Landfill Mining as a Remediation Technique for Open Dumpsites in India: A Review

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Abstract: The study was originally carried out in 2014 assessing the potential of Landfill mining from a standpoint of financial project feasibility, and as a possible solution for the looming challenges posed by open dumping practices and dumps to the Environment. The study is based upon the prospects of the landfill mining looked upon as a standard mining operation, and the excavated stuff segregated into combustible portions that can be utilized as soil amendment additive or recyclable fractions that can be sold to recyclers to be processed into utilizable products, or a combustible fraction that can be made into refuse derived fuel. The remaining portion can be looked upon as inert and be safely disposed-off into scientific landfills that are made as per the CPHEEO guidelines on Municipal Solid Waste Management. The work presented here is an update of the 2014 exercise considering the 2019 conditions as a review in light of the recent Bio-mining project undertaken at Ahmedabad, Pirana Dumpsite.

Keywords *– Ahmedabad, Dumpsite, Landfill Mining, Remediation, Pirana*

I. Introduction

The Pirana dumpsite at Ahmedabad, Gujarat, has been witnessing non-segregated, open dumping of MSW (Municipal Solid Waste) since over 30 years and has been the center of many controversies relating to various negative environmental impacts including contamination of the surrounding ground water, and moreover the odour that is developed is an ever present irritant. The situation in other cities is not much different either. Open dumpsites, unlined areas, used for disposing off unsegregated MSW are constant entities in every city in India. All of these sites are either already polluting, or are extremely potent sources of pollution posing threat to the air, water and the land quality, and the environment at large.

Various studies to find suitable solutions for the above mentioned challenge have been attempted time and again in various contexts all through the globe. Of the options explored, Landfill-mining has been found to be the most effective in cases of Open Dumpsites where majority of the waste dumped is of organic nature. This is majorly because of the nature of the organic refuse that has a bulk volume, which reduces greatly with the loss of moisture and also decomposed into compost under suitable conditions. This drastically reduces the volume of the waste to be handled at such mining operations, and subsequently leaving even lesser waste to be disposed-off to scientific landfills upon the completion of the Landfill mining process. Such process has in recent times has seen some acceptance in India, and has been used on more than one occasion in various developed countries and has yielded satisfactory results towards the end goal.

The effort to assess the financial viability is a cornerstone to this process, as it is to any other project and the same has been attempted here-in with context to the Ahmedabad, Pirana Dumpsite, building upon the work carried out in 2014.

II. Landfill Mining

Landfill mining is the process of excavating from an operating or closed solid waste landfills, and sorting the unearthed materials for recycling, processing, or for other dispositions (Lee and Jones, 1990; Cosu et alm 1996; Hogland et al, 1998; Carius et al, 1996). It is the process whereby solid waste that has been previously land filled is excavated and processed (Strange, 1998).

Landfill mining essentially deploys the same methods as open mining to reclaim the refuse that has been accumulated in a waste dump or landfill. This excavated refuse is then sorted through a screening machine to separate the larger pieces from the smaller ones. Large pieces of refuse generally consist of tyres, and stones and the small ones are generally paper and plastics.

The objectives with which Landfill mining is resorted to can be listed as follows:

- **i.** Conservation of landfill space
- **ii.** Reduction in Landfill area
- **iii.** Elimination of potential contamination source
- **iv.** Rehabilitation of dump sites
- **v.** Energy recovery from recovered wastes
- **vi.** Reuse of recovered materials
- **vii.** Reduction in waste management costs
- **viii.** Redevelopment of landfill sites (Hogland et al, 1997)

Landfill mining also remediates the dump by removing the entire accumulated waste thereby enhancing the overall hygiene and quality of that patch of land and the surroundings. As a second option, it also facilitates the placing of an impervious liner and replacing the collected waste, thus preventing any leachate from polluting the soil or the ground water, and makes it manageable to introduce proper waste management measures.

Landfill mining deploys mechanical segregation to reclaim one or more of the below stated materials:

- **i.** Landfill Volume
- **ii.** Soil enricher/Compost
- **iii.** Wood
- **iv.** Recyclable metals such as iron, aluminium, etc.
- **v.** Concrete and bricks for use in roads etc.

Traditionally, a setup involving a conveyor and a trommel for segregating the excavated material into over-sized, under sized and intermediate portion is the key step in any landfill mining operation. The undersized fine fraction generally consists of soil and humus, over-sized matter is composed of metals, textiles, rubber and plastics, intermediate sized fraction is made up of combustible materials, recyclable materials and decomposed organic matter upto some extent. Ferrous metals are generally taken off the stream by deploying a magnetic separator and an air classifier arrangement is put in place to separate the non-ferrous metallic portion, leaving behind combustible fraction from the waste. The same is graphically represented in Figure 1.

A landfill mining project usually consists of an excavator that removes the deposited matter from the dump. The bulky pieces are then removed from the excavated stuff and smaller stockpiles which are easier to handle are made using a front end loader. A trommel is then deployed to physically segregate the soil and solid waste. Trommel screens are much more effective than vibrating screens for basic project (Murphy 1993). The size and type of the screen deployed depend on the end use of the recovered material. A 6.25 mm screen for example, would be deployed when the reclaimed soil is to be used for landfill cover, where as a 2.5mm sieve would be deployed when tiny fractions of metals, plastics, glass etc are to be recovered from within a large soil fraction. The efficiency of the material recovery is largely governed by the waste composition, mining technology and the efficiency of the segregation technology. The recovery of various materials ranges from 50 to 90% of the waste (Strange, 1998). The average of soil fraction in MSW landfills is observed to be around 50-60%, however it can vary between 20 and 80% depending on moisture content and decomposition rate (Hogland, 2002). The soil fraction can be used as cover or lining of new landfill. Landfill needs to be 15 years old before a successful mining project can be performed (Strange, 1998).

a. Benefits of Landfill Mining

Landfill mining carried out with the objective of reclamation extends the life of the landfill by decreasing the volume through the removal of recoverable material, combustion of suitable material and compaction. Potential benefits include the following:

- **i.** Recovered materials such as ferrous metals, plastic, aluminium, and glass can be sold if markets exist for these materials.
- **ii.** Reclaimed soil can be used on site as daily cover material on other landfill cells, thus avoiding the cost of importing cover material. Also a market might exist for reclaimed soil for use in other applications such as compost.
- **iii.** Combustible reclaimed waste can be mixed with fresh waste and burned to produce energy.
- **iv.** By reducing the size of the landfill footprint through cell reclamation the facility operator may also be able to either lower the cost of closing the landfill or make land available for other uses.
- **v.** Hazardous wastes if uncovered during LFMR, especially at older landfills, could be managed in an environmentally sound manner. (Hogland et al, 1997)

The most relevant benefits of any landfill mining operation in economic terms are more often than not, indirect, and can be summarized as follows:

- **i.** Reclaimed volume for disposal of solid waste
- **ii.** Decreased or completely avoided expense of any closure procedure and the monitoring that follows such closure procedures.
- **iii.** Revenues can be generated by the sale of the reclaimed materials such as recyclable metals, plastics etc. Combustible material can be processed into fuel and the soil fraction can be used as compost, or for filling in construction projects or as cover soil for new cells, thus avoiding the cost of virgin soil and protecting a natural resource (fertile soil)
- **iv.** The value of the land that is thus reclaimed, when deployed for other uses.

The most direct and impactful of these benefits for large municipalities facing land scarcity is the freeing up of the landfill capacity avoiding on all the time and money that would be invested to come up with a new site for disposing of the solid wastes. Though, for Indian context, the benefits are multi-fold in the sense that majority of the solid waste disposal in India is done in open dumpsites, which constantly contribute to degrading the environment on some scale, which can be remediated by deploying a landfill mining project, and preventing any further contamination from happening, thus conserving our already scarce natural resources such as water and land.

b. Case Studies from Asia

i. Landfill Mining in China

In china, experiments have been carried out where-in landfill mining and horticulture has been combined. Trials were performed at Sai Lin, after an extremely fertile soil fraction and incombustible inorganic fraction was encountered on visual inspection. Following this, old cells of the landfill were excavated, and the biodegraded soil fraction, combustible inorganic fraction and remaining incombustible fraction were separated by screening. The cells thus emptied were lined with impervious layer, and new gas and lechate collection systems were installed. The residual incombustible portion of the excavated waste was deposited back into the upgraded cells. The recovered soil was mixed with excavated virgin silt and the bund wall trimmings, and yielded an extremely fertile mixture used for the final cover and the basis for the horticulture program (Dumpsite Rehabilitation and Landfill Mining, Asian Regional Research Program on Environment Technology (ARRPET), Kurien, J. et al, 2004). The upgraded cells were then used as biological reactors and the degradation process within was accelerated by locating recycling and drainage and resulted in larger methane yield. The cells that were completed were topped with greenhouses constructed on them, and horticulture activities were carried out there. The methane gather from the cells was used to fuel a waste to energy plant along with other combustible fraction recovered from the mining operation and produced electricity for local consumption or sale to the electricity grid. Excess heat was used for keeping the temperatures of the greenhouses elevated all through the year for better production of the horticulture products.

ii. Landfill Mining in India

In 1997, the excavation and reuse of decomposed refuse from Deonar dump site in Mumbai, India was reported by Manfred Scheu and Bhattacharya. The excavation was carried out manually in a portion which was 4 to 12 years old and the soil fraction, formed by the decomposition of the biodegradable matter was separated from the rest of the waste by screening. The screened soil was then bagged and taken off the site, leaving the rest of the waste behind at the site itself.

The reclaimed soil was mixed with cow dung, dolomite, gypsum and neem cake (the residue after the oil is extracted from the neem seeds) and sold as a mixed fertilizer (Dumpsite Rehabilitation and Landfill Mining, Asian Regional Research Program on Environment Technology (ARRPET), Kurien, J. et al, 2004). The product was marketed in an appealing fashion, stating various benefits of the product to yield and soil improvement.

Based on the above discussion, it can be inferred that landfill mining is more resource efficient in terms of utilizing the deposited refuse and land reclamation, as the other technologies typically bury all the deposited refuse forever in place, and the land is lost too. Moreover, landfill mining also provides a permanent remediation of the open dump sites which are potent sources of pollution and can contaminate the surrounding environment to very dire outcomes. To the same end, it becomes of high importance to study the waste composition of the Indian cities, and the dump sites, as the first step to ascertaining the feasibility of landfill mining operations on a conceptual level.

c. Suitability Parameter of Landfill for Landfill Mining

Assessing the suitability of Landfill mining as a remediation technique for open dumpsites used for the disposal of MSW in state capitals and metro cities around India will mainly depend on the economics of the exercise. The study undertaken for the same entails assessing the waste characterization, amount of waste, the resources to be deployed and the resources made available for use.

III. Feasibility Analysis for Pirana

a. Scope

The study focuses on assessing the potential for resource recovery from the MSW dumpsite at Pirana, Ahmedabad. The dumpsite characterization was considered for the same. Based upon the characterization, the revenue generation opportunity is assessed and based on the expected amounts of the various fractions that are expected to be recovered. Finally a benefit-cost ratio was arrived at as an indicator for the feasibility.

b. Methodology

The waste characterization for the current waste being generated, spread of the MSW dump sites (area), and the total waste accumulated in the dumpsite was acquired from the local governing body, i.e. Ahmedabad Municipal Corporation so far as available, and calculated based on the information available, using the method prescribed in the "Manual for Solid Waste Management" by the Central Public Health and Environment Engineering Organization (CPHEEO). Based on the current waste characterization and the total waste accumulated, the amount of different fractions of refuse likely to be recovered by deploying a landfill mining operation at the dump site in consideration, was assessed.

c. Data Collection

The data collection was done from reports and other publications by the local governing body, reports by the Central Pollution Control Board, and published research reports and papers. Where direct data from the above stated sources was not available, secondary sources such as newspaper reports and articles were resorted to, and the missing data was calculated as per the methods prescribed in the CPHEEO manual for MSWM.

d. Analysis

The analysis for the feasibility of a landfill mining project at each of the above mentioned dump site is done by comparing the costs to the revenues, arriving at a benefit-cost ratio. The assumptions made for the analysis are as follows:

- **i.** The landfill mining shall simply be aimed at excavating the accumulated waste and segregating it into the four categories which are soil/clay fraction, combustible (paper, textiles, rubber, wood, plastic films and the likes), recyclable incombustible (metal, glass, dense plastic other than films) and others.
- **ii.** The only process equipment other than those deployed for the excavation and handling shall be a physical segregation setup for the separation into the above mentioned categories.
- **iii.** The separated materials shall be sold to the respective recyclers for further processing.
- **iv.** The rates taken for the assessment of the revenue generation are the minimum market rates of Ahmedabad for similar nature of MSW, as paid for by the recyclers. Hence no decrease in these rates is expected, especially amid the increasing awareness of the benefits of recycling and the demand generated thereby (sourced from AMC).

The land value for the purpose of revenue estimation is taken as the price that the chunk of land currently serving as the dumpsite shall fetch if developed into a residential or commercial real estate.

Iv. Figures and Tables

V. Conclusion

Based on the study, from the point view of effectiveness of proof, as well as financial feasibility, it can be safely concluded that Landfill Mining is possibly the most feasibly and practical solution to remedy the challenge of open dumpsites existing throughout the country. For the specific case of Ahmedabad that was studied, the benefit-cost ratio came to be around 2.7 based on the above method, which, even if looked upon conservatively, points to encouraging odds to deploy the solution.

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Figures and Tables

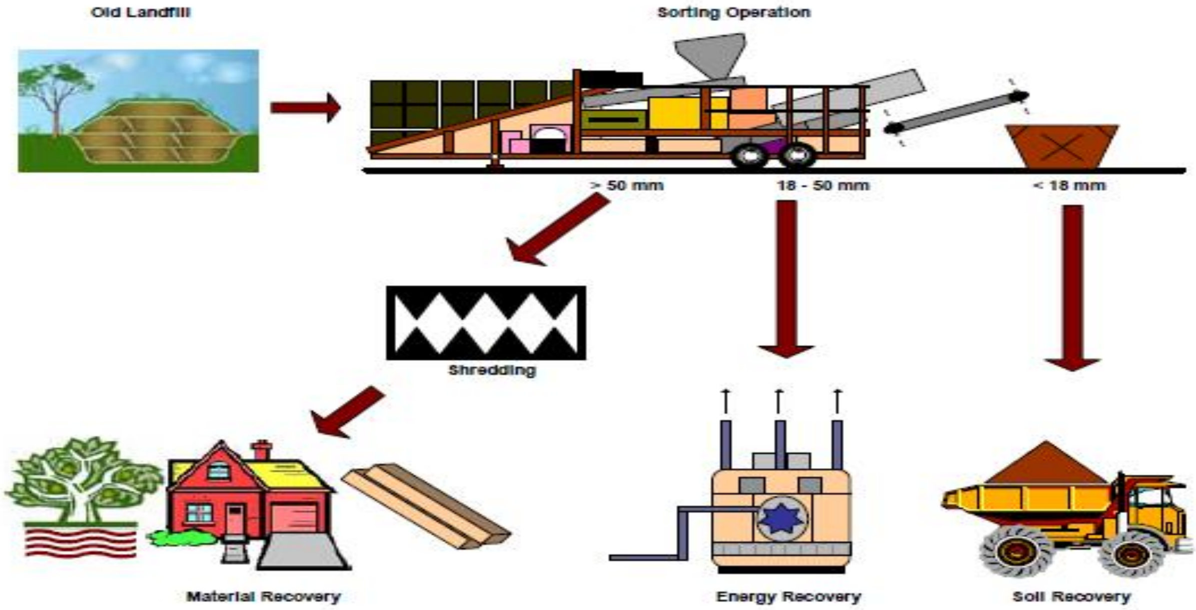

Figure 1 Schematic of a Typical Landfill Mining Process (Carius et al, 1999)