Risk Assessment of The Kingtom And Granville Brook Dumpsites In Freetown, Sierra Leone

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Abstract

The Kingtom and Granville Brook dumpsites are the only two official and final waste disposal sites in Freetown. Waste management practices in both sites could be described as crude, uncontrolled and unacceptable according to modern method of handling of waste resulting in poor environmental hygiene with its associated health consequences in and around the site. Consequently, there is increasing cry of residents for both sites to be closed and relocated to a new engineered landfill site outside the capital Freetown. However, for such a decision to be made, officials must be well informed with facts and data that will guide them in decision making. As such, assessing the relative health and environment hazards posed by the Kingtom and Granville dumpsites could help prioritize, plan and initiate their rehabilitation or relocation. In light of this, this study presents an Integrated Risk Based Approach (IRBA) for developing a decision making tool for dumpsite rehabilitation or relocation and propose proper management for solid waste. The risk index (RI) was computed from the summation of the product of the sensitivity of the variables studied and their respective weights of their attributes. Results of hazard potential for both the Kingtom and Granville Brook dumpsites scored a RI of 585.0 and 583.5 respectively. The RI scores fell within the range of moderate hazard. Moderate hazard recommends immediate rehabilitation of the dumpsite into sustainable landfill.

Key words: Granville dumpsite, Integrated Risk Based Approach (IRBA) , Kingtom dumpsite, risk assessment.

INTRODUCTION

By the standard definition of a landfill (a waste dump site characterized by engineered piping network to transfer leachates, covering and base liner etc), there are no landfill in Freetown as the above is completely absent. However, there are officially two main open dumpsites; namely the Kingtom and Granville Brook in Freetown. In addition, there are several transit points (transfer stations) unevenly distributed across the capital. Waste management in Freetown is plagued with several problems.

Part of the problems relating to solid waste management in Freetown relates to the institutional and legislative framework of waste management in the city. To illustrate, the legal framework for waste management in Freetown is old and inconsistent. One of the main existing texts in effect is the Public Health Ordinance. It has still not been reviewed since 1978. However, over the years, there have been continued changes in the institution responsible for leadership of waste management. It has moved from the Ministry of Health and Sanitation (MOHS) to the Freetown City Council (FCC), then Ministry of Youth and Sports. A decade ago, the responsibility was handed over to FCC. Presently, waste management is currently jointly managed by the Environmental Health Division (EHD) of the Ministry of Health and Sanitation, "Klin Salone (a private Non Governmental Organization – NGO), The Freetown Solid Waste Management Company (FSWMC) and Freetown Municipal Council although only "Klin Salone" is the one actively involved in the day-to-day collection and disposal services. This current organization of waste collection was established by the FCC in 2006 with the support of an International Waste consulting firm - GTZ and the World Bank. The FSWMC was created in the framework of an Emergency Phase Operation for waste management. With regard to solid waste environmental laws, there is a duplication between the FCC and the MOHS. Besides the National Health Policy published in October 2002 and the MOHS's draft Environmental health Policy developed as an addendum to the latter, there is no clear policy on medical waste in Sierra Leone.

In general, both dumpsites receives all categories of waste (i.e. general and domestic, hospital, industrial and hazardous waste) Gogra *et al*., (2010). Waste management at both sites could generally be described as crude, uncontrolled and unacceptable according to modern method of handling of waste. The lack of finance, logistics and technological inadequacies and poor management at national and local levels have resulted in poor environmental hygiene with its associated health consequences in and around the site.

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The absence of waste cover and the close proximity of residents to dumpsites allow for easy rampant scavenging on waste heap for valuable recyclable materials (Hingston *et al*., 2002; Kurian *et al*., 2004).

In a study to determine the environmental health impacts of residents around the vicinity of the Granville dumpsite, Sankoh *et al*., (2013) showed that the site contributes to diseases such as malaria, chest pain, diarrhea, cholera suffered by residents. In an earlier study on both the Kingtom and Granvillebrook dumpsites, Hingston *et al*., (2002) and Frazer-Williams *et al.,* (2011) reported that dumpsite leachates and runoff pollute nearby streams, estuarine waters and the Rokel river. Their studies showed that higher levels of nickel, cobalt, zinc and lead compared to World Health Organization (WHO) values were found in both soil samples and vegetables at the sites. Similar findings have been reported elsewhere. For instance, Akobundo (2011) reported leaching of heavy metals from the Aladimma dumpsite of Imo state Nigeria to ground water. Results of physical, chemical and biological analysis of raw water from boreholes collected close to refuse dumps in Benin city showed that these wastes produce leachates that percolates into the groundwater (Omofonmwan , 2009). Open burning is also a public health concern to residents around dumpsites as the resulting green house gases (CH_4, CO etc) contaminate the air and causes respiratory problems (Boardi, and Kuitunen, 2005; Gouveia and do Prado, 2009). Taylor and Nakai (2012) reported higher levels of Polyaromatic Hydrocarbons (PAHs), carbon monoxide (CO) and Suspended Particulate Matter (SPM) relative to World Health Organization (WHO) guidelines around the Granville brook dumpsite. Such high level is a public health risk.

As a result of the foregoing, concerns of the impact of these two dumpsites on the health of the residents in Freetown is increasing. Another concern expressed by residents is the fact that the Granville Brook dumpsite is located along the Bai Bureh road where visitors to the country sometimes use when they first enter into the Country. This they view, with utmost dismay, is wrongly placed for visitors. Many have even argued that both dumpsites should be relocated to the outskirts. However, for such a decision to be made, officials must be well informed with facts and data that will guide them in decision making. As such, assessing the relative health and environment hazards posed by the Kingtom and Granville dumpsites could help prioritize, plan and initiate their rehabilitation or relocation. Furthermore, identifying the risk factors from the sites and transit points will allow residence of Freetown to work with government officials and other stakeholders to minimize environmental health risk. Hence, the purpose of this study is to provide a scientific assessment of the Kingtom and Granville brook dumpsites using an Integrated Risk Based Approach (IRBA) developed by Kurian *et al*., (2005). It is hoped that the findings will enable a decision towards rehabilitation or relocation and propose proper management for solid waste at the dumpsites.

MATERIALS AND METHODS

The study area

The Kingtom dumpsite was established in the 1940s. It is situated in the west-central part of Freetown within an area of 14.544 Acres. The southern border is Ascension Town road. Kingtom Community lies to the north and to the west is bay. The Kingtom dumpsite serves the western and central sectors of Freetown. The site supports a growing and vibrant community engaged in scavenging of materials at the site and selling mangrove wood for cooking. The Kingtom Dump site is on the estuary of the Congo River where it empties to Man of War Bay which borders the Atlantic Ocean. The area is an integral part of an intertidal brackish water zone ecosystem containing almost exhausted mangrove vegetation.

The Granville Brook dumpsite has been in operation since the late 1980s. It is located in a deep valley of the Granville Brook River along the Bai Bureh road within residential area and its surroundings are fully urbanized communities. The dumpsite covers an area of 14.968 Acres. It serves the eastern sector of Freetown. The site is bordered to the east by the valley wall and to the south by the Waterloo Road (Figure 2). The west of the site is limited by the Granville Brook stream channel and is open ended to the north where the Granville Brook joins the Sierra Leone River.

Spatial distribution of risk relating to waste management in Freetown

Solid waste presents one of the areas of environmental health risk for residents in Freetown. Communities close to dumpsites are at greater risk than those far apart. For instance, residents of Kingtom, Ascension Town, Congo Town that live in the vicinity of the Kingtom dumpsite suffer from odour and fly problems. Also, communities of very high population densities with a corresponding low income e.g. the slums do not practice proper hygiene. The just ended cholera epidemic in Sierra Leone during the 2013 rainy season recorded greater incidences in the eastern part of Freetown relative to the west. One contributing factor to this observation is there are greater number of slums and un-standard accommodation in the eastern part of Freetown compared to the west.

Figure1: GIS image of the Kingtom dumpsite

Figure 2: GIS image of the Eastern (Granville Brook) dumpsite along the Bai Bureh road

Studies show that environmental health risk related to solid waste is very low in communities where people can both afford a better standard of living and practice household solid waste management (Sankoh *et al*., 2012).

Analysis of risks at the dumpsites and transit points

The following risk can be outlined for both the Kingtom and Granville dumpsites:

(i) At the Kingtom and Granville dumpsites, there is no base or top seal to prevent the flow of leachates to underground water or rivers or the infiltration of water into the waste. At the Kingtom dumpsite, leachate seeps into the White Man's Bay where it mixes with discharges of raw sewage effluent from sludge drying ponds on the same site. This result in the spread of contagious and water borne diseases into soil and water.

(ii) Waste is dumped indiscriminately, left untreated and uncovered. This results in infestations by rats, flies and other pests that sometimes spread to nearby areas carrying germs to residents of people living in the vicinity of the dumpsite,

(iii) Metals: Recently, there is an increase of the metal markets, notably in China. Metal scraps are bought from locals who scavenge dumpsites in search of metal scraps and in the process contract infectious diseases. Barefooted children are often seen scavenging waste for recycling materials. Another problem with the recuperation of metals from the waste hips is that people set fire to waste in order to separate metals from other materials. These fires constitute an important nuisance, release of toxic chemical fumes such as dioxins and furans as well as a risk of fire outbreak,

(iv) Scavengers search for lead from batteries and other recyclable materials in waste hips and in the process contract diseases from working alongside decomposed animal carcasses,

(v) Very pungent gases such as hydrogen sulphide are toxic to inhale and are also of great nuisance to the people living in the vicinity of the site and to the frequent passers-by.

(vi) Deliberate fires are placed on old waste dump to create room for new incoming waste as well as for unofficial gardening practices. As a result of the fire, smog is left in the air for days.

(vii) The dumpsites are a source of acidity to nearby streams and rivers. Frazer-Williams *et al*., (2011), reported acidic nature of waters in streams along the Kingtom dumpsite. In addition, pH of soil at various locations around the site as well as various locations along the stream are acidic in nature. One possible source of acidity identified at both dumpsites is the anthropogenic deposits of used dry cell and car batteries containing acidic electrolytes seen on waste hips which leached into the subsoil, underground waters, and nearby waters.

(viii) The dumpsites are a source of metals and other pollutants which leach into subsoil and underground water of the dumpsite. Accumulation of the following metals: lead, copper, zinc and nickel above the accepted limit in fishes have been reported by Frazer-Williams *et al*., (2009) due to high levels of metals in the nearby streams that possibly leached from the Kingtom dumpsite.

(ix) Leachates and runoffs emanating from the waste infiltrate directly into the soil beneath as well as flow into the nearby stream, depositing pollutants in the process especially in the bay which is a major source of water for domestic purposes for people residing close to the site when tap water is unavailable. At the rear end of the Kingtom dumpsite, close to the Cemetery, there is an underground spring which flow only during the rainy season (when the water table rises). Water from this spring showed high levels of water quality pollutants such as heavy metals and nutrients (Frazer-Williams *et al*., 2011). The findings suggest possible seepage and infiltration of leachates into subsoil of the dumpsite and eventually into the ground waters thus highlighting high risk of ground water pollution in the Kingtom area.

(x) Health risk to operating staff of Ministry of Health, FCC, Klin Salone especially when waste contains hazardous clinical wastes including syringes/sharps.

Definition of criteria used to assess risk at the dumpsites

A Risk Index (RI) procedure for assessing the potential risk/hazard of the Kingtom and Granville Brook dumpsites was adapted from Kurian *et al*.,(2005) being reported as one of the best available tool developed for developing countries. This approach provides a higher priority to dumpsites with high health risk, maximum environmental impacts, minimum rehabilitation costs and sensitive public concerns.

The attributes contained in Tables 1 and 2 are identical to those reported in Kurian *et al*., (2005). Information for attributes (first column of Tables 1 and 2), example, site specific criteria, characteristics related to waste, BOD, COD, public acceptance, total quantity of waste etc were obtained from reported studies (Kanu, 1999; Conteh, 2000; Hingston *et al*, 2002; Frazer-Williams *et al*., 2009; Frazer-Williams *et al*., 2010; Frazer-Williams *et al*., 2011; Lake, 2010; Sankoh *et al*., 2012) on the two dumpsites.

Each attribute was measured in terms of a sensitivity index (Si) on a scale of 0 to 1 to facilitate computation of cumulative scores called risk Index (RI) that can be used in the classification of the dumpsites. Zero (0) indicated none or very low potential hazard whilst one (1) indicated the highest potential hazard.

The Risk Index (RI) for each site was calculated based on the formula:

$$RI = \sum_{i=1}^{n} W_i S_i$$

Where,
W_i - weightage of the ith variable ranging from 0 – 1000
S_i – sensitive index of the ith variable ranging from 0 – 1
RI - Risk Index variable from 0 – 1000

Table 1. Attribute Weightage and Sensitivity

No	**Attribute**	**Attribute Weightage**	**Sensitivity Index**			
			0.0 – 0.25	**0.25 – 0.50**	**0.50 – 0.75**	**0.75 – 1.00**
	I – Site specific criteria					
1	Distance from nearest water supply source (m)	69	>5000	2500 - 5000	1000 - 2500	<1000
2	Depth of filling of waste (m)	64	<3	3 - 10	10 - 20	>20
3	Area of the dumpsite (Ha)	61	<5	5 - 10	10 - 20	>20
4	Ground water depth (m)	54	>20	10 - 20	3 - 10	<3
5	Permeability of soil (1×10^{-6} cm/s)	54	<0.1	1 – 0.1	1 - 10	>10
6	Ground water quality	50	Not a concern	Potable	Potable if no alternative	Non-potable
7	Distance to critical habitats such as wetlands and reserved forest (km)	46	>25	10 - 25	5 - 10	<5
8	Distance to nearest airport (km)	46	>20	10 - 20	5 - 10	<5
9	Distance from surface water body (m)	41	>8000	1500 - 8000	500 - 1500	<500
10	Type of underlying soil (%clay)	41	>50	30 - 50	15 - 30	0 - 15
11	Life of the site for future use (years)	36	<5	5 -10	10 - 20	>20
12	Type of waste (MSW/HW)	30	100% MSW	75% MSW +25% HW	50% MSW + 50% HW	>50% HW
13	Total quantity of waste at site (t)	30	$<10^4$	10^4 - 10^5	10^5 - 10^6	$>10^6$
14	Quantity of waste disposed (t/day)	24	<250	250 - 500	500 - 1000	>1000

15	Distance to nearest village in the predominant wind (m)	21	>1000	600 - 1000	300 - 600	<300
16	Flood prones (flood period in years)	16	>100	30 - 100	10 - 30	<10
17	Annual rainfall at site (cm/y)	11	<25	25 - 125	125 - 250	>250
18	Distance from the city (km)	7	>20	10 - 20	5 - 10	<5
19	Public acceptance	7	No Public concerns	Accepts Dump Rehabilitation	Accepts Dump Closure	Accepts Dump Closure and Remediation
20	Ambient air quality (CH_4(%)	3	<0.01	0.05 – 0.01	0.05 – 0.1	>0.1
	II – Related to characteristics of waste at dumpsite					
21	Hazardous contents of waste (%)	71	<10	10 - 20	20 -30	>30
22	Biodegradable fraction of waste at site (%)	66	<10	10 - 30	30 - 60	60 - 100
23	Age of filling (years)	58	>30	20 - 30	10 - 20	<10
24	Moisture of waste at site (%)	26	<10	10 - 20	20 - 40	>40
	III – Related to leachate quality					
25	BOD (mg/L)	36	<30	30 - 60	60 - 100	>100
26	COD (mg/L)	19	<250	250 - 350	350 - 500	>500
27	TDS mg/L)	13	<2100	2100 - 3000	3000 - 4000	>4000
	Risk index					

Table 2: Criteria for Hazard Evaluation based on the Hazard Potential Index

No	Overall score	Hazard Evaluation	Recommended Action
1	750 – 1000	Very high	Close the dump with no more land filling in the area. Take remedial action to mitigate the impacts
2	600 – 749	High	Close the dump with no more land filling in the area. Remediation is optional.
3	450 – 599	Moderate	Immediate rehabilitation of the dumpsite into sustainable landfill
4	300 - 449	Low	Rehabilitate the dumpsite into sustainable Landfill in a phased manner
5	<300	Very Low	Potential Site for future Landfill

RESULTS AND DISCUSSION

Results of hazard potential for both sites is presented (Table 3). Both the Kingtom and Granville Brook dumpsite scored a risk index (RI) of 585.0 and 583.5 respectively. The hazard potential of both sites was evaluated based on the overall score as outlined for the Criteria for Hazard Evaluation on the Hazard Potential Index (Table 2).

Table 3 – Estimated Risk Index work Sheet for Kingtom and Granville dumpsites

No	Attributes	Attribute Weightage	Kingtom dumpsite			Granville brook dumpsite		
			Attribute measurement	Sensitivity Index	score	Attribute measurement	Sensitivity Index	score
1. Site specific criteria								
1	Distance from nearest water supply source (m)	69	1000	0.85	**58.7**	1000	0.85	**58.7**
2	Depth of filling of waste (m)	64	10	0.4	**19.2**	8	0.375	**24**
3	Area of the dumpsite (Ha)	61	5.89	0.3	**18.3**	6.05	0.15	**9.2**
4	Ground water depth (m)	54	15	0.35	**18.9**	15	0.35	**18.9**
5	Permeability of soil (1×10^{-6} cm/s)	54	5×10^{-6}	0.6	**32.4**	5×10^{-6}	0.6	**32.4**
6	Ground water quality	50	NP	0.8	**40**	NP	0.8	**40**
7	Distance to critical habitats such as wetlands and reserved forest (km)	46	<5	0.9	**41.4**	25	0.5	**41.4**
8	Distance to nearest airport (km)	46	>20	0.1	**4.6**	>20	0.1	**4.6**
9	Distance from surface water body (m)	41	<500	0.95	**38.9**	<500	0.95	**38.9**
10	Type of underlying soil (%clay)	41	10%	0.8	**32.8**	10%	0.8	**32.8**
11	Life of the site for future use (years)	36	5	0.25	**9**	5	0.25	**9**
12	Type of waste (MSW/HW)	30	75%/25%	0.35	**10.5**	75%/25%	0.35	**10.5**
13	Total quantity of waste at site (t)	30	$>10^6$	0.9	**27**	10^5 - 10^6	0.7	**21**
14	Quantity of waste disposed (t/day)	24	<250	0.1	**2.4**	<250	0.1	**2.4**
15	Distance to nearest village in the predominant wind (m)	21	800	0.35	**7.4**	>1000	0.1	**2.1**
16	Flood prones (flood period in years)	16	<10	0.9	**14.4**	<10	0.9	**14.4**

17	Annual rainfall at site (cm/y)	11	500	0.9	**9.9**	500	0.9	**9.9**
18	Distance from the city (km)	7	0.1	0.95	**6.7**	0.1	0.95	**6.7**
19	Public acceptance	7	Accepts dump closure	0.7	**4.9**	Accepts dump closure	0.7	**4.9**
20	Ambient air quality (CH_4(%)	3	0.05	0.5	**1.5**	0.05	0.5	**1.5**
II – Related to characteristics of waste at dumpsite								
21	Hazardous contents of waste (%)	71	25	0.65	**46.2**	25	0.65	**46.2**
22	Biodegradable fraction of waste at site (%)	66	65%	0.75	**49.5**	65%	0.75	**49.5**
23	Age of filling (years)	58	>30 yrs	0.1	**5.8**	20 – 30 yrs	0.35	**20.3**
24	Moisture of waste at site (%)	26	30%	0.6	**15.6**	30%	0.6	**15.6**
III – Related to leachate Quality								
25	BOD (mg/L)	36	>100	0.9	**32.4**	>100	0.9	**32.4**
26	COD (mg/L)	19	>500	0.9	**17.1**	>500	0.9	**17.1**
27	TDS mg/L)	13	<2100	0.15	**19.5**	<2100	0.15	**19.5**
	Risk index				**585.0**			**583.5**

The risk indices for both sites are reasonably close: 585.0 for the Kingtom dumpsite and 583.5 for the Granville brook dumpsite. This depicts the fact that although both sites are miles away, similar practices occur in both sites. The RI scores fell within the range of moderate hazard. Albeit both scores lie towards the upper end of moderate and is closer to the lower end of high. Moderate hazard recommends immediate rehabilitation of the dumpsite into sustainable landfill. This is because past and present conditions at the Kingtom and Granville Brook dumpsites are deplorable. Both sites have been operated at sub-standard level as outlined above and are a threat to human health and to the aesthetic beauty of the environment. Taylor and Nakai (2012) reported that ambient concentrations of PAHs and CO in the vicinity of the dumpsites were in excess of WHO guidelines, whilst Sankoh *et al*., (2013) reported that residents less than fifty metres from the Granville brook dumpsite are most affected from health problems such as irritation of the skin, nose and eyes than those much farther away.

The findings of this study are consistent with previous authors on waste management practices in Freetown.

The study demonstrates the importance of IRBA in making decision on the management of waste dump facilities. This approach was used by Abah and Ohimain (2010) in a study on risk assessment for the Eneka dumpsite, Nigeria. A total risk factor of 452.3 corresponding to a moderate hazard potential status was obtained.

The result of this study is consistent to recommendation made by Lake (2010) in a Technical Study for The Freetown Waste Management Company for the relocation of the two dumpsites as well as residents in the vicinity of the dumpsites. An environmental and health impact study of Granville brook in Freetown by Sankoh *et al*., (2013) also recommended the relocation of the dumpsite.

In as much as efforts must be made in addressing management practices at the dumpsites, much is required of residents in Freetown to ensure a clean and healthy environment. For this, the following mitigation strategies are recommended: (i) Encourage waste segregation at source at all levels (i.e. in homes, offices etc) and buy organic and recyclable waste from consumers (ii) Ensure frequent/regular collection of waste from households (iii) Collect waste frequently from collection points, (iv) Provide cover for waste during transportation, (v) Levy fines or apply appropriate penal action to offenders who throw rubbish indiscriminately or into the streets, streams,

(vi) Ensure proper management at the dumpsite by discouraging scavengers gain access into the sites for recyclable materials at waste heaps, (vii) Prevent the practice of setting fires on old waste dump to create room for new incoming waste as well as for unofficial gardening practices (viii) Provide appropriate personal protective equipment (PPE) for staff of Ministry of Health, FCC, Klin Salone especially when waste contains hazardous clinical wastes including syringes/sharps. The above recommendations would require an autonomous solid waste institution with private sector and local community as key participants. A situational analysis of waste management in Freetown by Gogra *et al*., (2010) strongly recommended the need of a sound institution that would ensure proper waste management.

CONCLUSION

An assessment of the Kingtom and Granille Brook dumpsites conducted to assess their hazard potential using the Integrated Risk based Approach according to Kurian *et al.*, (2005) revealed moderate hazard. According to the model, an immediate rehabilitation is recommended. It is hoped that the study will provide stakeholders that formulate policies and take decisions necessary information in the execution of their duties. The study demonstrates the importance of Integrated Risk based Approach in decision making on dumpsites management.

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