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Turning Trash to Treasure: Unlocking Revenue and Clean Air from Kolkata's Dhapa Dumpsite

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Abstract: Solid waste generation has become a pressing environmental issue in India, exacerbated by rapid urbanization, industrialization, and population growth. Kolkata, as one of India's most populous cities, faces significant challenges in managing its solid waste effectively. This paper explores the state of solid waste generation in Kolkata, focusing on the Dhapa dumpsite, and proposes solutions to generate revenue from waste management activities. Kolkata generates approximately 4,500 metric tonnes of solid waste daily, comprising various types such as organic, plastic, paper, glass, and electronic waste. The city's waste management infrastructure struggles to cope with the escalating volume and complexity of waste generated. Legacy waste, accumulated over decades at sites like Dhapa landfill, poses additional challenges, including environmental degradation and health risks. Discussions on the efforts to address legacy waste through biomining and bioremediation techniques have been discussed. Landfill gas (LFG) extraction and utilization as well as possible opportunities for converting waste into energy, is also discussed. The economic feasibility of waste management initiatives at Dhapa depends on factors such as technological innovation, political will, and revenue generation from recovered materials. Public-private partnerships and incentivizing private sector involvement can enhance efficiency and innovation in waste management. Finally, addressing the economic dimensions of waste management in Kolkata requires a holistic approach integrating technological innovation, policy reform, and stakeholder engagement. By aligning economic incentives with environmental objectives, Kolkata can create a sustainable and prosperous future where waste is treated as a valuable resource.

Keywords: Solid waste management, Legacy waste, Biomining, Landfill gases, Bio-CNG

1. Introduction

Solid waste generation has emerged as a significant environmental challenge in India, fuelled by rapid urbanization, industrialization, and population growth. With its vast population and diverse socio-economic landscape, India faces unique challenges in managing solid waste effectively. India, as one of the world's most populous countries, experiences immense pressure on its waste management systems. The country generates an estimated 62 million tonnes [1] of municipal solid waste annually, and this figure is projected to rise significantly in the coming years. Despite various policy initiatives and efforts at the national and local levels, challenges persist in waste collection, segregation, treatment, and disposal across urban and rural areas. Among its bustling cities, Kolkata, the capital of West Bengal, stands as a prominent example, grappling with the complex dynamics of waste generation and management [2-3]. In this paper, we delve into the state of solid waste generation in Kolkata with workable solutions that can generate revenue.

2. Waste Production in Kolkata

2.1 Current Waste Production

Kolkata, known for its rich cultural heritage and bustling streets, is home to a substantial population contributing to its solid waste generation. With over 14 million residents, Kolkata stands as one of India's most populous cities. However, along with its vibrant character, the city grapples with the burden of waste management. Recent studies shed light on Kolkata's waste generation trends. According to a report published by the Kolkata Municipal Corporation (KMC), the city generates approximately 4,500 metric tonnes of solid waste daily. This waste consists of various types, including organic, plastic, paper, glass, and electronic waste. The rapid urbanization and changing consumption patterns contribute to the escalating volume and complexity of waste generated in Kolkata.

Recent research and initiatives have aimed to address the challenges posed by solid waste in Kolkata. For instance, a study conducted by researchers at Jadavpur University examined the composition and characteristics of solid waste in different areas of the city. Their findings underscored the pressing need for enhanced waste segregation and recycling infrastructure to manage Kolkata's diverse waste streams effectively. Furthermore, the Kolkata Solid Waste Management Improvement Project, supported by the Asian Development Bank, focuses on improving waste collection, segregation, and disposal practices in the city. Through community engagement and infrastructure development, the project aims to mitigate the environmental and health impacts of solid waste in Kolkata [4].

Statistics on Daily Production of Various Types of Waste in Kolkata is as follows:

i. Organic Waste: Approximately 2,800 metric tonnes per day.
ii. Plastic Waste: Around 950 metric tonnes per day.

iii. Paper Waste: Roughly 450 metric tonnes per day.
iv. Glass Waste: Approximately 200 metric tonnes per day.
v. Electronic Waste: Estimated at 100 metric tonnes per day.

These statistics underscore the magnitude and diversity of solid waste generated in Kolkata, highlighting the urgent need for holistic waste management strategies tailored to the city's unique dynamics. This is about the current daily production of MSW. This is often termed as "Live" waste.

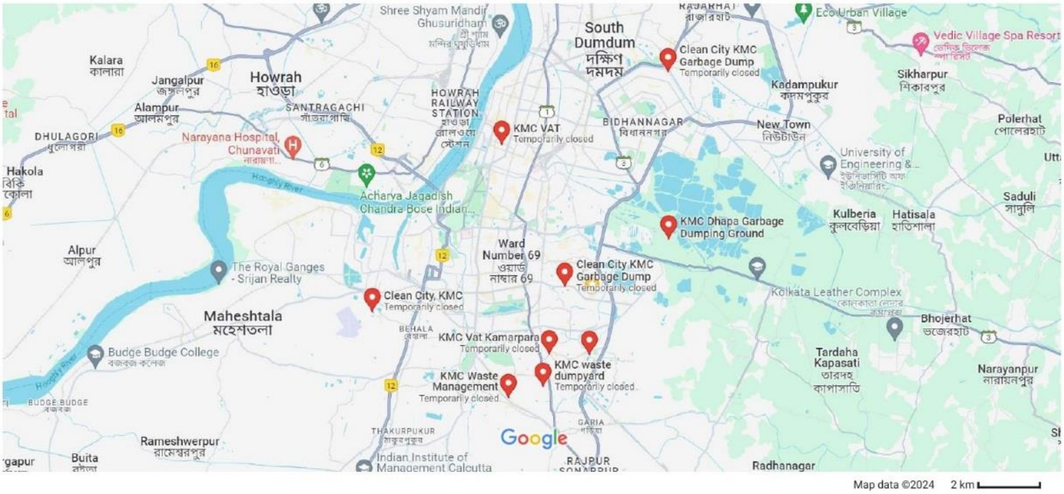

Figure 1. Red Flags depicting the Major dumpsites in Kolkata

2.2 Legacy Waste

Legacy waste refers to a blend of biodegradable waste that has undergone partial or complete decomposition, along with plastic waste, textiles, metals, glass, and other components, often dating back as far as 15 years and resulting in adverse environmental and health impacts. Legacy waste in Kolkata presents a formidable challenge, encapsulating decades of accumulated refuse that strains the city's environmental, social, and economic fabric. Beginning in the late 20th century, Kolkata's waste management infrastructure struggled to keep pace with the burgeoning urban population and rapid industrialization. As a result, significant quantities of solid waste found their way into open dumpsites, most notably the Dhapa landfill, which has served as the primary repository for Kolkata's refuse since the last four decades (Figure 1 and 2).

Here in Kolkata, this legacy waste comprises a complex mixture of organic matter, plastics, paper, glass, metals, and other materials, intermingled and compacted over time. The Dhapa landfill, sprawling over acres of land on the eastern fringes of the city, epitomizes the gravity of the situation, with towering mounds of refuse bearing witness to decades of neglect and mismanagement. The legacy waste crisis in Kolkata is multifaceted, with ramifications extending beyond immediate environmental concerns. Environmental degradation, groundwater contamination, air pollution, and the proliferation of disease vectors pose significant risks to public health and well-being. Moreover, the presence of legacy waste impedes urban development and land use planning, constraining the city's growth and exacerbating socio-economic disparities, particularly in nearby communities bearing the brunt of the landfill's impacts.

Efforts to address the legacy waste dilemma in Kolkata have been hindered by various challenges, including inadequate waste management infrastructure, limited resources, and institutional barriers. While incremental improvements have been made in waste collection and disposal practices, the sheer scale of the problem demands innovative and sustainable solutions. Recognizing the urgency of the situation, the Kolkata Municipal Corporation (KMC) has initiated measures to mitigate the impact of legacy waste, including the implementation of bio-mining techniques aimed at recovering valuable materials and reclaiming landlocked urban spaces within dumpsites.

However, the task ahead is daunting, requiring a concerted and coordinated effort from government authorities, community stakeholders, and environmental experts. Comprehensive waste management strategies, encompassing waste segregation, recycling, composting, and energy recovery, are essential for addressing Kolkata's legacy waste legacy comprehensively. Furthermore, public awareness campaigns and community engagement initiatives play a pivotal role in fostering a culture of waste reduction and responsible consumption practices.

Figure 2. The East and West mounds of Dhapa landfill area, Kolkata

3. Revenue from the Waste

3.1 Biomining

In an online discussion Manish Goyal, a leading environmental technologist explained Biomining in layman's terms as a process of converting old dump yard material into usable resources.

According to this resources, biomining typically involves the following steps:

i. Scientific treatment of old waste to remove any remaining organic matter.
ii. Application of cultures to control odours.
iii. Drying of the material.
iv. Sorting and classifying the material using various types of equipment.
v. Manufacturing new products using the recovered waste material.
vi. Leveling the reclaimed land.
vii. Planting trees to enhance environmental recovery.

Legacy waste usually consists of the following fractions, which can be repurposed [5]:

i. Soil (Humus): 35%
ii. Recyclables (glass, rubber, metals, etc.): 5%
iii. Synthetic Textiles: 4%
iv. Various grades of Plastics: 16%
v. Inerts of various sizes: 40%

Each fraction has potential for further utilization. For instance Humus, a fibrous material, can be used as manure for soil enrichment or in road construction. Recyclables like glass, rubber, and metals can be sold in recycling markets. Textiles can be used as fuel for furnaces due to their high calorific value. Plastics can be recycled or used in innovative products such as roof tiles, paving blocks, or in furnaces as refuse-derived fuels. Inerts can be utilized in making recycled bricks, paving blocks, manhole covers, road dividers, etc., representing a valuable resource. Given the decreasing availability of land, land recovery through Biomining is poised to become increasingly vital in the future. Engaging in this business requires determination and innovation, offering both the satisfaction of contributing to social welfare and the potential for economic returns.

From the work of Banerjee et al. [6] regarding the prospect of biomining of Kolkata Dhapa area we learn Kolkata alone generates around 4500 metric tonnes of waste per day, much of which has accumulated at the major landfill site in Dhapa since late eighties, constituting legacy waste [7]. Analysis indicates that up to 85-90% of this legacy waste could be recovered through Bio-mining. Material balance assessments delineate various components of Bio-mining, including combustible (5.23%) and non-combustible materials (29.97%), compostable (56.04%), recyclables (0.476%), and residuals (8.642%). Sample analysis of dumpsite materials reveals varying fractions, including non-combustible or construction and demolition (C&D) materials (25-30%), combustible or refuse-derived fuel (RDF) materials (10-15%), recyclables (1-2%), bio-earth (15-20%), coarser organic fraction (20-30%), process rejects (5-10%), and evaporated moisture (15-25%). Comparative analysis, utilizing probabilistic and site-specific primary data, supports the efficacy of this approach. Achieving a waste-to-soil ratio of 40:60, the methodology offers a circularity solution. Recovered legacy waste can undergo further processing for incineration/RDF/co-processing, construction materials, filling materials, paving blocks from waste plastics, composting, and landscaping. This strategy aims to extract valuable materials and recover energy resources, fostering environmental sustainability within a circular economy framework. This generic methodology holds promise for implementation in various landfill sites across India where Bio-mining has yet to be adopted.

In fact, legacy waste poses a formidable challenge in Kolkata, epitomizing the complex interplay between urbanization, environmental degradation, and public health. Addressing this challenge requires a multi-pronged approach, integrating technological innovation, policy reform, and community participation to create a more sustainable and resilient urban environment for future generations [8].

In a report by Snigdhendu Bhattacharya [9] published in Mongabay series on 26 June 2023 on the attempts taken by KMC, it clearly shows that the Dhapa landfill, Kolkata's primary municipal dumping ground, has been a source of frequent fires, exacerbating air quality issues in the city. To address this, biomining and bioremediation techniques, mandated by the National Green Tribunal (NGT), have been employed to clear legacy waste, enabling the extraction of usable materials from the accumulated refuse. Despite starting in 2019, as of February this year, only 0.78 million tonnes of the 4 million tonnes of legacy waste have been processed, with the COVID-19 pandemic impeding progress.

Landfills like Dhapa significantly contribute to global warming by producing methane, a potent greenhouse gas with over 21 times the warming potential of carbon dioxide. Furthermore, the fires facilitated by methane exacerbate air pollution, posing health risks to nearby residents. Efforts to clear the Dhapa landfill have been underway since 2019, with a target completion date of June 2024, as recommended by the NGT. However, progress has been slower than anticipated, with only 20% of the waste processed by February 2023 as per the records, current updates are yet to be obtained. The remaining 80% must be cleared within a year to meet the NGT deadline, raising concerns about the project's feasibility. The biomining project at Dhapa involves segregating six different types of components, including recyclables, combustible materials, and non-combustible waste. Sample analysis reveals the composition of these components, highlighting the complexity of waste management at the site. Recent attempts to reuse and recycle segregated waste materials are underway, with refuse-derived fuel (RDF) being sent to cement manufacturing industries and power plants, and recyclables transferred to authorized recyclers. However, logistical challenges, such as the distant location of suitable facilities, pose additional hurdles to efficient waste management practices. While efforts to clear legacy waste at Dhapa are underway, challenges persist in meeting the NGT deadline and ensuring sustainable waste management practices. Collaboration between government agencies, environmental experts, and the community is essential to address these challenges and mitigate the environmental and health impacts of legacy waste accumulation in Kolkata.

3.2 Landfill Gas: Another resource to Tap

Landfill gas (LFG) [10] is gas generated under anaerobic conditions within a landfill. Due to varying degradation stages and levels of air infiltration, the composition of LFG fluctuates over time and across locations. Additionally, the operation of gas extraction systems can inadvertently introduce air into the landfill, mingling with LFG. Acknowledging this complexity, the author has identified six distinct gas types. LFG comprises numerous organic and inorganic trace gases, some of which are highly toxic, particularly those containing chlorine, fluorine, sulphur, and silicon.

Landfill gas (LFG) represents a substantial energy source that should be harnessed whenever feasible from environmental, technical, and economic standpoints. Approximately 60–80 m^3 of LFG per tonne of wet municipal solid waste (MSW) can be utilized over a span of about 15–20 years. While LFG collection systems are commonly installed, the gas is primarily used for energy production; however, significant amounts are sometimes flared due to low electricity costs in certain countries, rendering investment in gas utilization plants economically unviable. In some cases, gas extraction and flaring are only feasible with financial backing from carbon credit programs, especially in economically developing countries where energy is both desperately needed and wasted [11].

Challenges may also arise from utility companies uninterested in incorporating electricity generated from LFG into their grid or the absence of nearby grids altogether. In such instances, on-site energy use, such as electricity generation or fuel substitution in existing engines, should be considered. Nonetheless, addressing these issues requires political intervention to establish the legal framework supporting LFG utilization.

Given the fluctuating gas production curve, adaptable gas utilization plant capacities are crucial to avoid excessive flaring. The utilization method varies depending on circumstances, with electricity production via gas engines being common in industrialized countries due to proximity to the public grid. Upgrading LFG to natural gas quality, though costly, may be viable for large-scale, long-term gas production. Heat production in boilers adapted to LFG's relatively low methane content is also a technical standard, with surplus heat from gas engine cooling systems occasionally utilized. While direct use in nearby power or industrial plants via gas pipelines is feasible in some cases, gas storage is costly. However, storing LFG for short periods in gas tanks may optimize electricity production during peak hours, particularly in regions with intermittent wind power generation. Prior to constructing a gas utilization plant, careful evaluation of technical, economic, and environmental factors is imperative, given LFG emissions' significant contribution to global warming. Keeping in mind the huge volume (more than 4 million Tonnes) of Legacy waste in the Dhapa site, it will be very profitable to setup a high capacity Bio-CNG plant. It will solve the fuel demand to a great extent. The capital cost of such a plant depending on the capacity can range from 15 crores INR for a 100 TPD plant to upward. In any case it is projected to be profitable from the very second year.

4. Conclusion

In conclusion, the economic aspect of waste management in Kolkata's dumpsites, particularly Dhapa, underscores the urgent need for innovative solutions that balance environmental sustainability with economic viability. The Dhapa landfill, serving as a poignant symbol of decades of neglect and mismanagement, presents a multifaceted challenge requiring concerted efforts from government authorities, private enterprises, and community stakeholders. Efforts to address the economic dimensions of waste management at Dhapa must prioritize the implementation of cost-effective technologies and strategies for waste collection, segregation, and processing. Biomining and bioremediation techniques offer promising avenues for reclaiming valuable resources from legacy waste while minimizing environmental impact. However, the economic feasibility of such initiatives hinges on factors such as right mindset, political willingness, technological soundness, operational ingenuity and revenue generation from recovered materials. Moreover, the integration of waste-to-energy technologies, such as landfill gas (LFG) extraction and utilization, can potentially transform waste into a valuable energy resource, contributing to both environmental sustainability and economic growth. However, challenges related to infrastructure development, technological advancement, and regulatory frameworks must be addressed to fully unlock the economic potential of waste-to-energy initiatives at Dhapa and other dumpsites in Kolkata. Furthermore, fostering public-private partnerships and incentivizing private sector involvement in waste management operations can enhance efficiency, innovation, and investment in the sector. By creating a conducive business environment and leveraging financial mechanisms such as carbon credits, governments can encourage private sector participation in waste management ventures while ensuring equitable distribution of benefits and addressing social and environmental concerns. Ultimately, the economic aspect of waste management in Kolkata's dumpsites necessitates a holistic approach that encompasses technological innovation, policy reform, and stakeholder engagement. By aligning economic incentives with environmental objectives, Kolkata can pave the way for a sustainable and prosperous future, where waste is viewed not as a burden but as a valuable resource to be managed responsibly for the benefit of present and future generations.

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