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Remediation of landfills in and around cities

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Abstract
With the rapid urbanization and increase in population, the waste generation around the world also increases, amounting to a footprint of 0.79 kilograms per person per day (2020 - 'World Bank' estimate). Waste disposal in open landfills cannot be a suitable method since the legacy waste in those landfills is still untreated posing a threat to the built environment. Thus, for the renewal of land on large scale and to bring about life scape in that area two eco-friendly processes - bio mining and landfill capping are being widely used in various parts of the world to solve the former problem.

Introduction
Aim: Remediation or renewal of old landfills into inclusive spaces that are located in or around cities.
Objective: Study of existing scenario
Analyze the processes conducted in order to remediate the landfill.
Need of study: Manual of Municipal solid waste management (2016) states that, municipal solid waste management is part of a broader urbanization planning. An essential outcome is creation of landfill sites.
According to the World Bank in 2020, over 90% of waste is disposed of in unregulated or open dumping sites in low-income or developing countries.
As the presence of urbanization rises, these landfill sites get filled up faster than their anticipated life span and get over used and in itself becomes an urbanization problem.
These utilities which were once used to solve the waste disposal problem later turns into an eye sore which needs to be remediated to restore the urban landscape or built environment of that place.
Scope: Use of resources to redevelop the land.
To study revival of land which brought up opportunities to design inclusive spaces within the periphery of land.
Limitation: The paper is limited to the study of the processes conducted in order to remediate the landfill as well as the case studies of landfills which have been remediated using the same processes.
Hypothesis: Landfills can be remediated and resolved to be designed into inclusive spaces.

Keywords: Psychiatric disorders, suicide, suicide attempt

1. Introduction

1.1 Municipal solid waste

Solid wastes which are defined as semi solid / solid waste (domestic /industriaI) which are discarded after their primary purpose is fulfilled.

1.2 Landfills

Open dumping sites where solid wastes are disposed of indiscriminately without planning or control mechanisms.

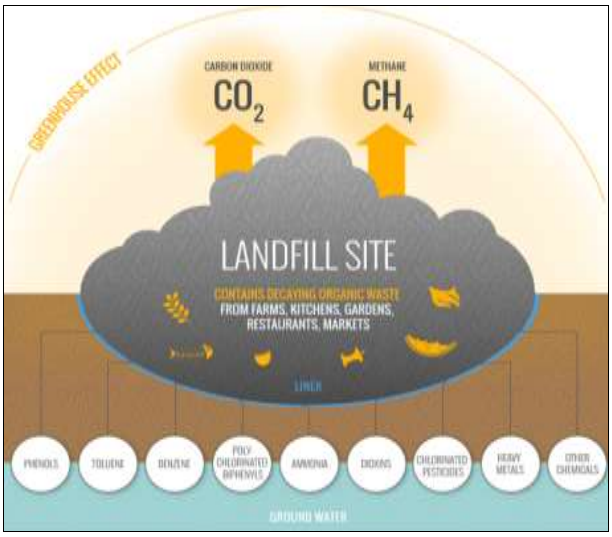
Characteristics

The open landfill becomes a breeding ground for mosquitoes as well as other disease vectors.
If landfill is untreated and still operational for more than 20 years, then it can be an eyesore to the built environment, which even reduces the surrounding significance as a tourist attraction or for a residential area.
Infrastructure disruption, such as damage to access roads by heavy vehicles, may occur amongst others.
Leachate formation can take place, when precipitation falls on open landfills, where water percolates through the garbage and becomes contaminated with suspended and dissolved material. If this is not contained, it can contaminate groundwater and render the soil toxic.

Source - www.reddit.com

Fig 1: Ghazipur landfill, Delhi

The soil is thus, considered as infertile making the land unusable due to the underlying waste not being treated for a long time.



Source-geoenvironmental-engineering.org

Fig 2: Gas emissions from landfill

Decaying organic waste create decomposition gases, especially carbon dioxide and methane from aerobic and anaerobic decomposition.

Some birds feed from landfill sites, inevitably ingesting plastic, and other materials that are common among waste which can affect their health (refer fig 3.).

Source- www.huffpost.com

Fig 3: Migratory birds feeding from the landfill

1.3 Remediation of landfills

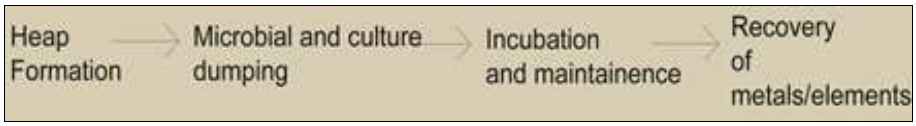
Remediation of landfills is a process of removal or treatment of the legacy waste that has been disposed of for more than a given period of time in an open dumpsite.

It gives an opportunity to design inclusive spaces by upcycling land that had been considered as non-usable.

The most common methods are-

1.3.1 Bio Mining

It refers to the process of extracting disposed materials from an open landfill that had been dumped previously, to recover metal, plastic and other fine materials.



It is a scientific process that brings out the value in legacy waste by segregating it into different categories where the biodegradable portion is converted into compost or biodegradable gas and non-recyclable plastic into 'Refuse Derived Fuel or RDF' or alternative fuels in industries. The compostable portion is removed through sieving which is later on used as fertilizer for landscaping.

This process was initiated in developed countries such as the US, and at present is being adapted in many developing countries.

Methods of bio mining

Bioleaching: Low grade ore is dumped into a heap (leach pile) then soaked with acid wash which degrades the ore and releases minerals or metals in fluid state.

Bio-oxidation: It is used for extraction of gold from ores.

Common metals: This technique is applied for metals such as copper, zinc, silver etc.

Advantages

- It allows us to recycle resources by extracting useful components from the waste such as metal, as compost in fertilizer etc.
- These processes can be in situ and ex-situ.
- NormaI Processes of incineration require a lot of energy whereas these processes do not need energy at all.
- It is Eco-friendly and environmentally sustainable also after using this technique we can use the contaminated land for other purposes.

After the completion of the legacy waste treatment, the land can be used for building commercial structures.

Disadvantages

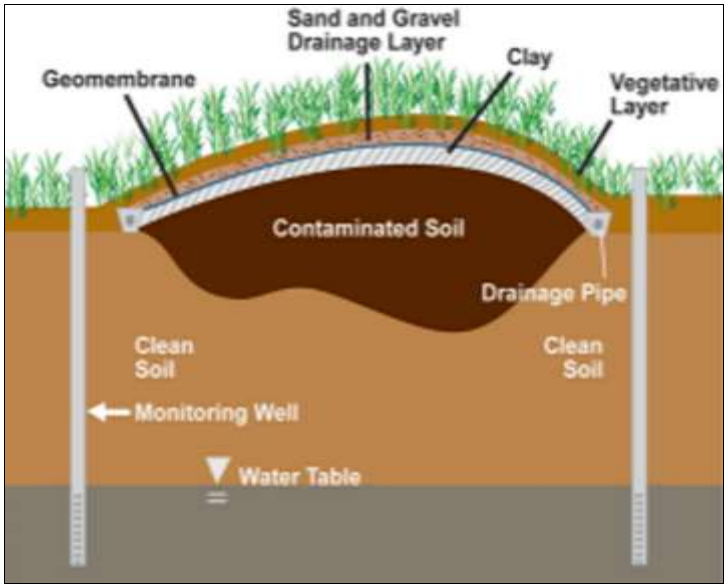
Generally the process is ex-situ because of the requirement of heavy machinery used in order to upcycle all the waste which can be time consuming due to transportation.

It is difficult forthe authorities to choose a new site for the remediation process

1.3.2. Landfill Capping

Landfill capping is a process where the prevailing waste in an open dumpsite is covered or capped and the top layer of cap is provided with vegetation.

The cap forms a barrier between the contaminated area and the surface of the ground to provide minimum exposure of the waste body to the environment.



Source- www.epa.gov/a citizens guide to capping

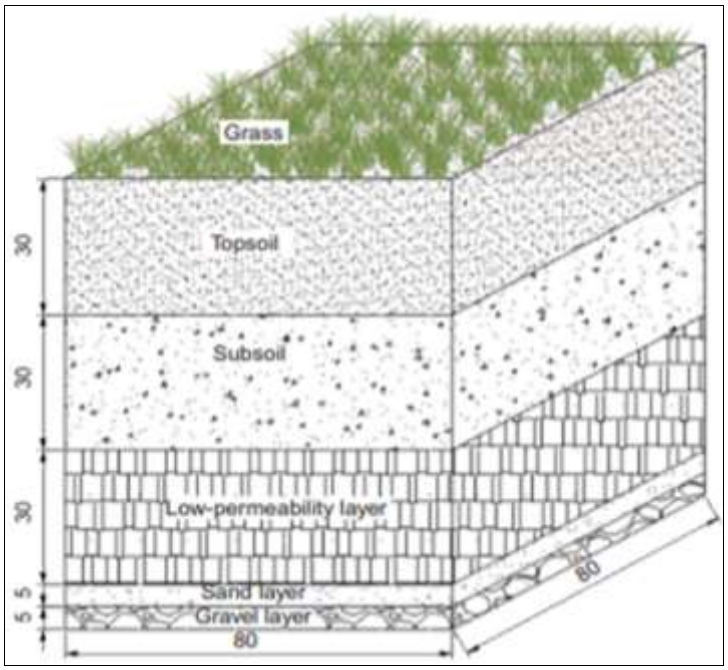
Fig 4: Schematic diagram of landfill capping

Design of cap is 'site specific' and depends on many factors including

- The nature of wastes being managed
- LocaI climate
- HydrogeoLogy
- Future use of site
- Terrain
- LocaI availability and costs of cap materials

The range of caps can be from one layer of vegetated soil to complex multiple layers of soils and geosynthetics.

Less complex systems are required in dry climate whereas more complex systems are required in wet climates.



Source- researchgate.net-geot64-0095

Fig 5: Schematic diagram of landfill capping

The capping layer is 3-12 ft deep where the soil barrier layer over the waste can be of varying thickness so the mounded waste can be shaped into rolling hills.

Advantages
- It prevents odour from waste and diseases carriers to occur and affect the surface environment.
- It creates a surface which can used to built inclusive spaces such as parks, that can also serve as an aesthetic appeal to the built environment.
- It is an efficient process on waste masses that are so large where other treatment is impractical.

Disadvantages
- OnIy a green space can be designed and no structure with heavy foundation can be built due to the underlying waste beneath the surface.
- The effective life of landfill components (Including cap) can be extended by continuous inspection and maintenance. Vegetation, which has a tendency for deep root penetration, must be eliminated from the cap area.
- Landfill caps are most effective where most of the underlying waste is above the water table.

2. Case Studies
2.1 Dhapa landfill
Kolkata, West Bengal

Location
Situated in the extended part of East Kolkata wetlands.
Dhapa landfill was set up during colonial period as an open dumping site in 1941 which was spread across 12 to 13 hectares, which was later on extended to an area of 56 acres.

Source -TimesofIndia.net

Fig 6: Dhapa Landfill (2013)

The landfill had expired its capacity in the 1960s but was operational till 2015 and had crossed over a height of 50 feet.

Source - Author

Fig 7: Dhapa Landfill

In 2015 the civic body had made the 12 hectares of wasteland non-operational which was later on remediated and a green zone was built.
Ex-situ method of land remediation was carried out to treat 40 lakh tonnes of total legacy waste at the landfill, out of which 4.5 lakh tonnes of waste has been removed and transformed into green space (fig.) from the landfill to the 'Eastern Metropolitan Bypass using the procedure of bio-mining.
During the first phase the remediation procedure 300 tonnes of garbage was recycled daily which was later on increased to a capacity of 900 tonnes per day.

Source - www.bhaskar.com

Fig 8: Current status

According to KMC, the process for remediation will be finished in 2025 the landfill would be converted into a sanitary landfill for scientific disposal of waste.

2.2 Bhanpur Landfill
Bhopal, Madhya Pradesh
Location - Huzur Tehsil and the Phanda square in Bhopal, Madhya Pradesh.
Bhanpur Kanti was a 37 acre open landfill which served as a dumpsite for the Bhopal city for around 48 years with a legacy waste of 5 million tonnes with an average height of 8-9m, generating more than or equal to 800 tonnes of 'Municipal solid waste (MSW)' daily.

Source - www.bhaskar.com

Fig 9: Bhanpur landfill - 2014

Impact of Dumpsite on Built Environment

- The haul roads to the dumpsite were almost impassable and not well maintained.
- During rains, the leachate (waste water) formed posed a threat to the built environment.
- Using the conventional method of igniting the waste led to the emission of harmful gasses such as methane and carbon dioxide.
- The waste workers were completely unprotected as they did not use proper equipment while working in the dumpsite.
- The foul smell from the site used to be an indication for the arrival of the city.

Remediation Process

In 2018, Bhopal Municipal Corporation (BMC) initiated the bio remediation process of the landfill by using biomining on 21 acres of land and landfill capping on the remaining 16 acres of land.

Source - downtoearth.org

Fig 10: Areas allotted for bio mining and landfill capping

The reason for division of the dumpyard was to fasten up the process.

In the case of bio mining, the technical expertise was adapted from the Kolkata Dhapa dumpsite model.

Bio Mining: The legacy waste of 21 acre landfill area was transferred to the treatment plant to carry out the process of bio mining.

Source - downtoearth.org

Fig 11: Current status

Heaps of waste were segregated on which culture was added which was kept in the windrow for 27 days,later on the waste was processed through trommel segregation (3 - set trommel segregation).

Source - downtoearth.org

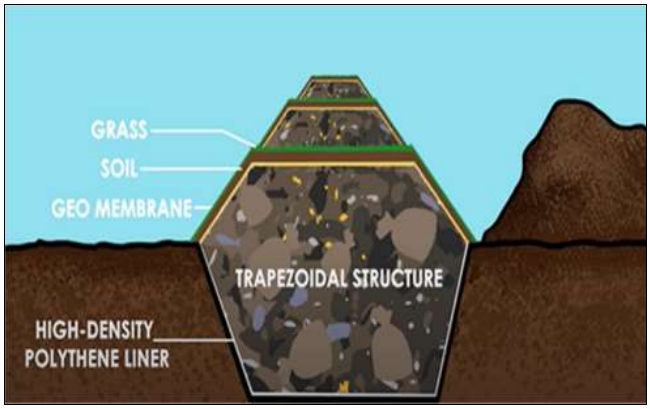
Fig 12: Schematic diagram of bio mining

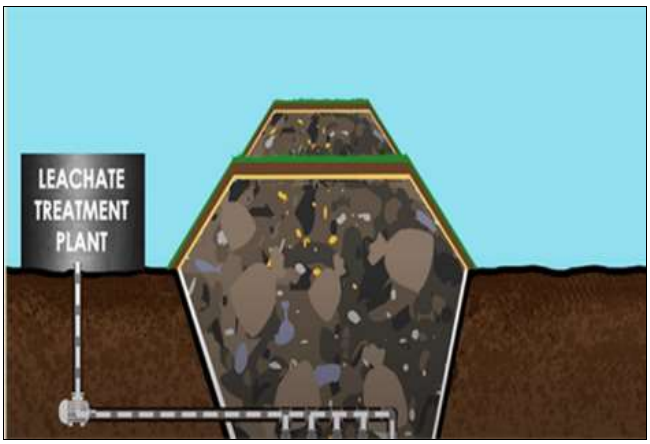
Landfill Capping

As mentioned earlier about the landfill capping process, a trench was dug on the remaining 16 acre land on which a layer of high density polyethene liner was placed.

A trapezoidal waste structure was placed over that layer which is covered with grass.

For leachate and gasses emerged from the waste are collected from the peripheral pipeline installed around the landfill which is then treated in 'Leachate Treatment Plants'.





(Source - downtoearth.org)

Fig 13: Schematic diagram of landfill capping

Process conducted on site

Fig 14: Digging of trench on site

↓

Fig 15: Layer of high density polythene liner provided on the surface

↓

Source - downtoearth.org

Fig 16: Final outcome of the capping process where the garbage layer is covered by the layer of grass.

2.3 Fresh Kills Park

New York, US

Area - More than 2200 Acres

Being located on the western edge of Staten island, the periphery of the landfill intact wetlands and significant wildlife habitats which makes it a suitable land for designing recreational space to make complete use of its scenic views.

Source - freshkillspark.org

Fig 17: Fresh kills landfill (1999)

Fresh Kills operated from 1948 until it closed initially in 2001.

Remediation

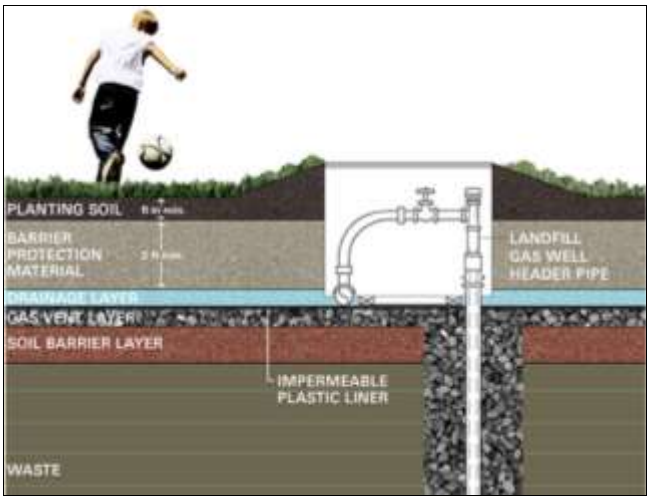
45% of the Fresh kills is landfill whereas the other 55% is made up of creeks, wetlands and open fields.

To remediate the fresh kills site, the park is divided into five areas where at some parts landfill capping is under process whereas in some it has already been done.

Fig 18: Landfill mounds in Fresh kills

Open water	210 acres
Wetland	360 acres
Water basins	47 acres
Lowland	668 acres
Landfill mounds	1030 acres

The landfill is covered with different layers of soil, geotextiles, and a geomembrane.

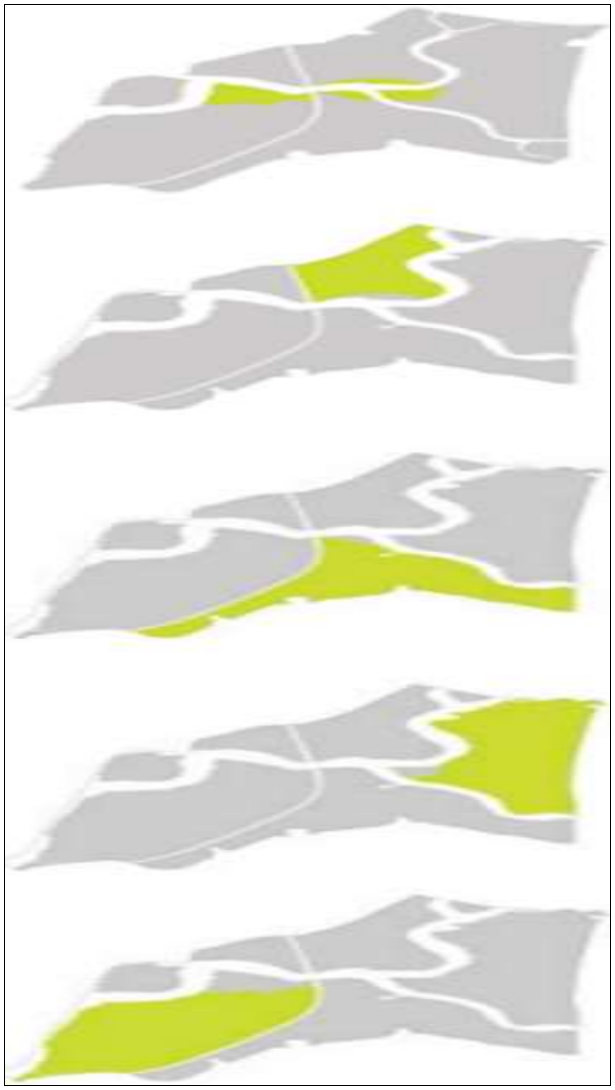


Source - freshkillspark.org

Fig 19: Schematic diagram of landfill capping on Fresh kills

These layers stabilize landfilled waste, separate the waste from the environment and park visitors and prevent the release of landfill gas to the atmosphere.

Proposal of Spaces To Be Designed In Different Areas - (Refer Fig.20)



Source - freshkillspark.org

Fig 20: Division of the landfill into different areas (Nomenclature mentioned below based on the hierarchy of diagram)

1. The Confluence-100 acres

Programmatic core of the site + waterfront recreation hub

- The Point 50 acres
- Creek Landing 20 acres
- The Terrace 10 acres
- The Marsh and the Sunken Forest 20 acres

2. North Park - 233 acres

Lightly programmed natural and open areas + Travis Neighborhood Park

- Wetland and lowland natural areas that extend William T. Davis Wildlife Refuge
- North Mound natural areas with light trail network
- Travis neighborhood recreation area, with trails, fishing and bird-watching docks

3. South Park -425 acres

Concentrated active recreation + programmed natural areas + Arden Heights Neighborhood Park
- Sports and active recreation center
- Mountain biking trails
- South Mound natural areas with mixed-use trail network
- Lowland natural areas
- Arden Heights neighborhood picnic and play area

4. East Park-482 acres
Specialized programming + programmed natural areas
- Freshwater marsh and nature education center
- East Mound golf course
- Berm overlooks and trail
- Boat docks
- Public art installations

5. West Park-545 acres
- September 11 programs + lightly-programmed natural areas
- Earthwork monument to the recovery effort
- West Mound natural areas with light trail network
- Arthur Kill promenade and picnic areas with fishing piers
- DSNY and park infrastructure + management facilities

3. Conclusion
The landfills which were once herald to a significant enhancement to the quality of life and land use can be transformed to new cultural, programmatic and environmentally friendly spaces.
The two processes stated in the paper can play a significant role in designing inclusive spaces where in case of bio mining after the completion of this process, the site can be used for commercial purpose keeping in mind the requirement of the stakeholders around the vicinity of the open landfill site.
Whereas, in case of landfill capping process, it can play a major role in urban landscape by restoring the once infertile land into inclusive green spaces as wells as other recreational purposes.

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