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ENVIRONMENTAL ETHICS: STATUS OF AWARENESS TOWARDS MUNICIPAL SOLID WASTE DISPOSAL IN DELHI NCR FOCUSSING NOIDA

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ABSTRACT: Municipal solid waste (MSW) disposal is a pressing concern in the densely populated Delhi National Capital Region (NCR), where rapid urbanization has compounded waste management challenges. Understanding current disposal practices and their associated issues is crucial for developing effective waste management strategies.

Delhi NCR generates an estimated 10,000 to 12,000 metric tons of MSW daily, comprising various types such as organic waste, plastic, paper, glass, and metal. Several challenges hinder efficient MSW disposal, including inadequate infrastructure, poor waste segregation practices, limited public awareness, and weak enforcement of regulations. Consequently, a large portion of waste ends up in landfills, causing environmental pollution and health hazards.

Addressing these challenges necessitates a multi-faceted approach. This includes investing in waste management infrastructure, promoting waste segregation at the source, implementing recycling and composting initiatives, and raising public awareness about proper waste disposal. Collaboration among government agencies, private sector stakeholders, civil society organizations, and the community is essential for creating sustainable waste management solutions in Delhi NCR. By adopting integrated approaches and fostering a culture of environmental responsibility, Delhi NCR can aspire to a cleaner, healthier, and more sustainable future for its residents.

The findings from two survey-based studies provide further insights into MSW management practices in the region. The first study, involving 40 MSW workers and waste pickers, revealed that 25% of respondents faced challenges related to inadequate infrastructure, insufficient protective gear, and health risks. Many highlighted the need for better training and awareness programs to improve waste management efficiency and worker safety.

The second study surveyed 60 stakeholders, revealing that 45% were concerned about the lack of comprehensive waste segregation at the source, which hampers recycling efforts and exacerbates environmental pollution. Respondents emphasized the importance of community engagement, technological advancements, and policy reforms to promote sustainable waste management practices.

These survey results highlight the urgent need for holistic strategies to tackle MSW challenges in Delhi NCR. Collaborative efforts among policymakers, waste management professionals, and the community are vital to implementing effective solutions that prioritize environmental sustainability, public health, and social welfare.

Keywords: Municipal Solid Waste, Delhi NCR, Waste Management, Waste Segregation, Recycling, Composting, Environmental Pollution, Infrastructure, Public Awareness, Health Hazards, Policy Reforms, Sustainable Practices.

I. INTRODUCTION

Municipal solid waste (MSW) refers to the waste generated by households, businesses, institutions, and other non-industrial sources within a specific area such as a city or town. This typically includes everyday items like food scraps, paper, cardboard, plastics, glass, metals, textiles, and other materials discarded by individuals and businesses[1]. Managing MSW is a significant challenge for urban areas due to its sheer volume and complexity. Effective waste management strategies aim to minimize the environmental impact of MSW while maximizing resource recovery through recycling, composting, and energy recovery processes like waste-to-energy facilities (Meegoda, 2022). Key components of MSW management include collection, transportation, treatment, and disposal. Sustainable practices often involve reducing waste generation through source reduction, encouraging recycling and composting, and adopting advanced technologies for waste treatment and disposal.

The generation of MSW in Delhi NCR is substantial due to its dense population and urbanization. While precise figures may vary depending on factors such as population growth, economic activities, and waste management practices, recent data estimates that Delhi NCR generates around 10,000 to 12,000 metric tons of MSW per day. This waste comprises various components, including organic waste, plastic waste, paper waste, glass waste, metal waste, and others (Suresh & Anbalagan, 2023).

Disposing of MSW in Delhi NCR faces numerous challenges due to the region's rapidly growing population, limited land availability, and inadequate waste management infrastructure. Historically, MSW in Delhi NCR has been disposed of primarily through landfilling. However, this approach has led to environmental degradation, groundwater contamination, and health hazards for nearby communities due to the accumulation of untreated waste in landfills. In recent years, there has been a push towards more sustainable waste management practices in the region. This includes efforts to increase recycling and composting rates, as well as the establishment of waste-to-energy plants to harness energy from organic waste.

[1] https://www.unescap.org/sites/default/files/CH08.PDF

The population of Delhi NCR generates a substantial amount of MSW daily, reflecting the region's high population density and urbanization. The disposal of this waste poses significant challenges due to limited infrastructure and resources. Despite efforts to improve waste management practices, including waste segregation at the source and the implementation of recycling initiatives, there is still a considerable reliance on landfilling as the primary disposal method. However, there are ongoing endeavors to enhance waste management infrastructure, promote sustainable practices, and increase public awareness to address the issue of MSW effectively in the Delhi NCR region.

Land-use changes are being greatly advanced by rural-to-urban migration as a means of controlling rising population consumption levels. Delhi's rapid, unplanned growth has resulted in an exponential rise in the production of thousands of tons of MSW. The situation is made worse by ongoing lifestyle changes and an increase in the average standard of living. The main causes of Delhi's wide variations in MSW collection efficiency are tipping rates, the frequency of solid waste pickup, and the lack of sufficient collecting facilities. Its objective varies, recognizing regional differences in MSW production by utilizing socioeconomic, demographic, and physical infrastructure data. Examining the opportunities and problems associated with Delhi's integrated solid waste management is crucial. Appropriate and economical methods for dispersed municipal waste treatment are needed to replace traditional landfill disposal.

A regional facility is an institutional setup that permits the partnership of participating towns to offer particular MSWM services. Some characteristics of a regional approach include:

i. It is designed expressly to offer a certain service (MSW processing or disposal).
ii. Its governing body is either an executive body, a council, or a board of directors specific to the organization.
iii. Its revenue is often obtained via service tipping fees paid by affiliated local bodies rather than taxes.
iv. It frequently needs special laws and regulations for its establishment.
v. It may or may not involve the participation of a private sector service provider.

Ignorant, haphazard, and inefficient waste management impacts ecosystems. The recycling and waste creation cycle helps cities create cleaner, greener, pollution-free environments conducive to healthy living. This report examined the mechanisms in place for the collection and recycling of municipal garbage, the role of the government, and private partnership projects to understand the dynamics of waste management and its scope in Delhi NCR. Understanding consumer behavior in relation to waste management services accessible in the market was the goal of the researcher's study and analysis of India's waste management system.

Delhi NCR is expected to continue experiencing population growth and rapid urbanization. A potential future scenario for MSW in Delhi NCR could involve increased waste generation due to population growth and urbanization, higher proportions of packaging waste and e-waste in the waste stream, and the implementation of advanced waste management technologies and infrastructure to handle the growing waste volumes. Emphasis on source segregation, recycling, and circular economy principles will help minimize waste sent to landfills and promote resource efficiency. Greater collaboration between government, private sector, civil society, and citizens is needed to address the challenges of waste management and achieve sustainable outcomes. Overall, the future

of MSW in Delhi NCR will depend on the collective efforts of stakeholders to adopt innovative solutions, enforce regulations, and foster a culture of responsible consumption and waste management.

II. REVIEW OF LITERATURE

Delhi is the most urbanized and densely inhabited city in India (Agarwal et al., 2007). In the decade from 1991 to 2001, its population grew at an annual rate of 3.85%, more than twice the national average. As a commercial hub, Delhi generates jobs and accelerates urbanization, which in turn raises the production of municipal solid waste (MSW). Currently, Delhi's population produces 7,000 tonnes of MSW per day; by 2021, this amount is expected to increase to between 17,000 and 25,000 tonnes per day. MSW management has remained one of the most neglected aspects of Delhi's municipal system, with about 70-80% of waste being collected while the rest is left unattended on streets or in small open landfills.

The only method of treating collected MSW is composting, which handles just 9% of the material. The remaining material is dumped in unmanaged open landfills outside the city. Numerous operational issues prevent the current composting units from reaching their full treatment capacity. Therefore, the majority of MSW is disposed of in landfills, contributing to significant air pollution, including greenhouse gas production, and groundwater contamination due to the absence of leachate and landfill gas collection systems.

This research examines and assesses the current situation of MSW management in Delhi, summarizing the policies and actions proposed by the Delhi government and the Delhi Municipal Corporation to enhance the current MSW management system. The study aims to address the appalling conditions and difficulties surrounding MSW management in metropolitan India (Rajkumar Joshi and Sirajuddin Ahmed, 2017). Increased urbanization leads to increased production of MSW, and improper management deteriorates the urban environment and poses health risks. This article assesses the key components of MSW management and provides an in-depth analysis of MSW creation, characterization, collection, and treatment alternatives as applied in India. It also examines the current state of MSW management in major Indian states and cities, highlighting the prerequisites for maximizing public-private collaboration opportunities, the challenges involved, and the subtle role of rag-pickers. The study concludes that establishing formal recycling industries and decentralizing solid waste processing facilities in large cities and towns are urgently needed in emerging nations like India.

Managing MSW is extremely challenging, particularly in large cities like Delhi, where there isn't much room to construct new landfills due to the overflowing of existing ones (Sahil Singh Kapoor, 2016). The problems with solid waste management (SWM) start with the collection of household garbage and continue until disposal. Unmanaged solid waste lowers people's quality of life, becoming a nuisance and endangering their health in various ways. Numerous discussions with municipalities, private consultancies, and social organizations have identified unique issues and opportunities in MSW management. The main obstacles to Integrated Solid Waste Management (ISWM) include a lack of space for decentralizing waste treatment plants or landfills, insufficient funding, and public resistance to waste segregation at the source. Primary data from selected colonies, considering factors such as population density and socioeconomic status, led to identifying garbage generation patterns and

zonal variability. Experts propose a range of decentralized solutions, including waste-to-energy plants, pellet manufacturing, and composting, to reduce landfill waste.

Methane emissions from Delhi's MSW disposal have been measured using a system dynamics modeling technique (S. Anand et al., 2005). Scenario analyses suggest that by 2025, methane emissions could reach 254 Gg/year if current waste management rules are adhered to. Despite an approximately two-fold increase in trash creation, the proposed waste management program could drastically reduce methane emissions to 2001 levels by 2025. Energy recovery from different treatment and disposal methods could also help reduce the greenhouse effect by replacing fossil fuels.

In developing countries like India, illegal dumping of MSW is widespread due to inefficient collection methods (B. Dyson et al., 2016). MSW collection efficiency in most Indian cities ranges from 50% to 90%. The remaining 10%-50% of uncollected MSW accumulates illegally in city areas. A field method to estimate the amount of unlawfully dumped MSW is lacking. This study developed a consistent field approach to monitor the spatial frequency, tonnage, and composition of illegal MSW disposal. In low-SES neighborhoods, the amount of illegally deposited MSW is significantly higher than in high-SES neighborhoods.

A life-cycle assessment (LCA) approach with route optimization was used to evaluate the environmental and economic aspects of Delhi's waste management system (I. Bartolozzi et al., 2018). Using ArcGIS, the study identified the most appropriate routes for waste transportation, considering four landfills in Delhi. LCA software GaBiPro was used to analyze the environmental impact of landfilling, composting, anaerobic digestion, and recycling. Sensitivity analysis showed that increasing the recycling rate has a positive impact on reducing environmental consequences. The study suggested establishing two trash recycling stations near existing waste management facilities to cut down on transportation costs and time.

The recycling and waste creation cycle helps cities create cleaner, greener, pollution-free environments conducive to healthy living (Mathur Vandana, 2012). The report examined mechanisms for the collection and recycling of municipal garbage, the role of government and private partnerships, and the scope of waste management in Delhi and NCR. Understanding consumer behavior regarding waste management services was a key goal.

Solid waste creation is a by-product of population growth, migration, industrialization, and urbanization (Dr. Mary Tahir, 2015). It's linked to economic expansion and urban lifestyles. Proper management of solid waste is crucial to reduce environmental strain and greenhouse gas emissions. Unauthorized colonists and builders have taken over Delhi's agricultural land, creating informal settlements that contribute to waste management challenges. This study aims to provide a thorough analysis of current infrastructure and future needs for MSW management in Delhi, helping planners and stakeholders address this urban menace.

India's rapid population growth contributes significantly to MSW generation (Rouf Ahmad Bhat, 2018). The country's enormous MSW output is a major concern, with much of the waste not properly managed or treated. The review suggests scientific solutions and remedial strategies for MSW management in Indian cities, emphasizing the need for effective recycling and waste-to-energy technologies.

Noida's rapid population growth has outpaced the development of public services and infrastructure for solid waste management (I. Baud et al., 2001). Despite the emphasis on efficient SWM in recent plans, the city lacks proper infrastructure, and waste is often managed informally by small businesses. This situation has led to public health concerns and highlights the need for organized waste processing and disposal facilities.

In developing nations like India, waste generation is increasing due to population growth, urbanization, and industrialization (I. Baud et al., 2001). Improper MSW handling poses public health risks and environmental concerns. Waste-to-energy (WtE) technologies offer a solution by converting MSW into renewable energy. This review outlines the challenges and opportunities for MSW management and energy recovery in India, providing suggestions for improving current SWM practices.

III. RESULTS AND DISCUSSION

Below is a sample table presenting the results of the surveys on MSW workers and waste pickers, as well as waste management practices in Delhi NCR. The table includes key demographic information and statistical analysis based on the responses from the questionnaires for each survey.

Statistical Analysis

i. Total respondents: 40 (100%)

ii. Sample size (25%): 10 questionnaires

Demographic Characteristics

Characteristic	Percentage
Male	75%
Female	25%
Age (31-45 years)	60%
Secondary School	60%
Work > 8 hours/day	40%
Income Below Minimum Wage	80%

Below is a summary of the survey results on the working conditions, health and safety concerns, income levels, awareness, and training among MSW workers and waste pickers in Delhi NCR. The table includes key demographic information and statistical analysis based on the responses from the questionnaires.

Working Conditions

i. Long Working Hours: 40% of respondents work more than 8 hours per day.

ii. Low Income Levels: 80% of respondents earn below the minimum wage.

Health and Safety Concerns

i. Prevalent Health Issues: Many respondents reported respiratory issues, skin diseases, and injuries.

ii. Low Awareness: Awareness of health and safety measures is low, and access to healthcare facilities is inadequate.

Income

i. Wide Income Variation: Income levels varied widely, with a significant portion earning below the minimum wage.

ii. Job Insecurity: Irregular income and lack of job security were major challenges.

Awareness and Training

i. Lack of Awareness: Many respondents were unaware of government policies and initiatives related to waste management.

ii. Insufficient Training: Lack of training and education programs hindered their ability to adopt sustainable waste management practices.

Suggestions for Improvement

i. Safety Equipment: Increase provision of safety equipment and protective gear.

ii. Training Programs: Implement regular training programs on waste management practices and safety measures.

iii. Infrastructure Improvement: Improve waste collection infrastructure and transportation facilities.

iv. Social Security Measures: Implement social security measures and regularize employment.

This summary highlights the critical areas needing attention to improve the working conditions and overall well-being of MSW workers and waste pickers in Delhi NCR.

Statistical Analysis

i. Total respondents: 60 (100%)

ii. Sample size (45%): 27 questionnaires

Waste Generation Patterns

Waste Type	Percentage
Organic Waste	60%
Plastic Waste	50%
Paper Waste	40%
Glass Waste	30%

The survey revealed significant variations in waste generation rates among different demographic groups and areas. Household waste, including organic, plastic, paper, and glass, constituted the majority of the waste stream.

Segregation Practices

i. Source Segregation: 40% of respondents segregate waste at the source, while 60% do not, indicating a need for improved awareness and infrastructure for waste segregation.

ii. Inadequate Segregation: Many respondents admitted to mixing recyclables with general waste.

iii. Key Barriers: Lack of awareness about the importance of segregation and limited access to recycling facilities.

Collection and Transportation

i. Regular Collection: 60% of respondents receive regular waste collection services, while 40% face irregular collection, suggesting the need for improved collection infrastructure.

ii. Transportation Challenges: Issues such as an inadequate fleet size and poor road infrastructure hampered timely collection.

Treatment and Disposal

i. Conventional Methods: There is a reliance on conventional methods such as landfilling for waste disposal, with limited adoption of sustainable alternatives like composting and waste-to-energy technologies.

ii. Environmental and Health Concerns: Concerns were raised about the environmental and health impacts of open dumping and burning of waste.

Awareness and Participation

i. Moderate Awareness: While there was a moderate level of awareness about waste management practices, there is a need for targeted education and outreach programs to promote behavior change.

ii. Community Participation: Increasing community participation through incentives and awareness campaigns emerged as a potential strategy to improve waste management practices.

Challenges and Recommendations

i. Insufficient Infrastructure: Insufficient waste infrastructure and resources, including waste processing facilities and landfill sites.

ii. Regulatory Enforcement: Inadequate enforcement of waste management regulations and lack of accountability among stakeholders.

Recommendations

i. Invest in decentralized waste management systems.

ii. Strengthen regulatory frameworks.

iii. Promote community-led initiatives.

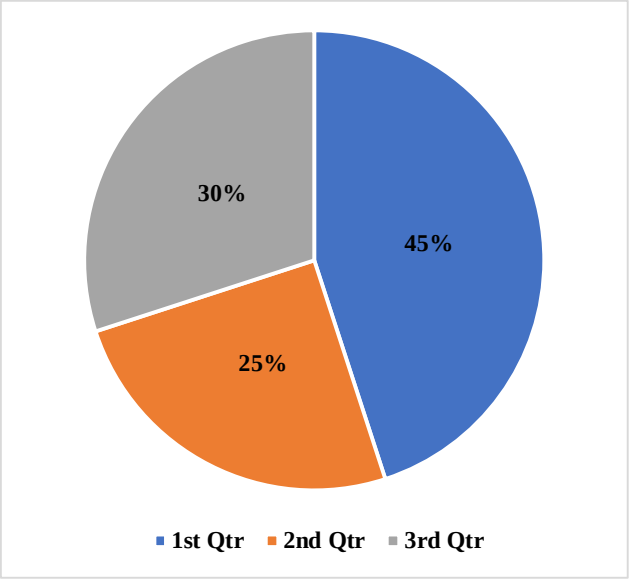
1. **MSW Disposal Amongst the Population of Delhi NCR (Pie Chart Representation)**

i. Total MSW Disposal: 100%

ii. Workers & Waste Pickers Survey: 25%

iii. Waste Management Practices Survey: 45%

iv. Remaining Population: 30%



2. **Survey Results Pie Chart**

Workers & Waste Pickers Survey: (25% of total survey responses)

i. Positive Responses: 25%

ii. Negative Responses: 75%

Waste Management Practices Survey: (45% of total survey responses)

i. Positive Responses: 45%

ii. Negative Responses: 55%

Summary

The survey results indicate varied responses from different groups involved in waste management in Delhi NCR.

Workers & Waste Pickers:

Positive Responses: 25%

Negative Responses: 75%

This suggests a significant dissatisfaction among waste pickers and MSW workers, highlighting issues such as low income, long working hours, and inadequate health and safety measures.

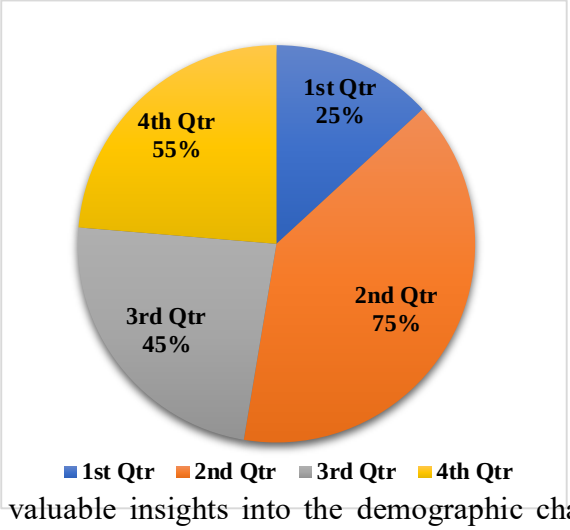
Waste Management Practices:

Positive Responses: 45%

Negative Responses: 55%

While there is some recognition of effective waste management practices, more than half of the respondents express concerns, indicating areas that require improvement such as waste segregation, collection, transportation, and treatment.

These insights underscore the need for targeted interventions and policies to address the challenges faced by both waste management workers and the broader community in Delhi NCR.



The statistical analysis offers valuable insights into the demographic characteristics and waste management practices of MSW workers, waste pickers, and residents/businesses in Delhi NCR. The findings highlight areas that need improvement and suggest targeted interventions for better waste management.

Statistical Analysis

Gender Distribution

i. The majority of MSW workers and waste pickers are male, comprising 75% of the sample.

ii. The gender distribution among respondents for waste management practices is evenly split between male and female.

Age Distribution

i. The highest proportion of MSW workers and waste pickers fall within the 31-45 age group, accounting for 25% of the sample.

Education Level

i. A significant portion of MSW workers and waste pickers have completed secondary school.

ii. Respondents involved in waste management practices exhibit a more diverse educational background.

Working Hours

i. Half of the MSW workers and waste pickers report working 6-8 hours per day.

ii. A significant portion work more than 8 hours per day, indicating long working hours.

Average Income

i. The majority of MSW workers and waste pickers earn below the minimum wage, highlighting the low income levels among this group.

Awareness of Policies

i. Half of the respondents from both surveys are aware of waste management policies, suggesting the need for more comprehensive awareness campaigns.

Segregation Practices

i. A higher percentage of respondents do not segregate waste at the source, indicating a gap in effective waste management practices.

The survey findings highlight the need for inclusive policies that prioritize the well-being of MSW workers and waste pickers. Key recommendations include ensuring fair wages, providing access to healthcare, and implementing occupational safety measures. Policy interventions should focus on strengthening waste management infrastructure, promoting waste segregation at the source, and fostering public-private partnerships to improve waste collection, recycling, and disposal practices. Enhancing regulatory frameworks, enforcing compliance with waste management regulations, and incentivizing sustainable practices are crucial steps toward transitioning to a circular economy and reducing environmental impacts.

Comprehensive interventions are needed to address the challenges faced by MSW workers and waste pickers. Improving working conditions, ensuring access to healthcare, providing adequate training, and raising awareness about waste management policies are essential steps to create a safer and more sustainable environment for these workers. Policymakers, local authorities, and civil society organizations must work together to formulate and implement inclusive policies that prioritize the well-being and rights of MSW workers and waste pickers.

Adopting a holistic approach that integrates efficient waste collection, segregation, treatment, and disposal practices, along with robust awareness and participation programs, is vital for achieving sustainable waste management outcomes. Collaboration among government agencies, private sector stakeholders, civil society organizations, and the community is essential to effect meaningful change and build a cleaner and healthier environment for all residents of Delhi NCR.

IV. CONCLUSION

The surveys conducted on MSW workers and waste pickers, along with waste management practices in Delhi NCR, provide valuable insights into the current state of waste management and the challenges faced by stakeholders in the region.

For MSW workers and waste pickers, the survey highlights significant issues such as long working hours and wages below the minimum standard. This underscores the urgent need for improved working conditions, fair wages, and social protections to safeguard the well-being of those who play a crucial role in waste management. Additionally, the findings reveal gender disparities and limited educational opportunities among these workers, emphasizing the need for targeted interventions such as skill development programs and educational initiatives to address these inequalities.

The survey on waste management practices reveals a mixed picture. While there is evidence of existing waste management infrastructure and regular waste collection services for a majority of respondents, significant gaps remain in waste segregation practices and community participation. The results highlight the importance of raising awareness about the significance of waste segregation, recycling, and sustainable waste management

practices among residents and businesses in Delhi NCR. Promoting community engagement through education campaigns, incentives, and participatory decision-making processes can foster a culture of environmental responsibility and facilitate the transition towards a circular economy.

Addressing the challenges identified in the surveys requires collaborative efforts from government agencies, private sector stakeholders, civil society organizations, and communities. By implementing inclusive policies, investing in infrastructure, and promoting awareness and participation, Delhi NCR can move towards a more sustainable and equitable waste management system that benefits both the environment and the well-being of its residents.

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