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# Remediation Techniques, for Open Dump Sites, used for the Disposal of Municipal Solid Waste in India

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**Abstract—***Open Dumping of Municipal Solid waste which is the widely practiced method for disposal of the same has time and again proven to pose threats on multiple fronts, such as environmental pollution encompassing soil contamination, air pollution, water pollution; an ever so potent source of disease outbreak and finally, degrading the overall surrounding in the nearby vicinity. Many incidences of the negative impact of open dumping have come to the light in terms of water contamination, heavy degradation of air quality, surrounding soil contamination leading to negative impacts on its value for agriculture and commerce. These challenges have time and again, called for methods to neutralize them and prevent damages to the maximum possible extent. These methods, typically referred to as 'remediation', meaning 'to correct', have been thought over since decades and many different approaches have evolved during the process. The following is a documentation of the better established remediation techniques, which are suitable for dump sites containing one or the other kind of refuse, depending on the characteristics of the waste. The suitability of the discussed techniques has further been contemplated with relation to the Indian context where-in, like most developing countries, waste segregation is to a very low extent.*

## 1. INTRODUCTION

Various methods of remediation can be deployed to neutralize the ill effects of the dump sites, and the threat they pose to the environment at large. Dump site remediation, in essence, is the operation of nullifying the ill impacts of the dump on the environment and simultaneously recovering utilizable material as and when possible. Some of the methods deployed to remediate MSW dumps are temporary solutions while others are of a more permanents nature unless subjected to large forces.

Some of the mainstream remediation processes are landfill capping and closure, in-situ vitrification, sub-surface cut-off walls, and Landfill mining.

## 2. SCOPE, OBJECTIVE AND METHODOLOGY

### 2.1 Objective

The objective of the paper is to study and assess the suitability of remediation techniques for open dumpsites used for the disposal of Municipal Solid Waste in state capitals and metro cities around India.

### 2.2 Scope of Work

Scope of the work includes studying the types of remediation techniques for open dumpsites used for the disposal of Municipal Solid Waste and assessing their suitability.

### 2.3 Methodology

The objective of the paper being the study of the remediation techniques for open dumpsites used for the disposal of MSW in India, the approach taken up was to find out about the various methods deployed at other open dumpsites and the probable suitable methods with respect to the Indian scenario.

## 3. REMEDIATION TECHNIQUES

### 3.1 Landfill Capping and Closure

Capping and closure of landfill essentially includes creating a bifurcating layer between the accumulated waste and the environment, humans and other animals, protecting them from the adverse effects of the contaminated waste that is accumulated and is also believed to limit the migration of the harmful contents.

As per guidelines, caps are of two types, of which those used for landfills containing hazardous materials include three layers, wherein the top layer is soil that can support native vegetation, the middle layer is a drainage layer and the bottom most and third layer consists of an impervious synthetic covering over a compacted two feel thick layer of clay. The design of the cap is strongly influenced by the gas release mechanism that is to be adopted for the letting out of the gases produced as a result of the decomposition of the waste inside.

A major concern with the capping method is that it's life is 50-100 years which is relatively less when the neutralization of the underlying waste might take much more time than that, and make the underlying matter non-hazardous.

### 3.2 In-situ Vitrification

This technology is deployed when the wastes deposited in the dump are of such nature that their degradation period is too long and they pose dire threats to the environment and other living beings. This technology ensures the entrapping of the wastes into a completely impervious monolithic enclosure and render them completely in-effective what so ever.

The process typically involves graphite electrodes hammered into the dump, at the corners of a square layout on plan. A very high capacity generator or a direct line from the grid is connected to the electrode and the arc (electricity) is allowed to jump from one electrode to other. When the arc passes through the soils and wastes it produces tremendous heat and reduces the soil into molten mass. As the mass below and around the electrodes turns liquid, the electrodes sink deeper and in-turn more of the matter is liquefied. When the entire of the electrodes have sunk within the molten mass, and is not possible for them to penetrate deeper, the electricity is shut off and the molten mass is allowed to cool down, turning into a glass cube entrapping all the waste in between along with the electrodes. The depth of vitrification is governed by the amount of electric power that is available and the depth of the graphite electrodes.

Various materials of those disposed off in the dump react in different manner to the vitrification process. Organics are generally converted into gasses and these gasses rise to the top, and are collected in gas collectors placed at the top. This gas is treated at gas treatment centre to neutralize the volatile substances in them. The rest of the matter gets entombed within the glass. Nuclear wastes can also be neutralized by this method as the glass thickness also aids in obstructing the radiation upto significant levels. The formation of glass also removes almost all of the voids within the waste mass, and leads to almost 20-50% of volume reduction (Study on the Various Methods of Landfill Remediation, Vasudevan, Naveen. K, et al, 2003).

Compared to the conventional processes vitrification is much quicker, and a one-step process.

### 3.3 Sub Surface cut-off walls

These systems are akin to cut-off walls used for the containment of water in some enclosed volume. The cut-off walls for MSW dump sites are usually designed to separate the waste dump from any underlying water stream/source. It is usually done by grouting with any impervious material such as cement, concrete, bentonite, bentonite slurry, bentonite cement slurries, geo-membranes etc. (Study on the Various Methods of Landfill Remediation, Vasudevan, Naveen. K, et al, 2003).

### 3.4 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 oversized, under sized and intermediate portion is the key step in any landfill mining operation. The undersized fine fraction generally consists of soil and humus, oversized 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.

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.

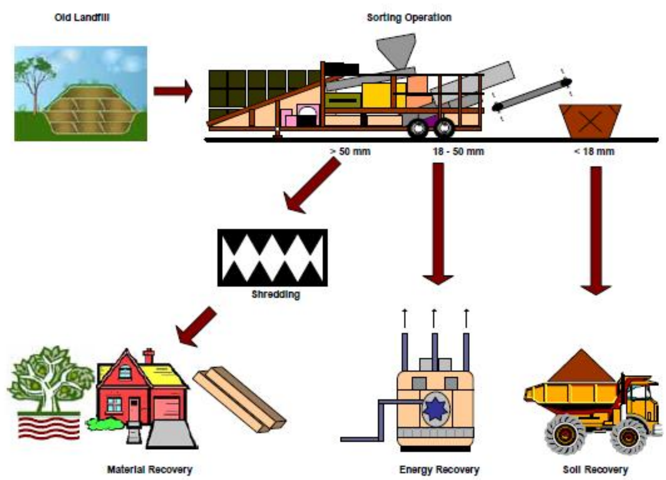


**Fig. 1 Schematic of landfill mining process (Carius et al, 1999)**

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).

### 3.4.1 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:

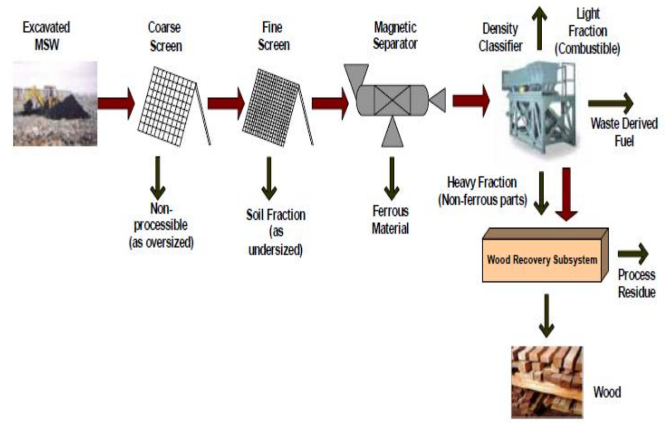


**Fig. 2: Process Scheme for a landfill mining plant (Savage and Diaz,1994)**

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 summarised 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.

**3.4.2 History of Landfill Mining**

Since the first instance of Landfill mining, carried out in1953 in Tel Aviv, Israel, it has widely been deployed as the preferred mode of sustainable landfill management. The operation deployed in Tel Aviv was taken up with the sole objective of reclaiming soil fraction which was to be utilized as soil improvement for citrus orchards. The equipments deployed were a front end loader, clamshell, conveyors and a rotating trommel screen. The trommel had openings of 25mm and a length of 7m with a 2m diameter and was rotated at the speed of 13rpm. The fraction that was retained on the screen was sent away for manual sorting to recover ferrous materials, and other matter for recycling.

Though the first landfill mining operation was carried our way back in 1953, the first well documented operation was undertaken in 1988, Collier County in Florida. The major objective of this operation was to eliminate a potential pollution source that could degrade the quality of ground water, recovering soil for use as cover material for the active cells, and to recover landfill volume. Receiving around 4,00,000 tons of refuse every year, the landfill was estimated to have a capacity to cater for another 9 years. After the mining operation it was found that the dirt and humus portion was almost 60-70% of the total excavated refuse. 15% of the dug up refuse was intermediate sized fraction composed of majorly plastic, textile, wood, glass, aluminium, rubber and brass and was found to have a significant calorific value. The intermediate sized fraction thus presented opportunity for further recycling and processing and selling those materials in the market generating revenue.

By mining the unlined portion of the landfill which was 20 years old, reclaiming and removing the refuse from there and selling the saleable fraction or utilizing the soil, the Collier County managed to lower their landfill operating costs significantly and extend the life of the landfill. Though, the most important outcome of the entire operation was the remediation of a potential pollution source that was posing threat to the ground water.

Since 1988, i.e. after the Collier County operation, landfill mining gained a new momentum globally, and has been experimented with numerous times.

**3.4.3 Case studies from Asia**

**3.4.3.1. 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 lechate recycling and drainage and resulted into 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.

**3.4.3.2. 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.

## 4. CONCLUSION

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. For 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.

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