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Solid Waste Management in India: A Review of Current Practices, Technological Advancements, and Future Directions

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***Abstract* - Solid waste management has become a problem for the environment and health in India. Fast city growth more people, more factories changing ways of living and trash have all pushed this issue. This review looks at what's happening now the ways people try to handle trash the problems they face and fresh ideas to make solid waste management sustainable in cities across India. The studies cover how trash is made and sorted how it is picked up and moved, how people separate junk at the source, recycling, composting, making biogas turning waste into energy, how landfills work, building debris how rules are applied and new technology. The papers say that not enough separation, not places to treat trash, lack of money, weak organizations, uneven monitoring, people not aware and weak rule enforcement keep solid waste management from working well. At the time treating trash locally getting useful resources back recycling using waste to make energy watching progress digitally and having people join in give hopeful chances. The review shows how crucial it is to put in place systems that work together fit local needs, use technology and let people help so that solid waste management in India can be good for the environment good for money and good, for society**

Keywords - Solid Waste Management; Municipal Solid Waste; Source Segregation; Waste-to-Energy; Recycling; Resource Recovery; Sustainable Waste Management; Decentralized Waste Management.

I. INTRODUCTION

Solid waste management (SWM) has become one of the most serious environmental issues in India today due to rapid urbanization, population growth, industrialization, economic development, and shifts in lifestyle. As a result, there has been a continuous rise in the amount and complexity of municipal solid waste (MSW) with severe strains on existing waste-management systems. Literature reviewed for this study indicates that the growing trend of waste production in India has not been accompanied by improved collection, segregation, treatment, recycling, and disposal mechanisms. In Indian cities, source segregation, collection, treatment and composting, monitoring, finances, and institutional authority are critical constraints to effective MSW management. Similarly, improper disposal and unscientific landfill practices add to the challenges of waste management, while the absence of appropriate landfill sites further overwhelms municipal waste-management systems. Several studies reviewed highlight inadequate waste-characterization data and inconsistencies as impediments to understanding waste-generation patterns that could help design appropriate management approaches.

The studies reviewed concur that appropriate policy formulation and regulation for effective SWM require capacity building, institutional coordination, and effective local governance. The rules developed under the Solid Waste Management Rules, 2016 further obligate states to promote source segregation, specify the roles and responsibilities of various stakeholders, and emphasize treatment and resource recovery, waste-to-energy, user-fee structures, and scientific landfilling of MSW. Nonetheless, the reviewed articles report a dearth of enforcement and follow-up measures at various levels as well as gaps in coordination, which hinder progress toward improved SWM practices. Municipal authorities need to be capacitated to ensure that SWM regulations and rules are enforced effectively.

The reviewed articles present source segregation and resource recovery, including composting, biogas production, recycling, and recovery of refuse-derived fuel, as integral to effective SWM. Concurrently, decentralized SWM systems can relieve pressure on urban centers by reducing transport costs and promoting localized recycling and composting while promoting the recycling potential of diverse streams of waste. In contrast, the establishment of centralized treatment plants and the use of advanced waste-processing technologies such as gasification and pyrolysis present economic, environmental, and technical challenges that must be evaluated carefully. Municipal authorities considering the adoption of innovative technologies for SWM should conduct comprehensive cost-benefit analyses while taking into account such factors as operational costs and environmental impact.

Waste-to-energy technologies can play a significant role in sustainable SWM through the production of electricity and heat while minimizing the volume of MSW that requires disposal. Information and communication technologies can also be used in a variety of ways, including improving collection practices, promoting recycling and composting, monitoring landfill gas emissions, and detecting unauthorized landfill sites. One of the studies reviewed discusses an innovative AI-based multi-path convolutional neural network for identifying illegal dumpsites and suggests that digital technologies will become increasingly important in smart city SWM systems in the future.

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Although improved technology can contribute to sustainable SWM, it cannot replace the importance of engaging communities and promoting stakeholder partnerships. Municipal authorities need to invest more in sensitizing the public about the importance of segregation, proper disposal, and promoting recycling and composting initiatives at the community level. Furthermore, informal waste pickers must be integrated into the formal waste-management system by improving their working conditions, providing training, and enhancing their safety and general welfare. This process requires sensitizing various stakeholders, including local government authorities, about the roles and rights of informal waste pickers as well as providing them with appropriate tools and personal protection equipment.

The reviewed studies report a growing challenge of construction and demolition waste (C&D waste) in India due to rapid infrastructural development and growing construction activities. The studies highlight the need for promoting waste minimization, use of recycled construction materials, and developing formal sources of recovery and recycling of C&D waste while encouraging its characterization, source segregation, and establishing standards and regulations for processing and reusing C&D waste. Similar to MSW, effective management of C&D waste requires data collection on its generation and characteristics, as well as enhanced institutional coordination and enforcement of policies and regulations.

This review of the literature focuses on the current state of solid waste management and the main emerging trends and technologies critical to sustainable SWM in India. Effective SWM requires a coordinated approach that promotes source segregation, efficient collection, recycling, composting, and recovery of resources such as energy. Concurrently, proper methods for landfilling, monitoring, and enforcing SWM regulations while ensuring sufficient funding and community participation are essential for sustainable SWM. This review aims to promote a better understanding of the current status of solid waste management in India while investigating the implications of emerging trends and technologies and potential approaches to promoting sustainable solid waste management.

II. REVIEW OF LITERATURE

A. *Solid Waste Management Situation in India: Issues and Views.*

The author focuses on expanding trash creation linked to urbanization, population expansion, and rising disposable income, the study looks at the current state and difficulties of solid waste management in India. In order to determine the root causes of inefficient waste management techniques, it examines secondary data from several Indian states. Municipal solid waste management, waste mismanagement, trash diversion, processing, and the need for behavioral change are the main topics of the study. Its main conclusion is that current waste-management techniques need to be implemented effectively at the local level, and that enhancing trash processing and diverting garbage from landfills should receive more attention. Its wide state-level viewpoint is one of its main advantages, although direct evaluation of implementation on the ground is limited by its reliance on secondary data.

The study comes to the conclusion that stronger implementation, technology investment, skilled labor, and decentralized management systems are necessary to improve solid waste management in India. While other states are urged to implement better technology and training procedures, Maharashtra is recognized as having relatively advanced garbage collection and generation management. The authors stress that the application of the updated 2016 waste-management recommendations at the local level is crucial to their efficacy. The participation of the unorganized sector, decentralized collection and segregation, and standardization of waste management procedures are emphasized as crucial actions. Additionally, the study highlights the need of individual behavioral interventions and emphasizes uncontrolled open dumping as a persistent problem. Overall, the conclusion successfully links community involvement with policy execution, however the research mostly offers suggestions rather than assessing their viability.

B. *Evaluating municipal solid waste: A route toward waste-to-energy in smart cities in India.*

The author highlights the potential of waste-to-energy (WTE) technology as a different approach to MSW management in smart cities in India. Using secondary data from particular cities and an Integrated Solid Waste Management (ISWM) framework, it evaluates the current waste-management infrastructure, including collection, segregation, transportation, and processing. The study looks at the viability of implementing WTE systems and identifies variations in waste-management performance among cities. Its conclusions show that efficient WTE implementation is hampered by insufficient segregation, inconsistent data, a lack of funding, inadequate monitoring, and administrative limitations. The study also highlights the significance of stakeholder involvement, technology integration, and proper waste processing. The paper's comparative evaluation of many Indian cities is one of its strongest points; however, the accuracy of the evaluation is impacted by the availability and consistency of secondary data.

The study comes to the conclusion that inadequacies in trash collection and segregation, monitoring, financial resources, and administrative planning continue to hinder the integration of waste-to-energy pathways into Indian municipal solid waste management. Through efficient governance, public involvement, and ICT-based technologies like vehicle monitoring and real-time data management, Indore exhibits rather excellent waste segregation. On the other hand, Pune and Surat struggle with processing, resource usage, public participation, and skilled labor, while places like Ranchi, Srinagar, and Varanasi have issues relating to legislation, funding, and awareness. The authors suggest bolstering source segregation, incorporating the unorganized garbage sector, enhancing ICT infrastructure, promoting public involvement, and fostering multi-stakeholder cooperation. The necessity for sorting and the diverse composition of MSW in India are also noted in the study as significant obstacles to the adoption of WTE.

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C. An overview of waste generation and management in India's rapidly growing cities

The author analyses growing municipal solid waste (MSW) and industrial hazardous waste (IHW) management challenges in India's rapidly expanding cities. The research evaluates IHW generation and waste-management circumstances, especially in Mumbai, and looks at per-capita MSW generation patterns in the 10 most populous Indian cities. The study finds a steady rise in per-capita MSW output using secondary waste-generation statistics together with population projection and estimating techniques. While Chennai, Kolkata, and Mumbai reached OECD-level per-capita generation, Surat and Delhi showed very high total growth. The study also finds a general correlation between trash production and higher living levels. The longitudinal comparison of waste patterns is its main strength; nevertheless, measurement reliability is impacted by limits in the availability and quality of municipal data. The authors place a strong emphasis on source isolation, PAYT systems, cleaner technologies, and scientific disposal.

The result shows that garbage production has significantly expanded in tandem with urbanization and economic growth in India's 10 major cities. The per-capita MSW generation levels in Chennai, Kolkata, and Mumbai were 1.01, 0.84, and 0.82 kg/capita/day, respectively; the rise in Surat and Delhi was especially concerning. The paper also emphasizes Mumbai's growing IHW challenges and the ongoing imbalance between waste creation and available treatment capacity, which leads to untreated disposal. The Solid Waste Management Rules, 2016 are regarded by the authors as a suitable foundation for policy, but they emphasize that successful implementation is still a significant obstacle. They suggest pay-as-you-throw (PAYT) systems to promote trash reduction and decoupling after "generators as segregators" for source-wise waste separation. Future studies should look at incentives, municipal capacity building, behavioral hurdles, and the viability of PAYT for various businesses.

D. Waste management in India using "WASTE TO ENERGY" projects.

The paper examines India's increasing municipal solid waste (MSW) problem and evaluates waste-to-energy (WTE) initiatives as an alternative to conventional waste-management practices. It discusses methods including combustion, incineration, gasification, pyrolysis, and plasma technology while reviewing the state of waste creation, financial and environmental effects, and current management strategies. The study draws attention to the increasing amount of MSW and the drawbacks of conventional techniques, namely their environmental effects, lengthy treatment times, and land needs. Because of its high-temperature operation, significant waste-volume reduction, possible energy recovery, and capacity to handle heterogeneous waste, plasma-based WTE is offered as a viable substitute. Although the evaluation is mostly review-based rather than backed by thorough experimental validation, the paper's strength is its extensive technological comparison and concentration on Indian settings.

Due to India's fast population expansion, shifting lifestyles, growing waste volumes, land limits, and environmental effects, traditional MSW treatment techniques are becoming more and more insufficient. Plasma gasification and plasma pyrolysis have been highlighted as potential advanced solutions for waste-to-energy technologies, which provide opportunities to recover energy and lessen reliance on landfilling. Plasma technique produces vitrified material with possible uses in construction, produces syngas for energy recovery, and significantly decreases waste volume. The authors do, however, recognize significant obstacles, such as high installation costs, low public awareness, a modest level of community preparedness, safety concerns, a lack of process understanding, and inadequate standards and regulations. Plasma plants at the community level are recommended to lower transportation needs and increase viability. The study concludes that although plasma-based WTE is theoretically promising, widespread application will require more public acceptability, legislative development, and commercial feasibility.

E. India's Solid Waste Management Scenario and Deep Learning-Based Illegal Dump Detection: A Comprehensive Approach to Sustainable Waste Management

The Author examines India's municipal solid waste (MSW) management scenario by combining statistical analysis of waste-generation patterns with an artificial intelligence-based approach for illegal dump detection. It cites shortcomings include ineffective collection efficiency, a lack of real-time monitoring, a lack of citizen online platforms, and insufficient illegal-dump monitoring. It also identifies fast urbanization and population increase as important factors driving growing trash creation. Using a self-constructed dataset and poorly supervised learning based on trash and non-waste picture classifications, the authors create a multipath convolutional neural network (MP-CNN) to combat unlawful dumping. 97.82% precision, 98.86% recall, 98.34% F1-score, 98.33% accuracy, and 98.63% AUROC are all attained by the model. Although the lack of a benchmark dataset limits quantitative localization assessment, the abstract successfully links SWM problems with AI-based solutions.

The conclusion shows that India's waste generation has significantly increased in tandem with urbanization and population growth, and that the country's current SWM services suffer from poor monitoring, ineffective collection, inappropriate bin locations, a lack of online platforms, and inadequate illegal-dump detection. With 98.33% classification accuracy, high precision, recall, F1-score, and AUROC, the suggested MP-CNN offers a promising technical approach. Its multipath design uses numerous receptive fields and feature concatenation to handle changes in dump size, shape, and contextual information. The authors do, however, recognize a significant drawback: traditional quantitative assessment of localization performance is not possible due to the lack of a publicly accessible benchmark dataset. Rather, an average localization score of 3.884/5 was obtained through a manual survey-based evaluation. In the end, the paper proposes two

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theoretical future uses of MP-CNN for smart-city and sustainable development in underdeveloped nations.

F. An Analysis of Pune, Visakhapatnam, and Tirupati in the Context of Solid Waste Management in Indian Cities

The author focuses on the implementation of the Solid Waste Management Rules, 2016, Smart City Mission, and Swachh Bharat Abhiyan, the research looks at the advancements, shortcomings, and practical aspects of municipal solid waste management (SWM) in Pune, Visakhapatnam, and Tirupati. To evaluate real circumstances, the authors combine a primary survey of 322 residents with an examination of SWM procedures and reported service-level data. The results show advancements in material recovery, scientific disposal, decentralized wet-waste treatment, and waste segregation. Important technologies include bio methanation in Tirupati, compressed biogas in Pune, and waste-to-energy in Visakhapatnam. Although the abstract's focus on three comparatively high-performing cities restricts the findings' wider applicability to other Indian towns, it successfully illustrates both managerial and technology advancements.

The study finds that public participation combined with data-driven monitoring using Service-Level Benchmarks and Service-Level Progress indicators has significantly improved SWM in all three cities. Compressed biogas, source segregation, waste recovery, centralized treatment, decentralized composting, waste-to-energy, and dumpsite rehabilitation have all improved waste management systems and eased the strain on disposal facilities. Nonetheless, the authors stress that user fees must be increased in accordance with the polluter-pays concept and that the systems are still financially reliant. Developing markets for recovered goods and maintaining capital-intensive treatment facilities continue to be significant obstacles. The report also emphasizes the necessity of more robust industry integration into recycling and reuse as well as dependable collection. To enhance SWM procedures, future studies should look at developing technology such waste converters and shredders as well as best practices in other cities.

G. A Synopsis of India's Solid Waste Management Scenario and a Comparison of Related Laws

The author provides overview of solid waste management (SWM) scenario in India and comparatively examines the Municipal Solid Wastes (Management and Handling) Rules, 2000 and the Solid Waste Management Rules (SWMR), 2016. It draws attention to the growing solid waste issue brought on by fast urbanization, industry, population expansion, and shifting lifestyles, highlighting the consequences for the environment and human health. The study assesses the significant modifications brought about by SWMR 2016 by reviewing previous studies, governmental regulations, and legal frameworks. Source segregation, waste generators' obligations, composting and bio methanation, waste-to-energy, RDF use, user fees, hygienic landfills, and pollution-control criteria are among the important elements included. Although the analysis is mostly legislative and overview-based rather than backed by field-based performance evaluation, the comparison methodology clearly illustrates the 2016 Rules' wider breadth.

The study comes to the conclusion that while current methods have not advanced proportionately, India's solid waste management problems have gotten worse due to growing urbanization, industrialization, economic expansion, and population increase. The 2000 Rules were superseded by the Solid Waste Management Rules, 2016, which greatly expanded their scope and filled up a number of key gaps with stricter obligations for waste producers, source segregation, treatment, waste-to-energy, and regulatory measures. However, the authors point out that two significant drawbacks are inadequately severe sanctions and insufficient enforcement. Additionally, they contend that an overemphasis on centralized administration leads to system breakdowns and landfill saturation. Therefore, a complete structure that combines decentralized waste disposal, stringent monitoring and sanctions, community involvement, and efficient source segregation is recommended in the article. To ensure long-term efficacy, future SWM planning must strike a balance between environmental and economical sustainability.

H. ENVIRONMENTAL ETHICS: DELHI NCR'S STATUS OF AWARENESS RELATING TO NOIDA'S MUNICIPAL SOLID WASTE DISPOSAL

The author focuses at municipal solid waste (MSW) disposal procedures and awareness in the Delhi NCR, with a special emphasis on Noida. It draws attention to the mounting problems with waste management brought on by fast urbanization, poor infrastructure, poor source segregation, low public awareness, and lax regulatory enforcement. Two survey-based evaluations including MSW employees, garbage pickers, and stakeholders engaged in waste management procedures are included in the study. Inadequate protective gear, health hazards, poor salaries, inadequate training, irregular collection, and minimal source segregation are among the issues raised by the study. The integrated approaches of recycling, composting, decentralized management, enhanced infrastructure, technology development, and community involvement are highlighted in the article. Its incorporation of stakeholder and worker perspectives is a major feature; yet, the comparatively small survey samples restrict the wider generalizability of the

Delhi NCR's municipal solid waste management is confronted with major operational, social, and infrastructure obstacles. The results of the survey specifically point out that MSW workers and garbage pickers have lengthy work hours, below-minimum earnings, insufficient safety precautions, restricted access to healthcare, and poor training. Despite the fact that many respondents had access to collection equipment, the evaluation of waste-management techniques also shows deficiencies in source segregation and community involvement. Fair salaries, social protection, skill development, safety precautions, better collecting infrastructure, and more public awareness are all stressed by the writers. It is also advised to strengthen public-private partnerships, recycling, segregation, regulatory enforcement, and sustainable practices. Its comprehensive approach to environmental sustainability, worker welfare, and community involvement is its primary strength. Its conclusions, however,

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are based on small survey groups, indicating the need for larger, more representative

I. India's Solid Waste Management: A Cutting Edge Analysis

The author provides a cutting-edge analysis of solid waste management (SWM) in India, emphasizing its current status, key issues, and possible fixes. It links population increase, urbanization, rising living standards, and shifting lifestyles to the growing amount and shifting makeup of solid waste. Waste creation, characterization, collection, segregation, treatment, recycling, disposal, greenhouse gas emissions, and waste-to-energy technologies are all taken into account in this assessment. It draws attention to the growing percentage of garbage that is inorganic as well as the negative effects incorrect disposal and lax regulatory execution have on the environment and public health. Integrated management, source segregation, recycling, resource recovery, public-private partnerships, and location-specific solutions are further highlighted in the report. Although the evaluation is mostly literature-based and does not offer fresh experimental or field-based validation of the suggested solutions, its extensive, criteria-based literature coverage is a significant strength.

The study comes to the conclusion that quick advancements in planning, monitoring, teaching, training, law, regulatory systems, and public awareness are necessary for efficient solid waste management in emerging nations. Inadequate infrastructure, ineffective treatment and disposal, weak organizational structures, budgetary constraints, and inadequate segregation are among the ongoing issues identified by the report. It places a strong emphasis on integrated solid waste management, low-cost and site-specific methods, waste-to-energy, recycling and material recovery, landfill-gas usage, and scientific monitoring. The authors specifically emphasize the necessity of lowering greenhouse gas emissions from waste processing and disposal and enhancing waste-management infrastructure in quickly expanding metropolitan regions. In order to achieve sustainable waste management, the conclusion also highlights the importance of increased public awareness and coordinated international initiatives. Future studies on energy recovery, landfill gas usage, infrastructure development, and greenhouse gas reduction are advised.

J. Urban India's integrated solid waste management: A brief overview

The author represents a state-of-the-art review of solid waste management (SWM) in India, focusing on the current scenario, waste-generation trends, waste characteristics, management practices, and major challenges. Population expansion, shifting lifestyles, increased per capita income, urbanization, and industrial development are the main causes of the growing amount and variety of solid garbage. Waste creation, collection, segregation, classification, storage, transportation, treatment, recycling, disposal, effects on the environment and human health, greenhouse gas emissions, and waste-to-energy methods are all taken into account. The detrimental impacts of inappropriate disposal on the air, land, water, and public health are further highlighted. The paper's extensive discussion of SWM problems and possible fixes is one of its main advantages. Nonetheless, the assessment highlights that insufficient infrastructure and policy implementation continue to be major obstacles to efficient and sustainable waste management in India.

The paper finds that solid waste management in developing nations calls for prompt upgrades in data handling, training, education, planning, monitoring, legislation, regulation, public outreach, and everyday site maintenance. Major hurdles include weak institutions, funding shortages, poor infrastructure, unsafe disposal habits, and low public awareness. The review points to integrated models built around waste separation, recycling, resource recovery, waste-to-energy, GIS-assisted route planning, life-cycle assessment, and cleaner treatment options like composting. Future studies should prioritize the lack of proper waste facilities in rapidly expanding cities, energy capture from waste and landfill gas, and lower greenhouse gas emissions from waste handling and disposal. Overall, the conclusion makes clear that solutions need to be coordinated and adapted to local contexts, but their success largely depends on institutional strength, community participation, and more rigorous enforcement.

K. New Advancements in India's Urban Solid Waste Management: Current Situation, Challenges, and Opportunities

The author provides a comprehensive overview of municipal solid waste management (MSWM) in urban India, relating growing waste-management demands to fast population development, urbanization, shifting consumption habits, and cultural diversity. It describes the negative effects of improper disposal, collection, management, and treatment on the environment, public health, and the economy. With a focus on recycling, waste-to-energy, composting, and the creation of sustainable cities, the paper looks at present circumstances, significant challenges, and potential future developments. Its comprehensive presentation of MSWM as a governance and infrastructure concern rather than just a disposal issue is its main strength. However, the description limits the transparency and analytical depth of the paper's synthesis by describing it mainly as a thorough overview and failing to provide a systematic review technique or explicit criteria for assessing the technologies covered.

The conclusion makes the case that India's solid waste problem is made worse by the country's high population density, poor infrastructure, poor source segregation, small institutional capacity, and the social shame associated with garbage labor. It places a strong emphasis on waste separation at the source, processing wet waste through composting or biogas production, and directing dry trash toward recycling, reuse, refuse-derived fuel, or energy recovery. While centralized treatment, gasification, and pyrolysis require rigorous evaluation of environmental implications, costs, land, equipment, and monitoring requirements before wider application, decentralized solutions are shown to be especially promising. The importance of integrating informal garbage workers with governmental, private, and community organizations is also acknowledged in the report. Though they are still mostly strategic rather than empirically supported, its

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proposals are realistically applicable. Therefore, integrated governance, public involvement, technological adaptability, and more robust implementation mechanisms are necessary for future growth.

L. Managing Waste from Construction and Demolition in India

The author highlights India's fast urbanization, industrialization, infrastructure development, and growing construction activity, this looks at the management of construction and demolition (C&D) waste. For builders, contractors, local governments, and the entire nation, material waste is identified as a financial and environmental burden. The study examines the state of construction and demolition (C&D) waste in India and around the world, takes into account the origins and composition of trash, and assesses the sustainable waste-management hierarchy based on reduction, reuse, recycling, and limited landfilling. The lack of accurate estimates, a specific legal framework, and efficient enforcement in India are all highlighted in the discussion. The paper's strength is its ability to link institutional flaws with technical management techniques. Nevertheless, the abstract gives scant information about the interview sample, analytical process, and empirical validation of its suggestions, and its summary is mostly descriptive.

The C&D waste management is a growing concern that highlights the need for accurate data on trash generation, composition, and characteristics. It suggests formal collection mechanisms, source separation, educating the unorganized sector in sorting, reuse, and reprocessing, as well as the creation of products like tiles from crushed garbage. The study also suggests fees for waste producers, formal standards, eco-friendly usage technology, enhanced public information access, and more robust legislative and regulatory processes. These suggestions suitably address the main issues raised in the article, including the lack of a clear regulatory framework and inadequate institutional coordination. However, the conclusion is still policy-focused and does not determine the relative viability or efficacy of certain technologies. Therefore, systematic data creation, enforced standards, stakeholder participation, and workable implementation methods will determine its future course.

M. Indian municipal solid waste management: current state, issues, and difficulties

In the face of fast urbanization, population increase, industrialization, and economic expansion, the abstract examines the state of municipal solid waste management (MSWM) in India. It highlights the preponderance of biodegradable materials, fluctuating per-capita generation, and growing waste volume as key issues. Waste creation and composition, collection, recycling, treatment, disposal, current management obstacles, and pertinent policy viewpoints are all examined in this article. Recycling, sanitary landfilling, incineration, source segregation, involvement from the unorganized sector, and financial tools like user fees are all taken into account. Its extensive integration of institutional, technical, environmental, and socioeconomic aspects, backed by data at the national and local levels, is a major contribution. However, the evaluation focuses significantly on secondary information, and variations in reported trash quantities and insufficient state-level data restrict the precision of its judgment.

India's MSWM dilemma is explained in the conclusion as a result of the country's fast urbanization, population expansion, insufficient public sector capacity, and ongoing reliance on unofficial systems. Public awareness, household-level collection, source segregation, better recycling professionalism, market expansion, and more precise operational requirements are all suggested. The authors also support more scientifically regulated disposal methods, better landfill design with leachate and methane management, and collaboration with manufacturers to minimize packaging. The 2016 regulations offer a significant foundation for policy, but their execution is still hampered by a lack of land, inadequate infrastructure, unreliable data, and inconsistent waste characteristics. While acknowledging that landfill-based disposal poses environmental dangers, the conclusion rightly emphasizes stakeholder coordination, research, and technology development. Therefore, updated surveys, statistically sound waste characterization, appropriate regionally adapted technology, and more robust MSWM regulation implementation are necessary for future progress.

N. A study of current solid waste management trends, obstacles, and prospects for Indian cities in the future

The author presents a set of facts related to the current situation with waste management in Indian cities. It thoroughly covers the main aspects of MSW management, including waste occurrence, collection, treatment, recycling, and disposal. The focus is on the peculiarities of segregation at the source and the technical and technological capabilities in terms of appropriate treatment of various waste fractions in India. Main options for composting and biogas production from organic waste, recycling, and RDF production, as well as other forms of waste utilization are reviewed. The article highlights the issues of centralized and decentralized MSW management and the role of private and informal sectors in this process. The primary strength of this work is that it provides a general view on MSW in India with considerations of different factors affecting management and treatment processes. However, it does not go beyond the presentation of the available knowledge; thus, it lacks experimental findings.

The conclusion points to the inadequate source segregation, lack of assessment of the quantum and quality of waste, inadequate infrastructure, policy implementation and public awareness as the key challenges to sustainable MSWM in India. The authors highlight successful municipal cases of decentralized composting and biogas production and suggest source separation of wet and dry waste to aid composting, biogas, recycling, RDF, and energy from waste systems. The study also emphasizes that Indian waste differs from that in developed countries and that local specificities should be taken into account when adopting approaches used abroad. Gasification and pyrolysis are seen as promising innovative solutions, but their introduction requires an economic and environmental assessment. Networking of informal waste pickers with government and private entities is also presented as an important strategy. Notably, the conclusion promotes the

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coordinated system of centralized and decentralized management as a way to achieve sustainable MSWM in India.

O. Urbanization and solid waste management in India: Current methods and potential problems

The presented paper addresses the issue of the rapid urbanization of Indian society and the associated challenges of municipal solid waste (MSW). In that regard, the paper focuses on the current state and future prospects of MSW management practices and problems in India. Indeed, the paper highlights the fact that urbanization and the associated changes in the ecological and social environments pose serious challenges to MSW management in India. The paper assesses the current practices of MSW collection, transportation, disposal, and treatment and identifies the issues caused by inadequate funding, institutional and infrastructural limitations, inadequate technologies, and the lack of community participation. Moreover, the article discusses the negative environmental and health consequences of improper and non-scientific waste management. The key strength of this paper is that it integrates the issues of urbanization, MSW generation, management, and related challenges. However, the main limitation of the article is that it relies on secondary data and the analysis of the existing case studies and does not provide any empirical research.

The conclusion points to the need for increased engagement from government and civic authorities, better legislation, and public participation to improve solid waste management. The paper reveals public apathy and low social status of waste-management activities as major problems and advocates for strict regulations for waste disposal and treatment. The authors recommend that new housing developments and businesses should be designed in a way that they can accommodate waste disposal and treatment from the start. The authors highlight the potential of the private sector in solid waste management through such resources as expertise, technology, capital, and efficiency. They also stress the importance of community participation in effective waste management. Overall, the conclusion appropriately addresses institutional responsibility, private-sector participation, and public participation. Its recommendations are realistic but require significant financial, technical, planning, and institutional capabilities that the paper revealed earlier.

III. CONCLUSION

The analysis of these studies shows that India's municipal solid waste management issues have grown due to the country's fast urbanization, population expansion, industrialization, economic growth, and shifting lifestyles. Inadequate source segregation, inadequate infrastructure, insufficient funding, weak institutional capacity, unreliable waste data, low public awareness, and inefficient regulatory execution are some of the main issues. Source segregation, recycling, composting, bio methanation, resource recovery, waste-to-energy, and scientific landfill management are examples of integrated techniques that should replace traditional collection and landfill disposal, according to the analysed studies. Additional ways to increase efficiency include decentralized treatment, digital monitoring, GIS-based planning, and new technologies like gasification, pyrolysis, and artificial intelligence. However, local waste characteristics, environmental effects, economic viability, and infrastructure availability should all be taken into account when choosing a technique. Stronger enforcement, community involvement, stakeholder cooperation, and the inclusion of informal trash workers are all crucial to the successful implementation of the Solid trash Management Rules, 2016. In general, coordinated institutional, technological, social, and economic strategies that are appropriate for the local environment are needed for sustainable waste management.

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