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Assessment of Solid Waste Management in Freetown, Sierra Leone towards Sustainable Development

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Abstract: The aim of this study is to evaluate the status and challenges of solid waste management system in Freetown, Sierra Leone and possible recommendations towards sustainable development. Structured questionnaires were administered with respect to socioeconomic characteristics and waste management data in four selected constituencies of Freetown because they were the most populated constituencies that generate 70% of the total quantity of solid waste in the city. Door-to-door survey approach was used to determine the rate of solid waste generation through sorting and weighing of solid waste. The data obtained was analyzed by using SPSS software packages. The results showed that on the average, 0.45 kg/person/day of solid waste was generated in Freetown because respondents' socioeconomic characteristics were significantly related to solid waste generation and physical composition. Due to institutional, regulatory, financial, technical and public participation shortcomings, the Solid Waste Management system was weak and ineffective in management and hence result to environmental and health hazards in Freetown. The study concludes that solid waste generation and physical composition were two important factors in designing the cost effectiveness and environmentally compatible solid waste management system in Freetown given the fact that waste management authority's activities were very unsatisfactory. Therefore, there was need for support from government, private sector and Non-governmental Organizations for a rehabilitation of the entire solid waste management system, first on an emergency basis, followed by development and implementation of long-term sustainable measures.

Key words: Solid waste management, sustainable development, enabling environment, elements of waste management, waste hierarchy

INTRODUCTION

The waste management system in Freetown has been under variable organizations, both public and private. Unfortunately, each change further deteriorated the system, bringing it on the verge of collapse. This change under shifting authorities has been treated as a political football. Regardless of the context, solid waste management is one of the biggest challenges of the urban areas of all sizes, from mega-cities to the small towns and large villages which are home to the majority of human kind. It is almost always in the top five of the most challenging problems for city managers (Hoornweg and Bhada-Tata, 2012). The quality of waste management services is a good indicator of a city's governance. The way in which waste is produced and discarded gives us a key insight into how people live. In fact if a city is dirty, the local administration may be considered ineffective or its residents may be accused of littering. For instance, according to studies, it was noted that for years, the major problem in Israel (especially in Ramat Hovar) was the accumulation of tens of thousands of tons of organic wastes; the plague outbreak in Surat is another good example of a city which suffered due to the callous attitude of the local body in maintaining cleanliness in the city. Also, in the U.S until the 1970's Federal Agencies had little authority to regulate hazardous waste and solid waste disposal often took in an unsafe manner at landfills or lagoons, with some wastes simply dumped on the ground or in surface waters. Given the rapid rates of urbanization occurring around the world, the importance of an efficient and effective solid waste management system is more critical than ever before. Nowhere is this truer than in urban areas in the developing world, where unprecedented urban growth has resulted in greater amounts of municipal solid waste being generated. These urban areas are a focal point of environmental problems (Wilson *et al*., 2012) with impact that can extend over a wide range of spatial scales-the household, the place of work, the neighbourhood, the city, the wider region and

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ultimately the world. In the rapidly growing cities of the developing countries, urban solid waste management system is currently regarded as one of the most immediate and serious problems faced by the city authorities. In high-income countries, the problems usually centre on the difficulties and high cost of disposing of the large volume of waste generated by households and businesses. In lower-income countries, the main problems are related to collection and disposal, with one-third to half of all solid waste generated in the third world countries remaining uncollected (Sood, 2004).

Generally, the environmental degradation due by improper solid waste management system can be expressed by the contamination of surface ground water through leachate, soil contamination through direct waste contact or leachate, air pollution by burning of waste, spreading of diseases by different vectors like birds, insects and rodents, or an uncontrolled release of methane by anaerobic decomposition of waste. The sustainability of the land filling system has become a global challenge in the solid waste management system due to increased environmental concerns. Due to public opposition together with unavailability of land in developing countries, obtaining sites for new landfills is becoming increasingly difficult. Locating a landfill far away from the urban area can be adventitious from public opposition (Gogra *et al*., 2010). When the site is far away from the source of waste generation, it increases transfer costs and additional investments for infrastructure of roads, hence intensifying the problems of the responsible authorities. Increased solid waste generation creates more environmental problems in developing countries, as many cities are not able to manage it due to institutional, regulatory, financial, technical and public participation shortcomings. These and other factors which concern proper waste management propelled the researcher to investigate the solid waste management system in Freetown, Sierra Leone towards sustainable development.

SOLID WASTE MANAGEMENT

Waste is something for which we have no further use and which we wish to get rid of. Solid wastes arise from unusable residues in raw materials, leftovers, rejects and scrap from process operations, used or scrap packaging materials. According to Williams (2005), solid waste is an object the holder discards, intends to discard or is required to discard. The 'holder' can either be the producer of waste or be in possession of waste. Once a substance or object has become waste it will remain waste until it has been fully recovered and no longer poses a potential threat to the environment or to human health.

Since the beginning human kind has been generating waste, be it the bones and other parts of animals they slaughter for their food or the wood they cut to make their fire, cart and build houses. With the progress of civilization, the waste generated became of a more complex nature. At the end of the nineteenth century the industrial revolution saw the rise of the world of consumers which consequently contribute to the increase of waste generated. Therefore, increase in population and urbanization is largely responsible for the increase in solid waste (Thanh *et al*., 2011).

Many previous studies have examined solid waste generation and composition due to socioeconomic factors. In every human settlement, the microscopic unit of waste generation is the household (Monavari *et al*., 2012). Due to societal changes, the household plays an important role in environmental problems associated with the generation of solid waste. These societal changes influence the characteristics of given households, including family size, family income, marital status and education. Several studies conducted by researchers have shown that there is a correlation between household solid waste generation and composition and these relevant socioeconomic characteristics (Sujauddin *et al*., 2008; Burnley *et al*., 2007; Buenrostro and Bocco, 2003). Household size, cultural patterns and personal attitudes are said to influence solid waste generation as well (Bandara *et al*., 2007). Economists also compared the composition and quantity of wastes in terms of income level, household size and age structure of the household as these affect the quantity and composition of solid waste (Burnley *et al*., 2007). Sujauddin *et al*. (2008) also showed that the quantity of waste generated by a country is proportional to its population and the mean living standards of the people is related to the income levels of the people hence individual household's waste generation is correlated. Wilson *et al*. (2012) reported that income level and urbanization are highly correlated and as disposal incomes and living standards increase, consumption of goods and services correspondingly increases, as does the amount of waste generated. In addition, a statistical analysis on the relationship between socioeconomic characteristics and waste generation and composition showed that a clear difference exist between the more prosperous section in relation to the total and the individual components of the waste streams. The whole set of activities related to generation, collection, transfer and transportation, treatment and disposal of solid wastes is termed the waste management system (Joseph, 2006). Collection of waste is not an arbitrary job. It is an important aspect in maintaining public health in cities around the world (Hoornweg and Bhada-Tata, 2012),

with the most predominant methods including house-to-house, community bins, curbside pick-up, self-delivered and contracted or delegated service. However, waste collection methods vary widely between different countries and regions. In Freetown, household waste is collected using 6m^3 skips which are strategically located along few streets and due to their (skips) highly inadequate number, wastes can be seen everywhere, scattered, or illegally dumped in small or large heaps/piles along the streets, markets and business areas, many of which are regularly set on fire used as a waste disposal option; thus making collection inefficient and expensive. At the same time, immobilization rate of waste collection vehicles reaches about 70% in Freetown, thereby seriously impacting the rate of collection (Gogra *et al*., 2010). Domestic waste collection services are often provided by local government authorities, or by private agencies. In some areas, especially those in less developed countries do not have formal- waste collection system (Wilson *et al*., 2009). The predominant system of collection is through storage communal bins placed at various points along the streets and sometimes this leads to the creation of unauthorized open collection points-an attitude that affects effective waste management system.

A typical solid waste management system in a developing country displays an array of problems, including low collection coverage and irregular collection services, crude open dumping and burning without air and water pollution control, the breeding of flies and vermin and the handling and control of informal waste picking or scavenging activities (Oguntoyinbo, 2012). Broadly, these problems fall into four main categories: technical/institutional, financial/economic, environmental/ social factors and legal/political frame work (Ezeah and Roberts, 2012). People's attitudes and perceptions towards solid waste management system are negative (Mangizvo and Wiseman, 2012). Solid waste management issues are viewed as one of the social services of the government through Freetown City Council and hence their unwillingness to pay for disposal services. Despite the stringent effort the Freetown Waste Management Company (FWMC) is making to ensure that Freetown is a clean and decent environment, little effort has been made by residents; instead they choose to deposit their garbage on the streets and in the gutters while others throw their garbage on the roof tops of residents. Some even put the rubbish in polythene bags and throw them to the streets while it rains. This rubbish will eventually be exposed in the streets and drainages after the rain has seized.

In the area of legislative frame work on solid waste management, (Ezeah and Roberts, 2012) further observed that lack of effective legislation for solid waste management for developing countries is responsible for the ineffective delivery of solid waste management services towards sustainable development. Legislation related to solid waste management system in Freetown is fragmented into public health acts, local government acts and Environmental Protection Acts. No stipulated discharge rules/regulations to enforce the acts were contained in these Acts. In addition, the institutional capacity of solid waste management has been grossly inadequate to enforce and monitor any regulations included in these acts regarding solid waste management system. They are sometimes enforced by different agencies. However, duplication of responsibilities of the agencies involved and gaps/missing elements in the regulatory provisions for the development of effective solid waste management system sometimes existed which made the FWMC very ineffective. These challenges faced by waste management authority led to several environmental and health impacts in the city. Hence, the following hypotheses were proposed.

Socioeconomic characteristics of stakeholders relate to solid waste generation:

H1: Average family size of respondents will be positively related to the quantity of solid waste generated

H2: Marital status of respondents will be positively related to the quantity of solid waste generated

H3: Educational level of respondents will be positively related to the quantity of solid waste generated

H4: Income level of respondents will be positively related to the quantity of solid waste generated

H5: Age of respondents will be positively related to the quantity of solid waste generated

H6: Employment status of respondents will be positively related to the quantity of solid waste generated

Attitudes and perceptions of stakeholders towards sanitation issues in solid waste management: Issues of attitudes appear to affect both inhabitants and the authorities regarding solid waste management in developing urban cities. Such issues include people's opinion on responsibilities for ensuring clean surroundings, education of households to clean their surroundings, disposal of household solid waste and children's involvement in solid waste management and accepting the pay as you throw system.

H7: Wrong attitude and perceptions of people on sanitation issues will negatively affect the effectiveness of the solid waste management system towards sustainable development

Elements of solid waste management towards sustainable development: The whole set of activities related to generation, collection, transfer and transportation treatment and disposal of solid wastes is termed the waste management system. The stakeholders play an important role in sustainable solid waste management for which awareness on reduction, segregation and recycling needs to be enhanced. Waste collection, the next element is labour intensive and consumes almost the full budget of waste management in developing countries (Demirbas, 2011). Therefore, the technical, environmental, financial, legal and social aspects of these elements need to be balanced to attain sustainable development in waste management. Hence hypothesis 8 was proposed as:

H8: Waste management authority's problems on the elements of solid waste management will negatively affect the efficiency of the system towards sustainable development

The elements most commonly associated with integrated solid waste management are waste prevention, waste reduction/minimization, reuse of materials and products, material recovery from waste streams, recycling of materials, composting to produce manures, incineration with energy recovery, incineration without energy recovery and disposal in landfills in that order of priority. These elements of ISSWM frequently formulated into waste hierarchy are described by Girling (2005) as a penny-plain piece of common sense that places the various strategies for waste management in order of environmental friendliness, from best to worst. Thus hypothesis 9 can be stated as:

H9: Lack of knowledge by respondents on the use of the waste hierarchy will negatively affect the solid waste management system towards sustainable development

Enabling environment on the effects of improper solid waste management system: Solid waste management is a major problem being faced by waste management authorities in development countries. It involves a huge expenditure and thus receives scant attention. It is not only a technical problem but it is also strongly influenced by political/legal, socio-cultural, environmental and economic factors as well as available resources. Moreover, these factors have interrelationships that are usually complex in the solid waste management system (Kum *et al*., 2005). Hence integrated waste management and the waste hierarchy both inspire sustainable waste management and can reduce the environmental and health hazards associated with improper management of solid waste (Siddiqui *et al*., 2012). Therefore, hypotheses 10 and 11 were proposed as:

H10: Improper management of solid waste will negatively affect the environment of the respondent's communities

H11: Improper management of solid waste will negatively affect the health of the respondents' communities

MATERIALS AND METHODS

Sample preparation: A stratified-simple random sampling method was used. Eight households, two from each of the four randomly selected constituencies in Freetown were used. Questionnaires were administered to four categories of respondents: household residents, Freetown City Council, Ministry of Health and Sanitation and Freetown Waste Management Company charged with waste management responsibilities. Sample size of 400 for household residents, 144 for Freetown Waste Management Company, 210 for Freetown City Council and 147 for the Ministry of Health and Sanitation was used in the survey, thus giving a total sample size of 901 (74.9%) for the entire survey. Out of this sample, only 631 (70%) actively participated in the study. About 70% sample size was the representative population which was easy to manage and come up with good results. This method ensured that there was no biasness in the selection of the population who were part of the sample. Also, through stratified-simple random sampling every member of the study area had an equal probability of being selected to be part of the study. Household questionnaires were completed by either the head of the household or a responsible adult in their absence.

Pilot study: To provide a basis for the validation of the main survey, it was necessary to carry out a pilot survey prior to the commencement of the actual survey. Population sample for the pilot survey was drawn from twenty five staff members of Freetown Waste Management Company (FWMC) who have had a contextual knowledge of waste management in the case study area. A total of eighteen responses were returned equivalent to 72% response rate. This was a satisfactory response rate in order to check the clarity of the questions, to eliminate difficulties or ambiguities and to estimate the length of time a respondent would take to complete the questionnaires (Ott and Longnecker, 2001). The results obtained provide an opportunity for a revision of the questions in designing the questionnaires

for the main survey and validation of the final outcomes of this study. The length of time invested in the pilot study was valuable and enriching for later phases of the study. The questionnaires took approximately twenty minutes to be completed. Some revisions to the scales were made to take account of the level of education of the respondents.

Data collection: The data for the study was collected from both primary and secondary sources to present an assessment of the current solid waste management system towards sustainable development in Freetown, Sierra Leone. The method of data collection for primary sources involved the following.

Firstly, household door-to-door surveys approach in eight households of four selected constituencies in the city to determine the rate of solid waste generation in Freetown for twenty one consecutive days. These constituencies were selected because they were the most populated constituencies that generate 70% of the total quantity of solid waste in the city. The solid wastes from each selected household were sorted out and measured (in Kilograms) to obtain the rates of generation as quantity of solid waste measured divided by the number of people in the household. The average for the city was then obtained by adding individual rates for the different constituencies and divided by the total number of households used. One hundred household residents and fifty staff members from Freetown Waste Management Company (FWMC), Freetown City Council (FCC) and the Ministry of Health and Sanitation were interviewed to confirm the collection, disposal, treatment procedures, recycling practice, environmental and health hazards and problems facing the solid waste management system, given rise to 80% response. The interviews were aimed to obtain descriptive data that helped the researcher to get broader inputs based on the participant's knowledge. The questions designed were tailored to derive information on solid waste management system in Freetown, Sierra Leone towards sustainable development. Direct observations through on-site visits also helped the researcher to gain some insight on the issues of interest concerning waste management; for example, how waste is collected transported, recycled, treated and disposed. Information obtained was used to update the data collected during the desk study.

Secondly, a questionnaire guide was prepared according to Buenrostro *et al*. (2001) which allowed a direct door stepping questionnaire administration approach after the method adopted by Phillips *et al*. (2002) and Read (1999). This method enhanced the rate of return since the questionnaires were delivered directly by hand to the respondents and taken back immediately on completion. An important drawback of this approach is that it is laborious, time-consuming and expensive. Using this method, the researcher hired two assistants to assist in the administration of nine hundred and one (901) questionnaires to randomly selected respondents in the study area. At the end of the exercise, a total of 631 questionnaires were returned, an equivalent to a 70% response rate. Besides ensuring a rather high return rate, direct door stepping questionnaire administration strategy also ensured effective completion of questionnaires by respondents as the author was at hand to provide guidance. As a result all 631 questionnaires returned were effectively completed.

The first part of the questionnaires sought information on demographic data such as age, marital status, family size, educational level, employment status and income level. The second part of the questionnaires obtained information on the current solid waste management system in Freetown with regards: cleanliness of the environment, methods of disposal, collection, transfer stations and transportation, problems affecting solid waste management system towards sustainable development and the health and environmental effects of solid wastes. When designing the questionnaires, care was taken in the presentation to ensure an attractive layout. In addition different print styles for instructions, questions and answers were applied consistently to enhance the appearance of the questionnaires. Close ended questions were primarily used throughout the questionnaire to allow the respondents to answer the questions quickly and with ease. In addition, close ended questions made the processing of answers easier and enhance the comparability of answers. Few open ended questions were included on the questionnaire to allow the respondent to make additional inputs. These comments helped overcome one of the main disadvantage of close ended questions. A potential loss of spontaneity in answers and interesting replies. Data from the main study was collected at different times from all the respondents in their constituencies.

The secondary sources of data was collected through a desk study in which documents and records from appropriate data sources including books, journals, newspapers and activities both published and unpublished were studied. These sources provided background information as well as data which enabled the analysis of an inferential statistics on solid waste management system in Freetown, Sierra Leone, towards sustainable development.

Statistical analysis: Analysis of data generated from the questionnaire survey was carried out using the Statistical Package for the Social Sciences (SPSS) software. Some of the data from the questionnaires survey were nominal in nature, such data were analysed using descriptive and inferential statistics. Most of the data was, however,

ordinal. This group of data was initially subjected to a test for normality which showed that data was approximately normally distributed. Following Tonglet *et al.* (2004) analyses, such rating data were performed using parametric statistical tests, namely analysis of variance (ANOVA) and Chi-square tests to establish inferential statistical significance on whether or not the data supported the various hypotheses stated.

RESULTS AND DISCUSSION

Socioeconomic characteristics of respondents: Socioeconomic characteristics of households have always been related to solid waste generation. These include marital status, occupation, Income level, educational level, average family size and average age of family. Table 1 is an SPSS analysis output showing five key descriptive statistical parameters: Number in household, mean, standard deviation, percentage and cumulative percentage for the identified socioeconomic characteristics of households affecting solid waste management system in Freetown.

The data in Table 1 shows that the average family size was 8 persons with an average age of 36.5 years and a monthly household income of Le 800000.00.

Relationship between solid waste generation and socioeconomic characteristics: Table 2 shows results of the statistical analysis conducted to determine the relationships between independent variables (socioeconomic characteristics) and dependent variables (solid waste generation). The generation of household waste was found to be positively correlated with average family size, monthly income, marital status (significant at probability level $p<0.05$) and educational level (significant at probability level $p<0.01$). With regards the marital status of the respondents, married life affects family size which in turn influences consumption patterns and waste generation and management. Married people encourage

Table 1: Statistical analysis of socioeconomic characteristics of households

Socioeconomic characteristics	No. in households	Percentage	Cumulative percentage
Average family size			
Less than 7 persons	149	23.6	23.6
8-12 persons	287	45.5	69.1
Above 12 persons	195	30.9	100
Total	631	100	
Mean = 8			
Standard deviation = 3.07			
Age (years)			
Less than 20	17	2.7	2.7
21-30	172	27.3	15
31-40	298	47.3	36
41-50	86	13.6	63
Above 50	58	9.1	100
Total	631	100	
Mean = 36.5 (years)			
Standard deviation = 9.0			
Marital status			
Married	264	41.8	41.8
Single	154	24.5	66.3
Widow/widower	109	17.3	83.6
Separated	69	10.9	94.5
Divorce	35	5.5	100
Total	631	100	
Educational level			
Higher education	75	11.8	11.8
Not educated	413	65.5	77.3
Primary	143	22.7	100
Total	631	100	
Employment status			
Formal employment	149	23.6	23.6
Non-formal employment	482	76.4	100
Total	631	100	
Income levels (in Leones)			
Less than 200000.00	29	4.5	4.5
200000.00-500000.00	143	22.7	27.2
500000.00-900000.00	287	45.5	72.7
Above 900000.00	172	27.3	100
Total	631	100	
Mean = Le 800000.00			
Standard deviation = Le515488.70			

meals that are African in nature and minimum packaged food with attendant wastes like plastic materials. Single people on the other hand consume more of packaged foods which generate plastic materials as wastes. Married people are more likely to be affected when the solid waste management system is not effective than those who are single. Marriage increases the number of people in a given household and hence the amount of solid zwaste generated. The income level of an individual member of any community is a vital factor which determines his/her demands for goods and services. The higher the income of respondents the higher the demand for goods and services, hence the higher the rate of waste generated. These results confirm the findings of Sujauddin *et al.* (2008) that there is a positive relationship between income and solid waste generation. Additionally, there was non-significant negative correlations amongst age, occupation($r = -0.2759$, $p>0.05$; $r = -0.3852$, $p>0.05$) and solid waste generation.

Table 2: Pearson's correlation coefficients of socioeconomic characteristics and solid waste generation

Socioeconomic characteristics	Solid waste generation	Significant test
Age	-0.2759	Not significant
Marital status	+0.9914*	Significant
Average family size	+0.8934*	Significant
Employment status	-0.3852	Not significant
Income level	+0.9215*	Significant
Educational level	+0.2570**	Significant

*,**Significant at 5% ($p<0.05$) and 1% ($p<0.01$) probability level, respectively

Solid waste composition in freetown: In developing urban areas waste which comes from the residential population, commercial establishment and public and private institutions have different composition. Table 3 shows the composition of solid waste component in Freetown. SPSS analysis output showing mean, standard deviation and percentage for each solid waste component in Freetown determined by sampling weight measurement in kilograms is described in Table 3.

Table 3: Statistical analysis of composition of solid waste components in Freetown

Solid waste and sample location	Mean (kg)	Standard deviation	Percentage
Garbage			
Freetown East 1	83.5	15.5	69.1
Freetown Central 1	72.9	19.9	62.3
Freetown East 2	100.5	8.3	77.5
Freetown West 2	76.0	12.3	66.0
Total	332.9		
Plastic			
Freetown East 1	9.2	2.2	7.6
Freetown Central 1	11.0	4.9	9.4
Freetown East 2	6.7	2.4	5.2
Freetown West 2	9.9	3.4	8.6
Total	36.8		
Metal			
Freetown East 1	3.4	0.8	2.8
Freetown Central 1	4.1	2.0	3.5
Freetown East 2	2.5	1.7	1.9
Freetown West 2	3.7	2.5	3.2
Total	13.7		
Glass			
Freetown East 1	3.6	0.2	3.0
Freetown Central 1	3.4	2.3	2.9
Freetown East 2	3.8	2.3	2.9
Freetown West 2	3.4	1.4	3.0
Total	14.2		
Paper and cardboard			
Freetown East 1	11.0	4.2	9.1
Freetown Central 1	14.3	6.9	12.2
Freetown East 2	6.4	1.9	4.9
Freetown West 2	12.4	2.6	10.8
Total	44.1		
Ash			
Freetown East 1	3.7	0.6	3.1
Freetown Central 1	4.2	2.7	3.6
Freetown East 2	3.9	3.0	3.0
Freetown West 2	3.1	2.0	2.7
Total	14.9		
Others			
Freetown East 1	6.5	0.7	5.3
Freetown Central 1	7.2	3.7	6.1
Freetown East 2	5.8	4.5	4.5
Freetown West 2	6.6	3.2	5.7
Total	26.1		

The composition of solid waste is an important issue in waste management. It affects the density of the waste, the proposed methodology of disposal and is necessary for determining reuse, reduction and recycle of waste. The figures shown in Table 3 are averages of all the samples taken and are not weighted in any way. Using analysis of variance (ANOVA) technique with 5% significant level ($p<0.05$), differences in waste composition between the sampling locations were not found to be statistically significant on weight basis, confirming the similarity in the solid waste variation across different constituencies in Freetown. This is in support of studies carried out by Burnley *et al.* (2007) in Wales that ANOVA technique can be used to find statistically significant relationships between wastes produced per household and variables such as location, season, etc. In addition, the main components of solid waste in the sample locations on an average percentage weight basis are: compostable organic-garbage (69%), plastic (7.7%), metal (2.9%), glass (3%), paper and cardboard (29%), ash (3.1%) and others (5.4%). These results confirm the studies that in developing countries, waste stream is over 50% organic materials. The great majority of the total solid waste generated in Freetown is organic (garbage). The high level of reuse of recyclable waste reflects the extent of poverty in the developing countries.

The average rate of solid waste generation by each sample location (constituency) and hence the rate of solid waste generation in Freetown was determined by using the relationship:

$$E = TR/TN$$

where, E = Rate of solid waste generation, TR = Total rate of waste generation, TN = Total number of residents in a given household.

Therefore, the average rate of solid waste generation in Freetown East 2 was 0.49 kg/person/day; Freetown East 1 was 0.46 kg/person/day; Freetown Central 1 was 0.44 kg/person/day; Freetown West 2 was 0.41 kg/person/day. Hence the average rate of solid waste generation in Freetown was 0.45 kg/person/day. The estimated daily generation of solid waste rate for the city of Freetown correlated well with other developing cities 0.4 kg/person/day for the city of Kabul. However, the reported solid waste generation rate for post conflict countries such as Iraq, Palestine and Lebanon are 0.66, 0.7 and 0.5, respectively (Aziz *et al.*, 2011). These solid waste generation rates are slightly higher than the values for Freetown suggesting that factors such as better infrastructure and economic conditions in these countries contribute to greater solid waste generation rates.

Education and solid waste disposal methods: Education plays an important societal role in solid waste management system. In Table 4, column 1 lists the 5 identified respondents' disposal methods of solid waste in the city; column 2 is a list of corresponding educational levels of respondents, column 3 is the number of responses, columns 4 and 5 are the mean and standard values respectively while column 6 is the percentage of the corresponding respondents. Using ANOVA technique, differences in waste disposal methods due to the level of respondents' education were found to be statistically significant. Sample size was denoted by N,

Table 4: Statistical analysis of solid waste disposal methods in Freetown

Disposal methods and educational levels	No. of responses	Mean	Standard deviation	Percentage
Street bins				
Not educated	10	33.8	0.033	1.60
Primary education	30	6.2	0.099	4.80
Higher education	37	2.9	0.610	5.90
Total	77	42.4	0.742	12.30
Dumpsites				
Not educated	125	2.7	0.413	19.80
Primary education	50	3.2	0.165	7.90
Higher education	10	10.8	0.033	1.60
Total	185	16.7	0.611	29.30
Bury and burn in pits at back yard				
Not educated	9	37.6	0.030	1.40
Primary education	23	8.0	0.076	3.60
Higher education	78	1.4	0.258	12.40
Total	110	47.0	0.364	17.40
In bags from freetown management company				
Not educated	12	28.2	0.040	1.90
Primary education	35	5.3	0.116	5.50
Higher education	35	5.3	0.116	5.50
Total	82	38.8	0.272	12.90
In drains and streets				
Not educated	116	2.9	0.383	18.40
Primary education	55	3.4	0.182	8.70
Higher education	6	18.0	0.020	0.95
Total	177	24.3	0.585	28.10

total degree of freedom (df) = N-1 while the ratio of the mean square deviation is given as the F statistic with 5% significance level ($p<0.05$). The preference of educated people to adopt better methods of waste disposal is higher than illiterates. A majority of the people who dispose wastes in dumpsites, drains and streets are not educated (38.2%). Those who keep waste in bags from the Waste Management Company, bury and burn it in pits at the back yard and dispose it in street bins are mostly those with education. In general, 57.4% of the respondents indicated that they either throw waste on the open land or in drains and streets while 12.3% of them deposit wastes in street bins where they can be transferred to the designated points for ultimate disposal sites which is often delayed. In some instances, waste is not removed from respondents' surroundings while in other areas wastes are removed once a month.

Relationship between attitudes and perceptions of the people and solid waste management system: Issues of attitudes and perceptions in solid waste management system which include education of household to clean their surroundings, people's opinion on the responsibilities of ensuring clean surroundings, disposal of household waste, children's involvement in solid waste management and acceptance of user fee system appear to affect both inhabitants and authorities regarding solid waste management in Freetown. Table 5 shows results of statistical analysis conducted to determine the relationships between attitudes and perceptions of respondents affecting solid waste management and lessons taught to household members on sanitation issues in the City. In Table 5 the analysis reveals that significant correlations exit between the respondents' attitudes and perceptions and the lessons taught on sanitation issues. A significant correlation of +0.7420 at 5% level ($p<0.05$) implies that many respondents were thinking that the Freetown Waste Management Company (FWMC) is solely responsible for ensuring clean surroundings and it is likely that the people may not support clean up campaigns meant for making the surroundings clean.

This result confirms the studies of Sood (2004) that with the establishment of the Freetown Waste Management Company, the public tend to have the view that the FWMC should be solely responsible for managing waste. In order to change this trend it was suggested that the people be educated to see the problem as shared responsibility of both the individuals in Freetown and the FWMC. Some of the respondents thought it was appropriate for individuals to share in the responsibility of cleaning their own surrounding. Those respondents who thought individuals must be responsible for cleaning their own surroundings gave reasons as, dirty surroundings cause diseases, effects of bad odour resulting from dirty surroundings and saving individual's money. Besides the reasons given by respondents that individuals should take responsibility for the cleanliness of their surroundings, there are other reasons. These reasons include the general impressions of visitors to the city since it is the gate way to the country, destruction of the city's scenic beauty and the choking of drainage channels that will lead to flooding and environmental pollutions. Individuals should therefore help in the cleaning of their surroundings. The reasons given for not doing it suggest low level of respondents' knowledge concerning sanitation issues. More seminars and talk shows on sanitation could be organized by the government or Non-Governmental Organization as a remedy. It was also realized that there was a significant positive correlation between the respondents' level of education and their perceptions about cleaning their own surroundings (+0.8846 at 5% level with $p<0.05$). This means that majority of the households do not educate their members on the need to clean the surroundings while few of them do.

Majority of the people do not care to educate their households on making the surroundings clean. This has an implication that could affect the society. This effect will be translated into acceptable behaviour in relation to solid waste management. For instance, children will not develop the right attitudes and perceptions for sanitation at an early stage in life. This is likely to impact negatively on how the present and next generation would handle sanitation in general and solid waste in particular. This is because it was realized that some households involved children below the age of ten in the disposal of their household waste (+0.3536 at 1% level, with $p<0.01$). Such children are often asked by their parents and other family members to carry household refuse to the sanitary sites

Table 5: Pearson's correlation coefficients of attitudes and perceptions of respondents affecting sanitation behaviour in the city

Attitudes and perceptions of respondents	Sanitation behaviour in the city	Significant test
Education of households to clean their surroundings	+0.8846*	Significant
People's opinion on responsibilities of ensuring clean surroundings	+0.7420*	Significant
Disposal of household waste	+0.5346*	Significant
Children's involvement in solid waste management	+0.3536**	Significant
Acceptance of user fee system	+0.9453*	Significant

*,**Significant at 5 ($p<0.05$) and 1% ($p<0.01$) probability level, respectively

for disposal. Those households which involved such children in solid waste disposal claimed it was children's responsibility to carry the household waste to the sanitary site. Thus, according to these respondents carrying of household waste was not the duty of adults. Those who did not involve such children in solid waste disposal explained that they did not have such children in their households to carry refuse. There is a greater likelihood of indiscriminate disposal of household waste in Freetown with children dominating as carriers of household waste to the designated sanitary sites. This problem might be changed for the better if the children (under ten) who carry household wastes are given special training about solid waste handling. In addition, one of the ways of sustaining solid waste management system is through the user fee system. It is a holistic approach policy where solid waste management becomes a public utility, rather than a general service. It is expected to impose a pay-as-you-throw system. Waste generators are expected to pay for solid waste management services depending on the amount of waste that is collected. However they were unwilling to accept the user fee system (+0.9453 at 5% significant level, $p<0.05$) due to the following reasons: Cannot afford, no effective monitoring and control, already paying tax, it is government responsibility and others will not pay.

Impacts of solid wastes: Poor solid waste management system has many environmental effects in the city of Freetown. Analysis of variance (ANOVA) was used to carry out a between subjects multiple comparison analysis of impacts of poor solid waste management to both the environment and the health of the respondents in Freetown. A breakdown of responses received from the four respondents is as follows: Households (HHR) 200; Freetown Waste Management Company (FWMC) 135; Freetown City Council (FCC) 190 and Ministry of Health and Sanitation (MoHS) 106 responses. Table 6 is an output analysis showing mean (this value describes impacts of solid waste), standard deviation and number of responses as three key descriptive statistical parameters for the listed reasons given by respondents. In Table 6, column 1 list (a) The 4 identified effects of solid waste to the environment and (b) The 5 identified effects of solid waste to the health of the respondents, column 2 is a list of corresponding respondents while columns 3 and 4 are the corresponding mean and standard deviation values, respectively. Analysis of variance of responses from the four groups on these two variables in the case study area was carried out. Each effect in Table 6 was tested for its ability to account for variation on the dependent variable. Sample size is denoted by N, total degree of freedom (df) = N-1 while the ratio of the mean square deviation is given as the F statistic with significance level (P). Where $p<0.05$, there is an indication of strong variation. The results of the analysis of variance (ANOVA) technique on the impacts of solid waste to the environment and the health of the respondents were found to be statistically significant. By order of importance these impacts include:

- **To the environment:** Poor visual appearance of the city, traffic congestion, flooding and accidents. These effects have a negative impact on official and tourist visits and foreign investments since Freetown is the gate way to Sierra Leone
- **To the health of the respondents:** Malaria, chest pain, cholera, diarrhoea and irritation of skin, nose and eyes

Problems of solid waste management system: In this study it was found that the Freetown Waste Management Company was faced with a myriad of problems that have greatly constrained provision of services. Therefore, analysis of variance (ANOVA) was used to carry out a between subjects multiple comparison analysis of problems affecting waste management system in Freetown. A breakdown of responses received from the four respondents is as follows: Households (HHR) 200; Freetown Waste Management Company (FWMC) 135; Freetown City Council (FCC) 190 and Ministry of Health and Sanitation (MoHS) 106 responses. Table 7 is an output analysis showing mean (this value describes the problems affecting solid waste management on measurement scale reaction by some Likert 5 point scoring method, where 1 implies minor problem while 5 implies a major problem), standard deviation and number of responses as three key descriptive statistical parameters for the listed problems affecting solid waste management in the City. In Table 7, column 1 lists the 8 identified problems affecting solid waste management in the city, column 2 is a list of corresponding respondents while columns 3 and 4 are the corresponding mean and standard deviation values respectively. Analysis of variance (ANOVA) responses from the four groups on the problems affecting solid waste management in the case study area were carried out. Each item in the model was tested for its ability to account for variation on the dependent variables. Sample size is denoted by N,

Table 6: Statistical analysis of impacts of solid waste

Impact and respondents	Mean	Standard deviation	No. of respondents
(a) To the environment			
Poor visual appearance			
FWMC	1.32	0.712	135
FCC	0.88	0.475	190
HHR	1.30	0.697	200
MoHS	1.21	0.657	106
Total	4.71	2.536	631
Flooding			
FWMC	1.18	0.670	135
FCC	0.69	0.390	190
HHR	1.32	0.750	200
MoHS	0.58	0.327	106
Total	3.77	2.137	631
Traffic congestion			
FWMC	1.24	0.669	135
FCC	0.87	0.469	190
HHR	1.27	0.681	200
MoHS	0.70	0.377	106
Total	4.08	2.196	631
Accidents			
FWMC	0.89	0.599	135
FCC	0.68	0.454	190
HHR	0.88	0.586	200
MoHS	0.63	0.424	106
Total	3.08	2.063	631
(b) To the health of respondents			
Chest pain			
FWMC	1.20	0.591	135
FCC	0.67	0.330	190
HHR	1.25	0.615	200
MoHS	0.95	0.466	106
Total	4.08	2.002	631
Diarrhoea			
FWMC	1.01	0.534	135
FCC	0.94	0.493	190
HHR	1.10	0.581	200
MoHS	0.30	0.160	106
Total	3.35	2.668	631
Irritation of Skin, nose, and eyes			
FWMC	1.02	0.683	135
FCC	0.66	0.441	190
HHR	0.80	0.531	200
MoHS	0.56	0.377	106
Total	3.04	2.032	631
Malaria			
FWMC	1.44	0.651	135
FCC	1.10	0.500	190
HHR	1.40	0.636	200
MoHS	0.63	0.285	106
Total	4.67	2.072	631
Cholera			
FWMC	1.27	0.683	135
FCC	0.67	0.636	190
HHR	1.38	0.743	200
MoHS	0.72	0.386	106
Total	4.04	2.175	631

total degree of freedom (df) = N-1 while the ratio of the mean square deviation is given as the F statistic with significance level (P). Where $p<0.05$, there is an indication of strong variation. From Table 7 the responses of the respondents, HHR (household residents), FCC (Freetown City Council), FWMC (Freetown Waste Management Company) and MoHS (Ministry of Health and Sanitation) on the problems affecting solid waste management in Freetown by order of importance include: inadequate funding, wrong attitudes and perceptions of people towards sanitation issues, inadequate tools and equipment, poor conditions of waste worker, lack of trained personnel, lack of effective legislation, excessive population and unavailability of land for dumpsite location. Broadly, these problems fall into four main categories: Environmental/socio-cultural, Financial/ Economic, Technical/Institutional and Political/ Legal/Policy problems. These findings also reflect the

Table 7: Statistical analysis of problems affecting solid waste management system

Problems and respondent	Mean	Standard deviation	No. of responses
Lack of trained personnel			
FWMC	1.25	0.661	135
FCC	0.85	0.446	190
HHR	1.19	0.628	200
MOHS	0.66	0.351	106
Total	3.95	2.087	631
Wrong attitudes andPerceptions of the people towards sanitation issues			
FWMC	1.41	0.694	135
FCC	0.95	0.468	190
HHR	1.34	0.659	200
MOHS	0.75	0.368	106
Total	4.45	2.189	631
Inadequate tools and equipment			
FWMC	1.37	0.373	135
FCC	0.92	0.498	190
HHR	1.30	0.700	200
MOHS	0.73	0.391	106
Total	4.32	2.326	631
Unavailability of land for dumpsite location			
FWMC	1.00	0.670	135
FCC	0.68	0.454	190
HHR	0.96	0.639	200
MOHS	0.53	0.357	106
Total	3.18	2.122	631
Inadequate funding			
FWMC	1.49	0.674	135
FCC	1.00	0.455	190
HHR	1.41	0.641	200
MOHS	0.79	0357	106
Total	4.69	2.128	631
Poor conditions of waste workers			
FWMC	1.32	0.712	135
FCC	0.89	0.480	190
HHR	1.26	0.676	200
MOHS	0.70	0.377	106
Total	4.18	2.245	631
Lack of effective legislation			
FWMC	1.18	0.670	135
FCC	0.80	0.452	190
HHR	1.12	0.636	200
MOHS	0.63	0.355	106
Total	3.73	2.113	631
Excessive population			
FWMC	1.00	0.673	135
FCC	0.68	0.454	190
HHR	0.96	0.639	200
MOHS	0.53	0.357	106
Total	3.18	2.122	631

status of solid waste management in other developing countries as there are a number of generic issues common to most developing countries (Ahmed and Ali, 2004; Mensah, 2006).

Summary of hypotheses testing results: The hypotheses of study were tested by assessing statistical significance of socioeconomic characteristics, attitudes and perceptions of stakeholders, problems on the elements of waste management, the effects of solid waste and solid waste management data using analysis of variance (ANOVA) and Chi-square with p-values. The results of the hypotheses tested were presented in Table 8. The results indicated that eight of the hypotheses tested were statistically significant and supported. These variable pairs were, average family size and solid waste generation, marital status and solid waste generation, educational level and solid waste generation, income level and solid waste generation, attitudes and perceptions of people and effectiveness of solid waste management system towards sustainable development, knowledge on the use of the waste hierarchy and solid waste management system towards sustainable development, improper management of solid waste and its effects on the environment of Freetown, improper management of solid waste and its effects on the health of the respondents' communities. However, one hypothesis was significant but partially supported with a variable pair: waste management authority's problems on the elements of solid waste management and the efficiency of the system towards

Table 8: Results of hypotheses testing

Hypothesis	p-value	Chi-square	ANOVA	Results
H1: Average family size of respondents will be positively related to the quantity of solid waste generated	p<0.001	27.14	22.46	Supported
H2: Marital status of respondents will be positively related to the quantity of solid waste generated	p<0.001	48.7	24.32	Supported
H3: Educational level of respondents will be positively related to the quantity of solid waste generated	p<0.001	56.44	26.13	Supported
H4: Income level of respondents will be positively related to the quantity of solid waste generated	p<0.001	53.01	27.88	Supported
H5: Age of respondents will be positively related to the quantity of solid waste generated	p<0.001	2.17	27.88	Not supported
H6: Employment status of respondents will be positively related to the quantity of solid waste generated	p<0.001	4.63	19.04	Not supported
H7: Wrong attitudes and perceptions of the people on sanitation issues will negatively affect the effectivenessof the solid waste management towards sustainable development	p<0.001	48.7	24.32	Supported
H8: Waste management authority's problems on the elements of solid waste management will negatively affect the efficiency of the system towards sustainable development	p<0.001	59.36	27.88	Partially supported
H9: Lack of knowledge by respondents on the use of the waste hierarchy will negatively affect the solid waste management system towards sustainable development	p<0.05	29.27	3.49	Supported
H10: Improper management of solid waste will negatively affect the environment of the respondents' communities	p<0.05	4.14	3.06	Supported
H11: Improper management of solid waste will negatively affect the health of the respondent's communities	p<0.05	4.44	2.57	Supported

sustainable development. While as two hypotheses were found to be significant but not supported. These variable pairs were: age and solid waste generation and employment status and solid waste generation.

DISCUSSION

Solid waste management simply means the collection, keeping, treatment and disposal of wastes in such a way as to render them harmless to human and animal life, the ecology and environment generally. It could also be said to be the organized and systematic dumping and channeling of waste through or into landfills or path ways to ensure that they are disposed of with the attention to acceptable public health and environmental safeguard. Solid waste management has become an area of major concern in Freetown, Sierra Leone today. It is a battle against the harmful consequences of unguarded waste and the attainment of a clean healthy environment for all residents in Freetown. It is common site in Freetown today to see heaps or accumulation of festering waste dumps in the city. Most sides of residential apartments, the drains, the highways, corners of major or minor streets and undeveloped plots of land have all become waste dumps for many households. Improper management of solid waste has serious environmental and health consequences. Such practices contribute to widespread environmental pollution (example unpleasant odour, smoke), the spread of diseases (malaria, bronchitis asthma, diarrhea, chest pains, cholera and dysentery) as well as giving rise to negative effects including accidents, flood occurrences and environmental pressures. Open dumps as well as controlled dumps have the potential to significantly pollute areas of groundwater. As water percolates through the solid landfills, it absorbs chemicals and microorganism present in the putrefying materials. The uncontrolled discharge of liquid formed in solid waste dumps or landfills, known as leachate, contaminates ground and surface waters and thus, pose environmental and public health risks to the local community. In addition, the migration and emission of harmful gases such as methane (highly flammable, risk of explosion) need to be controlled and economically utilized, given its high calorific value.

In Freetown, administration is one of the major weaknesses of solid waste management-limited budgets, inability to raise revenues through user fees, as well as poor organizational set up are also serious constraints to effectively implement and manage the solid waste management system. Effective administrative and organizational systems on which the services ultimately depend are crucial to a sustainable solid waste management system. A successful solid waste management depends on efficient operational systems from the outset. In any solid waste management system, four technical pillars are commonly recognized- storage at or near the point of generation, collection of waste, street cleansing and transport and disposal of wastes. Each of these pillars for sustainable development also requires careful planning and implementation by financially, well-footed agency that has executive authorities, adequate equipment and tools and appropriate policy and legislative support. In addition, the participation, organization and management relationships between all

key stakeholders must also include consensus building throughout the planning process. There was virtually no house-to-house collection of wastes in Freetown. One of the biggest problems is that the residents are unwilling and/or unable to pay for these services. In addition, largeareas of the city are highly congested, constituting more than 60% of all city neighborhoods. Moreover, waste storage at homes is based on poor storage practices, adding to the collection difficulties. Wastes without sorting, is often stored in old leaky buckets and used paper bags instead of a bin lined plastic bags. Collection workers are not provided gloves and other safety tools for use.

Recycling and reuse are important elements to be considered in waste management system. At present, recycling in Freetown is very limited and practiced in a highly informal manner. Recycling is a series of activities that include collecting recyclables that would otherwise be considered wastes, sorting and processing recyclables into raw materials such as fibres and manufacturing raw materials into new products. Common household items that can be recycled include paper, aluminium and plastic containers and bottles. Many scavengers mostly women and children working at the two landfills, illegal dumps and garbage skips pick up some of the saleable materials such as plastic sheets, cans, scrap metals, used batteries and bottles for sale to local industries. Due to unhealthy and often smoke-filled environment, especially at the two dumpsites, the practice poses considerable health risks to scavengers. There are a few private recycling industries profitably operating in Freetown. These industries manufacture footwear, wheelbarrows, cooking post, watering cans, cutlasses and other items using recyclable materials. However, there is no formal program of waste recycling and material recovery, in spite of scarcity of new materials, the high electricity costs among many others.

Public awareness and attitudes to sanitation issues can affect the population's willingness to cooperate and participate in adequate waste management practices. For instance, general environmental awareness and information on health risks due to deficient solid waste management are important factors which need to be continuously communicated to all sectors of the population. It is therefore important to keep the community informed and seek it cooperation. Implementing education and awareness strategies can significantly help to keep solid waste management system sustainable. In addition, corruption, a negative public attitude, is a canker worm that has eaten deep into every fabric of our society today. The collapse in most of Freetown waste management authority may allegedly be traced to this menace of corruption. In some instances market women and other shop owners have had cause to bribe Freetown waste management agency workers before waste could be removed from the market and shop places. Also, push carts (omolankay) pushers and scavengers have been known to bribe officials before they can be allowed to dispose their waste at designated points. This has led to illegal dumpsites springing up at different points in the city creating bottle neck to the already chaotic situation of waste management.

For sustainable solid waste management system, human resource development is very important for the training of skilled, semi-skilled or unskilled waste management workers. Regular formal or informal training programs for the workforce would enhance the work efficiency and improve the situation that now exists in the city. Such training could be in the form of workshops, seminars and in country classroom training. Such trainings must relate to wastes, goals to be achieved and the means by which they will be reached. For street sweepers and collectors, the course should focus on workplace efficiency and personal safety or health; for mechanics and truck drivers, the course should cover the machinery they operate or repair. A classroom teaching style with the aid of some written materials should also be used.

In Sierra Leone, environmental legislation and its enforcement are in a shambles. The environmental division in the Ministry of Lands and the environment has a total of eight employees to manage environmental issues across Sierra Leone. It lacks enforcement authority. Also bye-laws and statues overall are non-existent. Even those that exist have weak penalties for non-compliance. For instance, penalty for littering, established in 1962 is 25 Leones (9 cents) per occurrence is very low and ineffective. Furthermore, solid wastes environmental laws are scattered across several agencies. For example, the Freetown City Council (FCC) and the Ministry of Health and Sanitation (MoHS) have their own waste management regulations.

Socioeconomic characteristics of stakeholders were found to affect the generation of solid waste. This was supported by the results of analyzed data which showed that average family size, income levels, marital status and educational level were the main socioeconomic characteristics affecting solid waste generation and composition in Freetown. These two factors, solid waste generation and composition are important factors in designing the cost effectiveness and environmentally compatible solid waste management system towards sustainable development in Freetown.

Additionally, solid waste services have a cost as any other services provided but in general the expenditures are not recovered. Therefore, the sustainability of the

solid waste management system in the long run is crucial since household residents do not pay user-fee for the management of waste in the city. Also, an effective solid waste management system should not only based in technological solutions but also environmental, socio-cultural, legal, institutional and economic linkages that should be present to enable the overall system to function. Furthermore, waste management involves a large number of different stakeholders, with different fields of interest. The different stakeholders of the solid waste management system should be seen to play a role in shaping the system of the city but often it is seen only as a responsibility of the Freetown City Council through the Freetown Waste Management Company. Therefore, public attitudes and perceptions towards waste disposal can be seen to affect the solid waste management system. Since the public is seemingly little sensitive to the garbage around them or not aware of what represents responsible waste management, hence the appalling solid waste situation in Freetown which borders collapse, needs effective remedial measures.

CONCLUSION

The analyzed data results showed that household solid waste generation and composition varies across the study area. Average family size, income level, marital status and educational level were the main socioeconomic characteristics affecting solid waste generation and composition in Freetown. Age and employment status of respondents were found to be negatively related to solid waste generation. Wrong attitudes and perceptions such as education of households to clean their surroundings, disposal of household waste, children's involvement in solid waste management and acceptance of user fee system were found to affect the efficiency of the waste management system towards sustainable development. Therefore bringing all stakeholders participating in and affected by the waste management system on board in order to participate in solid waste management towards sustainable development will intensify zero waste tolerance; thus reduce more pollution, less spread of infectious diseases and low related mortality due to malaria. Wise use of the waste hierarchy (example, reduce the amount of waste produce; encourage re-use and recycling of products to prevent them from getting into the waste stream; process waste to recover their intrinsic value such as energy) will contribute to more decline of greenhouse gas (Carbon dioxide, Methane and Nitrous oxide) emissions discharged during the life cycle of solid wastes reducing climate change. Additionally, the construction and maintenance of semi-controlled designed landfills in the city will reduce the mixing of high organic contaminant concentrations and high concentration of ammonia with ground water supplies and surface water ecosystems in the communities.

Notwithstanding these contributions this study is not without limitations. One outstanding limitation is the small size of the sample. The small sample size for this study makes it difficult to generalize findings across the entire cities of the country. Therefore, the limitations of this study not only stress the importance of advancing empirical study on solid waste management system in different ways but also underline the necessity of developing a comprehensive theoretical model for the entire country using a larger sample. While this endeavor is beyond the scope of this dissertation, the results of the analyzed data about solid waste management system in Freetown, Sierra Leone towards sustainable development lead to several suggestions for future study.

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