PROPOSAL FOR INFRASTRUCTURE DEVELOPMENT OF ADAMPUR LANDFILL SITE AT BHOPAL IN MP

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ABSTRACT:
Municipal solid waste generation and management has been a challenging issue for Bhopal Municipal Corporation (BMC) from past two decades. Designing of Adampur landfill site for municipal solid waste is the only solution for BMC to solve the problem of municipal solid waste management. The design parameters were adopted from standards stipulated by the Govt. of India regulatory agency. These incorporate formulae tables, standards and guidelines.

KEYWORDS: *Disposal of MSW, Recycling method and Technologies, Infrastructure, Operation and Maintenance of Sanitary landfill.*

I. INTRODUCTION

Industrialization and urbanization of Bhopal and surrounding region is continuously going on at a rapid pace. The existing infrastructure facilities are unable to keep pace with the population growth and economic development of the region. Environment and public health services are essential for the growth and well-being of the population and surrounding environment. Appropriate management of municipal solid wastes has considerable impact on health, physical and aesthetic environment. Therefore in order to move towards sustainable future development. Bhopal the capital of Madhya Pradesh needs to adopt an integrated and an advanced municipal solid waste management approach. Some component like construction of Transfer Station at Bhanpura & purchase of SWM Equipment will be executed. Sanitary Land fill site at Adampur Chhawni is proposed to be developed by Bhopal Municipal Corporation by their own finance.

Bhopal City

Bhopal, one of the largest city and capital of Madhya Pradesh, popularly known as Lake City, has experienced a rapid growth in the last decade. Bhopal is located at Longitude 23^0 16'N, Latitude $77^0$36'E, Elevation ranging from 503 to 550m MSL. The climate condition of the Bhopal is tropical and dry except in monsoon. The temperature ranges between 80C and 440C. Average annual rainfall is observed to b about 1244mm.

RECYCLING METHODS OF AND TECHNOLOGIES

The purpose of this chapter is to introduce the key issues involved in the recovery and processing of waste materials. The fundamental issues in material recycling include identification of

a) Materials that are to be diverted from the waste stream
b) Reuse and recycling opportunities
c) Specification of buyers of recovered materials

IDENTIFICATION OFMATERIAL TO BE DIVERTED

Solid waste managers must decide that what materials should be pulled from waste stream to meet diversions goals and the decision is complicated by the fact that many materials (e.g. glass) have weak markets or cannot be transported economically. Another problem is that materials with high market value (i.e. aluminum are always recovered by consumers and compromise only a small fraction that enters waste management system, thus reducing for income.

IDENTIFICATION OF REUSE AND RECYCLING OPPORTUNITIES

Management personnel responsible for developing recycling programme must consider the markets for recovered materials the collection infrastructure and the overall cost. Markets for recovered materials only exist only when manufactures or processors need those materials or can use as economic substituent for raw materials, therefore the market depends upon quantity of the materials overall industry capacity and the cost of competing raw materials. In most cases recovered materials are inferior in quality to virgin materials so that market price must be suitable to the buyers.

II. MARKET FOR PLASTICS

Low Value of Recovered Plastics

Scrap plastic has a low value because virgin material are rarely inexpensive. There is little financial incentive for collection and thus recycling must be promoted.

SUBSIDES FOR RECYCLING PROGRAMS

Solid waste managers often have limited control over program economic. Although landfill diversion has been implemented in many states and recycling programmes are becoming more common, few municipal programmes are self supporting: generally they are subsidized by tax players or subscribes to the local waste hauling service. The type of collection system (e.g. curbside, buy –back center) length of collection routes, terrain, degree of sorting required. And transportation system influence the programme cost. Successful programme usually exist only for those materials that are high in demand such as aluminum cans or plastic bottles.

MAKING SPECIFICATION FORO RECOVERED MATERIALS

Processors and end users of recovered materials require that materials be homogeneous and free of contamination many buyers also requires that baled material to be compacted t specified sizes and specific weights. Some industries adhere to strict standards and cannot be tolerate even low level of contamination (e.g. Glass container manufactures) other process material sufficient to remove almost all foreign materials (e.g. aluminum and tin can buyers). In general there is less contamination in source separated material but collection is more labor intensive, many countries are choosing to sort all materials at a central materials recovery facility (MRF). In many regions market for materials are not keeping pace with the volume collected and it is expected that buyers will tighten specifications consequently vendors will no longer have assured markets and will be competing to sell materials. As the specifications for recovered materials become more restrictive, recovery program must consider buyer specification carefully when choosing collection and sorting system especially where large capital expenditures are involved.

WASTE MINIMIZATION AND RECYCLING

Minimizing the quantities of waste through source reduction at material recovery, reuse and recycling. This is increasingly being recognized as the main basis of an integrated approach to MSW management. Most developing countries are adopting various processes aimed at the recovery of materials from the solid waste stream itself. Local industries in some cases are strongly dependent on the availability of secondary materials for re-processing. Some pf these materials include cardboard, various paper.

STEP1-COLLECTION AND PROCESSING

Collecting recyclables varies from community to community. There are four established primary methods: curbside, drop-off centers, buy-back centers and deposit/refund programs. The separation takes place at the source of generation (in the home, factory, institution) at a drop off center or at a central Material Recovery Facility (MRF) designed for taking unprocessed MSW, sometimes called a "dirty" MRF because of the presence of **putrescible** or unrecyclable waste is present. Besides, source separation can help in sorting into major categories (blue bag-metal, glass and plastics, green or clear bag-types of papers) and brought to a clean MRF which is designed to sort recyclables only.

STEP2-MANUFACTURING

Once recyclables are cleaned and separated these are ready to undergo the second part of the recycling loop. More and more of today's are being manufactured using total or partial recycled content. Common household items that contain recycled material include newspapers and paper towels, aluminum, plastic and glass soft drink containers, steel cans and plastic laundry detergent bottles. Recycled materials also are used in innovative applications such as recovered glass in roadway

asphalt (glassphalt) or recovered plastic in carpeting and road making park benches and pedestrian bridges.

Remanufacturing secondary materials into new product/packaging can take place at factories site. Sometimes refinement is required to be necessary to prepare the materials for manufacture. Marketing and sale of recycled content products and packaging occurs on ordinary store shelves.

STEP3-PURCHSING RECYCLED PRODUCTS

Purchasing of recycled product completes the loop of recycling. By "buying recycled" government as well as businesses and individual consumers, play and important role in making the recycling process a success. As consumers demand more environmentally sound products, manufacturers continue to meet that demand by producing high-quality recycled products.

Table 1: Advantages and Disadvantages of recycle material

Materials	Advantages	Drawbacks
Waste	Compositing and anaerobic digestion	Beneficial to develop soils, it still has a low market value and only seasonal demand.
Other metal	Scrap metal has a high market value (especially steel, silver, copper and platinum). It can be recycled indefinitely because it does not deteriorate from reprocessing	High value metals are as copper and silver are incorporated in electronic devices but extraction in an unscientific way can cause severe environmental impacts
Paper	Papers can be easily recycled, however quality detoriates with each cycle. Paper or cardboard from recycled paper requires less energy to produce and protects forests	Appropriate technologies with proper processes are required to product the environment.
Polyethylene terephthalate	PET can be recycled if segregated from other waste. Reprocessing into granulate is very easy. PET has a high market value if processing plants are available	More "down cycling" than recycling occurs because quality decreases with every processing cycle.
Other Plastic	Other plastic such as polyethylene or polyvinyl chloride can be recycled but has less value on the market that PET, the value depends upon recycling and manufacturing options in the vicinity	Recycling requires specific machinery
Electronic Waste	Electronic waste (such as computers or mobile phones) contains high value metals	Metals are often covered with polyvinyl chloride or resins which are often smelted or burned causing toxic emissions.

INFRASTRUCTURES FOR LANDFILL SITES

The infrastructure facilities proposed at landfill sites (AdampurChhawni) are as follows:

- Boundary wall/fencing with gates
- Approach road, Internal roads, road side storm water drains
- Guard House
- Administrative Building cum Laboratory
- Weigh bridge and record room
- Labours rest Room
- Two wheeler parking shed
- Vehicles parking shed sum Sore Room
- Vehicle cleaning shed
- Staff Quarters
- Compost plant (Window Platform, Central Shed, Process Hall, Service Garage, Refuge collection platform, Intermediate storage and Finishing Godown)
- Water supply and Sanitation facility
- Leachate collection sump and Treatment unit
- Pre-sorting Unit
- Fire protection system
- Electrical works (Transformer yard, Panel cum DG room, Internal & external lighting etc)

Compound Wall/fencing with gates

Municipal Solid Waste (Management and Handling) Rules, 2000 require the Landfill site to be fenced or hedged to prevent entry of unauthorized persons and stray animals. Fencing also demarcates the boundaries of landfill site prevents encroachment and provides security. With this purpose a stone masonry compound wall is proposed around the infrastructure facilities. The landfill area is proposed to be protected by barbed wire fencing. The vehicular entry to the land fill site will be controlled by two 6m wide gates (one each for entry and exit of vehicles). 1m wide wicket gate will be provided to regulate entry of personnel.

Administrative Building cum Laboratory

The administrative work (like attendance of staff, payment of labours, distribution of works to labours, record of consumables, record keeping documents for landfill operation, accounting) will be carried out from the administrative building. A laboratory will be provided in the building for testing facilities. The tests to be conducted in the laboratory include consolidation and compaction test of soil, leachate properties, pH of compost material, maturation test of compost and C/N ration. Separate rooms will be provided in the building for Site-in-charge of the landfill and Store keeper.

Size of Office Building – 7m x 4m
Size of Laboratory – 7m x 4m
Size of Store room – 4m x 3m

Provision of 1 urinal, 1 WC and 1 washbasin will be made. One HDPE overhead tank of capacity 1000 litres will be installed on the roof. The rooms in the office building shall be adequately furnished and communication facilities shall be provided.

Weighbridge Record Room

A weighbridge will be provided at an appropriate location for weighing each vehicle (in and out) and the weights will be recorded in the record room. Recording instruments (weight display), computer printout facility for the weight slip and space for the recorder will be provided in the record room.

Size of Weighbridge Record Room – 3m x 3m

Labours Rest Room

A room is required for welfare activity and resting of the workers. This room will also facilitate changing of dress, rest in lunch time, waiting between the change of shifts etc.

Size of Labours Rest Room – 10m x 4m

Provision of 2 nos. urinals, 1 bathroom, 1 WC and 1 washbasin is made in labours rest room. One HDPE overhead tank of capacity 1000 litres will be installed on the roof.

Size of Toilet Block – 3m x 3m

Two wheeler parking shed

A shed is proposed for parking of 25 bi-cycles/motor cycles. It will be 3 m high constructed in steel truss with AC roofing.

Size of Two Wheeler Parking shed – 9m x 3m

Compost plant

Windrow Platform

A concrete platform with proper gradient has been provided to accommodate fresh and digested garbage. A peripheral drain around the platform is proposed for Leachate collection. An area of about 1.1 hectare (139m x 78m) is reserved for windrow platform which has been provided for 8 days storage of fresh garbage and turning of the same after every 7-8 days for total 28 days. The clear space of 3m is provided between the windrow platform for access of vehicle for turning of waste.

Size of windrow platform – 34m x 6m x 2.5m height

Central Shed (Monsoon Shed)

The composted waste obtained after 28 days turning from the windrow platform will be stored in this shed. It will also be used as emergency platform during rainy season. A8m high shed covered with A.C. sheet roof has been proposed for this purpose.

Size of central shed – 40m x 15m

Process Hall (Machine Shed)

The hall were composted waste will be processed to be separated out (recyclable and inert material). The machinery like conveyor belt, trommels will be installed in this hall. It has been designed to meet

the requirements of the Plant. Space necessary for movement of in-plant material handling equipments has been considered while designing the size of the hall.

Size of process hall (with 1m side wall) – 30m x 6m

Refuse collection platform

The reject from the composted waste will be collected on refuge collection platform. From there they will be loaded onto trucks and transported either for sale of recyclable waste (like plastic, paper) or for disposal of inert wastes to landfill.

Refuge collection platform – 30m x 10m

Intermediate Storage and Finished Godown (Curing shed)

Intermediate Storage Godown

A closedsheed with AC sheet roof provided for intermediate storage and curing of semi-finished material. The compost will be weighed and packed in 25 or 50kg HDPE bags in this stores. Curing shed is designed to store material.

Leachate collection sump

Leachate generated from the landfill area will be collected in sump through laterals and header. The location of leachate collection sump shall be based on the topography to suit the gravity flow of leachate. The laterals and header (with perforations) of required size will be provided in the bottom of landfill section with granular media above it.

Size of leachate Collection Sump – 2m dia.

Pre-sorting Unit

It has been located near entry of landfill site for easy access of incoming vehicles. An area of 0.36 hectare (100m x 36m) has been reserved for pre-sorting facility. The recyclable waste or large objects can be sorted out before taking the waste to windrow yard.

Green belt/tree plantation

A green belt should be developed as per provisions of Municipal Solid Waste (management and Handing) Rule, 2000. The green belt of 5m width is proposed along the landfill sites boundary. The tree plantation will increase the aesthetical appearance of the site at the same time it will prevent littering of the waste absorption of gases. The green belt shall be maintained by the O & M agency.
Type of trees to be planted – Neem, Gulmohar, Cashrona, Dropping Asoka, Rain tree, Equlipitus.

Fire protection system

Fire exhausting kit and first aid kit should be provided in the office building. The CO2
Type fire extinguishers will installed to be used during any fire breakout. A water tapping of size 50mm GI pipe is proposed near the landfill area for prevention of fire hazards. The operating staff should have basic knowledge about the various fire events, working of fire extinguisher and action to be taken to control fire.

III. SITE PROCEDURES

It is important to formalize and document the record keeping procedures as well as waste acceptance procedures to be followed at the landfill site.

Record Keeping

As per the Manual on Municipal Solid Waste Management by CPHEEO, May 2000, records of the various activities shall be kept on daily, weekly and monthly basis.

Site Manual

The site manual shall be kept at the site office giving all site investigation, design and construction details. These are necessary as landfill design may get modified during the operational phase. The site manual shall contain the following information:

(a) Data collected during site selection
(b) Environmental impact assessment report
(c) Site investigation and characterization data
(d) Detailed topographical map
(e) Design of all landfill components
(f) Landfill layout and its phases
(g) Construction plans
(h) Details of Leachate Management Plan

(i) Details of Gas Management Plan
(j) Environmental Monitoring Program
(k) Closure and Post-closure Plan
(l) All permissions/licenses from concerned authorities.

Site Report

The daily weekly and monthly reports shall comprise of the following:
(a) Weighbridge data (daily inflow and outflow for each vehicle).
(b) Waste inspection data (daily)
(c) Materials, stores etc. (daily)
(d) Bills/ accounts (daily)
(e) Visitor record (daily)
(f) Complaints record from nearby areas (daily)
(g) Topographic survey at operating phase (daily/weekly)

Prior to the commencement of monsoon season an intermediate cover of 45cm thickness of soil shall be placed on the landfill with proper compaction and grading to prevent infiltration during monsoon. Proper drainage shall be provided to divert run off away from the active cell of the landfill. It can be achieved by diverting the runoff to the surrounding drain (garland) constructed at landfill area.

A lift is a complete layer pf cells over the active area of the landfill. Typically, each landfill phase is composed of a series of lifts. Intermediate covers (45cm) are placed at the end of each phase, these are thicker than daily covers and remain exposed till the next phase is placed over it. The final lift includes the cover layer.

Daily Operation

For an organized operation of the site total area and volume shall be calculated and the area shall be divided into different sub-plots or cells. Due to the concentration of rainfall during monsoon, movement within the landfill site becomes difficult during this season. It is thus desirable to use few sub plots near the entrance during monsoon. The subsidiary roads in the section to be utilized during monsoon shall be very carefully located and constructed to ensure trouble free and safe movement of refuse vehicles and bulldozers.

The space between any two vehicles unloading at a site shall be minimum 4m. The incoming vehicle shall be directed form the main road to the sub road and then to the working face of the cell, it shall approach the unloading point in reverse gear, unload and move out in 5-10 minutes.

A single pass of a bulldozer moving in the transverse direction will level the deposited waste. As subsequent loads are unloaded and leveled, the bulldozer operator shall ensure that at least three passes are made over every deposite refuse load.

Experience has shown that three passes shall achieve the requisite compaction. These passes are made one after another by the movement of bulldozer or while leveling subsequent loads. In this manner the entire cell shall be planned and after filling the cell by solid waste it shall be covered with a 30cm cover layer on the top as well as on the sides. After completion of one cell the second cell is taken up.

During filling of one sub area, the adjacent sub area shall be prepared and kept ready for filling. In this manner the whole plot shall be filled and covered.

Bulldozer shall be used on a daily basis for spreading and compacting the waste and covering it with inert material.

The waste may be covered on daily basis with 30cm thickness of inert material such as construction waste or soil to avoid any foul smell and breeding of rodents and insects.

Waste shall not be allowed to be burnt at the landfill site to avoid air pollution.

Waste Placement (Spreading)

Once waste has been discharges it must be spread in layers and compacted in well defined manner to ensure that complete slope of daily cell are at designed gradient.

1. Face tipping method: Waste is deposited on top of the existing surface and spread horizontally by tipping over and advancing face.

2. Inclined layering method (onion skin tipping): Similar to (1) but inclined layering (gentle slope) done instead of advancing of face.
3. Working upwards: Waste is deposited on the lower surface and push upwards. Inclined layering method can be adopted for landfilling operation.

Prevention of Pollution During Landfill Operation

Measures are needed to ensure that the landfill operation does not adversely affect local environment within and outside the landfill. The CPHEEO Manual of Municipal Solid Waste, May 2002, suggests ensure availability of Community Liaison Officers to visit complainants and to establish the nature and source of the problem. This is reported to the landfill in-charge to initiate corrective measures.

Traffic

Heavy vehicular traffic can cause nuisance, damage to road surface and verges and routing problems. The following guidelines shall be helpful.

(a) Vehicle routes shall avoid residential areas
(b) Using one way routes to avoid traffic conflict in narrow roads
(c) Carrying out road improvements (e.g. strengthening or widening roads improved provision of footpath's, improvement of sight lines, provision of passing places, provision of new roads).
(d) Minimising the vehicular movements.
(e) Restriction on vehicular movement during peak traffic hours, stagger the movement.

Bird Control

Birds are attached to the landfill site in large numbers mainly where site receive appreciable amounts of food wastes. Measures which can be used to mitigate bird nuisance includes the following:

- Employment of good landfill practice
- Working in a small active areas
- Progressive prompt covering of waste

Vermin, Fly and Other Pests

The solid waste is dumped at landfill site and it remains a favorite place for disease spreading vectors, even though it is well-managed landfill site. Any amount of daily cover material cannot completely stop the growth pf these vectors mainly files and mosquitoes. Landfills have potential to harbour files and vermin, particularly where the waste contains food materials. Modern landfilling techniques including prompt emplacement, consolidation and covering of wastes in well defined cells are effective in the prevention of infestation of rodents and insects. Rats and flies are the main pests which require control.

Effective measures to deal with rodent infestation regular visit by pest control contractors or fully trained operatives. The use of insecticides on exposed faces and flanks of the tipping area by spraying and fogging is an effective means of exterminating insects.

(a) Mosquitoes:

A part from causing nuisance to mankind mosquitoes play a major role in the transmission of more diseases than any arthropods. These include malaria, filariasis, dengue/Dengue Hemorrhagic Fever (DHF), Japanese Encephalitis (JE) etc. causing high morbidity and mortality. Adult males fees on nectar from plants. Female mosquitoes bite and fees on blood of humans and or animals. Because female mosquitoes fees regularly on blood disease causing pathogens can be transmitted from man to man (e.g. malaria parasites) or in some cases from animal to man (e.g. arboviruses) via vector mosquitoes.

Small pools of water are created in any landfill site either due to presence of moisture in the waste or during rainy season. These small depressions often from a potential source for mosquitoes breeding. Since mosquitoes undergo a complete metamorphosis during their life cycle, there are two methods by which mosquito problem can be controlled completely namely:

Dust suppression can be controlled by

(a) Limiting vehicle speed
(b) Spraying roads with water
(c) Spraying site and powder type waste with water.

Landfill Fire Management

Fires in waste on landfill sites are very common and it is important for site operators to be aware of the dangers how to treat fires and to address the problems associated with them. All fires on-site shall be treated as a potential emergency and dealt with accordingly. All sites shall have an emergency tipping area set aside from the immediate working area where incoming loads of material known to be on fire or suspected of being so can be deposited, inspected and dealt with.

Waste that is burning on delivery shall be doused with water or more preferably covered progressively with adequate supplies of damp soil/cover followed by cooling and finally removal to its disposal point. It shall not normally be allowed to burn itself out as this will give rise to nuisance from smoke and odour and may constitute a health risk. Fire fighting techniques shall be appropriate for the waste type.

Fires within the operational area are either surface fires or deep-seated fires. The former usually occur in recently deposited and as yet un compacted materials adjacent to the current working area while the latter are found at depth in material deposited weeks or months earlier. Site operators shall have a plan to deal with each type of fire and have a code of practice for their operator stating exactly how to tackle any outbreak. Deep-seated fires require expensive remediation techniques including vertical cut-offs.

Landfill Safety Aspects

Training of employees shall include site safety, first aid and the handling of dangerous materials where appropriate. Since landfill sites can pose dangers to both site operator and users, emergency plans shall be laid down. Landfill sites shall be regarded as potentially hazardous locations and the operators shall have a written safely plan for the site.

Safely hazards present at landfill sites may include:

(a) Moving plant and vehicle
(b) Steep slopes

A grain size analysis for every 400 cu m of material used is recommended for quality control purposes. The layer shall be compacted to above 95% density to provide a firm sub base fir the low-permeability layer above. The density shall be tested at 30m grid points.

Laying pf the topsoil layer shall be done as soon as the protective layer construction is finished, Heavy construction equipment shall not be allowed on the finished surface. The nutrient and liming requirements for the topsoil shall be assessed from a competent agricultural laboratory. In the absence if a regulatory recommendation/requirement regarding seed mix, a horticulturist or soil scientist shall be consulted. A combination of grass and bush type vegetation capable of surviving without irrigation water shall be planted. At least five samples of topsoil per hectare shall be testes for nutrient and liming requirements. Nutrient and seed mix application rates shall be supervised on site for quality control purpose. Utmost care shall be exercised in installation of the gas vents in the final cover where ever to be provided.

The final cover shall have a gradient of 3 to 5% to assist surface runoff. Lined ditches or channels are constructed on the final cover to intercept and carry surface water off the cover to the storm water basin.

On the cover of each phase, settlement devices shall be installed for monitoring settlement of the landfill cover. This helps in identifying the quantity of soil required periodically for each of the landfill cover.

LANDFILL CLOSURE

As each phase is completed and as the final level is reached in successive phases the following interconnectivities are established:

(a) The leachate collection system of phase is sequentially connected (if so designed)
(b) The surface water drainage system for the cover of each phase is sequentially connected (if so designed)
(c) The temporary surface water drainage system constructed at the base of each complete phase is dismantled.

Closure and Post Closure Maintenance Plan

Determination of the end-use of landfill site is essential to decide the measures of closure and post-closure maintenance. Some of the closed landfill sites near urban centers include park, recreational area, golf courses, vehicle parking area and sometimes even commercial development.

A closure and post closure plan for landfill involves following components.

- Plan for vegetative stabilization of the final cover
- Plan for management of surface water runoff with an effective drainage system.
- Plan for periodical inspection and maintenance of landfill cover and facilities.

Operation after closure

The following facilities will be operated routinely after closure.

a) Leachate management system
b) Surface water management system.
c) Environmental monitoring system
d) Cover rehabilitation and repair system

The operating mythology will depend on the type of system adopted at the landfill.

a. A property selected offsite testing laboratory capable of measuring the constituents at correct detection levels.
b. A methodology for acquiring and storing data
c. A statistical procedure for analysis of the data.

The following instruments/equipment shall be used for monitoring

(a) Ground water samplers for monitoring water in wells.
(b) Leachate samplers for leachate monitoring within the landfill and at the leachate tank.
(c) Vaccumlysimeters, filter tip samplers, free drainage samples for leakage detection beneath landfill liner.
(d) Surface water samplers for collection of sample sedimentation basin.
(e) Down hole water quality sensors for measuring conductivity, pH, DO temperature in leachate wells, ground water wells and sedimentation basins.
(f) Portable gas monitors for on site monitoring of gases.
(g) Active and passive air samplers for monitoring ambient air quantity.

It is recommended that location of each type of instrument/equipment shall be finalized in consultation with an expert on the basis of topography of the area and layout of the landfill. A minimum of 4 sets of ground water monitoring wells (one up-gradient and three down gradient) for each aquifer are considered desirable.

Quantitative parameter to be monitored will be:

(a) Leachate quantity
(b) Gas quantity
(c) Surface water run-off quantity and
(d) Cover system settlement quantities.

Qualitative parameter to be monitored will be:

(a) Leachate quality within the landfill (at the base)
(b) Leachate quality after treatment
(c) Groundwater quality (up gradient and down gradient)
(d) Surface water quality at the exit of landfill
(e) Gas quality within the landfill
(f) Air quality above the landfill and at gas vents
(g) Air quality at gas control facilities

Gas and Leachate Management System

Periodic inspection of the gas and leachate collection system shall be undertaken to identify broken pipes, leaking gas (if any) and damaged or clogged wells/sumps. Repair work for gas and leachate management system requires skilled man power and shall be carried out by the agencies operating the gas treatment and leachate treatment facilities. One may often have to install new gas extraction and leachate collection wells if the damaged/clogged facilities are inaccessible and irreparable.

Environmental Monitoring System

Ground water monitoring wells, air quality monitoring system and vadose zone monitoring instruments shall be periodically inspected to check satisfactory functioning of the systems and to ensure good health of all well caps and sampling ports.
Environmental monitoring system shall be maintained during the entire post-closure period as per the requirements of the local environments regulatory agencies. Wherever possible monitoring instruments shall be periodically recalibrated. Sample devices shall be routinely detoxified and checked for proper functioning of the opening and closing of valves or springs loaded mechanisms.

LANDFILL WAULITY ASSURANCE AND QUALITY CONTROL

Quality Assurance plan shall be prepared for each stage of the landfilling process, accordingly the quality shall be controlled to ensure:

1) The landfill design of a high standard
2) Effective mechanisms are in place too ensure construction and operation to design parameters.
3) Documentation is carried out during design, construction. Operation, closure monitoring and post closure care for purposes of satisfying regulations and legal liability.
4) Public has access to and is aware about the acceptability of land filling quality. An independent engineer shall over see the implementation of QC programme. Advice may be taken from a Quality Assurance Agency for incorporation of quality control conciliation in award of contracts relating to siting, planning, design, construction, operation, monitoring and maintenance.

Table 2: Staff Required

S.No.	Designation/Post	Nos.	Area of Service
1.	Office boy	1	For office routine service
2.	Gardener	1	To maintain the plants, trees
	Total	**02**	

IV. CONCLUSION AND RECOMMENDATIONS

Conclusions

- BMC which comprises of 70 municipal wards has been divided into 14 SWM zones covering an area of 285.50 km2 and population of about 1999537 crores (ward wise estimated) generate 828 tons of municipal solid waste per day. Current tr5eatment practice involves direct dumping of waste.
- Quantum of waste generation varies between 0.2-0.5 kg/capita/day in the suburban centers (municipal councils) and but on an average BMC generates0.416 kg/capita/day.
- Compositing if carried out effectively the final product is stable, odour-free does not attract files and is a good manure, soil stabilizer and soil conditioner. Compositing is considered when biodegradable waste is available in considerable fraction in the waste stream. There is the availability of market for compost provided there is a proper tie up with agro industries, fertilizer companies to sell organic fertilizers together with chemical fartilizers.
- Under ideal conditions incineration may reduce the volume of waste by 75% to 95%. Incineration may be used as a disposal option only when land filling is not possible and the waste composite is of high combustible (i.e. self-sustaining combustible matter which saves the energy needed to maintain the combustion) paper or plastics. It requires an appropriate technology, infrastructure and skilled manpower to operate and maintain the plant. Technology can be made suitable with addition of auxiliary fuel.
- RDF technology is well established and systems for the production of both coarse and densified fluffs are commercially available. High costs are likely to make such technology nonviable in a low income country context. Would be limited market for RDF product as only main stream application would be for use as feedstock for industrial boliers/cement kilns etc.
- No single technological option is able to provide complete solution to waste management problem of the region. The choice of technology for the treatment of wastes has to be done carefully only after taking into consideration the factors-

a) Mixed from of MSW
b) Excess moisture content in MSW
c) Low Calorific Value

Therefore, it should be noted that the composition of MSW plays a significant role in determining and deciding the appropriate technology for treatment Irrespective of the viability and feasibility of various treatment technologies, landfills form the backbone of waste disposal plan. Landfills have served as ultimate waste receptors for inert, remnants of treatment technologies, industrial discards.
Regionalizing the implementation of landfill facilities has many benefits. The single most important reason for considering regional facilities is economy of scale. The cost effective and viable solution lies in adopting a regional approach that enables several municipalities of the region to derive the benefits of economy of scale.

- In addition, RDF would reduce waste volume thus freeing up land that would otherwise have been used for landfills. If sufficient quantity of RDF is produced throughout the year waste to energy incineration plants on RDF as fuel can be installed to produce electricity.
- From an environment point of view, a thermal conversion would be beneficial because it prevents the formation of leachate that contaminates groundwater and if installed with proper pollution control measures, reduces emissions of toxic pollutants from burning of garbage. Thermal conversion if feasible will reduce considerable amount of the waste and thus land requirement for scientific landfill.
- Although waste to Energy Incineration technology (mass burn) is technically and commercially feasible with addition of auxiliary fuel, BMC should be careful in implementing this option for treatment of waste considering likely reduction in the calorific value on account of source segregation of recyclable waste (which has a high calorific value) at ULBs level. The same thing shall also be taken into consideration while considering other thermal treatment technologies which has been given very low preference.
- It is recommended that only process rejects and degraded waste has to be deposite in the scientific landfill. Landfill sites must be planned and designed with proper documentation of a phased construction plan as well as a closure plan. All environment, health ad safety precautionary measures supported with advanced monitoring system shall be taken and compliance of municipal solid waste handling rules and guidelines shall strictly be followed. Landfill sites shall be selected near the waste processing facility.
- BMC needs to select appropriate recycling technologies to comply with mandatory directions of segregation or segregated dry waste like paper, card board and plastic materials at the processing plants. Recycling should be done as a part of processing facility in order to dispose of the entire quantity of the waste received at processing plant effectively in scientific manner.
- All screened technologies claimed to be technically appropriate, environmentally sound and economically feasible. The decision concerning which treatment technology or mix technologies are the best or most appropriate for that requires a reliable data and information as well as a good structure for the decision making process.

REFERENCES

[1]. Letter from Maharashtra Pollution Control Board, vide No. MPCB/RO(HQ)/MSW/B- 1609 dated 11/03/2008
[2]. Letter from CPCB, Zonal Office –Bangalore, vide No. Tech/30/MSW/ZOB/2007- 08/7804 dated 19/03/2008
[3]. Report forwarded by Indian Institute of technology-Delhi, vide letter No. IITD/CE/MD/07 dated 12th March, 2008.
[4]. Letter from Karnataka State Pollution Control Board, vide No. KSPCB/RO (KWR)/ Landfill-site / 2007-08/1262 dated 19.9.2007
[5]. Letter from Karnataka State Pollution Control Board, vide No. KSPCB/EO(MNG)/DEO/TMC Puttur/2007-08/2628 dated 5.10,2007
[6]. Pollution Control Acts, Rules and Notifications Issued thereunder, SERIES:PCLS/02/ 2006.

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