Environmental and Health Risks of Open Landfill in Chittagong City, Bangladesh

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ABSTRACT: Waste dumping and its effects on public health and the environment have become significant concerns. This paper presents research conducted in two waste dumping sites in the Chittagong City Corporation area, Arefin nagar (Site 1) and Anondobazar (Site 2), to determine people's perception of the environmental and health impacts of the landfill. Data were acquired using 250 pre-tested structured questionnaires (170 for the neighborhood and 80 for the working group). We conducted five key-informant interviews with officials from the Chittagong municipality and medical practitioners, along with four focus group discussions involving local residents and garbage workers to gather qualitative data. Descriptive statistics (frequency, percentages) were used for data analysis. Selected quantitative data was tested for significant associations using the Chi-squared test, and qualitative data was described using respondents' narratives. The results suggest that most respondents were 26–35, illiterate, and worked in low-income jobs such as homemaking, small business, and day labour, reflecting landfill residents' socioeconomic vulnerability. Residents complained of bad smells, soil fertility loss, and landfill leachate water contamination. Residents reported eye irritation (38.2%), hepatitis (27.9%), and headaches (23.5%). In contrast, waste collectors indicated frequent headaches (51.3%), skin conditions (43.6%), and nausea (42.1%). This underscores considerable risks to public health. Children exhibited notable susceptibility, with documented rates of vomiting at 67.6%, diarrhoea at 62.9%, and respiratory difficulties at 58.8%. The presence of disease vectors such as flies, mosquitoes, and rats near landfills has increased health risks. This investigation emphasises the necessity for improved waste management practices, such as establishing sanitary landfills and relocating dumping sites, while incorporating community feedback to shape inclusive landfill policies in urban Bangladesh.

Keywords: Environmental Impact; Public Health; Waste Disposal; Open Dumping; Chittagong City

INTRODUCTION

In developing countries, the management of municipal solid waste materials is a serious problem (Norsa'adah et al., 2021). In Bangladesh, waste generation has been increasing exponentially with rapid population growth, urbanization, and industrial development in the country (Alam and Qiao, 2020). Solid waste management is a serious concern for Bangladesh as waste generation per capita will be 0.75 kg/capita/day by 2025 and the total amount of waste will reach 21.07 million tons per year (Ashikuzzaman and Howlader, 2019). Like in other developing countries, dumping of non-segregated solid waste in an uncontrolled manner to landfill sites is the most prevalent waste disposal practice in Bangladesh (Abedin and Jahiruddin, 2015; DNCC 2016; Hossain et al., 2018; Alam et al., 2020). Landfill is the most preferred option in Bangladesh, because of its simple and easy operation, low cost, less technological involvement and comfort of implementation (Hossain et al., 2018; Urme et al., 2021).

Landfills and/or open dumpsites were the common practice for municipal solid waste disposal all over the world (Vaverková, 2019). Approximately 70% nations worldwide dispose of their municipal solid trash indiscriminately, without any planning or control measures, through a process known as "open dumping." (Ozbay et al., 2021). It is a generally accepted, used, and effective method because of its economic advantages and low-technical requirements (Gonzalez et al., 2016; Jovanov et al., 2018; Feng et al., 2018; Chakravarty and Kumar, 2019). The majority of waste produced by homes, businesses, schools, and hospitals in developing nations is dumped in municipal solid waste landfills (Ozbay et al., 2021). Although open landfills have met

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the need for short-term garbage disposal, they are not the best option for long-term waste management and have several detrimental effects on the environment and public health (Norsa'adah et al., 2020; Ozbay et al., 2021; Urme et al., 2021).

Landfills affect the environment in a number of ways, including contaminating surface and groundwater through leachate production, emitting greenhouse gases from landfill gas, and making nearby soil and land unsuitable (Hossain et al., 2018; Kusari, 2018; Njoku et al., 2019; Vaverková, 2019; Ozbay et al., 2021; Urme et al., 2021). Leachates represent complex mixtures of substances including dissolved organic matter, inorganic macro-components, and a wide range of xenobiotic organic compounds, which are hazardous and toxic to human health and the environment (Vaverková, 2019; Norsa'adah et al., 2020). Moreover, the waste deposits at landfill sites act as the breeding ground for various disease vectors such as rats, mosquitoes, flies, cockroaches, and pathogenic microorganisms (Dey et al., 2019). Numerous health issues, including respiratory symptoms, skin, nose, and eye irritation, gastrointestinal issues, exhaustion, headaches, psychiatric disorders, and allergies, are brought on by prolonged exposure to chemicals, poisonous fumes, and dust from waste sites (Njoku et al., 2019; Norsa'adah et al., 2020; Urme et al., 2021). In developing nations, little research has been done on the environmental and health implications on people who live close to garbage sites, despite the fact that the negative effects have increased recently (Njoku et al., 2019).

Chittagong, the second-largest city in Bangladesh, with 2.62 million populations, generated a total of 1161-1548 tons/day of municipal solid waste, of which about 58% remained uncollected (Ashraf et al., 2015; Waste Concern, 2009). Chittagong City Corporation (CCC), the responsible authority for solid waste management, is involved in the collection of waste from communal bins and secondary disposal sites and transfers them to the ultimate dumping sites (Debnath et al., 2015). The CCC has two landfill sites at Ananda Bazar and Arefin Nagar within the metropolitan area, which are located near to residential areas. Dey et al. (2019) reported that waste collection, transportation, and disposal techniques for landfilling are not well established in the city (Dey et al., 2019). The number of landfill sites and their capacity, and budget allocation for waste management in CCC are not enough compared to the population (Masud et al., 2018; Dey et al., 2019).

There are several previous studies on landfills in Bangladesh from various perspectives (Das et al., 2015; Debnath et al., 2015; Hossain et al., 2018; Dey et al., 2019; Islam et al., 2020; Urme et al., 2021). These studies generally focused on selection of landfill sites using GIS techniques, the suitability of the existing landfill sites, the sources and collection process of solid waste, and existing management practice. Hossain et al. (2018) studied environmental impacts of solid waste disposal in Matuail landfill site, Dhaka. Urme et al. (2021) investigated urban pollution and health hazards of landfills in Dhaka. To the best of our knowledge, there was no previous studies in Chittagong city of Bangladesh on the impact of landfills on surrounding environment and health of nearby residents. This study has two objectives: i) to explore residents' perception on impact of landfills on surrounding environment, and ii) To understand self-reported health risks of residents and waste collectors living near landfill**s**.

MATERIALS AND METHODS

Study Area

The study was conducted in the Chittagong city corporation area, which extends from 220 14 to 220 22 N latitude and between 910 46 to 910 51 E longitude (Hussain et al., 2016) (Fig. 1). The study was conducted in deliberately selected two landfills' areas of CCC namely, Arefin nagar (site 1 hereafter) and Anondobazar (site 2 hereafter). The reason for selecting those areas is that these are the two biggest landfills of Chittagong city located adjacent to residential areas and the landfill workers live in nearby those landfill sites. The impact of health and environmental effects due to these landfills were not documented yet.

Data Collection and Analysis

Data were collected using a pre-tested structured questionnaire, four focus group discussions, and five key informants' interviews. The questionnaire was prepared following similar past research conducted elsewhere (Debnath et al., 2015; Hossain et al., 2018).

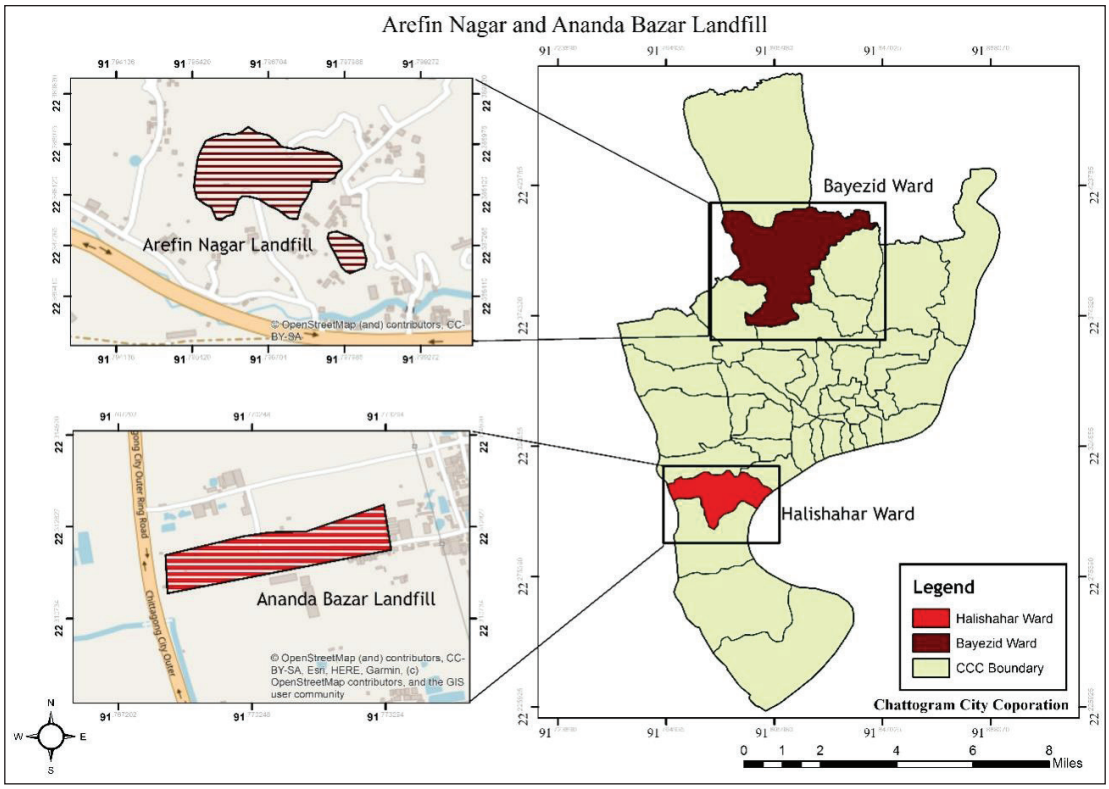

Figure 1: Map of Study Areas

It consisted of three parts including socio-demographic information of respondents, environmental impact, and health risks (Supplementary Table 1). We interviewed 170 households, 85 from each landfill site, living within 100m of landfills and willing to participate in interviews. The number of respondents was determined based on prior research and accessibility. We interviewed 80 waste collectors, 40 from each site and their interviews were only for health risks-related questions. Each interview took about 30 minutes and their verbal consent was taken before interviews. Four focus group discussions (two from each site) were arranged with 4-6 elderly people in both sites. A checklist was prepared to facilitate the discussions. We asked them to share their opinion on environmental and health risks due to open landfills in their locality. Respondents' verbal consent was obtained before each interview. These FGDs were essential for gathering qualitative insights from the community. Five relevant local stakeholders participated in key informant interviews (KIIs) to share their perspectives on the environmental and health impacts of open dumping sites. The interviews included three local physicians, the Deputy Director of the Department of Environment, and the Chief City Planner of the CCC. Medical professionals were specifically requested to verify whether respondents' self-reported medical conditions, including headaches, skin disorders, and respiratory issues, could be associated with the presence of landfills. This method confirmed the results and enhanced understanding from both administrative and medical perspectives.

For Data analysis, descriptive statistics (frequency, percentages) were estimated. A chi-squared test was conducted for significant association between the two sites, and p-values of less than 0.05 were considered significant. Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 16 (SPSS for Windows, Version 16.0. Chicago, SPSS Inc.). Thematic analysis was applied to qualitative data, which were recorded, transcribed, and systematically analyzed to identify major patterns and recurring themes. This approach allowed for a detailed exploration of participants' experiences and perceptions of the study's focus.

RESULTS AND DISCUSSION

Respondent's Socio-demographic Characteristics

Both male and female respondents who were present at house and agreed to participate in this research were

interviewed (Table 1). Most of the respondents, in both sites, were between 26 to 35 years age brackets. The educational background of respondents revealed a significant difference between the two sites ($\chi^2 = 22.00$, $p = 0.001$), with Site-1 exhibiting a higher proportion of illiterate respondents (51.8%) in contrast to Site-2 (38.8%). This disparity may be attributed to differences in access to educational facilities and socio-economic factors between the two regions. In site-1, about 32% respondents were involved with small local business followed by day laborer (28.2%) and housemakers (22.4%). In site-2, majority of the respondents (36.5%) were homemakers followed by day laborers (27%). Day laborers were working in local industries and in waste dumping sites. In both sites, majority of the respondents were illiterate (cannot read and can sign only). As most of the respondents were housemakers, day laborers and small businessmen, their monthly income was low. In both sites, about 60% houses were semi-pacca (brick wall with tin roof) and kacha (mud wall and thatch roof), and 67% of respondents were tenants. Many respondents had been living in there for up to 20 years mainly due to job purposes and lower house rent. The duration of residency between the two sites did not show a statistically significant difference ($\chi^2 = 3.47$, $p = 0.48$), suggesting a comparable trend in long-term resident patterns.

Table 1: Basic Socio-Demographic Information of the Respondents in the Study Sites, Chittagong, Bangladesh

Variable	Site 1		Site 2		Significance (Chi-squared, p-value)
	Frequency	Percentage	Frequency	Percentage	
Gender					
Male	44	51.8	54	63.5	$\chi2 = 1.47$, $p = 0.23$
Female	41	48.2	31	36.5	
Age (years)					
Up to 20	7	8.2	5	5.9	
21-25	7	8.2	10	11.8	
26-30	39	45.9	26	30.6	
31-35	19	22.4	26	30.6	$\chi2 = 33.12$, $p = 0.001$
36-40	10	11.8	5	5.9	
Above 40	3	3.5	13	15.2	
Occupation					
Business	27	31.8	18	21.2	
Day laborer	24	28.2	23	27.0	
Job holder	15	17.6	10	11.8	
Housemakers	19	22.4	31	36.5	
Others	-	-	3	3.5	
Educational Background					
Primary	29	34.1	21	24.7	
SSC	7	8.2	23	27.1	$\chi2 = 22.00$, $p = 0.001$
HSC	5	5.9	8	9.4	
Illiterate	44	51.8	33	38.8	

Monthly Income (Bangladesh Taka, BDT)*					
5000-10000	44	51.8	43	50.6	
11000-15000	29	34.1	33	38.8	$\chi2 = 27.03$, p =0.001
16000-20000	10	11.8	9	10.6	
21000-25000	2	2.3			
Housing Type					
Kacha	49	57.6	26	30.6	
Pacca	12	14.1	5	6.9	
Semi-pacca	22	25.9	54	63.5	
Others	2	2.4	-	-	
House Ownership					
Own	36	42.4	28	32.9	$\chi2 = 3.76$, p =0.05
Tenant	49	57.6	57	67.1	
Years of living in the locality					
1-5 years	10	11.8	33	38.8	
6-10 years	19	22.4	23	27.1	
11-15 years	12	14.1	18	21.2	$\chi2 = 3.47$, p =0.48
16-20 years	29	34.1	3	3.5	
20years above	15	17.6	8	9.4	
Reason of living in the locality					
By birth	49	57.6	10	11.8	
job purpose	17	20.0	44	51.8	
low house rent	19	22.4	28	32.9	
Others	-	-	3	3.5	

*1US$=BDT110.00

(Source: Fieldwork, 2024)

A 37-year-old local shop-holder in site-1 stated that:

"This place is not suitable to live in with family after having odor problem and insalubrious environment. But we are forced to stay here as my business is here and we are not capable to shift somewhere else due to limited income."

The narrative of the local shopkeeper presents a qualitative perspective that complements the quantitative data and highlights the socioeconomic constraints affecting individuals' decisions to reside in hazardous areas. The significant presence of low-income respondents and individuals with lower educational attainment indicates that financial limitations and local job ties often compel residents to remain in areas despite awareness of unsanitary conditions. This qualitative analysis offers a comprehensive understanding of the societal challenges and aligns with the socio-demographic findings.

Environmental Risks of Open Landfills

Household surveys and focus group discussions revealed that open landfills in study sites have caused several environmental risks. Most respondents (65.8% in site-1; 75.3% in site-2) were aware of environmental damages due to the existence of landfills in their areas (Table 2). The chi-squared test ($\varphi^2 = 11.53$, p = 0.001) indicated a significant difference between the locations, highlighting the impact of exposure and education on awareness levels, particularly in site 1,

which has a high percentage of illiterate individuals. There was a significant variation in the severity of the odour issue across sites ($\varphi^2 = 8.59$, $p = 0.03$). A greater number of respondents in Site-2 reported being "habituated" to the odor, whereas a higher proportion of respondents in Site-1 indicated experiencing a "very severe" odor. This may indicate that prolonged exposure is leading to the desensitization of Site-2. According to Sakawi et al. (2011), Malaysia's peace and quality of life have been impacted by the unpleasant stench of landfills. According to Urme et al. (2021), landfill gas has an unpleasant odor that can make adjacent residents and landfill workers sick and have headaches. We noticed that the landfills were messy, with trash, food scraps, plastic bags, cans, and disgusting human and animal waste piled up up to 100 meters from nearby residences. To 80% of the respondents in site-1, toxicity from landfills caused loss of soil fertility. This response was 63.6% for site-2. In focus group discussions, attendees commented that many people gave up agricultural practices on surrounding land due to declining crop production and an unhealthy environment. Khoiron et al. (2020) confirmed that the negative impacts of landfills can extend to adjacent agricultural land, resulting in ecotoxicological effects that degrade soil quality and potentially lead to soil infertility.

More than 60% of respondents in both sites perceived that landfills' leachate polluted surrounding water bodies, which they understood through blackish watercolor, bad smell, and toxic elements (eye-irritation). The opinions of respondents in both sites regarding water pollution from leachate ($\varphi^2 = 7.12$, $p = 0.01$) indicated a significant correlation, suggesting that factors such as proximity to water bodies, waste composition, or drainage may influence the experiences of inhabitants.

Landfills' leachate is a significant source of pollutants as a consequence of the leaching of hazardous substances and uncontrolled and untreated leachate (Azim et al. 2011; Bhuiya et al. 2002; Hai and Ali 2005) that adversely affect people living close to landfill sites (Njoku et al., 2019). About 80% respondents in both study sites said that surrounding environment were worsening due to the presence of open landfills, which they described through increase of temperature (due to open burning), toxic substances, reduction of crop production, and loss of vegetation. Researchers (e. g. Hossain et al., 2018; Urme et al., 2021) also reported that open landfills have detrimental effects in surrounding agricultural land, water bodies and settlements. The improper management of landfills and generation of toxic leachate thereby exert significant impacts on surrounding freshwater and groundwater (Kamal et al., 2016; Mishra et al., 2019).

Table 2: Residents' Perception on Environmental Impact of Open Dumping sites in Chittagong, Bangladesh

Variables	Site 1		Site 2		Significance (Chi-squared, P-value)
	Frequency	Percentage	Frequency	Percentage	
Are you aware that landfill causes environmental damage in your area?					
Yes	56	65.8	64	75.3	
No	29	34.2	21	24.7	$\chi 2 = 11.53$, p =0.001
Do you experience unpleasant smell in your area?					
Yes	66	77.6	75	88.2	
No	19	22.4	10	11.8	$\chi 2 = 28.47$, p =0.001

How severe does the unpleasant smell?					
Very severe	36	42.4	13	15.3	
Severe	17	20.0	28	32.9	
Less severe	13	15.3	5	5.9	
Habituated	19	22.3	39	45.9	$\chi2 = 8.59$, p =0.03
Do you think that landfill causes soil fertility loss?					
Yes	68	80.0	54	63.6	
No	17	20.0	31	36.4	$\chi2 = 13.24$, p =0.001
Do you think that landfill leachate causes water pollution?					
Yes	53	62.4	59	69.4	
No	32	37.6	26	30.6	$\chi2 = 7.12$, p =0.01
How do you perceive the impact of landfill on water bodies?					
Blackish water	24	28.2	18	21.2	
Odor problem	34	40.0	33	38.8	
Toxic components	20	23.5	26	30.6	
Others	7	8.3	8	9.4	$\chi2 = 13.06$, p =0.01
Do you think that surrounding environment is getting worsen due to landfill?					
Yes	63	74.1	69	81.2	
No	22	25.9	16	18.8	$\chi2 = 21.24$, p =0.001
What are the reasons for this?					
Temperature increases	25	29.4	33	38.8	
Toxic substances	22	25.9	33	38.8	
Crop production reduces	16	18.8	19	22.4	
Vegetation loss	22	25.9	-	-	

(Source: Fieldwork, 2024)

We looked at respondents' perceptions of environmental risks with respect to their duration of living in the localities. Responses across variables were slightly higher for residents living there for up to 10 years than those living there for more than 20 years. However, no significant associations were observed between environmental risks and duration of residency (Supplementary Table 1).

One of the key informants, the Deputy Director of the Department of Environment (DoE), Chittagong, said that microplastic is produced daily from landfill sites, which is later mixed with soil and water and causes soil and water

pollution that is harmful for zooplankton and vegetation growth. An assistant engineer of the DoE commented that they advised the Chittagong City Corporation (CCC) to establish sanitary landfills instead of open landfills.

Impact of Landfills on Surrounding Biota

Local people reported that waste dumping sites have become the sources of unwanted biota because of the incubation and proliferation of flies, mosquitoes, and rodents. In both study sites, a majority of the respondents were "agreed" to "strongly agreed" concerning the intensification of insects due to landfills in their locality (Table 3). As there is a statistically significant correlation between the presence of landfills and the perceived increase in insect populations ($\varphi 2 = 28.94$, $p = 0.001$), along with the observed rise in populations of rats, mice, and crows ($\varphi 2 = 17.29$, $p = 0.001$), these findings suggest that individuals' opinions are closely associated with landfill-related factors, rather than being arbitrary. Respondents believed that the increasing insects population had effects on food contamination (about 38% responses), disease transmission (about 38% responses), and the environment. Most respondents were also "agreed" to "strongly agreed" that the population of rats, rodents, crows, etc. had increased surrounding the waste dumping sites. Landfill sites are potential reservoirs for vector breeding (rats, mosquitoes, flies, other animals and insects) (Tomita et al., 2020), which increase the risk of health ailments among the surrounding people.

Table 3: Residents' Perception on Impact of Open Dumping sites on Surrounding Biota in Chittagong, Bangladesh

Variables	Site-1		Site-2		Significance (Chi-squared, p-value)
	Frequency	Percentage	Frequency	Percentage	
To what extend do you agree that landfill has caused intensification of insects in your area?					
Strongly disagree	12	14.1	2	2.3	
Disagree	10	11.8	5	5.9	
Agree	19	22.3	57	67.1	
Strongly agree	44	51.8	21	24.7	$\chi 2 = 28.94$, $p = 0.001$
What are the effects of increasing insects?					
Food Contamination	32	37.6	33	38.9	
Diseases spreading	36	42.4	31	36.4	
Unhygienic environment	17	20.0	21	24.7	$\chi 2 = 3.91$, $p = 0.14$
To what extend do you agree that rats, rodents, crows, etc. have increased in your area due to landfill?					
Strongly disagree	29	34.1	3	3.5	
Disagree	10	11.8	10	11.8	
Agree	24	28.2	54	63.5	
Strongly agree	22	25.9	18	21.2	$\chi 2 = 17.29$, $p = 0.001$

(Source: Fieldwork, 2024)

A 28 year old male respondent in study site-2 reported that,

> *"The number of flies, rats, and crows has increased in our area. The intensity of these numbers of insects' upturn when waste carrying truck unloads at the landfill site. Flies sat on the food and contaminate it whereas rats and crows fly with stomach, bone of dead animals and fall into our house which creates an unhygienic environment for us".*

The narrative reinforces the quantitative data by highlighting a purported rise in insect and rodent

populations near landfill sites. Table 3 illustrates that numerous respondents linked waste disposal to increasing populations of flies, mosquitoes, and rodents, aligning with their observations.

Public Health Risks of Landfills

This study identifies health hazards based on self-reported data from respondents, including waste collectors and residents of disposal sites. The respondents frequently reported ailments, including headaches, skin issues, nausea, eye irritation, hepatitis, asthma, diarrhea, dysentery, and malaria. We consulted local physicians, conducted focus group discussions, and reviewed previous research to substantiate these conclusions. All of these sources consistently indicate that populations near open landfills frequently exhibit such health issues. Among waste collectors, 51.3% very often experience headache, skin disease (43.6%), nausea (42.1%), eye irritation (4.1%), hepatitis (38.5%) and asthma (36%) (Table 4). Another 43.4% of them reported to suffer often from diarrhea followed by dysentery (42.1%), and malaria (38.5%). Residents reported that they very often suffer from eye irritation (38.2%), hepatitis (27.9%), and headache (23.5%). However, majority of residents stated that they sometimes experience malaria (83.8%), typhoid (70.6%), diarrhea (67.4%), nausea (48.5%), and asthma (47.1%) (Table 4). Participants in the focus group discussions said that burning in dumping sites produces dusts which cause eye irritation, breathing difficulty, cold and asthma among local population. They also stated that the causes of typhoid, malaria, diarrhea, and dysentery in their localities may be attributed to increasing flies and mosquitos due to open dumping sites. Bad odors and smoke from landfill burning that produce hydrogen sulphide, methane, and ammonia gases cause nausea, fatigue, headache, and irritation of the eyes, nose, and throat of surrounding people and put into danger the vulnerable populations such as the elderly, children, pregnant women and/or people with pre-existing chronic respiratory conditions (Kampa and Castanas, 2008; Rovira et al., 2018; Njoku et al., 2019; Urme et al., 2021). Chokandre et al. (2017) found a high prevalence of breathing difficulties among waste collectors. According to a South African study, residing five kilometers from a trash site was substantially linked to higher chances of depression, diabetes, asthma, and tuberculosis (Tomita et al., 2020).

Table 4: Experience of Different Diseases Reported by Waste Collectors and the Local Residents in the Study Sites

Diseases	**Waste collectors (% of responses)**			**Local residents (% of responses)**		
	Very Often	**Often**	**Sometimes**	**Very Often**	**Often**	**Sometimes**
Diarrhea	15.6	43.4	41.0	4.3	28.3	67.4
Malaria	-	38.5	61.5	2.9	13.2	83.8
Headache	51.3	25.6	23.1	23.5	47.1	29.4
Eye Irritation	41.1	25.6	33.3	38.2	35.3	26.5
Dysentery	-	42.1	57.9	10.3	33.8	55.9
Stomach Problem	-	27.3	72.7	17.6	32.4	50.0
Typhoid	-	-	100	4.4	25	70.6
Asthma	36.0	24.0	40.0	14.7	38.2	47.1
Hepatitis	38.5	43.6	17.9	27.9	38.2	33.8
Skin disease	43.6	35.9	20.5	16.2	42.6	41.2
Vomiting	-	34.6	65.4	23.5	38.2	38.2
Nausea	42.1	31.6	26.3	25.0	26.5	48.5

(Source: Fieldwork, 2024)

We also examined common diseases among adults and children in the study sites. The information regarding children was obtained directly from responding parents. Participants with children were specifically selected for the survey, and data was compiled based on their responses regarding health issues and experiences related to their children. In both sites, more than 50% of adults experience malaria, headache, eye irritation, asthma, hepatitis, skin disease, and nausea (Table 5). On the other hand, 67.6% of children suffer from vomiting, followed by diarrhea (62.9%), breathing problems (58.8%), eye irritation, and malaria (48.2%). During this study, we noticed that children were playing in an open field adjacent to landfills, which might cause breathing problems and eye irritation.

Table 5: Common Diseases Among Adults and Children in the Study Sites

Diseases	Adults		Children	
	Frequency	Percentage	Frequency	Percentage
Diarrhea	63	37.1	107	62.9
Malaria	88	51.8	82	48.2
Headache	97	57.1	73	42.9
Eye irritation	88	51.8	82	48.2
Dysentery	40	23.5	47	27.6
Breathing problem	70	41.2	100	58.8
Typhoid	45	26.8	60	35.3
Asthma	100	58.8	70	41.2
Hepatitis	90	52.9	80	47.1
Skin disease	95	55.9	75	44.1
Vomiting	55	32.4	115	67.6
Nausea	92	54.1	77	45.3

(Source: Fieldwork, 2024)

DISCUSSION

This research investigates the environmental and health effects of open dumping sites in Chittagong, Bangladesh, based on residents' perceptions. The study indicated that most respondents at both locations were aged 26 to 35, illiterate, and employed in low-income occupations such as homemaking, small businesses, and day labour. The findings are consistent with studies in other developing countries, indicating that individuals living near dump sites generally belong to lower socioeconomic strata (Njoku et al., 2019; Tomita et al., 2020). Many individuals live as tenants in semi-pacca or kacha housing adjacent to landfills, highlighting the financial vulnerability of these areas, as confirmed by Hossain et al. (2018) and Urme et al. (2021). The lack of resources for relocation or mitigation of landfill impacts heightens the probability that these socio-demographic characteristics will expose populations to environmental and health risks.

The primary environmental issues identified in this study include unpleasant odours, loss of soil fertility, and water contamination resulting from landfill leachate. These findings are consistent with the research conducted in Malaysia (Sakawi et al., 2011), Nigeria (Njoku et al., 2019), and India (Mishra et al., 2019). Parvin and Tareq (2021) noted that inadequate lining systems and leachate treatment facilities permit the infiltration of toxic substances into water bodies and soil, which adversely impacts agricultural productivity and ecosystem health. The respondents' perceptions of blackish water and hazardous substances in water bodies align with the findings of Azim et al. (2011) and Bhuiya et al. (2002), who identified leachate as a significant contributor to water pollution. Kamal et al. (2016) asserted that improper landfill management leads to the deterioration of adjacent agricultural land and water resources.

This investigation presents an alternative perspective by emphasising the adaptation of local inhabitants to

the unpleasant smell; 45.9% of participants in Site-2 indicated that they had become "habituated" to the odour. This finding contradicts studies by Urme et al. (2021), which emphasized the persistent discomfort caused by odors from landfills. The observed habituation in this study may indicate that residents have been consistently exposed to these disorders, highlighting the critical need for prompt intervention to address environmental damage.

Survey respondents strongly agreed that landfills have increased populations of flies, mosquitoes, rats, and crows, thereby contaminated food and facilitating the spread of diseases. Research conducted by Chokandre et al. (2017) and Rovira et al. (2018) linking landfill proximity to increased health risks aligns with respondents' concerns regarding food contamination and unsanitary environments. Khoiron et al. (2020) highlighted the ecological effects of landfill leachate on soil and water quality, emphasizing the role of landfills in disrupting local ecosystems.

The public health hazards identified in this investigation—headaches, skin disorders, eye irritation, and respiratory conditions—align with findings from other regions. Kampa and Castanas (2008) and Rovira et al. (2018) observed similar health issues in individuals residing near landfills, attributing these concerns to exposure to waste gases and particulate matter. The elevated incidence of malaria, diarrhea, and dysentery among individuals aligns with findings from Tomita et al. (2020), who established a link between the closeness of landfills and an increase in vector-borne diseases. The findings further correspond to the assertions made by Njoku et al. (2019), who indicated that landfills' emissions exacerbate digestion and respiration issues.

This study provides additional insights into the varying health effects on waste collectors and residents. Waste collectors, likely due to their direct exposure to waste products, reported a higher incidence of headaches, skin disorders, and nausea than residents. Chokandre et al. (2017) showed that waste collectors face increased risks for dermatological and respiratory issues. Children exhibit increased vulnerability due to their proximity to garbage dumps and exposure to contaminated environments, as evidenced by higher reported rates of vomiting, diarrhoea, and respiratory issues. Limoli et al. (2019) indicated that illegal landfilling negatively impacts children's health due to their developing immune systems and spending significant time outdoors.

The findings are consistent with existing literature regarding landfills' environmental and health impacts while also providing unique insights into the community's experiences and perceptions. Integrating scientific evidence with community perspectives will enable policymakers to formulate more effective and inclusive strategies for mitigating landfills' negative impacts.

CONCLUSIONS

Waste disposal in Bangladesh presents a significant challenge, characterised by limited awareness and financial resources, resulting in unsanitary living conditions for the population. To mitigate environmental and health hazards, landfills must be situated away from residential and commercial areas (Njoku et al., 2019). The residents of Chittagong face heightened health concerns due to unpleasant odors, disease-carrying vectors, and water pollution resulting from landfill leachate. Addressing these issues requires integrating scientific data with local perspectives to develop comprehensive and effective waste management strategies.

This study highlights the detrimental impacts of landfills in Chittagong on environmental and health outcomes, thereby establishing a foundation for further research and policy advancement. Bangladesh can achieve a more cleaner and healthier future by prioritising sustainable waste management and community well-being.

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Supplementary Table 1: Residents' Perception on Environmental Impact of Open Dumping Sites in Chittagong, Bangladesh with Regard to Duration of Residency

Variables	Duration of living in the sites (years) (% of respondents)					Significance (Chi-squared, P-value)
	1-5	6-10	11-15	16-20	> 20	
Soil fertility decreasing						
Yes	18.0	18.0	12.7	13.8	9.5	$\chi2 = 2.599$, df = 4 p =.627
No	7.0	7.0	4.9	5.4	3.7	
Odor problem						
Yes	20.6	20.6	14.5	15.8	10.9	$\chi2 = 1.649$, df = 4, p =.800
No	4.4	4.4	3.1	3.4	2.3	
The severity of unpleasant smell						
Severe	7.4	7.4	5.2	5.6	3.9	$\chi2 = 12.858$, df = 12, p =.379
Very severe	6.6	6.6	4.7	5.1	3.5	
Less severe	2.6	2.6	1.8	2.0	1.4	
Habituated	8.5	8.5	5.9	6.5	4.4	
Landfill leachate cause water pollution						
Yes	16.6	16.6	11.7	12.6	8.7	$\chi2 = 2.075$, df = 4, p =.722
No	8.5	8.5	5.9	6.5	4.4	
Environment getting worsen by landfill						
Yes	19.5	19.5	13.7	14.9	10.3	$\chi2 = 5.570$, df = 4, p =.234
No	5.5	5.5	3.9	4.3	2.9	

Extent of worseness						
Very little	2.4	2.4	1.6	1.8	1.2	
Little	3.8	3.8	2.6	2.9	2.0	$\chi2 = 9.581$, df = 12, p =.653
Moderate	9.9	9.9	6.9	7.7	5.2	
Highly	9.0	9.0	6.3	6.8	4.7	
Threat to environment						
Yes	19.5	19.5	13.7	14.9	10.3	$\chi2 = 6.564$, df = 4, p =.161
No	5.5	5.5	3.9	4.3	2.9	
Types of threat						
Temperature increase	8.6	8.6	6.1	6.6	4.6	
Toxic substances	8.2	8.2	5.8	6.2	4.3	
Crop production reduce	5.0	5.0	3.6	3.8	2.6	$\chi2 = 5.424$, df = 12, p =.942
Vegetation loss	3.2	3.2	2.2	2.4	1.7	