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REVIEW ARTICLE

LITERATURE REVIEW ON MUNICIPAL SOLID WASTE MANAGEMENT AND ITS RISING RISKS & MANAGEMENT SKILLS IN SPECIAL REFERENCE TO JAMSHEDPUR, JHARKHAND, INDIA

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Abstract

Municipal Solid Waste is a rising issue in developing countries. Tons of waste are produced in India and are currently being disposed of in landfills. They are not managed well from the view or thought of protecting the environment, nature, soil, water, or air. Municipal waste in landfills is releasing Methane which is one of the most prominent greenhouse gases that is responsible for the rise in global temperature. In Jamshedpur JUSCO, a branch of TATA STEEL is taking the initiative to manage this waste, turn it into Manure, and use it for growing plants around the city. Initiatives like Waste to Wealth are also in full motion to reduce the overall waste load in the city and manage it according to the guidelines.

Introduction:-

Municipal Solid Waste Management (MSWM) in India faces significant challenges due to rapid urbanization, population growth, and inadequate infrastructure. With increasing waste generation, there is an urgent need for effective management strategies to mitigate the environmental impacts associated with waste accumulation. This review synthesizes key findings from recent studies, providing insights into the current status of MSWM in Indian cities, existing regulations, processes in place, and future directions to lower waste accumulation.

Current Status of MSWM in India

The status of MSWM in India reveals a complex landscape characterized by inefficiencies and challenges. This highlights that the rapid increase in urban population has escalated waste generation, thereby complicating management efforts. [1] Their study emphasizes the necessity for a comprehensive understanding of waste characterization, collection methods, and treatment technologies to address the growing crisis in various Indian states and cities [2] provide a detailed overview of the existing MSWM practices, underscoring the lack of cohesive policies across different regions. Their analysis indicates that while some cities implement advanced waste management technologies, others lag due to inadequate infrastructure and investment.[3] Further, discusses the importance of integrating sustainable landfilling practices with existing technologies to improve waste disposal methods.

Governance Dynamics and Reforms

The governance dynamics of smart cities in India reveal the complexities of urban management and stress the importance of structural transformations within municipal governance to effectively tackle challenges like

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MSWM.[4] They critique the uncritical adoption of governance models from developed countries, suggesting that local contexts must be considered to improve MSWM practices.[5] Additionally, emphasizes the potential pitfalls of neoliberal urban transformations, which may undermine democratic governance processes and marginalize local governance structures. This critique aligns with the objectives of the 74th Amendment, which calls for inclusive governance that prioritizes the needs of all citizens. The challenges of landfilling as a waste disposal method further complicate the MSWM landscape highlighting the need for forecasting solid waste generation, which is crucial for effective waste management strategies.[6] The findings from this research can aid ULBs in planning and implementing more efficient waste management systems. Conversely, points out the inadequacies of existing waste management systems and advocates for reforms such as waste incineration, which also have their limitations.[7]

Article 38 urges the state to secure a social order for the promotion of the welfare of people. Article 47 imposes a duty on the state to improve the standard of living and public health. The constitution also imposes certain duties on citizens of the country and courts have expanded the understanding of certain provisions in keeping with changing times. In this connection, Article 21 of the constitution says 'No person shall be deprived of his life or personal liberty except according to procedure established by law' while Article 48A is 'The state shall endeavor to protect and improve the environment and to safeguard the forests and wildlife of the country'.[15]

Research highlights the multifaceted challenges faced in the current MSWM landscape in India, including ineffective waste collection systems, lack of segregation at the source, and inadequate recycling practices. The need for a comprehensive evaluation of MSWM parameters, including generation, characterization, collection, and treatment options, has been emphasized.[2][8]

The significance of public-private partnerships and the role of informal waste workers, such as rag-pickers, is also critical in the waste management process. Their involvement can improve the effectiveness of waste segregation and recycling efforts, which are essential components of the legal frameworks established under Article 48A.[1]

Furthermore, studies have identified the environmental impacts of open dumping and the necessity for integrated waste management schemes. The potential benefits of increasing recycling rates are paramount in promoting sustainable waste management, reinforcing the objectives of Article 48A.[9]

Regulations Governing MSWM

Regulatory frameworks play a crucial role in guiding MSWM practices in India. The Solid Waste Management Rules (2016) set forth by the Ministry of Environment, Forest and Climate Change provide a regulatory backdrop for waste management, mandating segregation at source, processing, and disposal.[9] However, the enforcement of these regulations remains inconsistent across different municipalities, contributing to the ongoing challenges in waste management[10] emphasizing the need for stringent enforcement of these regulations and suggesting that public-private partnerships could enhance resource mobilization and efficiency in waste management. The socio-economic aspects of waste management, as discussed by[1] indicate that engaging informal waste workers, such as rag-pickers, can be instrumental in improving waste segregation and recycling rates.

Assessment of Waste Management Processes

The assessment of various waste management processes indicates a pressing need for integrated approaches. Researchers[8] conducted a life cycle assessment of different waste management strategies, revealing that recycling and composting significantly mitigate the environmental impacts associated with landfilling. Their findings suggest that an integrated approach, combining multiple waste management strategies, could effectively lower waste accumulation. Researchers[11] explored the potential of microbial consortia for the degradation of plastic waste, underscoring the importance of innovative biological treatments in waste management. Additionally, Researchers[12] identified barriers to adopting Internet of Things (IoT) technologies in smart city waste management, which could enhance operational efficiency and real-time monitoring of waste collection and processing.

India's burgeoning urban population and accelerating economic development have precipitated a significant rise in the production of municipal solid waste, presenting formidable challenges for its efficient management. The inadequate and unscientific practices employed in the handling and disposal of this waste have led to severe environmental degradation and public health concerns [13]. To address this pressing issue, a multifaceted approach

encompassing improved source segregation, door-to-door collection, and scientific processing and disposal of waste is crucial.

Community Participation in MSWM Practices

Enhancing community participation is central to the long-term success of municipal solid waste management programs in India [14]. Positive public opinion and active involvement of citizens are crucial in transitioning from the current disposal-centric approaches to a more recovery-centric waste management system.[14] This requires a partnership between the government, private sector, and citizens, with civil society organizations and educational institutes playing a pivotal role in raising awareness and promoting sustainable waste management practices.

Source segregation involves separating waste at the point of generation into different categories, primarily dry waste (recyclables), wet waste (biodegradable), and hazardous waste. This practice not only facilitates recycling and composting but also significantly reduces the burden on landfills. In India, various initiatives have been taken to promote source segregation among households, including awareness campaigns and community engagement programs. Research indicates that effective public awareness and participation are crucial for the successful implementation of source segregation practices in urban areas.[16][17]

Door-to-door collection refers to the direct collection of segregated waste from households, ensuring that waste is collected promptly. This method has been implemented in several Indian cities and has shown positive results in improving waste collection efficiency and promoting community participation. Studies by the author emphasize the importance of door-to-door collection in maintaining hygienic conditions and reducing the littering of waste in public spaces.[18] Furthermore, the implementation of door-to-door collection systems requires adequate infrastructure and adequate training for waste collectors to ensure effective segregation at the source.

Organizational Participation in MSWM Practices

India's rapid population growth and industrialization have led to a significant increase in the generation of municipal solid waste. Proper management of this waste is critical, as improper handling and disposal can have severe consequences for public health and the environment, including the contamination of soil and water resources, the emission of greenhouse gases, and the spread of infectious diseases.[19]

India generates over 60 million tons of municipal solid waste (MSW) annually, with a significant portion ending up in poorly managed landfills due to inefficiencies in sorting, segregation, and disposal practices. Sorting and segregation are pivotal for effective waste management. Government initiatives like the Solid Waste Management Rules, 2016, mandate segregation at the source into biodegradable, recyclable, and hazardous waste. However, implementation remains inconsistent due to low public awareness and inadequate enforcement. IoT-enabled technologies, such as smart bins and RFID systems, are being integrated into urban systems to enhance segregation efficiency and data monitoring, providing promising solutions for scalable MSW management.[20]

According to various research studies, the current municipal solid waste management practices in India face numerous challenges. The organic fraction of municipal solid waste in India is particularly problematic, as it is often high in moisture content and low in calorific value, making it difficult to process and dispose of effectively.[21] The lack of well-developed systems for the separate collection of biodegradable waste, which is a crucial step in ensuring the efficient processing and disposal of different waste streams, further exacerbates this issue.[22]

In addition, the solid waste management system in India is often characterized by low collection coverage, irregular collection services, open dumping and burning without proper pollution control, and the prevalence of informal waste picking or scavenging activities.[23]

Landfill practice in MSWM

In India, landfill practices remain the predominant method for disposing of municipal solid waste (MSW), accounting for over 70% of waste management solutions. However, open dumping is still prevalent due to financial constraints and inadequate infrastructure, leading to significant environmental and health risks. Leachate generation, greenhouse gas emissions, and land consumption are critical challenges associated with unregulated landfills. Studies indicate that by 2030, India will require over 660 km² of land for waste disposal unless sustainable practices are implemented.[24]

Sanitary landfilling, characterized by engineered systems to contain leachate and manage landfill gas emissions, offers a feasible alternative to mitigate the adverse effects of traditional landfills. However, its adoption remains limited due to high initial costs and operational requirements.[25] Biomining, an emerging practice for rehabilitating open dumps, has shown promise in reclaiming land, recovering valuable resources, and reducing landfill gas emissions, particularly in megacities.[24]

Environmental studies of landfill sites, such as Ghazipur in Delhi, have revealed severe groundwater contamination due to leachate percolation, highlighting the urgent need for better landfill management and monitoring.[26] Effective strategies include improved segregation at source, enhanced waste processing technologies, and transitioning to a circular economy model to minimize waste reaching landfills. Institutional reforms, public awareness, and government support are pivotal in achieving sustainable landfill management.[27]

Landfill practices play a crucial role in municipal solid waste management (MSWM) in Jamshedpur, a prominent city in India. Effective landfill operations are essential for controlling waste disposal, minimizing environmental impact, and promoting public health. The landfill sites in Jamshedpur are designed to adhere to guidelines that encompass waste segregation, leachate management, and methane capture to minimize environmental hazards. According to a study the implementation of rigorous waste management policies and the promotion of community awareness have significantly improved landfill operations in the region [28]. Despite these advancements, challenges such as inadequate infrastructure and the need for more sustainable practices persist. Continuous monitoring and improvements of landfill practices remain vital for the city to achieve a more sustainable waste management system.[29] Ongoing research suggests that integrating modern technologies and community participation can further enhance the effectiveness of landfill management in Jamshedpur.[30]

Waste-to-Wealth: the return of waste to money.
The waste-to-wealth approach transforms waste into usable resources, fostering economic, environmental, and social benefits. Below, notable examples from across India and Jamshedpur highlight innovations and achievements.

1. National Achievements in Waste-to-Wealth
Several Indian cities have implemented successful waste-to-wealth initiatives:
Pune's SWaCH Initiative:
Pune's cooperative model integrates waste pickers into the formal waste management system. This initiative empowers women, promotes segregation at source, and emphasizes recycling. The collaboration between the municipality, NGOs, and waste-pickers enhances efficiency and social inclusion.[31]

Delhi's Waste-to-Energy (WTE) Plants: WTE technologies in Delhi convert solid waste into energy, addressing landfill issues while generating electricity. However, challenges remain in emissions control and inclusivity of informal sectors.[32]

2. Jamshedpur's Achievements
Jamshedpur exemplifies a model of sustainable MSWM:
Recycling and Composting:
The city utilizes composting techniques for biodegradable waste, converting it into agricultural fertilizers. These practices reduce landfill dependency while benefiting local agriculture.[33]

Zero Waste Management Practices:
An innovative "Zero Waste" strategy focuses on segregation at source, with support from the local municipal corporation. This approach integrates informal workers for efficient waste collection and recycling.[34]

Waste Characterization Studies:
Research on the physico-chemical properties of waste informs better recycling and waste-to-energy decisions.[33]

3. Sustainable Agricultural Integration
Jamshedpur also excels in using compost from municipal waste to improve soil quality and agricultural output. Such integration of MSWM and agriculture reflects a circular economy model.[33]

4. Policy and Technological Innovations

Technology-Driven Waste Management:

IoT-enabled solutions in waste bins, as seen in Shimla, offer inspiration for cities like Jamshedpur to optimize waste collection routes and minimize environmental impact.[35]

Policy-Driven Success:

National policies like the Swachh Bharat Mission complement local efforts to reduce landfill waste, improve recycling, and support waste-to-energy initiatives.[36]

Future Directions for MSWM

Despite existing frameworks and strategies, significant knowledge gaps persist regarding the long-term sustainability of waste management practices in India. The research indicates a need for further studies focused on decentralized waste processing units that can adapt to local conditions and community needs.[3] There is also a pressing need for empirical research on the effectiveness of public-private partnerships in enhancing waste management efficiency.

India's overreliance on landfilling as the primary means of waste disposal is unsustainable and environmentally damaging. To reduce the burden on landfills, a multifaceted approach is necessary. Separate collection of the biodegradable fraction of municipal solid waste can enable its utilization for green energy generation, reducing the quantity destined for landfills, conserving natural resources, and mitigating greenhouse gas emissions.[22]

Furthermore, the integration of advanced technologies, such as IoT and artificial intelligence, into waste management systems holds promise for improving operational efficiency.[12] Future research should explore the socio-economic impacts of these technologies on waste management practices and the role of community engagement in promoting sustainable waste practices.

Innovative solutions like using mobile applications for waste collection scheduling and tracking have emerged, making it easier for residents to comply with segregation practices and for municipalities to monitor collection efficiency.[37] Local governments are crucial in facilitating these practices by providing the necessary resources, training, and support to both residents and waste management personnel.

Conclusion:-

In conclusion, the literature reveals significant challenges and opportunities in Municipal Solid Waste Management in Indian cities. While existing regulations provide a framework for management practices, inconsistencies in enforcement and implementation hinder progress. The integration of sustainable practices, innovative technologies, and community engagement are essential for developing effective waste management strategies. Future research should focus on bridging the knowledge gaps identified in this review, particularly regarding decentralized approaches and the socio-economic implications of emerging technologies in waste management.

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