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INDORE'S BIOREMEDIATION OF LEGACY WASTE: TRANSFORMING THE URBAN WASTE MOUNTAINS

CASE STUDY- INDORE

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Abstract:
The goal of creating sustainable cities may be threatened by the numerous difficulties presented by waste management in urban environments. To create long-term, cost-effective, non-hazardous waste management plans, it is necessary to evaluate the current waste management procedures in our communities and look into new options. The 2016 Solid Waste Management Rules gave Indian Urban Local Bodies (ULBs) the mandate to examine and analyze existing dumpsites to determine whether they have the potential for bio mining and bioremediation. In addition to giving a brief overview of the steps taken by the Indore Municipal Corporation (IMC) to successfully implement the bio-remediation process, this paper briefly discusses the difficulties caused by improperly handled municipal solid waste.

Keywords: **Municipal Solid Waste Management; Bioremediation; Legacy Waste; Indore.**

A PROBLEM WITH URBAN WASTE: AN INTRODUCTION

Cities have always been intricate systems of consumption and production. This feature of the metropolis brings exponential population expansion, rising earnings, and consequently higher consumption, which in turn fuels greater garbage production. According to the World Bank's "What A Waste 2.0: A Global Snapshot of Global Solid Waste Management to 2050" report from 2018, waste creation would rise from 2.01 billion tons in 2016 to 3.40 billion tons in 2050. According to a 2014 Planning Commission report, urban India produces 62 million tons of MSW annually. Additionally, it was expected that by 2030, the volume would rise to 165 million tons. Concerns over overflowing landfills in Indian cities were highlighted in the 2016 report Not In My Backyard: Solid Waste Management in Indian Cities by The Centre for Science and Environment (CSE). It advised treating waste as a resource and avoiding using valuable and rare land for waste disposal. Urban Local Bodies (ULBs) in India have been trying to rethink waste management in recent years, partly as a result of the Swach Bharat programme, which was launched in 2014. The goal of the second phase, which was initiated in September 2021, was to eliminate rubbish from cities by effective source segregation, 100% door-to-door pickup, and thorough waste remediation.

The issues related to urban solid waste in India are highlighted in this research, which also describes the precise planning, strenuous efforts, coordination, collaboration, and cooperation required for the successful implementation of the bioremediation process.

Globally, especially in developing nations, proper management of urban solid waste has proven to be a significant burden for ULBs and citizens. However, in most places, it simply consists of four activities, namely waste generation, collection, transportation, and disposal. MSW Management System covers actions related to the generation, storage, collection, transfer and transport, processing, and disposal of solid wastes (Bundela, GAUTAM, et al. 2010). Poor waste management can negatively or positively impact many facets of a city and its residents, leaving ULBs with a wide range of unforeseen difficulties to deal with, including environmental, societal, health, and spatial challenges.

Challenges Associated With Space

Land is a limited and expensive resource in Indian cities, however landfilling is a popular strategy used by many ULBs to manage urban waste. In India, landfills are used to dispose of the majority of the country's solid waste in and around urban areas that are low-lying (Kumar, Gaikwad et al. 2004). In India, between 70 and 90 percent of landfills are open dumps (Jha, Sharma, et al. 2008). Rubbish has

been dumped to heights ranging from 300 feet in Bhalswa, Delhi, to 78 feet in Kolkata in landfills that have accumulated waste for almost two or three decades in Indian megacities including Delhi, Bangalore, Chennai, Kolkata, and Mumbai (S. Goswami & S. Baswak, 2021).Landfills are an unappealing sight that can harm the city's aesthetics and cover the area with an intolerable odour. By using landfill reclamation, ULBs can avoid paying a high price for new land and recover reclamation costs through sales or usage of recycled materials (USEPA, 1997)

Challenges in Managing legacy waste

1. The presence of heavy metals
2. There is not enough data available on legacy waste in India.
3. One policy is not feasible.
4. India do not have enough capacity to process these landfills. At present, India only has 1604 solid waste treatment plants. These plants are not enough to treat the present landfills.
5. Unable to follow the CPCB guidelines

Wellness and Good Health

Health risks from improper waste management can affect both people who handle the waste and those who live close to dumping grounds or Waste Management Plants. Constant landfill exposure puts people at risk for a number of health problems, including musculoskeletal illnesses, respiratory problems, mental health problems, and impaired lung function. As a result of flies feeding on the trash, constant contact with it can potentially expose workers to skin conditions, infections, depression, and intestinal issues (Garrido, Bittner, et al. 2015). Furthermore, there is a chance that leachate from these waste disposal sites will contaminate the water supply, draw disease-carrying rodents, and release odours if they are close to populated areas.

The improper management of trash and sewage in Surat in 1994 was one of the causes of the pneumonic plague. Up to 1200 persons were impacted by the plague, which also claimed 63 deaths. Cities with zero landfills will advance the development of both sustainable cities and healthy cities.

Environmental Challenges

Poor waste management can have an impact on the land, the air, and the groundwater. Due to organic waste's ability to produce Green House Gases like carbon dioxide and methane, it may even have an impact on climate change. The hazardous and harmful materials present in municipal solid trash can permeate the soil, lowering its quality and having an impact on the ground water, if the waste is dumped directly onto the surface of the land without a barrier or protective layer. It can change the chemical, physical, and physico-chemical characteristics of soil. Additionally, this would weaken the soil's overall structure, making it less suitable as a building material (Pillai, Peter, et al. 2014).

Waste burning, whether planned or accidental, can be hazardous to the environment. Black carbon, a short-lived climatic pollutant that contributes to climate change, is produced by open burning of waste and is a deadly carcinogen that produces dioxins, furans, and other carcinogens. Methane, a powerful greenhouse gas that is produced by the organic component found primarily in residential waste, causes global warming (Mor, Suman, et al. 2006). This methane can also ignite landfill fires, which sometimes burn for days on end. The worrisome frequency of these dump fires is shown by data from the Delhi Fire Services (DFS), which shows that in 2018, the Bhalswa site had 69 significant fire occurrences, Okhla had 35, and Ghazipur had 27. (The Times of India, 2019).

Societal problems (Caste and Class)

People from the lowest strata of society are involved in every step of the waste management process, from collecting rubbish at each person's doorstep to transporting, sorting, or recycling it.

These people include the underprivileged, those at the bottom of the caste system, women, the elderly, and occasionally even young children. They frequently endure unhealthy working conditions, lack social security or health insurance, have limited possibilities for education and training, and are subject to severe social stigma (Kaza, Yao, et al. 2018). This task is "reserved" for the underprivileged and lower caste, and they are caught in this cycle because the kin of these employees also take over this job once they retire or pass away.

MUNICIPAL WASTE MANAGEMENT IN INDIA

To develop a cost-effective and efficient waste management strategy that would not only address the current issues but also anticipate and prevent future crises, it is essential to determine the quantity, quality, and characteristics of waste. The most waste was produced in 2015–16 in Mumbai (11,000TPD), Delhi (8,000TPD), Chennai (5,000TPD), Bangalore (3700TPD), Kolkata (4000TPD), Hyderabad (4000TPD), and Ahmedabad (2500TPD), according to data from the Central Pollution Control Board on the generation of solid waste in 46 major cities. However, because trash segregation is not a common practice, there is a chronic shortage of information regarding the composition of waste in India. According to the High Powered Expert Committee's report from 2011 titled "Indian Urban Infrastructure and Services," neither households nor municipalities separate biodegradable garbage from other waste because of lax implementation of the Municipal Solid Waste (Management and Handling) Rules, 2000.

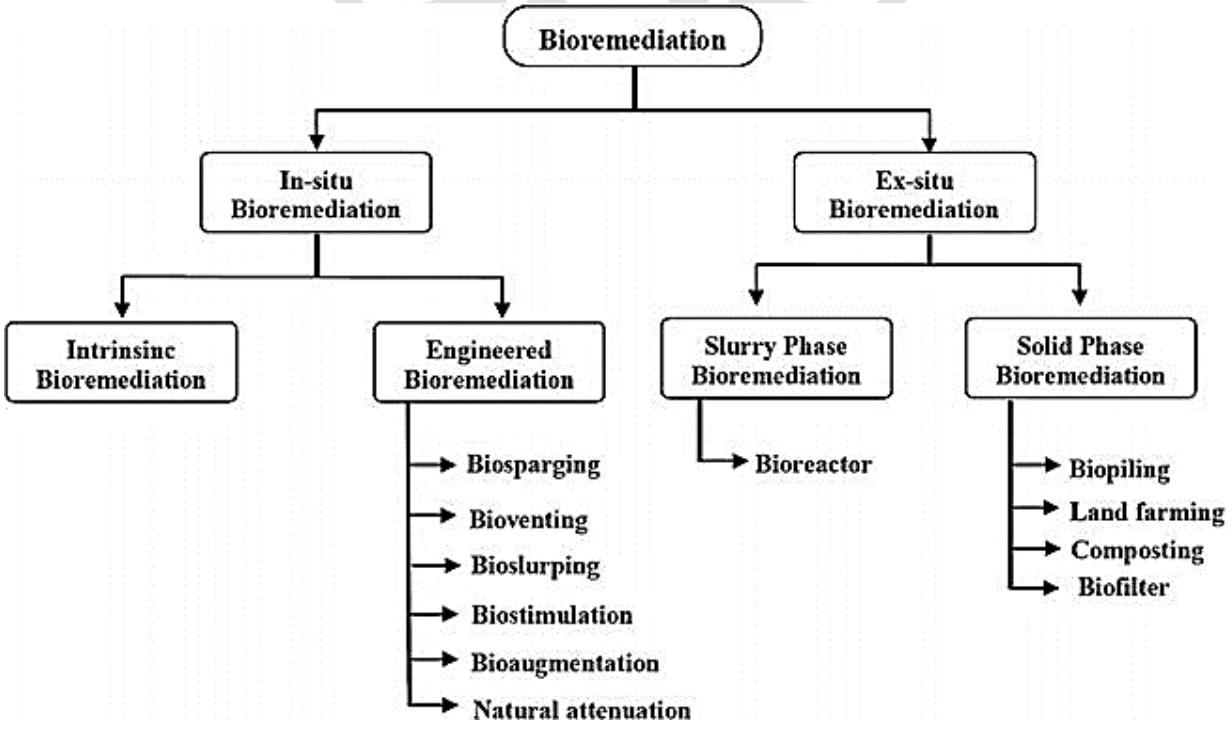
Municipal Solid Waste (MSW) is described in these regulations as "commercial and residential wastes generated in a municipal or notified regions, either in solid or semi-solid form, excluding industrial hazardous wastes but including treated bio-medical wastes." The Resident Welfare and Market Associations, gated communities, institutions, and Special Economic Zones (SEZ) were given

responsibility under the Solid Waste Management Rules, 2016, which expanded its jurisdiction beyond municipal areas and emphasized the need for source segregation of waste by the generators. Food trash, plastic, rags, metal, glass, and minor amounts of hazardous waste, such as electric bulbs, batteries, automotive parts, wasted pharmaceuticals, and chemicals, are thought to be the main constituents of MSW. Around 3159 dumpsites have popped up in India throughout the years due to negligence and lax rules (Centre for Science and Environment, 2020). According to the World Bank's "What a Waste 2.0" study from 2018, only 5% of the waste produced in India is recycled and 77% is dumped in landfills. Swach Survekshan, a competitive monitoring framework for advancing Swachhata results in Urban India, which the Indian government conducts annually to evaluate and rank urban regions on their cleanliness, hygienic conditions, and sanitation, nevertheless, demonstrates developments in MSWM in India.

500 Indian cities were included in the Swach Survekshan 2017 survey, which found that 297 of them used door-to-door waste collection, 407 of them found that 75% of their residential areas were essentially clean, and 85 of them maintained waste segregation at all stages of waste processing in more than 75% of the wards. The research, which has subsequently expanded tremendously, had 4320 cities involved by 2021. The paper claims that 1161 ULBs have improved their trash collection methods, and 762 cities have built bulk rule/act waste producers to process garbage locally. These findings highlight the positive changes in MSWM and reveal that ULBs all across the nation are moving in the right way. These numbers demonstrate the constructive transformations that have occurred in MSWM and demonstrate that the Swachh Bharat Abhiyan's objectives are being steadily attained by ULBs all around the country. Additionally, contemporary and original methods have also been seen in Indian cities. The best municipal solid waste management (MSWM) practices in 28 Indian cities across 15 states were documented by NITI Ayog for its 2021 report titled "Waste-Wise Cities - Best practices in municipal solid waste management" in order to highlight the cost-effective and environmentally friendly strategies used by several ULBs to manage their MSW. In 10 MSWM thematic zones, the cities were located. Panaji was able to accomplish 99% source segregation by the division of garbage into 16 fractions, the collection of that waste on scheduled days, and ongoing information, education, and communication (IEC).By creating 20 km of roads out of non-recyclable plastic from its Dry Waste Collection Centers and encouraging the use of eco-bricks in homes and schools, Jamshedpur has emerged as a leader in material recovery. In order to achieve 100% door-to-door collection and eliminate garbage-vulnerable locations from the city, Bruhat Bengaluru Mahanagar Palika used information, communication, and technology (ICT) tools like an RFID-based attendance system, geo-tagging of collection routes, and the smartphone app Ezetap.

BIOREMEDIATION PROCESS

Simply said, bioremediation involves using live microorganisms to break down pollutants. This approach encourages the growth of certain bacteria that break down pollutants into innocuous gases like carbon dioxide and ethane or tiny quantities of water. Since then, it has been used to remove contaminants from water bodies, groundwater, soil, etc. and restore them to their original pristine form. It was first widely utilized in 1972 to clean up a Sun Oil pipeline leak in Ambler, Pennsylvania. The proper selection criteria and performance criteria are necessary for the bioremediation process to be successful. When selecting a bioremediation method, many selection factors are taken into account, including the kind of pollutant, the amount of the contamination, the type of environment, the location, the cost, and regional environmental legislation (Frutos et al. 2012; Smith et al. 2015). Bioremediation procedures can be categorized as ex situ or in situ depending on the place of application. Treatment of the polluted material takes place on the same location thanks to in situ technology. The in situ technologies of bioventing, biosparging, and phytoremediation may require improvement or they may not (intrinsic bioremediation or natural attenuation).



Ex-situ approach calls for moving the contaminated material physically to another location for treatment in a regulated setting. Ex-situ is the more expensive of the two due to the expense of digging and transporting the material, and it also carries some danger from inappropriate management. In contrast to in situ approach, it is chosen since it is quicker, simpler to manage, and appropriate for a range of pollutants. The correct circumstances, such as soil structure, moisture content, pH level, oxygen content, temperature, and microbial diversity, are essential for bioremediation to be successful (Vidali, 2001). In the presence of favorable circumstances and toxins, the bacteria can thrive, proliferate, and consume additional contaminants; otherwise, they perish (EPA, There are certain restrictions on bioremediation. For example, only a few number of fungus or bacteria may affect the organic substance, therefore it might be quite challenging to destroy a significant amount of chemicals. Additionally, it is a highly drawn-out procedure that takes time to manifest results. Nevertheless, it has several advantages, making it a sensible choice that ULBs may take to lower the amount of trash in their various jurisdictions. It is a natural process that does not endanger the environment or the health and safety of people who live nearby.

Indore: City Profile

The most prominent city of Madhya Pradesh, situated on the western part of the Malwa on the banks of the two rivers, the Khan and the Saraswati. Indore is a dominant commercial center and host multi-level market for maximum goods and services. Most of the regions surrounding the city are administered by the Indore Development Authority (IDA). It consist of 15 zones and 69 wards.

Population 2011 = 1,960,631.
Area = 130.17 sq.km.
The literacy rate was 82%, and the sex ratio was 924. The majority of people in Indore speak Marathi as their first language. English, Hindi, Gujarati, and Sindhi are also spoken in the city.
One of the busiest cities in M.P., Indore serves as a significant hub for commercial activity and is also home to established agro-industries, cutting-edge corporations, and IT firms. It also offers a large number of management and engineering colleges to meet the supply of the expanding demand for professionals. The traditional sectors of steel, IT & autos, and textiles are all well represented in the marketplaces of Indore, which makes it the commercial hub of M.P. In addition to its culture, customs, and economics, Indore has gained a reputation for cleanliness during the past five years. The Ministry of Housing and Urban Development's annual Swachh Survekshan Survey was done in 2016 and In terms of performance, Urban Affairs placed Indore 25th, which was below average. This was mostly because of the way the Indore Municipal Corporation handled the collection and transportation of MSW (Fig. 1), which resulted in garbage vulnerable points (GVPs) and secondary storage bins all across the city being filled with trash. But things began to change in 2017, as Indore managed to maintain the top spot in the Swachh Survekshan for five years in a row. Ground confirmation, trash handling, new approaches, financial stability, recovering solid waste administration costs, etc. were among the aspects taken into account for the ranking. (R. Singh 2021)

The Waste Scenario pre-2015

Prior to being the cleanest city in India, waste management in Indore was similar to that of other Indian cities. Unsorted rubbish was deposited in open areas of the city and at the Devguradia trenching site. The city also has a lot of garbage vulnerable points (GVPs), which drew stray animals, birds, and rats. Jagirdaars (traditional garbage collectors) and private companies handled most of the trash management; they provided poor service quality and discarded rubbish either in open areas or in dustbins scattered across the city. The

Madhya Pradesh Pollution Control Board recommended expanding the capacity of garbage collection and disposal in a report it filed to the Madhya Pradesh High Court in November 2013.

The study also mentioned that the Devguradia trenching site's illicit garbage burning was polluting the area. Additionally, it claimed that just 250 metric tons (or around 29%) of the 875 metric tons of garbage handled each day at the Devguradia trenching facility (DNA, 2013). The Indore Municipal Corporation (IMC) was ordered by the Madhya Pradesh High Court on October 27, 2015, to provide a thorough, time-bound plan to address its waste management challenges by November 6, 2015. By December 2015, the IMC had sprang into action by starting door-to-door rubbish collection in wards 42 and 71 and implementing awareness campaigns to promote waste segregation into biodegradable and non-biodegradable waste at residences. Following 2016, IMC was successful in remediating 15 MT of legacy trash that had been dumped over a 60-year period in the Devguradia trenching site within three years thanks to its effective planning, exacting implementation, and meticulous monitoring approach. The IMC was able to reclaim almost 40 acres of land thanks to this profitable endeavor, which was later transformed into a green belt. It also enabled the city achieve the distinction of being a garbage-free, landfill-free city.

The Implementation Plan

ULBs were under intense pressure to take the necessary steps to solve the sanitation issue in their various jurisdictions with the introduction of the Swachh Bharat Mission in 2014. Three simultaneous phases made up the IMC's implementation plan:

1) Door-to-door trash collection;
2) The removal of GVPs, landfills, and open dumpsites; and
3) The bioremediation of legacy waste. These actions were planned not just to deal with the current problems but also to prevent potential problems in the future.

1) Door-to-Door Collection

Door-to-door garbage collection is one of the crucial elements to achieving a landfill-free status since it avoids improper waste disposal and makes it easier to determine the volume and quality of waste produced. Door-to-door rubbish collection was therefore implemented in Indore to collect residential waste, with bulk collection systems covering semi-bulk and bulk waste sources. To determine the amount of garbage produced in each ward, an identification survey was carried out. In response, a thorough route plan for waste collection from every ward and personnel deployment was developed. In December 2015, the pilot initiative that was implemented in 2 wards got underway. By the end of 2016, all 85 wards were included in the programme. Domestic hazardous garbage, dry waste, and wet waste were the three forms of waste that were once separated at the source and collected from homes in partitioned vehicles. At the moment, garbage is divided into six fractions at the source: wet, plastic, non-plastic (dry), sanitary waste, home hazardous waste, and e-waste.

By 2016, IMC had made sure that MSW was regularly collected and transported to GTSs and processing facilities. The city has 10 GTSs with daily waste capacities of between 150 and 200 MT and a processing facility in Devguradia, which spans 146 acres and has a daily waste capacity of 254 MT. Around 685 trucks were used to bring rubbish from various sources to GTSs, where it is weighed using weighing bridges before being delivered to the processing plant. Rag pickers and scrap merchants were hired to collect the waste.

As of 2021, 650 3.2-cubic-meter cars for door-to-door rubbish collection and 100 5 cubic-meter vehicles for bulk waste, along with 1100 drivers and an additional 1100 assistants, have been deployed.

2) Initiatives to become a bin free city

Alongside the door-to-door activity, the IMC worked to close open landfills, GVPs, and secondary storage containers.

IMC performed a poll to determine their numbers, and the findings showed how poorly the city is managing its garbage. The city has 4753 back roads, 408 trash sites, and 1380 secondary storage bins. The door-to-door technique assisted in reducing improper rubbish disposal, resulting in the city being bin-free by December 2016. The city is free of GVPs and dumpsites, according to a survey conducted in 2017 by M/S Eco Pro Environmental Services to determine the status of these locations. However, the survey located 171 abandoned landfills. Later, these locations received renovation. The IMC has worked nonstop to keep an eye on them and stop them from reemerging. In order to keep a careful eye on the situation and uphold the city's position as a bin-free city, the IMC agreed to undertake a quarterly poll in 2020.

3) Bioremediation/ bio-mining of legacy waste

The 2016 Solid Trash Management Rules served as the foundation for the IMC's investigation into the viability of bio remediating legacy waste. It was decided to create a two-phase action plan. The first phase, which was implemented by M/s A to Z infrastructure from July to December 2016, was launched to test the waters; the second phase was started after having empirical evidence to support the previous phase's success. E-tech projects completed the second phase between 2017 and 2019. For the bioremediation process, there were eight steps:

1) Identification of an area
2) Conducting Surveys
3) Excavation or bio-mining process
4) Adding Bio-cultures
5) Raking leftover recyclables
6) Installation of machines for removal and segregation ofwaste
7) Removal of Inert and plastic waste
8) Addition of soil and Construction of Green Belt andplantation

CONCLUSION: INDORE'S BIOREMEDIATION PROCESS

Indore became a city without landfills because to the commendable efforts of the Indore Municipal Corporation. Indore was able to restore 40 acres of priceless land by using the bioremediation technique to remove over 15 lakh metric tonnes of garbage from the area in three years and turn it into a green belt. The project had also been carefully planned by the IMC. To decrease needless transit and make the cleaning process simpler and more affordable, the bioremediation unit, weighbridges, and MRF centres were all situated on the site. Additionally, this made sure that the steady flow of trucks into and out of the site would not interrupt living nearby. (The site's machinery's noise production may have been the sole drawback.) The workers' health and safety were also taken into account, and they had the necessary training and safety equipment.

One of the most effective municipal waste management techniques is without a doubt bioremediation. Instead of endangering neighboring residents or site workers, it makes use of harmless bacteria that can aid in boosting the fertility of the soil. It does, however, have certain drawbacks. Only locations with large levels of organic waste, or locations with both fresh and legacy garbage, may successfully implement the method. Legacy garbage that has been dumped carelessly in landfills for years and has already reached the point of maximal microbial degradation cannot be bio remediated and cannot always be recycled, therefore it has no economic value. Additionally, legacy waste management should be paired with an integrated waste management facility that has sufficient capacity for both the daily production of MSW and the legacy garbage that has been trapped in dumpsites. To make things simpler, the IMC in Indore first ensured door-to-door collection and source segregation of garbage.

Before beginning the bioremediation, they tackled the city's overflowing GVPs and secondary storage bins. Even after the bioremediation is finished, IMC continues to practice door-to-door garbage collection, six types of waste segregation, conducts quarterly surveys to stop the re-emergence of GVPs and secondary storage bins, and instils sound waste management habits in the populace. Together, the three phases helped this endeavor succeed. Before beginning the bioremediation, they tackled the city's overflowing GVPs and secondary storage bins. Even after the bioremediation is finished, IMC continues to practice door-to-door garbage collection, six types of waste segregation, conducts quarterly surveys to stop the re-emergence of GVPs and secondary storage bins, and instils sound waste management habits in the populace. Together, the three phases helped this endeavor succeed.

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