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LANDSCAPING OF MUNICIPAL SANITARY LANDFILLS – COMPREHENSIVE STUDY ON POLICIES, REGULATIONS, ISSUES, IMPACTS IN INDIAN CONTEXT- SITE STUDY AND DESIGN INTERVENTIONS IN VISAKHAPATNAM CITY, ANDHRA PRADESH.

Title Name: Landscaping of Municipal Sanitary Landfills – Comprehensive Study on Policies, Regulations, Issues, Impacts and design in Indian Context.

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ABSTRACT :

Municipal solid waste management (MSWM) is one of the major issues in developing countries today. In India, Over 377 million urban people live in 7,935 towns and cities and generate 62 million tons of municipal solid waste per annum. Only 43 million tonne is collected, 11.9 million is treated and 31 million tonne is dumped in landfill sites.

The solid waste has been polluting the air, soil and water because of improper dumping.

Neighboring habitants of the landfill sites undergo a lot of physical and mental pain and illness, especially during monsoons and fire accidents in landfills.

Monsoons cause the nauseating smell to become severe to cause breathing problems, and spread to long distances. There is an ever existent public outcry on the health conditions of nearby residents depleting due to the fatal ailments every now and then due to reasons like Pests and houseflies, underground water pollution, mosquitoes, stink, etc.

The study focuses on various issues and impacts caused by Sanitary landfills in Indian cities and various landscape related policy level regulations and guidelines and implementations shown in design in an Indian context in the city of Visakhapatnam.

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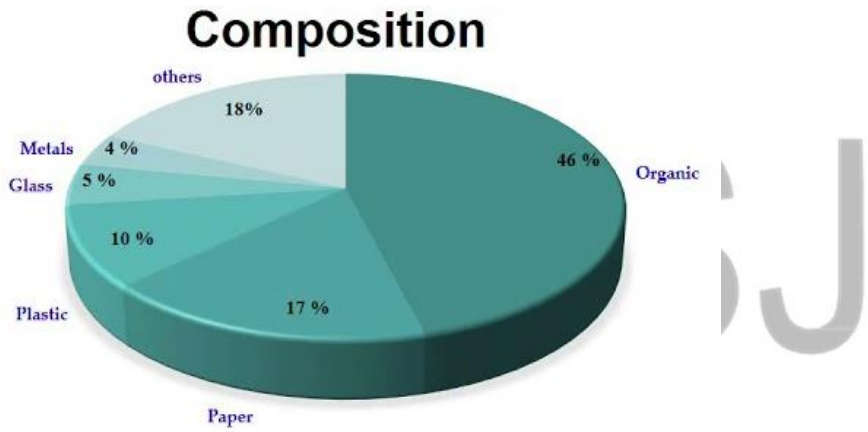
Keywords: *Sanitary landfills, landfill landscaping, issues, environmental impact, health issues, Municipal solid waste, regulations, policies, guidelines, site selection criteria.*

1. INTRODUCTION :

1.1 What is municipal Solid waste?

- Solid wastes are defined as all the discarded solid materials from municipal, industrial, and agricultural activities.
- Biodegradable waste: food and kitchen waste, paper(can also be recycled).
- Recyclable material: paper, glass, bottles, cans, metals, certain plastics, fabrics, clothes etc.

1.2 What is the composition of waste?



1.3 What is Solid Waste management ?

Collection: transfer and emptying garbage truck

Segregation : separation of hazardous waste

Transportation and Compaction: Garbage trucks and compactors

Disposal: Landfills

1.4 Importance OF WASTE MANAGEMENT:

- Poor waste handling and disposal leads to
- environmental pollution
- breeding of disease-vector insects, animal scavengers and rodents diseases
- Public or community nuisance due to foul odour and unsightliness

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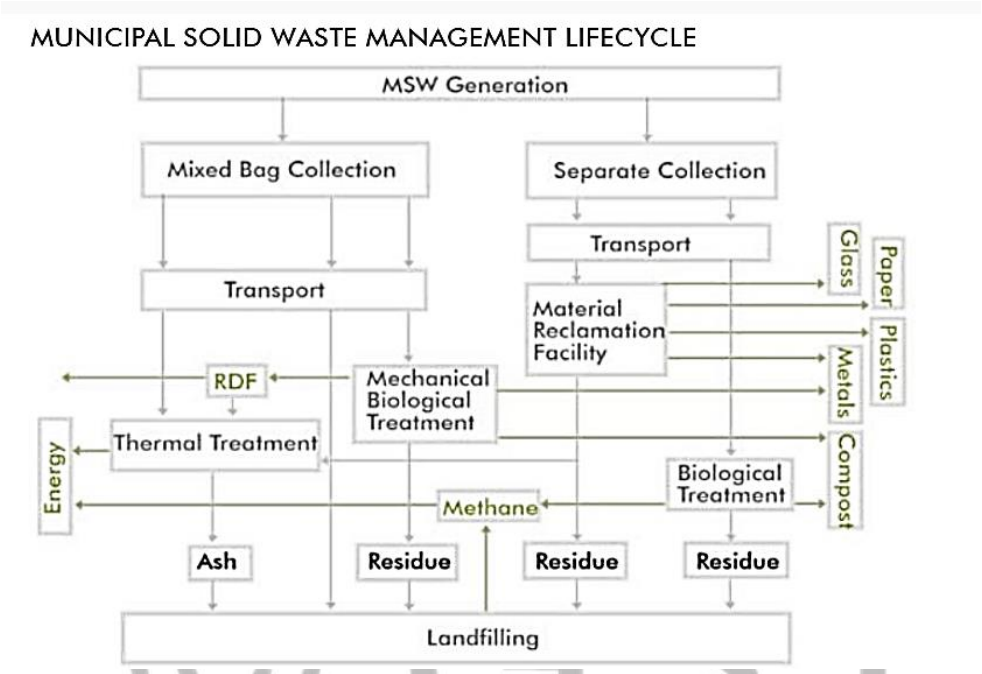
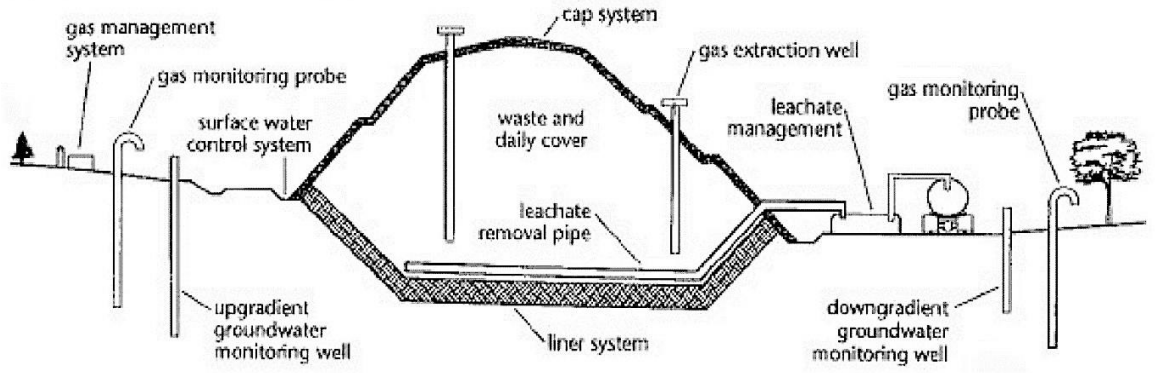
- Obstruction of drainage systems
- Fire hazards.

1.5 Journey of Municipal Solid Waste:



1.6 What is a landfill? Anatomy of a sanitary landfill



1.7 Benefits of landfill reclamation

Environmental:

- Scope for Brownfield development
- Protection of public health
- Protection of water resources and air
- Protection and recycling of soil

Social:

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- Recreational opportunities
- Betterment of public health
- Social Awareness on recycling

Economic:

- Increase in land value by improving degraded property.
- By-Products of bio-mining and composting can be a source of income.

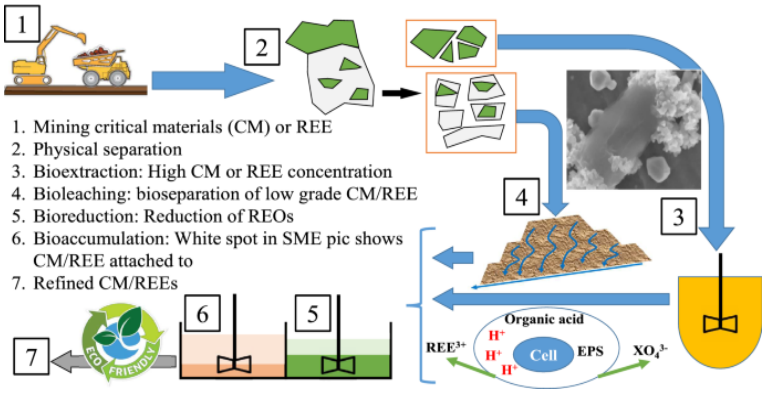
1.8 Issues with open landfills:

1.Surface and Ground water pollution

Air Pollution

1.9 What is the process involved in landfill reclamation?

1.9.1.Bio-mining



REE- Rare Earth elements

1.9.2.Compacting

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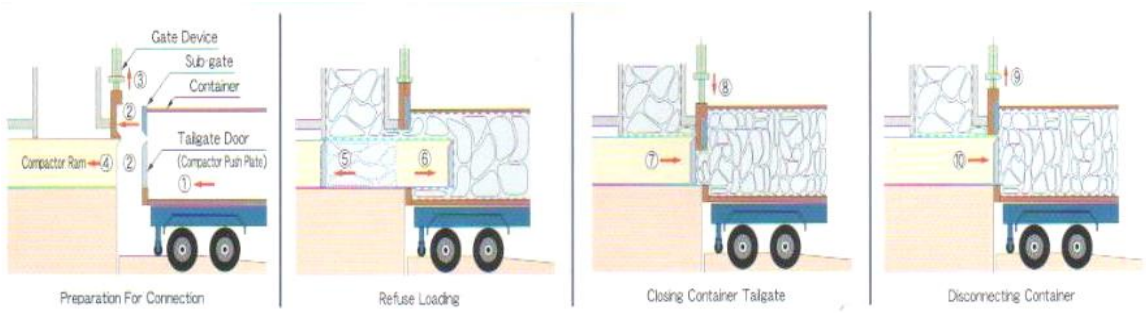
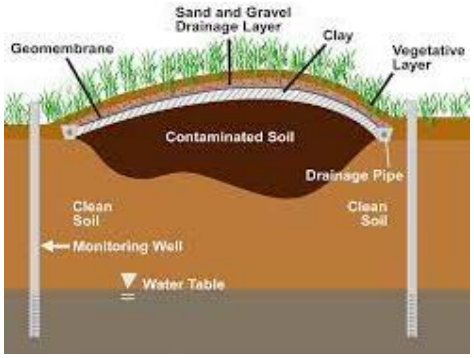
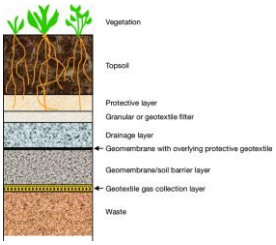
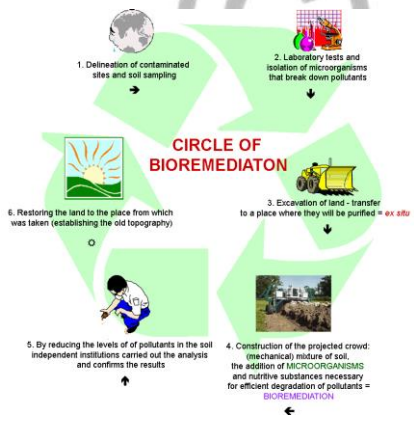


1.9.3.Scientific vegetative capping





1.9.4.Bio-remediation Process



2. LANDFILL WORKING AND SITE GUIDELINES:

2.1. SITE SELECTION:

2.1.1Locational Criteria : No landfill is permitted to be located near the specified areas within the buffer area listed below.

Table-1:Table showing landfill restriction near different zones

Area	Landfill restricted within

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Lake or Pond	200 m
River	100 m
Flood Plain	100 year flood plain
Highway	200 m, not closer than 50 m after tree buffer
Human Habitation	500 m around landfill -No development buffer zone
Public parks	300 m
Critical Habitat Area	No landfill-Area with one or more endangered species live
Wetlands	No landfill
Ground Water Table	less than 2m below ground surface
Airports	8kms radius
Water Supply Well	500 m
Coastal Regulation Zone	No landfill
Unstable Zone/Fault zone etc.	No landfill
Buffer Zone	As prescribed by regulatory agencies

Source: CPHEEO

Search Area: "search areas" are delineated on a map, while searching for a potential landfill site, governed by the economics of waste transportation.

- Search radius= 5 to 10 km
- Center= waste generating unit

Development of a List of Potential Sites: In areas where land availability is scarce, degraded sites such as abandoned quarry sites or old waste dump sites can be considered with Special design measures.

Data collection and other geophysical investigations: factors like topography, soil test, Preliminary Boreholes, Environmental Impact Assessment (EIA) , Establishment of Ground Truths etc are considered.

Soil permeability: ease with which water seeps through a soil.

3. GUIDELINES SPECIFIC TO LANDSCAPING IN LANDFILLS:

3.1 CPWD GUIDELINES FOR SUSTAINABLE HABITAT:

- Adoption of **treatment and processing before disposal** and adopting waste to energy technologies. It will not only reduce the quantity of wastes but also improves its quality to meet the required pollution control standards.

3.2 CPCB (Central Pollution Control Board) GUIDELINES:

Plantation at Landfill site:

- Selected species of locally adopted non-edible perennial plants that resistance to drought and extreme temperature
- The roots of the plants grown should not penetrate more than 30 cm
- thrive on low nutrient soil
- to minimize soil erosion

3.3 Clean Kathmandu Valley Guidelines:

- The final cover will be at least 1.0 meter thick and will include layers of soil to reduce infiltration, prevent erosion along the slopes, resistant to waste and support vegetation.
- The final landfill **cover will be re-seeded with native vegetation to minimize the visual impact** of the final landfill surface and to provide a natural habitat consistent with the surrounding environment.

3.4 United States Environmental Protection Agency:

- A completed sanitary landfill can be made productive by turning into pasture or crop land.
- Depth of final cover must be increased accordingly. If landfill is to be cultivated a 1ft-2ft layer of relatively impermeable layer of soil must be placed on solid waste and additional layer of agricultural soil to prevent the clay from drying out.

Table-4 : Table showing infrastructure facilities that are to be provided for functioning of a Sanitary landfill

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Landfill Component	Requirement	Reference
Bottom Liner / Composite Liner	• A 90cm thick compacted clay or amended soil (amended with bentonite) of permeability not greater than $1X10^{-7}$ cm/sec • A HDPE geomembrane liner of thickness 1.5mm • A drainage layer of 300mm thick granular material of permeability not greater than $1X10^{-2}$ cm/sec.	MSW Rules, 2000
Final Cover	• Vegetative layer of 450mm thick with good vegetation supporting soil • Barrier layer of 600mm thick clay/amended soil with permeability $1 X 10^{-7}$cm/sec • Gas venting layer of 450mm thick granular material with permeability $1 X 10^{-2}$cm/sec	MSW Rules, 2000
Maximum Allowable Leachate Head with in Landfill	30 cm	USEPA's Manual on SWM (Subpart – D, Design Criteria)
Base Slope	2%	CPHEEO Manual
Cover Slope	Not steeper than 1:4	CPHEEO Manual

Source: Krishna, V.K., Reddy, V. and Rao, P.R., 2015.

3.5 Spanish guidelines:

- grass and plants with short roots should be planted.
  Reduction of impact on the landscape: Perimeter fence, preferably using native vegetation.
- plant in holes filled with fertilized soil and grass, in order to prevent erosion and the increase of leachate.
- Cover grass should be planted on finished areas of the landfill.
- The plant cover of the initial areas will need to be stored and conserved, for vegetation of covered landfill.
- In buffer area a hedge of shrubs and fast-growing trees (pine, eucalyptus, laurel, bamboo, etc.) that will prevent neighbors and passers-by from seeing the MSW.

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4. LANDSCAPE RELATED MUNICIPAL SOLID WASTE MANAGEMENT POLICY GUIDELINES:

4.1. National level policies:

5.1.1. Karnataka state polic-Integrated Waste Management:

- promoting public awareness on minimizing waste
- defining the roles and responsibilities of various **stakeholders**

4.1.2 KN state policy also proposes the following innovations-

(ISWM-integrated solid waste management):

- Information, education, and communication (IEC) activities
- Non-government organizations (NGOs) as a bridge among- ULB(Urban local bodies), self-help groups (SHGs), and resident welfare associations (RWAs) -overcome challenges in implementation.

4.1.3 Swachh Bharat Mission:

- Capacity building of urban local bodies - design, execution and operation of systems related to service provision.
- encouraged the participation of private sector.

4.1.4. Integrating the Informal Waste Sector: Policy Directives

- "**Give legal recognition** to, and strengthen the informal sector (**kabadi system** and waste pickers) systems of collection and recycling of various material.
- enhance **their "access to institutional finance and relevant technologies."**

4.1.5 Decentralized Solid Waste Management-: An example of implementation in an institutional building.

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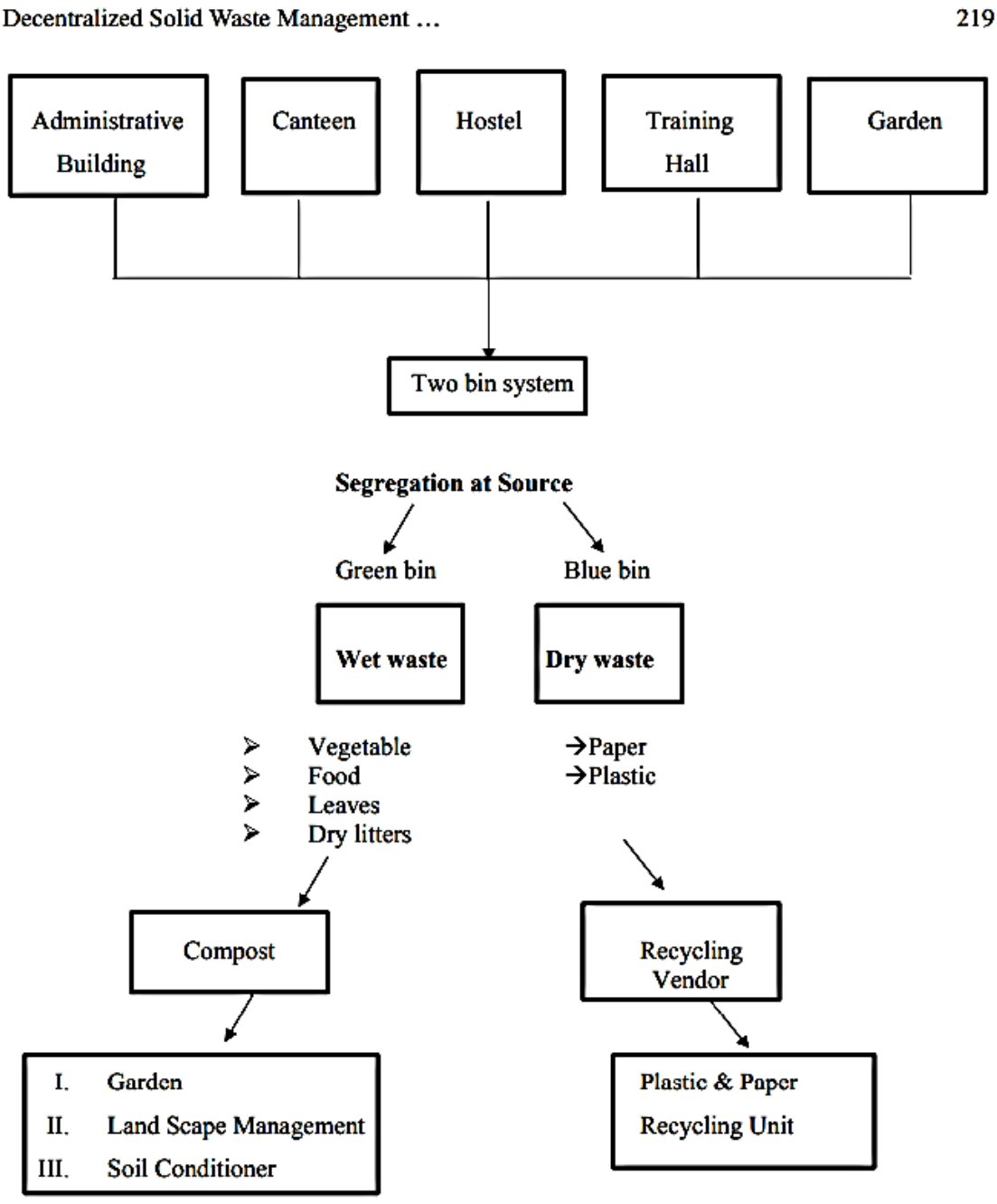

Fig. 2 Adopted scheme of waste management at ESCI campus

4.2 . International Policies:

4.2.1. Food waste-to-energy policy landscape: US policies

- **Awareness** and voluntary initiative with target.
- Research on Renewable fuel standard
- Landfill ban and renewable energy standard

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4.2.2 UNEP (UNITED NATIONS ENVIRONMENTAL PROGRAMME):

UNEP Strategy for ISWM:

- develop partnerships with other **organizations working for Waste Management** – **complimenting & multiplier effect** for - International Co-operation.
- **Managing and Reducing Wastes online**:
  ENERGY STAR Portfolio Manager- free, online tool for tracking waste for multiple buildings(for commercial buildings)
- Track Waste
- Assess waste Program
- Improve waste Practices
- Sharing a Successful practice

4.2.3 Implementational level:

- **Business Toolkits i.e. Business ideas for start-ups** for managing and recycling wastes are into practice.
- On Site recycling, composting and reuse facilities
- **Reducing office paper waste**- making information available electronically.

4.2.4 Landscape waste management Programs and Strategies -**Dallas/Fort Worth** :

- **compost** solid waste or biosolids

- **ban grass clippings**
- **collect brush clippings** separate from garbage
- Contractors that **"chip" brush** collected separately from garbage
- **centralized composting** for landscape waste
- **vermicomposting** (demonstration or educational sites)
- distribute backyard **compost bins** at no cost to citizens-to promote backyard composting

4.2.5 Zero Waste Masterplan (2019)-Singapore:

- Commercial and industrial food manufacturers- set aside space for- 1.segregation- 2. on-site or off-site food waste treatment systems.

4.2.6 CPCB guidelines :

Composting is one of the methods of waste utilization. Vermi-composting techniques to be researched on.

5. ISSUES

5.1 Problems and Issues Related to Landfills in India:

5.1.1Environmental:

a. Unscientific management of wastes
b. Disposal facilities: not being able to handle the quantity of waste.
c. rainy season run-off and high humid conditions: increase the health hazards.
d. groundwater contamination: due to leachate percolation.
e. Methane gas: Mature landfills are dominated by methanogenic microorganisms which convert VFA (Volatile fatty acids) into biogas (CH 4,

CO 2) and leachate get dominated by non-biodegradable compounds. This phase of mature landfills is known as methanogenic phase.

f. Greenhouse gases: produced due to the decomposition of organic waste in landfill site cause the climate change

5.1.2Health impacts:

a. Open dumping-**breeding ground for disease vectors** such as flies, mosquitoes, cockroaches, rats and other pests.
b. High risks of spreading Vector-borne diseases(**caused by parasites, viruses and bacteria)** like typhoid, cholera, dysentery, yellow fever, encephalitis, plague and dengue fever.
c. Particulate air pollution : high PM10(particulate matter) exposure leads to breathing problems, bacterial infections, increased mucus production, asthma, elevated cardiovascular risk, and other infections.
d. Odour Problem: leads to nausea. In India, it is aggravated in summer with 45Deg C.

5.1.3. Management of solid waste (CTD):

a. Collection :**1) Primitive waste collection meathods and absence of standard practices.** 2)**untreated waste:** 75% of total waste is collected, 28% of it was treated. The rest is dumped in landfills. 3)**land availability issue:** Current requirement- 1,240 ha of land as landfill per year.

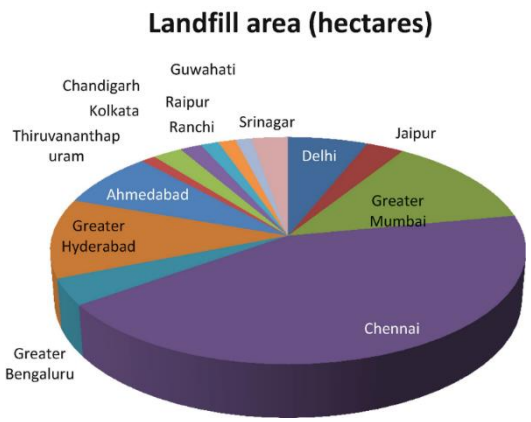

Fig: Area of landfills in different cities of India. (Source: CPCB)

b. Transportation : use of outdated trucks, tippers and refuse collectors. Insufficient garbage transportation system leading to failure in garbage collection.

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c. Disposal: generally landfilled, now the lands are being over used.

Table-5 : Table indicating the composition of municipal waste

Description	Percent by weight
Vegetable, leaves	40.15
Grass	3.80
Paper	0.81
Plastic	0.62
Glass, ceramics	0.44
Metal	0.64
Stones, ashes	41.81
Miscellaneous	11.73

Source: CPCB

5.2. Issues Particular to Metro cities:-

5.2.1 Location of L.F.S.(landfill site)-

- So far being referred as " Dumping Site"
- Waste left untreated due to lack of treatment plants-shortage of space.
- Technology is available, but execution is not taking place.6.2.2. Travel Time to L.F.S. - with an area above 1000 Sq. Km, travel time varies from 30 minutes to 75 minutes (one way). Loading, unloading and waiting time in the LFS accounts to huge accumulation of waste either in collection or transfer site.

5.2.2. Road Width- 25 to 30 % of the roads are below 4 m width.

6. IMPACTS OF LANDFILL SITE ON ENVIRONMENT-LITERATURE REVIEW AND ANALYSIS:

S.no	Title of the article-Authors-Year	Summary	Preventive measures
1	**Pervez Alam1 & Kafeel Ahmad** *Department of Civil Engineering, New Delhi, India*	Environmental concerns -Methane Gas, Greenhouse gases and liquid leachate. Effects: concentration of heavy metals in the food chain, i.e. liquid industrial effluents containing heavy metals discharged to a drainage/sewerage system.	use of dense clay deposits at the bottom of waste pits, coupled with plastic sheeting-type liners – prevent effluent infiltration into soil-encourages evaporation-best strategy to contain excess liquid.

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2	Pervez Alam, Mufeed Sharholy and Kafeel Ahmad-2020	• Presence of electronic , painting waste, and used batteries are accountable for the occurrence of weighty metals make the leachate non- biodegradable volatile compound. • Cause- unsegregated waste. Effect- surface and groundwater mix with heavy metals. • Monsoon season's leachate- less dangerous	• If BOD and COD are high, then that groundwater is unsuitable for both household and commercial uses. • Diluted leachate is less harmful.
3	Jenin Rajasingh J, Sundararajan R, Ashiga T.S and Jenisha G *Coimbatore, Tamil Nadu, India*	The leachate at study area, i.e. vellalore dumping site, shows high value of COD and BOD for both Summer and winter seasons and moderate concentration levels in heavy metals.	leachate treatment and adequate channels for leachate collection can decrease of leachate contamination.

6.1. CONTROL OF LEACHATE- Effective operational practices like finger drain layout, Phytoremediation ponds and engineering controls at landfill facility is a must.

6.2. CONTROL OF METHANE GAS- Methane gas can be extracted to help generate electricity or the waste has to be made less toxic in order for the effect of Methane Gas to be neutralized.

7.LANDFILL LANDSCAPING DESIGN STRATEGIES: HOW TO DEAL WITH ACCUMULATED WASTE?

7.1 Literature review on probable technological experimental solution through landfill Landscape design :

S.no	Type of the research paper-Authors-Year	Summary-Design strategies- illustrations	Implementable aspects/Takeaways

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1	Research type-experimental. *Amritha P.K. , Anilkumar P.P. NIT Calicut, India-2015*	The paper describes a waste management strategy to fit landfills into urban landscapes through enhancing its environmental significance and visual quality for sustainability. Methodology: • Type of collected waste-kitchen waste Filled in eight pits of 30cm and 60cm depths Observation period -60-70days. A typical pit is divided into three different phases as explained below. • Phase 1(Dumping) - wet waste was put first, then the dry waste, reducing the foul odour. • Phase II (Degradation) - Turning of waste at regular intervals, aerobic digestion, accelerating the decomposition. • Phase III (Planting) – selected suitable plants utilize the nutrient content in the pits. Degraded refuse obtained- High nutrient Organic compost . Process: open dump/Micro landfill is to be treated as a micro landscaped landfill	This type of technique can be used as urban level scheme of developing organic compost by giving an incentive for number of bags generated out of micro landfills.

7.2 Landfill Landscaping Design Strategies

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Strategy	Application	Example
Hide- Make waste invisible	capping and planting screening of dump yards Buffering the landfill	
Removal waste	Depends on the volume and characteristics of the waste involved. Restore and return removing extreme toxic materials, pumping out polluted water, and leakages Excavating polluted soil	Eg: Bio-mining and bio-remediation of landfill 
Neutralize waste	to achieve an inner-site digestion/assimilation of waste harmful impacts. "Clean-and-Green" design approach, using ecological restoration, bioremediation, scientific clean-up, natural purification. contaminants are converted to nontoxic substances.	Eg: Using Phyto remediation for Leachate treatment, so that it can be used for irrigation after neutralization 
Frame waste and celebrate it	contact with waste without safety and health concerns. encourages cultural, educational and social identity of waste Inviting people to experience the real matter of waste and its processes, awareness of waste	Eg: Using waste to display the history or culture of the site, Landscaping, Sculptres with scrap 
Using waste as a medium	Making urban products and artifacts out of waste Creating a recognizable and consistent pattern of elements for landscape using waste	

7.3 Landfill Landscaping Design Strategies based on issues

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Issues		Mitigation/ Remediation techniques	Landscape design techniques
Environmental	Methane gas	Plantation Buffer	Vegetating landfills intermediately helps in containment of Methane gas by plants
	Greenhouse gases	Dense vegetation to break down the green house gases	Effect of Green house gases can be usually broken down through dense vegetation
	Volatile Organic Compounds(VOC's)	Synthetic membranes and segregation	Plants which help break down petrochemicals can be planted in affected areas- Phyto-Volatilization
Air	Vector-borne diseases	Plantation Buffer	Pumping out waste stagnant water from inside the site will prevent insect reproduction and also insect repelling species can be planted
	Particulate air pollution (PM 2.5, PM 10)	Green belt	Dense vegetation along the periphery of various heights and widths to block the polluted air from going outside the site.
	Odour Problem	Plantation Buffer	Selection of Fragrant trees and planting them along the periphery.
Water	Surface run-off	Vegetative capping, Underside lining, Peripheral pipes to collect run off water	Landfill capping should be vegetated with species with shallow roots, drought and erosion resistant, which can be irrigated through leachate.
	groundwater contamination	Benetonite cut off wall	Cut-off wall of suitable material must be given to avoid the mixing of leachate contaminating ground water.
	Leachate emissions	Phyto-remediation Ponds	Native species for phytoremediation must be planted along the synthetic lined leachate ponds.
Soil	Breeding ground for disease vectors	Neutralizing the waste	allowing sunlight and aerating waste can reduce moisture content in the solid waste.
	Heavy metals mix into soil through leachate	Bio-remediation	Removal of affected soil, remediating it after separation

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8. CASE STUDY:

8.1 Case study-1: Jawahar Nagar Waste to energy plant, Hyderabad

- **Location: Jawahar Nagar , Dammaiguda, 30kms from the GHMC.**
- Year of Establishment : 2002
- Estimated Life Span : 15 years
- **Stakeholders:** Public Private Partnership (GHMC & RAMKY Enviro engineers Ltd)
- Amount of waste Disposed : 3450 tons/day
- **Landfill area:130 acres**
- **Total site area:705 acres**
- Disposal Method: Scientific disposal – processing & disposal
- Total workers: 490
- medical precautions : Masks , Shoes , spectacles , safety jackets
- **Treatment : Aerobic Decomposition of waste**
- Frequency : Daily
- Leachate collection: Leachate collection ponds
- Open Burning at site : because of old dump
- Surface water near the site: Malkaram pond
- Ground water table : 120 ft below

Fig-19: Figure showing site plan of Jawahar Nagar landfill site.

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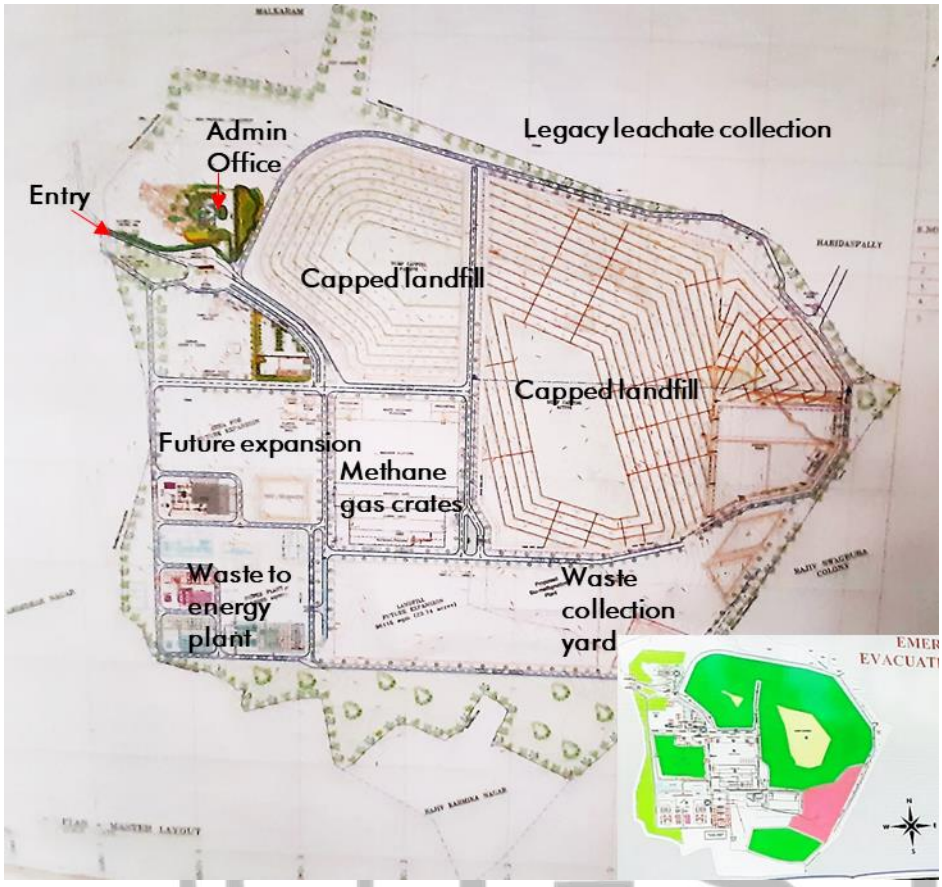

Fig-20:Hyd land use plan

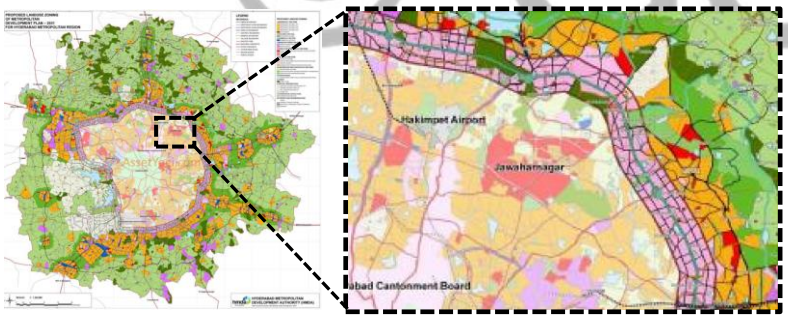

Table-7 : Table showing the chemical properties of Municipal waste received in Hyderabad

Chemical properties of waste recieved	Range
pH	6.24-7.15
Moisture content	31.73- 59.24

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Carbon content mg/kg	7.60-15.6
Nitrogen mg/kg	4500-7200
Zinc mg/kg	132-272
Lead mg/kg	10-25
Nickel mg/kg	1-6
Calorific value k.	1250-2550

Source: Krishna, V.K., Reddy, V. and Rao, P.R., 2015.

8.2 ISSUES AND OBSERVATIONS:

- LOCATION-Landfill/Dumping yard is at higher elevation from residential area.
- WIND DIRECTION & PUBLIC HEALTH -Direction of wind from land fill site is towards south west direction which is on the side of residential area which is negative impact on public health, this direction of wind helps harmful air pollutants released from site to easily move towards settlements which creates major effects on public health . • The soil pollution is making the area into barren lands.

• The lakes surrounding the study area are highly polluted due to dump yard.

- BAD ODOUR: Bad Smell from the Landfill/dumping yard comes to around 2 Kms radius. Previously upto 8 to 10 Kms. i. e. 15-20 villages nearby.
- GROUND WATER AND SURFACE WATER CONTAMINATION-In rainy season water & waste from dump yard flow towards settlements and ground water gets contaminated in surrounding area due to Leachate in dump yard
- FIRES AND EXPLOSIONS – AIR POLLUTION Fires and explosions occur at waste treatment facilities because of improper storage or handling of materials. Large amount of heat is generated in wasted dumped which results in sudden explosion and also leading to air pollution in that area.

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8.3 MAJOR DRAWBACK: The facility is not open for public use or recreation and also not maintained were the capping part is done. Hence lack of awareness on what is happening inside the site to neighbors.

<table>
<tr>
<td>Existing and capped landfills- Trash is getting onto the new capped landfill and causing landscape degeneration
  </td>
<td>Machinery is exposed to climate without any buffer
  </td>
</tr>
<tr>
<td>Surface run-off on the landfill is collected through the peripheral drains.
  </td>
<td>Surface collection ponds for leachate collection. But the leachate under the landfill is collected through the natural slopes of the site and collected through a drain pipe.
  </td>
</tr>
<tr>
<td>The methane collection plant on landfill
  </td>
<td>Bores for methane gas extraction
  </td>
</tr>
</table>

8.4 Landscape Design Strategies Observed:

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Scientific landfill to avoid fire accidents, exposing the landfill to monsoon and buffer the smell and to prevent the poisonous gas emitting from the landfill and generating energy through it.

Before

After

Vegetating the landfill and the surrounding site to prevent dust particles mixing with air from moving garbage trucks and act as smell buffer

Before

After

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The original rocks which were present on site were retained and landscaping id one along the landform

Before After

Entrance green belt- To prevent noise pollution and visual buffer to all the oncoming vehicular activities

Before After

8.5. Site Sections:

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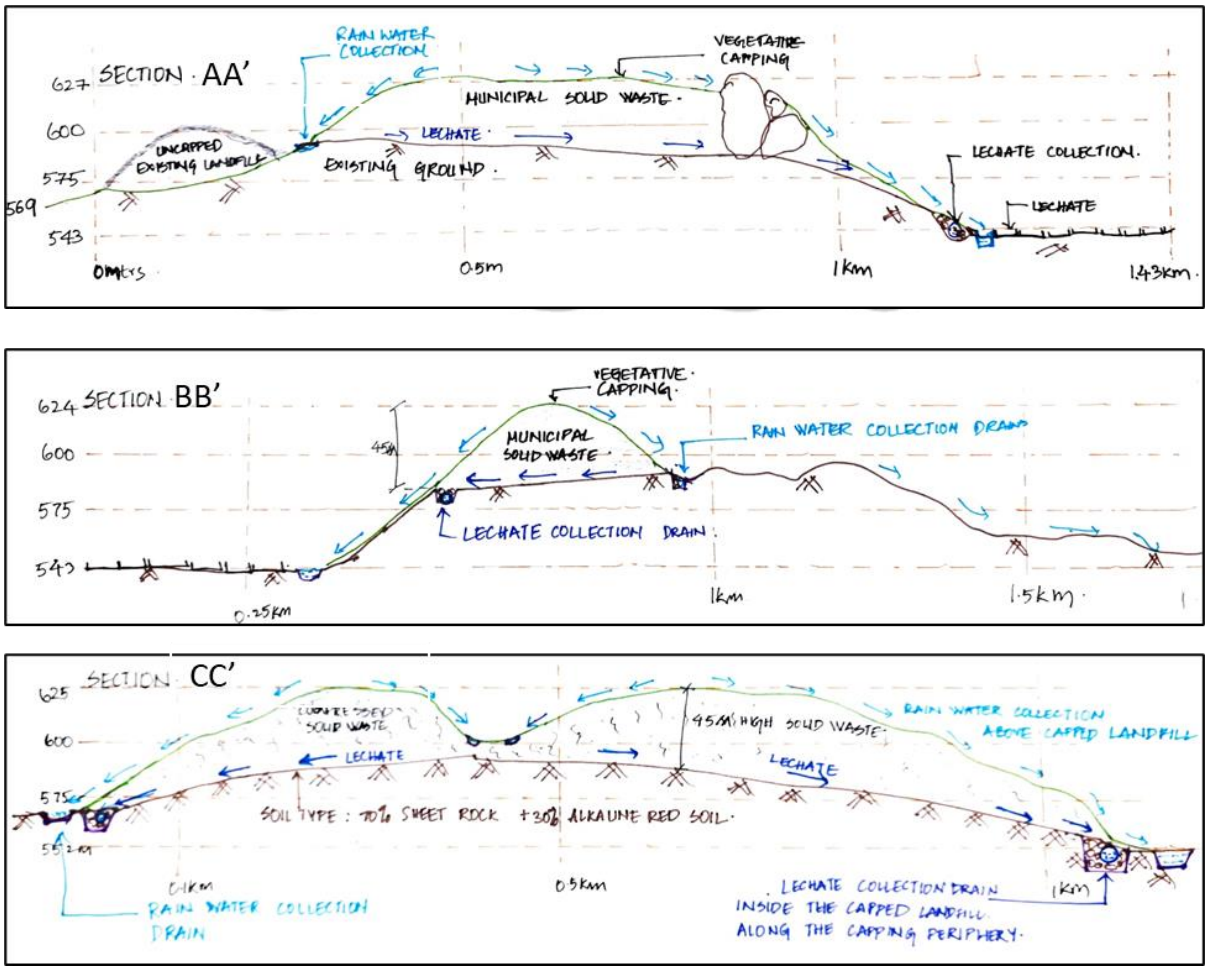
Fig-21:Site sections showing Leachate drainage under capped landfill in Jawahar Nagar.



Inferences: The major intervention being the vegetative capping of the landfill, it has been contoured along the existing mounds of dump. The south west being the

lowest part of the site, the waste water treatment plant and rain water run-off and leachate collection drains of the garbage mound have been directed towards that side of the site through peripheral drains inside the capping(made of gravel and perforated pipe in RCC).

- The leachate collection and treatment facility is given on North-east part of the site as half of the garbage mound slopes that way.
- Due to the placement of the landfill on the top part of hilly topography, and the dump height being 45 meters above the ground level, the winds carry the smell till 8kms from the site during the functional stage of the landfill.
- It is an advantage in a way as the garbage have plenty of aeration which reduces the risk which comes with toxicity of volatile compounds in leachate and lesser chance of rainwater stagnation and also helps the waste degrade faster.

9. Desktop study:

9.1. **Ramayanpatti Landfill Tirunelveli:**

Before

After

Location: Ramayanapatti, Thirunelvelli

Land use Typology after land fill: eco park

- Climate: Tropical
- Avg temp:2.5
- Rainfall: 968mm
- Surrounding villages-10

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- Soil type : Dry land with moderate vegetation
- Compaction: 32.50 acres to 6 acres.
- Completion date:2018

9.2. Major Issues Identified:

•Unbearable Stench

•Ground water pollution in nearby areas

9.3. Design strategies:

- With technical assistance from National Institute of Technology-Trichy, compacted clay liner was provided over the compressed garbage and covered by 1.50 mm High Density Poly Ethylene (HDPE) geo-membrane liner.
- Storm water drain on periphery
- Methane vents are placed at vantage points.
- Doob grass ,Korean grass/ Manila Grass species for mat forming- Perennial grass native to temperate coastal south Eastern Asia, to make each heap look like a grass 'mound'.
- Enclosure height was designed in two stages to prevent sliding.

9.4. Observations:

- Lawn vegetation is taken into consideration but diversity in vegetation is not seen.
- Buffer for traffic routes is not given
- Absence of dense vegetation around the periphery.

10. Technical details:

Table-8 : Table showing the Question and answers of survey conducted at waste to energy plant at Dammaiguda, Hyderabad.

Questions	Answers
Starting and closure year of landfill?	2003 to 2012
Total Site area of the landfill site?	705 acres
Quality of waste deposited in terms of Volume, depth, height	Height-45m

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Quantity of waste after compression: Area, volume, Depth, Height	Before compression-358 Acres, After compression-130Acres
Capping Type?	Geo membrane liner
Covering type?	Native scrub vegetation with 15cm root depth
Leachate collection system	Leachate is collected in Overhead tank and sent to STP onsite
Leachate monitoring	Once in every 45 days, STP- Pre-treatment, Reverse osmosis. Good water + salt TDS(Total dissolved solids).
Soil type and permeability	70% Sheet rock, 30% Alkaline red soil
Groundwater depth?	No Permission
Ground water monitoring measures and methods?	Done Every month by CPEEHO(Central Public Health & Environmental Engineering Organisation)
Ground water containment areas?	Restricted up to 2-3 surrounding villages
Surface water monitoring methods and measures?	5 surface water bodies in 1 km radius Totally polluted, No STP
Landfill gas control system	Borewell methane gas pipes get collected in Gas crates
Landfill gas effects on workers?	Periodic health checkups are done every 6 months in site. Happens Outside the site also sometimes.
Private water supply extraction points within 3kms?	Restricted upto 1.5 Kms
Any Complaints on landfill while in function, during monsoon season?	Odour and surface run off water from the dumpster existing. As per MOEP Instructions, Odour misting is done through 3 drones-9Hrs per day. 20mins can cover 1 acre
Stakeholders involved?	GHMC & RAMKY Enviro engineers Ltd(25 years contract)
Is the plant being used for power generation?	Yes, generates 20-28 Megawatt/ day
Are there any sensitive ecosystem around the landfill ? If yes, where and of what type?	Yes, Lakes used to exist before but many have disappeared past 10 years
How is the surface water prevented from contamination?	Shed top drains are connected to leachate collector to STP.
What is the irrigation system for the new vegetation?	Drip irrigation
Is the planting done after studying suitable species?	Yes
Is the final topography of the landfill aligning with landscape?	Yes, this site was previously a quarry site.

Source: interview.

11.Case/ desktop studies Comparative analysis:

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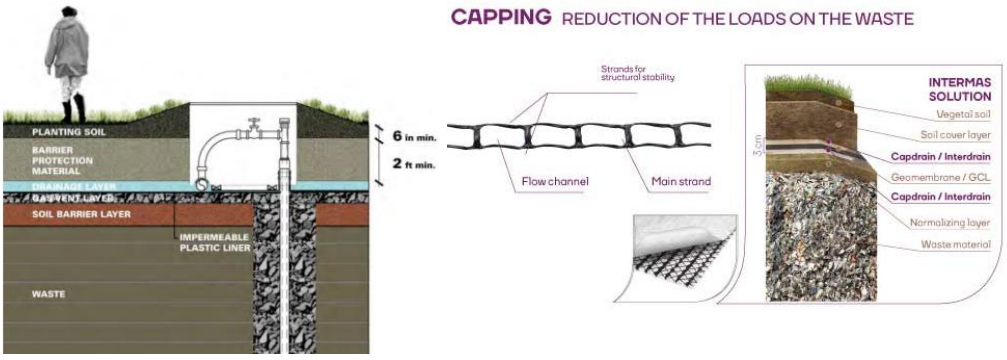
Parameters	Jawahar Nagar Waste to energy plant, Hyderabad	Ramayanpatti Landfill Tirunelveli	Inferences
Climate	Dry semi arid	Tropical	Dry climates allow more waste to get deposited whereas humid climates tend to get capped earlier
Post-closure Land use type	Waste to energy plant	Eco-park	Landfills in Indian context also need to allow public access for landfills
Topography	Hilly region,	-	Hilly landforms are more preferred as they are rocky on the bottom
Previous land use	Mining site	Agricultural	Most of the landfill sites are previously degraded lands.
Surrounding context	Encroached lands- Residential	Agricultural, Residential	Most of the landfills are surrounded by residential context and dense urban fabric
Area	705 acres	32.5 acres	Humid regions have smaller landfill area. Implies that the landfills in humid areas become quickly unbearable.
Soil type	Red soil	Dry land with moderate vegetation	All the soil types are not favourable for a landfill due to high soil permeability
Design Strategies/facilities	• leachate collection and treatment facility. • Scientific landfill to avoid fire accidents. • Vegetative buffer around the site. original rocks retained • Entrance green belt • Placement of waste is 70% on sheet rock and 30% on soil -lesser percolation of leachate into the ground.	• compacted clay liner and covered by (HDPE) geo-membrane liner. • Storm water drain on periphery • Methane vents are placed at vantage points. • Enclosure height was designed in two stages to prevent sliding.	Technological advancements in landfill management allow more waste to energy conversion
Vegetation type	Native plantations are used for plantations on capping as well as on site.	Korean grass/ Manila Grass species for mat forming- Perennial grass native to temperate coastal south Eastern Asia and northern Australia.	Grass cover for capping does not present much opportunity for bio-diversity and ecological functions.

1.13Technology :

1.13.1GEO-COMPOSITE DRAIN USED FOR CAPPING AND UNDER-LINER IN THE LANDFILL :



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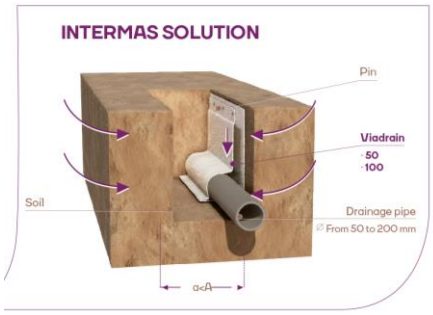
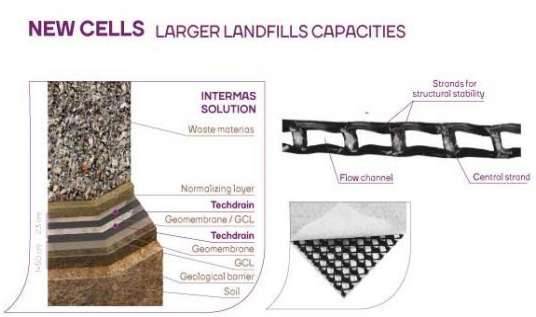
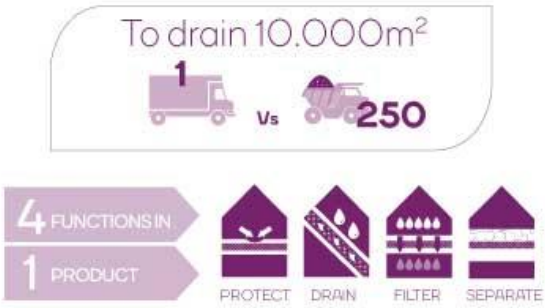
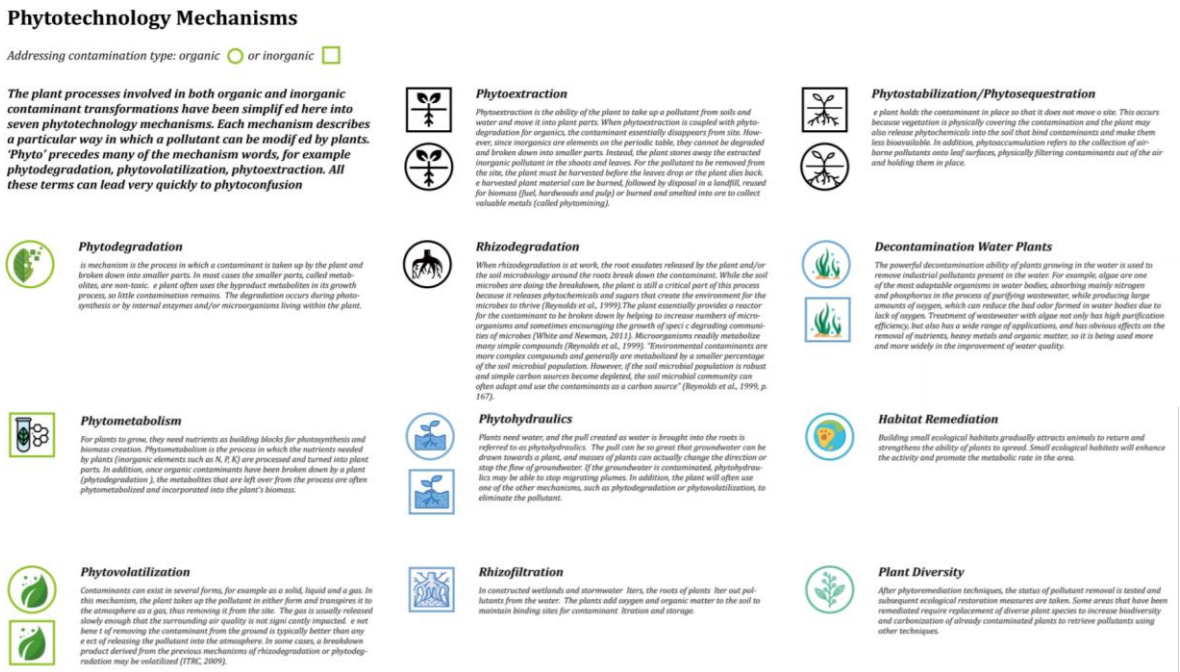






1.13.2.Types of Remediation techniques involved with landfills:



1.14.What are the end-use Opportunities of a sanitary landfill?

Open space developments which are easy to construct, maintain and recreational facilities that are not easily affected due to change of landfill topography due to decomposing waste are opted.

Usually landfills are accompanied by waste- to energy plants for methane gas collection and leachate management and constant monitoring of landfill.

Examples : golf courses, nature parks, fields, and walking or biking trails for public use, Forest park, City park, etc.




2. SITE STUDY:

2.1 Introduction to the site:

The site is located at Kapuluppada in the city of Visakhapatnam, which is a port city and has a long shoreline adjoining the Bay of Bengal. The site is located 4Kms away from the Coastline. Visakhapatnam has a tropical (hot and humid) climate (Avg Temp-24.7–30.6 °C).

The Greater Visakhapatnam Municipal Corporation (GVMC) is preparing to reclaim 100 acres of land at the dumping yard, through a bio-mining process which removes bulky items from the waste. (GVMC) has constructed 15 megawatt waste-to-energy plant on the site.

The proposed dimensions of landfill were estimated as 300m x 325m measured from top of the bund to the bottom bund to accommodate 1.52millions m3.

Total Site Area- 120Acres

Dumping area-97 acres

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Source: VUDA; AECOM, 2016

Dump yard is Operational since -2001.

Population Of Visakhapatnam City in 2021-2.3 Million.

Vizag city generates 960 Tons per day with density of 0.95 tons per Cubic Meter.

2.4.Physical Features of Site:

- **APIIC** Hill (Andhra Pradesh Industrial Infrastructure Corporation) surrounds the site on three sides.
- Site is located near foot of two hills and in near proximity to **kamabalakonda Wildlife Sanctuary- dry evergreen forests** mixed with shrub and meadows- Indicator Species being Indian **leopard** .
- There is a high chance of water contamination due to the presence of **a stream 330m away** from the site that directly flows into the sea.
- It is 22 Kms away from the city centre
- 400mtrs away from **NH16- 80meters** wide.

2.5. Urban Growth of the city:

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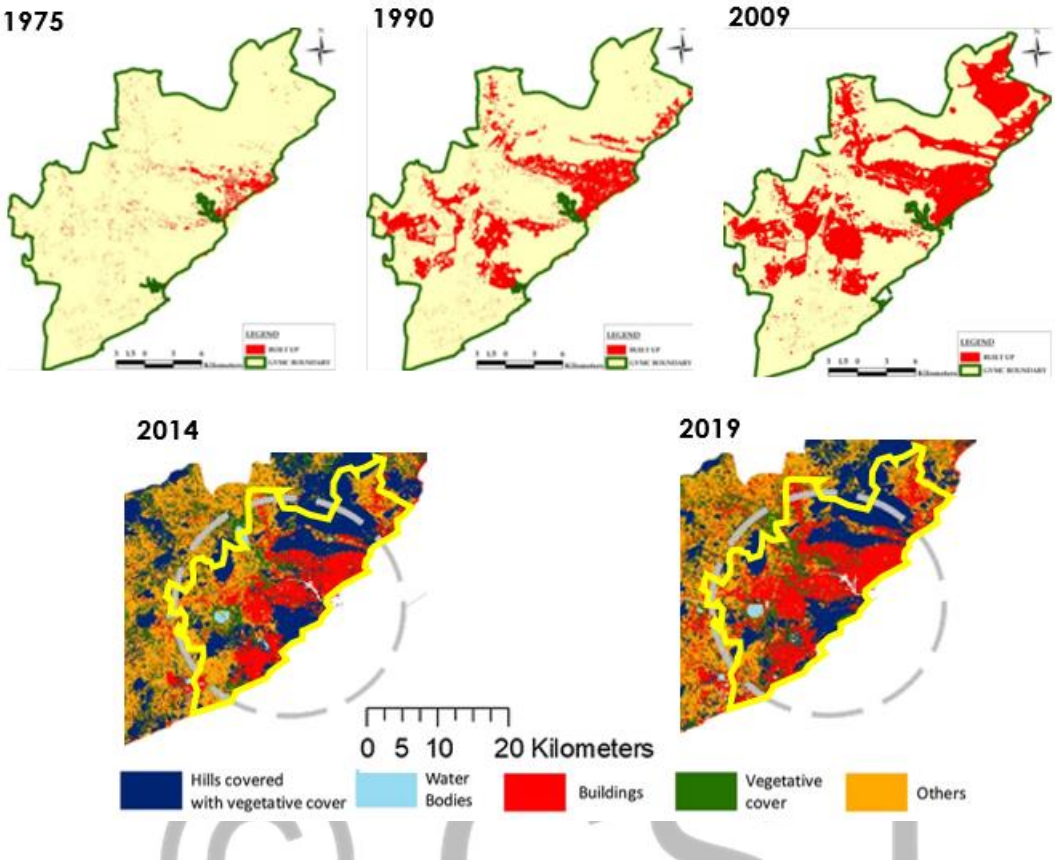

Table 2 Breakup of temporal land use land cover of Visakhapatnam

Type	Area in 2014 (km^2)	%	Area in 2019 (km^2)	%
Hills (covered with thick vegetation)	810.1	0.31	570.7	0.22
Buildings	278.4	0.11	453.8	0.18
Vegetation	392.8	0.15	450.5	0.17
Water bodies	19.9	0.01	17.4	0.01
Other land	1091.6	0.42	1100.4	0.42

2.8. SITE SURROUNDINGS:

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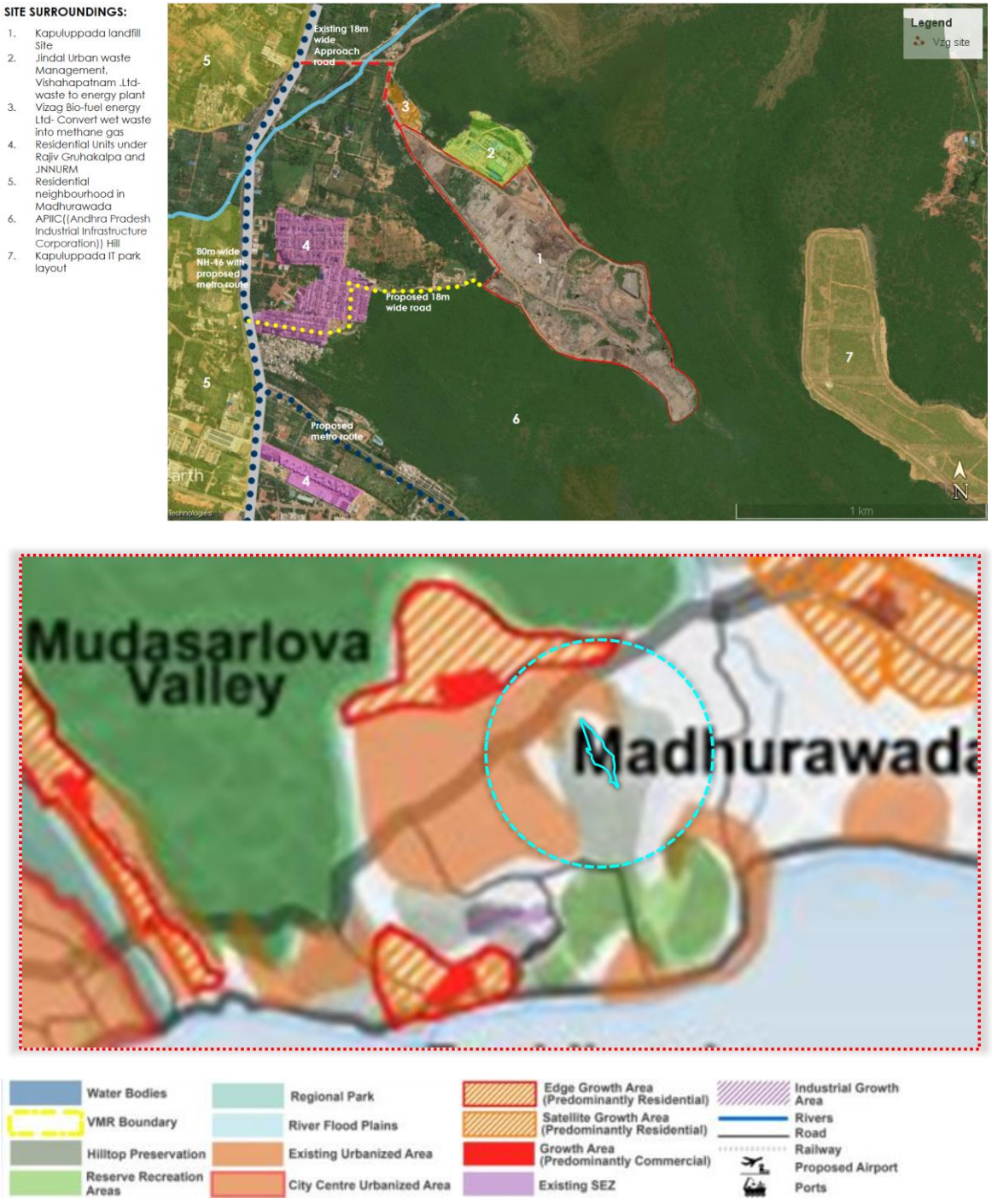

Fig: Generalized Land-use Plan of Visakhapatnam

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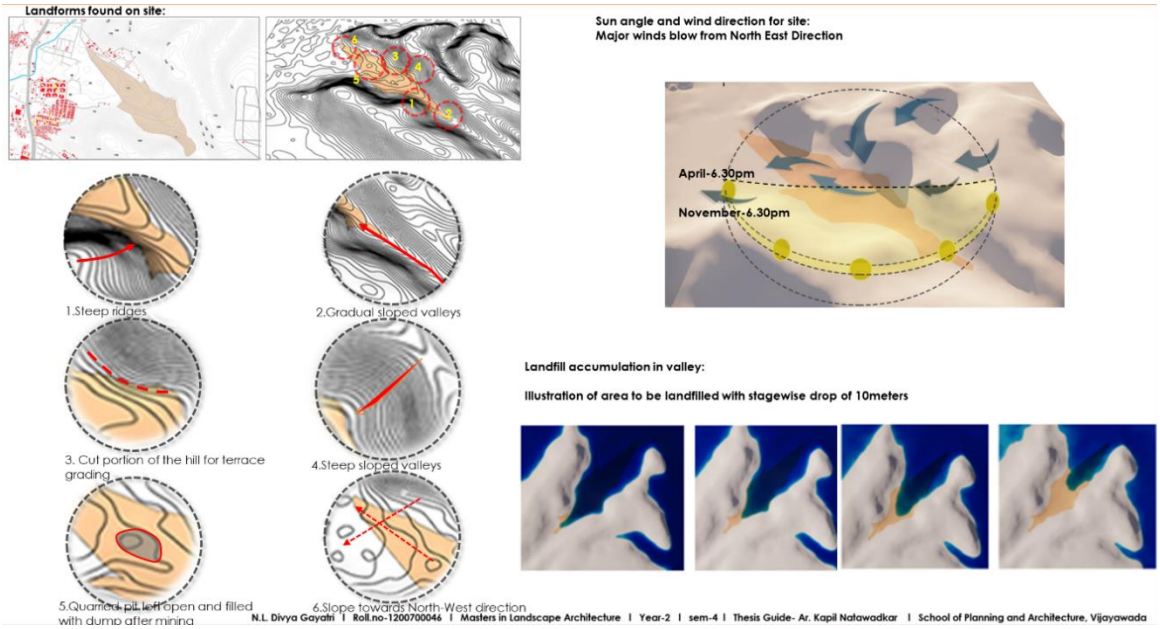
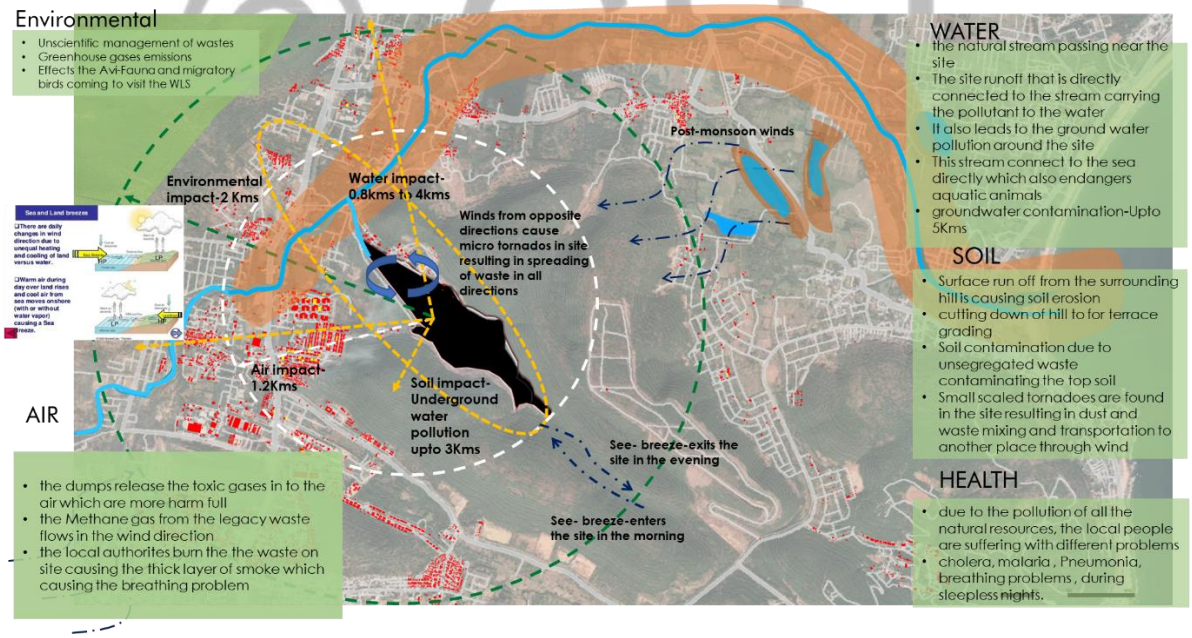


Fig: landforms found on site.

Issues pertaining to site:



Guidelines based on the issues identified:

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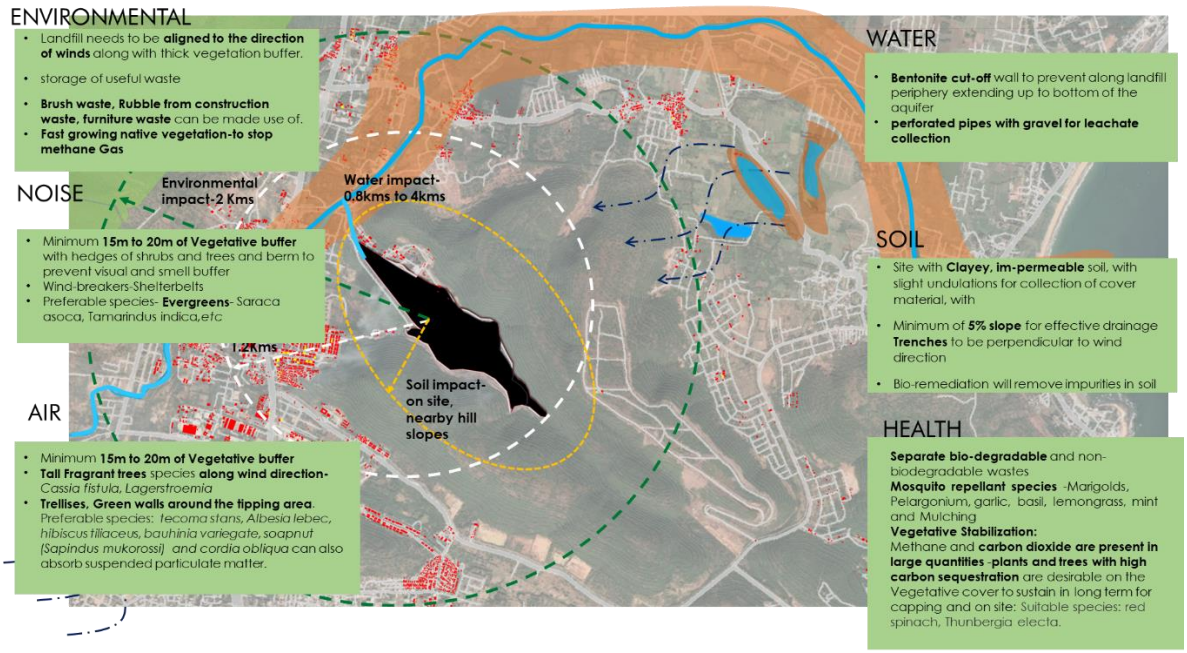

Landscape and Plantation Based guidelines:

Leachate management	**Bioremediation/Phytoremediation**	**Evergreen grasses and shrubs are tolerant to leachate irrigation. Neutralizing leachate and makes it useful for irrigation. *Decontamination water plants like Alge help in improvement of water quality.*** ***Species used for Phyto remediation: Eucalyptus tereticornis, Populus deltoids, Terminalia arjuna, Acacia auriculiformis, Syzigium cumini, Albizia lebbek, Dalbergia sissoo, Conocarpus and Pongamia pinnata) and grasses (para grass, cord grass, lemon grass, and Setaria grass.***
Operational phase	Fire prevention	Trees like *jamun (naaval)*- remove sulphur dioxide *neem, soapnut (Sapindus mukorossi) and Bauhinia variegata* - remove lead from atmosphere and act as green barrier which makes the landfill les prone to fire.
	Plantation near parking	
Closure phase	Cover vegetation	Planting Flowering plants and appropriate species mixes help in propagation, regeneration and increase biodiversity of grasslands and sustainability on vegetated capping. Suitable non-edible species- combination of grass and short-rooted shrubs capable of surviving without irrigation water.eg: *S. secundatum, K. scoparia and N. oleander.*
	Cover slope	4Horizontal:1 vertical or less can be considered safe for Final cover slope. Plants can be sown for slope stability.
POST-CLOSURE phase	Vegetative Stabilization	As methane and carbon dioxide are present in large quantities in site due to gas emissions, plants and trees with high carbon sequestration are desirable on the Vegetative cover to sustain in long term. Suitable species: red spinach, Thunbergia electa.
		Creating Patches of trees by clearing waste in a particular area, can neutralize the gaseous effect on environment. Suitable species: Tectona grandis, Diospyros melanoxylon.
END Use phase	Shading, low maintenance, prevent soil erosion, resilient trees	*Species used for Leachate Irrigation: Cynodon dactylon, Nerium oleander, Pelargonium pellatum, Stenotaphrum secundatum, Pennisetum clandestinum*
	Sacred groves	Christmas tree (Araucaria excelsa), peepal/sacred fig/aswaddha (Ficus religiosa), banyan/marri/vata (Ficus benghalensis), ashoka tree (Saraca asoca), date palm (Phoenix dactylifera), cypress (Cupressus sempervirens), neem (Azadirachta indica), mango (Mangifera indica), kadamba (Anthocephalus cadamba), sandal wood (Santalum album), sami or jammi (Prosopis cineraria), bel, bilva or maredu (Aegle marmelos), moduga/flame of the forest (Butea monosperma), Indian lotus or padmam (Nelumbo nucifera), basilicum / tulasi (Ocimum sanctum),rudraksha (Elaeocarpus ganitrus).
	Staple crops and cash crops seen abundantly in Vizag region.	Rice, Ragi, Bajra and Jowar. Sugarcane, Groundnut, Sesame Niger and Chilies are the important cash crop of the district
	Traditional Natural farming species	Green gram is interlaced with heavy patches of guava plants. Green gram fixes biological nitrogen, so it can grow as a green manure crop, and this works well for guava. Rows of ladies finger plantations with alternating rows of flat beans, wide beans, and leafy vegetables . Among the greens, the yellow marigolds serve as a trap crop, growing alongside the main crop to attract insects.
	Indegenous tribal practices	Maize, rice, soy-bean, Marigold, Rice and red-gram, Tadipattu village style: Turmeric, Ground-nut, Marigold, Millets
	Natural fences	Jatropha and Agave

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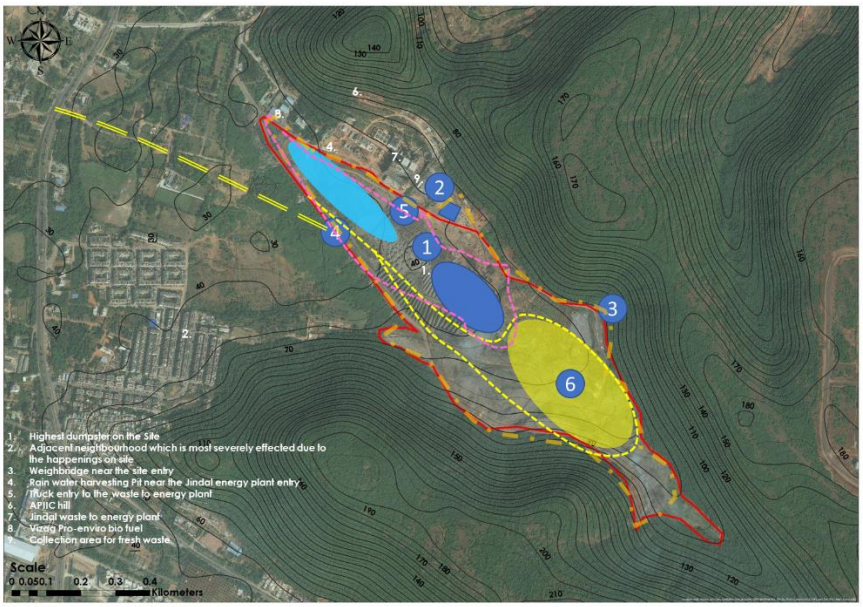
Conceptual Zoning-based on Function

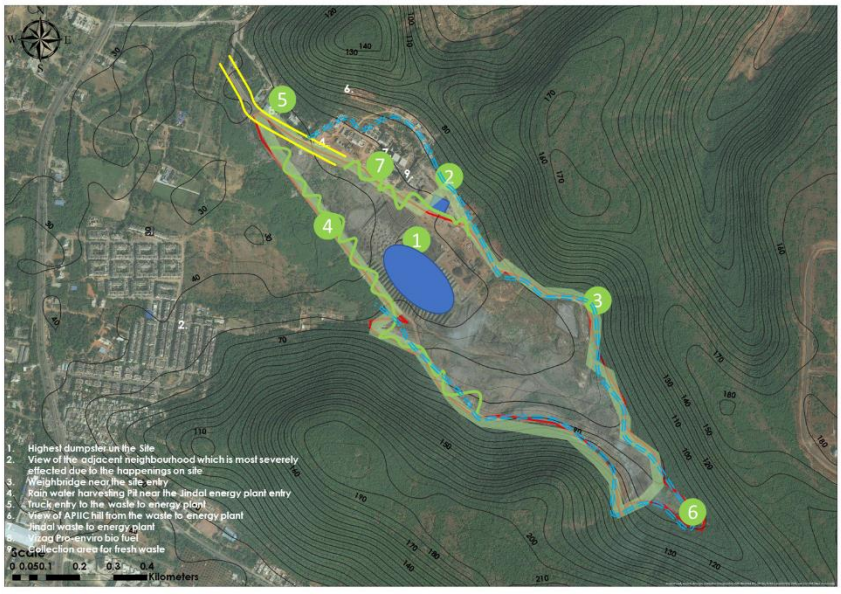
Construction level

Concept Legend:
1. Capped Sanitary landfill
2. Storehouse
3. Garland Drains to collect run off
4. Approach road for park Visitors
5. Truck access road



Vegetation layer

Vegetation Legend:
1. Sanitary landfill
2. Storehouse
3. Garland Drains to collect run off
4. Approach road for park Visitors
5. Truck access road



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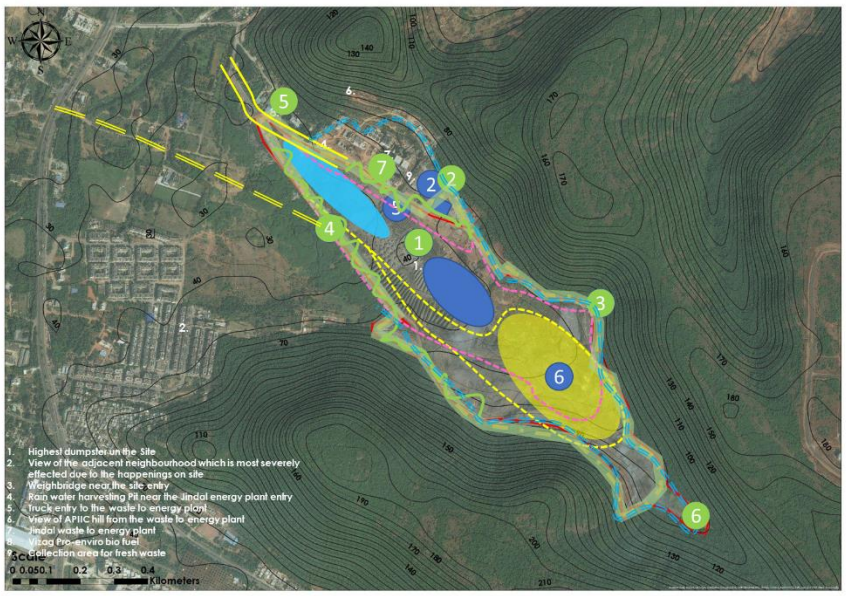
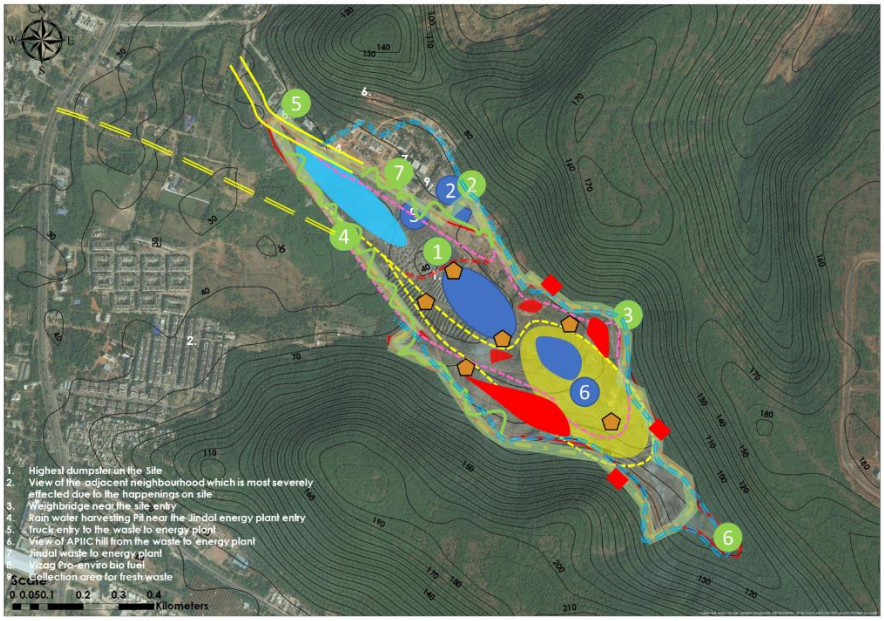
Vegetation + construction level

Conceptual Zoning-based on Function



Conceptual-level1

Conceptual Zoning-based on Function



LANDFILLED PORTION OF THE SITE AND LANDFILL PHASING:

Stage-1 (1-3 Years) Bioremediation of the entire site except the area to be landfilled

Phase-2 (1-5 Years)Landfilling of middle part of Valley from low level to high level

Phase-3 (5-10 years) and 4 (10-15 years) Landfilling of one side of valley to allow the other side to be accessible for recreation purposes.

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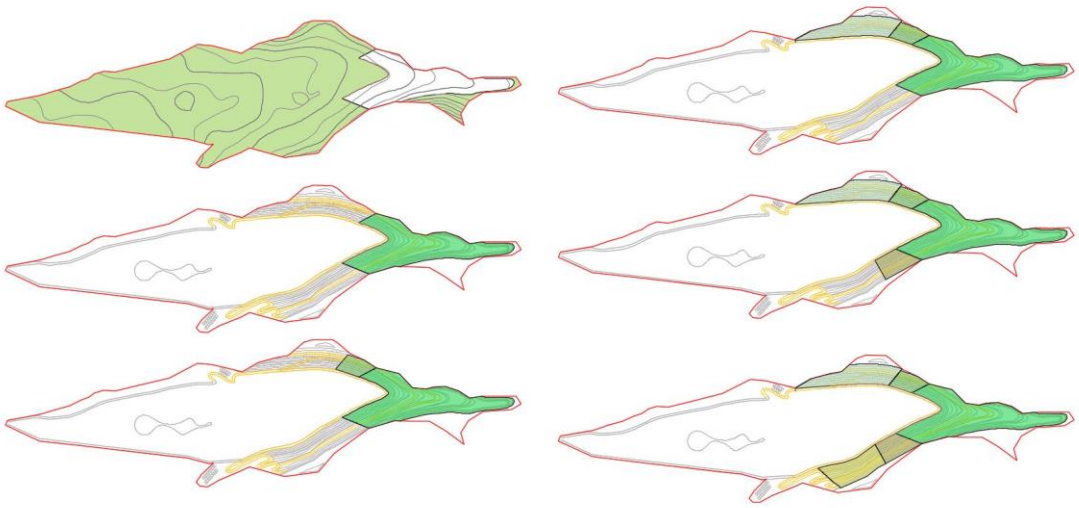
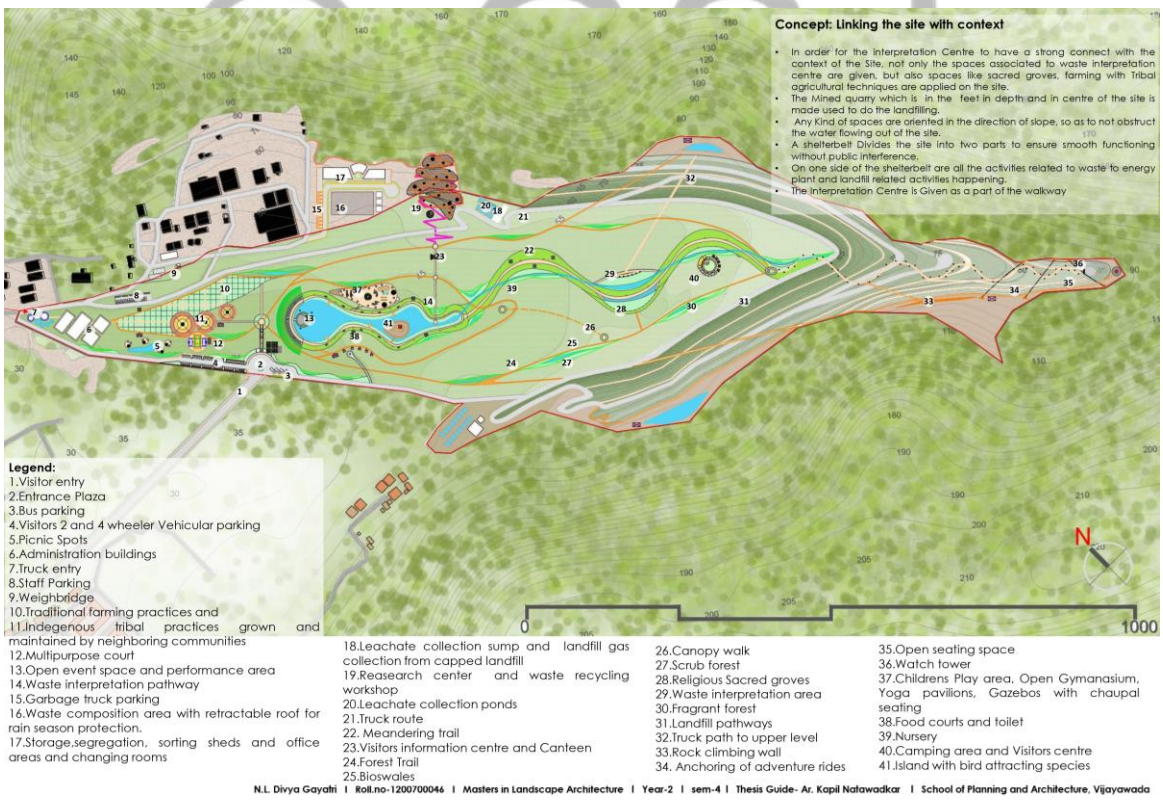
Phase-5 and 6 Landfilling of the other side of valley with the capped landfill being accessible for recreation purposes.



5 Years Masterplan



Conclusion:

Landscaping Of Municipal Sanitary Landfills – Comprehensive Study On Policies, Regulations, Issues And Impacts in Indian context- Site study and Design Interventions in Visakhapatnam City, Andhra Pradesh.

Proper policies and guidelines on decentralization, waste segregation, recycling waste and source reduction will help reduce stress on landfills and increasing waste land demands. Composting technologies, waste -to-energy plants , Vermiculture, along with effective maintenance can greatly reduce the quantity of waste generated in our country.

Landfills if systematically implemented in microscale can also help save a lot of energy and help in getting community benefits at no cost.

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