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Biomining of Legacy Waste Management

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Abstract*— Most Indian cities are surrounded by hills of garbage, which are a testimony to India's neglect on the usage of valuable natural resources. Improper treatment of the waste produced in the process and defective conducts has given birth to 3159 dumpsites in India which creates about 1.50 lakh metric tones of MSW(Municipal Solid Waste) annually. The absolute amount of legacy waste on those dumpsites is becoming a huge matter of concern, along with environmental effects like air, water and land pollution. Studies have shown that individual Indian citizen on average annually produce approximately three and half times their weight as waste, which creates nuisance and more difficulties in finding land for dumping sites. So, reclamation of these dumpsites is the way to decrease the harmful impacts generated over time. As per the 2011 census, Amravati City in Maharashtra has 6,47,058 population and 250 MTPD wastage has been generated by this population, hence Amravati Municipal Corporation, Amravati (AMC) adopted the Bio-mining concept for the Sukali composting site in which 9.35Ha land is available out of which 6.55Ha land has to be cleaned by biomining. Sukali compost depot includes formation of trenches, spreading of bio-culture, periodic rotation of hips, screening of legacy waste, shredding, sorting, maturing, batching & marketing. A mindful forethought for bio-miningof MSW in Sukali Compost Depot in Amravati has been developed by AMC and its implementation at the site in progress. Also, entire plan for future management of these dumpsites had been proposed to ensure our effort under the "Swachh Bharat Mission".

***Index Terms*— Bio-mining, Bio-culture, solid waste, Bioremediation, Land reclamation etc**

I. INTRODUCTION

According to the census of 2011, about 377 million people live in urban areas i.e., 31% of the total population, and it is estimated to become 600 million by 2031[1]. Providing proper sanitization and appropriate management of solid waste is a stinging and widespread problem [2] for any municipal corporation. About 90% of the staggering 1.50 lakh metric tonnes of urban municipal solid waste make it's way to open landfills i.e., dumpsites [3]. Maharashtra attains 2nd place and has 302 active dumpsites, only 28% of it is treated and the remaining solid waste continues to stay on dumpsites for decades producing nuisance and infertile lands which needs to be reclaimed or closed permanently (Fig 1) [4]. These toxic sites are known disturbing truth of India's bursting, glittering cities, and workplaces for tens of thousands of people [5].

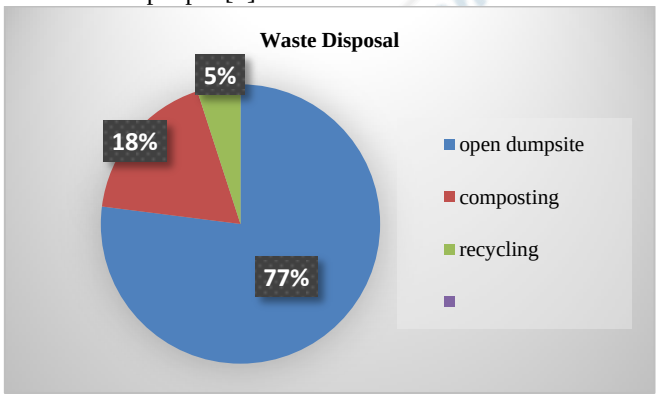

Fig 1: Waste Disposal

"Swachh Bharat Mission – Urban" a major initiative is taken by the government of India, aims for the vision of "Clean India" by the year 2020 and to fulfill this objectives of the Swachh Maharashtra Mission, the Amravati Municipal Corporation (AMC) has proposed the work of "Scientific Dumpsite Land Reclamation Through Biomining, resource recovery and scientifically reject disposal at Sukali compost depot, Amravati ".Through this proposed project AMC aims at reclamation of land from the existing old legacy waste dumpsite at sukali compost depot, Amravati [6], [8]. There are 6 various methods used for the process of land reclamation, which are Bio-mining through Tractor Tiller by Windrows, Bio-mining through Trench Method, Bio-mining through Cone Method, Bio-mining through Windrow Method for Spacious Landfill Sites, Bio-mining through Thin Layer Spreading Method. AMC has adopted Biomining through Trench Method for scientific dumpsite land reclamation [7].

A major step towards ensuring effective and sustainable solid waste management, AMC has started biomining the existing dumpsite which covers about 9.35 Ha of the previous land. As per the 2011 census, Amravati City in Maharashtra has 6,47,058 population (Fig 2) and at present 250 tonnes of municipal fresh solid waste is dumped every day on this site. For reclamation of this land, biomining is adopted which is adopted by a process called bioremediation [6]. The process is carried out by adding a biological culture or inoculum to the dumpsite to initiate microbe–mediated degradation of organic waste. It is can be done for partially or fully decomposed solid waste when there is no segregation between wet and dry waste. This treatment is done by

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dividing the old legacy waste into heaps of suitable blocks so that air can percolate through them.. Just as aeration process progresses it allows harmful gases such as CO_2, CH_4, and ammonia to get dump off and waste will be the toxic-free [12]. As a result, leachate with the suspended solid particle is drained off and to initiate the biological decomposition a cultures are spread in heaps of legacy waste. A continued rotation of waste into these heaps are carried out to make the waste free from leachate as much as possible. This biological decomposition of organic waste in the dumpsite can potentially decreases the volume of waste situated in harsh land by 40%. This process is done repeatedly after every 5 days, then this legacy waste is screened by trommels and waste is segregated as per requirement [7] [11].

Fig 2: Amravati District

While the outcome of legacy waste will be in different forms, it may vary from 100 mm to 150mm (large plastic, footwear) 100mm to 80mm (RDFs), 30 to 50 mm (plastic, glass), less than 30 mm (cloths) and 4 to 6 mm (soil conditioner). The actual output is expected after this process and which is helpful for farmers, soil, and landscaping [6], [13]. Afterward, a test has to be done for the compost/humus/fertilizers. The above map indicates the exact location of sukali compost depot, Amravati in Maharashtra, India under which all the above-mentioned process is carried out which is nothing but the biomining through Trench Method for scientific dumpsite land reclamation.

II. METHODOLOGY

Sukali compost depot site as dumpsite is being in operation since last more than 30 years. Amravati open dumps at a sukali are about 10 meters high. The quantity of waste dumped in this dumpsite was derived is about 4.51 Lakh M^3 under earmark area of 6.55 Ha. The Amravati Municipal Corporation proposed the work required for scientific dumpsite land reclamation through bio-remediation and biomining of dumped legacy waste.

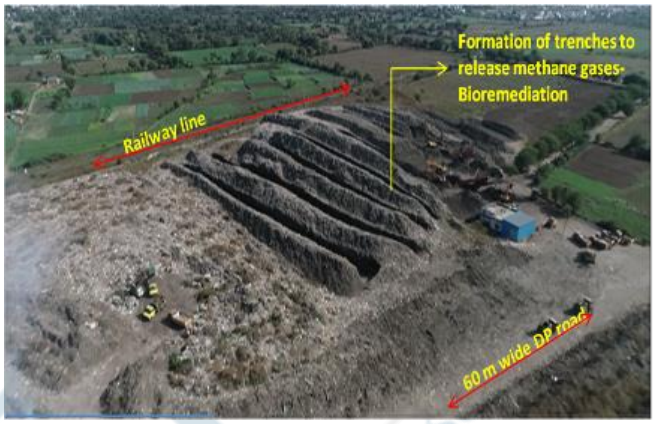

Fig 3 : Formation of windrows

As per the SWM guidelines AMC has to excavate old dumped waste and ensure to make windrows (Fig 3) of legacy waste and afterwards make sure to stabilized the old dump waste through bio-mining. Simply excavator will be used to dig a trench of 2.0-2.5-meter-deep from the top of a legacy waste heap keeping an interval of 1.5-to-2.0-meter between the two windrows. Now spreading of bio cultures must be adopted so that aeration process can takes place and which help to remove all the harmful gases such as CO_2 and CH_4 and hence dumpsites can be odourless at least in few amounts. Also, the microbes which spread on the legacy waste starts the decomposition process and dispersed into the waste. This process is adopted repeatedly until and unless almost the ground level is reached. Addition of these biological inoculum speeds up decomposition process and aggressively creates biological heat inside windrows of legacy waste which helps to make it dry out and decrease its volume by 30-40%. Due to this water content inside windrows gets evaporated and by decomposition of waste some gases are evolved such as CO_2, CH_4, and water vapour. This is called bio-remediation and this process helps to makes the dry organic waste ready for screening. When there is no more heat is generated, landfill gas are all evolved and no leachate is dripping off then it is called as stabilized waste and plant seeds are able to germinate inside those lands.

Screening is nothing but the segregation of processed legacy waste with the help of machines like trommels. The main motive of screening process is to segregate waste into resources like clothes, bricks, organic fines, stones, plastics, metals, glass, etc. and making necessary provision of recovered material such as plastics/RDF/ biosolids /inserts. Then sustainable management of these materials is done

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through recycling, co-processing. The stabilized waste recovered from the dumpsite are screened into different size particles that can be reused outside of site or disposed off without having any adverse effect on environment. Screen sizes commonly used are 150 mm, 80 to 100 mm, 30 to 50mm, 30- 10 mm, and 4-6 mm. The 150 mm screening of waste contains bricks coconut, shells, cloths, footwear, large plastics, etc. The 80 to less than 30 mm screening of waste shredding as per requirement or industry need. The lighter materials mostly such as plastics are shredded as per requirement of industry for use in bitumen hot mix plants usually to make recyclable Plastic Roads or as refuse derived fuel (RDF) which is use in cement kilns. The 4-6 mm screening of waste contains the finest materials and is called bio-earth or good earth.

III. PROPOSED TECHNOLOGY FOR BIO-REMEDIATION AND BIO-MINING

A hectic processes such as excavation, shredding, screening, air classification, and separation of ferrous from the dumpsite waste are carried out by heavy duty machineries that comes under following heads, as per their +suitability for the given conditions and requirement of the project should be chosen wisely :

1. Mechanical excavators for the formation of trenches and spreading of bio-culture for bioremediation.
2. Mobile Trommel screens with a screen size of 25 mm.
3. Static Trommel screen of 4 mm screen size for bio solids.
4. Shredder for dry waste- RDF and bailing machine if required.

Following steps /processes should be adopted for biomining through Trench Method for scientific dumpsite land reclamation.

1. Municipalities/local bodies should make a distinct plan for execution bioremediation process to clear the old waste and reclaim the land scientifically.
2. Then this legacy waste will be in vast amounts so this volume of legacy waste should be recognized through Total Station Survey and also point the layout on exact site. Drone mapping of complete site area and volumes of waste at different stages is costly but it speeds up the process. Samples shall be collected on site such as subsurface soil, surface soil, water and contaminated blackish liquid which is nothing but the leachate and do the laboratory test initial so that toxicity can be avoided if required.

Fig 4: Screening of Legacy Waste

3. Spraying of bio culture on the new surface of legacy waste with mixing the water. This process is really helpful for control smell and can definetly speed up decomposition process for our benefit. Usually, the several materials which are in the active biological state are always present in the top layer of the heap and also the fresh. Segregating the legacy waste layer by layer, the main materials which are extracted from legacy waste are:
   a. metals
   b. plastic
   c. glass
   d. soil
   e. rubbers
   f. Textiles
   g. Construction and demolition (C&D) waste

   Bulky organic waste and tyres and rocks are picked manually before the screening of waste for bio-mining. If needed this manually picked up waste shall store in separate places and in different heaps for sale to industries or use.
4. Rotation of these trenches happens once in a week unless no more heat is generated into heaps. By adopting this procedure, if the waste is converted into stabilized form, then there will be no formation of odour or contaminated liquid/leachate formation and the material will be automatically ready and dry enough for segregation.
5. Municipalities may place Trommels (Fig 4) as per requirement. For screening the stabilized waste in a movable screen, rotary screen or gravity screens and static screen of different openings of variable sizes, preferably 150mm to 4mm.. A fan attached to the screeners can easily blow out the plastic materials out of screeners.To execute this entire procedure an appropriate numbers of excavators, loaders, and workers will be required.
6. Non-Recyclable plastic material shall be sent to industries whether it would be used for road making or to RDF which is used in cement plants. The recycled materials like plastic, glass, metals, and cloth which are recovered

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from the legacy waste during screening process should be segregated and should be cleaned before sending to recycling industries.

7. The recovered materials shall be used as soil conditioner or for gardening or for farming. The soil from the dumpsite can also be used as a "Soil Conditioner" to develop a suitable fertile land appropriate for plantation and vegetation.
8. The heavy comparatively bigger particles maybe sand and gravel are used for making road shoulders, plinth filling of houses or several residential buildings. A solid building materials such as stones or concrete can be recycled and reuse in the construction industry.
9. In every legacy waste with layers of high degraded organic content, organic matter just already starting to decomposed. If required to check then do a seed germination test to ensure that waste is stabilized and useful for further process.
10. Add some bio cultures to fully stabilize the waste, if still heat is generated in heaps trenches then process continues and volume reduction is observed and will be useful for biogas plants as that heat contains mainly CH_4 which is methane and this process is nothing but the bio capping.
11. 7-10 days after the waste id set to stabilize, the waste can be ready to do the screening. The finest material will be an organic matter in its highest content with fine soil, called as 'bio-earth' or 'good earth', which is extremely concentrated and used as a soil improver or soil conditioner and can be used as organic manure.
12. Coarser particles are gravel and boulders and can be used for embankments of road and railway. There is(maximum 4-25% of total) leftover waste including lumps of waste which are not homogenous in nature. The leachate is added into the waste is rest to soaked and difficult to segregate. This waste can again be sent to a disposal.
13. The recovered land from dumpsite through the bio-mining process can be used for any purpose regarding as per municipalities or local bodies requirements. Ideally, it is expected that after the whole procedure of biomining or bioremediation the land which is reclaimed through this process should be reused for other waste processing, or else for at least for non-habitation other activities. And all these steps have been followed by AMC.

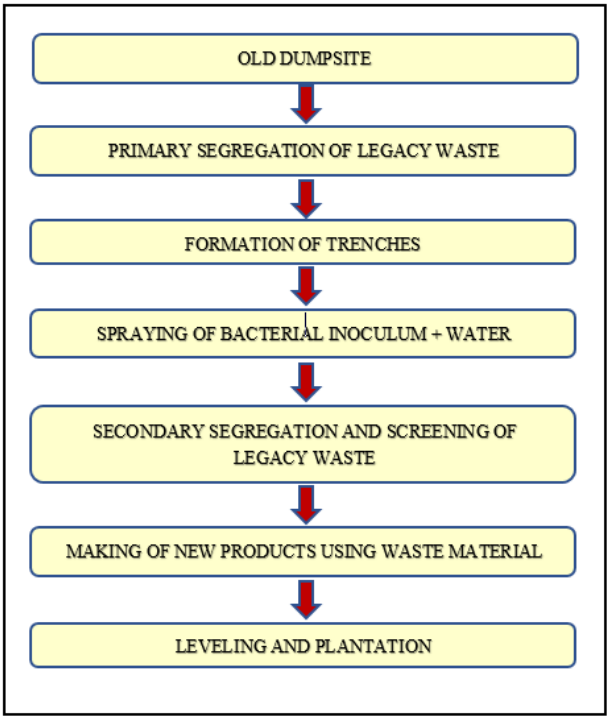

Fig 5: Dumpsite Management Process

IV. PROCESS MANAGEMENT:

There are many impacts that must be kept in forethought during the process of the project

4.1 Land Management:

In every type of waste stabilization process, land management is an obstacle to municipalities/local bodies, to bring back existing land in a proper condition. Excavating the existing waste is compacted MSW till the OGL (Original Ground Level) in the land portion allocated and clean by a mechanical sieving machine or any other kind of proposed technologies. This all is done by experienced and knowledged staff. Excavating the soil below that of MSW dumping heaps which has lost its stability is recovered with necessary dewatering works in the portion of land. MSW waste brought for segregation and processing from the earmarked land portion must be quantified after excavation. So that we can manage the land space purposely.

4.2 Leachate Management:

Generally, huge heaps of legacy waste on the dumpsite are badly water-logged with concentrated leachate water to an absolute state and contains fresh waste, dust, and may have several materials which are in active biological state. By spreading bio culture, herbal/biological sanitizers, inoculants by any suitable scientific method the layers of these waste are to be stabilized. As passage of air is necessary for the added microbes to digest contaminated solid which is suspended in leachate. This leachate sludge is not produced by trenches which in fact helps to dry out the waste by air holes or

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channels which carry out aerated decomposition or drains must be created to lead the percolating leachate to pass into the leachate tank or pond for treatment and is reused onto wind-rows as a type of bio culture. Progress can be recognized by gradual change in colour of leachate from dark to light and also the odour of leachates which is extremely decomposing in nature.

4.3 Fire Control and Safety:

Sukali compost depot is the topmost large dumpsite in Amravati. As we know from this legacy waste methane (CH4) gas releases and methane is highly flammable gas with a blue flame. It is very problematic to begin bio-remediation procedure work on a live burning dumpsite land. So, fire control is important. Adding water is not an option as it promotes the generation of both flammable methane and concentrated leachate and is non-productive, not a appropriate solution, adding soil to cover flames of methane gases is like adding more material to a heap of waste that we are already trying to eliminate. A better solution needs to be there, requiring common-sense and experience of work. Quantitatively most fires inside heaps have a point source – for this precaution, provision, installation, operation, and maintenance of plant, machineries, infrastructure facilities, creation of facilities to control the fire. For all this purposes on site, AMC has deployed exact and sufficient machineries, manpower, and required resources to execute the proper biomining of legacy waste under the SWM rule 2016 and CPCB guidelines of legacy waste.

4.4 Use of Recovered Space:

The major boon or benefit of bio-mining is that it acts as a helping hand for present and future pollution control and reduce adverse health issues on humans and the re-use of valuable land space. The merit of this process is ideal for continuously progressing long-term waste management problems. Applied methods, processes, equipment that has been deployed, and resources that would reduce the impact of dumpsite reclamation activity in the adjacent areas. Create facilities and must make an arrangement for controlling mitigating the emission of gases, pollution, and contamination including air, water, and soil including mitigation for dust and odour and also the noise pollution facilities. All facilities must be used in the recovered space. Also, construction of temporary site office, water facilities, electric power supply, sanitation facilities, accommodation facilities and labour camp for a worker must be there and also providing security arrangement for the project site must be included on the recovered land of site. AMC has executed the above-mentioned detailed plan purposely and recovered 3.28 Ha of land (Fig 6) as per the official's guidelines. The land recovered from the bio-mining the legacy waste are not preferable for recitation for at least 15 to 20 years (SWM Rules Schedule I, H (2)). This reason is of unhealthy and concentrated leachate water on the site and release of flammable methane and carbon dioxide gases and displeasing landfill odours from land may remain unexcavated and which is extremely harmful for human health.

V. CONCLUSION

Legacy waste situated in the dumpsites is a huge threat to our physical body conditions, really has disturbing effects on environment,disturbs cycles of wildlife and should invest in greater sustainability towards our planet. Bioremediation a microbial decomposition procedure can help to reduce and remove the said pollution and attempt to provide clean drinkable water, air and healthy soil for plantation and vegetation and can invest in future generations. Biomining requires lesser resources and minimum energy than conventional technology that uses conventional energy resources and does not gather a dangerous by-product as waste in the envirements. Management of legacy waste has created an ecosystem of technology waste solutions for deriving land as a resource from legacy waste dumpsite. But it came with its unique operational and technical challenges. The above study explored the importance of management of legacy waste for sustainable development. Out of the 9.35 Ha of dumpsite land, 3.28 Ha of land had been reclaimed by AMC through the process of biomining results in reduction of environmental and soil pollution by 35%. The reclaimed land can be used for future projects. Because of biomining process the large quantity of legacy waste is eliminated and this process will be very beneficial for sustainable development.

Fig 6: 3.28Ha of reclaimed land at sukali dumpsite

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