Domestic Waste Generation Rate and Its Environmental Impact on the Growing Population of Bonny Island

KELECHI UCHENNA UGOJI [1], JOHN O. ADAJI[2], DR. ABDUL MUSA[3], IBIM ABBA GREEN[4]
[1] Department of Mechanical Engineering Technology, Federal Polytechnic of Oil and Gas, Bonny
[2]Registry Department, Federal Polytechnic of Oil and Gas, Bonny
[3]Department of Mechanical Engineering Technology, Federal Polytechnic Idah
[4]Department of Mechanical Engineering Technology, Federal Polytechnic of Oil and Gas, Bonny

Abstract- Waste generation undoubtedly is as old as man. What changed over the years are its generation rate, disposal means or handling methods and management. Most uncontrolled and often unprofessional locations of waste disposal are termed open dump or Dump sites. Dumps pose a risk to the environment in many ways; microorganisms present in the refuse use the refuse as a food source. Under the anaerobic conditions typical of most dumps, these microorganisms convert the organic material in the refuse to methane and carbon dioxide[1]. In response to these waste challenges in July last year, the Federal Executive Council of Nigeria approved a Solid Waste Management Policy for the country. Intended to improve cleanliness across the country and facilitate the conversion of waste to wealth[2]. With the population of Bonny Island increasing in quantum leaps, the environment is daily inundated with the weight of waste materials emanating from the activities of the citizens and resident alike. Going by the sights of huge waste disposed at notable sites and the evidence of the local governments' open effort at combating its effect, one needs no expert knowledge to understand that we need to work very fast in the implementation of new waste policy with the good knowledge of waste generation. The study therefore aims at evaluating the characteristics of wastes dumped in selected areas of Bonny Island, evaluation of some of the soil properties within the dump region, attempt at characterization of the surface run-off from the dumpsite. The study revealed that waste generated is non-uniformly increasing at the rate of 2.1 tons per week. Additionally, the areas studied are experiencing accumulation of some physicochemical parameters and Microbial load. Possible effects of these accumulations were highlighted and recommendations were made.

Indexed Terms- Environmental Impact, health risk, Energy, aesthetic improvement, Waste generation rate.

I. INTRODUCTION

Numerous attentions and research have been raised regarding oils spills and its impact on the environment and socio-economic wellbeing of residents of Niger Delta in Nigeria. Yet 'waste' a substance produced on daily bases, which has the capacity to adversely affect humans, reduce the labour force through epidemic and deface the environment appeared to be receiving trivial, neglected or inappropriate attention especially on Bonny Island. A publication on 'What are the environmental impacts of economic development in Nigeria?, Retrieved from Internetgeography.net stated that inadequate sanitation and increased domestic and industrial waste has caused watercourses to become polluted. Waste means any material or substance in whatever form, whether solid, liquid or gaseous, hazardous or non-hazardous, organic or inorganic that has lost its primary value and is disposed of, intended to be disposed of or recycled[3]. Solid wastes can be defined as non-liquid and non-gaseous products of human activities, regarded as being useless. It could take the forms of refuse, garbage and sludge[4]. These solid wastes often found their ways into open dumps sites littered at any convenient location to the ignorant waste disposer. The recipient areas of these wastes designated by appropriate authority or not in most cases without proper controls are generally referred to as Open dumps.

The production of solid waste did not start with our generation; it has always been associated with human settlement. When humans lived in small communities, the solid waste produced by these communities could easily be burned or buried. The potential adverse impact of these waste were minor because the generated waste were rarely non degradable, hazardous and voluminous[5]. The Final Investment Decision (FID) to build a Liquefied Natural Gas (LNG) plant in Finima, Bonny Island in Rivers State and the subsequent Construction at the Plant site in February 1996[6] and on August 12, 1999, undoubtedly open the shores of the Island to the influx of both professionals and artisans. This is expected of any green location receiving industrialization or urbanization attention, so the project was a welcomed development and NLNG been a reputable company must have a good waste management practice in place. However, many workers of the company in contract terms, job seekers, merchants exploring new shores to improve or expand their businesses, etc that trooped into the island reside within the environment outside the control of the company and generated waste on daily basis.

The adverse environmental impacts of these open dumps became apparent early in the 20th Century. Today we know that open dumps pose many risks to the environment and community health[5]. In open dumps, rainwater dissolves soluble as it seeps through the refuse, washing down the dissolved soluble or tiny particles of organic and inorganic compounds (including -metals, pesticides, and solvents) that are in the refuse. This liquid is known as leachate. This leachate then enters the soil below the dump and may eventually enter the groundwater. For coastal communities and Islands even uplands that depend on ground or surface water to supply their drinking water, source of farming or food productions, the formation and movement of leachate through the soil and into aquifers/nearby water bodies poses a risk to the environment and to human health, especially if the leachate contains toxic chemicals.

Waste can be classified as either domestic or commercial waste. Domestic waste is waste that is generated as a result of the ordinary day-to-day use of a domestic premise and is either: taken from the premises by or on behalf of the occupier who generated the waste; without consideration (e.g. payment, reward or other benefit); or collected by or on behalf of a local government as part of a waste collection and disposal system. Naturally, as areas and locations developed, people will begin to live in densely populated areas with change in taste of consumables; the production of waste will respond accordingly and their management will have to be taken seriously to avert its attendant effects. Domestic wastes in Nigeria and particularly on the Island as with most developing states contain unsorted wastes, demolition debris, construction and garbage and electronic wastes etc. Bases on its nature, locations designated dumping areas for solid waste, usually are on the outskirts of humans dwelling or towns though not in all cases. Developing such areas in the near future may requires huge engineering inputs that ordinarily would not have been due to accumulation effects leading to increased resource expenditure and possible degradation of land and water resources. Having a good data of the rate of waste generation on the Island will provide an inestimable tool; for policy makers to effectively manage the waste and save the environment.

II. PROBLEM STATEMENT

Assessing the root cause of a challenge makes for a better solution. Waste generation rate and its impact on the environment is a needed tool or data if appropriate and efficient waste handling and management must be achieved. Every open dump presents different risks, depending on the types of wastes the dump contains, the environmental conditions at the site, and the proximity of vulnerable communities. Water borne diseases, which at times lead to loss of lives of both infants and adult alike could be caused by dumps site polluting water sources. In the open dump sites, leachate is being produced, and in some areas the leachate might lead to contamination of the surface, ground water and soil.

Islands are land area surrounded by water and present some limitations with respect to availability of land resources. Bonny as an Island may not have witnessed any waste related inferno but that is not a precursor that it cannot occur and its occurrence can be catastrophic based on the available inflammable resources/installations. Once policy makers can be equipped with the rate of waste generation on the Island, proactive steps can be initiated to forestall potential crisis. The findings of this research will provide requisite data for the design, implementation and improvement of good waste management policy and strategy, create jobs and improve upon the aesthetic nature of Bonny Island. No doubt this will in no measure drive home dividends of good governance to the citizens.

III. LITERATURE REVIEW

This literature review targets provision of broad overview of approaches and efforts employed in the study of physico-chemical characteristics of the dumpsite. The review focused on waste generation because volume of waste generated is directly proportional to the amount of contaminants where the contaminants exist, factors affecting solid waste, waste collection and disposal, waste management, and its attendant environmental problems.

Recently Onwughara[7] reported that msw contains a great deal of energy that potentially could be recovered. It also contains a great deal of valuable raw materials. Ordinarily it will be observe that little or no attention is given to some traditional suburban settlements for provision of waste collection and disposal services. According to Babayemi[8] the quantity and rate of solid waste generation in the various states of Nigeria depends on the population, level of industrialization, socio-economic status of the citizens and the kinds of commercial activities being predominant. Nigeria's waste generation is projected to rise to 107 million tonnes by 2050[9]. This figure portrays a serious threat if nothing proactive is done. According to Braimah[10] Nigeria produces an estimation of 32 million tons of solid waste per year, with only about 20-30 percent of it being collected and managed correctly. She believed that Addressing these issues such as weak regulatory framework, limited funding, lack of awareness amongst other will necessitate significant investment in waste management infrastructure, increased public awareness, strengthened regulatory frameworks, and increased stakeholder cooperation. Nnaji[11] executed a study by a combination of an extensive literature search and field study. He stated that Solid waste generation rates for 31 Nigerian cities were obtained from literature. In addition, characteristics of municipal solid waste from 26 Nigerian cities were also obtained from literature. Other aspects such as characterization of solid waste obtained from final dumpsite and heavy metals accumulation in solid waste dumpsites were undertaken first hand. His findings revealed that solid waste generation rate vary from 0.13 kg/capita/day in Ogbomosho to 0.71 kg/capita/day in Ado-Ekiti. Factors affecting solid waste generation rates were identified. Typically, food waste was found to constitute close to 50 percent of overall municipal solid waste in Nigeria cites. Until recently Port Harcourt was known as the "garden city of Nigeria" because of its neatness and the overwhelming presence of vegetation and flowers all over the metropolis. But today, the presence of piles of refuse dotting the entire city may have turned Port Harcourt rather to a "garbage city"[12]. In all these data on waste generation and its effect on Bonny Island is missing.

IV. METHODOLOGY

The study involved several activities: Identification of the dump site boundaries: The study covered four main location of waste collection but due to the insignificant nature of one location, attention was focused mainly on three locations. One was located close to Coconut Estate Bonny, with estimated land area of about 0.5 hectare of land and lies within the coordinates 4°26'03.5"N 7°11'41.0"E and 4°26'03.2"N 7°11'40.6"E. It lies less than 5m from the road, less than 150m away from a water front and an abattoir. The second was located at Mor Jackson street on which lies within the coordinates 4°26'04.4"N 7°10'37.0"E and 4°26'03.1"N 7°10'37.3"E. Lastly the third is located at light house road Finima within the coordinates 4°24'03.7"N 7°08'46.1"E and 4°24'05.4"N 7°08'38.1"E with estimated land area of 1.1 hectare of land and less than 5m from the light house road.

Three major dump sites were visited for sampling. soil, water and air (for bacteriology analysis) samples were collected for analysis and sample collection was geo-referenced. All measuring equipment was first calibrated to ensure accurate measurements. The sampling was done in a way that was representative of the entire dumpsite. The location and number of samples were adapted to the sensitivity of waste dumped in the environment and the layout/area of the site, which excludes all company or industrial domiciled areas. The average sampling plan consisted of thirteen (13) sampling points that were located in the open dumpsite, which was analyzed as a composite sample designated as waste soil sample for the particular location. The soil samples used were collected at a depth of about 2.5m for both the control (unaffected area) and that of the affected areas from each of the main locations. Both composite samples were analysed separately. The soil samples were analysed for pH, Lead (Pb), Arsenic (As). Cadmium (Cd), Iron (Fe), Mercury (Hg), Chromium (Cr), Copper (Cu), Nickel (Ni), Nitrate, Chloride (Cl-), Potassium (K), Fluoride (F-), Cation exchange capacity (CEC) and Sulphate (SO4). The water samples were analysed for pH, Lead (Pb), Arsenic (As). Cadmium (Cd), Iron (Fe), Mercury (Hg), Chromium (Cr), Copper (Cu), Nickel (Ni), Nitrate, Chloride (Cl-), Potassium (K), Fluoride (F-), Cation exchange capacity (CEC) and Sulphate (SO4), Turbidity, Electrical conductivity (EC), Total Hydrocarbons (TH) and Biochemical oxygen demand (BOD).

Spatula was used to slice off the sides of the hand held auger when pulled out from the required depth before taken the soil samples from the tip of the auger. Sampling tools were washed with water and dried before the next sample was collected. Similarly the water samples were collected using prepared laboratory sampling tubes. Each tube was rinsed with the sample to be collected thrice and poured far away from the sampling point before the main samples were collected. Samples were collected under the maximum environmental allowable conditions to avoid interference, put into appropriately labeled containers and transported to the laboratory as soon as possible. Standard analytical procedure/measures were employed to ascertain empirical data while analyzing samples for their characteristic and content. The details of the sample locations are contained in Table 5.1, 5.2 and 5.3.

Strategic daily volume disposal measurement was employed to ascertain daily deposit on dumpsites. Empty waste collecting drums were first weighed and recorded, and then they were filled with waste and their respective weights taken. This exercise was conducted with the assistance of waste workers for a period of eight (8) weeks and the average value was taken each week, which represents waste generated within the study area. The first week and the last week values were discarded for enhanced data collection. Similarly the waste collected was segregated or sorted out and weighed during the research period and the average waste content or composition taken. Maximum possible safety measures were put in place to prevent accidents related to waste sorting, handling, sampling and analysis. Surface run off is addressed as waste water.

Attempt was made to monitor air quality around the sites, through insitu bacteriology sampling. The collecting sampling media was transported to laboratory under maximum obtainable precaution and analyzed accordingly. As mentioned earlier control samples were taken at locations distant from the sampling points to ascertain possible impact and its potential effects on humans/environment.

V. INSTRUMENTATION AND SAMPLING

The research instruments used were hand auger; used to collect soil samples at the required depth within the chosen sampling locations. Geographical Positioning System (GPS); used to geo-reference the locations, collection tools like hand trowel used to take soil samples from the tip of the earth auger, spatula and appropriate containers; used to preserve the samples, labels, Heat Proof Wireless Crane weighing Scale and a Casio Exilim EX-Z330 Model camera for photographs, Garmin 010-01735-10 in Reach Explorer Sat. Comm. with Topo Map. For air sampling media. Nutrient agar, Maconkey aga, Eiosine methylene blue agar, dioxychocolate citrate agar and Sabroud Dextrose agar were used.

Table 5.1: Sampling locations of from the study Area

Finima sampling locations

S/N	Sample type	Geo-Reference location
1	Soil, Water and Air	4°24'04.9"N 7°08'43.8"E
2	Soil, Water and Air	4°24'05.1"N 7°08'40.0"E
3	Soil, Water and Air	4°24'03.4"N 7°08'49.9"E

4	Soil, Water and Air	4°24'05.4"N 7°08'38.1"E
5	Soil, Water and Air	4°24'03.7"N 7°08'46.1"E
6	Soil, Water and Air	4°24'19.0"N 7°08'34.2"E
7	Soil, Water and Air	4°24'03.8"N 7°08'44.5"E
8	Soil, Water and Air	4°24'04.3"N 7°08'43.8"E
9	Soil, Water and Air	4°24'05.0"N 7°08'43.0"E
10	Soil, Water and Air	4°24'04.7"N 7°08'42.9"E
11	Soil, Water and Air	4°24'04.6"N 7°08'39.8"E
12	Soil, Water and Air	4°24'04.9"N 7°08'46.5"E

Source: Research field visit and sampling

Table 5.2 Sampling locations of from the study Area

Moorjackson		
S/N	Sample type	Geo-Reference location
1	Soil, Water and Air	4°26'03.8"N 7°10'36.9"E
2	Soil, Water and Air	4°26'03.6"N 7°10'36.8"E
3	Soil, Water and Air	4°26'04.2"N 7°10'37.0"E
4	Soil, Water and Air	4°26'04.3"N 7°10'37.0"E
5	Soil, Water and Air	4°26'04.4"N 7°10'37.0"E
6	Soil, Water and Air	4°26'00.1"N 7°10'41.5"E
7	Soil, Water and Air	4°26'03.7"N 7°10'37.5"E
8	Soil, Water and Air	4°26'03.1"N 7°10'37.3"E
9	Soil, Water and Air	4°26'03.9"N 7°10'36.4"E
10	Soil, Water and Air	4°26'26.1"N 7°10'28.5"E
12	Soil, Water and Air	4°26'26.1"N 7°10'28.3"E
13	Soil, Water and Air	4°26'26.0"N 7°10'28.2"E
14	Soil, Water and Air	4°26'25.9"N 7°10'28.4"E

Source: Research field visit and sampling

Table 5.3 Sampling locations of from the study Area

Coconut Sampling locations		
S/N	Sample type	Geo-Reference location
1	Soil, Water and Air	4°25'55.5"N 7°11'39.2"E
2	Soil, Water and Air	4°25'56.2"N 7°11'22.7"E
3	Soil, Water and Air	4°26'03.5"N 7°11'41.0"E
4	Soil, Water and Air	4°26'03.5"N 7°11'41.4"E
5	Soil, Water and Air	4°26'03.2"N 7°11'40.6"E
7	Soil, Water and Air	4°26'03.9"N 7°11'39.1"E
8	Soil, Water and Air	4°26'02.9"N 7°11'39.2"E
10	Soil, Water and Air	4°26'02.9"N 7°11'38.0"E
11	Soil, Water and Air	4°26'03.0"N 7°11'39.3"E
12	Soil, Water and Air	4°26'02.7"N 7°11'39.4"E
13	Soil, Water and Air	4°26'02.9"N 7°11'39.4"E

Source: Research field visit and sampling

VI. CHALLENGES AND LIMITATION

Study of this nature involving management activities, communities and waste like most researches, have its challenges and limitations:

Challenges/Limitations:

- Location: Bonny is an Island and most a times the unfriendly waves of the sea makes ease of transportation both to procure equipment and to assess some needed laboratories outside the island very challenging and risky.
- Level of illiteracy: Bonny Island is a friendly location yet efforts to avoid the possible reaction of self-satisfying residents and community boys seeking for undue settlement before sample collections was treated with levity.
- Accuracy: due to the hectic and inconveniencing task of waste handling, monitoring sorting and recording was challenging. Efforts was put in pace to minimize like fatigue and errors.
- Topography: much was required to assess some of the dumpsites sampling locations given the swampy nature of the areas.
- Maintenance: Sampling device like scale, GPS, etc require regular maintenance to ensure accurate readings. Sampling auger was damaged once and had to be fixed before sampling could continue.

Despite these challenges, Researchers ensure maximum possible reliable results which will be useful for numerous purposes.

VII. RESULTS

Reconnaissance and detailed survey reveals that the dumpsites sampled serve the entirely Bonny Island excluding non-land linked surrounding villages and insignificant pockets of dumps around a few corners. From the study the waste generated is non-uniformly increasing at the rate of 2.1 tons per weeks. See fig 7.1

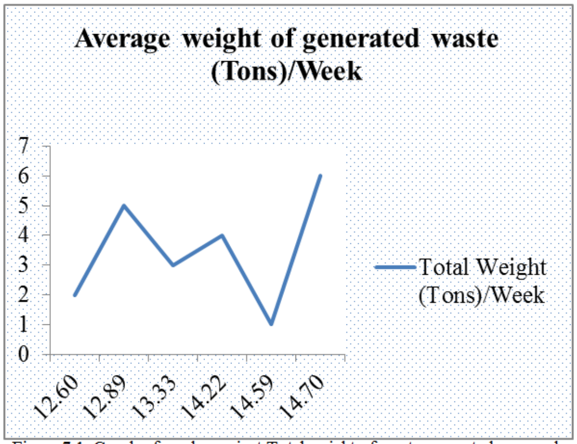

Figure 7.1: Graph of weeks against Total weight of waste generated per week

What this means is that barring any external addition or subtraction to the existing factors of consumption such population density, economic status and lifestyle, compromising good waste legislative implication etc, in the next ten years (10) the present volume of waste would have been increased by one hundred and seventy four (174) times. However, with increase influx of people into the Island and development, the projected period may not be reached before the estimated increase will be experienced. It is be pertinent to note that the present volume of waste contains the observed values of physicochemical parameters, microbial counts and Cultural and Morphological above the threshold value meaning all things been equal, if something positive is not done, the probability of an epidemic on the Island anytime from beginning from the year 2035 is imminent.

Week	Weight of waste/ drum (Kg)	Number of drums/ Week	Total weight (Kg)/ Week	Total Weight (Tons)/ Week	Average weight (Tons) /day
1	43.75	333.50	14590.63	14.59	2.08
2	40.5	311.00	12595.50	12.60	1.80
3	41.50	321.25	13331.88	13.33	1.90
4	41.75	340.50	14215.88	14.22	2.03
5	40.92	315.00	12889.80	12.89	1.84
6	44.4	331.00	14696.40	14.70	2.10
Average waste			13720.01	13.72	1.96

- Data Presentation and Analysis

The results derived from field observations, investigations and unpublished materials are presented in Tables. Estimated percentage composition of different categories of solid waste generated in Bonny Island is presented in Table 7.2. Table 7.3 contains Physicochemical characteristics of waste soil Samples in the study area. Table 7.4 contains Physio-chemical parameters and the standards used in the analysis of soil Samples. Table 7.5 contains the Physio-chemical characteristics of waste water samples used in the study. Table 7.6 shows the Physio-chemical parameters and standards used in the analysis of waste water samples.

Table 7.2: Percentage components of Categories of Solid Waste Generated in Bonny

Table 7.2: Percentage components of Categories of Solid Waste Generated In Bonny		
s/n	Composition	Percentage (%)
1	Cartons	2.18
2	Bottles	2.42
3	Water proofs	1.69
4	Rubber pipes	2.54
5	Sticks/lumber or woods waste	4.76
6	Aluminum	3.11
7	Plastics	2.42
8	Nylon and Polythene materials	6.05
9	Metallic and Sharp objects	8.87
10	Market, storage and food waste	34.69
11	Hospital, Hazardous/ toxic	2.02
12	Building scraps, waste sands/ cements	11.70
13	Sewage, dungs, dog, poop etc	3.63
14	leaves, roots and garden waste	6.58

15	Unsorted/unclassified	7.66

Snapshot showing the three dumpsites and one soil sampling point

Table 7.3**:** Physicochemical characteristics of waste soil Samples in the study area

S/N	PARAMETER	RESULT		
		Waste soil (Finima)	Waste Soil (Estate)	Waste control soil (dumpsite control)
1	pH	6.82	6.31	6.41
2	Chloride, Cl^- (mg/kg)	14.90	20.90	2.90
3	Fluoride, F^- (mg/kg)	<0.001	<0.001	<0.001
4	Nitrate, NO_3^- (mg/kg)	0.021	0.090	0.023
5	Sulphate, SO_4^{2-} (mg/kg)	0.306	0.415	0.300
6	Lead, Pb (mg/kg)	1.504	1.544	1.670
7	Arsenic, As (mg/kg)	<0.001	<0.001	<0.001
8	Cadmium, Cd (mg/kg)	<0.001	<0.001	<0.001
9	Iron, Fe (mg/kg)	64.479	80.614	97.907
10	Mercury, Hg (mg/kg)	<0.001	<0.001	<0.001
11	Chromium, Cr (mg/kg)	1.470	1.060	0.028
12	Copper, Cu (mg/kg)	0.580	0.099	<0.001
13	Nickel, Ni (mg/kg)	0.040	0.165	0.020
14	Potassium, K (mg/kg)	2.352	6.692	3.549
15	CEC (Cation exchange capacity), mg/kg	14.07	11.09	42.01

Table 7.4**:** Physio-chemical parameters and standards used in the analysis of soil Samples.

S/N	PARAMETER	METHOD
1	pH	HANNA HI9829
2	Chloride, Cl^- (mg/kg)	ASTM D512
3	Fluoride, F^- (mg/kg)	ASTM 1179
4	Nitrate, NO_3^- (mg/kg)	ASTM D6837
5	Sulphate, SO_4^{2-} (mg/kg)	ASTM C1580
6	Lead, Pb (mg/kg)	AAS
7	Arsenic, As (mg/kg)	AAS
8	Cadmium, Cd (mg/kg)	AAS
9	Iron, Fe (mg/kg)	AAS
10	Mercury, Hg (mg/kg)	AAS
11	Chromium, Cr (mg/kg)	AAS
12	Copper, Cu (mg/kg)	AAS
13	Nickel, Ni (mg/kg)	AAS
14	Potassium, K (mg/kg)	AAS
15	CEC (Cation exchange capacity), mg/kg	ASTM D7503

Table 7.5: Physio-chemical characteristics of waste water samples used in the study

S/N	PARAMETER	RESULT			
		Waste water (Finima)	Waste water (Estate)	Waste water (Moorejacson)	Control
1	Color (TCU)	172.0	84.0	205.0	1.0
2	pH	5.76	6.67	6.61	5.24
3	Turbidity (NTU)	218.8	109.50	680.00	0.30
4	Electrical Conductivity	378.00	12290.00	1624.00	258.00

	(µS/cm)				
5	Chloride, Cl^- (mg/L)	32.90	88.90	74.90	9.90
6	Fluoride, F^- (mg/L)	<0.001	<0.001	<0.001	<0.001
7	Nitrate, NO_3^- (mg/L)	0.011	0.202	0.067	0.001
8	Sulphate, SO_4^{2-} (mg/L)	0.619	3.251	1.604	0.122
9	Lead, Pb (mg/L)	1.153	1.491	1.279	<0.001
10	Arsenic, As (mg/L)	<0.001	<0.001	<0.001	<0.001
11	Cadmium, Cd (mg/L)	<0.001	<0.001	<0.001	<0.001
12	Iron, Fe (mg/L)	1.827	2.401	3.586	2.069
13	Mercury, Hg (mg/kg)	<0.001	<0.001	<0.001	-
14	Chromium, Cr (mg/L)	0.061	0.048	0.223	<0.001
15	Copper, Cu (mg/L)	<0.001	<0.001	0.029	<0.001
16	Nickel, Ni (mg/L)	0.191	<0.001	0.351	<0.001
17	Potassium, K (mg/L)	18.082	54.887	87.618	9.674
18	Biochemical Oxygen Demand, BOD5 (mg/L)	5.11	9.03	18.65	0.23
19	Total Petroleum Content, THC (mg/L)	56.789	78.032	87.889	91.342

Table 6.6**:** Physio-chemical parameters and standards used in the analysis of soil Samples.

S/N	PARAMETER	METHOD
1	Color (TCU)	APHA Pt-Co (Hazen)
2	pH	HANNA HI9829
3	Turbidity (NTU)	HANNA HI9829
4	Electrical Conductivity (µS/cm)	HANNA HI9829
5	Chloride, Cl^- (mg/L)	APHA 4500
6	Fluoride, F^- (mg/L)	APHA 4500 F
7	Nitrate, NO_3^- (mg/L)	EPA 352.1-NO_3^-
8	Sulphate, SO_4^{2-} (mg/L)	APHA 4500 E
9	Lead, Pb (mg/L)	AAS
10	Arsenic, As (mg/L)	AAS
11	Cadmium, Cd (mg/L)	AAS
12	Iron, Fe (mg/L)	AAS
13	Mercury, Hg (mg/kg)	AAS
14	Chromium, Cr (mg/L)	AAS
15	Copper, Cu (mg/L)	AAS
16	Nickel, Ni (mg/L)	AAS
17	Potassium, K (mg/L)	AAS
18	Biochemical Oxygen Demand, BOD5 (mg/L)	APHA 5210-B (5-Days Method)
19	Total Petroleum Content, THC (mg/L)	IR

Table 6.7: Microbial Counts of water Samples

Counts	Finima	Estate	Moore-jackson	Control
THB (cfu/ml)	$7.5x10^7$	$4.0x10^7$	$8.3x10^7$	$1.45x10^5$
coliform (cfu/ml)	$1.50x10^6$	$1.20x10^6$	$2.20x10^6$	-
Feacal coliform (cfu/ml)	$2.0x10^4$	$1.2x10^4$	$3.5x10^4$	-
Fungal count (cfu/ml)	$2x10^3$	$3x10^3$	$3x10^3$	$2x10^2$

Keys: THB= Total heterotrophic Bacteria.

Table 6.8 Microbial Counts of Soil Samples

Counts	Finima	Estate	Control
THB (cfu/ml)	$9.5x10^5$	$1.7X10^5$	$3.5X10^5$
coliform (cfu/ml)	$5.3x10^5$	$8x10^4$	$1.2X10^5$
Feacal coliform (cfu/ml)	$9.4x10^5$	$9X10^4$	$8X10^4$
Fungal count (cfu/ml)	$3x10^2$	$1x10^2$	$1x10^2$

Keys: THB= Total heterotrophic Bacteria

Table 6.9: Microbial Counts of air Samples

Counts	Finima	Estate	Control
THB (cfu/m^2)	2500	4000	333.3
coliform (cfu/m^2)	1500	1133.3	333.3
Feacal coliform(cfu/m^2)	500	833.3	33.3
Fungal count (Cfu/m^2)	66.7	100	33.3

Keys: THB= Total heterotrophic Bacteria

VIII. DISCUSSION

When water percolates through the waste, it promotes and assists process of decomposition by bacteria and fungi. These processes in turn release by- product of decomposition and rapidly used up any available oxygen creating an anoxic environment. In actively decomposing waste, the temperature rises and the pH falls rapidly and many metal ions which are relatively insoluble at neutral pH can dissolved in the developing leachate and also react with materials that are not themselves prone to decomposition such as fire ash, cement based building materials and gypsum based materials changing the chemical composition.

The result from table 6.7, table 6.8 and table 6.9 revealed that the soil, the water and the air are from all the three dumpsites are experiencing microbial load when benchmarked with the values obtained from the control sample. Though heterotrophic bacteria are not indicators of pathogenic conditions and could have economic importance but some of them like Pseudomonas is opportunists and can cause some infections in skin and lung and the other type like Aeromonas cause gastroenteritis[13.] According to the publication of Disease Control and Prevention, Fungi can live outdoors in soil and on plants, indoors on surfaces and in the air, and on people’s skin and inside the body. Fungal infections can range from mild fungal skin infections, like ringworm, to lung infections from breathing in fungal spores, like Valley fever. Though Severe and life-threatening fungal infections are less common and are often associated with medical procedures or healthcare facilities. For all fungal infections, finding the correct diagnosis can be difficult and cause delays in getting the right treatment[14].

Varying colony characteristics of *Staphylococcus sp*, *Bacillus* sp, *Escherichia coli*, *Aeromonas sp* were isolated from Soil, water and air samples from Finima, Coconut Estate and Moorjackson dumpsites respectively. *Aeromonas* enteric infection may range from, most commonly, an acute watery diarrhea to dysenteric illness. Symptoms may include abdominal cramps (70%), nausea (40%), vomiting (40%) and fever (40%). Infection is usually self-limiting although children may rarely be hospitalized because of dehydration[15]. Symptoms of infection with E. coli also include watery or bloody diarrhea, fever, abdominal cramps, nausea, and vomiting including kidney failure and can even lead to death[16]. Other Phenotypic and Biochemical Characterization of Isolates of the samples from the three locations recorded *Serratia* sp, *Pseudomonas* sp, *Shigella* sp, *Vibrio* sp, *Micrococcus* sp, *Enterobacter* sp, *Proteus* sp isolates in either the soil, air or the water samples or in most cases from both the soil and the water together. Cultural and Morphological Characteristics of Fungi Isolated from the three dumpsites revealed the propbable presence of *Fusarium sp, Aspergillus sp, Penicillium sp, Saccharomyces sp, Aspergillus Penicillium sp sp, Rhizopus sp and Aureobasidium*

- Colour, Appearance, Turbidity

The colour index for the water sample (control) is 1.0 TCU, while turbidity is 0.3NTU. The control was colourless, tasteless and odourless. This implies that there is an absence of decomposed vegetation, colloidal substances or other impurities. These characteristics met the WHO[17] and Nigerian Standard for drinking water quality (NSDWQ)[18]. The waste water samples are dark brownish in colour with elevated values of 172TCU, 84TCU and 205TCU for Finima, Coconut and Moorjackson samples respectively. The waste samples shows elevated values of 218.8 NTU, 109.5 NTU, 680 NTU for Finima, Coconut and Moorjackson samples respectively. According to NSDWQ Turbidity has no direct health impact but can harbour microorganisms protecting them from disinfection and can entrap heavy metals and biocides. This can bring problem in water treatment process and can also be a potential risk of pathogen in treated water. It is also related to the content of diseases causing organisms in water, which may come from soil runoff.

- pH

The pH results from the waste water show slightly lower acidic values of 5.76, 6.67 and 6.61 for Finima, Coconut and Moorjackson samples respectively against 5.24 of the control. For the waste soil samples the pH shows 6.82 and 6.31 for Finima waste and Coconut waste against 2.9 value of the control. These values could be due to soluble mineral salts from the waste dump been washed away with the water while the soil's control sample value is slightly acidic. This proves that the Bonny island soil is acidic and acidic water can lead to corrosion of metal pipes and plumping system.

- Conductivity

EC is a good measure of salinity hazard to crops. Excess salinity reduces the osmotic activity of plants and thus interferes with the absorption of water and nutrients from the soil [19]. Electrical conductivity is a function of magnesium, calcium, sodium and sulphates.

According to NSDWQ[18], the maximum allowable level of conductivity is 1000 μS/cm. The results show that the measured conductivity of all the waste water samples are experiencing significant variation as they range from 378 μS/cm, 12290 μS/cm and 1624 μS/cm for Finima, Coconut estate and Moorjackson against the control value of 256 μS/cm. The low salinity of the control water sample indicates low mineral content. The high Salinity of the waste water samples indicates that the surface water of the waste dumpsite is in contact with inorganic constituents materials. Conductivity does not have direct impact on human health. However, water with high conductivity may cause corrosion of metal surfaces of equipment[20].

- Lead (Pb), Arsenic (As), Cadmium (Cd), Iron (Fe) and Mercury (Hg)

From the analysis result, the heavy metals in the waste water and soil samples have values of <1 x 10^{-3} mg/kg and <1 x 10^{-3} mg/L for As, Cd and Hg showing no accumulation when benchmarked with the values obtained from the control samples. The result revealed elevated values of Pb, 1.153mg/L, 1.491mg/L and 1.279mg/L for Finima, Coconut estate and Moorjackson's waste water when benchmarked with the value from the control sample and slightly lower waste soil values of 1.504mg/kg, 1.544mg/kg from Finima and Coconut estate. The higher value in waste water is an indication of Pb washing away from the soil by the water. Above NSDWQ maximum permitted limit of 0.01 mg/L for drinking water, Pb can lead to Cancer, interference with Vitamin D metabolism, affect mental development in infants, toxic to the central and peripheral nervous systems. Fe water samples values of 64.479mg/L and 80.614mg/L for Finima and Coconut estate shows elevated value when compared with the publication of NSDWQ[18]. Also average (2.6mg/kg) Fe soil sample values of 1.827mg/kg, 2.401mg/kg and 3.586mg/kg for Finima, Coconut estate and Moorjackson shows slight accumulation when benchmarked with the control sample value of 2.069. According to the publication of the Nigerian Standards for Drinking water quality, (NSDWQ 2015) Iron has a maximum permitted value of 0.3 and insignificant health challenge but in excess iron gets deposited in the liver, heart and pancreas, where it can cause cirrhosis, liver cancer, cardiac arrhythmias and diabetes[21]. National Institute of Diabetes and digestive and Kidney Diseases[22] webpage article on Hemochromatosis, says that Hemochromatosis is a metabolic disorder in which your organs accumulate excess iron, leading to organ damage[20]. The write up further supports that Iron deposits in the heart muscle may cause an arrhythmia, or heart failure, Iron deposits in the liver can predispose a patient to fibrosis, cirrhosis and liver cancer, Iron deposits in the pancreas can cause diabetes mellitus, Iron deposits in the brain and gonads (ovaries and testicles) can lead to impotence. There is no assurance that the increasing Iron deposits observed will not find its way into the food chain and subsequently in humans

The presence of heavy metals in drinking water poses a serious threat to health. Except for Iron, these metals were detected in very insignificant quantities in both soil and water samples. These low levels of Cd, As and Hg is an indication of absence of industrial waste involved in the manufacture of insecticides as well as deposition of aerosols particles.

- Chloride

Chloride is one of the major anions in water. It is generally associated with sodium. High concentration of Cl^- may result in an objectionably salty taste. There exists an increase in the values of chloride in both soil and waste water samples when compared with the values obtained from the control as shown in Table 7.3 and Table 7.5. The chloride concentration in the soil samples showed values of 14.9mg/kg and 20.90mg/kg for the soil samples of Finima and Coconut estate against 2.9mg/kg in the control. The water samples have concentration of 32.9mg/L, 88.90mh/L and 774.90mg/L for Finima, Coconut estate and Moorjackson respectively against 9.90mg/L in the control sample. The elevated chloride values of the waste dump samples could be an indication of a soluble salt-related waste being dumped in the dumpsite, hence the salt accumulation. Inspite of this high Chloride value in the analysed samples, the values are still below the Nigerian Standard for Drinking Water Quality value of 250mg/l [18]

- Nitrate

Consumption of water contaminated by nitrates above 50mg/L could lead to several adverse health effects such as Cyanosis, and asphyxia ('blue-baby syndrome") in infants under 3 months according to NSDWQ[18]. There is an increase in the value of nitrate in both the soil and water samples from the dumpsite except for Finima soil sample when compared with their controls. The result of the waste water analysis shows nitrate values of 0.011mg/L, 0.202mg/L and 0.067mg/L against 0.001mg/L value from the control sample. For Finima soil sample, the value of 0.021mg/kg is slight less than 0.023mg/kg from the control value but the value of 0.090mg/kg shows a slight increase. The variation in the result of the analysis is because of their concentration at the various locations. It is evident that there is a possibility of nitrate contamination over time. The result of the analysed samples showed slight increment when compared to the permissible value of 50mg/L for drinking water[21]

- Chromium (Cr**)**

Above Chromium (CR) maximum permissible limit of 0.05mg/L, a cancer infection is imminent according to the NSDWQ (2015). Waste water samples values of 0.061mg/L, 0.048mg/L and 0.223mg/L from Finima, Coconut estate and Moorjackson samples shows elevated values when compared to the NSDWQ maximum permissible limit and the control see Table 7.3 and table 7.5. No doubt a potential cancer causing agent is building up as these can contaminate food chain through leachate or crop assimilation that can eventually end up in human system.

- Copper

Copper (Cu) above the maximum permissible limit of 1mg/L according NSDWQ[18] can cause Gastrointestinal disorder. The results from soil and water samples showed values of 0.580mgmg/kg and 0.099mg/kg for Finima and Coconut estate respectively then 0.029mg/L for waste water of Moorjackson. Though the values are below the NSDWQ drinking water maximum permissible limit, they are slightly elevated when benchmarked with 0.001mg/kg of the control value.

- Sulphate, SO_4^{2-}

The sulphate values of 0,306mg/kg, 0.414mg/kg, 0.619mg/kg, 3.251mg/kg and 1.604mg/L from soil and water samples of Finima, coconut estate and Moorjackon waste water showed elevated values when compared with the control values of 0.3mg/kg indicating accumulation in the dumpsite areas. Similarly Ni,K and BOD results from Finima, Coconut estate and Moorjackson showed increased values against their control samples revealing possible accumulation. While CEC and THC values from Tables 7.3 and Table 7.5 indicates absence of possible accumulation. The lower values of CEC in the soils indicates possible absence of degradations of cations making the dumpsites a source or susceptible to nutrient loss by leaching. High values of Biochemical Oxygen Demand (BOD) in the waste water samples against the values obtained from the control samples indicates the possible presence of microbes and organic compound pollution.

CONCLUSION

From the findings, the researchers have reached a number of conclusions. First, the three dump sites if not controlled are gradually creating some serious problems. The dumpsite is gradually impacting on the land leading to damages to potential farmlands with accumulation of health threatening actors. These actors or agents can find their ways into human food chain by environmental/natural means leading to epidemic disease in the near possible future. It is a good thing that THC accumulation was not observed because if taken in by humans by any means the compounds in some TPH fractions can also affect the blood, immune systems, liver, spleen, kidney, developing fetus and lungs and can be irritating to the skin and eyes[23].

Smokes from the burning waste dump were seen on most site visit and this can add to air pollution creating both health and safety, and environmental problems like respiratory tract, impaired vision etc. The effect of gradual increase in the volume of waste generated can be challenging. Especially in a country like ours where conclusions are drawn by most believers largely based on hearsay. Secondly because the impact of these waste do not trigger immediate consequences further makes it a time bomb as by the time its impact would have been known a lot of damages must have already been done. Worse still where no data on the volume, disposal rate, impact on the soil and water exist, any waste related epidemic can trigger colossal damages due to lack of its initial cause. The above and much more are covered by the outcome of this research as empirical data has been provided that can form the foundation for further studies and make available useful data for waste management authorities to cash on. The study provides further research areas, providing opportunity for employment and improvement on the aesthetic appearance of our environment

RECOMMENDATIONS

Based on this work, we have recommended a waste management plan (wmp) for cities like Bonny Island. The wmp uses a practical and reasonable measure such as adoption of cradle to grave approach in waste management to minimize the generation of solid waste. A better and modern waste management technique that will incorporate controlled incineration and waste to wealth technique is needed in order to preserve and sustain both the soil and the groundwater quality in the study area. This Wmp measures when put in place will also avert possible health related challenges such as respiratory tract infection and possible ecotoxicity of water. Also, they will form the basis of the recommended waste management plan (wmp) that will provide avenues for the maintenance of soil in the study area and suitable for a developing country like Nigeria.

The Extended Producer Responsibility (EPR) incorporating controlled incineration and waste to wealth approach is preferred in applying the cradle to grave approach to waste management. This is because this strategy will effectively and efficiently minimizes the potentials of the harmful built up observed in the study including non-biodegradable waste.

ACKNOWLEDGMENT

Researchers acknowledge the support of Tetfund and Federal Polytechnic of Oil and Gas, who made this study possible. The contributions of colleagues, laboratory staff, students and the Polytechnic host community-Bonny Kingdom is well noted and appreciated.

REFERENCES

[1] Jarvie, M. E. Anaerobic digestion. Encyclopedia Britannica. https://www.britannica.com/science/anaerobic-digestion 2023..

[2] Odogwu, G. Nigeria's solid waste management policy. *The Punch*. 2021. https://punchng.com/nigerias-solid-waste-management-policy/

[3] National definition of waste [Film]. Basel Convention 2011. *2a*.

[4] Leton, T.G. and Omotosho, O.. Landfill operations in the Niger delta region of Nigeria. *Engineering Geology*. *73(1-2)*: 2004. 171-177.

[5] Ugoji, K. U., Green, I. A., Nmoye, R. N., & Igbere, N. B. A Partial Environmental Engineering Management Study of Open Dump Site and Its Impact on Land and Water. *European Journal of Engineering Research and Science*,. *Vol 5*(10), 2020. 1247–1234. https://doi.org/10.24018/ejeng.2020.5.10.2120.

[6] The plant a publication of the Nigeria LNG Limited https://www.nigerialng.com/operations-strategies/Pages/The-Plant.aspx

[7] Onwughara, I. N., Nnorom, I. C., Kanno, O. C. and R. C. Chukwuma. "Disposal methods and heavy metals released from certain electrical and electronic equipment wastes in Nigeria: Adoption of environmental sound recycling system *International Journal of Environmental Science and Development*, Vol. 1, No. 4, 2010 ISSN: 2010-0264

[8] J. O Babayemi. & amp K. T Dauda,. Evaluation of Solid Waste Generation, Categories and Disposal Options in Developing Countries: A Case Study of Nigeria. Journal of Applied Sciences and Environmental Management,. Vol. 13, No. 3, 2009. 83-88.

[9] Mathias Agbo Jr. The Problem With Solid Waste Management In Nigeria's Low-Income Neighbourhoods Earth.Org 2023. https://earth.org/the-problem-with-solid-waste-management-in-nigerias-low-income-neighbourhoods/

[10] E. Braimah The current state of waste management in Nigeria and the challenges of transitioning to a circular economy. 2023. https://www.linkedin.com/pulse/current-state-waste-management-nigeria-challenges-circular-braimah/

[11] C.C Nnaji. "Status of municipal solid waste generation and disposal in Nigeria", *Management of Environmental Quality*, Vol. 26 No. 1, 2015. 53-71. https://doi.org/10.1108/MEQ-08-2013-0092

[12] Josiah M. Ayotamuno and Akuro E. Gobo Municipal solid waste management in Port Harcourt, Nigeria: Obstacles and prospects Management of Environmental Quality. Volume 15 Issue 4. 2004

[13] Nazak Amanidaz, Ali Zafarzadeh, And Amir Hossein Mahvi The Interaction between Heterotrophic Bacteria and Coliform, Fecal Coliform, Fecal Streptococci Bacteria in the Water Supply Networks Iran J Public Health. . 44(12): 2015. 1685–1692. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4724742/#:~:text=Heterotrophic%20bacteria%20are%20not%20indicators,gastroenteritis%20(2%E2%80%934).

[14] Fungal Infections: Protect Your Health. https://www.cdc.gov/fungal/features/fungi-infections.html

[15] *E. coli* Infection https://www.cdc.gov/healthypets/diseases/ecoli.html#:~:text=Symptoms%20of%20infection%20with%20this,can%20even%20die%20from%20E.

[16] Michel Drancourt, 38 - Acute Diarrhea, Infectious Diseases (Fourth Edition), Elsevier, 2017, 335-340.e2, https://www.sciencedirect.com/science/article/pii/B9780702062858000381

[17] WHO Guidelines for drinking-water quality - 4th ed. ISBN 978 92 4 154815 1 NLM classification: WA 675, 2011

[18] NSDWQ. Nigerian Standard for Drinking Water Quality. Nigerian Industrial Standard, NIS:554 - 2015, 17

[19] K Atta, S Mondal, S Gorai, AP Singh, A Kumari, T Ghosh, A Roy, S Hembram, DJ Gaikwad, S Bhattacharya, UC Jha and D Jespersen Impacts of salinity stress on crop plants: improving salt tolerance through genetic and molecular dissection. Front. Plant Sci. 14:1241736. doi: 10.3389/fpls.2023.1241736, 2023

[20] N. Rahmanian, Siti Hajar Bt Ali, M. Homayoonfard, N. J. Ali, M. Rehan, Y. Sadef, A. S. Nizami "Analysis of Physicochemical Parameters to Evaluate the Drinking Water Quality in the State of Perak, Malaysia", Journal of Chemistry, vol. 2015, Article ID 716125, 2015, 10 pages,. https://doi.org/10.1155/2015/716125

[21] Brody Jane E. Personal Health: A Host of Ills When Iron's Out of Balance. New York website: http://well.blogs.nytimes.com/2012/08/13/a-host-of-ills-when-irons-out-of-balance/

[22] National Institute of Diabetes and digestive and Kidney Diseases. Hemochromatosis. Retrieved https://www.niddk.nih.gov/health-information/liver-disease/hemochromatosis.

[23] Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for total petroleum hydrocarbons (TPH). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. 1999.