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The Role of Community Engagement in Environmental Protection

Iram Khalid[a]
Sami Ullah[b]

Abstract
Solid waste generation rates vary significantly across different sectors in the country. Currently, waste is classified and sorted based on supply sources rather than by type, leading to inefficiencies in waste management practices. Notably, there are no established standards or regulations governing the sorting and disposal of solid waste. In Pakistan, 40-65% of solid waste consists of biodegradable materials. This study focuses on solid waste management in Lahore, specifically examining the work conducted in collaboration with the Citizens Commission for Human Development (CCHD). CCHD is a non-governmental organization dedicated to providing social and environmental services, including solid waste management, raising awareness, and educating the public about environmental issues. The organization's efforts are directed towards the residents of Johar Town, Township, and Model Town in Lahore, serving over 70,000 individuals. The study highlights the critical role of CCHD in promoting environmental protection, pollution prevention, and the reduction of solid waste in the environment. CCHD's initiatives include not only the proper disposal of waste but also educating the community about the importance of maintaining a cleaner environment and reducing the environmental burden. One of the primary focuses of the study is to underline the significance of proper waste management practices in Lahore. Without adequate regulations and standards, the process of waste sorting and disposal remains inconsistent and inefficient. By collaborating with CCHD, the study aims to shed light on effective strategies for managing solid waste, emphasizing the need for a systematic approach to classify and handle waste materials. CCHD's efforts in Lahore encompass a range of activities designed to enhance environmental quality. The organization conducts awareness campaigns to educate residents about the impact of waste on the environment and the importance of proper waste management. These campaigns aim to foster a sense of responsibility among the community members, encouraging them to participate actively in waste reduction and proper disposal practices. Moreover, CCHD's work extends to providing practical solutions for waste management. The organization implements programs for the collection, sorting, and disposal of solid waste in the areas it serves. By focusing on biodegradable waste, which constitutes a significant portion of the total waste, CCHD promotes composting and other environmentally friendly disposal methods. This approach not only reduces the volume of waste that ends up in landfills but also contributes to soil enrichment and reduces pollution. The study also emphasizes the importance of community involvement in achieving effective waste management. By engaging residents in educational programs and encouraging their participation in waste reduction initiatives, CCHD fosters a collaborative approach to environmental protection. The organization's efforts demonstrate that with proper guidance and support, communities can play a pivotal role in maintaining a cleaner and healthier environment.
Keywords: Solid Waste Management, Environmental Awareness, Community Involvement
JEL Codes: Q53, I18, R11

1. INTRODUCTION
Anthropogenic activities, which are human-induced, play a substantial role in the generation of waste. These activities encompass a wide range of processes and practices across various sectors, from industrial manufacturing and agriculture to everyday household consumption. Effective management strategies are essential to address the challenges posed by this waste, including its proper handling, safe storage, efficient collection, and environmentally sound disposal methods. The risks associated with inadequate waste management are manifold, with one of the most significant being atmospheric pollution. Improper disposal and treatment of waste can release harmful substances into the air, contributing to air pollution and potentially impacting human health and the environment. The need for rigorous management practices is underscored by studies such as those by Rathi (2007), which highlight the critical importance of mitigating these risks through comprehensive waste management strategies. The solid waste management challenges in developing countries such as Pakistan are becoming increasingly daunting, exacerbated by the rapid expansion of both population and industrial activities (Qasim et al., 2014). As urbanization accelerates and industries grow, the volume and complexity of solid waste generated are straining existing infrastructure and management systems. This surge in waste production poses significant environmental and public health

[a] University of Engineering and Technology Lahore, Lahore, Pakistan
[b] University of Engineering and Technology Lahore, Lahore, Pakistan

risks, including contamination of soil, water sources, and air quality. Effective strategies for handling, storing, collecting, and disposing of waste are crucial to mitigate these challenges and ensure sustainable development. Governments and communities must implement comprehensive waste management policies and infrastructural investments to address these pressing issues effectively.

Addressing the surge in waste generation necessitates systematic approaches for sorting, storage, transportation, and disposal across urban and rural areas globally (Sharholy et al., 2008; Hazra & Goel, 2009). Effective waste management strategies are essential to minimize environmental pollution, preserve public health, and promote sustainable development. Implementing efficient waste sorting at the source, robust storage facilities, reliable transportation networks, and environmentally sound disposal methods are critical components of a comprehensive waste management framework. Such measures not only mitigate the adverse impacts of waste on ecosystems and human health but also contribute to resource conservation and the circular economy principles. In cities such as Karachi, Pakistan, the volume of waste, including municipal solid waste, industrial waste, hazardous waste, and medical waste, is increasing due to shifting lifestyles and economic development (Talyan et al., 2008). As urbanization accelerates and economic activities expand, the demand for effective waste management strategies becomes paramount to mitigate environmental pollution and safeguard public health. Implementing comprehensive waste management systems is crucial to address these challenges, ensuring proper sorting, collection, transportation, treatment, and disposal of various types of waste generated within urban centers. In Pakistan, the rates of solid waste generation vary significantly across different regions of the country, and waste is generally categorized and managed based on its source rather than its composition. Presently, there is a lack of uniform regulations governing the sorting and disposal of solid waste nationwide. It is estimated that approximately 40-65% of solid waste in Pakistan comprises biodegradable materials (Hafeez, 2013). Addressing these challenges requires the implementation of standardized waste management practices that encompass efficient sorting, collection, transportation, and environmentally sound disposal methods tailored to the specific characteristics of the waste generated in different regions.

Solid waste management encompasses essential activities like sorting, transportation, and disposal of waste (Baud et al., 2004). In Pakistan, the approach to waste collection varies significantly based on the socioeconomic status of different areas. Municipalities primarily focus on solid waste collection in low-income neighborhoods, where collection efficiency can range from minimal, sometimes as low as 0%, to relatively high percentages, up to 90%, in affluent areas (Bhutto et al., 2012). This disparity underscores the need for equitable and effective waste management strategies across all socioeconomic strata to mitigate environmental and health risks associated with inadequate waste disposal practices.

2. MATERIALS AND METHODS

The study was performed on the base of secondary data obtained from TMA and LDA Lahore. Dumping of waste has usually been acknowledged as the least encouraging treatment method. By combining it with incineration, it becomes the unique treatment methodology handling mixed household waste. In case of recycling, incineration is considered as the only sound treatment methodology for the waste that is not segregated.

The calculated emissions of system are categorized using LCA methodology into the following types of environmental impact:

- NOx-emissions
- Acidification potential (AP)
- Eutrophication potential (EP)
- Global warming potential (GWP)
- Heavy metals

The environmental impacts and their financial implications are assessed based on the costs associated with waste releases. These costs are estimated using willingness-to-pay approximations, focusing particularly on issues like eutrophication. Solid waste management involves both waste treatment and transportation. This process considers annual energy consumption and economic resources utilized in these procedures. Energy revenue involves the use of various energy sources such as oil, coal, and the recovery of heat, biogas, hydrogen, and electricity from waste materials. Economic revenue refers to the monetary values generated through these processes. Material flows in the system start from waste sources like households and industries, referred to as "waste in the bin." Environmental and economic impacts related to these waste sources are evaluated within the system. The movement of solid waste is closely monitored throughout the waste management system, including changes in composition and emission counts at waste stream outputs.

Solid waste collection was conducted from two designated locations. A minimum of 100 kg of waste was collected once a month throughout the year. Samples were dried to a constant weight at 103 ± 5°C and then reduced to <0.5 mm in size. These standardized samples were used to represent the average composition of solid waste in Lahore. The composition of elements (nitrogen and carbon) in the solid waste was analyzed using a CE-440 instrument. Moisture content was determined by comparing sample masses before and after heating at 105°C for 24 hours. Volatile solids and ash content were measured by comparing sample masses before and after heating at 600°C for 2 hours. The calorific value was determined using an oxygen bomb calorimeter. The average values from these measurements were considered for the higher calorific value (HCV) outcome.

3. DISCUSSION

Lahore, the cultural and economic heart of Punjab, Pakistan, occupies a significant place in the region's landscape. Spread over an area of approximately 1,773 square kilometers, Lahore is not just a city but a bustling metropolis teeming with diversity and historical significance. Its strategic location alongside the Ravi River, near the border with India, has historically made it a hub for trade, commerce, and cultural exchange. With a population of around 8 million people, Lahore is densely populated and divided into nine administrative units or towns: Samanabad, Gulberg, Iqbal Town, Ravi, Data Ganj Bakhsh, Aziz Bhatti, Shalimar, Nishtar, and Wagha Town. Each of these townships contributes uniquely to the city's vibrant tapestry, from commercial centers and residential areas to historical landmarks and modern infrastructure developments. Known for its rich cultural heritage, Lahore boasts architectural marvels such as the Lahore Fort, Badshahi Mosque, and Shalimar Gardens, which attract tourists and historians alike from around the world. The city's economic significance extends beyond its cultural heritage; Lahore is a vital center for industries ranging from textiles and manufacturing to services and information technology. As a central transport hub within Pakistan, Lahore connects the country's major cities and serves as a gateway for regional trade and commerce. Its bustling markets, educational institutions, and healthcare facilities further underline its importance as a major urban center in South Asia. In recent years, Lahore has witnessed rapid urbanization and infrastructure development, reflecting its role as a dynamic city poised for growth and expansion in the coming decades.

Lahore, the capital of Punjab in Pakistan, boasts a thriving economy with a GDP of approximately US$43 billion, significantly contributing to Pakistan's overall GDP of US$401 billion. The city's economic landscape is diverse, with about 42% of its workforce employed in sectors such as finance, social services, NGOs, banking, and real estate (Batool et al., 2008). Over the years, Lahore has experienced substantial demographic and economic growth. The population of Lahore increased from 13.45 million in 2001 to 19.9 million in 2011, marking an average annual growth rate of 3.38%. Concurrently, Pakistan's national population grew from 104.7 million in 2000 to 182.9 million in 2010, showing an average annual growth rate of 5.30%. Despite this, Lahore's GDP exhibited a rapid increase, growing at an average annual rate of 14.57%, outpacing the growth rate of its population. These growth trends highlight Lahore's significance as a major economic and demographic hub within Pakistan, driving its economic vitality and contributing significantly to the national economy.

In the year 2000, Lahore produced a total of 2.98 million tons of solid waste, which increased to 6.65 million tons by 2008. However, there was a notable decrease in waste production starting in 2009 and continuing into 2010. Specifically, waste volumes decreased by 5.09%, from 6.70 million tons in 2009 to 6.33 million tons in 2010. The composition of solid waste varies across different areas of Lahore, influenced by factors such as local demographics, economic activities, regulations, and consumer behavior. Waste is typically classified based on its source rather than its specific composition or type. According to a study by the Lahore Waste Management Company (LWMC) in 2012, significant components of the waste stream include vegetable and fruit peels, along with dirt, leaves, straw, and grasses. Organic materials make up about 60% of the waste and are biodegradable. Additionally, there is an 11.7% component of non-biodegradable materials like nylon, textiles, and diapers. This data underscores the importance of effective waste management strategies in Lahore, considering the dynamic nature of waste generation and its environmental implications.

The main factor for eutrophication is dispersing the organic manure which causes the nitrate emissions and also releases the ammonia gas. All the vehicles and other machinery that run on Biogas are the main polluting factors releasing the higher amounts of oxide elements. Whereas diesel engines control the pollution image. The diagram of energy carriers illustrates the relationship between renewable and non-renewable energy resources rather than explicitly comparing compensative and management systems. There's a slight distinction between biomass (Bio) and incineration (Inc.) states, often likened to the recycling of cardboard. Landfilling tends to consume more biomass for heat production, while plastic recycling uses less fuel gas and oil in its manufacturing process, despite differences in area units being more pronounced and resulting in minimal waste exaggeration. All scenarios studied, except landfilling, depend on non-renewable energy sources like petroleum or gas for collection and transportation, with significant coal use for electricity generation, particularly in plastic treatment. Pakistan's economic development requires increased GDP, which necessitates a rise in renewable energy consumption (Shabbir et al., 2014).

Gas is utilized in the primary plastic manufacturing process, with renewable proportions being minimal across all scenarios except landfilling, where biomass increases energy usage and stands out among scenarios. Biomass is primarily used in combustion to produce primary cardboard and some upstream processes. Disparate of the scenarios of discussed above the waste has larger effect than the compensative system. Landfilling waste is a costly method due to the expenses incurred in managing real entities, primarily heat. Recycling plastic generally costs more compared to incineration, largely because of the higher costs associated with processed plastics. However, in the BioCar system, it tends to be slightly cheaper due to lower fuel costs. Waste management systems incur higher costs for waste collection and incineration. While collection methods do not vary significantly across scenarios, they have a greater economic impact than environmental implications. Incineration is costlier due to the burning of most waste, except in landfill scenarios. From an economic standpoint, incineration is more cost-effective than recycling options, particularly when anaerobic digestion of organic waste, which produces gas as a fuel, is avoided. In this study, emissions of NOx, volatile organic compounds, and metals were also taken into account. The findings indicate that landfilling waste is the most polluting scenario.

Recycling plastics has the least impact on volatile organic compounds. The compensative system primarily contributes through plastic manufacturing and vehicle fuel production. Significant emissions from petroleum engines contribute to higher emission rates across all Bio scenarios and landfills, with the compensative system outweighing waste management systems excluding BioBus. This method is preferable as it reduces system costs and resource consumption. Source reduction prevents waste at its origin by eliminating its entry into the waste stream. It also reduces material use in production, extends product lifespans, and promotes more efficient consumer use of materials. Material recovery involves collecting materials that could become waste, such as glass, aluminum, steel, plastic, and paper, and sorting and processing them to create new products. When recycled, these materials become new product feedstock instead of using virgin resources. The new products may or may not closely resemble the original, preventing items from ending up in landfills and conserving natural resources.

4. CONCLUSIONS

Managing solid waste presents significant challenges due to several factors. Firstly, the process involves complex sorting methods and mechanical expertise to effectively handle different types of waste materials. Moreover, the challenges in solid waste management extend beyond technical aspects. They encompass logistical issues such as transportation and disposal logistics, as well as environmental concerns related to pollution and greenhouse gas emissions. Additionally, social factors like public awareness and participation in waste reduction and recycling efforts play crucial roles in effective waste management strategies. These multifaceted challenges necessitate comprehensive approaches that integrate technological advancements with community engagement and sustainable practices. Previously, there was a lack of awareness and inadequate planning, compounded by the challenges posed by smaller administrative bodies responsible for managing waste in cities. This situation often led to inefficient waste management practices, including improper collection, sorting, transportation, and disposal of waste. As a result, urban areas faced significant issues related to environmental pollution, public health risks, and overall cleanliness. Effective waste management requires cohesive planning, adequate infrastructure, and proactive governance at all levels to ensure sustainable and environmentally responsible practices are implemented. In many cases, insufficient resources and a lack of trained personnel can hinder the progress of effective waste management systems. These challenges often manifest in inadequate equipment for waste collection and disposal, limited funding for infrastructure development, and a shortage of skilled workers trained in modern waste management practices. Addressing these issues typically requires investment in technology, capacity building, and education to improve the efficiency and sustainability of waste management efforts. Having accurate information about waste production, its characteristics, and the environmental impacts of landfill disposal is crucial for effective planning and management strategies in the future. Improved data collection and analysis can help policymakers and planners make informed decisions to mitigate environmental impacts and enhance waste management practices across the country. Implementing effective rules and strategies for solid waste management is crucial to advancing sustainable practices in Pakistan. By enforcing robust regulations, the country can significantly improve its waste management infrastructure, leading to environmental, social, and economic benefits. Improved waste management practices not only mitigate environmental pollution but also enhance public health outcomes by reducing exposure to hazardous materials. Moreover, efficient waste management can create economic opportunities through recycling and resource recovery, contributing to job creation and economic growth. Therefore, prioritizing upgraded solid waste management practices can yield multifaceted benefits for Pakistan's development and sustainability goals.

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