 40 feet (12.2 m) |
| Construction of base liner | 1993 | 1993 |
| Waste filling of cells | April to October 1995 | April to October 1995 |
| Total nr. of waste lifts (5 feet lifts) | 9 | 9 |
| Total solid waste (residential and commercial, no bulky waste) | 8,726 tons (8866 MT) | 8,557 tons (8694 MT) |
| Amount of alternative daily cover | 1,443 tons (1466 MT) | 1,326 tons (1347 MT) |
| Green waste, placed between lifts (typically 18.5% of residential municipal solid waste) | 17% of total | 16% of total |
| Average waste compaction | 1,014 lbs./cubic yard (601 kg/cum) | 1,027 lbs./cubic yard (609 kg/cum) |
| Total amount of shredded tires used for gas collection systems | 200 tons (~20,000 tires) | 295 tons (~29,500 tires) |

| **Instrumentation** | **Control Cell** | **Enhanced Cell** |
|---|---|---|
| Temperature sensors | 11 thermistors | 13 thermistors |
| Moisture sensors | 15 gypsum & 4 PVC | 25 gypsum & 12 PVC |

| *Cell temperatures at…* | | |
|---|---|---|
| Bottom of cell (Level 1) | 78°F (26°C) | 93°F (34°C) |
| 15' from bottom (Level 2) | 94°F (34°C) | 110°F (43°C) |
| 35' from bottom (Level 3) | 95°F (35°C) | 109°F (43°C) |

| **Landfill Gas** | **Control Cell** | **Enhanced Cell** |
|---|---|---|
| Gas collection systems | Vertical shredded tire gas well | Vertical gravel gas well |
| Total landfill gas volume (measured Oct. 21, 1998) | 15.24 x $10^6$ SCF (0.43 million std. cum) | 28.7 x $10^6$ SCF (0.81 million std. cum) |
| Average landfill gas flow rate | 0 SCFM | 11.88 SCFM (0.34 std. cum/min) |
| Average methane content | 31% | 57% |
| Average total settlement of cells (from 5/96 to 6/98) | 11inches (28 cm) | 46 inches (117 cm) |

| **Liquid additions to enhanced cell** | Liquid additions to the enhanced cell began on October 23, 1996 |
|---|---|
| Total amount of liquid added (groundwater and leachate 10/21/98) | 1,139,965 gallons (4.33 million liters) |
| Total amount of groundwater added (87% of the groundwater was added from 10/96 to 12/96) | 377,690 gallons (1.43 million liters) |
| Total amount of recirculated leachate (June 22, 1998) | 762,275 gallons (669 gal/day) (2.9 million liters (2532 liters/day)) |

(Source http://www.yolocounty.org/recycle/bioreactor.htm)

11.28 As per another available reference (under comparable conditions) for a bioreactor type sanitary landfill planned for Hanoi, Vietnam, the incremental capital cost over a conventional sanitary landfill was estimated to be Rs. 0.52 crore/ha (USD 53,100-76,700/acre, 1996) and the incremental O&M cost was estimated to be around Rs. 20,000/ha/day (USD 200/acre/day, 1996) (*Augenstein*). Accordingly, for the 3.5 ha landfill planned for Phase-I under the Asansol Urban Area Project (with a life span of 5 years and disposal of 320 MT/day), the incremental capital cost is estimated to be around Rs. 1.82 crore, representing 12% of the capital cost of the SLF and about 4% of the total project cost. As a matter of fact, the increase in the capital cost due to the bioreactor and for disposal of a higher quantity of mixed waste into the landfill can be offset by possible exclusion of some of the proposed compost plants.

11.29 In the overall analysis, a bioreactor can be considered as a combined treatment and disposal system, which offers the benefits of an anaerobic digester and the robustness of a sanitary landfill. It enables simultaneous waste stabilization and maximization of methane capture.

11.30 Prima facie, the boundary conditions of the proposed SLF site at Mangalpur also offer the following several favorable features for setting up a bioreactor type of landfill:

- Large expanse of wasteland (167 acres) with no encumbrance of human settlements, agriculture farms, protected or reserved forest, etc.
- The local topography offers large voids for filling of waste
- Convenient location close to the national highway, enabling unhindered rapid transport and disposal of waste
- Proximity to some large-, medium- and small-scale industries, which could be potential bulk consumers of the landfill gas for thermal application, thereby enabling higher energy utilization efficiency and obviating the need for setting up generators on-site, and lastly
- Absence of water bodies or other sensitive environmental attributes, which can be of concern from the point of view of impacts from the proposed activities.

11.31 In view of a variety of risk factors that have been found to be associated with different treatment technologies, the numerous benefits of bioreactors available at a slight incremental cost, and the favorable boundary conditions at the Mangalpure site, it is determined that under the Asnasol Urban Area MSW Management Project a bioreactor is the most efficient and appropriate option from the point of view of maximizing methane capture.

11.32 From the point of view of achieving maximum methane capture, the strategy at the proposed Mangalpur SLF site could comprise a compost plant of modest capacity operating in conjunction with four independent bioreactors (one for each phase), each with an operational life of 5 years. Over a cycle of 15-20 years, the four bioreactors working in rotation would help in capturing methane to the maximum potential, as well as yield stabilized organics. The concerned urban local bodies would find this arrangement far more sustainable and effective as it is free from the liabilities and risks associated with large and multiple compost plants.

## 12. RECOMMENDATIONS

12.1 This section is structured to firstly facilitate responding to the study's findings and comments on the project's design in its 'current form', which we recognize is in an advanced stage of project development. Secondly, this section takes the opportunity to explore the introduction of an unconventional approach, 'methane capture', into the project's design, which is untried in the Indian context and apparently not permissible under the current MSW Rules, 2000. (We understand the Rules are under review and are likely to be modified, taking into account the experience of the past 7 years.) In view of the above, two distinct options emerge from the analysis presented in previous chapters:

| | | |
|---|---|---|
| Option I | : | Project in its 'current form' with suggested modifications |
| Option II | : | Modified project with methane capture involving 3 transfer stations and 1 compost plant in conjunction with the SLF/bioreactor |

12.2 Each of these options is described in detail in the sections that follow. It is further reiterated, albeit the unique situation under which this study has come about, its overriding objective is to achieve the universal objective of safeguarding public health at all times through safe disposal of MSW. This implies bringing long-term sustainability considerations into the selection of the treatment and disposal technology options and, while doing so, **the opportunity of availing methane capture becomes apparent**. These attributes and advantages are elaborated under Option II later in this chapter.

### OPTION I : PROJECT IN ITS 'CURRENT FORM' WITH SUGGESTED MODIFICATIONS

12.3 If the project were to be taken forward in its 'current form', it is recommended that a set of modifications and additional features be incorporated in its design so as to enhance sustainability of the proposed interventions. As a minimum, Part A provides recommendations on technical aspects related to the compost plants and sanitary landfill site that are found in the present DPR. Part B suggests a set of modifications and corrections in the Concession Agreement and the RFP document to bring them in line with the design corrections suggested in Part A. In view of the short timeline, and provided the project's various stakeholders decide to proceed with Option I, recommendations in Part A and Part B must be implemented on a priority basis and are, therefore, presented upfront. Part C attempts to integrate other diverse issues related to project development and implementation, which must be taken up at the appropriate stage. It is pertinent to mention that the latter set of recommendations, i.e., Part C, is also valid for Option II, which is presented later in this chapter.

**Part A: DPR and other related technical aspects**

12.4 In this part, a set of technical changes is recommended in the DPR with the objective of improving overall performance of the plants and the landfill. Likewise, environmental and social due diligence are recommended for successful anchoring of the project under the given boundary conditions.

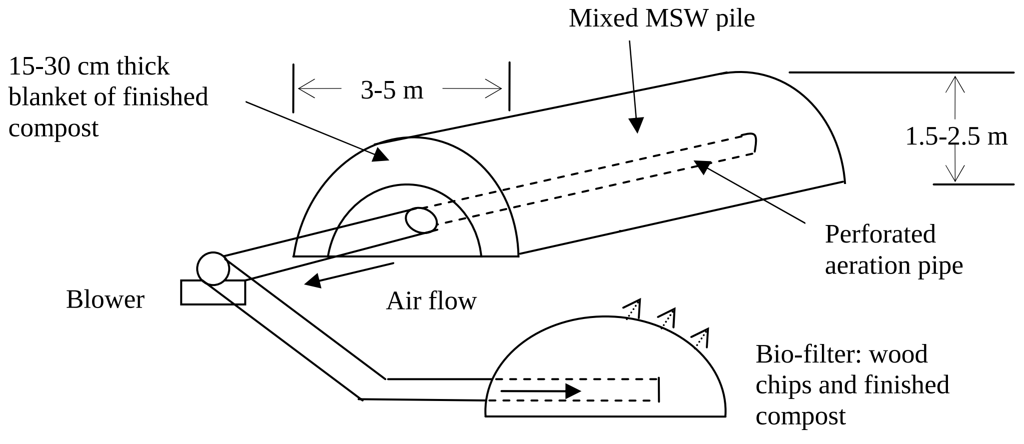
<u>The treatment process</u>

12.5 As a minimum, for all the composting plants, it is recommended to adopt accelerated aerated pile composting rather than the conventional windrow composting process. This technique is also known as ‘static aerated pile’ composting, which is very similar to windrow composting except for the mode of aeration (a schematic of this technology is presented in Exhibit 12.1 below). As in the case of windrow technology, here the waste is also stacked in long rows. Instead of providing aeration through turning of the windrows once a week or so through front-end loaders, the waste is provided a regulated air supply through an embedded perforated pipe, which is connected to a vacuum blower. This offers the following advantages:

- Reduced operational costs as mechanized turning is not required
- Continuous oxygen supply eliminates formation of anaerobic conditions and thereby odor problems
- The foul air passing through the stacked pile of waste is routed through a bio-filter, thereby further removing odorous substances
- The air flow can be regulated according to the stage of composting, temperature of the static pile and requirement of oxygen for the waste, thereby accelerating and/or optimizing the process and controlling operating expenses
- Higher throughput in the same plot of land as a result of the accelerated process, and finally
- The above features make the entire operations more acceptable to the communities in the vicinity.

12.6 A detailed description of the technology is provided in Appendix I entitled ‘Static aerated pile composting – an odor free option’ attached with this report. In this regard, appropriate design and specifications for the aeration system need to be suitably incorporated in the technical section of the RPF document.

**EXHIBIT 12.1: STATIC AERATED PILE FOR COMPOSTING MSW**




Source : Decision Maker's Guide to Solid Waste Management, Vol. II (EPA 530-R-95-023), 1995.

<u>Pre-processing</u>

12.7 In order to have better control over the feedstock, it is recommended to incorporate a pre-processing section in each of the composting plants. Besides the inspection area that is provided for in the current scheme, this will comprise:

- Conveyor belt for manual sorting of large non-degradable objects as well as green coconut shells, etc.
- Screening of coal ash which comprises a fairly large fraction
- Size reduction by cutting and shearing of large degradable objects and plastic bags containing waste, and
- Screening of loose plastic bags, etc.

12.8 The area to be allocated for the pre-processing section must consider an average or peak load situation corresponding to the design year rather than the minimum capacities specified in the Concession Agreement. This will allow accommodating excess waste, which is possible when collection efficiency increases in the ULBs, under emergency situations, and during the monsoon when accumulation of raw waste takes place due to disruption of the downstream treatment process.

<u>Specifications for equipment</u>

12.9 It is recommended that the specifications for compost plant equipment must correspond to an appropriately high-grade steel to minimize wear and tear and corrosion, which is unavoidable due to the presence of highly abrasive and corrosive feedstock.

12.10 The final screen size for the finished compost is specified (in DPR and Concession Agreement) to be 14 mm, which is much higher than the typically adopted specification of 4 mm. It is recommended to make necessary corrections at the appropriate places.

Integration of collection and transport

12.11 In order to synchronize operations, minimize multiple handling and optimize the cost of collection, it is recommended to appoint one agency in a particular zone of wards for primary collection and transport of waste to the treatment plant or SLF.

Transfer station at Kulti

12.12 Prima facie the waste at Kulti does not contain high organics. Instead it contains a higher fraction of coal ash and inerts. In view of such waste characteristics, it could be sent straight to the sanitary landfill site at Mangalpure, rather than to the compost plant at Asansol. Furthermore, considering the long distance between Kulti and the sanitary landfill, it would be desirable to incorporate a transfer station at Kulti to minimize transport costs.

Processing plant at SLF

12.13 In view of apparently high presence of coal ash and inerts and rather low levels of degradables from the Jamuria and Raniganj municipality areas, and the low market for compost, it is recommended that the third compost plant proposed at the SLF be **dropped** from the scheme. Should it be required, this plant can be constructed in the second or third year of the project depending on the quality and quantity of waste received from these municipalities and other governing factors. Such an arrangement will help in reducing the capital expenditure at the outset and also minimize the skilled manpower requirement.

12.14 This plant must also not be viewed as a backstopping arrangement for the two plants proposed at Asansol and Durgapur. Additional capital investment for the third plant need not be made from this point of view as the SLF is supposed to provide for backstopping anyway. In this regard, it is pertinent to highlight that the project cost as per the DPR does not presently include the cost of this component.

Landfill leachate treatment

12.15 Landfill leachate is expected to comprise complex wastewater, which may not be readily amenable to biological processing, e.g., aerated lagoon as proposed in the present design. Instead it may require pre-treatment comprising robust chemical precipitation. A subsequent holding pond could help by way of evaporation and natural aeration. In some cases where toxicity is high, thermal destruction has also been adopted, which may be achieved by using a part of the landfill gas.

Landfill gas collection

12.16 It is recommended that the landfill gas be collected through active venting and brought to a single point through a pipe network. At the outset, one flare along with a standby should be provided to safely dispose of the potent greenhouse gas.

12.17 Depending on the quantity and quality of gas, the operator could be given an option to clean it and supply it to a few selected industries in the vicinity for their fuel requirements.

12.18 In order to minimize landfill gas migration, it is recommended to provide observation/ monitoring wells on the perimeter of the SLF at a designated distance.

Environmental due diligence

12.19 An environmental impact assessment (though an initial examination has been done in this report) will identify possible adverse impacts, provide for remedial measures and secure early clearance from the regulatory agencies. Among others, location of the compost plants and SLF in relation to predominant wind direction and habitations, surface and ground water bodies, etc. needs to be studied.

12.20 As a part of the environmental due diligence and in view of the extensive mining activity that has been carried out at the Mangalpur site, and the overburden on which the new sanitary landfill facility is to be created, a geological and geotechnical assessment is also recommended. Accordingly, appropriate structural measures might need to be identified to make the proposed landfill construction structurally safe.

Social due diligence

12.21 In view of the strong interface of the project with the community, it is recommended that a rapid social impact assessment be carried out for the proposed set of components of the integrated solid waste management project. This could comprise identifying relevant community groups and their concerns and developing a framework to address them ahead of the implementation of the project. Key aspects on 'host community requirements' are brought out later under the heading of stakeholder participation in Part C.

**Part B: Concession Agreement and RFP document**

12.22 It is understood that the prospective bidders would not have access to the DPR. Instead the required technical specifications are to be provided in the Concession Agreement and the RFP document. In that context, based on an analysis of these documents a set of modifications and changes is recommended. These were presented earlier in Section 7 and 8 of this report, respectively, however, for the sake of completeness, they are recapitulated hereunder. It is further emphasized that the following recommendations are applicable under Option I, if the project in its 'current form' is taken forward.

Technical aspects

- For the benefit of the bidders, the 'Scope of Work' attached as 'Schedule A' of the RFP document should ideally provide a synopsis of the entire project in one location covering the locations, capacities of plants and SLF, aerial spread of different phases of SLF, duration of concession, etc. Currently, the technical information is scattered in different schedules of the Concession Agreement, which leaves scope for gaps in developing a comprehensive understanding of the project and bidding commensurately for the entire range of construction and services called for.
- The Concession Agreement must categorically define responsibility for construction and capital expenditure in the 2$^{nd}$, 3$^{rd}$, and 4$^{th}$ phases of the sanitary landfill. Aerial spread of all the four phases should be mentioned.
- It is recommended to provide a reliable and representative set of waste characteristics data to the prospective bidders as a part of the RFP document. This would provide information about the feedstock quality based on which the bidders would be able to incorporate appropriate unit operations in their proposals for the treatment scheme. To this effect a representative sampling may be carried out for a reasonable period of time in the project area.
- Capacities of the two main compost plants and their land requirements must be based on the long-term waste generation pattern and not on a fraction of the current estimated loads as specified in the Concession Agreement. A modular construction approach would help overcome uncertainties associated with estimated and expected waste loads.
- In order to minimize odor emissions, it is recommended to include specifications in relevant sections of the Concession Agreement for pre-processing, an external aeration system for static aerated pile composting, and a bio-filter in the suggested scheme of composting.
- The Concession Agreement must incorporate appropriate corrections (in section 2.7 of Schedule 3) for installing a leachate treatment plant at the SLF, which complies with a given effluent discharge criteria (Table 4.3 of the Concession Agreement 'Schedule 4: O&M requirements for the waste processing facility'). Capacity of the plant needs to be specified and a modular construction can be proposed to accommodate increases in flows over the life of the SLF.
- Under the gas recovery and greenhouse gas mitigation component, it is recommended to categorically specify a gas collection piping network, active

withdrawal system, and provisions for flaring (at a single point) with a standby flare.

- It is recommended to specify inclusion of observation wells for monitoring of landfill gas migration in the scope of work of the operator.
- At all the three main treatment and/or disposal facilities, it is recommended that the Concession Agreement specify provision for a vehicle and tyre wash arrangement.

Institutional aspects

- Payment to the project engineer should be made independent of the concessionaire. Ideally this payment must be made by the consortium of the ULBs.
- For payment to the concessionaire, a mechanism must be evolved to create a corpus with proportionate contributions from all the ULBs to an escrow account. Payment against concessionaire invoices can be released through this single window.
- With regard to compensation to the concessionaire in the event of deficit in delivery of waste to the SLF, it is recommended to adopt an objective approach based on percentage of rejects in the preceding 3-6 months period.
- The concessionaire should not be made responsible for conducting an environmental impact assessment of the project interventions. This responsibility should rest with the implementing agency. A prior environmental clearance will help in avoiding project delays and cost overruns, if any.
- In the RFP document, it is recommended to include broad guidelines for the bidders on preparation of the financial proposal to maintain consistency and to avoid the possibility of omission of critical components.

Financial modeling for tipping fee estimates

12.23 As a part of the bid document preparation activity and in order to arrive at a ballpark estimate for expected tipping fee quotations from prospective bidders, it is recommended to develop a financial model to serve as a decision tool. This is especially required in view of the unique structuring and the continuous capital and operating expenditure involved in the project. The model could factor in all the lifecycle costs of the project, the expected grants at the outset, and various provisions required to be made on the part of the operator. Based on this analysis, a reasonably good estimate of the tipping fee could be arrived at which would help in a rational appraisal of the proposals/bids.

12.24 Tipping fee being the singular evaluation criteria, the lowest quotation is expected to win the contract. However, in order to assess the quotations objectively, the proposed financial model would help check if the lowest bid incorporates all the necessary capex and opex for the various infrastructure components proposed under the several distinct phases of the project. Some of the critical aspects in this are the typically higher replacement costs for equipment and machinery, cost of subsequent phases of the landfill, the uncertainty of generating revenue by selling compost and carbon credits, creation of the obligatory corpus for post closure monitoring, etc. Unambiguous delineation at this stage will help in preventing any disagreement during the operational stage of the project.

**Part C: Integration of other aspects for MSW management**

12.25 This part provides a set of recommendations primarily related to institutional aspects of solid waste management. It covers wide ranging issues such as project steering, engagement of ULBs, stakeholder participation, capacity building, NGO participation, local media management, etc. As these issues are independent of technology choices for treatment and disposal, the recommendations provided hereunder remain valid for the Option II that is described later in this report.

Project Steering Committee

12.26 The project has so far been taken forward under the leadership of the ADDA. Since eventually it is the ULBs who will be responsible during the SWM project's long-term operational phase, it is desirable to make the initiative more broad-based. A steering committee covering all the ULBs and ideally with participation from state nodal agencies should be constituted with a mandate to steer the project through possible obstacles. Chairmanship and Member Secretary positions need to be categorically defined.

12.27 During the implementation phase, there will be a need for a project management agency. It is understood that the 'project engineer' will perform this role. The agency assigned the 'project engineer' responsibility should report to the project steering committee.

Enhanced engagement of other ULBs

12.28 There appears to be a need to bring the three smaller ULBs, and particularly Kulti Municipality, on board through hand holding and capacity building at appropriate levels. Capacity building at the ULBs through training of the relevant technical and administrative staff, exposure visits and regular interactions with AMC and DMC personnel would serve the larger project objectives.

12.29 In order to formalize the engagement of all the five ULBs, an option that could be considered is formation of an independent corporate entity with proportionate representation and equity. An appropriate legal structure for this entity should be evolved with mutual consent and agreement, e.g., revolving chairmanship, voting rights, etc. This entity could then deal with the institutional and financial matters on behalf of its member ULBs and serve as a single front for interaction with the concessionaire and the project engineer.

Stakeholder participation

12.30 It is recommended to engage in a proactive and constructive dialogue with the project's various stakeholders. To start with, it is of utmost importance to consult with the communities of Mohishila ward in Asansol and Sankarpur village in Durgapur, which are likely to experience some degree of adverse impact as a result of increased movement of waste laden trucks through their areas and operation of the plants. These communities can be classified as 'host communities' and proactive engagement by the ULBs would help in dispelling their apprehensions, avoid any future conflicts, e.g., blockage of roads, etc., enhance their participation/support and also help in incorporating remedial measures, if any, which could emerge during the consultation. Typically these are classified as 'host community requirements' which could be in the form of improved road conditions, provision of other long pending amenities/facilities, or in any other form as articulated by the communities. To that effect a reasonable provision in project costs also needs to be made. Such arrangements will help lower any objections and secure the communities' commitment for the project.

12.31 Consultation with appropriate PSUs, their township administrations and other industries needs to be initiated to mobilize support for project initiatives. This is a strong stakeholder group, which must be made to perceive the larger public health benefits likely to accrue out of the project. Appropriate strategies must be discussed with various agencies in this group for their individual and collective involvement.

Positive briefing of local media

12.32 Local media plays a very crucial role in mobilizing positive public opinion towards any solid waste treatment and disposal facility. If not briefed in advance, it can actually attempt to exploit the situation by highlighting perceived and likely adverse impacts of the proposed initiatives, if any, as has been experienced in other parts of the country, e.g., Bangalore, Trivendrum, etc. This has the potential to adversely affect public opinion. In order to avoid such a situation, it is recommended that ADDA and the ULBs take appropriate pre-emptive measures for positive briefing of the media.

Local by-laws for feedstock quality control

12.33 While it is recognized that segregation of waste at source will give the highest benefits with regard to composting, this is perceived to be an extremely challenging task to accomplish, particularly under the given socio-economic setting of the project area. At several locations in the country, in spite of sustained inputs on awareness creation and offering of incentives and disincentives, segregation at source has had limited success. Therefore, the respective municipalities would have to adopt innovative communication methods to achieve this objective, or go beyond and consider those treatment and disposal solutions which do not entail source segregation as a pre-requisite.

12.34 Notwithstanding the above, all the 5 ULBs under the project need to enact a set of local by-laws under the given framework of municipal legislation to ensure:

- Segregation of construction debris and demolition waste
- Segregation of coal ash from domestic and commercial waste, and
- Prevention of burning of leaves from the plantation areas.

12.35 The West Bengal Municipal Building Rules, 2007, provide for charging of 'stacking fee' for construction debris and demolition waste and to this effect the Durgapur Municipal Corporation has already taken necessary steps. Likewise other ULBs can take up necessary measures. In this regard an important aspect that needs to be specified is that all the ULBs must make alternate appropriate measures for safe disposal of construction debris, which would not be accepted at the compost plant nor would it be taken directly by their own vehicles to the proposed SLF.

12.36 Besides the above, the practice by ULB workers of mixing drain silt with the rest of the waste needs to be checked. Appropriate measures for awareness creation, sensitization and separate collection and disposal must be taken by each ULB to demonstrate their own commitment towards the composting initiatives. Collectively, these measures will minimize wear and tear of the treatment plant, minimize operating costs and help improve quality of compost.

Localized composting for horticulture waste

12.37 Dry leaves are found in large quantity in the ULB's industrial townships, particularly during the fall season, i.e., February to April. Instead of burning the dry leaves, which is the current practice, it is recommended to adopt a more sustainable practice of localized compositing in each of these townships. The ULBs can achieve this in association with concerned township administrations (who engage contract workers for sweeping), local

NGOs or a micro-enterprise of rag pickers. This operation can also help generate a certain level of livelihood through sale of ‘leaf mold’/mulch for the involved NGOs/rag pickers.

Broad-basing the initiatives

12.38 In order to have wider appeal for the proposed initiatives among the concerned residents and stakeholders, it is recommended that the ULBs broadbase the interventions along the following lines:

- Creation of community-based organizations (CBOs) and their capacity building
- Organizing informal solid waste workers and imparting training on livelihood activities related to solid waste management (e.g., composting of horticulture/yard waste in PSU townships)
- Addressing concerns and demands of the MSW workers and transporters and offering a tangible stake in operations, and
- Addressing occupational health and safety issues for the municipal workers.

12.39 These measures will help in instilling confidence among such stakeholder groups who will be involved at the very primary level of the project when it is operationalized. Offering appropriate incentives and recognition to these stakeholders would go a long way in ensuring their cooperation and participation in successful operation of the project.

12.40 Resident Welfare Associations (RWAs) or Ward Area Committees (WACs) have proved to be very important links in the overall process of reaching out to the communities. These grassroot organizations help in conveying and disseminating project policies to the eventual target groups/beneficiaries, which result in enhanced acceptance of the project initiatives. It is recommended that all the urban local bodies under the project adopt appropriate measures for formation of such bodies, if not already existing, and for their capacity building and sensitization about the proposed initiatives.

12.41 Engagement with the communities on the subject of solid waste management is to be viewed as a continuous task and therefore there would be a need to create appropriate capacity within the project. This can be achieved in several ways, e.g.,:

(a) Capacity within each of the ULBs
(b) Outsourcing to a private agency or an NGO, and
(c) Asking the operator to create a separate cell and deploy community workers.

12.42 Option (a) would require each ULB to engage suitable personnel and develop a town specific strategy. This can be costly, time consuming and not necessarily consistent with the ULBs' strategy. Option (b) has the advantage of bringing in an experienced agency, which can evolve a suitable program in a short period according to the local conditions and thus have a consistent strategy over the entire project area. This will also offer the benefit of economy of scale. Option (c) is akin to option (b) except that the engagement of the personnel/agency is by the concessionaire. Option (c) offers the benefit of synergy between the logistics operations and the community awareness component. Among the three, option (c) appears to be most suitable under the given setting and structuring of the project.

12.43 Agencies such as Centre for Development Communication, Jaipur, have now accumulated considerable experience in community mobilization and participation, particularly for solid waste related initiatives. They are working with the ULBs of Jaipur, Nagpur, Surat, etc., where they have created micro-enterprises of informal workers on these lines and built their capacity for primary collection and disposal. They could be approached to assess their interest in working in the Asansol Urban Area project. On the other hand, the highly respected local institution Ram Krishna Mission is another option to explore. The Mission has done tremendous work in the area of rural sanitation in the nearby district of Maidinipur and during a preliminary interaction it has prima facie shown interest in solid waste management related urban sanitation work in the project area.

12.44 Polluclean and Mahila Sangha are the other agencies to target and to help build capacity therein. Polluclean has already demonstrated its commitment by voluntarily undertaking primary collection work in selected wards of Asansol. Mahila Sangha, based in the IISCO township of Asansol and with a focus on livelihood training for women, can possibly serve as an important link. Decentralized composting of horticulture waste can be promoted at a small scale through 'Self Help Groups' of women under urban poverty alleviation schemes. ULBs could provide capital costs and a part of the fixed operating costs and facilitate marketing tie-ups with private nurseries, horticulture departments of various PSUs, etc., to help the initiative become financially sustainable. Hyderabad Urban Development Authority has successfully operationalized this model with the help of women SHGs.

Exposure visits

12.45 It is recommended to take key personnel from all the ULBs, ADDA and some other organizations likely to be involved in the implementation of the project on exposure visits/study tours to selected places in the country where similar initiatives have been taken. For primary collection and transportation Nagpur offers a good case study. For critical learning on compost plants either Kolkata, Jagannathpuri, Vijaywada or Trivendrum could be considered. For sanitary landfills, Bangalore could serve as a good case study and there are also lessons to be drawn from initiatives taken in Pune and Surat.

‘No development zone’

12.46 It is recommended that an area of 500 to 1,000m (as feasible) surrounding the treatment and disposal facilities be declared as a ‘no development zone’. This measure along with a tree cover will help in alleviating odor related problems and avoid potential conflicts with the general public.

**Summary of risk factors associated with Option I**

12.48 Although wide ranging recommendations have been provided in the preceding sections, Option I, as it stands, calls for a multiplicity of infrastructure at three separate locations. The associated risks of this option, over and above what have been delineated earlier are listed below:

- It entails land acquisition, due diligence and securing necessary clearances at three separate locations
- It creates three separate groups of project-affected communities and, accordingly, involves potentially higher compensation or ‘host fee’ element
- It requires identical environmental remedial measures at three locations
- It requires declaration of a ‘no development zone’ at three locations
- It requires dispersed managerial, administrative and skilled manpower at three locations, and
- It requires dispersed monitoring by a project engineer at three locations.

12.49 In addition, the analysis in the preceding chapters brings out a wide range of other factors associated with compost plants in general and specific to the project area. The main factors are recapitulated hereunder:

- Potential strong odor emissions and resistance from affected communities
- Likely resistance by residents to movement of vehicles along narrow roads through habitation areas for delivery of feedstock to the plants
- High presence of coal ash, drain silt and inerts in feedstock and technological challenges in achieving source segregation
- High wear and tear and corrosion of equipment entailing replacement every 5-7 years, leading to high life cycle costs of the plants
- Expected poor quality of compost and as a result poor salability, and

- Weak demand for compost in the project area, a major part of which is characterized by coal mining activity rather than agriculture activity.

12.50 In view of these perceived risks and other factors, it is possible that the compost plant(s) may either close down in due course or continue to operate at lower capacity without the output being sold. In the former case, with no provision for transfer stations, the cost of transporting loose/uncompacted mixed waste to the landfill would be prohibitive and the concerned ULBs might revert to open dumping either at the respective plant sites or at the present open dump sites, thereby defeating the ultimate objective of safe disposal and safeguarding public health. Moreover, this would also have a cascading effect of declining loads reaching the SLF, drop in revenue for the operator, and subsequent problems arising there from.

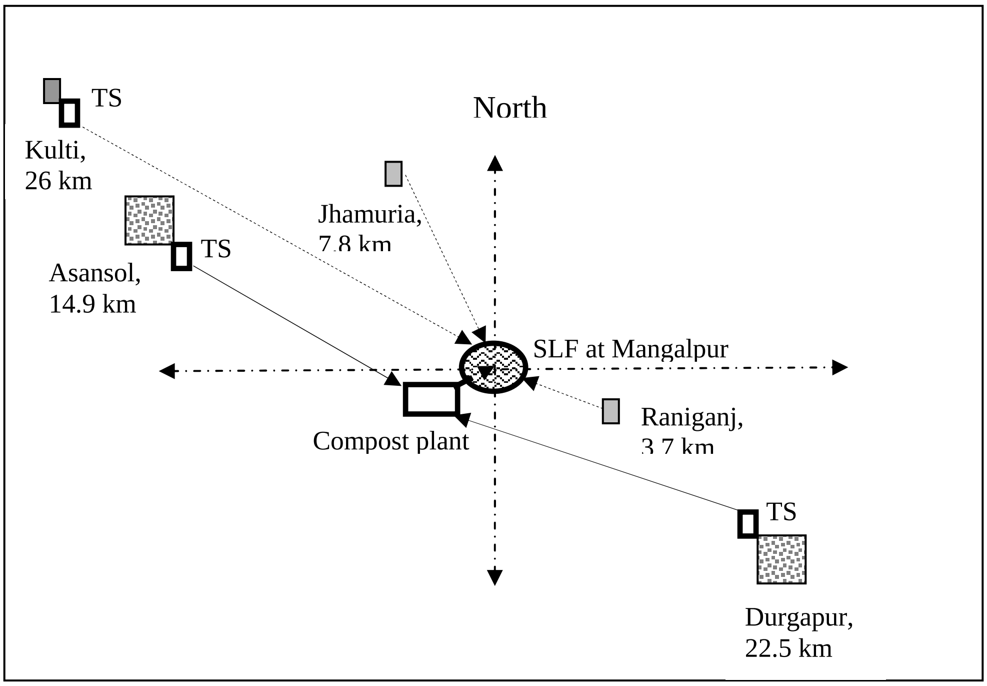
12.51 On the other hand, in the case of no off-take of compost, it is envisaged (in the DPR as well) that eventually the majority of the compost may need to be transported to the sanitary landfill site for use as a covering material. If such a situation arises, it would represent leakage of energy from the system, since in the first place stabilizing/oxidizing the biodegradable waste into compost would entail considerable energy input with subsequent little contribution of the stabilized material towards landfill gas generation. **Accordingly, Option I offers virtually no methane capture and rather limited carbon credits, if any.**

12.52 In view of all the reasoning provided above and in the preceding chapters, the point that needs to be considered is whether setting up multiple compost plants and restricting disposal of organic waste into the SLF is an appropriate approach to follow? This question is addressed by proposing an alternative, which offers a high degree of sustainability and maximum opportunity for methane capture. This option is described in the section that follows.

**OPTION II: MODIFIED PROJECT WITH ENHANCED METHANE CAPTURE INVOLVING 3 TRANSFER STATIONS AND A COMPOST PLANT IN CONJUNCTION WITH THE SLF**

12.53 In response to the arguments presented in the preceding section, Option II has been developed considering long-term sustainability and safeguarding public health at all times, while offering the inherent feature of maximizing methane capture. The modified design comprises three transfer stations and a compost plant, which is to operate in conjunction with the SLF. Under this option, one transfer station is proposed for each of the three large waste generation nodes, e.g., Asansol, Durgapur, and Kulti, where waste shall be compacted and transferred into large vehicles, for onward transport to the integrated facility at Mangalpur. A part of the waste (preferably the segregated stream) from Asansol and Durgapur can go to the compost plant, while the rest and that from the three smaller ULBs of Kulti, Jhamuria and Raniganj can go directly for land filling as the latter prima facie contains a lower fraction of biodegradables. A schematic of this option is presented in Exhibit 12.2.

**EXHIBIT 12.2: PROJECT COMPONENTS UNDER OPTION II**




Notes

TS : Transfer station

—► : MSW going to compost plant

·····► : MSW and rejects going to SLF

12.54 The compost plant can initially be designed for a smaller capacity (~100 MT/d) corresponding to the demand of compost in the local market and that which may be required as daily cover material for the sanitary landfill. Subsequently, a second module can be installed at an appropriate stage depending on the experience of the first plant and off-take of the finished compost. The apparently perceived disadvantage of this option that relates to higher transportation costs can be addressed by adopting appropriate compaction at the three transfer stations and the use of large-size trailers, which can carry higher payloads to the SLF.

**Advantages of Option II**

12.55 In comparison to Option I, this option has several inherent advantages, which are listed below:

- Deployment of optimal capacity for composting as per local demand
- Avoiding the need for construction of multiple compost plants, thereby restricting to one location (at the SLF) the potential for adverse environmental and social impacts
- Reducing the need for land acquisition and the carrying out environmental and social due diligence and the associated possible delays at multiple locations
- Avoiding the need for declaring 'no development zone' at three distinct locations and the associated regulatory and administrative procedures
- Avoiding the need to secure environmental clearance for three separate locations and the associated possible delays
- Minimizing the size of the project-affected communities, scale of likely protests and thus the likely compensation or host fees
- Avoiding triplication of infrastructure for approach roads, weigh bridges, wastewater treatment, storage, office and laboratory buildings, vehicle washing facilities, garages, water and power supply, boundary walls, loading and unloading equipment, etc., and thereby achieving a significant economy of scale
- Providing common infrastructure for leachate treatment, administration, and other services for the compost plant and the landfill operations
- Reduced requirement of managerial, administrative and skilled manpower for plant operation and services at a single location
- Reduced requirement for monitoring by the project engineer at a single location
- Availability of the National Highway for faster movement of large trailers to the integrated facility thus avoiding the possibility of protests by communities along whose narrow roads the waste would be transported to the compost plants
- Higher system reliability on account of reduced number of discreet facilities
- Minimizing the chances of operator disputes as the excess and reject waste loads can be easily diverted to the adjoining landfill
- Reducing the possibility of indiscriminate and distress disposal of excess and reject waste loads at individual plant sites or at the existing open dumps, and
- Ease in moving the rejects for land filling and the finished compost for daily cover material from the plant to the adjoining SLF.

**12.56 This option also has the inherent advantage of permitting implementation of an alternate plan for safe disposal of the entire quantity of waste into the SLF in the event**

**of malfunction or temporary shut down of the compost plant, thereby ensuring environmental and public health in the project area AT ALL TIMES.**

**12.57 This option also has the inherent advantage of offering methane capture as the bulk of the degradable mixed waste to be deposited in the landfill will eventually release landfill gas.** This aspect is further discussed in the paragraphs that follow.

**Methane capture**

12.58 As brought out in Chapter 9, both the sanitary landfill and a bioreactor type landfill offer methane capture. However, it is the bioreactor, which offers the advantage of a combined treatment and disposal facility that enables significantly increased decomposition of the deposited waste and, in the process, offers higher conversion rates to methane and higher process effectiveness as compared to 'dry' sanitary landfill. Numerous advantages of a bioreactor are recapitulated as follows:

- Maximization of landfill gas capture for resource recovery through incremental investment over a sanitary landfill
- Increased landfill capacity due to concurrent waste stabilization and its possible use as compost
- Improved opportunities for leachate treatment and storage
- Reduction of post-closure activities
- Abatement of greenhouse gases, and
- Greatly reduced technical and financial risks.

12.59 A set of specific, additional advantages under the boundary conditions available at the proposed Mangalpure site are:

- Large expanse of wasteland (167 acres) available with no encumbrance of human settlements, agriculture farms, protected or reserved forest, etc.
- Flexibility in developing multiple phases/bioreactors with cyclic operations, thereby offering the option of fill-and-mine and thus prolonging the land filling activity
- Ease in upgradation from a sanitary landfill (already proposed) to a bioreactor at an incremental capital cost of approximately Rs. 1.8 crore, while avoiding potentially unviable multiple compost plants
- Convenient location on a highway, enabling unhindered rapid transport
- Proximity to industries – potential bulk consumers of landfill gas for thermal application, thereby enabling higher energy utilization efficiency and avoiding the need for setting up electricity generators on-site, and lastly

- Free from any major environmental concerns.

12.60 In view of a variety of risk and other factors associated with different treatment technologies, the numerous benefits of bioreactors that are available at a slight incremental cost, and the favorable boundary conditions at the Mangalpure site, it is determined that under the Asnasol Urban Area MSW Management Project a bioreactor is the most efficient and appropriate option from the viewpoint of maximizing methane capture (and possibly availing significant carbon credits) and achieving the universal objective of public health at all times.

Constraint

12.61 Having delineated the above, it is recognized that prima facie the MSW Rules, 2000, do not permit **prolonged** disposal of organics into a landfill (which is primarily to minimize land requirement) and as a corollary, maximization of methane capture from the naturally degrading waste there-from. Nevertheless, it is understood that the Rules are under review and the concerned regulatory agencies are open to evaluate viable project proposals under favorable boundary conditions.

Strategy

12.62 As the deposited waste becomes stabilized in a bioreactor over a period of 5-10 years, it can be mined as humus or compost. Therefore, a bioreactor can be operated in two ways, viz., (a) deposition of mixed waste with no plans for mining, or (b) deposition of segregated organic waste and, should it be required, mining of the stabilized waste in a cycle of 10-15 years. The mined stabilized waste is fit for use as compost after processing and grading while the space can be again used for filling. Mining of stabilized waste will also help counter the land constraint perceived to be imposed under the MSW Rules, 2000.

12.63 From the point of view of achieving maximum methane capture, the strategy at the proposed Mangalpur SLF site could comprise a compost plant of modest capacity operating in conjunction with four independent bioreactors (one for each phase), each with an operational life of 5 years. Over a cycle of 15-20 years, the four bioreactors working in rotation would help in capturing methane to the maximum potential (landfill gas @ $6.24 \times 10^{-3}$ standard $m^3$/kg of wet waste/year or more), as well as yield stabilized organics. The concerned urban local bodies would find this arrangement far more sustainable and effective as it is free from the normal liabilities and risks associated with large and multiple compost plants.

12.64 Should Option II be taken forward, it is recommended that in order to develop the design and specifications for a bioreactor, an international expert with experience in this area be engaged.

End use of landfill gas

12.65 As briefly mentioned in the findings of the field visit , there are seven large sponge iron plants and a couple of small-scale cement industries near the proposed SLF site. Should methane capture be considered as a final option based on the above suggested approach of developing the SLF as a bioreactor, it is further suggested that the landfill gas be supplied for thermal application to selected industries. This will help achieve the higher energy utilization efficiency of over 40-50%, rather than attempting to generate electricity, which at best can yield 25% efficiency (without the cogeneration component which is not feasible under the given boundary conditions). However, this level of efficiency will depend on the generation rate, and the quality and quantity of landfill gas over the life of the landfill. This arrangement on the one hand does not entail capital investment on an electricity generation system while potentially offering higher carbon credits.

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