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Research Article

Waste Management Practices as Catalyst for Climate Change Mitigation and Environmental Sustainability

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ABSTRACT

In today's world, humans are exploiting Mother Earth to the fullest. It is necessary to foster awareness and infuse environmental consciousness amongst citizens. One of the simplest ways to achieve this is through imparting the knowledge of waste management practices. As climate change intensifies, waste management has emerged as a critical frontline in the battle against environmental degradation. Effective waste management practices have become a beacon of hope for mitigating climate change and promoting environmental sustainability. Harnessing the potential of waste reduction, recycling, and waste-to-energy technologies will significantly reduce greenhouse gas emissions, conserve natural resources, and promote sustainable environmental development. This paper, therefore, explores waste management practices as a catalyst for climate change mitigation and environmental sustainability. It cited that Climate change is indeed a menace ravaging the world, and that effective waste management practices are critical for mitigating the impacts associated with climate change to ensure environmental sustainability and balance the needs of humanity. The paper adopted a deductive approach, drawing on qualitative data from relevant existing reports on waste management, climate change, and environmental ethics. The paper thus recommended, among others, that Nigerians should be enlightened on proper waste disposal and other achievable practices to mitigate the impacts of climate change; necessary segregation techniques should be implemented to separate waste at source, collection, and the process of recycling, and communities should set up composting facilities to manage organic and other forms of waste as to promote sustainable environment.

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1 Introduction

The goal of the Man-Environment relationship is to reshape the environment to support sustainable development through an overarching educational process. In view of the extreme importance of the natural environment, the quest has always been to improve its quality. The conception of waste management practices is closely linked to climate change mitigation and environmental sustainability. Environmental sustainability is concerned with balancing human needs with those of the natural world. It implies making thoughtful decisions that will safeguard natural resources, ensuring they continue to thrive and support life on Earth for far into the future. The escalating challenge of waste management in Nigeria has significant implications for climate change mitigation and environmental sustainability. The country's rapid urbanization and population growth have led to increased waste generation, with the World Bank (2023) estimating that Nigeria generates over 32 million tons of waste annually.

The inadequate management of this waste has resulted in environmental pollution, health risks, and greenhouse gas emissions, thereby exacerbating climate change. Climate change is the set of activities by humans and nature that lead to the emission of billions of tons of CO_2 from industries and other sources. According to Siegel (2020) states that climate change is associated with extreme increases in temperature, air and water pollution, floods, droughts, irregular rainfall, health hazards, deforestation, desertification, forced migration, and displacement. Climate change, therefore, brings about changes in precipitation levels, a rise in sea level, and more frequent and intense weather events, which can threaten access to such basic needs as food, water, health, and shelter. It is a pressing global issue that requires immediate attention, and the severe impacts of global warming, which drives climate change, pose great threats to environmental sustainability (Ladan, 2021). These impacts are exacerbating existing challenges, including poverty, food insecurity, and water scarcity, across various parts of the country (Federal Ministry of Environment, 2023). Effective waste management practices are critical for mitigating these impacts. The adoption of practices such as waste reduction, recycling, and proper disposal can significantly reduce greenhouse gas emissions and other climate change impacts, and conserve natural resources.

However, Nigeria's waste management sector is characterized by inadequate infrastructure, insufficient policies, and limited community engagement. The country's waste management systems are often overwhelmed, leading to open dumping and burning of

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waste, which contributes to environmental pollution and the impacts of climate change (Ogbonna, 2022). To address these challenges, Nigeria needs to implement robust waste management policies, invest in advanced technologies, and engage communities in waste management initiatives. This can include developing waste-to-energy facilities, implementing waste-sorting and recycling programs, and promoting public awareness campaigns on proper waste disposal.

In the context of this study, fostering effective waste management practices is crucial for mitigating climate change and promoting environmental sustainability in Nigeria. This can indeed be achieved by adopting sustainable waste management strategies, which reduce greenhouse gas emissions, conserve natural resources, and promote sustainable development, ultimately contributing to national development goals and improving quality of life.

2 Conceptual Framework

2.1 Climate Change Mitigation

As the world grapples with the escalating climate crisis, it is becoming increasingly evident that its effects are far from equitable. While the entire planet is feeling the consequences of a warming climate, it is the low-income communities and developing countries that bear the heaviest burden (Marlon et al., 2022). From disrupted livelihoods to increased vulnerability to extreme weather events, these marginalized populations face a disproportionate impact from climate change that demands urgent attention and action.

According to the Sixth Assessment Report published by the Intergovernmental Panel for Climate Change (IPCC, 2023), the top 10% of income households, including a significant share in developed countries, emit more than 45% of the world's Green House Gases (GHGs), while those in the bottom 50% account for 15% at most. Similarly, the International Monetary Fund (IMF) links a country's GHG emissions to its wealth. The wealthiest countries represent only 16% of the world's population and emit almost 40% of global CO_2 emissions. In contrast, the poorest countries account for nearly 60% of the world's population but emit less than 15% of global emissions (IPCC, 2023). Mitigating the impacts of climate change, therefore, includes reducing the GHGs emitted from energy production and use (e.g., that reduces use of fossil fuels), and land use, and methods to mitigate warming, for example, by carbon sinks which remove emissions from the atmosphere through land-use or other (including artificial) mechanisms.

Climate change mitigation refers to actions that limit the emissions of greenhouse gases (GHGs) to the atmosphere and/or reduce their concentrations in the atmosphere. Dioha and Emodi (2018) opined that climate change mitigation strategies entail efforts to reduce or prevent the emission of greenhouse gases (GHGs) into the atmosphere, thereby limiting the extent of global warming and associated climate change impacts. Also, it involves cutting greenhouse gas emissions from major sources such as power plants, factories, cars, and farms (European Environment Agency, 2025). The goal of mitigation is to preserve a biosphere that can sustain human civilization and the complex of ecosystem services that surround and support it. This means reducing anthropogenic GHG emissions to net zero to limit warming. Effective mitigation strategies require an understanding of the mechanisms that underpin emissions, and the technical, policy, and societal options for influencing them.

Climate change mitigation efforts include, but are not limited to, proper and sustainable waste management, transitioning to renewable energy sources, enhancing energy efficiency, adopting regenerative agricultural practices, and protecting and restoring forests and critical ecosystems; waste management practices are the focus of this paper. Mitigating climate change implies reducing the flow of heat-trapping greenhouse gases into the atmosphere. Climate change mitigation requires actions by governments, businesses, or individuals to reduce or prevent greenhouse gas emissions or to enhance carbon sinks that remove them from the atmosphere. These gases trap heat from the sun in the planet's atmosphere, thereby keeping it warm.

Mitigating the impacts of the gases and other substances resulting from climate change involves sustainable land use, including practices such as reforestation, sustainable agriculture, and reducing deforestation. Dioha and Emodi (2018) observed that climate change mitigation strategies focus on a transition to renewable energy, shifting from fossil fuels to sources such as solar, wind, hydro, and geothermal. Mitigating climate change could reduce greenhouse gas emissions. In like manner, climate change mitigation can help preserve natural ecosystems and biodiversity through effective waste management practices.

2.2 Waste

The importance of effective waste management cannot be overstated in today's world. As the global population continues to grow, so does the amount of waste generated, posing significant environmental and health challenges. Waste, also known as rubbish, trash, refuse, garbage, junk, litter, is an unwanted or useless material (Ezerim & Agbo, 2018). In environmental science, waste is any unwanted substance or toxin expelled from living organisms, such as urea, sweat, or faeces. Adnane et al. (2021) posited that waste or litter is directly linked to human development, both technologically and socially. The compositions of different waste streams have varied over time and across locations, with industrial development and innovation

directly linked to the types of waste materials. Examples of this include plastics and nuclear technology. Some components of waste have economic value and can be properly managed or recycled once correctly recovered (Dehghani et al., 2008).

2.3 Waste Management

Waste management involves the processes of managing waste from cradle to grave. The term usually relates to materials produced by human activities and is generally undertaken to reduce their effects on health, the environment, or aesthetics. Waste management is the collection, transport, processing, recycling, or disposal, managing, and monitoring of waste materials (Ogbonna, 2022). Waste management can involve solid, liquid, gaseous, or radioactive waste, each requiring different methods and fields of expertise. According to Ogbonna (2022), waste management practices differ across developed and developing nations, urban and rural areas, and residential and industrial producers.

Waste management has evolved from the simple transportation of waste to landfills to complex systems that include waste prevention, recycling, and various treatment technologies. This is in response to the increasing quantity, complexity, and challenges in the composition of waste generated worldwide. In response to the challenge of waste management patterns and practices, San Juan (2019) found that individuals' participation in the solid waste management program depends on the actions taken by management and the heads of institutions and governments. Moreover, Al-Khatib et al. (2020) emphasized that solid waste management requires technical, political, legal, socio-cultural, environmental, and economic factors, as well as access to resources. The absence of any of the resources will make the solid waste management program fail.

Effective waste management and reduction practices are essential to mitigating the impacts of climate change and achieving a sustainable environment. However, the reality is that poor waste management and inadequate waste-reduction practices among humans pose significant environmental and health challenges. Also, improper waste management in the environment is leading to pollution, contamination of water sources, and the spread of communicable and infectious diseases like Hepatitis B, C, Measles, Acquired Immunodeficiency Syndrome, Tuberculosis, Chickenpox, Cholera, and others, which have been traced to the inappropriate management and disposal of environmental waste. Furthermore, the lack of effective waste management and reduction practices is contributing to the aesthetic degradation of the natural environment, which negatively impacts its overall setting. Without proper waste management and reduction strategies, climate change impacts risk compromising human and environmental health and safety, while undermining overall environmental sustainability, as mitigation practices can promote sustainable development (Dioha & Emodi, 2018).

Achieving environmental sustainability could also involve reducing gas flaring, as it accounts for the highest percentage of carbon dioxide (CO_2) emissions. It is important to control CO_2 emissions and other associated greenhouse gases by moving towards renewable energy development and implementing an energy-efficiency mechanism (Yahaya & Nwabuogo, 2016). Nigeria has abundant renewable energy resources but lacks adequate government support to harness them for electricity generation (Yahaya & Nwabuogo, 2016). The conversion of agricultural and municipal wastes into bioenergy can contribute to climate change mitigation and job creation. Mitigating the effects of climate change requires a multi-faceted approach involving various stakeholders, including students, school communities, government, civil society, and the private sector.

2.4 Nexus between Waste Management and Environmental Sustainability

Waste management is the need of the hour, given the soaring volume of waste generated by the growing population and economies in modern society. It is essential to protect the environment, public health, and quality of life. Benefits of waste management practices to the environment include, but are not limited to, protection of the environment and public health, conservation of natural resources, minimization of greenhouse gas emissions, creation of job opportunities, increased energy efficiency, and improved quality of life. The concept of a sustainable environment has thus been associated with environmental education, which aims to build awareness and knowledge of waste management practices to ensure that individuals adopt a culture of adequate management and wise use of environmental resources, with a focus on equity and durability.

Environmental sustainability, at its core, is the mindful usage of resources to meet current needs without compromising the ability of future generations to meet theirs. This involves safeguarding the natural world, ensuring that practices and habits, such as waste management, are essential to a healthy ecosystem, and making deliberate efforts to conserve and protect resources. Environmental sustainability also encompasses managing natural resources, conserving biodiversity, and controlling pollution to maintain a balance that ensures

that the Earth remains a prosperous home for all beings. A world where every action taken considers its impact on the environment, thereby ensuring vitality for all future generations. Within the framework of the international environmental education program, the United Nations Educational, Scientific, and Cultural Organization (UNESCO, 2005) proposed sustainable development as the goal of Man's relation with the environment. It is therefore suggested that learners be reoriented and that environmental education be reintegrated into the curriculum, thereby reshaping the entire educational process to meet this end. It is therefore worth noting the alignment of climate change actions, awareness, adaptation, and mitigation with the overall concept of environmental education for sustainability.

Sustainable development, as promoted by the World Commission on Environment and Development (WCED, 1987) and popularized by the Rio Conference (UNCED, 1992), has been successful in initiating a dialogue between the economic and environmental worlds. However, it is still subject to challenge and contestation (Disinger, 2021). Waste management practices are of prime importance for promoting environmental sustainability. It will ensure that people develop the competencies to address environmental issues; hence, proper waste management practices are closely associated with environmental sustainability.

This relationship, however, can be perceived in different ways. For some, environmental sustainability is an offshoot of a well-managed and protected environment, with waste management among its practices. As a result, waste management is expedient for a sustainable environment (Disinger, 2021). For others, a sustainable environment refers to specific objectives that should be incorporated into waste management studies within environmental education; therefore, they use the expression "education for the environment and sustainable development". According to the document proposed by UNESCO (1992) at the ECO-ED Conference, EE is just one of many thematic areas of education that contribute to the overall education for a sustainable environment. For others, the term environmental education implicitly includes knowledge and awareness of sustainable development in the environment.

3 Waste Management Practices for Climate Change Mitigation

3.1 Waste Prevention

Waste prevention is the most important method of all the other practices. So, before diving into this, it is crucial to track the amount of waste generated to prevent pollution. To prevent waste, Rakesh (2024) proposed using environmentally friendly manufacturing techniques, implementing chemical neutralization methods, adopting water-saving technologies, going paperless by being more digital, reducing single-use plastic, and donating useful items instead of trashing them.

3.2 Waste Reduction

When eliminating waste is not feasible in some cases, this strategy can minimize waste generation. This is considered the best option on the waste minimization ladder. It involves the least energy and raw material consumption. One essential aspect of solid waste management is minimizing generation. Other avoidance-related practices include reusing products, repairing broken products rather than buying new ones, and producing refillable or reusable products, such as plastic bags. Waste or source minimization is useful when the trends or products that may be causing waste-stream problems are identified. Waste can be reduced in industry by using less-hazardous alternative materials, reusing substances, or modifying design and processing components. Reducing the usage of waste material also minimizes manufacturing and disposal costs. This can be achieved through a variety of methods, including reducing consumption, reusing items, repairing and refurbishing items, and improving product packaging techniques to minimize waste. The International Committee of the Red Cross (2022) stated that the objective of waste reduction is to decrease the amount of urban and other waste that must be disposed of in landfills, incinerators, or other waste management facilities. Reducing waste can be facilitated by better packaging, the establishment of recycling programs, and large-scale composting programs.

3.3 Waste Recycling and Reusing

This approach is centered on eliminating the likelihood of waste generation in the first place. It can be done by reusing items as much as possible and recycling them when they reach the end of their useful life. Schliebs (2023) opined that recycling reduces greenhouse gas emissions by avoiding energy use to produce new materials. It also has the co-benefits of conserving natural resources, reducing waste sent to landfills and incinerators, and preventing land degradation that often accompanies the extraction of new raw materials such as metals. Metals such as steel and aluminum can be recycled repeatedly. Waste reuse practices suggest using the same materials for the same purpose again, rather than disposing of them. Reusing means finding new ways to use previously discarded materials (wood, glass, plastics, metals, textiles, cardboard, paper, leather, rubber, and ceramics) to produce further usable goods. This practice helps conserve natural resources and reduce the demand for new products. It is one of the key trends in the waste management industry. With higher usage of recycled

materials, the utilization of raw materials, and thereby greenhouse gas emissions, is reduced.

3.4 Incineration

Nigeria, with a population of over 200 million, generates approximately 33 Mt of municipal solid waste annually. Inefficient collection methods, insufficient coverage of the collection system, and improper disposal characterize the management of this waste. The management is generally based on co-mingled collection, transportation, and codisposal at designated open dumpsites, where there is no designated area for any waste category. In most cases, hazardous waste is mixed with municipal waste at dumpsites, where scavengers manually segregate resources from the waste. In areas where waste is not collected, it is dumped in undesignated locations and typically burned periodically to reduce its volume. At the designated dumpsites, open burning of waste occurs either due to intentional fires set by scavengers to reduce waste volume and recover valuable materials, or due to spontaneous combustion resulting from methane emissions from the anaerobic decomposition of organic materials and elevated temperatures. Waste incineration contributes to air pollution, and, like many other forms of air pollution, it seems that toxic fumes from incinerators are most likely to affect deprived areas and areas with high populations of people of colour. People living near incinerators complain of noise, litter, increased vehicle traffic, smells, and air pollution. As temperatures rise in the summer, the smell often gets worse, forcing people to close their windows and avoid sitting outside. To address open burning and other waste management issues, the Federal Government is promoting the implementation of the Integrated Waste Management Programme (IWMP) through Public-Private Partnerships (PPPs) in major cities nationwide. The IWMP programme includes key infrastructure such as materials recovery facilities, composting plants, incinerators where needed, landfill cells, a methane recovery system, a leachate treatment facility, and a plastic recycling plant.

3.5 Landfill Disposal

Landfilling involves burying solid waste in a well-designed and constructed landfill. It is the common practice in many developed nations. Landfilling is one of the most hygienic and cheapest methods of solid waste disposal. It could, however, still have adverse conditions as it ages or if the design and construction were poor. Some adverse environmental conditions include litter spread by wind, groundwater contamination from leachate, and rodent attraction. Another challenge of the landfill technique is the emission of methane and carbon dioxide, which contribute significantly to the greenhouse effect. Deshar and Koirala (2020) stated that methane can leak into the atmosphere, where it acts as a powerful greenhouse gas. Organic matter in a well-tended compost pile with access to oxygen will decompose aerobically, producing carbon dioxide rather than methane.

Another way to reduce greenhouse gas emissions from waste is to recover landfill gas. This technique focuses on capturing and utilizing methane generated by bacterial anaerobic decomposition of landfill waste. Over a few decades, a landfill gas recovery project can cut methane emissions from a landfill by 60 to 90% (Deshar & Koirala, 2020). The captured methane can be burned to produce heat or electricity, avoiding the use of fossil fuels for these needs. Although burning methane produces CO_2, CO_2 is a far less potent greenhouse gas than methane. A landfill gas recovery project that produces electricity can use some of the electricity to power the system and sell the rest to help pay for the required technology and infrastructure. A major concern with these types of systems is leaks and accidental methane releases into the air. These systems must be monitored, and leaks must be repaired quickly. Deshar and Koirala (2020) opined that another way to manage waste and reduce carbon emissions is through incineration, which generates heat and electricity and is often referred to as "waste-to-energy."

4 Conclusion

In the absence of an efficient waste management system in most Nigerian societies, solid waste is typically dumped in illegal, makeshift landfills, gathered in heaps and incinerated in situ, or abandoned along highways and at street corners. In contrast, others end up in open drains, nearby streams, and water channels, littering streets and clogging drainage channels. Sometimes, water leaches through the landfill, carrying contaminants into groundwater aquifers or adjacent water bodies, potentially entering the food chain or drinking water sources. Improper disposal of batteries and other hazardous chemical waste leads to the leaching of dioxins into the surrounding soil, contaminating it. In addition, burning organic waste on the open streets releases carcinogens into the atmosphere, which could potentially cause respiratory problems in humans.

Effective waste management is important for safeguarding human health and conserving natural resources in Nigeria. The study observed that, in addition to numerous climate change mitigation strategies, effective waste management practices such as waste reduction, recycling, reuse, and incineration can mitigate the devastating impacts of climate change and promote a sustainable environment. When people have sufficient

knowledge of various waste management practices and their environmental benefits, they will be motivated to consistently adopt these measures to protect and conserve the natural environment and its components for future generations.

Based on the findings of this study, the following recommendations were made:

i. Government, community leaders, and various stakeholders should come up with enlightenment campaigns and various means of environmental literacy in low-income neighborhoods through mass education and behavioral change campaigns on proper waste disposal and other achievable practices to mitigate the impacts of climate change.
ii. Government and relevant stakeholders should set up necessary segregation mechanisms to separate waste at source, collection, and before the process of recycling. This can be achieved by incentivizing and encouraging residents and scavengers to sort waste into compostable, recyclable, and non-biodegradable components.
iii. Communities should enforce anti-littering laws and crack down on indiscriminate waste dumping. This can be done through periodic sanitary inspections to enforce baseline environmental benchmarks across all neighborhoods.

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