ISRG Journal of Arts, Humanities and Social Sciences (ISRGJAHSS)

ISRG PUBLISHERS
Abbreviated Key Title: ISRG J Arts Humanit Soc Sci
ISSN: 2583-7672 (Online)
Journal homepage: https://isrgpublishers.com/isrgjahss
Volume – II Issue-IV (July – August) 2024
Frequency: Bimonthly

THE SOCIO-ENVIRONMENTAL IMPLICATIONS OF SOLOUS LANDFILL ON RESIDENTIAL DEVELOPMENT IN IGANDO, LAGOS

Enisan, O. F.[1*], Akinrogunde, O. O.[2], Oginni, O. E.[3] and Akinola, O. O.[4]

[1]Department of Urban and Regional Planning, Federal University of Technology, Akure, Nigeria
[2]Department of Urban and Regional Planning, Ogun State Institute of Technology, Igbesa, Nigeria
[3]Department of Architectural Technology, Ogun State Institute of Technology, Igbesa, Nigeria
[4]Department of Estate Management and Valuation, Ogun State Institute of Technology, Igbesa, Nigeria

| **Received:** 22.06.2024 | **Accepted:** 26.06.2024 | **Published:** 15.07.2024

*__Corresponding author:__ Enisan, O. F.
Department of Urban and Regional Planning, Federal University of Technology, Akure, Nigeria

Abstract

This study assessed the socio-environmental implications of Solous landfill on residential development in Igando, Lagos. The research examined the sociodemographic characteristics of residents residing within the range of 200-500 meters from the landfill, conducted an extensive evaluation of health and environmental risks in this context, examined the physical condition of residential buildings near the landfill, and explored the potential link between the duration of residence and residents' perceived health outcomes. To establish a robust empirical foundation, an extensive review of relevant literature was conducted. Both primary and secondary sources of data were employed, and the sampling methodology involved the purposive and stratified random selection of six prominent areas based on their proximity to the landfill sites and the prevalence of residential development. Out of the 105 questionnaires administered, 100 were successfully retrieved and became the basis for the ensuing analysis. The study's findings uncover significant environmental and health challenges faced by residents near the Solous landfill, encompassing issues such as flooding, water pollution, and diseases such as malaria. Furthermore, the research identifies structural damage to buildings located in close proximity to the landfill site. The Chi-Square test results (X2 cal. = 135.382, X2 tab. = 0.000) indicate a significant association between the duration of residence and residents' perceived health outcomes near the landfill. Therefore, far-reaching suggestions were proffered to address the escalating waste management challenges in Lagos State.

Keywords: *socio-environmental, residential development, landfill impact, waste management*

DOI: 10.5281/zenodo.12744029

1. INTRODUCTION

In developing nations, the challenge of selecting suitable municipal solid waste disposal sites arises due to the high generation of solid waste from residential and industrial areas, leading to significant environmental concerns (Kharlamova et al., 2016). Various waste management techniques, including landfilling, thermal treatment, biological treatment, and recycling, are employed to minimise environmental impact and align with local biophysical conditions and ecosystems. Economic and geomorphological factors of the region also need consideration. However, in many developing countries, local governments struggle to provide efficient services, resulting in widespread indiscriminate municipal solid waste dumping in undesignated areas like open dumps, exacerbating environmental pressures (Practical Action, 2006). Landfills, which include open dumps, secured or sanitary landfills, and controlled landfills, are seen as the most cost-effective means of final Municipal Solid Waste (MSW) disposal (Egun et al., 2016). Unfortunately, open dumps lack prescribed standards for refuse deposition (Gouveia & Prado, 2010), accumulating illegally dumped waste and debris, creating unsanitary environments detrimental to public health and urban residents. Waste management is a complex issue deeply intertwined with living standards, socio-economic factors, and cultural attributes (Olawoye et al., 2019). According to Huang (2008), solid waste can be categorised into eight distinct categories: residential, industrial, commercial, institutional, construction and demolition, municipal services, process-related, and agricultural waste. Solid waste, as defined by Huang (2008), consists of materials in solid or semi-solid forms originating from human and animal activities, often perceived as useless, unwanted, or potentially hazardous.

Globally, the issue of solid waste generation in megacities looms large, with an annual production of 1.3 billion tons, projected to increase to 2.2 billion tons by 2025. However, the waste generation rates vary considerably among cities, with Delhi producing 11,500 tons daily. Due to advanced eco-friendly incineration technologies, Tokyo, Seoul, and London generate waste at higher rates. In stark contrast, Lagos State in Nigeria, accommodating 22 million residents and ranking seventh globally in waste generation, grapples with a daily disposal of 13,000 tons and a collection rate of just 27.7%, leading to dire consequences such as environmental crises and public health risks. This deficiency in waste management is exacerbated by rapid population growth, as Lagos is projected to reach 40 million residents by 2020. The escalating waste generation in Lagos has strained infrastructure and services, contributing to environmental issues like Lassa fever outbreaks and recurrent flooding. Addressing this challenge is pivotal for the state's economic development, necessitating a robust waste management system to align with its burgeoning population and waste generation rates (Proshare, 2018; Oyekanmi, 2018).

The process of landfill siting is intricate, involving rigorous regulations and multifaceted criteria encompassing economic, environmental, and social factors (Adeoye & Okeleke, 2022). Economic considerations, such as proximity to transportation infrastructure and topography, bear significant weight as they influence initial development costs and ongoing operational expenses (Erkut and Moran, 1991, as cited in Adeoye and Okeleke, 2022). Environmental factors, including the distance to surface waters and reservoirs, are crucial due to their potential ecological impacts (Kontos et al., 2003). Furthermore, social and physical factors, such as proximity to residential, commercial, and industrial areas, play a pivotal role, given the "Not in my backyard" (NIMBY) and "Not in anyone's backyard" (NIABY) sentiments that influence landfill site selection (Chang et al., 2008). Meticulous and systematic procedures for identifying and selecting suitable landfill sites are imperative to mitigate environmental degradation and public opposition. A substantial body of literature underscores the adverse environmental consequences, public health concerns, socio-economic challenges, and heightened public resistance associated with unregulated municipal solid waste landfills (Bagchi, 1994; WHO, 2000; Aatamila et al., 2010; Ayub & Khan, 2011; Alanbari et al., 2014; Egun et al., 2015; Guler & Yomralioglu, 2017; Olawoye et al., 2019; Adeoye & Okeleke, 2022).

This study assumes a pivotal role in shaping future urban planning initiatives, addressing research gaps in comprehensively exploring the socio-economic and environmental consequences of residential neighbourhoods' proximity to landfills. Additionally, empirical investigations are needed to delve into the influence of spatial planning and land use policies on landfill selection and expansion concerning nearby residential development. Importantly, this study aligns with Sustainable Development Goal (SDG) 11, contributing to sustainable urban development and improved living conditions. It offers valuable insights to inform urban planning and policy decisions, promoting safer and more sustainable communities while addressing critical challenges in waste management, health, and property values.

The disposal of waste in depressions or closed mining areas in developing nations, exemplified by the situation in Lagos, Nigeria, poses significant health and environmental risks to nearby residential areas, as highlighted by Daskalopoulous et al. (1998) as cited in Aderemi & Falade (2012). These risks exacerbate the already formidable challenges in waste management faced by Nigerian urban areas, compounded by factors such as poverty, inadequate urban governance, and a lack of interdisciplinary approaches, resulting in strained infrastructure and public services and a threat to the well-being of both the population and the natural environment (Olawoye et al., 2019). To address these escalating waste management challenges, this research focuses on investigating the socio-economic and environmental consequences of landfills located near residential structures in Solous I & II, Igando, Lagos. The study involves analysing the socio-demographic characteristics of residents residing within 200-500 meters of the landfill site, evaluating health and environmental risks, assessing the condition of residential buildings in proximity to the landfill, and exploring the association between the duration of residence and residents' perceived health outcomes living close to the dump site.

1.1. Description of the study area

Igando, located in Lagos State, Nigeria, is characterized by its geographical coordinates at Latitude 6° 33' 00" and Longitude 3° 15' 00". It serves as a prominent landmark with the LASU-Isheri road and Igando bus stop. The community houses the Lagos State General Hospital. It is primarily inhabited by low-income individuals engaged in trading activities, particularly at the bustling market situated at the intersection of Igando-Ikotun Road and Lasu-Isheri Road. In contrast, the Soluos landfills, managed by the Lagos Waste Management Authority (LAWMA), are located in the eastern region of metropolitan Lagos within Alimosho Local Government. These landfills, including Soluos 1, Soluos 2, and the largest among them, Soluos 3, function as waste disposal sites,

DOI: 10.5281/zenodo.12744029

initially being borrow pits for lateritic soil and surrounded by residential areas. Notably, Soluos 3 is situated in close proximity to Igando General Hospital, separated only by perimeter fencing, with the linear settlement of Raimi Ajibowo Street lying in between (LAWMA, 2011; Olasokan & Toki, 2022).

Soluos 1 Landfill, spanning 7.5 hectares, is the oldest and commenced operations in 1993. It temporarily closed in 2006 without a final cap or cover and reopened in 2011. Its geographical coordinates are N06º 34. 307' latitude and E003º 15. 211' longitude. Soluos 2 Landfill, covering approximately 7.8 hectares and nearing full capacity, started operations in 2008, receiving an average of around 2,250 cubic meters of waste daily, with coordinates at N06º 34. 286', E003º 15. 146'. The largest Soluos 3 Landfill spans 12 hectares, also commencing operations in 2008, with an estimated daily waste volume of 2,250 cubic meters and located at N06º 33. 897', E003º 15. 082'. Soluos 3 is segmented into cells with access roads, and it is noteworthy that a government hospital adjoins it (LAWMA, 2011).

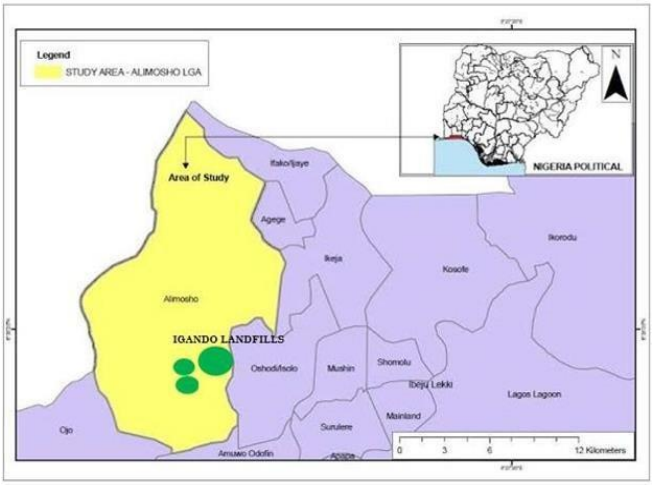

Figure 1: Showing the map of Solous landfill sites, Igando in Lagos State context

Source: Aliu (2021)

1.1. Adjoining land uses around Solous I and II landfill sites

Based on the research conducted by Adeoye and Okeleke (2022), it becomes apparent that the suitability of Solous I and II landfills in their current location is questionable. Adeoye & and Okeleke (2022) employed GIS and buffering operations to arrive at this conclusion. As illustrated in Figure 2 below, the nearest land use/cover to the landfills is the built-up area, which includes residential zones, markets, commercial establishments, and places of worship. The buffering operation reveals that the built-up areas are situated within a 200-meter radius of the landfills, rendering it an unsuitable location. The primary road in front of the landfill is less than 30 meters away, while the inlet behind it is situated between a 400 to 600-meter buffer zone. Based on these findings, it is evident that Solous I and II landfills are no longer appropriate for their current environment due to their proximity to sensitive land uses.

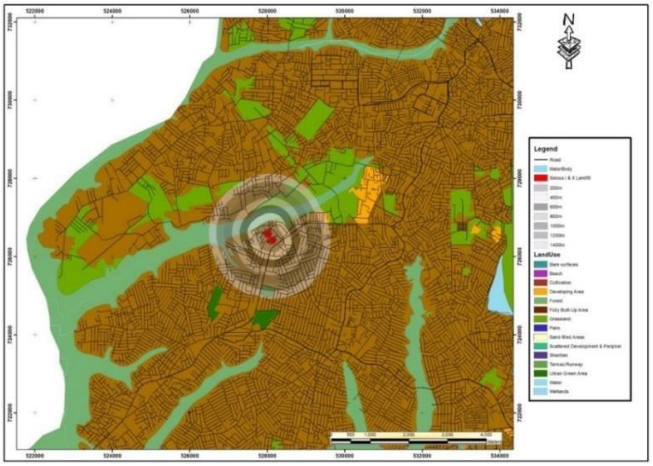

Figure 2: Land use surrounding Solous I and II landfill

Source: Adeoye & Okeleke (2022)

2. LITERATURE REVIEW & CONCEPTUAL FRAMEWORK

2.1. Literature review

Waste dumps or landfills are meticulously designed and constructed to minimize potential adverse effects and hazards, particularly groundwater contamination through leaching, on the surrounding areas. According to the Environmental Research Foundation (2011), a secure landfill is a carefully engineered depression in the ground (or constructed above the ground, resembling a football stadium) for depositing waste materials. The primary aim is to prevent any hydraulic connection between the waste and the surrounding environment, specifically groundwater. This landfill concept can be likened to a bathtub in the ground, and a double-lined landfill involves one "bathtub" inside another. There are three primary types of landfills: secured or sanitary landfills, controlled landfills, and open dumps. Secured or sanitary landfills feature substantial lining at the base to prevent infiltration by percolating liquids like leachate. In contrast, controlled landfills involve covering refuse with soil, while open dumps lack prescribed standards for refuse disposal (Gouveia & do Prado, 2010).

2.2. Environmental Protection Agency (EPA) landfill site selection criteria

Adeoye and Okeleke's study (2022) involved an assessment of the suitability of Solous I, II and III landfills using various measurements based on EPA landfill conformity criteria. The findings revealed that the distance from the landfill site to the Igando main road was 24.16 meters. From the Isheri Olofin road, it was 20.29 meters, indicating that these landfills were no longer appropriate for their current location. The closest water body to Solous landfills was measured at 530.41 meters away, classifying it as a moderately suitable location; however, EPA standards stipulate that a highly suitable landfill location should be positioned more than 960 meters away from any water body. The study concludes that Solous I, II and III landfills are unsuitable for the environment, particularly as urbanization has encroached upon their boundaries, resulting in nearby residential and commercial land uses. Despite the obnoxious odour from the landfill, residents in the area have seemingly adapted to the conditions, continuing their daily activities without complaints. Furthermore, while the gradients of Solous landfills range from 0.080 to 0.40, none meet EPA requirements for suitability. The only criterion met based on

DOI: 10.5281/zenodo.12744029

EPA requirements was the type of soil (Nitisols) on which the landfill was situated. In contrast, the underlying rock of Solous landfill sites, characterized as coastal plain sand, is unsuitable for the facility (Adeoye & Okeleke, 2022).

Table 1: Factor criteria formulated by EPA

Criteria	Least suitable	Moderately suitable	Highly suitable
Distance to water body	160 - 480m	480 - 960m	>960m
Slope	0^0-5^0	5^0-10^0	10^0-15^0
Distance to road	100- 1000m	1000- 2000m	>2000m
Distance to residential area	300-500m	500- 800m	>800m
Soil	Alluvial	Alisols	Nitisols
Geology	Sandstone, unconsolidated sandstone/ gravel, Quartzite	Migmatite-Gneiss complex	Charnock/Granite

Source: Landfill Manual (2006) in Adeoye & Okeleke (2022)

2.3. Environmental impact of landfill

Undoubtedly, landfills pose significant environmental challenges, impacting both the immediate vicinity and broader ecosystems. These waste disposal sites contribute to air pollution through the emission of methane and other greenhouse gases, exacerbating climate change concerns (Olawoye et al., 2019). Leachate, a toxic liquid formed as waste decomposes, can contaminate soil and groundwater, potentially affecting local water supplies and ecosystems. Moreover, Akinjare & Ayedun, 2011 acknowledged that 'landfills often lead to habitat destruction and biodiversity loss in surrounding areas. The presence of a landfill can also result in increased noise pollution, unpleasant odours, and visual blight, negatively affecting the quality of life for nearby residents (Olawoye et al., 2019). As urban areas expand, the environmental footprint of landfills becomes increasingly problematic, necessitating more sustainable waste management practices and improved landfill technologies to mitigate these impacts.

Landfills, integral to waste disposal, have raised environmental concerns due to their role in greenhouse gas emissions, notably carbon dioxide and methane. These emissions result from landfill degradation, posing a substantial environmental threat. Landfill pollution encompasses air, water, and soil pollution with complex inter-media impacts. Harmful gases like sulphur dioxide and nitrogen dioxide can lead to health problems when inhaled. Rainwater percolation through landfills can release toxic chemicals, affecting human health and aquatic ecosystems. Landfills are also significant sources of methane emissions, contributing to global warming, and can disrupt local biodiversity. Research in various regions has highlighted landfills' health and environmental impacts, emphasizing the need for improved management practices.

Despite the negative impact, landfills offer valuable resources but release toxic gases and leachate that can contaminate soil and water (Majolagbe et al., 2017). Rainfall can exacerbate these issues, emphasizing the importance of proper landfill management. The environmental impact of landfills varies based on location, management, and waste disposal methods. However, studies suggest controlled releases and re-utilization of waste, responsible landfill location, and a global shift toward recycling and sustainable waste disposal as potential solutions to mitigate landfill pollution and promote sustainable waste management practices (Araújo et al., 2018; Kazour et al., 2019; Brand & Spencer, 2019).

2.4. The potential hazards of residential buildings close to landfill

Building near or on landfill sites poses various potential hazards, including the production of landfill gas, chemical contamination of soil and groundwater, and land subsidence (Olawoye et al., 2019). These risks can significantly impact human health and structural integrity, necessitating careful consideration in urban planning and development processes. Landfill gas, mainly composed of methane and carbon dioxide, poses a significant risk due to its flammability, with even slow methane production leading to explosive gas concentrations, especially in confined spaces within buildings near landfills (Emberton & Parker, 1986). Furthermore, landfill gas can migrate laterally over significant distances if gas pressures within the waste are high or intentional gas withdrawal is practised, potentially resulting in landfill fires. While concerns exist regarding the toxicity of minor components in landfill gas, such as vinyl chloride, their concentrations typically dilute when released into the atmosphere, reducing risks to landfill workers and the public during or after redevelopment. The odorous nature of landfill gas varies depending on its composition, influenced by waste composition and bacterial communities in the landfill. However, it is generally not considered a significant problem on suitable redevelopment sites due to low gas production and high dilution factors (Stearns & Petoyan, 1984a).

Landfill sites present significant environmental challenges, as noted by Aderemi & Falade (2012), including the production of hazardous landfill gas, primarily methane and carbon dioxide, which can lead to explosive concentrations when ignited. There are also potential toxicity concerns from minor gas components. Chemical contamination of building materials, like concrete and metal, is a further issue, as acids, alkalis, and ions in landfill fluids and leachates can corrode these materials (USFA, 2002). Additionally, landfill fires release toxic pollutants into the air, water, and soil, posing health risks to firefighters and nearby residents. These fires, including those in the Soluos landfill sites, may result from spontaneous combustion, releasing hazardous chemicals like dioxins from burning tires, with potential carcinogenic and reproductive effects. Proper management and monitoring of landfill sites are crucial to mitigate these environmental and health hazards (2004; BRE, 1981; O'Brian, 1977).

DOI: 10.5281/zenodo.12744029

2.5. Health and social-economic impact of landfill

Landfills not only have significant environmental consequences but also pose socio-economic impacts, particularly on public health. Exposure to landfill gas and contamination of ground and surface water by landfill leachate can lead to health issues for individuals living and working near these sites. Research has shown that exposure to contaminants and emissions from landfills can occur through direct contact, inhalation, or ingestion of contaminated food and water, with drinking water contamination being a common source of exposure. This exposure has been linked to congenital malformations, low birth weight, prematurity, impaired child growth, and an increased risk of cancers, as demonstrated in studies conducted in regions such as New York State and Europe. For instance, in Ghana, research on landfill communities revealed a high prevalence of infectious diseases due to landfill site locations and management (Owusu-Sekyere et al., 2013a).

Moreover, studies have indicated an increased prevalence of health symptoms among residents near landfill sites, including fatigue, sleepiness, and headaches. Additionally, landfills negatively affect land values, land degradation, and land availability, reducing housing values and deterring potential homebuyers and residents due to hazards like flies, odours, smoke, noise, and threats to water supplies, as evidenced by several studies (Coffie, 2010; Goldberg et al., 1999; Reichert et al., 1992; Limoli et al., 2019). These socio-economic impacts underscore the necessity for proper landfill management and mitigation measures (Limoli et al., 2019).

Growing concerns about the health impacts of landfill mismanagement and pollution have emerged globally, exacerbated by urbanization and increased waste generation (Liu et al., 2016). Pollution from landfills, stemming from both human activities and natural forces, poses significant public health risks, particularly in densely populated urban-industrial areas of developed countries where polluted water sources may be used for irrigation, affecting food and living safety. These environmental health issues associated with landfill pollution encompass various problems, including infectious diseases like cancer, congenital disabilities, and respiratory conditions, underscoring the wide-ranging consequences of improper waste disposal practices (Assou et al., 2014; Kret et al., 2018).

From the socio-economic perspective, proximity to landfills has been found to impact property values negatively, with studies consistently showing a decrease in market values of residential properties as the distance from landfill sites decreases, reflecting the aversion of homebuyers and residents to living near these facilities (Akinjare & Ayedun, 2011; Ready, 2005). This trend is reinforced by a WHO report suggesting that potential exposure to landfill impacts is typically limited to a 1 km radius via the air pathway and 2 km via the water pathway (WHO, 2000). On a broader scale, communities perceiving landfills as health threats experience declining housing prices across the area, leading to a reduced tax base and diminished public services. Additionally, illegal landfilling poses significant health risks, particularly for nearby residents, with children being more vulnerable due to developing immune systems and increased outdoor activities. These health risks range from acute intoxication to more severe concerns like carcinogenicity, endocrine-related toxicity, and environmental pollution due to contaminant dissolution and gaseous emissions, further exacerbating environmental pollution. Hazardous waste materials in landfill environments pose substantial risks to living organisms (Limoli et al., 2019; WHO, 2000; Rachel et al., 2000).

2.6. Benefits of landfill site to residents

There is no doubt that landfill sites raise significant health and environmental concerns for nearby residents, they also hold economic benefits for specific groups, exemplified by the Solous landfill. It is deemed economically viable due to cost considerations, offering opportunities for scavengers who play a pivotal role in this context. Despite its illegality in areas like Solous, scavenging is a common practice in many developing countries, providing a source of livelihood for those involved. Scavengers, often residing in proximity to landfill sites, recover reusable and recyclable materials, not only boosting their income but also extending the landfill's lifespan and alleviating the pressure on urban land use. In Solous, predominantly male scavengers earn daily incomes ranging from ₦900 to ₦1,500 by collecting plastic and metal items from the landfill (see Fig. 3 and 4). To optimize the economic advantages while avoiding interference with regular landfill operations, it may be beneficial to organize and confine scavenging to specific designated areas within the landfill (AduBoahen, 2012; Oduro, 2004; Owusu-Sekyere et al., 2013b).

Figure 3. Scavengers on Solous II picking items

Figure 4. Food seller on Soluos I landfill

Source: Authors' Field work, 2024

DOI: 10.5281/zenodo.12744029

2.7. Conceptual framework

This study investigates the phenomenon of residential buildings located in close proximity to landfill sites, aiming to comprehend the reasons behind people's choice to reside near these sites despite the evident environmental and health challenges. The research is underpinned by the "Environmental Stress-Coping theory," which emphasizes the role of stress appraisal and coping mechanisms in dealing with environmental stressors. This theory, as identified by Olorunfemi (2009) and Olawoye et al. (2019), is closely intertwined with the literature on risk perception, focusing on the perceptual processes employed to evaluate the threats posed by environmental contaminants. The study also incorporates psychosocial impacts research, delving into the psychosocial consequences of exposure to environmental contaminants, with a particular focus on expanding our understanding of the scope of such research, drawing from the works of Lazarus & Folkman (1984), Taylor et al. (1993), and Elliott & Taylor (1996). This is based on the following:

i. the awareness and prevalence of psychosocial impacts of exposure;
ii. the relative absence of theory and empirical evidence to explain their determinants and
iii. uncertainty as to ways to intervene to reduce their adverse effects on individual and community well-being effectively.

Previous research has predominantly focused on the physical health consequences of exposure to environmental contaminants, such as cancer and adverse reproductive outcomes. However, there is an increasing recognition of the significance of investigating the psychosocial impacts of exposure, which encompass a multifaceted range of distress, dysfunction, and disability arising from actual or perceived environmental contamination (Baum et al., 1985; Elliott, 1998). Environmental stress, characterized as the process by which environmental events pose threats, harm, or challenges to an organism's well-being, and the organism's subsequent response to these stressors, plays a crucial role in understanding these psychosocial impacts (Baumann et al., 1985). Lazarus and Folkman's (1984) psychosocial model offers a valuable framework for comprehending individuals' reactions to environmental stressors, involving two stages: primary appraisal, where individuals perceive an environmental stressor as a threat, harm, or challenge, and secondary appraisal, whereby one of two coping strategies is selected:

i. Problem-focused coping (e.g., joining a citizens' action group) or
ii. Emotion-focused coping (e.g., adjusting attitudes towards the stressor).

Environmental stress, characterized by psychological effects and coping responses, is influenced by four mediating factors related to the stressor: the individual, the social network, and the broader community system. These factors interact and impact psychological reactions to environmental contamination, particularly in the context of waste disposal facilities. These reactions occur within community systems and are influenced by social and cultural factors specific to the study setting (Evans & Jacobs, 1982; Sims & Baumann, 1983; Edelstein, 1988; Elliott et al., 1993).

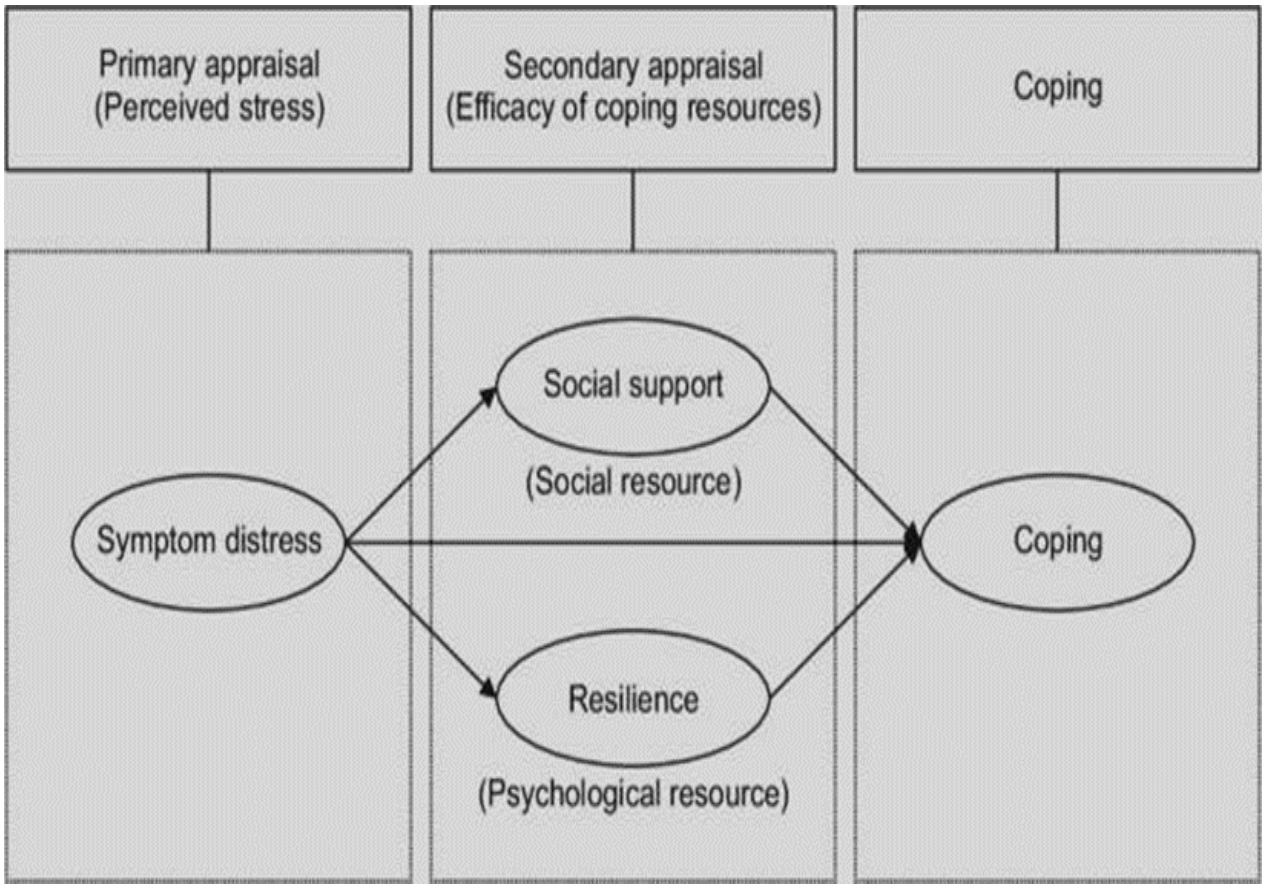

Figure 5. Stress-coping theory and hypothetical model

Source: Lazarus & Folkman (1984)

DOI: 10.5281/zenodo.12744029

3. MATERIALS AND METHODS

3.1. Research design and methods of data collection

This study employed both the primary and secondary data sources, focusing on households in the Igando area near the Solous landfill facilities. The sampling frame included buildings within 200m and 500m radii of the landfill sites, with a systematic random sampling method used to select respondents from various wards in the Igando area of Alimoso LGA, utilizing structured questionnaires administered at the household level. The researcher purposively selected six communities in the study area, with two communities near each landfill site (Solous I, II, and III), based on their proximity to the landfill sites and the prevalence of residential development. It is worth noting that the impact of such facilities typically extends within a range of one to five kilometres, beyond which the effects become negligible or imperceptible, as indicated by previous studies (Arimah, 1995; Arimah & Adinnu, 1990; Olokesusi, 1990; Elliott, 1993). The provided table details the selected areas within the 200m - 500m radius and estimates the retrieved questionnaires.

Table 2: The sampled areas and estimate of retrieved questionnaires

Sampled Area	Number of Residential buildings	10% of buildings (sample size)	Number of questionnaires administered	Number of questionnaires retrieved	Percentage of retrieved questionnaires
Shekooni Way	306	31	31	30	96.8
Oshindairo Community	114	11	11	10	91
Raimi Ajibowo	102	10	10	10	100
Agbe Road	156	16	16	15	93.8
Bamshakin Road	247	25	25	24	96
Babatunde Adeyinka Way	119	12	12	11	91.7
Total	1,044	105	105	100	95.2

Source: Authors' Field work, 2024

The study initiated the sampling process by identifying the total number of residential buildings located within the 200m to 500m radius of the landfill sites. A systematic sampling method was employed, beginning on each street from the second house, with a consistent interval of 5 houses between selections, leading to the random selection of one respondent per building for the interview. Impressively, 95.2% of the administered questionnaires, amounting to 100, were successfully retrieved from the respondents.

Respondents completed the questionnaires independently, with the researcher providing assistance to those who had no formal education or were struggling to understand the content. This approach ensures comprehensive data collection while accommodating varying literacy levels among participants, thus enhancing the validity and inclusivity of the study. The collected data underwent analysis, incorporating descriptive methods such as histogram representations and simple percentage tables, along with inferential statistics, including the Chi-Square (X^2) test, which assessed the null hypothesis (H_0) and alternative hypothesis (H_I) at a 95% confidence level, with the degrees of freedom (df) calculated as (N - K), where 'N' represents the total sample or cases and 'K' signifies the number of variables. The null hypothesis (H_0) would be rejected if the calculated Chi-Square value exceeded the critical value at a 95% confidence level.

4. RESULTS AND DISCUSSION

4.1. Demographic and socio-economic characteristics of respondents

This section examines the socio-demographic and economic profiles of individuals living near the Solous landfill sites in Igando. The analysis reveals a significant gender imbalance, with 68% of respondents being male and 32% female, which could influence community dynamics and perspectives on landfill site-related issues. The majority of respondents were household heads, enhancing the reliability of their provided information. Moreover, the distribution of marital status shows that 48% of respondents are married, 36% are single, 12% are divorced, and 4% are widowed, potentially affecting resource allocation, household dynamics, and community involvement in addressing landfill site-related concerns. A nuanced understanding of these demographics is essential for tailoring effective environmental policies, community engagement strategies, and mitigation initiatives that consider the distinct needs and perspectives of different segments within the affected population.

Table 3. Demographic attributes of respondents

Variable	Attribute Level	Frequency	Percentage
Gender	Male Female	68 32	68 32
	Total	**100**	**100**
	Single Married	36 48	36 48

DOI: 10.5281/zenodo.12744029

Marital Status	Divorced	12	12
	Widowed	4	4
	Total	**100**	**100**

Source: Authors' Field work, 2024

The analysis of respondents' age composition reveals a demographic pattern where the largest group consists of middle-aged residents aged 31-40 years, followed by those in the 20-30 years age bracket. Conversely, individuals aged 41 years and above form the smallest group, making up around 18% of the respondents. This profile indicates a prevalence of youth and middle-aged individuals, with a relatively small representation of older age groups, suggesting a high dependency ratio and potential pressure on essential facilities such as electricity, water supply, and housing. Moreover, from an environmental perspective, this demographic distribution implies a substantial generation of waste, as most respondents come from various households, contributing to solid waste generation, which can result in littered surroundings, groundwater contamination, and potential adverse health impacts on the population.

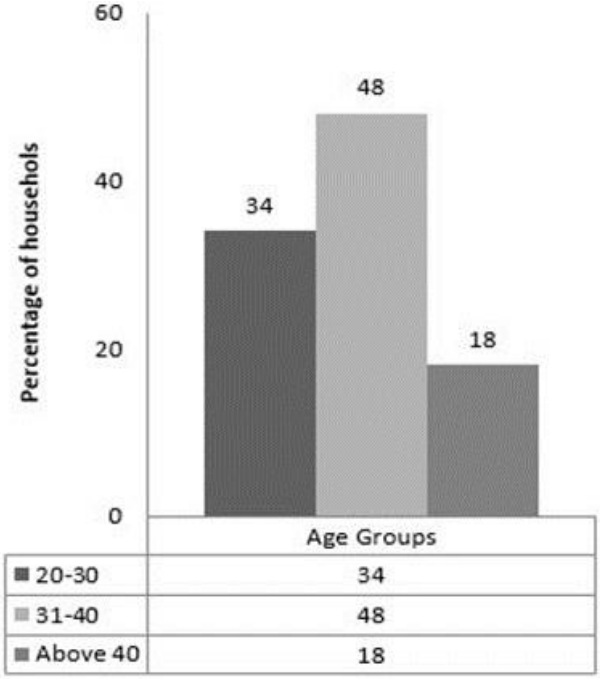

Figure 6: Age distribution of respondents

Source: Authors' Field work, 2024

Table 4 presents insights into the socio-economic characteristics of the respondents. The majority (66%) have received education up to the secondary level, with a significant portion (30%) having attained tertiary-level education, while a small percentage (4%) have had no formal education. These educational differences suggest varying levels of environmental awareness and potential for informed engagement. Moreover, with 68% of respondents being employed, there is a potentially higher financial capacity and more significant resources for active participation in addressing landfill site-related issues. Conversely, the 32% who are either unemployed or retired may face different constraints or have different priorities affecting their civic involvement. These findings underscore the importance of considering the diverse educational backgrounds and occupational statuses in developing effective environmental policies and community engagement strategies to address challenges associated with the Solous landfill sites in Igando, promoting inclusivity and comprehensiveness.

Table 4: Socio-economic attributes of respondents

Variable	Attribute Level	Frequency	Percentage
Educated	Educated to secondary level	66	68
	Educated to Tertiary Level	30	30
	No Formal	4	4
	Education **Total**	**100**	**100**
Occupation	Employed	68	68
	Unemployed /Retired	32	32
	Total	**100**	**100**

Source: Authors' Field work, 2024

Table 5 presents an analysis of the duration of respondents' residence near the Solous landfill site in Igando, providing insights into the community's temporal connection to the area. A significant portion, 21% of respondents, has resided in the area for over two decades, indicating a longstanding and potentially deeply rooted relationship with the neighbourhood. This group likely possesses extensive local knowledge and experience related to the environmental and socioeconomic implications of the landfill site. In contrast, the 16% who have lived in the area for 2 to 6 years may represent a more transient segment of the community, potentially bringing fresh perspectives and expectations. Additionally, the 18% residing for 7 to 11 years and the 14% residing for 12 to 16 years reflect varying degrees of community integration. This diversity in residency duration highlights the importance of acknowledging and accommodating the distinct perspectives and requirements of residents when developing effective environmental policies, community engagement strategies, and mitigation measures related to the Solous landfill site.

Table 5. Duration of residing in the area

Variable	Attribute Level	Frequency	Percentage
Period of residing in the area	Less than 2 years	8	8
	2 – 6 years	16	16
	7 – 11 years	18	18
	12 – 16 years	14	14
	17 – 21 years	23	23
	Above 21 years	21	21
	Total	**100**	**100**

Source: Authors' Field work, 2024

Within the socio-economic segment, the income levels of the respondents were also examined. Figure 9 illustrates that among the three categories, namely low-income, middle-income, and high-income earners, the majority fall within the middle-income bracket. In contrast, the high-income group is notably small in size. This demographic composition reveals that these communities

DOI: 10.5281/zenodo.12744029

primarily consist of middle-income residents, who may be relatively more susceptible to the adverse impacts of landfill pollution.

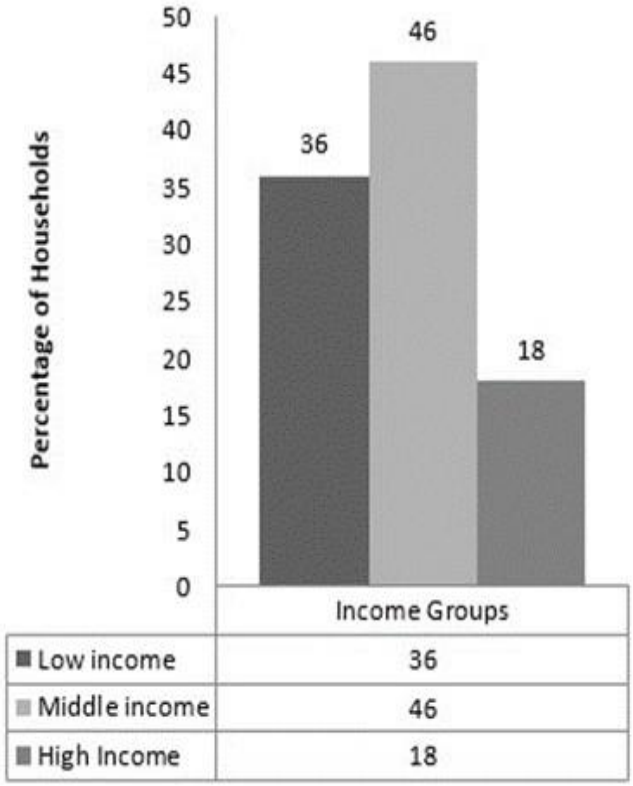

Figure 7: Income level of respondents

Source: Authors' Field work, 2024

4.2. Socio-environmental and Health effects of waste Landfills in Igando

The analysis in the table below reveals prevailing environmental concerns within the community near the Solous landfill site. The most significant concern, reported by 53% of respondents, is flooding, indicating the area's vulnerability to water-related hazards, potentially influenced by the presence of landfill sites. The absence of reported concerns related to fire incidents may suggest effective fire prevention measures or a lower likelihood of such events in the region. Moreover, 27% of respondents are troubled by water pollution, while 20% express concern about traffic noise, highlighting the multifaceted nature of environmental challenges faced by the community. These findings emphasize the need for a comprehensive and integrated approach to environmental management, addressing not only flooding but also issues related to water quality and noise pollution. These findings align with a previous study by Majolagbe et al. (2017), which highlighted detrimental effects on groundwater quality from leachate from the landfill.

Table 6. Socio-environmental effects of dumpsite

Variable	Attribute Level	Frequency	Percentage
Socio-environmental effects	Flood	53	53
	Fire	0	0
	Water pollution	27	27
	Traffic pollution	20	20
	Total	100	100

The analysis of respondents' perceptions regarding the health implications of dumpsites in the study area reveals prevalent health concerns within the community. Malaria, the foremost health issue with a significant majority of 58% of respondents expressing concern, is closely associated with dumpsites, indicating their potential role in providing breeding grounds for disease-carrying vectors, particularly mosquitoes. Typhoid, a concern for 29% of respondents, suggests that water source contamination may be a pressing issue near these dumpsites. Cholera, reported by 10% of respondents, further emphasizes the importance of water quality and sanitation measures in mitigating waterborne diseases. Despite its relatively lower percentage, the presence of dysentery at 3% underscores the multifaceted health risks posed by dumpsites. This analysis underscores the urgent need for robust waste management strategies, particularly for controlling vector-borne diseases and preventing water contamination. It also highlights the community's awareness of these health concerns, providing a basis for proactive community engagement and advocacy to address these critical issues effectively. These socio-environmental and health effects of dumpsites align with studies conducted in Nigeria and other parts of the world, which have empirically linked dumpsites to the occurrence of typhoid, cholera, and even child mortality.

Table 7. Socio-environmental effects of dumpsite

Variable	Attribute Level	Frequency	Percentage
Potential diseases	Malaria	58	58
	Typhoid	29	29
	Cholera	10	10
	Dysentery	3	3
	Total	**100**	**100**

Source: Authors' Field work, 2024

4.3. Impacts of waste dumpsites on residential conditions

The analysis of respondents' perceptions of dumpsite effects on buildings and their level of satisfaction with their place of residence provides insights into the living conditions in the study area. A significant majority (60%) of respondents perceive the impact of dumpsites on buildings as "Very High," indicating widespread concerns about potential structural and aesthetic damage within the community. This raises important questions about the long-term sustainability and safety of residential structures located in proximity to these dumpsites. In contrast, levels of satisfaction with their place of abode reveal a diverse range of experiences, with 23% expressing satisfaction and a substantial 31% reporting varying degrees of dissatisfaction. This suggests that while some residents are content with their living conditions, a notable segment faces challenges and concerns that affect their overall satisfaction with their place of residence. In essence, this analysis underscores the urgent need for comprehensive waste management strategies to mitigate structural impacts and the importance of community-focused initiatives to address diverse concerns and improve the overall quality of life for residents living near the dumpsites.

DOI: 10.5281/zenodo.12744029

Table 8: Dumpsite effects on building and the level of satisfaction of residents

Variable	Attribute Level	Frequency	Percentage
Dumpsite effects on buildings	Very High	60	60
	High	22	22
	Moderate	4	4
	Low	8	8
	Very low	6	6
	Total	**100**	**100**
Satisfaction derived	Highly satisfied	8	8
	Satisfied	12	12
	Fairly satisfied	15	15
	Unsatisfied	46	46
	Highly unsatisfied	19	19
	Total	**100**	**100**

Source: Authors' Field work, 2024

4.4. Hypothesis testing

A hypothesis was tested for veracity in the study, and it was on whether the level of diseases reported is related to the dumpsites in the area. Specifically, the hypothesis was expressed thus:

H_0: There is no significant association between the duration of residence and residents' perceived health outcomes living close to the dump site.

H_I: There is a significant association between the duration of residence and residents' perceived health outcomes living close to the dump site.

Table 9: Health outcomes of living close to the dumpsite and Duration of residence Crosstabulation

			Duration of residence				
	Less than 2 years	2 – 6 years	7 - 11 years	12 - 16 years	17 - 21 years	Above 21 years	Total
Health outcomes Malaria living close to the Typhoid dumpsite Cholera	8	16	18	14	2	0	58
	0	0	0	0	21	8	29
	0	0	0	0	0	10	10
Dysentery	0	0	0	0	0	3	3
Total	8	16	18	14	23	21	100

Source: Authors' Field work, 2024

Table 10: Chi-Square tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	135.382[a]	15	.000
Likelihood Ratio	146.530	15	.000
Linear-by-Linear Association	61.284	1	.000
N of Valid Cases	100		

a. 16 cells (66.7%) have expected count less than 5. The minimum expected count is .24.

Source: Field Survey, 2024

Decision rule: From the analysis in Table 10, since the calculated value, i.e., the 'p value', is lesser than the chosen significance level, i.e., the 'alpha value' ($\alpha = 0.05$), then the null hypothesis is rejected. Rather, it can be concluded that there is enough evidence to suggest an association between the duration of residence and residents' perceived health outcomes living close to the dump site. Thus, based on these results, it can be stated as follows:

i. The test statistics showed that at 0.05 level of significance (X^2 cal. = 135.382, X^2 tab. = 0.000). The test concluded that there is a significant association between the duration of residence and residents' perceived health outcomes living close to the dump site.

ii. The two variables were interdependent, and there was a significant statistical relationship between these categorical variables.

This indicates that residents in the study area have experienced various health issues, including malaria, typhoid fever, cholera, and dysentery, which can be attributed to the presence of dumpsites in the community. These findings align with existing research that has established a connection between waste dumpsites and the occurrence of epidemics such as dysentery, cholera, and cancer (Tomita et al., 2020; Ziraba et al., 2016; Przydatek & Kanownik, 2019; Mataloni et al., 2016).

5. CONCLUSION AND RECOMMENDATIONS

This study has offered valuable insights into the socio-economic and environmental implications of residential buildings located near the Solous landfill sites in Lagos State, Nigeria. The analysis has revealed residents' significant concerns regarding environmental issues, health risks, and structural impacts attributed to the landfill site's proximity. These concerns emphasize the urgent need for comprehensive waste management strategies to mitigate these adverse effects. Furthermore, residents' varying levels of satisfaction with their living conditions underscore the importance of community focused initiatives to address specific

DOI: 10.5281/zenodo.12744029

challenges and enhance overall well-being. The duration of residency also plays a pivotal role, highlighting the valuable local knowledge of long-term residents in guiding effective environmental management and community engagement strategies. In conclusion, this study underscores the necessity for collaborative efforts among governmental agencies, environmental organizations, and the local community to prioritize sustainable waste management practices and environmental sustainability to improve the living conditions of residents near the landfill site. To address these challenges and promote the well-being of residents in the area, the following recommendations are proposed:

i. Implement stringent waste disposal and management protocols to minimize environmental contamination and health risks.

ii. Invest in modern landfill site infrastructure, including lining, covering, and monitoring systems, to reduce the adverse impact on the environment.

iii. Launch community awareness campaigns to inform residents about the potential risks associated with the landfill site and educate them on proper waste disposal methods.

iv. Conduct regular workshops and seminars to empower residents with the knowledge and skills to mitigate environmental and health concerns.

v. Offer regular health check-ups and screenings to identify and address health issues linked to living near the landfill.

vi. Collaborate with relevant authorities to conduct structural assessments of residential buildings in the area and undertake necessary repairs or upgrades to ensure safety and resilience.

vii. Encourage residents to engage in advocacy efforts to influence local policies and demand government and environmental agency accountability.

viii. Initiate long-term environmental and health studies to continuously assess the impact of the landfill site and make data-driven decisions.

ix. Seek collaboration with relevant government agencies to ensure adherence to environmental regulations and standards in landfill operations.

x. Explore sustainable waste management alternatives such as recycling and composting to reduce the volume of waste sent to landfills.

REFERENCES

1. Aatamila, M., Verkasalo, P., Korhonen, M. J., Viluksela, M. K., Pasanen, K., Tittanen, P., and Vevalainen, A. (2010). Odour annoyance near waste treatment centres: A population- based study in Finland, *Journal of Air and Waste Management Association*, 60(3) 412-418.
2. Adeoye, N. O and Okeleke, C. C. (2022). Geospatial analysis of Lagos state landfill site suitability and multi-criteria spatial decision support system. *Journal of Geospatial Science and Technology* 3 (1). 36-56. doi: https://doi.org/10.54222/afrigist/jgst/v3i1.4.
3. Aderemi, A. O. and Falade, T. C. (2012). Environmental and health concerns associated with the open dumping of municipal solid waste: A Lagos, Nigeria experience. *American Journal of Environmental Engineering* 2(6), 160-165. DOI: 10.5923/j.ajee.20120206.03.
4. Alanbari, M. A., Al-Ansari, N., Jasim, H. K., & Knutsson, S. (2014). Modelling landfill suitability based on GIS and multi-criteria decision analysis: Case study in Al-Mahaweelqadaa. *Natural Science*, 6, 828-851.
5. Akinjare O. A, Ayedun C. A, Oluwatobi A. O and Iroham O. C, (2011). Impact of sanitary landfills on urban residential property value in Lagos State, Nigeria. www.ccsenet.org/jsd. *Journal of Sustainable Development*. 4(2). 129-132.
6. Aliu, I. R. (2021). Socio-environmental, residential and health effects of waste dumpsites in Igando Alimoso area of Lagos, Nigeria. *J. Appl. Sci. Environ. Manage*. 25 (6) 977-984.
7. Araújo Y. R. V, de Góis M. L, Junior L. M. C and Carvalho M. (2018). Carbon footprint associated with four disposal scenarios for urban pruning waste. *Environ Sci Pollut Res* 25,1863–1868.
8. Arimah, B, C. (1995). Willingness to Pay for Improved Environmental Sanitation in a Nigerian City. *Journal of Environmental Management.* 48(2) 127–138, https://doi.org/10.1006/jema.1996.0068.
9. Assou M., Madenzi A., Abdelkader A., Aboulhassan M. A, Souabi S. and Hafdi M. (2014). Reducing pollution of stabilized landfill leachate by mixing of coagulants and flocculants: A comparative study. *Int J Eng Innov Technol.* 4, 20–25.
10. Ayub, S. and Khan, A.H. (2011). Landfill practice in India: A review. *Journal of Chemical and Pharmaceutical Research.* 3(4), 270-279. ISSN No: 0975-7384, CODEN(USA): JCPRC5,
11. Bagchi, A. (1994). *Design, construction and monitoring of landfills*, 2nd Edition, John Wiley & Sons, Inc., New York.
12. Brand J. H. and Spencer K. L. (2019). Potential contamination of the coastal zone by eroding historic landflls. *Mar Pollut Bull* 146:282–291.
13. Champion V. L., Wagner L. I., Monahan P. O., Daggy J., Smith L., Cohee A. (2014). Comparison of younger and older breast cancer survivors and age-matched controls on specific and overall quality of life domains. 120(15), 2237-2246. Doi: https://doi.org/10.1002/cncr.28737.
14. Chang, N., Parvathinathanb, G., and Breden, J. B. (2008). Combining GIS with fuzzy multicriteria decision making for landfill siting in a fast-growing urban region, *Journal of Environmental Management*, 87, 139-153.
15. Coffie, F. M (2010). Landfill sites management challenges: The perceived effect and willingness on the part of the people in the GA East and South Municipalities to pay for improvement (Master's Thesis, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana). Retrieved from: http://www.udsspace.uds.edu.gh/bitstream/123456789/455/1/willingness. Retrieved On 05/09/2023.
16. Daskalopoulous E., Badr O. and Probert S. D (1998). An integrated approach to municipal solid waste management. *Resources, Conservation and Recycling*, 24(1). 33-50.

DOI: 10.5281/zenodo.12744029

17. Duffy, C. M., Allen, S. M., Clark, M. A. (2005). Discussions regarding reproductive health for young women with breast cancer undergoing chemotherapy. *Journal of Clinical Oncology.* 23(4):766-773. https://doi.org/10.1200/jco.2005.01.134.
18. Egbere, O. J., Itelima, J. U. and Opiah, F. O (2000). Municipal solid waste segregation and their health hazard implications in Agwan-Rogo ward of Jos, Plateau State. Nigeria. *Journal of Environmental Science* 4(1), 1-4.
19. Egun, N. K., Evbayiro, O. J. and Ukeko, A. O. (2015). Landfill site selection in Delta State Nigeria, *Journal of Global Ecology and Environment*, 3(1), 63-67.
20. Egun, N. K., Iniaghe, O. P. and Evbayiro, O. J. (2016). Assessment of landfill sites for solid waste management in Delta state, Nigeria. *Journal of Environment and Waste Management*, 3(1), 116 - 122.
21. Environment Protection Authority, (EPA) South Africa, (2009). Landfill gas and development near landfills–advice for planning authorities and developers. Waste information sheet. Environmental Protection Agency, Ireland (2009): Landfill Site Design.
22. Environmental Research Foundation, (2011). The basics of landfills: How they are constructed and why they fail, http://www.zerowasteamerica.org/BasicsofLandfills.htm, Accessed August 23, 2023.
23. Emberton, J. R., and A. Parker. (1987). The Problems Associated with Building on Landfill Sites. *Waste Management & Research.* 5(1), 473–482. https://doi.org/10.1177/0734242x8700500161. Accessed 11 July, 2023.
24. Erkut, E. and Moran, S.R. (1991). Locating obnoxious facilities in the public sector: An application of the hierarchy process to municipal landfill siting decisions. *Socio Economic Planning Sciences*, 25, 89-102.
25. Gouveia, N., and do Prado, R. R. (2010): Health risks in areas close to urban solid waste landfill sites. *Rev Saúde Pública.* 44(5), 1 – 8.
26. Goldberg, M. S., Siemiatyck, J., DeWar, R., Désy, M., & Riberdy, H. (1999): Risks of developing cancer relative to living near a municipal solid waste landfill site in Montreal, Quebec, Canada. *Arch of Environ Health.* 54(4), 291- 296.
27. Huang, Huang-jia, et al. (2008). Effect of growing watershed imperviousness on hydrograph parameters and peak discharge. *Hydrological Processes.* 22(13) 2075–2085. https://doi.org/10.1002/hyp.6807.
28. Kazour M., Terki S., Rabhi K., Jemaa S., Khalaf G. and Amara R. (2019). Sources of microplastics pollution in the marine environment: Importance of wastewater treatment plant and coastal landfill.*Mar Pollut Bull*. 146, 608–618.
29. Kharlamova M. D, Sheron Yeukai Mada and Grachev, V. A. (2016): Landfills: problems, solutions and decision making of waste disposal in Harare (Zimbabwe). *Biosciences Biotechnology Research Asia*, March 2016. Vol. 13(1), 307-318.
30. Kontos, T. D., Komilis, D. P. and Halvadakis, C.P. (2003). Siting MSW landfills on Lesvos Island with a GIS based methodology, *Waste Management & Research*, 21, 262-277.
31. Kret J., Dalidowitz Dame L., Tutlam N., DeClue R. W., Schmidt S., Donaldson K., Lewis R., Rigdon S. E, Davis S., Zelicof A., King C.,Wang Y., Patrick S. and Khan F. (2018) A respiratory health survey of a subsurface smouldering landfill. *Environ Res*, 166, 427–436.
32. Lagos State Waste Management Authority (LAWMA), (2011). Reports on Lagos dumpsites: Towards improvements.
33. Liu Y., Liu Y., Li H., Fu X., Guo H., Meng R., Lu W., Zhao M. and Wang H. (2016). Health risk impacts analysis of fugitive aromatic compounds emissions from the working face of a municipal solid waste landfill in China. *Environ Int*, 97, 15–27.
34. Limoli A., Garzia E., De Pretto A. and De Muri C. (2019). Illegal landfill in Italy (EU) – a multidisciplinary approach. *Environ Forensic*. 20, 26–38.
35. Lazarus R. S. and Folkman S. (1991). *Stress, appraisal, and coping.* 1st Engl. Ed. Kim JH, translator. Seoul: DaeKwang Moon Hwa Sa Publishing Co.; 1991. 46-206.
36. Majolagbe A., Oketola A., Osibanjo O., Adams A. and Ojuri O. (2017). Pollution vulnerability and health risk assessment of groundwater around an engineering Landfll in Lagos, Nigeria. *Chem Int.* 3, 58–68.
37. Olawoye, O. A., Akinola, O. O., Adeyemi, T. S., Oginni, O. E., Akande F. B. and Idris I. A. (2019). The socio-economic and environmental implications of residential buildings in proximate distance to landfill site. A case of Olusosun landfill, Ojota Lagos. *Journal of Environment and Earth Science* 9(6) 99 – 116. DOI: 10.7176/JEES.
38. Owusu-Sekyere E., Osumanu, I. K and Abdul- Kadri Y. (2013a). An analysis of the plastic waste collection and wealth linkages in Ghana. *International Journal of Current Research* 5(1), 205- 209.
39. Oyekanmi, J. (2018). *New face of waste management in Lagos (Clean Lagos Initiative)*. Current Affairs Directorate, Radio Lagos, Nigeria. (Audio record). Retrieved on 10th July, 2018.
40. Owusu-Sekyere, E., Osumanu, I. K., and Yaro, J. A. (2013b): Dompoase Landfill in the Kumasi Metropolitan Area of Ghana: A Blessing or a Curse? *Int. J. Cur. Tr. Res*, 2(1), 87-96.
41. Practical Action Nepal (2006). *Best practice on solid waste management of Nepalese cities.* Kathmandu: Practical Action Nepal.
42. Przydatek G. and Kanownik W. (2019). Impact of small municipal solid waste landfill on groundwater quality. *Environ Monit Assess*, 191, 169.
43. Tomita, A., Cuadros, D. F., Burns, J. K; Tanser, F. and Slotow, R. (2020). Exposure to waste sites and their impact on health: A panel and geo-spatial analysis of nationally representative data from South Africa, 2008-2015. *Lancet Planet Health, 4, e* 223-234.
44. USFA, United States Fire Administration (2002). Topical fire research series: Landfill fires, [Online] Available at: http://www.usfa.dhs.gov/download/pdf/tfrs/v1i18-508.pdf.
45. USFA, United States Fire Administration (2004). Landfill fires, their magnitude, characteristics and mitigation, Tri Data Approach to municipal solid waste management. *Resources, Conservation and Recycling*, 24 (1). 33-50.

DOI: 10.5281/zenodo.12744029

46. WHO (World Health Organisation) (2000). *Air quality guidelines for Europe*, WHO Regional Publication European Series, No. 91, World Health Organisation Regional Office for Europe, Copenhagen.
47. Ziraba, A. K., Haregu, T. N. and Mberu, B. (2016). A review and framework for understanding the potential impact of solid waste management on health in developing countries. *Arch Public Health*, 74: 55.

DOI: 10.5281/zenodo.12744029