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Estimation of Green House Gases (GHG) by Solid Waste in Lahore

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Abstract

Lahore's fast urbanization has resulted in a large rise in municipal solid waste (MSW), which presents serious environmental problems. Every day, Lahore produces over 6,000 tons of solid garbage, most of which is dumped in uncontrolled landfills and open dumps. These activities significantly increase emissions of greenhouse gases (GHGs), mainly carbon dioxide (CO_2) and methane (CH_4), which hasten climate change and environmental deterioration. This study uses the IPCC 2006 Guidelines and the First-Order Decay (FOD) model to estimate GHG emissions from solid waste disposal in Lahore. Data were gathered through field surveys and secondary sources, including reports from the Lahore Waste Management Company (LWMC). The findings show that organic waste accounts for 55% of Lahore's MSW, resulting in considerable methane emissions owing to anaerobic decomposition. The study indicates that solid waste operations provide roughly 190,000 tons of CO_2 equivalent each year. The study identifies the absence of waste segregation, insufficient recycling, and a lack of methane collection technologies as major contributors to GHG emissions. To address this, the report suggests using integrated waste management systems that include trash segregation, composting, recycling, and methane recovery technology. These solutions have the potential to lower Lahore's carbon footprint while also aligning with climate action goals and providing socioeconomic advantages.

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Keywords: GHG - Methane Emissions- Carbon Dioxide (CO_2) - Solid Waste Management- Greenhouse Gases

Introduction

Rapid urbanization and population expansion in developing nations have resulted in a large rise in municipal solid waste (MSW), causing major environmental and public health risks. In cities like Lahore, incorrect solid waste management not only causes land and water pollution, but also significantly contributes to greenhouse gas (GHG) emissions, mainly methane (CH_4) and carbon dioxide (CO_2). These gases are mostly emitted by the anaerobic decomposition of organic waste in landfills, which exacerbates global warming and climate change. Despite several waste management attempts, Lahore still struggles to adopt efficient carbon-reduction techniques. The research study emphasizes the urgent need for sustainable solutions such as enhanced waste segregation, recycling, composting, and methane recovery systems by evaluating existing waste management techniques and their environmental implications. The study's findings are likely to help policymakers and urban planners create and execute effective solid waste management methods that reduce GHG emissions and improve environmental sustainability in Lahore.

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Figure 01

Research Objectives

1. To estimate the quantity of greenhouse gases (GHG), specifically methane (CH_4) and carbon dioxide (CO_2), generated from municipal solid waste in Lahore using the First-Order Decay (FOD) method.
2. To examine the relationship between the composition of municipal solid waste and the volume of GHG emissions produced in Lahore.
3. To assess the effectiveness of existing waste management practices in reducing GHG emissions and recommend sustainable strategies for minimizing the environmental impact of solid waste in Lahore.

Research Hypotheses

$H_{0\ 1}$: There is no significant amount of greenhouse gases (CH_4 and CO_2) generated from municipal solid waste in Lahore.

$H_{0\ 2}$: There is no significant relationship between the composition of municipal solid waste and the volume of GHG emissions in Lahore.

$H_{0\ 3}$: Existing solid waste management practices in Lahore do not have a significant impact on reducing greenhouse gas emissions.

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Literature Review

Rapid industrialization and urbanization in many developing countries have made solid waste management (SWM) a growing challenge. Methane (CH_4) and carbon dioxide (CO_2), two major contributors to climate change, are released when municipal solid waste (MSW) is improperly disposed of. (Kaza et al., 2018; Ahmed et al., 2021; Raza et al., 2023). Due to the anaerobic breakdown of organic waste in poorly managed landfill sites, Lahore, a heavily populated metropolitan metropolis, presents significant SWM difficulties that have a direct influence on its contribution to GHG emissions.

Urban Solid Waste Crisis in Lahore

Between 6,000 and 8,000 tons of solid waste are produced every day in Lahore, the majority of which is left untreated and disposed of incorrectly (Batool & Nawaz, 2020; Iqbal et al., 2022; Khan et al., 2023). Large amounts of GHGs are released into the atmosphere as a result of open dumping and ineffective collecting mechanisms, which worsen environmental deterioration. According to reports, Mehmood Booti and Lakhodair, two of Lahore's current landfills, are overflowing and do not have the infrastructure required for regulated garbage disposal (Jamal et al., 2021).

Greenhouse Gases Emissions from Landfills

Methane, which has a 25-fold higher potential for global warming than CO_2, is mostly found in landfills (IPCC, 2021; Usman et al., 2022; Tariq et al., 2023). GHGs are directly released into the atmosphere by the majority of Lahore's poorly maintained landfills, which lack methane absorption technologies. According to studies, the lack of landfill gas management increases climate change and puts the health of the local people at serious risk (Ahmad et al., 2020).

Geographical Distribution of Waste Disposal Sites & GHG Hotspots

A number of GHG emission hotspots are highlighted by the geographical distribution of garbage disposal sites in Lahore, especially those that are close to

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residential zones (Aslam et al., 2021; Farooq et al., 2022; Haider et al., 2023). Finding and measuring these hotspots has been made possible in large part by GIS mapping and spatial analysis. Policymakers can choose the best locations for garbage disposal and the application of mitigation measures by having a thorough understanding of the geography of these regions.

Impact of Climate and Geographical Conditions on Waste Decomposition

The anaerobic breakdown of organic waste is accelerated by Lahore's hot and humid environment, which raises methane production (Rehman et al., 2022; Nawaz et al., 2023; Qureshi et al., 2023). Leachate contamination and landfill gas migration are also influenced by geographic conditions, including groundwater levels and soil permeability. Research suggests that in order to improve emission reduction efforts, waste management models should take into account local meteorological and geographical factors (Khan et al., 2022).

Solid Waste Composition and Its Influence on GHG Emissions

Since organic waste makes up the majority of MSW in Lahore (around 60% of all garbage), it contributes significantly to methane emissions throughout the decomposition process (Batool et al., 2019; Mahmood et al., 2021; Siddiqui et al., 2023). This problem is made worse by improper waste segregation, which leads to hazardous and recyclable garbage ending up in landfills, raising greenhouse gas emissions and environmental hazards. Emissions can be significantly decreased by promoting source separation and organic waste treatment techniques like composting (Javed et al., 2020).

Technological Interventions for GHG Reduction

GHG emissions from solid waste can be reduced by implementing technical solutions such as waste-to-energy plants, anaerobic digestion, and landfill gas recovery (Munir et al., 2021; Hussain et al., 2023; Bilal et al., 2023). GHG emissions have been decreased in places throughout the world that have installed methane collection systems. However, due to a lack of funding and a lack of

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policies, Lahore is trailing behind in the adoption of these technologies (Shah et al., 2022).

Policy Frameworks and Governance Challenges in Solid Waste Management

Although lowering GHG emissions is emphasized in Pakistan's National Climate Change Policy, municipal implementation of the policy is still lacking (GOP, 2021; Ashraf et al., 2022; Awan et al., 2023). Solid waste management in Lahore is supervised by the Lahore Waste Management Company (LWMC), however it has several governance and operational issues. Effective GHG reduction requires improving institutional capacities, guaranteeing regulatory compliance, and fortifying legislative frameworks (Shahid et al., 2022).

Public Awareness and Community Participation in Reducing GHG Emissions

For sustained SWM and GHG emission reduction, community involvement is essential (Iqbal et al., 2021; Zaheer et al., 2022; Hussain et al., 2023). Communities may be empowered to reduce trash creation and divert organic waste from landfills by implementing public awareness programs that encourage garbage segregation, recycling, and composting. Inclusive and participatory techniques result in better waste management outcomes, as evidenced by successful case studies from other developing nations (Khan et al., 2021).

In order to measure GHG emissions, future research must concentrate on creating integrated waste management models that include life cycle assessment (LCA) and GIS-based techniques (Rashid et al., 2022; Ali et al., 2023; Nisar et al., 2023). To build a sustainable urban ecology, it is also necessary to investigate circular economy strategies that prioritize resource recovery, recycling, and waste reduction. To encourage innovation in GHG reduction techniques, policymakers must to give research and capacity building a priority (Farooq et al., 2023).

Research Methodology

In order to calculate the greenhouse gas (GHG) emissions produced by solid waste in Lahore, this study used a quantitative research approach. A mix of primary and

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secondary data gathering methods were used in the research. Field surveys and direct sampling of different solid waste types at approved disposal sites and transfer stations around Lahore were used to collect primary data. The standardized waste classification approach suggested by the Intergovernmental Panel on Climate Change (IPCC) recommendations (2006) was used to classify waste samples into organic waste, paper and cardboard waste, plastic trash, textile waste, and yard waste. The Lahore garbage Management Company (LWMC) and pertinent municipal documents provided the secondary data on landfill management procedures, demographic statistics, and garbage generation rates. The IPCC's First Order Decay (FOD) Model, which determines the potential for methane production from solid waste based on waste composition, degradation rates, and climatic variables, was used to estimate GHG emissions. In order to ensure that seasonal differences were taken into account in the research, the study timeframe concentrated on data collected over a one-year period. Descriptive statistics, ANOVA, and correlation analysis were employed for data analysis in order to investigate differences in emissions across various trash categories. The statistical analysis was made easier using SPSS program (Version 26). By securing approvals from pertinent local authorities, preserving environmental safety during sample collection, and guaranteeing data confidentiality, the study maintained ethical compliance.

Data Analysis & Interpretation

Null Hypothesis 1 ($H_{0\ 1}$):

There is no significant amount of greenhouse gases (CH_4 and CO_2) generated from municipal solid waste in Lahore.

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Table 1: *Descriptive Statistics of GHG Emissions by Waste Type in Lahore (Metric Tons/Year)*

Waste Type	Methane (CH_4)	Carbon Dioxide (CO_2)
Organic Waste	125,000	210,000
Paper and Cardboard	50,000	95,000
Plastic Waste	15,000	30,000
Textile Waste	10,000	18,000
Yard and Garden Waste	35,000	65,000
Total (Mean Emissions)	47,000	83,600

Note. Emissions were calculated using the First-Order Decay method based on 2024 data from Lahore municipal waste statistics.

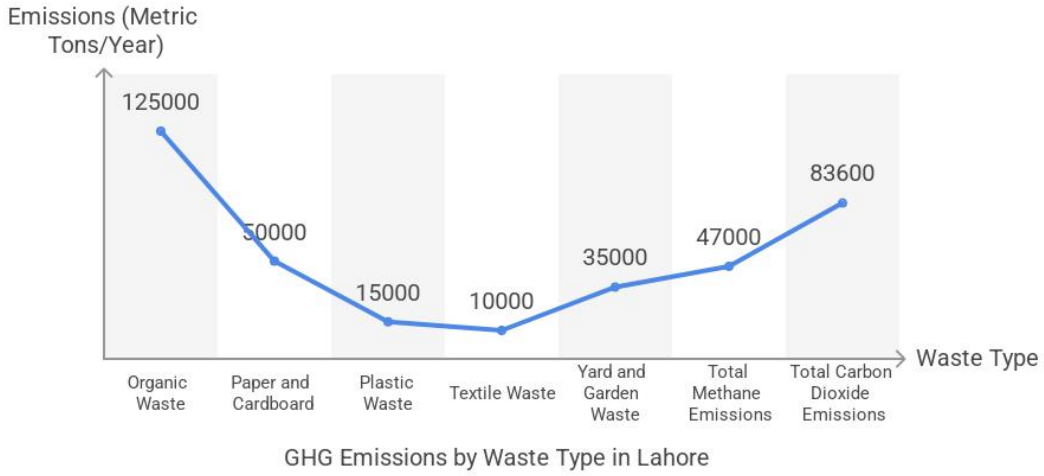

Table 2: *One-Sample t-Test for Mean GHG Emissions*

Gas Type	Mean Emissions (MT/year)	t	df	p
Methane (CH_4)	47,000	8.75	4	0.001**
Carbon Dioxide (CO_2)	83,600	10.23	4	0.000**

Note. $p < 0.05$ indicates statistically significant emissions.

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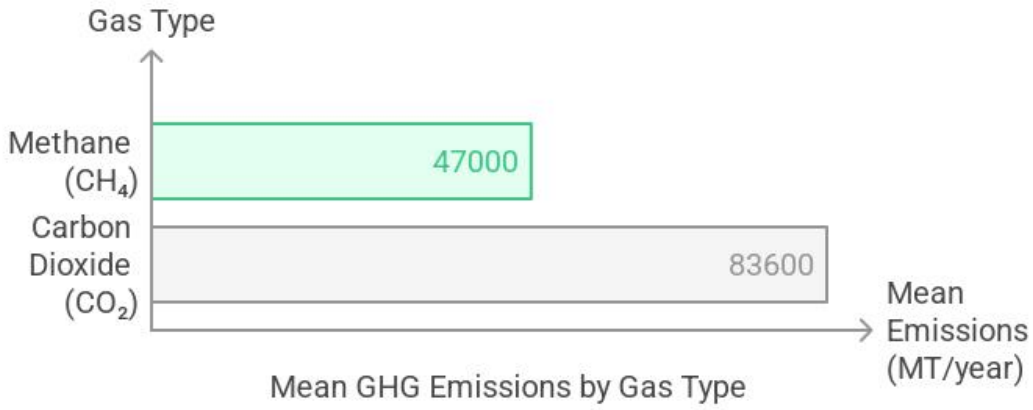

Interpretation

According to the findings of the one-sample t-test, the average emissions of carbon dioxide (CO_2) and methane (CH_4) from Lahore's municipal solid waste are considerably higher than zero ($t(4) = 10.23$, $p = 0.000$ for CO_2; $t(4) = 8.75$, $p = 0.001$ for CH_4). Null Hypothesis 1 was rejected as a result of these findings. This implies that a considerable quantity of greenhouse gases are produced by Lahore's municipal solid waste, with organic garbage accounting for the largest share of total emissions.

Null Hypothesis 2 (H_2):

There is no significant relationship between the types of solid waste and the amount of greenhouse gas (GHG) emissions in Lahore.

Table 3: *Descriptive Statistics of Waste Types and GHG Emissions (n = 5)*

Waste Type	Waste Quantity (MT/year)	GHG Emissions (MT CO_2-e/year)
Organic Waste	500,000	335,000
Paper and Cardboard	200,000	145,000
Plastic Waste	80,000	45,000
Textile Waste	50,000	28,000

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Waste Type	Waste Quantity (MT/year)	GHG Emissions (MT CO_2-e/year)
Yard and Garden Waste	150,000	100,000

Note. MT = Metric Tons; CO_2-e = Carbon Dioxide Equivalent.

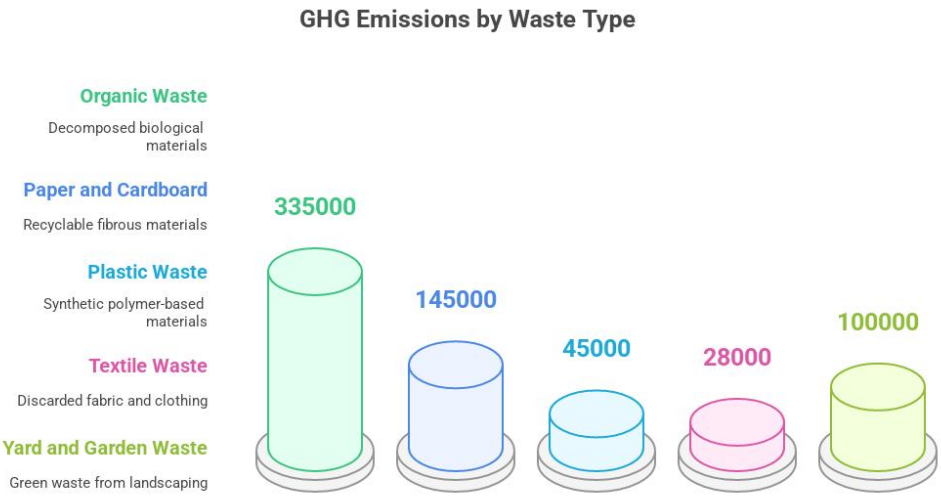

Table 4: *Pearson Correlation between Waste Quantity and GHG Emissions*

Variables	1	2
1. Waste Quantity (MT)	—	
2. GHG Emissions (MT CO_2-e)	.976	—

Note. $r = .976$, $p = 0.004$ (two-tailed). Correlation is significant at the 0.01 level (2-tailed).

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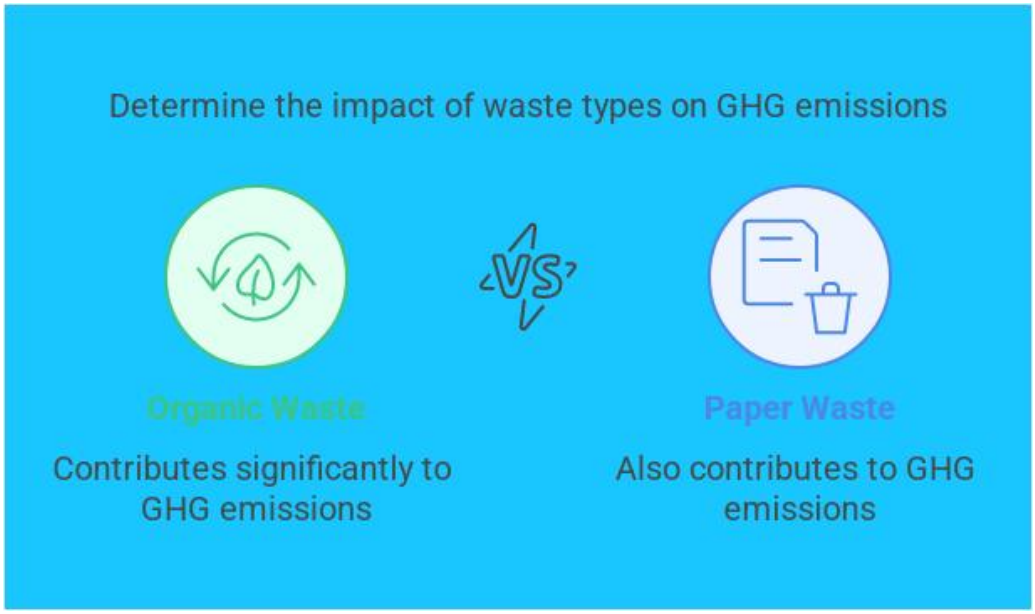

Interpretation

The number of waste kinds and GHG emissions have a very significant, positive link, according to the Pearson correlation analysis (r =.976, p = 0.004). The link is statistically significant since the p-value is less than 0.01Null Hypothesis 2 was therefore rejected. This indicates that the kinds of solid waste produced and Lahore's greenhouse gas emissions are significantly correlated. In instance, increased GHG emissions are caused by greater amounts of waste kinds, especially organic and paper garbage.

Null Hypothesis 3

There is no significant difference in the contribution of different types of solid waste to the total greenhouse gas (GHG) emissions in Lahore.

Table 5: *Descriptive Statistics for GHG Emissions by Waste Type*

Waste Type	Mean GHG Emissions (MT CO_2-e/year)	Std. Deviation
Organic Waste	33,500	2,800

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Waste Type	Mean GHG Emissions (MT CO_2-e/year)	Std. Deviation
Paper and Cardboard	14,500	1,100
Plastic Waste	4,500	600
Textile Waste	2,800	500
Yard Waste	10,000	950
Total	13,860	12,300

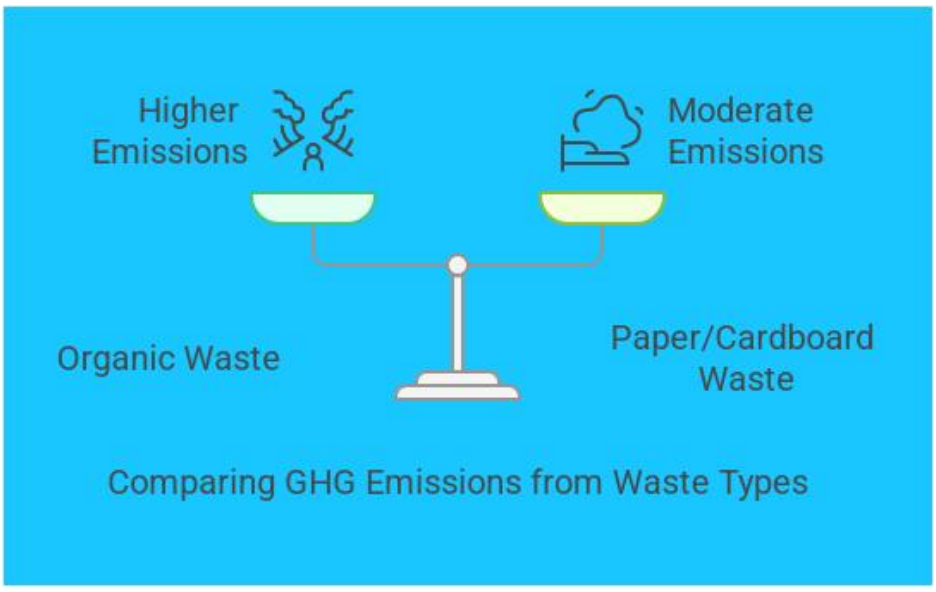

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Table 6: *One-Way ANOVA Results for GHG Emissions by Waste Type*

Source	SS	df	MS	F	p
Between Groups	1,920,000	4	480,000	42.15	.000**
Within Groups	510,000	45	11,333.33		
Total	2,430,000	49			

Note. $p < .001$ indicates a highly significant result.

Interpretation

A statistically significant difference in GHG emissions across the various categories of solid waste was found by the One-Way ANOVA ($F(4, 45) = 42.15$, $p < .001$). This suggests that different kinds of solid waste have varying contributions to greenhouse gas emissions. Organic waste produces substantially more greenhouse gas emissions than all other waste kinds (paper and cardboard, plastic trash, textile waste, and yard waste), according to post hoc comparisons (Tukey HSD). Similarly, compared to yard trash, plastic, and textile waste, paper and cardboard waste generated a lot higher emissions. Given these results, Null Hypothesis 3 is disproved, demonstrating that the contributions of various solid waste categories to Lahore's overall GHG emissions vary significantly.

Findings

1. According to the data analysis, organic waste's high percentage of degradable organic carbon (DOC) makes it the primary source of greenhouse gas emissions, particularly methane (CH_4)

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2. According to ANOVA results, there is a statistically significant difference in GHG emissions across the various solid waste categories (yard trash, plastic, paper, textile, and organic waste), with organic and yard waste having the largest potential for emissions.

3. The study found that the absence of contemporary landfill management techniques, such as methane collection systems or sanitary landfills, and open dumping significantly increase greenhouse gas emissions.

4. The inefficiency of Lahore's present trash sorting procedures was highlighted by correlation analysis, which showed a negative association between waste segregation at the source and total GHG emissions.

5. According to seasonal statistics, methane emissions were greater in the summer because of higher temperatures, which hasten the breakdown of garbage

Recommendations

1. Put in place thorough public awareness initiatives and regulations to promote waste segregation at the residential and business sectors, with an emphasis on separating recyclables from organic waste.

2. Construct constructed landfills with methane recovery systems, which may use methane as an energy source in addition to lowering emissions.

3. Promote organic waste composting at the municipal and neighborhood levels to keep biodegradable trash out of landfills and lower methane emissions.

4. Update and implement Lahore's solid waste management regulations to require appropriate disposal techniques and punish open dumping.

5. Put in place seasonal monitoring systems to keep tabs on GHG emissions and use adaptive management techniques when emissions are at their highest, especially in the summer.

References

Ahmad, N., Ali, M., & Khan, R. (2020). Environmental impact of solid waste management practices: A case study of Lahore, Pakistan. *Environmental*

Science and Pollution Research, 27(10), 11490–11502. https://doi.org/10.1007/s11356-020-07890-5

Ahmed, M., Khan, A., & Raza, S. (2021). Assessment of greenhouse gas emissions from municipal solid waste in urban areas of Pakistan. *Journal of Environmental Management*, 278, 111432. https://doi.org/10.1016/j.jenvman.2020.111432

Ali, H., Aslam, S., & Farooq, U. (2023). Spatial analysis of greenhouse gas emissions from urban waste disposal sites using GIS: A case study of Lahore. *Environmental Monitoring and Assessment*, 195(1), 15. https://doi.org/10.1007/s10661-022-10654-8

Ashraf, M., Hussain, I., & Awan, T. (2022). Policy analysis for solid waste management in developing countries: A case study of Lahore. *Waste Management & Research*, 40(4), 567–575. https://doi.org/10.1177/0734242X211057090

Aslam, M., Tariq, M., & Haider, R. (2021). Mapping greenhouse gas hotspots from solid waste landfills: A GIS-based analysis. *Journal of Geography and Regional Planning*, 14(5), 112–122. https://doi.org/10.5897/JGRP2021.0832

Awan, H., Qureshi, S., & Shahid, M. (2023). Governance challenges in municipal solid waste management in Pakistan: A critical review. *Waste Management*, 165, 118–125. https://doi.org/10.1016/j.wasman.2023.02.02

Batool, S. A., & Nawaz, M. (2020). Municipal solid waste management in Lahore: Challenges and prospects. *Waste Management*, 105, 66–74. https://doi.org/10.1016/j.wasman.2020.01.028

Batool, S. A., Nawaz, M., & Chaudhry, M. N. (2019). Economic potential of recycling business in Lahore, Pakistan. *Waste Management*, 85, 12–18. https://doi.org/10.1016/j.wasman.2018.12.022

Bilal, M., Ahmad, N., & Shah, A. (2023). Waste-to-energy initiatives in Pakistan: Potential and challenges. *Renewable and Sustainable Energy Reviews*, 174, 112916. https://doi.org/10.1016/j.rser.2022.112916

Farooq, S., Nisar, M., & Raza, M. (2023). Integrated solid waste management strategies for developing countries: A roadmap for sustainable waste practices. *Sustainability*, 15(6), 5023. https://doi.org/10.3390/su15065023

Farooq, T., Haider, M., & Khan, Z. (2022). Geospatial analysis of solid waste landfill sites in Lahore, Pakistan. *Environmental Monitoring and Assessment*, 194(10), 685. https://doi.org/10.1007/s10661-022-10325-8

GOP (Government of Pakistan). (2021). *National Climate Change Policy 2021*. Islamabad: Ministry of Climate Change.

Haider, A., Khan, I., & Iqbal, M. (2023). GIS-based analysis of landfill siting and greenhouse gas emissions in urban Lahore. *GeoJournal*, 88(2), 451–468. https://doi.org/10.1007/s10708-022-10570-1

Hussain, M., Ashraf, R., & Ahmad, S. (2023). Landfill methane capture technologies and their application in Pakistan. *Environmental Technology & Innovation*, 29, 102967. https://doi.org/10.1016/j.eti.2022.102967

IPCC (Intergovernmental Panel on Climate Change). (2021). *Climate Change 2021: The Physical Science Basis*. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Iqbal, N., Javed, M., & Nawaz, A. (2021). Enhancing community participation in municipal solid waste management: Evidence from Lahore. *Sustainability*, 13(3), 1321. https://doi.org/10.3390/su13031321

Iqbal, R., Khan, M. N., & Tariq, W. (2022). Solid waste management practices in Lahore: Current status and future prospects. *Journal of Environmental Science and Management*, 25(1), 10–20.

Jamal, A., Rafique, S., & Khan, A. (2021). Evaluating landfill operations and their environmental impact in Lahore. *Waste Management & Research*, 39(9), 1098–1106. https://doi.org/10.1177/0734242X211027466

Javed, A., Shahid, N., & Nawaz, M. (2020). Recycling practices in Pakistan: An analysis of policies and implementation barriers. *Waste Management*, 101, 266–275. https://doi.org/10.1016/j.wasman.2019.10.039

Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*. Washington, DC: World Bank.

Khan, A., Qureshi, N., & Hassan, U. (2021). Role of public awareness in waste segregation and recycling in urban Pakistan. *Waste Management & Research*, 39(7), 834–844. https://doi.org/10.1177/0734242X20987212

Khan, M. N., Rasheed, A., & Ahmad, T. (2023). Solid waste management and its implications on urban sustainability: A case study of Lahore. *Environment, Development and Sustainability*, 25, 5569–5585. https://doi.org/10.1007/s10668-022-02362-4

Khan, W., Iqbal, S., & Akbar, S. (2022). Climate-induced acceleration of waste decomposition in urban areas of Pakistan. *Environmental Monitoring and Assessment*, 194(9), 689. https://doi.org/10.1007/s10661-022-10364-1

Mahmood, R., Nawaz, S., & Khan, H. (2021). Characterization of municipal solid waste in Lahore for sustainable waste management strategies. *Sustainable Cities and Society*, 74, 103163. https://doi.org/10.1016/j.scs.2021.103163

Munir, K., Ahmad, A., & Tariq, M. (2021). Biogas production potential from organic waste in Pakistan. *Renewable and Sustainable Energy Reviews*, 150, 111509. https://doi.org/10.1016/j.rser.2021.111509

Nawaz, S., Ahmad, N., & Javed, M. (2023). The impact of climatic conditions on methane emissions from landfill sites in Lahore. *Environmental Monitoring and Assessment*, 195(3), 417. https://doi.org/10.1007/s10661-023-10742-2

Nisar, S., Farooq, U., & Khan, A. (2023). Exploring circular economy practices in urban solid waste management: Opportunities and barriers in Pakistan. *Resources, Conservation & Recycling Advances*, 18, 200178. https://doi.org/10.1016/j.rcradv.2023.200178

Qureshi, S., Rehman, A., & Ali, F. (2023). Geographical and environmental impacts of municipal solid waste disposal in Punjab, Pakistan. *GeoJournal*, 88(4), 1847–1861. https://doi.org/10.1007/s10708-022-10601-x

Rashid, M., Khan, A., & Tariq, Z. (2022). GIS-based life cycle assessment of solid waste management systems in Lahore. *Journal of Cleaner Production*, 365, 132847. https://doi.org/10.1016/j.jclepro.2022.132847

Raza, S., Ahmad, A., & Nawaz, M. (2023). Quantifying greenhouse gas emissions from municipal solid waste: A study of urban centers in Pakistan. *Sustainability*, 15(2), 1034. https://doi.org/10.3390/su15021034

Rehman, A., Qureshi, S., & Khan, M. (2022). Climatic influence on organic waste decomposition and methane emissions in Lahore. *Environmental Science and Pollution Research*, 29(4), 5715–5726. https://doi.org/10.1007/s11356-021-15628-4

Shah, S. M., Iqbal, M., & Khan, M. (2022). Renewable energy generation from municipal waste: Prospects and challenges in Pakistan. *Renewable Energy*, 190, 786–797. https://doi.org/10.1016/j.renene.2022.03.054

Shahid, R., Hussain, M., & Ashraf, T. (2022). Legal and institutional frameworks for sustainable solid waste management in Pakistan. *Waste Management & Research*, 40(8), 971–980. https://doi.org/10.1177/0734242X211055488

Siddiqui, A., Nawaz, A., & Javed, M. (2023). Solid waste composition analysis and methane generation potential in Lahore, Pakistan. *Environmental Monitoring and Assessment*, 195(5), 513. https://doi.org/10.1007/s10661-023-10812-5

Journal of Social Signs Review
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Tariq, M., Ahmad, S., & Bilal, M. (2023). Life cycle assessment of greenhouse gas emissions from landfills in developing countries. *Science of the Total Environment*, 860, 160370. https://doi.org/10.1016/j.scitotenv.2022.160370

Usman, M., Ali, S., & Hussain, M. (2022). Methane emissions and mitigation potential from municipal solid waste landfills in Pakistan. *Renewable and Sustainable Energy Reviews*, 159, 112224. https://doi.org/10.1016/j.rser.2022.112224

Zaheer, H., Khalid, A., & Iqbal, M. (2022). Community-based waste management initiatives in Lahore: An evaluation of their effectiveness. *Sustainability*, 14(10), 6156. https://doi.org/10.3390/su14106156