

# **Guidelines for Disposal of Legacy Waste (Old Municipal Solid Waste)**



## **CENTRAL POLLUTION CONTROL BOARD**

(Ministry of Environment, Forest and Climate Change, Government of India)

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## **BACKGROUND**

Until the 1970s, there were few dumpsites exists in India. Since Vedic times, household discards mostly food waste, which went back to the soil along with stable wastes via compost pits. Urban discards were collected by farmers, they converts it into compost and utilize it in farming and bring their produce to town/city. With the introduction of plastic in the seventies the composition of city waste started changing and people started discarded plastic along with kitchen wastes. These plastics blanketed the fields and made them infertile, as less rain could enter and few seeds could germinated, So farmers stopped collecting urban mixed wastes and cities were left with an unexpected burden. Initially most towns and cities in India started dumping all this unwanted waste outside city limits, along roadsides which are unsupervised and where dumped in no-mans-land. Uncontrolled and continuous dumping of municipal solid waste lead to mountains of legacy waste .

After three decades of neglection these open dumps have grown larger and higher, becoming point sources of pollution. Waste rotting in these airless heaps produces leachate, a foul dark liquid that kills vegetation around dumps and irreversibly pollutes groundwater due to leachate generation. The heaps of garbage also produce methane, a greenhouse gas that causes 21 times more global warming than carbon dioxide. Besides, contaminating air quality, which further, worsens due to frequent fire incidences.

Recently, Hon'ble NGT alarmed that due to incremental growth of Municipal Solid Waste (MSW), these MSW dumps are converting into virtual mountains. Hon'ble NGT further directed that every city/town should adhere to clause 'J' of Schedule-I of SWM Rules, 2016. Finally, Hon'ble NGT directed CPCB to propose Standard Operating Processing (SOP) for implementation of Bio-mining and Bio-remediation of legacy solid waste.

These guidelines are very useful to Municipal Corporations, Councils & Waste Management Agencies. The Contribution given by Mrs. Almitra Patel (Member, Hon'ble Supreme Court Committee for SWM & National Expert, Swachh Bharat Mission), Shri Snehal Jariwala (PRO) & Sh. Asad Warsi (Consultant, Indore Municipal Corporation) are highly appreciated. These guidelines have been edited by Dr. S.K. Nigam, Addl. Director (CPCB) and compiled by Ms. Gudiya Jaiswal (SA).

## 1.0 Present Status of Legacy Waste & its impact on Environment:

There are two major challenges of solid waste management in our cities/towns:

- (1) managing the continuous flow of solid waste on a daily basis, and
- (2) dealing with the legacy of neglect which has resulted in garbage heaps having been built up at dumpsites that were meant for waste processing and landfills.

The sites for landfills were originally located outside of the cities, but as the cities have expanded the dumpsites are now almost in the cities. Delhi's open dumps at Ghazipur (69 metres high), Okhla (55 metres high) and Bhalswa (56 metres high), for example, are all much higher than the permissible height limit of up to 20 metres, and way past their capacity of holding waste for which they were set up. It is estimated that more than 10,000 hectares of urban land is locked in these dumpsites in India. In the absence of exposure to air, the high-rises of rotting mixed waste on these sites generate methane (a greenhouse gas) and other landfill gases, which contribute to global warming. They also produce leachate (liquid generated by airless waste) which pollutes groundwater. Frequent outbreaks of fire at the dumpsites lead to air pollution. What is more, the presence of these dumps encourages further dumping at these sites, even though they are filled beyond capacity to take any more waste. Many municipal authorities across the country are opting for "capping" as a solution to the legacy of mixed waste, which is not the first option in the order of priority for environmentally save legacy waste management as per **Clause 'J' of Schedule-I** of the SWM Rules, 2016.



The methane produced at solid waste disposal sites contributes approximately 3 to 4 percent to the annual global anthropogenic greenhouse gas emissions (IPCC, 2001). Clearing these mounds of years-old waste, called legacy waste, is the easiest and fastest way to reduce our national emissions, and save surrounding villages from polluted water sources, smoke, , flies and stench.

Over the years, generation of dry waste, especially plastic waste and packaging, has increased at a tremendous rate. This is because of:

- i. Rapid increase in e-commerce industry from shopping to ordering food.
- ii. Many brand owners have shifted from larger SKU (Stock Keeping Unit) size to smaller SKU size due to changing market scenario.
- iii. Shifting of public consumer preferences to daily use plastic products like bottles, food containers, etc.
- iv. GST on recyclables making it uneconomical for waste-pickers and kabadiwalas to collect low-value waste.

These reasons have contributed to ever-growing dumping grounds. Some waste materials may or may not be recyclable and others might be too small to recover. Since 2016, MoEF & CC has transferred this downstream responsibility of collection and sustainable end disposal for plastic packaging through EPR as per Plastic Waste Management Rules, 2016. Now it is time to introduce upstream EPR also. The downstream EPR majorly focuses on managing a products disposal whereas upstream EPR stimulates product design for environment, reducing use of resources and reducing its adverse environmental and health impacts via use of materials that can be disposed of in a sustainable manner. Under upstream EPR, Producers, Importers and Brand Owners will have to Eco-Design their product packaging and design it considering its collection, recovery and end-of-life sustainable disposal to avoid formation of future legacy wastes. This means that the packaging should be made of eco-friendly material or can be recovered easily and have an established value chain to reduce the burden on ever-growing dumpsites.

Local Bodies also need to ensure that the upcoming infrastructure is designed to handle and store unmixed wastes separately. Government bodies should also create infrastructure for collection, handling, sorting, processing and sustainable end disposal infrastructure for all types of waste.

## 2.0 Key Definitions:

Some of the important keywords are explained below:

- i. **"aerobic composting"** means a controlled process involving microbial decomposition of organic matter in the presence of oxygen;
- ii. **"biodegradable waste"** means any organic material that can be degraded by micro-organisms into simpler stable compounds;
- iii. **"combustible waste"** means non-biodegradable, non-recyclable, non-reusable, non-hazardous solid waste having minimum calorific value exceeding 1500 kcal/kg and excluding chlorinated materials like PVC plastic, woody waste etc.;
- iv. **"composting"** means a controlled process involving microbial decomposition of organic matter;
- v. **"contractor"** means a person or agency that undertakes a contract to provide materials or labor to perform a service or do a job for a service-providing authority;
- vi. **"co-processing"** means use of combustible waste as raw material or as a source of energy or both to replace or supplement fossil fuels in industrial processes;
- vii. **"disposal"** means the final and safe disposal of post -processed residual solid waste and inert street sweepings and silt from surface drains on land as specified in Schedule I of SWM Rules, 2016 to prevent contamination of ground water, surface water, ambient air and attraction of animals or birds;
- viii. **"dry waste"** means waste other than bio-degradable waste and inerts and includes recyclable and non-recyclable waste, combustible waste and sanitary napkin and diapers, etc.;
- ix. **"dump sites"** means a land utilized by local body for open dumping to dispose of untreated solid waste without following the principles of sanitary land filling;
- x. **"extended producer responsibility" (EPR)** means responsibility of any producer and/or brand manager of packaging products such as plastic, tin, glass and corrugated boxes, etc., for environmentally sound management, till end-of-life of the packaging products;
- xi. **"inerts"** means wastes which are not bio-degradable, recyclable or combustible and include debris, construction and demolition wastes, street sweepings or dust and silt removed from the surface drains;
- xii. **"informal waste collector"** includes individuals, associations, waste traders or agency involved in collection, sorting, sale and purchase of waste and/or recyclable materials without valid authorization from respective urban local body or pollution control board to comply with guidelines issued by MoEF&CC under Environment (Protection) Act for waste handling, management, and disposal;

- xiii. **"leachate"** means the dark smelly liquid that seeps through or is generated within solid waste and has extracts of dissolved or suspended material from it;
- xiv. **"local body"** for the purpose of these rules means and includes the municipal corporation, nagar nigam, municipal council, nagarpalika, nagar palika parishad, municipal board, nagar panchayat and town panchayat, census towns, notified areas and notified industrial townships by whatever name they are called in different States and union territories in India;
- xv. **"materials recovery facility" (MRF, pronounced Merf)** means a facility where non-compostable solid waste can be temporarily stored by the local body or any other entity mentioned in rule 2 or any person or agency authorized by any of them to facilitate segregation, sorting, recycling and/or recovery of recyclables from various components of waste by authorized informal sector of waste pickers, informal recyclers or any other work force engaged by the local body or entity mentioned in rule 2 for the purpose before the waste is delivered or taken up for its processing or disposal;
- xvi. **"non-biodegradable waste"** means any waste that cannot be degraded by microorganisms into simpler stable compounds;
- xvii. **"processing"** means any scientific process by which segregated solid waste is handled for the purpose of reuse, recycling or transformation into new products;
- xviii. **"recycling"** means the process of transforming segregated non-biodegradable, recyclable solid waste into new material or product or as raw material for producing new products which may or may not be similar to the original products;
- xix. **"refuse derived fuel"(RDF)** means fuel derived from the combustible waste fraction of solid waste like plastic, woody waste or organic waste, other than chlorinated materials, in the form of pellets or fluff produced by drying, shredding and compacting of solid waste;
- xx. **"residual solid waste"** means and includes the waste and rejects from solid waste processing facilities which are not suitable for recycling or further processing or use;
- xxi. **"sanitary land filling "** means the final and safe disposal of residual solid waste and inert wastes on land in a facility designed with protective measures against pollution of ground water, surface water and fugitive air dust, wind-blown litter, bad odor, fire hazard, animal menace, bird menace, pests or rodents, greenhouse gas emissions, persistent organic pollutants, slope instability and erosion;
- xxii. **"segregation"** means the unmixed and separate storage and management of various components of solid waste namely biodegradable wastes including garden or agriculture and dairy waste, non-biodegradable wastes including recyclable waste, non-recyclable combustible waste, sanitary waste and non-recyclable inert waste, domestic hazardous wastes, and construction and demolition wastes;
- xxiii. **"solid waste"** means and includes solid or semi-solid domestic waste, sanitary



waste, commercial waste, institutional waste, catering and market waste and other non-residential wastes, street sweepings, silt removed or collected from the surface drains, horticulture waste, agriculture and dairy waste, treated bio-medical waste excluding hospital or industrial waste, e-waste, battery waste, hazardous and radioactive waste generated in the area under the local authorities and other entities mentioned in rule 2;

- xxiv. **"sorting"** means separating various components and categories of recyclables such as paper, plastic, card-board, metal, glass, etc., from mixed waste as may be appropriate to facilitate recycling and recovery;
- xxv. **"stabilizing"** means the biological decomposition of biodegradable wastes to a stable state where it generates no leachate or offensive odors/gases or fire and is fit for application to farm land, soil erosion control and soil remediation;
- xxvi. **"transportation"** means conveyance of solid waste, either treated, partly treated or untreated from a location to another location in an environmentally sound manner through specially designed and covered transport system so as to prevent foul odor, littering, leachate dripping and unsightly conditions;
- xxvii. **"treatment"** means the method, technique or process designed to modify physical, chemical or biological characteristics or composition of any waste so as to reduce its volume and potential to cause harm;
- xxviii. **"waste hierarchy"** means the priority order in which the solid waste should be managed by giving emphasis to waste prevention, reduction, reuse, recycling, recovery and disposal, with prevention being the most preferred option and disposal at the landfill being the least preferred;
- xxix. **"waste picker"** means a person or groups of persons informally engaged in collection and recovery of reusable and/or recyclable solid waste from the source of waste generation or from streets, bins, material recovery facilities, processing and waste disposal facilities for sale to recyclers directly or through intermediaries to earn their livelihood.

### **3.0 Provisions of SWM Rules, 2016:**

The Government of India has notified the Solid Waste Management Rules (SWM) Rules, 2016 for proper and effective management of municipal solid waste (MSW). Under the SWM Rules, 2016, following provisions have been made to manage old dumps of MSW.

#### **3.1 Rule 15 - Duties and responsibilities of local authorities and village Panchayats of census towns and urban agglomerations.** - The local authorities and Panchayats shall,-

(zj) investigate and analyze all old open dumpsites and existing operational dumpsites for their potential of bio-mining and bio-remediation and wheresoever feasible, take necessary actions to bio-mine or bio-remediate the sites;

(zk) in absence of the potential of bio-mining and bio-remediation of dumpsite, it shall be scientifically capped as per landfill capping norms to prevent further damage to the environment.

The by-laws shall apply to every urban local body, outgrowths in urban agglomerations, Cantonment boards, Panchayat, Industrial and Institutional Townships, railways and defence establishments

Further, provisions under Schedule I (j) are given below:-

**3.2 Schedule-I (j) - Closure and Rehabilitation of Old Dumps-** Solid waste dumps which have reached their full capacity or those which will not receive additional waste after setting up of new and properly designed landfills should be closed and rehabilitated by examining the following options:

- (i) Reduction of waste by bio-mining and waste processing followed by placement of residues in new landfills or capping as in (ii) below.
- (ii) Capping with solid waste cover or solid waste cover enhanced with geomembrane to enable collection and flaring / utilisation of greenhouse gases.
- (iii) Capping as in (ii) above with additional measures (in alluvial and other coarse grained soils) such as cut-off walls and extraction wells for pumping and treating contaminated ground water.
- (iv) Any other method suitable for reducing environmental impact to acceptable level.

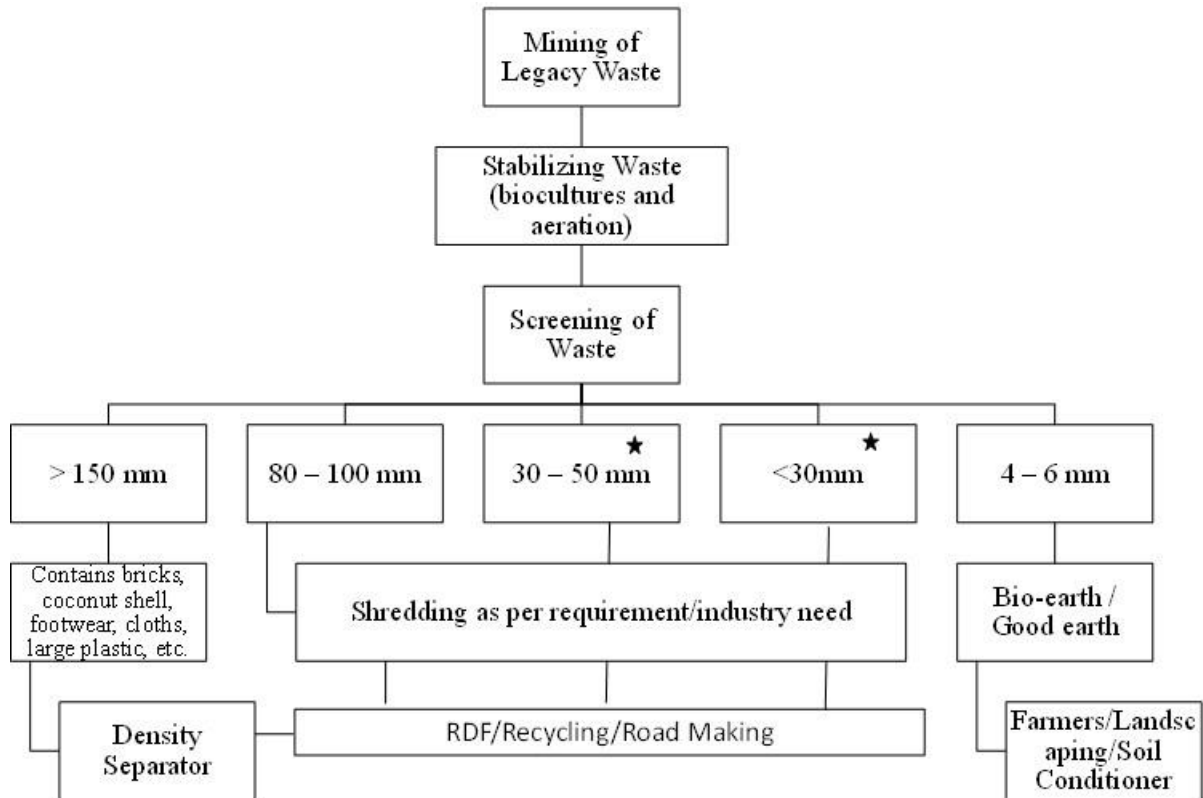
#### **4.0 Methodology:**

The treatment & disposal of Legacy MSW can be done by Bio-remediation and Bio-mining. A total station survey or drone mapping of any landfill/dumping site must be done prior to start of the project. Hence, it is suggested to ensure precursor study with history of the site, compositional analysis of waste. Site environment parameters such as baseline study of heavy metals in surface and subsurface soils and water, rainfall, soil type, surface hydrology, topography, wind direction etc. shall be studied before and after bio-mining. Periodic study should also to be carried out after completion of biomining to check for any adverse effects in the surrounding area.

#### **4.1 Bio-remediation & Bio-mining of Old Municipal Dumpsites:**

It refers to the excavation of old dumped waste and make windrow of legacy waste thereafter stabilization of the waste through bio-remediation i.e. exposure of all the waste to air along with use of composting bio-cultures, i.e. screening of the stabilized waste to recover all

valuable resources (like organic fines, bricks, stones, plastics, metals, clothes, rags etc.) followed by its sustainable management through recycling, co-processing, road making etc.



★ In Case of RDF (With Size Up to 50mm) shredding is not required

Fig. 1. Overview of Bio-remediation and Bio-mining of Legacy Waste

The first step is to excavate legacy waste, loosen it and make windrows so as the leachate can be dried of through solar exposure and all the entrapped methane is removed from the heap. All biodegradable waste, like discarded food, fruit, flower and garden waste, needs air to decompose it in an odourless way without producing leachate. So the first step in stabilizing and bringing down airless legacy waste is to expose as much of it as possible to air (Fig. 1).

Addition of composting bio-cultures speeds up decomposition and rapidly creates biological heat within the waste that helps to dry it out and reduce its volume by 35-40%. This happens through loss of moisture and by decomposition of some of the aerated waste to carbon dioxide and water vapour. This is called **bio-remediation** and makes the waste dry enough for screening. Waste is called stabilized when there is no more generation of heat or landfill gas or leachate, and seeds are able to germinate in it.

It means the screening of such stabilized waste into different size fractions that can be usefully used off-site or disposed of without affecting the environment. Screen sizes commonly used are one or more of the following: 150 mm, 80 to 100 mm, 24 to 50mm, 12-16 mm and 4-6 mm. The finest fraction is called bio-earth or good earth. It contains a mixture of humus-rich organics which improve soil fertility along with a high proportion of soil or sand, which is why it cannot meet FCO standards for compost. The coarsest fraction contains bricks, stones, coconut shells, footwear, cloth and larger plastics. Density separation helps recover combustibles which can be used (usually up to 5-10%) as fuel replacement after supplying it to customer requirements.

The lighter mid-fractions are mostly plastics and can be shredded as per industry requirement for use in bitumen hot-mix plants to make so-called Plastic Roads or as refuse derived fuel



for co-processing in cement kilns. Fractions up to 50mm do not require shredding for use as RDF. The heavier mid-fractions are mostly stony inert which can be used in the lowest layers of road-making or plinth-filling or in low-lying areas, but should not contain more than 3-5%



plastics by weight. Less than 10% of the original waste remains as totally unusable residual

rejects and may remain onsite, either in a small heap or spread to raise the ground level by a couple of meters.

The land which was hosting waste dumps is now fully recovered for alternate uses. Bio-mining and Bio-remediation processes should be adopted as early as possible to ensure holistic solid waste management.

#### 4.1.2 Process of Bio-remediation and Bio-mining:

Exposing the legacy waste to air to stabilize it has been done since 1998 in many ways. Almost all of them involve forming the waste into long low heaps of about 2 meter height called wind-rows, to get maximum surface area to volume. Repeated turning is necessary to ensure that the innermost waste in wind-rows also gets exposed to air. Usually 3-4 turnings of legacy waste are necessary to stabilize it.

1. Use a tractor-tiller to repeatedly loosen the topmost 150 mm layer of legacy waste. Mist-spray the waste lightly with bio-cultures to control odour and get the decomposing microbes dispersed into the waste. Hand-pick out large objects like rocks or coconut-shells or long pieces of cloth. Form the waste into wind-rows using a Bob-cat or JCB or similar earth-moving equipment. Turn these wind-rows every 5 days. After 2-3 weeks when the heaps are free-flowing enough for screening, move the material to multi-deck vibrating screens or to trommels (rotating cylinders with different size perforations) to get fractions of different size and weight.

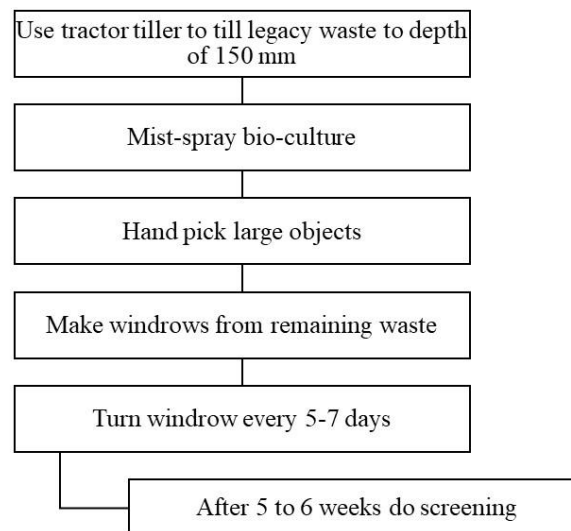


Fig. 2. Schematic representation of Bio-mining through Tractor Tiller by Windrows

2. Use a JCB to dig 2-2.5 meter deep trenches downwards from the top of a legacy waste heap at 1.5 to 2 meter intervals. This is a rapid and cost-effective way to slice the uppermost layer into in-situ wind-rows. Mist-spray the sides of the

trenches to get microbes to reach exposed waste surfaces. Bring down these slices to form terraces and turn one aerated windrow onto another weekly before repeating the process until almost ground level is reached. Start screening when waste moisture is low enough.

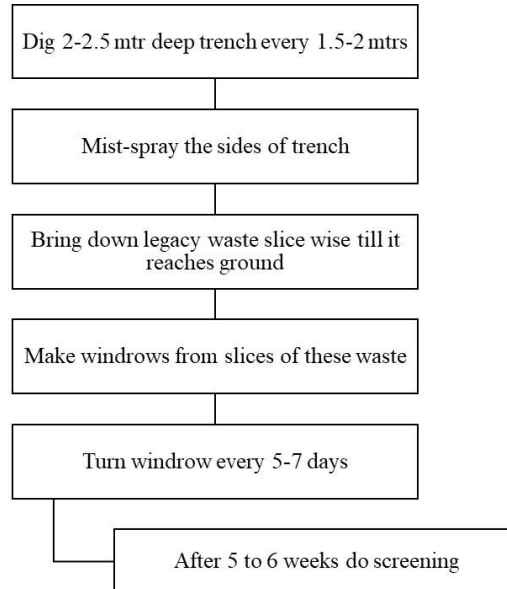


Fig. 3. Schematic representation of Bio-mining through Trench Method

- Use a JCB to lift legacy waste off the top of a heap and drop it from a height to aerate and loosen the waste and form 2-3 meter high cones. Mist-spray bio culture on the cones. Every day or 2-3 days use the JCB to lift waste from the cones and drop it back to the same or a nearby location, to aerate the waste. This is rather fuel-intensive.

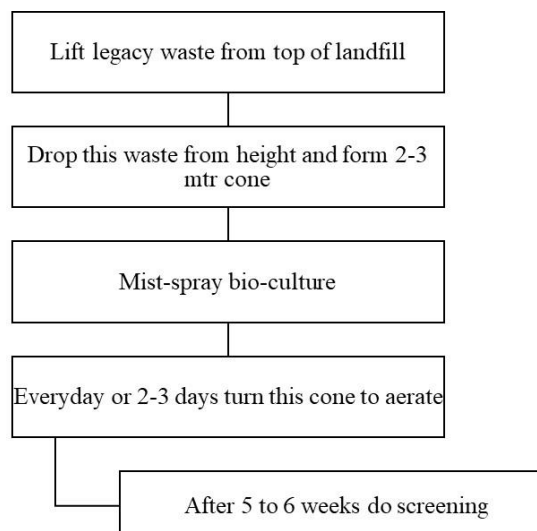


Fig. 4. Schematic representation of Bio-mining through Cone Method

- Where space permits, move the waste to form several long parallel windrows. Turn these weekly with a JCB. Often at the second or third turning, one heap can be

combined with a second one as their volumes decrease. Windrows can be aerated either by moving all the waste to form a new parallel windrow, with the innermost waste on the outside for aeration, or by moving all the waste forward in small steps while dropping it from a height for aeration.

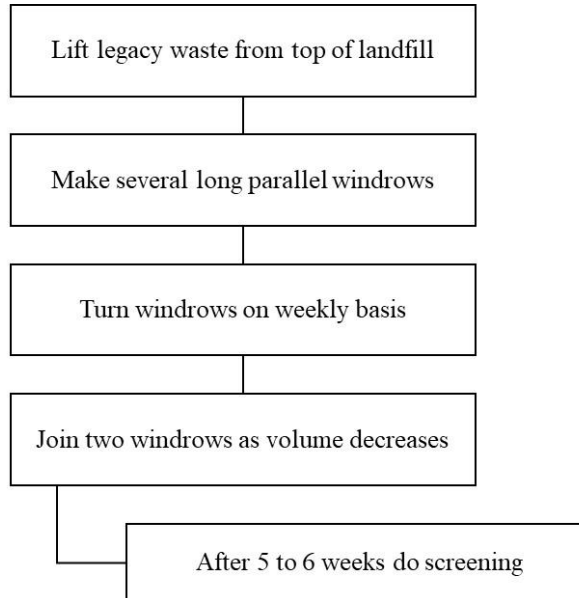


Fig. 5. Schematic representation of Bio-mining through Windrow Method for Spacious Landfill Sites

5. If waste needs to be moved from one location to another part of the same site, usually the perimeter, place it in thin 150 mm layers and mist-spray bio cultures. Allow 5 days to aerate one layer before adding the next one and mist-spraying bio cultures on that also. Turning may not be necessary when waste is spread thin like this, to decompose like leaves on a forest floor.

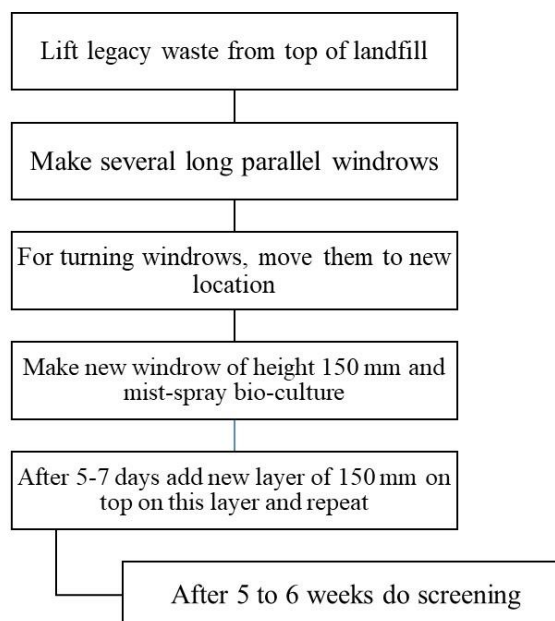


Fig. 6. Schematic representation of Bio-mining through Thin Layer Spreading Method

6. This is a constantly-evolving field. Hence other cost effective and space effective methods can also be applied.

#### **4.1.3 Processing Equipment's for Processing of Legacy Waste:**

The major equipment that would come in use would fall under the following heads of processes like excavation, shredding, screening, air classification and ferrous separation. As per suitability and requirement the appropriate choices should be made.

##### **Screening**

- Trommel
- Vibrating Screen
- Disc/ Star

##### **Handling Equipment**

- Loader (Front Load)
- Conveyers
- Fork Lifts

##### **Screening**

- Trommel
- Vibrating Screen
- Disc/ Star

##### **Handling Equipment**

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- Conveyers
- Fork Lifts

#### **4.2 Treatment Process:**

Processing of accumulated waste shall be done in following manner as given below:

1. Local Body (LB) shall make a time bound plan to execute the bio-mining process to clear the old waste.
2. Volume of waste to be determined through contour survey (Total Station Survey) and site measurements. Drone mapping of heap volumes at different stages is most cost-effective and fast. Weighment of heaps is difficult and problematic as payment would be collected for heavy fractions, leaving behind the more pollution-prone lighter fractions.
3. Initial Contour level survey of the site shall be done on start of work and Final Contour level survey shall be done on final completion of the work.
- 4 Do an initial baseline survey of surface and subsurface soils and waters and also leachate present, to check for heavy metals and toxics if any. Samples should be drawn by an NABL



or MOEF certified lab, also at the final stage. During operations, the operator should collect and keep daily samples of the finest fractions, to be pooled and analysed monthly or at random by an NABL lab. This is to ensure that unsterilized rotted waste is not simply moved from one location to another by mining without bioremediation.

**4.** Sprinkle the newly exposed surfaces with a composting bio culture solution or a dilute solution of 5% fresh cow dung in water. This will control smell and speed up decomposition. With the help of Back Hoe loader, the waste in the demarcated area should be loosened up.

**5.** Usually the top layer has several materials in the active biological state. This layer shall be stabilised through composting bio-cultures, as well as herbal/biological sanitizers if found necessary for odour control.

**6.** Raking of garbage layers by a long spike harrow operating in cross directions may be done as needed to pull out large rags, plastic, rubber, textiles etc.

**7.** Waste pickers or labour should manually pick out bulky waste like coconut shells, banana stems, tyres and rocks prior to screening for bio-mining. Store in separate heaps for sale or use.

**8.** Turn these windrow heaps once a week until no more volume reduction is observed in the heaps and no more heat is generated. If the garbage is stabilized, there will be no smell or leachate formation and the material will be dry enough for sieving.

**9.** LB or its agency may deploy Trommels and/or Horizontal Screens or other types of screens for the purpose of screening. Screen the stabilized waste in a rotary screen or gravity screens of different size openings, preferably 35mm and 8mm. A fan can blow out the plastic fraction for use by recyclers. Compost

**10.** Appropriate numbers of excavators, back hoe loaders and workers will be required to execute the work.

**11.** The recyclables recovered from the bio-mining process should be sent for recycling as per the quality of the material, which should also be randomly sampled by an NABL lab and tested for heavy metals, salinity/electrical conductivity and leachability to ensure no environmental harm during use. FCO standards for pH and contaminants could be provisionally used as a benchmark.. Non-Recyclable plastic material shall be sent for road making or to RDF units or cement plants. Initial cleaning of recyclable waste shall be done before it is transported for sale or disposal.

**12.** The recovered earthy fines shall preferably be used for landscaping or gardening or road medians within the Local Body or the site. The recovered soil can also be used as “Soil enricher” to develop green areas or by farmers.

**13.** The recyclables like plastic, glass, metals, rags and cloth recovered from the waste during screening shall be sorted out and preferably cleaned before sending to recycling industries or as RDF.

**14.** The heavy fractions may be sand and gravel usable for road shoulders or for plinth filling. Stones and concrete if any can be used for road sub-grade, or for crushing, recycling and reuse in the construction industry. The recovered construction and demolition waste recovered from the bio-mining process may be sent to a C&D processing facility if suitable for production of building materials.

**15.** In very old garbage layers with high debris content, most of the organic matter may have already been decomposed. Do a seed germination test to ensure it is stabilised. Add biocultures to fully stabilise it if heat is still generated in windrow heaps or volume reduction is observed. After 7-10 days of stabilization the waste can be taken up for screening.

**16.** Usually the finest fraction will be organic matter plus fine soil, called 'bio-earth', which can be used as soil improver, especially for restoring alkaline or saline soils to fertility, or to grow some vegetation for erosion control. It is also useful as a lawn subgrade cum drainage layer, or it can be used as organic manure in tree pits. . The next coarser fraction will be gravel and coarse organics, which can be used for road and railway embankments the coarsest fraction may have a lot of combustibles (cloth etc.) which can be baled and supplied as Alternate Fuel Resources in cement kilns or boilers.

**17.** There may be some (maximum 5-10% of total) left over waste including lumps of heterogeneous nature. The waste may be soaked with leachate or hard and difficult to disintegrate. This waste can be sent to scientific landfill for disposal (near zero residues).

**18.** The recovered land from the bio-mining process shall be utilized for any purpose deemed appropriate. Ideally reclaimed space should be reused for waste processing, otherwise for alternate non-habitation uses.



### **4.3 Use of Screened Fractions:**

When planning for bio-remediation and bio-mining, it is important at the same time to identify where the screened fractions will go, in order to bring down the heap of mixed waste to fractions that would each have been usable if unmixed. None of these fractions will bring in income. In fact, their transport offsite is a cost to be budgeted for. Look for the nearest industries using solid fuel. Look for the nearest bitumen hot-mix plants and also specify Plastic Roads in road tenders to ensure offtake of the thin-film plastic fractions. Start a dialogue with all kabadiwalas within the local body to see who will be willing to pick up or accept which items. Plan for offsite aggregation space for different fractions and types of waste that will result from screening. Identify aggregation and storage sheds for use by waste-picker groups or kabadiwalas. Identify transporters who can transport different fractions out on their return trips.

For the bio-earth or good earth finest fraction, test periodically for heavy metals, then look for farmers willing to accept it. It is excellent for reclaiming salt-affected soils and for restoration of mining overburden areas if any are nearby. There is a cess for restoration of mined areas, which is normally unspent as forest departments are supposed to revegetate them. But this is unviable in barren rocky soil by planting and watering saplings. Revegetation is instead possible and effective by mixing grass seed with the good earth fraction and spreading it on the overburden to start a natural succession of grasses, herbs and shrubs.

### **4.4 Process Management:**

There are several factors that must be kept in mind during implementation of the project.

#### **4.4.1 Space Management:**

For all waste-stabilising methods, management of space is the biggest challenge, as aeration, stabilizing and screening mostly needs to be done within the boundaries of an already overloaded dumpsite. This is achieved mainly by experience and creative common-sense. Onsite earth-mover operators often come up with the best solutions, so seek their opinions. Every dumpsite poses a case-by-case challenge, but there is no above-ground dump that cannot be successfully bio-remediated and bio-mined.



Fig. 7. Illustration of Trench Bio-mining at existing landfill site

Keep safety in mind. Always try to work downward from the top surface. Do not think of slicing waste from the top down along one side of the heap unless you can ensure leaving a stable wall of waste with a safe slope of 25 - 30 degrees while you work. Leaving a vertical wall of waste during operations can cause a dangerous landslide of disturbed waste.

#### **4.4.2 Leachate Management:**

Most high heaps of legacy waste are water-logged with leachate even near the topmost layers and all the way to the bottom, like a dhokla. This is not just from rainwater entering the heap but is produced by airless rotting within the entire waste heap. So when legacy waste heaps are opened up, some leachate almost always trickles out. This is not produced by the formation of wind-rows or cones, which in fact help to dry out the waste by aerated decomposition.

Channels must be created to lead the oozing leachate rivulets to a lined depression or pond for treatment or for leachate recirculation onto wind-rows as a type of bioculture. (test to see if heaps generate enough heat with its use). Leachate can also be treated in collection ponds by underwater composting. Bio-cultures that have been proved successful at other locations can be sprinkled onto the leachate pools. But intermittent aeration is a must, using small compressor pumps or aerators or airlift aeration or even simple manual or mechanical agitation. Aeration is necessary for the added microbes to do their work of digesting the polluting solids suspended in the dark and turbid leachate. Success is noticed by a progressive change in colour from dark to light, by reduction or absence of odour and by fine bubbles rising to the surface from digested solids.

#### **4.4.3 Fire Control and Safety:**

Most large dumpsites are smouldering from hidden fires. Methane itself is flammable with a blue flame, and supports the yellow-flame burning of combustible plastics, cloth and oily rags. Sometimes flammable industrial waste find its way onto dumpsites, aggravating the problem.

It is difficult to begin bio-remediation work on a smoking dump. Sometimes digging into the dump awakens hidden fires. So fire control is important. Adding water increases the generation of both methane and leachate and is counter-productive, not a long-term solution, Adding soil cover to smother the flames adds more material to a heap that one is trying to bring down.

There is a better way, again requiring creative common-sense and experience and training of earth-mover drivers. Most fires within heaps have a point source – a bag of textile discards or plastic waste or a ball of oily rags. Earthmover drivers must learn to dig in and pluck out these burning balls of fire. These should be laid nearby on the surface of the dump and then rubbed out with the back of the excavator shovel to extinguish the flames and smoke. Wet soil should be kept handy to immediately plug the excavated hole. Adding composting bio-cultures can be tried, to counter the anaerobic conditions around the burning spots. Smoking points must be tackled patiently and systematically, one by one, till the dump is smoke-free to begin stabilizing operations by bio-remediation.

It is important to do the risk assessment and an onsite emergency plan should be kept handy prior to commencement of dumpsite bio-remediation & bio-mining.

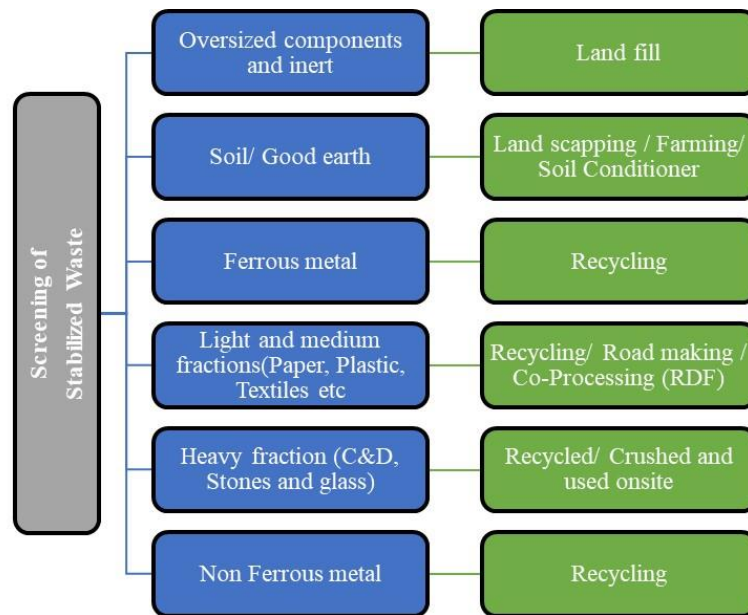


Fig.8: Schematic representation of screen components and its sustainable disposal

#### 4.4.4 Use of Recovered Space :

The benefit of bio-mining lies in abatement of ongoing and future pollution and ill health and in the recovery and re-use of valuable space. This is ideally for continued long-term waste management since public consent for new waste sites is increasingly difficult because of earlier visible mis-management of a virgin site. Ensure advance demarcation and declaration of a buffer zone of no new habitation for upto 500 meters around the cleared site to prevent real-estate activity from encroaching the buffer as soon as the dump is removed.

If a dump is engulfed within a growing city and its continued use for waste management is unsuitable, identify in advance the planned future use of that site and put up a signboard indicating that use, to ensure public acceptance of the biomining operations which will be temporarily noisy and dusty. This will also protect the site from land-grabbers.

Cleared dumps are not permitted for habitation for at least 15 years (SWM Rules Schedule I, H (2)). This is because of unhealthy leachate below the site and formation of flammable and offensive landfill gases from waste pockets that may remain unexcavated.

Permissible options are reuse for SWM, open stadia, sports grounds, parks and gardens, parking lots, container yards, warehouses of non-flammables and similar facilities where people are not living or working all day and night.

#### 4.5 Bio-mining Below-Ground Waste:

Many cities and towns chose abandoned quarry-pits to dump untreated waste, without realizing the permanently harmful effects of this. Leachate oozing out at the bottom of the pit cannot be seen or captured or treated and enters both shallow and deep groundwater through fissures in the rock. The hydrostatic pressure in deep quarries, as divers experience at increasing depths, forces the leachate even more forcefully into the cracks. Dark and smelly

water pollution begins to show up in nearby wells and bore wells after a year or further away even after 3-4 years, after which the damage is irreversible.

But leachate in an airless rotting mass continues to form for up to 30 years, so further damage can be prevented by bio-mining the quarry-pits. This has also been ordered by the NGT (in OA 179 of 2017). The waste needs to be excavated in descending layers like any open-cast mining and unloaded on the surface in windrows or conical heaps which can be turned weekly for 5-6 weeks before screening. Use of bio cultures is most important here, to control odour and the leachate which will run out while placing excavated material. Adding bio-cultures into the pit without excavation will not give the waste and the digesting microbes the air needed for stabilising the waste.

Immediate stoppage of further quarry-dumping of untreated waste is the most important action. The excavated quarry-pit, or any other quarry-pits that are planned for waste disposal, must first be filled to ground level with only debris and construction and demolition waste up to slightly above surrounding ground level. The newly-created space can then be used for waste stabilizing by unloading fresh waste in windrows here and turning them regularly. Any small quantity of leachate produced will be visible as it runs out from the edges of the heaps. Bio-mining /screening may have to be interrupted during monsoons, both above grounds and below ground.

#### **4.6 Engineered Landfill and Capping:**

Capping, in developed countries, is the preferred means of closure of scientifically engineered landfills with bottom and side liners. These lines as well as drainage layers and leachate and gas collection pipes are installed even before using the site for waste placement. Their capping is meant to keep out rain from the landfill so as not to add to the internally generated leachate which is continually pumped out through pipes and drainage layers for treatment. Landfill gas captured through pipes is generally flared, as generating power from its combustion is always loss-making.

The dumping of mixed MSW begins in low-lying areas without any prior waterproofing layers to protect groundwater or prevent landfill gas migration. Capping of unlined dumps is in fact dangerous as it makes the waste even more airless, generating more leachate and also more methane and landfill gas, which leaks out below the edges of the capping. This created a disaster at the Mindspace IT complex, constructed next to a capped landfill at Malad in Mumbai. The landfill gases entered the Mindspace basement where the central air-conditioning circulated it to every floor in the building, causing regular frequent failure of

every type of electronic equipment. Probably sulphur in the hydrogen sulphide gas made the circuit-board connections non-conducting. The problem is still unsolved. Another capping failure is at Bagalur in Bangalore, where leachate extraction wells were placed in a partly lined quarry pit before waste placement. A garden was constructed over the filled pit, with lawn sprinklers adding to the moisture in the waste through tears in the capping plastic. Now landfill gas and methane can be seen and even heard, vigorously bubbling up in every unemptied leachate-extraction well.

Capping should only be considered for the maximum 10% residual rejects after bio-mining (screening) of stabilized waste. The SWM Rules 2016 in Rule 15 (zk) permit it only where bio-mining and bio-remediation is not possible. Perhaps the only places where this is not possible are in steep inaccessible ravines and narrow valleys in mountainous regions.

#### **4.7 Clearing vs. Capping of Legacy Waste:**

The SWM Rules 2016 clearly mandate clearing of sites as a first option, by bio-mining and bio-remediation. Still, capping is often proposed or considered an option in India merely because it is done in the West. But clearing a dumpsite almost to ground level rather than capping it is a far better option for permanent pollution prevention, as well as for the following additional reasons:

Clearing by bio-mining recovers the entire base area of a dump at almost ground level. Capping gives only one-third of the base area as usable area at an inconvenient height for future use.

Cleared sites require no after-care. Capping requires at least 15 years of continuous leachate pump-out and treatment in a dedicated effluent treatment plant nearby. Gas extraction is very difficult and inefficient when attempts are made to insert suction pipes into dumped waste instead of before dumping begins. Poor success at Gorai capping led to the forced refund by Mumbai city of Rs 15 crore advance carbon credits.

Capping of open dumps (wrongly called SLFs or Sanitary Landfills) requires intake of fresh waste to be stopped and permanently diverted to a fresh site before capping begins. With increasing protests against fresh waste disposal sites, getting started elsewhere can often delay capping plans indefinitely. Bio-remediation and Bio-mining to clear a site can start



immediately at one part of an actively used dump while fresh waste continues to be received and stabilized at another part. Clearing can be done in phases to match available funds.

In the USA, only grass is permitted to be grown on the soil cover of a capped site. It must be regularly mowed for 15 years to prevent the growth of herbs or shrubs or trees whose roots may penetrate the plastic layer below the soil cover. If trees are planted over soil capping, they die in a few years as soon as their roots enter the hot airless waste below. Capped sites are closed to the public for 15 years. But if a dump is cleared to near ground level, it can be easily converted to a public tree park or garden if desired, unless below-ground waste remains untreated on the site.

Thus capping of dumpsites is not advisable. However, if any scientific landfill site for municipal waste is present which has been constructed as per the norms and guidelines of MoEF&CC and has been filled to its maximum level, possibility of capping can be explored.

## **5.0 Costs:**

### **Operation & Maintenance Cost for Bio-remediation and Bio-mining :**

Operational Expenditure of the project would depend on the size of dumpsite. The onsite bioremediation cum biomining cost ranges between Rs 400 to 700 per cubic meter, irrespective of capital cost. The case by case cost of moving screened fractions offsite will be extra and variable, depending on distance to farmers, cement plants etc.

### **Case Studies :**

Clearing of large dumps has been effectively done since at least 1998, at over 20 documented sites and perhaps other informally undocumented ones. Sites have been effectively reused for waste disposal or for parks and sports grounds and open maidans for periodic events.

There are at most five capped dumps to date in India, all with problems. Pune capped its old waste to create an impervious base for windrow composting, but instead dumped more waste which is now a stinking hill above it. Landfill gas leakage at Malad (Mumbai) and unsuccessful gas capture at Gorai (Mumbai) and Bagalur (Bangalore) have been described above. Case studies such as capping of legacy waste at Jawaharnagar in Hyderabad reveal issues of cost over-runs. . The dump contains 12 million tons of the city's waste accumulated till 2012. Every monsoon, leachate from the legacy dump seeps into the ground and pollutes the lakes around the site.

Leachate ponds to store the liquid have been of no use as they overflow during rains. Capping normally means laying of a thick soil cover over a cover of HDPE (High Density

Polyethylene). To facilitate release of gaseous emissions from the dump, pipes are planned to be installed. Besides, drainage pipes will also need to be laid to pump out leachate emanating from wet garbage inside. The concessionaire claims to have so far completed 95 per cent of the profiling of garbage, and capped about 30% of the dump with soil cover.

## **6. Training:**

Bio-remediation and bio-mining is currently (January 2019) going on at several places: Dimapur, Vijayawada, NOIDA, Vadodara, Indore and is planned at a few more cities in Tamil Nadu, Assam and Madhya Pradesh. The best way to learn how to do it well is to observe legacy waste stabilizing (bio-remediation) and screening (bio-mining) and disposal of fractions at such sites. Every State where dumpsite clearing is under way must arrange for educational field visits by the field officers of nearby cities and districts. Bio-remediation with 40% waste volume reduction has been done by cities in-house at over eight sites, using their existing earthmoving equipment and manpower available at the dump, and engaging only the bio-culture spraying services which often are paid for by savings in fire control and leachate management. So bio-remediation can begin at once anywhere, while tenders are floated for the bio-mining operations that usually begin five months later when the stabilized waste is dry enough for screening.

## **7. Stabilising Fresh Municipal Solid Waste:**

Clearing of old dumps is meaningless unless the creation of fresh open dumpsites is stopped. This is best done by proper segregation of biodegradable waste and its processing through aerobic composting or Biomethanation as mentioned in SWM 2016 Rule 15 (v) (a). For this the practice of unloading waste and then levelling it into airless heaps must stop. Instead, incoming waste must be unloaded in wind-rows.

This is easily done by moving the garbage vehicle slowly forward during unloading. This leaves the waste unloaded as a long low heap which can be bio-treated with composting bio-cultures and then shaped by a Bobcat or JCB into neat parallel windrows of maximum 2 – 2.5 meter height and of whatever length the site space permits. More than one row per day can be formed, depending on daily waste volumes. If prevailing winds in the area are West to East, let the wind-rows stretch from West to East (not North to South) so that the wind can blow freely between the rows for maximum aeration and moisture removal.

These windrows must be punctually and regularly turned every 5-7 days, using small earthmoving equipment or even tractors with lifting arrangement for smaller quantities. The

heaps can be turned to form a parallel windrow, with the innermost airless portion getting exposed to air on the outside of the new heap at each turning. Or the waste from one end of the windrow can be lifted up and dropped a little forward, so the entire heap is aerated and moved a little forward in the process. At the next turning the whole heap can be moved backward again similarly, if space is a constraint. Leave enough space between windrows for movement of turning equipment.

When the heaps are so hot inside that a lot of white water vapour like steam is seen coming out during turning, that is a good sign that stabilizing is going well. After 4-5 turnings, water vapour will no longer be visible and the waste will have reduced in volume by 40% and become free-flowing. A germination test is the best way to ensure that the waste is stabilized and good to use. Sprinkle exactly 50 or 100 ragi seeds in one tray of stabilized waste and in a similar tray of good red soil. Water both in the same way for a week and count the sprouted seedlings. If waste is well stabilized, the numbers in it should be similar to those in the red earth.

Smaller towns with farms nearby can keep a mesh screen available onsite for use by farmers who may wish to do some coarse screening before taking away the stabilized waste to their fields, preferably free or on nominal payment. It is never really free to farmers, who have to spend a day plus labour and vehicle hire to take it away to their fields. But it is a huge help to cities to have their disposal sites emptied this way.

If windrow unloading and stabilising is done for unmixed wet waste, all of the resulting material is usable. But this should invariably be done even for mixed waste. The non-biodegradable waste left over after screening may contain recyclables. These should reach the dry waste sorting centres for recycling or sustainable end of life disposal. Such Sorting Centres (SC) or Dry Waste Collection Centres (DWC) should preferably be present in every ward. Material Recovery Facilities (MRF) for processing the waste at city level should also be established based on the quantum of the waste generation. Establishment of such MRFs and DWC shall be at the discretion of Local Bodies.

Informal sector workers should be employed at such SC/DWC or MRFs to help include waste pickers into city's solid waste management together with their up-liftment. To ensure sustainable and maximum waste recovery and recycling from such centres, the prime responsibility can be contracted to competent executing agencies where disposal of dry waste can operate through the principle of Extended Producers Responsibility. The non-recyclables can be used to prepare refuse derived fuel for co-processing in cement plants or used in road making as per the city's requirement or pyrolysis etc.

## **8. Environmental Risks of Bio-mining :**

There are several potential environmental risks associated with bio-mining projects and therefore a plan addressing these potential risks should be kept ready. Most of the conditions present at the landfill and its surroundings will be unique to the specific landfill, and specific to the age of the waste being excavated.

Majorly the risks would be associated with proper management of hazardous waste that may be uncovered during the operations of reclamation, managing the releases of gases, odours, its associated risks to human health and controlling any fire, subsidence or collapse.

Environmental risks can be managed well if considered in advance of the operations and appropriate mitigation measures have been designed by the executing agency.

## **9. Safety**

- i. The execution of projects of legacy waste bio-remediation/ bio-mining all the workers involved should be covered under ESIC and proper safety equipment and kits should be provided
- ii. Such projects can be a part of regulatory compliances of environmental protection under PWM Rules, 2016.
- iii. Local Bodies (LB) shall ensure insurances of workers working at the Bio-remediation/ Bio-mining dumpsite for any hazards due to fire, radiation or explosion.
- iv. Small scale/ laboratory testing for monitoring a Bio-remediation / Bio-mining project will need to be borne by the LB in addition to Operational expenditure to achieve objectives of Bio-remediation / Bio-mining project.

v. Proper slope stabilization should be maintained during biomining.

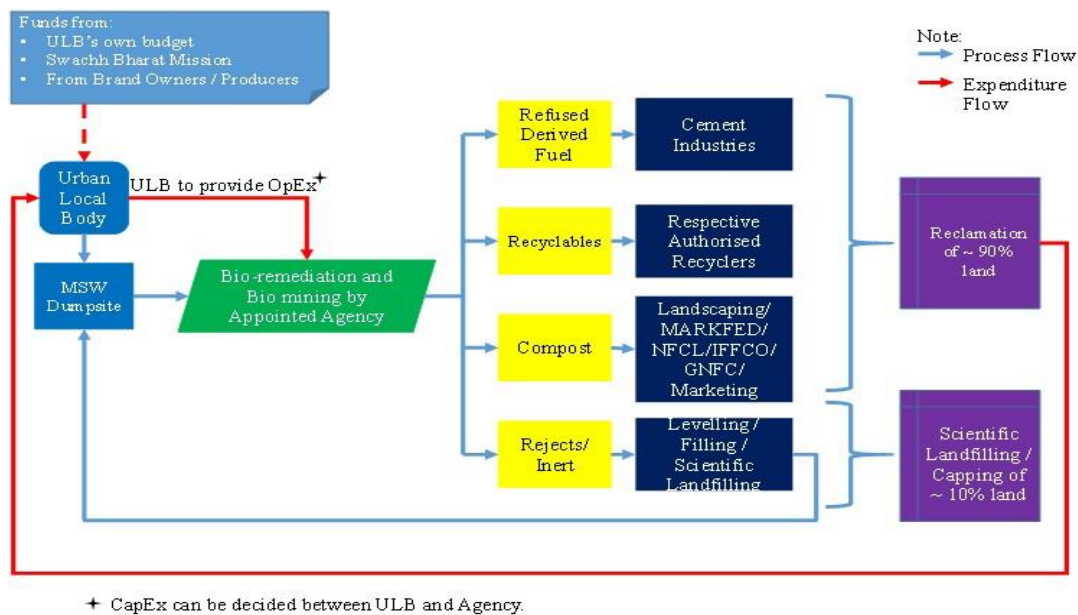


Fig. 9 Schematic representation of the operating model for legacy waste bio-remediation and bio-mining

## 10. Conclusion:

Legacy Waste has several ill-effects like generation of greenhouse gases, pollution of the entire ecosystem around the dump site, posing risk of uncontrollable fire, etc. Thus it is very critical to start working on clearing it today and ensuring that fresh waste is also handled accordingly. This will also improve the morale of the ULB and its residents.

It is the responsibility of ULB to ensure that remediation of dumpsite is done inhouse or by engaging a competent agency. ULB will have to pay an agency the expenditure for remediation of legacy waste as one cannot forecast the chance of recovering recyclables from the highly contaminated waste nor forecast revenue from selling of recyclables so as to financially sustain the entire model. However, a clause can be made by ULB during appointing agency that the revenue generated by selling any recoverable material shall be transferred back to ULB. This can make the executing agency a technology and manpower partner in the project, who is paid for a management cost.

ULB can either go with the 5 models explained for bio-remediation and bio-mining of legacy waste, or make its own cost-effective, space effective and sustainable option, introduce new technology or install various other machinery/equipment based on the practical circumstances of legacy waste. Various types of waste will be recovered from legacy waste like dry waste,

soil conditioner, hazardous waste, bio-medical waste, construction and debris waste, e-waste, etc. All these wastes should be disposed of as per the norms and guidelines issued by MoEF&CC under respective waste management and handling rules under the Environment (Protection) Act 1986. It would be the responsibility of ULB to bear the cost of disposal of all these types of waste,

Waste below the size of 50 mm need not be shredded before sending to cement companies for co-processing. For waste above the size of 50 mm, tie-up can be done with neighbouring cement plants to install shredder at their plant if agreeable.

ULB also needs to ensure that fresh waste generated in city is handled collected and processed separately as per the norms and guidelines issued by MoEF&CC. Covered collection vehicle and segregated collection needs to be ensured. For Dry Waste a Material Recovery Facility should be installed to recover maximum material for ensuring that our cities are Zero Waste to Landfill cities. Recyclable waste is sent to authorize recyclers and non-recyclable waste should be sent to hotmix plants for plastic roads or to P2F (Polymer To Fuel) plants or for co-processing to cement plants. Wet waste should be processed to get compost/ bio-gas etc. Bio-medical waste, hazardous waste, e-waste, construction and debris waste, etc. should be sent to respective authorized disposal sites.

It is also very important to understand that to ensure that no such legacy waste is accumulated in future, all ULB's should refrain from floating tenders for collection, handling, and processing of mixed waste. All ULB's should keep infrastructure required for collection, handling and processing different type of waste separately. There are various benefits attached to clearing dumpsites which need to be understood by ULB to speedily start work on it.

These guidelines apply to cities, towns and even villages. Bio-remediation and bio-mining of MSW projects may not be economically viable but are mandatory to improve waste management ecosystems across India. Besides, land cleared by way of bio-mining and bioremediation of legacy waste, huge land area is evacuated, which can compensate the cost of its treatment.

## **11. References:**

- i. Solid Waste Management Rules, 2016
- ii. Plastic Waste Management Rules, 2016 as amended 2018
- iii. IPCC Third Assessment Report, 2001
- iv. Feasibility and Viability of Landfill Mining and Reclamation in Scotland by Ricardo-AEA on behalf of Zero Waste Scotland.