Implications of Residential Buildings in Proximate Distance to the Haags Bosh Landfill Site

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Published in IJIRMPS (E-ISSN: 2349-7300), Volume 12, Issue 2, (March-April 2024)

Abstract

Twenty percent of the anthropogenic methane emissions worldwide originate from landfills. In addition, landfills typically contain a wide range of other gases, some of which are dangerous in low quantities. Through the liners' weaknesses, leachate can migrate to surface water or even groundwater, which is problematic because rehabilitating aquifers takes a long time. Landfill construction and operation have ecological repercussions that can result in altered landscapes, habitat loss, and fauna relocation. The socio-economic effects of landfills include the threats to public health posed by leachate-contaminated surface water or groundwater, the spread of litter into surrounding areas, and insufficient recycling efforts on the site. People typically list odors, noise, smoke, and annoyances like insects as reasons they are opposed to living near landfills. Numerous studies concluded that, depending on the actual distance from the landfill, home values are probably negatively impacted by landfills. In Guyana, several effects are reported due to the Haags Bosh Sanitary Landfill site being in the vicinity of residential and industrial areas. These include the spontaneous combustion of the landfill, which results in the suffering of inhabitants of neighboring settlements due to the heavy grey smoke polluting the atmosphere and the incidence of odour, noise, and dust pollution. Additionally, the lack of sorting of hazardous and recyclable materials results in the disposal of various kinds of waste in an environmentally unsafe way. Policies and regulations that support recycling, reusing, and minimizing waste need to be implemented, and extensive public consultations need to be done. Approaches for selecting the most appropriate solid waste disposal site need to be utilized.

Keywords: Landfill, Implications, Haags Bosh Sanitary Site, Landfill site, Proximate Distance

1. Introduction

A substantial quantity of waste continues to be landfilled even though the EU waste hierarchy, as laid out by the Waste Framework Directive (2008/98/EC), prioritizes reuse, recycling, and recovery of waste over landfilling (Crowley et al., 2003, as cited in Danthurebandara et al., 2012; Rahmat et al., 2017). The most popular technique for managing the disposal of solid, non-hazardous, and non-radioactive wastes is land filling. The process is essentially a biological waste management technique. Layers of the solid waste are distributed, compressed to the smallest practicable volume, and covered with material at the conclusion of each day. The landfill is constructed in what are known as "cell" units. The disposal facility is meticulously chosen, planned, built, and managed to safeguard the environment and general health of the public. Its advantages include ultimate disposal, flexible operation, and minimal cost. However, the drawbacks include the need for a sizable amount of land, and the potential for contaminants and hazardous metals to leak into groundwater (Narayanan, 2007, as mentioned in Mmom & Mbee, 2013). Since landfill disposal has been associated with a variety of community issues, starting with the construction stage, landfills frequently cause a hostile response from potential host communities (Cointreau, 2004 as cited in Rai & Singh, 2019). Choosing the best location for municipal solid waste disposal is one of the numerous issues facing developing nations today (Kharlamova et al., 2016, as cited in Olawoye et al., 2019).

It is a well-known fact that landfilling causes environmental effects, mainly due to long-term methane emissions and leachate production. It can also contain a large number of other gases at low concentrations, some of which are toxic (Crowley et al., 2003 as cited in Danthurebandara et al., 2012). The substances that are present in landfill gas are known to contribute to several environmental problems such as global warming, acidification, and depletion of the quality of ecosystems, as well as social issues like human health (Danthurebandara et al., 2012; see also Damgaard et al., 2011; Ready, 2005; Akinjare et al., 2001; EEA, 2000; Emery et al., 2007). Leachate production is also a major concern, as leachate can migrate to surface and groundwater. This is more serious than river pollution because aquifers require extensive time for rehabilitation (Crowley et al., 2003 as cited in Danthurebandara et al., 2012**)**. Landfill leachate may present significant concentrations of trace metals, nutrients such as nitrate and phosphate, ammonia, and chlorides. Apart from the environmental burdens, occupation and the requirement of enormous space for landfills may result in land scarcity for the development of human society and ecosystems. Moreover, landfills decrease the market value of the surrounding area (Danthurebandara et al., 2012; see also Ready, 2005; Akinjare et al., 2001). Substantial amounts of trace metals, nutrients like phosphate and nitrate, ammonia, and chlorides can be found in landfill leachate. In addition to the negative effects on the environment, the need for huge land areas for landfills creates a problem with land scarcity that hinders the advancement of human society and ecological systems.

Living in the proximity of a landfill poses a threat to the health of residents at risk due to pollution exposure via a variety of means, such as breathing in substances released by the site, coming into contact with contaminated water or soil, or consuming tainted food or water (Ifyalem & Jakada, 2023). Solid waste landfilling may also result in the growth of flies, rodents, and unpleasant odors. Litter could be released from the landfill if it is not adequately managed and monitored. Furthermore, the procedure of covering up and compacting solid waste with soil generates airborne dust that may pose a risk to nearby households and people around them (Akinjare et al., 2011). This article examines the impacts of landfills in the vicinity of housing areas, with special reference to the Haags Bosh sanitary site. It is also supplemented with steps for reducing the impacts caused by landfills.

2. Methodology

An extensive literature review was conducted utilizing credible sources such as government websites, newspapers, Science Direct, Research Gate, PubMed, Google Scholar, and Google General. The Google search results included a mix of grey literature and peer-reviewed articles. There was no time restriction on any of the searches. The review was conducted in order to ascertain the following: (1) The composition of landfill gas and leachate; (2) Concerns about exposure to landfill gas and to surface and ground water contaminated by leachate; (3) The effect of sanitary landfills on the cost of residential properties; (4) Issues associated with the Haags Bosh Sanitary Landfill Site in Guyana; (5) Steps for negating the impacts associated with landfill sites, with a special focus on the Haags Bosh Site.

3. Composition of Landfill Gas and Leachate

3.1. Landfill Gas

According to the EPA (2003 as reported in Danthurebandara et al., 2012), the biological breakdown of one ton of municipal solid waste should yield 442 m^3 of landfill gas, 55% of which is methane and has a calorific value of 15–21 MJ/m^3. This is roughly equivalent to fifty percent of natural gas. Methane (CH_4) and carbon dioxide (CO_2) make up the majority of landfill gas, with a wide range of other constituents present in trace amounts, including ammonia, sulfide, and volatile organic compounds (VOCs) (Crowley et al., 2003 as mentioned in Danthurebandara et al., 2012). New organic or inorganic molecules are produced by chemical and biological processes that occur in landfills; for example, amino acids can be converted to methyl and ethyl mercaptans, sulfur compounds can be converted to hydrogen sulfide (H_2S), and tri- and per-chlorethylene can become vinyl chloride. For these reasons, landfills may produce significant volumes of additional gaseous substances when they receive a substantial amount of certain kinds of industrial waste. For instance, H_2S emissions could result from a very high percentage of plasterboard (gypsum, $CaSO_4$) (Westlake, 1995 as mentioned in Danthurebandara et al., 2012). Benzene, toluene, vinyl chloride, carbon tetrachloride, chloroform, and 1,1,1 trichloroethane were among the 94 non-methane organic chemicals that the US EPA (1991) reported were present in air emissions from municipal solid waste landfills. Of these, 41 are halogenated substances. Landfills receiving both urban and industrial waste have been shown to contain toluene, xylenes, propylbenzenes, vinyl chloride, tetrachloroethylene, methanethiol, and methanol (O'Leary, P. and B., 1996 as cited in Danthurebandara et al., 2012). The 1997 Kyoto Agreement and subsequent attempts to reduce global emissions centered on two greenhouse gases: CH_4 and CO_2. According to Hutchinson et al. (1997 as stated in Danthurebandara et al., 2012), landfill sites account for 20% of all anthropogenic methane emissions worldwide.

If a source of ignition exists, an explosion may result when the air's methane concentration is between five and fifteen percent. In small areas, particularly in structures constructed on or near landfill sites, even a slow rate of methane production can cause explosive gas concentrations to build up. There are instances where the strata in which landfills are located are porous or contain bands of permeable material, which means that if the gas pressure within the waste is sufficiently high enough, landfill gas may migrate laterally. This type of migrating gas has been found over a distance of 400 meters from the landfill site (Stearns & Petoyan, 1984a as cited in Olawoye et al., 2019). Concerns regarding the possible toxicity of certain trace elements in landfill gas have surfaced lately. Typically, wells, either horizontal or vertical, are installed inside landfills to control landfill gas. These wells are either attached to a central blower system that extracts gas for a flare or other treatment procedure, or they are vented to the atmosphere. According to the Intergovernmental Panel on Climate Change (IPCC) assessment (2006), as reported in Danthurebandara et al. (2012), landfill gas collection efficiencies range from 9 to 90%, with a mean estimation of 20%. Because methane is a greenhouse gas and several of the volatile organic compounds (VOCs) are poisonous and odorous, the uncaptured gas may be dangerous to the environment (Danthurebandara et al., 2012).

3.2. Leachate

Any liquid released from or held in a landfill that seeps through the deposited waste is known as leachate. It takes up soluble and suspended materials that come from or are byproducts of the breakdown of waste when it seeps through it. Leachate's primary organic components are produced during the breakdown process, and their organic strength is typically expressed by way of total organic carbon (TOC), chemical oxygen demand (COD), or biochemical oxygen demand (BOD) (Crowley et al., 2003 as cited in Danthurebandara et al., 2012). Numerous harmful, poisonous, or cancer-causing chemical pollutants can be found in the leachate of municipal solid waste (European Environmental Agency, 2000 as referenced in Danthurebandara et al., 2012). Furthermore, residues from air pollution control equipment, sewage sludge, mining wastes, and residual solids include high levels of radioactive substances, various acids, and trace metals. Hazardous trace metals, including lead, copper, cadmium, and zinc, dissolve in acidic environments and migrate with leachate (Crowley et al., 2003 as quoted in Danthurebandara et al., 2012). Leachate production and properties vary greatly based on the waste composition, rates of precipitation, site hydrology, compaction, cover design, waste age, and leachate's interactions with the environment, as well as landfill layout and management. Leachate production and discharge must be controlled and managed since it poses a risk to human health as well as the environment, especially groundwater. All hazardous and non-hazardous landfill sites require an efficient leachate collection and removal system that remains operational for the duration of the landfill's design life (Danthurebandara et al., 2012).

4. Issues Associated with Exposure to Landfill Gas and Surface Water and Groundwater Contaminated by Leachate

4.1. Socioeconomic Effects

According to Danthurebandara et al. (2012), landfills can have a number of socioeconomic effects, including a negative impact on public health because of the gas released from the landfill and the contaminated ground and surface water caused by leachate. These are related to the occurrences of cancer (Ifyalem & Jakada, 2023; see also Porta et al., 2009; Mattiello et al., 2013; Geschwind et al., 1992 as cited in Danthurebandara et al., 2012); respiratory disorders and irritation (Ifyalem & Jakada, 2023; see also Porta et al., 2009; Mattiello et al., 2013); congenital malformations, prematurity, and child growth (Geschwind et al., 1992 as cited in Danthurebandara et al., 2012). Numerous studies found that living close to a landfill increases one's risk of being diagnosed with cancer of the trachea, bronchus, lung, cervix, stomach, liver, and intrahepatic bile ducts (Goldberg et al., 1995; 1999 as cited in Danthurebandara et al., 2012). Children born to families living within one mile of hazardous waste sites have a 12% higher incidence of congenital abnormalities, according to a multi-site survey of New York State residents (Geschwind et al., 1992 as quoted in Danthurebandara et al., 2012). Fielder (2000) and Vrijheid Dolk et al. (2002), as referenced in Danthurebandara et al. (2012), also discovered that communities living close to waste disposal sites have a higher incidence of congenital abnormalities. The findings of the United Kingdom study by Elliott et al. (2009) and the European EUROHAZCON study by Dolk et al. (1998 as quoted in Ifyalem & Jakada, 2023) are especially informative. Statistical analysis revealed higher likelihoods for all congenital malformations, neural tube defects, abdominal wall defects, surgical correction of exomphalos and gastroschisis, and low birth weight for babies born to residents within two kilometers of the sites, for both hazardous and non-hazardous waste. While there are a number of plausible explanations that are impossible to rule out, such as residual confounding and ascertainment bias, estimations of effects and their degree of confidence indicate that there is a higher chance of congenital anomalies as a result of landfills (Ifyalem & Jakada, 2023; see also Aatamila et al., 2011; Heaney et al., 2011). Dolk et al. (2001 as cited in Danthurebandara et al., 2012) and the multi-site European study (EUROHAZCON) found a 33 percent rise in non-chromosomal birth abnormalities for the population residing less than 3 kilometers of the 21 hazardous waste disposal sites evaluated. Elliott et al.'s (2001 as referenced in Danthurebandara et al., 2012) investigation supported this. Numerous studies have shown links between respiratory issues and exposure to odorous disposal sites, like landfills (Ifyalem & Jakada, 2023; see also Aatamila et al., 2011; Heaney et al., 2011).

4.2. Surface Water and Groundwater Contamination

Ineffective municipal waste disposal frequently leads to surface water and groundwater contamination. In drinking water contaminated by municipal solid waste, faecal coliform count levels up to 15.25 MPN/100 ml of water were reported by Karija et al. (2013 as cited in Ifyalem & Jakada (2023), contrary to the specified 0 MPN/100 ml of water (WHO, 1998, 2001 as cited in Ifyalem & Jakada, 2023; WHO, 2011). According to reports by Zurbrugg (2002 as mentioned in Ifyalem & Jakada, 2023), evidence exist that that human and animal excreta constitute components of municipal solid waste in poor nations. According to Karim et al. (2019 as cited in Ifyalem & Jakada, 2023), heavy metals from municipal solid waste, such as lead, cadmium, mercury, and arsenic, can pose substantial health risks to the population when they enter surface and groundwater. These heavy metals are frequently found in waste from sources such as paint and other lead-coated containers, batteries and cigarette stumps for cadmium, broken mercury thermometers and barometers, and containers containing arsenic insecticides and wood preservatives. Overall, heavy metals can have potentially fatal health effects. These effects can include headache, irritability, memory loss, reduced intellectual capacity, kidney damage (Ifyalem & Jakada, 2023; see also Karim et al., 2016, Mortada et al., 2001), liver disease (Hyder et al., 2013 as cited in Ifyalem & Jakada, 2023), and bioaccumulation that results in cancer (El-Safty, 2014 as cited in Ifyalem & Jakada, 2023).

4.3. Breeding Sites for Disease Vectors and Rodents

Rodent and insect vectors, which can transmit a range of diseases, can proliferate as a result of improper management of municipal solid waste, and if found in areas where people live, there is an increased risk to the public's health. Municipal solid waste landfills can either retain water or obstruct drainage systems, which causes water stagnation and can create breeding grounds for mosquitoes, resulting in the spread of malaria. An estimate of one million Africans die merely from malaria annually; the majority of these victims are young children (WHO, 2002 as mentioned in Ifyalem & Jakada, 2023). In addition, yellow fever and the dengue virus are spread by mosquitoes. Additionally, rodents from municipal solid waste sites have the ability to infiltrate neighboring homes, raising the possibility of diseases such as Lassa hemorrhagic fever. House flies from waste sites can enter nearby houses and spread a number of illnesses, including cholera when they are brought into contact with food (Ifyalem & Jakada, 2023). According to Olorunfemi's (2009), the influence of landfill-related nuisance elements decreases with increasing distance from the landfills.

4.4. Decrease in Property Prices

Landfills not only pose health risks, but they also negatively affect land availability and value. Numerous studies have concluded that landfills probably have a negative impact on property values based on their physical distance apart (Danthurebandara et al., 2012; see also Ready, 2005; Akinjare, et al., 2011; Reichert et al., 1992). There is a negative correlation between residential property prices and landfill vicinity, according to research on the effects of sanitary landfills on residential properties. The findings indicate that residential homes located within a six-kilometer radius of landfill site experience an increase in value between five and seven percent for every 1.6 kilometers. It is difficult to notice changes for homes farther than 6 kilometers from landfills. However, the closer a property is to a landfill site — that is, within a 400 to 800 m radius — the more drastically its value declines (between 21 and 30 percent). Some recently conducted research has not discovered any statistically significant correlation between home values and the location of modern landfills (Akinjare et al., 2011). According to research by Reichert et al. (1992, as cited in Danthurebandara et al., 2012), the impact of landfills on market value might range from 5.5 to 7.3%, depending on the proximity to the landfill.

A meta-analysis of all available hedonic price studies of the effect of landfills on surrounding property values was carried out. Research indicated that the value of a nearby property is diminished by 12.9% by large-volume landfills (500 tons or more per day), but only by 2.5% by low-volume landfills. Moreover, the utilization of vast areas for landfills exacerbates the scarcity of land needed for the growth of ecosystems and human society (Ready, 2005 as cited in Danthurebandara et al., 2012). According to a WHO report, the likelihood of exposure to landfill sites is expected to be restricted to 1 km by air and 2 km by water (WHO, 2000, as mentioned in Olawoye et al., 2019). It was noted that if residents believe that the landfill presents a risk, the home values in the community as a whole could possibly decline, which equates to a reduced tax base and subsequently results in a lower standard of service in those places (Rachel et al., 2000, as cited in Olawoye et al., 2019).

Mmom and Mbee (2013) sampled 2000 properties within a 500-metre radius of landfill sites for their study and around 600 property owners and agents, representing 30% of all real estate owners. The study found that properties adjacent to landfills were underpriced. In most circumstances, individuals were unwilling to reside in or purchase property near landfills. As a result, property owners near open pits are afraid of expansion because they fear the pits may turn into landfills. Similarly, people were afraid to rent houses near landfills, depressing the value of such real estate.

Bello (2007 as cited in Akinjare et al., 2011) conducted multiple regression analysis to estimate the impact of landfills on the value of properties in the Olusosun area of Ojota, Lagos State. From the investigations, it was discovered that property prices increased the further you moved away from dumpsites. Bello and Bello (2008) carried out research on Akure, Nigeria, residents' "willingness to pay" for environmental facilities such as waste water disposal, water and energy supply, neighborhood roadways, as well as additional locational services. The study employed a two-staged hedonic model to investigate residents' willingness to pay for improved environmental services in two Akure areas. A combination of multiple regressions and predictive model were used to calculate property prices as a function of housing features, as well as a logistic model to estimate willingness to pay. The study found that the income of households, the distance from landfill sites, and the consistency of electricity supply are the most vital considerations influencing families' inclination to pay for improved environmental services.

Bouvier et al. (2000 as cited in Akinjare et al., 2011) performed hedonic regression for dwellings close to six landfills in Central and Western Massachusetts, two of which were open and operational during the investigation time. The size, status of operation, and history of waste accumulation varied among the six landfills. The small sample size has brought a certain level of inaccuracy to the results reported. The investigation did, however, find an empirical link between the value of housing and its proximity to a landfill or a group of landfills.

Adewusi and Onifade (2006 as stated in Akinjare et al., 2011), investigated the impact of urban solid waste on the physical environment and property transactions in Surulere, Lagos State. The study revealed that rentals paid on homes adjacent to refuse dumpsites were lower than on equivalent properties a greater distance away, and property transaction rates were extremely low and unappealing as one approached a dumpsite. However, the study did not provide monetary information on the corresponding shift in values.

Akinjare et al. (2011) used a sample size of 2,341 people to investigate the effects of four operational sanitary landfills (Gbagada, Olusosun, Abule-Egba, and Solous) on nearby residences in the Nigerian metropolis of Lagos. Data for the research was submitted by 315 personnel from the Lagos State Waste Management Agency (LAWMA) and 229 estate surveyors. Data from the questionnaires were evaluated employing a hedonistically derived regression function, and the results indicated a slight statistically significant increase for all residential property values farther from the landfill sites, with an average of 6% for all four landfills. Based on available data, properties located between 601 and 900 meters away from the landfill had the highest property values. Properties located outside of the 900-meter concentric ring were not in danger from the landfill.

Ijasan et al.'s (2012) investigation on the depressionary effect of residential property closeness to waste disposal sites in Nigeria supports earlier studies findings that residential property value is negatively impacted by proximity to landfill facilities.

The goal of the Ham et al. (2013) study was to determine how Birmingham's historic and active landfill sites affected real estate values. According to their research, prices might be lowered by 2.6% over a 28.3 km^2 area, or within 3 km. According to the study, landfill size has a significant role in determining the total impact on the community. Furthermore, they noted that homes located further away from a landfill may be impacted by wind-blown debris and smells, which allowed for a follow-up study on landfill's directional effects.

Owusu et al. (2014) used the Oblogo and Mallam landfills in Accra as a case study to investigate the impacts of landfills on residential property values in Ghana. According to their research, landfills do lower the value of neighboring residential properties, but the impacts vary depending on the geographical position of the property, the degree of urbanization in the area, the year the construction was completed, and the overall cost of the project.

In their study on appropriate landfill location choice employing GIS-based multi-criteria decision analysis and evaluation in Robe town, Ethiopia, Balew et al. (2022) mentioned that the EPA in 2003 recommended that there should be a minimum of a 500-meter buffer zone between landfill sites and urban residential and commercial areas. Residents near landfills are more likely to experience landfill-related illnesses (Dasgpta 2014 as referenced in Balew et al., 2022). Landfills must be situated within 10 kilometers of an urban area but not within 500 meters, according to Demesouka et al. (2014, as referenced in Balew et al., 2022).

Abhyanka et al. (2023) collected data from 102 developers selling residential projects that lie within a radius of 15 km (approximately 9.32 mi) of a landfill site called "Uruli Devachi" in the Pune area using an exploratory and a case study approach. One-way ANOVA, ordinary least squares (OLS) regression, and basic descriptive statistics were utilized to examine the collected data. Correlation between residential property offer value and distance from the landfill site was found using the OLS regression. According to the research, offer values for residential properties are negatively impacted by landfill sites, and the impact is worse when the landfill is closer to the residence. The adverse impact seems to disappear when the distance increases to more than 10 km (about 6.21 mi).

5. Haags Bosh Sanitary Landfill

BK International and Puran Brothers Disposal Services were contracted in 2010 to build and operate the Haags Bosh Sanitary Landfill (Kaiteur News, December 30, 2015) with support for its construction provided by the IDB (Guyana Chronicle, March 21, 2021). This landfill site is situated behind Eccles, a housing scheme created for middle-class and upper-class families and has attracted several prestigious industrial enterprises, and is regarded as one of the fastest developing communities in Guyana. Haags Bosh landfill is the largest in Guyana, accepting waste from both residential and commercial sources. The Guyana Chronicle (March 21, 2021) reported that at the end of 2015, it received 300 tonnes of solid waste from 15 Neighborhood Democratic Councils (NDC) and Capital City Georgetown, even though it was designed to handle 150 tonnes of solid waste. Kaiteur News (December 02, 2021) reported that, with a total size of 6.5 hectares (16 acres), each cell at the landfill site can hold waste for ten years. As of late, the landfill receives about 500 tonnes of waste per day, which includes about 30 to 35 tonnes per day of residual waste produced by Esso Exploration and Production Guyana Limited (EEPGL) projects. The first cell, known as Cell 1, began receiving waste in 2011, and Cell 2 began operations in March 2021. It was mentioned that the amount of waste sent to the HBL will rise in the future due to anticipated increases in offshore activities and possible growth in other commercial and industrial sectors. "In addition to being specifically designed to safely contain waste and leachate, the Haags Bosch waste management system's operation and design also lessen the likelihood of pests and unpleasant odors." (Kaiteur News, December 02, 2021).

5.1. Impacts of the Haags Bosh Sanitary Landfill

Some of the impacts associated with the site are noted below as reported by several news media outlets.

Kaiteur News reported on December 30, 2015, the spontaneous combustion of the Haags Bosh Landfill that occurred on December 27, 2015, resulting in the closure of several areas of the Haags Bosh site and affecting the inhabitants of neighboring settlements due to the heavy grey smoke polluting the atmosphere. Garbage trucks were instantly diverted to the Lusignan dumpsite on East Coast Demerara. Stearns and Petoyan (1984a, as cited in Olawoye et al., 2019) stated that an explosion could take place if the methane content in the air is between five and fifteen percent and there is a source of ignition. Even low methane production rates in small areas, particularly in structures built on or near landfill sites, can result in explosive gas concentrations.

On February 1, 2024, News Room reported that the stench originating from the landfill site, which was negatively impacting residents of housing schemes and industrial areas in the proximity of the Eccles, was a topic of Parliamentary discussion. According to Stearns & Petoyan (1984a, quoted in Olawoye et al., 2019), odors are caused by the amount of odorous chemicals in the gas, including esters and organosulphurs. These will vary depending on the type of waste, age, and microorganism makeup. Ifyalem & Jakada (2023; see also Aatamila et al., 2011; Heaney et al., 2011) noted that several studies have shown connections between respiratory issues and exposure to odorous disposal sites, like landfills.

Residents of Eccles raised a number of critical issues during a meeting with the facility's consultant and representatives from the Ministry of Local Government, according to a report published in Stabroek News on June 19, 2013, about air, noise, and dust pollution from the Haags Bosch sanitary landfill site. The consultation was convened to tackle significant concerns and problems pertaining to the landfill. A local claimed that the area directly around the landfill site is a business district, and people who frequent the site on a daily basis find it quite unpleasant because of the facility's stench, which is blown by the wind. According to the consultant, the buffer zone was originally intended to be two kilometers in size. However, a new development effort launched by the Ministry of Housing resulted in a reduction of the buffer zone to about 500 meters. It should be noted that a high likelihood exists that prices for properties in close proximity to the Haags Bosh site can be negatively impacted, as indicated by several studies done in other countries, such as studies by Abhyanka et al. (2023), Akinjare et al. (2011), Balew et al. (2022), Danthurebandara et al. (2012), Ham et al. (2013), Ijasan et al. (2012), Mmom and Mbee (2013), Olawoye et al. (2019), Owusu et al. (2014) and others. Currently, the landfill receives about 500 tonnes of waste per day. Studies indicate that the value of a nearby property is diminished by 12.9% by large volume landfills (500 tons or more per day), but only by 2.5% by low volume landfills (Ready 2005 as cited in Danthurebandara et al., 2012).

Figure 1: Thick smoke emanating from the Haags Bosch Sanitary Landfill Site at Eccles, East Bank Demerara (Adopted from Kaiteur News, Dec 30, 2015)

There are various developments relating to the HBL that could have an impact on subsequent operations; new housing, commercial, and industrial buildings continue to be built in Eccles near the landfill site. Furthermore, landfills and housing developments are generally seen as incompatible land uses due to the possible pollution caused by odors, traffic, and smoke from fires. At HBL, the closest residences are now 500 meters away, and further along, the newly constructed Heroes Highway acts as a primary connector to the East Bank-East Coast Road Linkage Project. The new roads are designed to provide access to homes as well as economic operations in originally inaccessible places. It was further stated that the additional roadways would result in more traffic in the area. As a result, "these competing land uses and expansion of residential and commercial areas create uncertainty as to whether the HBL will be a sustainable landfill location in the future." According to Esso Exploration and Production Guyana Limited (EEPGL), "consequently, new landfill development in the region may be appropriate for consideration going forward" (Kaiteur News, December 2, 2021). The intensive use of land for landfills exacerbates the scarcity of suitable land for social and environmental development (Ready 2005, as cited in Danthurebandara et al., 2012). It should also be mentioned that Guyanese are not accustomed to sorting their waste, resulting in the combination of hazardous waste and recyclable materials, resulting in the disposal of waste in an environmentally unfriendly manner.

6. Steps for Reducing the Impacts caused by Landfills Site in Proximate Distance to Residential Buildings

One of the key steps in solid waste management (SWM) in developed nations is locating suitable sites for solid waste disposal. Determining a landfill site, for instance, is a laborious procedure that necessitates extensive public and government involvement in North America and Europe. The design of the facility, the influence on the environment, and the support and values of the community are all important considerations when it comes to the success of landfill sites (Zeiss and Lefsrud, 1996 as cited in Al-Khatib et al. 2015). A successful site selection process generally fulfills a number of objectives: (1) reducing public health risks; (2) limiting the impact on the environment; (3) maximization of service levels for facility users; and (4) reducing facility user costs (McBean et al., 1995 as cited in Al-Khatib et al., 2015). A suitable evaluation process must be in place for the selection of an approved landfill site (Cao et al., 2006 as referenced in Al-Khatib et al., 2015). These aspects include social, political, and environmental (geological, hydrological, and ecological). Every important component and criterion needs to be outlined and examined closely. "Groundwater depth, surface water proximity, elevation, land slope, soil permeability, soil stability, flooding susceptibility, lithology and stratification, faults, land use type, nearby settlements and urbanization, proximity to cultural and protected sites, wind direction, roads, railways, proximity to building materials, pipelines and powerlines, and proximity to airports" are among the most commonly considered factors when choosing a landfill site, according to Rahmat et al. (2017). See figure 2 for a ranked scheme for landfill site selection decision processes adopted from Kareem et al. (2021).

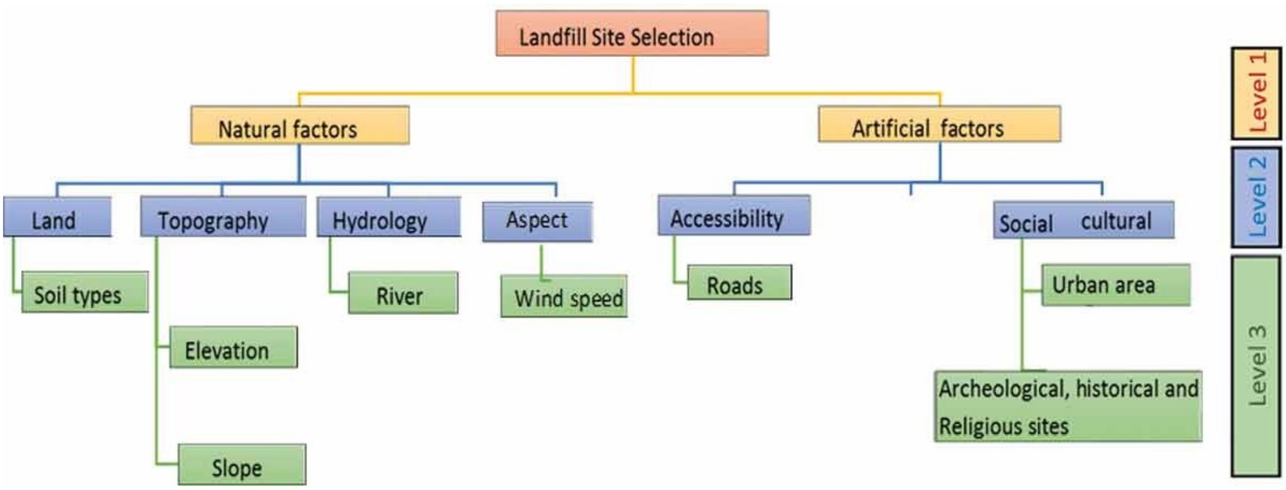

Figure 2: Ranked scheme for landfill site selection decision processes (Adopted from Kareem et al., 2021)

Geographical Information System (GIS) appears as a powerful tool for initial assessment of landfill site selection because it is capable of dealing with enormous spatial datasets. Multiple-Criteria Decision Analysis (MCDA) is used to give relative relevance to criteria, and overlay analysis is performed on criterion maps to identify appropriate locations. Various GIS tools and MCDA approaches are available to help identify suitable landfill locations (Chandel, 2024). Remote sensing and geographic information systems (GIS) can be used to choose the location of a waste disposal site (Anifowose et al., 2011). They noted that a number of other studies have taken into account GIS as a research tool in the evaluation process for choosing appropriate locations for landfill development. In Beijing, China, Wang et al. (2009 as referenced in Ayaim et al., 2019) used spatial technology and the analytical hierarchy process (AHP) to identify potential landfill locations. Their findings included the best, good, and inappropriate locations for landfill construction. When choosing appropriate locations, the real conditions of the site were taken into account, and criteria weightings were calculated using the AHP.

Mmom and Mbee (2013) suggest that the government take a proactive approach to waste management through the use of integrated waste management. Landfills should be maintained appropriately, and engineered landfills should replace open pit dumps to decrease the impact of these wastes on the environment. Ultimately, landfills ought to be positioned sufficiently far from neighborhoods and residential areas, and an environmental impact assessment must be performed prior to their location. Bello (2007 as cited in Akinjare et al., 2011) advocated economic empowerment for people, careful evaluation in the siting of landfills, and the use of public-private initiatives for public infrastructure development.

Policies and regulations should consistently support recycling, reusing, and minimizing waste. It is critical to acknowledge waste as a resource from this perspective. This would incentivize more people to search for opportunities to contribute to waste management projects. This perspective would lead to more employment from new manufacturing processes, savings from the decreased expense of landfilling various types of waste, and greater economic activity because of the valuable items marketed locally and even internationally. SWM strategies need to take into account the organization and formalization of informal recyclers at disposal sites when creating plans for solid waste recycling, treatment, and disposal. Since these unofficial laborers represent a valuable component of the solid waste value chain, it is not appropriate to replace them. Waste to Energy (WTE) programs need to make sense in relation to other solid waste management techniques, such as recycling and waste minimization. It is imperative to conduct an economic and financial analysis of WTE activities to ascertain their viability within the local milieu. If these initiatives are determined to be appropriate for the specific area, past experiences suggest that it may take several years for them to be put into action (Riquelme et al., 2016). Composting the organic portion of household garbage is one way that Guyanese were instructed to assist with solid waste management. “By separating this organic waste for composting, citizens can significantly reduce the amount of household waste taken to the landfill for disposal.” Compost improves the properties of soil (Kaiteur News. December 30, 2014).

To encourage actions, all stakeholders must participate, and there must be strong intra- and intergovernmental (horizontal and vertical) relationships. To guarantee that SWM policies are implemented through strategies and activities, public education is crucial. It is imperative to guarantee the implementation of community programs, educational initiatives, and a continual, adequately funded public awareness campaign in schools and other locations. Encouraging partnerships that involve private companies and involve informal waste recyclers in the process might be crucial in facilitating the transformation as well as the growth of the sector (Riquelme et al., 2016). The consultant for the Haags Bosh Landfill site noted that for the active duration of the landfill, the site needs to be monitored and the community involvement program needs to be adhered to. Additionally, he stated that local knowledge of waste management issues needs to be raised and the public grievances process needs to be addressed (Stabroek News, June 19, 2013).

The establishment of a sustainable finance system is necessary, as mentioned by Riquelme et al. (2016). They pointed out that in order to guarantee the sector's viability, nations must specify how they will pay for waste management, whether it be through taxes, tariffs, pay-for-service agreements, or other means. Countries must ascertain the exact cost of SWM initiatives, especially those pertaining to public and key stakeholder education, in order to appropriately collect fees. One of the cornerstones of a sustainable system is the implementation of techniques to recover expenses from waste generators after the actual cost has been ascertained. To instill trust in all parties involved, a sustainable finance method must be open and incorporate an accountability framework. They also discussed the necessity of better technology and resources for the collection and disposal of solid waste. It is crucial to understand that SWM is a business, and as such, its financial, human, and technical resources must be planned appropriately. Investments must be preplanned and ought to be founded on the strategies and policies that the nation has created. Competitive compensation packages reflecting staff qualifications must be offered in the human resources industry. Additionally, there should be opportunities for employee development through collaborations with other experienced organizations.

7. Conclusion

Although the full extent has not always been determined, landfills have the potential to substantially harm the environment, human health, ground and surface water, cause global warming, and impact the availability of land and land value; landfill gas and leachate are the principal sources of these potential consequences. Both are incredibly intricate combinations that vary according to the landfill's age, waste type, and location. The leachate of municipal solid waste contains several hazardous, toxic, and cancer-causing chemical contaminants. Solid waste landfilling may also lead to the proliferation of insects, rats, and unpleasant odors. Public education, the development and implementation of laws and regulations, increased financing, supervision and monitoring, waste recycling, reuse, and recovery, appropriate site location, and other methods can all help to reduce these health concerns.

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