ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 08, Issue, 04, pp.19765-19775, April, 2018

ORIGINAL RESEARCH ARTICLE OPEN ACCESS

OPEN REFUSE DUMPSITES: EFFECT ON SOIL AND UNDERGROUND WATER IN PORT HARCOURT METROPOLIS

***Faith. I. Okoronkwo and Gideon. C. Okpokwasili**

Department of Microbiology, University of Port Harcourt, P.M.B. 5323, Port Harcourt, Nigeria

ARTICLE INFO

Article History:
Received 14th January, 2018
Received in revised form
22nd February, 2018
Accepted 20th March, 2018
Published online 30th April, 2018

Key Words:
Groundwater,
Waste dumpsite,
Physico-chemical properties,
Particle size.

ABSTRACT

The microbiological and physico-chemical qualities of five solid waste dumpsites and a control site without dumpsite in Port Harcourt and its environs were determined during wet and dry seasons. The microbiological parameters examined in each sample included, total heterotrophic bacterial count (THB), counts of *Salmonella* and *Shigella*, *Vibrio cholerae*, total and faecal coliform bacteria. Pb, Cu, Mn, NO_3^-, SO_4^{2-}, pH and temperature were the physicochemical parameters analyzed. Sieve analysis was carried out to verify the permeability of the soil. The study showed high counts of microorganisms in all the location sampled for soil and water and these were higher than what was obtained from the control samples especially during the dry season. Feacal coliforms were not detected in any of the water samples while *Vibrio cholerae* was detected only in the soil samples during the two seasons. Total coliforms were high in some locations and within limits in some locations. Cu, Pb, Mn, were detected above the WHO acceptable limits for the well water samples while NO_3^- and SO_4^{2-} were within limits for the water samples. Metal concentrations decreased with depth in the soil samples. Permeability is in the order 10^{-3}cm/sec, typical of sandy soil, and implying that with time, there is the possibility of the aquifer being contaminated since their is no layer protecting the leachetes and the underground water. The bacterial genera isolated from the various water and soil samples include the *Bacillus, Pseudomonas, Proteus, Enterobacter, Chromobacter, Klebsiella* and *Serratia.* The general results suggest that the borehole water samples were good for drinking and domestic use while the wells which were shallow and open and the soil samples were contaminated due to the dumpsites close to them. This poses a risk to the health of the public within these areas.

Citation: Faith .I. Okoronkwo and Gideon .C. Okpokwasili, 2018. "Open refuse dumpsites: effect on soil and underground water in port harcourt metropolis", *International Journal of Development Research*, 8, (04), 19765-19775.

INTRODUCTION

Researchers have pointed out the fact that rapid population growth, improved standard of living and urbanization have rapidly increased the amount of waste generation (Longe and Balogun, 2010; Pushpendra *et al.,* 2012; Babatunde *et al.,* 2013; Nadem *et al.,* 2016), and this has led to indiscriminate dumping of these wastes on any available space or parcel of land and is termed 'open dump site' (Babatunde *et al.,* 2013). These open dumpsites are not only unsightly and open to scavengers but also contribute to problems such as air, water (surface and ground water) and soil pollution (Obire *et al.,* 2002 and Okpokwasili *et al.,* 2006). In Nigeria, over a quarter a million tonnes of solid waste is generated per year with average rate of generation ranging from 0.44kg/cap/day in rural areas to 0.66kg/cap/day in urban areas (Babatunde *et al.,* 2013). According to Igoni *et al.* (2007), Abah and Ohimain, (2010) and Babatunde *et al.* (2013), solid waste generation in Port Harcourt ranged from 0.56 -1.25kg/cap/day and is mainly comprised of organic matter, plastics, metals, nylon, glass and others. Port Harcourt has no properly designed solid waste landfill for the disposal of waste (Moffat and Linden, 1996; William and Hakam, 2016). Several studies abound which pointed out to the increasing threat of waste to soil quality, health, water and the entire ecosystem as a result of poor management (Slomczynska and Slomczynski, 2004; Longe and Balogun 2010; Adejumo, 2014; Adebara *et al.,* 2016) through the impact of leachate from dump sites (Ozebo *et al.,* 2014; Ugwoha and Emete, 2015) and this has resulted in at

Corresponding author:* **Faith .I. Okoronkwo,
Department of Microbiology, University of Port Harcourt, P.M.B. 5323, Port Harcourt, Nigeria.

least a quarter of all preventable ill health in the world (WHO, 2002; David and Oluyege, 2014). Water is vital to life and indispensable for man's activities and is therefore paramount to the survival, nourishment and growth of human beings and is among the most essential requisites that nature provides to sustain life for plants and animals (Pelczar *et al.,* 1993; Akpoborie *et al.,* 2008; Osunkiyesi 2012; Oko *et al.,* 2014), therefore, there is every need for its portability. Port Harcourt, one of the major cities across the country lack access to government treated water sources and so has depended largely on hand dug wells and boreholes for survival. The present study is therefore aimed at evaluating the effect of solid wastes of various dump sites on soils and ground water system in Port Harcourt metropolis, since a large number of the populace depends mostly on groundwater for their daily activities.

MATERIALS AND METHODS

Study area

The work was focused on five different locations with open dump sites and a location without dump site which served as a control site. The study areas are all located within Port Harcourt and its environs and the samples were collected between the months of May - August and October - January, to mark distinct wet and dry seasons respectively.

Sample Collection

Ten different well water and ten different borehole water samples and two control samples for each water type, were collected from five different locations with waste dumpsites (samples) while control samples were collected from areas without waste dumpsites, in Port Harcourt and its environs. Also, three sets of composite soil samples from different depths of 0-1m and at 50cm intervals beneath the dump sites (sample) were collected from the five different sampling locations and the control sites (without dumpsite). The water samples were collected in 2 litre clean plastic containers. The samples were collected at mid-depth of wells (Kashef, 1987) and at mid-streams for boreholes. The samples were collected within the adjoining areas of not more than 20m to the dumpsites. The sampling points were designated W1-W2 and BH1-BH2 for the well and borehole samples respectively for the different locations (Table 1-2).

Sample Analysis

Under aseptic laboratory conditions, the various soil and water samples were analyzed for the following microbiological parameters in triplicates using the spread plate technique on the enclosed media, prepared according to the manufacturer's instruction. Total heterotrophic bacterial count (Nutrient agar), Salmonella-Shigella (Salmonella-Shigella agar) and presence of Vibrio (Thiosulphate-citrate-bile salts (TCBS)) Serial dilutions of the soil samples were made up to 10^{-4} dilution. 0.1ml of the desired dilution was pipetted onto the already prepared and dried media on Petri dishes. Also, 0.1ml of the water samples were pipetted onto desired media plates too and the inocula, spread on the plate. All were incubated at 37^{o}C for 24 hrs. Multiple tube fermentation technique was used to detect the presence of both total coliforms and feacal coliforms (APHA, 1995). The following physico-chemical parameters were determined in the water and soil samples, sulphates ($S0_4^{2-}$), nitrate (NO_{3-}), manganese (Mn), copper (Cu), lead (Pb), pH and temperature according to APHA (1995) methods. Sieve analysis was also carried out on the soil to determine its permeability.

Isolation and purification of colonies: The colonies on nutrient agar for heterotrophic bacteria were further purified by sub culturing on nutrient agar for pure culture and characterized on the basis of their colonial, cellular and biochemical characteristics. The identification of bacteria followed the scheme of Holt (1994). On SSA, Salmonella and Shigella appear colourless whereas lactose-fermenting coliforms produce pink or red colonies on it (Harrigan and McCance, 1966). Thiosulphate-citrate-bile salts (TCBS) agar is a highly selective medium. It inhibits the growth of other organisms and permits the growth of only the Vibrios. Vibrio cholerae colonies appears yellow on TCBS while Vibrio parahaemolyticus appears green on it.

RESULTS AND DISCUSSION

Microbial parameters

Generally, a total of 12 bacterial types were isolated from the soil and water samples and their frequencies of occurencies were as shown in Table 3. A total of 34 bacteria were isolated from the water samples while a total of 25 bacteria were from the soil samples. The isolated bacteria which include *Bacillus* sp (most predominant), Staphylococcus aureus, Enterobacter sp and *E.coli* were all of public health importance. *Staphylococcus aureus* is a known enterotoxin producer (Bennet and Lancette, 1992; Adejumo, 2014). The microbial loads of the water and soil samples from the control site (without dumpsite) for both the wet and dry seasons as shown in Table 2a-f were much lower when compared to the samples, though both values exceeded the WHO permissible limit of 500 cfu/ml. This indicates that the dumpsites were responsible for the high microbial load of the samples. The higher plate count values must have resulted from poor storage systems and from insanitary human handling at the point source of collection of the water for use.

Faecal coliform were not detected in the water samples at both seasons and so is within the WHO limit of 0 (cfu/100ml). The absence of faecal coliform indicated that the source of the water contamination will not be faecal matter of human or animal origin. This also confirms the absence of some possible enteric pathogens like Vibrio cholerae (Wemedo *et al.,* 2004), The presence of total coliform bacteria in the water samples is an indication that the water is polluted by organisms from surface waters, soil or vegetation (Ugochukwu *et al.,* 2015) and therefore, an increased risk of contracting a water-borne illness, especially from the well water samples as they reveal higher counts for total coliforms. Coliform bacteria were higher in some boreholes and these may have come from mammalian colon. The presence of Salmonella and Shigella in some of the water samples also suggests the presence of some pathogenic organisms.

Temperature

The mean temperature values for the well water, borehole water and soil samples during both the wet and dry seasons are as shown in Tables 4a-c respectively. The temperatures all fell within the mesophilic range of between 20^{o}C and 45^{o}C and are within the WHO permissible limit for drinking water quality.

Table 1a. Locations of boreholes and their distances from dumpsites studied

Location	Boreholes	Distance from dumpsites (m)	Depth (m)
Eastern By-pass	BH1	10	Unknown
	BH2	11	Unknown
Omuigwe-Aluu	BH1	12	Unknown
	BH2	15	Unknown
Eagle Island	BH1	14	53.12
	BH2	11	59.38
Ogu Waterside	BH1	10.2	Unknown
	BH2	7.5	53.12
Cemetary Waterside	BH1	8	Unknown
	BH2	11	Unknown
Rumuolumeni	BH1	No dumpsite	Unknown
(Control)	BH2	No dumpsite	Unknown

Table 1b. Locations of hand-dug wells and their distances from dumpsites studied

Location	Wells	Distance from dumpsites (m)	Depth (m)
Eastern By-pass	W1	11	3.75
	W2	10	3.03
Omuigwe-Aluu	W1	10	4.69
	W2	15	3.28
Eagle Island	W1	15	2.5
	W2	14	3.47
Ogu Waterside	W1	10.1	2.5
	W2	10.5	3.13
Cemetary Waterside	W1	9	Unknown
	W2	10	Unknown
Rumuolumeni (Control)	W1	No dumpsite	2.56
	W2	No dumpsite	4.5

This temperature range accommodates the growth of most pathogenic bacteria like the *Salmonella* sp and the *Shigella* sp isolated from the study. This confirms the works of Hagerty *et al.* (1973), Obire *et al.* (2002), Arora (2004) and William and Hakam (2016) that during initial composting development, mesophilic flora predominate and is responsible for most metabolic activities that occurs. Temperature is a physical property which changes with weather condition. This explains the high bacterial counts on the different sample types during the dry season.

pH

Tables 4a-c also show the mean pH values for the well water, borehole water and soil samples during the different seasons respectively. Their values also fell within the WHO limits of between 6.5 – 8.5 and were within the neutral to alkaline range (6.31 – 7.81). This also supports the growth of most pathogenic organisms (Linton and Dick, 1990). According to Pavoni *et al.* (1975), in the first 2-5 days of composting, the pH drop to 5.0 or less and then increases to about 8.5 for the remaining aerobic activities in the compost. Some samples however, showed mild acidity due to the aerobic decomposition of the organic matter in the refuse. This decomposition leads to the formation of carbonic acids which enters the soil through leachate formation to reduce the soil pH and cause acidity. Temperature and pH therefore, are important properties which determine the quality and quantity (load) of microorganisms in the water and soil (Edward, 1990; Eze *et al.,* 2013). The other physico-chemical characteristics of well water, borehole water and soil samples studied are shown in Tables 4a-c. The mean concentration values of all the parameters were within the acceptable limits when compared to the control and WHO standards for drinking water, for the borehole water samples apart from lead (Pb) and copper (Cu) at dry seasons, which showed moderately high concentrations above the WHO permissible limits.

The parameters, microbiological and physic-chemical, were all higher for the well water sample during the two seasons apart from sulphate (SO_4^{2-}) and nitrate (NO_{3-}) when compared to WHO permissible limit.. This also confirms the result of Abdulrafiu *et al.* (2011) and Pushpendra *et al.* (2012) which also reported low sulphate concentration in groundwater near dumpsites. This indicated that the waste dumpsites are responsible for the high sulphate content of the water samples studied. The lower sulphate concentration values could have resulted from the fact that microorganisms present in the waste dumps had reduced SO_4^{2-} to S^- leading to sulphate reduction in the different samples. The water samples can therefore be said to be free of gastrointestinal contamination, catharsis, dehydration that could result from high level of sulphate content in any sample. Though, nitrate concentration in the water sample could be said to be below WHO limit and so could be termed safe, it exceeded the Environmental Protection Agency (EPA) maximum contaminant level (MCL) of nitrate, set at 10mg/l, for the safety of drinking water in both the borehole and well water samples.

Though the concentrations in the borehole are moderate, nitrate levels above this range is responsible for the blue baby syndrome. Jawad *et al.* (1998) and Pushpendra *et al.* (2012) reported this increase in nitrate concentration in groundwater as a result of waste dumps around them. The overall increase in the parameters studied on the well water samples could be because, these wells were shallow and wide open, allowing contaminants to find their way easily into them especially from the waste dumps closer to it and also from the unhygienic handling by the people who use these water sources. The physico-chemical parameters carried out on the soil samples showed a general trend across the depths with the high values occurring at the top soil and decreasing with increase in depth. This according to Nyanagababo and Hamya, (1986) is because top soils are better indicators of metallic burden. The concentrations of lead (Pb), copper (Cu), manganese (Mn), sulphate (SO_4^{2-}) and nitrate in the soil at the dumpsites all

Table 2a. Means of the microbial loads of water samples at different locations during the dry season

Location	Sample	Total Heterotrophic counts (cfu/ml)	Total Salmonella and Shigella counts (cfu/ml)		Total Vibrio counts(cfu/ml)	Total coliform index/100ml	Faecal coliform index/100ml
			Salmonella	*Shigella*			
Easstern By-pass	BH1	$2.8x10^4$	$1.7x10^2$	1.1×10^2	-	20	-
	BH2	$2.0x10^4$	$2.1x10^2$	1.0×10^1		11	-
Omuigwe Aluu	BH1	$2.2x10^4$	$2.0X10^2$	1.0×10^1	-	9	-
	BH2	$2.1x10^4$	$2.0x10^2$	1.2×10^2	-	39	-
Eagle Island	BH1	$3.5x10^4$	$5.0x10^2$	1.4×10^2	-	9	-
	BH2	$4.1x10^3$	$3.0x10^2$	1.1×10^1	-	150	-
Ogu Waterside	BH1	$2.5x10^3$		-	-	7	-
	BH2	$7.8x10^3$		-	-	<3	-
Cemetery Waterside	BH1	$2.0x10^4$	$1.4x10^2$	$1.0\ 10^2\times$	-	3	-
	BH2	$3.7x10^3$	$8.0x10^1$	1.0×10^1	-	9	-
Rumuolumeni (Control)	BH1	$1.2x10^3$		-	-	7	-
	BH2	$1.5x10^3$		-	-	9	-
Mean		$1.42x10^4$	$1.5x10^2$	4.26×10^1	-	-	-
Value Range		$1.2x10^3$ - $2.8x10^4$	0 -$5.0x10^2$	(0-1.4×10^2)	-	-	-

Key: BH = Borehole, - = Not detected

Table 2b: Means of the Microbial Loads of Water Samples At Different Locations During The Wet Season

Location	Sample	Total Heterotrophic counts (cfu/ml)	Total Salmonella and Shigella counts (cfu/ml)		Total Vibrio counts(cfu/ml)	Total coliform index/100ml	Faecal coliform index/100ml
			Salmonella	*Shigella*			
Easstern By-pass	BH1	1.3×10^4	2.5×10^2	1.0×10^2	-	11	-
	BH2	1.1×10^3	4.0×10^2	1.0×10^1		7	-
Omuigwe Aluu	BH1	1.0×10^4	1.3×10^2	2.0×10^1	-	<3	-
	BH2	8.0×10^3	1.0×10^1	-	-	23	-
Eagle Island	BH1	2.34×10^4	3.0×10^2	1.0×10^1	-	22	-
	BH2	2.7×10^3	1.2×10^2	1.4×10^1	-	75	-
Ogu Waterside	BH1	1.5×10^3	-	-	-	<3	-
	BH2	2.2×10^3	-	-	-	<3	-
Cemetery Waterside	BH1	3.6×10^3	6.0×10^1	-	-	<1	-
	BH2	1.88×10^3	4.0×10^1	-	-	<1	-
Rumuolumeni (Control)	BH1	3.6×10^2	-	-	-	4	-
	BH2	3.0×10^2	-	-	-	3	-
Mean		5.67×10^3	1.3×10^2	2.75×10^1	-	-	-
Value Range		3.0×10^2 - 2.34×10^4	0 - $4.0x10^2$	(0-1.5×10^1)	-	-	-

Key: BH = Borehole
- = Not detected

Table 2c. Means of the microbial loads of soil samples at different depths during the wet season

Location	Depth	Total Heterotrophic counts (cfu/g)	Total Salmonella and Shigella counts (cfu/g)		Total Vibrio counts(cfu/g)
			Salmolla	*Shigella*	
Eastern By-pass	0	2.04×10^6	2.5×10^5	1.2×10^4	4.1×10^3
	50	1.27×10^5	6.3×10^4	1.0×10^3	1.5×10^1
	100	1.62×10^4	-	-	1.0×10^1
Omuigwe Aluu	0	2.52×10^6	3.0×10^5	6.0×10^3	2.1×10^2
	50	1.42×10^5	1.7×10^4	-	1.0×10^1
	100	6.8×10^4	-	-	-
Eagle Island	0	1.6×10^6	5.2×10^5	2.0×10^4	-
	50	8.0×10^5	4.8×10^4	1.0×10^3	-
	100	4.5×10^4	1.0×10^3	-	-
Ogu Waterside	0	3.2×10^6	9.0×10^5	1.0×10^4	-
	50	2.1×10^5	4.3×10^4	-	-
	100	1.2×10^4	1.0×10^3	-	-
Cemetery Waterside	0	3.85×10^6	4.0×10^5	1.3×10^4	-
	50	2.20×10^5	3.1×10^4	-	-
	100	1.5×10^4	3.0×10^3	-	-
Rumuolumeni (control)	0	1.2×10^5	9.0×10^4	-	-
	50	1.2×10^4	4.0×10^3	-	-
	100	1.0×10^3	1.48×10^5	-	-
Mean		8.33×10^5	1.48×10^5	3.5×10^3	2.41×10^2
Value range		$(1.0 \times 10^3 - 3.85 \times 10^6)$	$(0 - 9.0 \times 10^5)$	$(1.0 \times 10^3 - 2.0 \times 10^4)$	$(0 - 4.1 \times 10^3)$

KEY: - = Not detected

Table 2d. Mean of the microbial loads of well water samples at different locations during the wet season

Location	Sample	Total heterotrophic counts (cfu/ml)	Total Salmonella and Shigella counts (cfu/ml)		Total Vibrio counts(cfu/ml)	Total coliform index/100ml	Faecal coliform index/100ml
			Salmonella	*Shigella*			
Eastern by-pass	W1	2.3×10^4	3.1×10^2	2.1×10^2	-	9	-
	W2	1.5×10^4	3.3×10^2	1.1×10^1	-	3	-
Omuigwe Aluu	W1	2.5×10^4	4.8×10^2	1.5×10^2	-	21	-
	W2	5.7×10^4	3.0×10^2	1.2×10^2	-	7	-
Eagle island	W1	1.8×10^4	3.2×10^2	1.5×10^2	-	>2400	-
	W2	1.9×10^4	3.7×10^2	1.1×10^1	-	1100	-
Ogu waterside	W1	2.8×10^4	1.0×10^2	-	-	11	-
	W2	7.8×10^4	1.0×10^2	-	-	75	-
Cemetery waterside	W1	3.9×10^4	8.0×10^1	1.0×10^1	-	120	-
	W2	1.6×10^4	6.2×10^1	1.3×10^2	-	39	-
Rumuolumeni (control)	W1	1.1×10^3	1.0×10^2	-	-	7	-
	W2	7.2×10^2	4.0×10^1	-	-	3	-
Mean		2.67×10^4	2.63×10^2	4.35×10^1	-		
Value range		7.2×10^2 - 7.8×10^4	4.0×10^1 - 6.2×10^2	0 - 2.1×10^2	-		

Key: W = Well
- = Not detected

Table 2e. Means of the microbial loads of soil samples at different depths during the dry season

Location	Depth	Total Heterotrophic counts (cfu/g)	Total Salmonella and Shigella counts (cfu/g)		Total Vibrio counts(cfu/g)
			Salmolla	*Shigella*	
Eastern By-pass	0	3.12×10^7	7.2×10^5	2.8×10^4	2.0×10^4
	50	5.12×10^6	1.2×10^4	1.0×10^3	1.0×10^4
	100	1.0×10^4	1.0×10^3	-	
Omuigwe Aluu	0	3.21×10^7	5.8×10^5	1.5×10^4	2.0×10^4
	50	2.5×10^6	5.1×10^4	1.0×10^3	2.0×10^3
	100	1.0×10^4	1.1×10^3	-	-
Eagle Island	0	1.3×10^7	9.2×10^5	5.4×10^4	2.0×10^4
	50	9.6×10^6	6.1×10^4	1.6×10^3	-
	100	1.0×10^4	7.0×10^3	-	-
Ogu Waterside	0	1.6×10^7	9.8×10^5	2.0×10^3	-
	50	6.5×10^6	6.1×10^3	-	-
	100	1.3×10^4	1.0×10^3	-	-
Cemetery Waterside	0	2.5×10^7	7.2×10^5	6.3×10^4	2.5×10^3
	50	6.3×10^6	4.7×10^4	1.0×10^3	1.0×10^1
	100	1.0×10^4	1.0×10^3	-	-
Rumuolumeni (control)	0	4.76×10^5	1.0×10^5	-	-
	50	2.10×10^5	6.0×10^3	-	-
	100	1.3×10^4	1.2×10^3	-	-
Mean		8.22×10^6	1.89×10^5	9.26×10^3	2.97×10^3
Value range		$(1.0 \times 10^3 - 3.21 \times 10^{7)}$	$(1.0 \times 10^3 - 9.2 \times 10^5)$	$(1.0 \times 10^3 - 2.0 \times 10^4)$	$(1.0 \times 10^1$ -2.0×10^4

KEY: - = Not detected

Table 3: Frequencies of occurrence (%) of the bacterial species isolated from the soil and water samples

S/No.	Isolates found	Frequency of occurrence (%) Water sample	Frequency of occurrence (%) Soil sample
1	*Staphylococcus aureus*	5(14.71)	2(8)
2.	*Proteus* sp	3(8.82)	4(16)
3	*Enterobacter* sp	4(11.77)	4(16)
4	*Bacillus* sp	5(14.71)	3(12)
5	*E.coli*	6(17.65)	-
6	*Salmonella* sp	2(5.88)	1(4)
7	*Shigella* sp	3(8.82)	2(8)
8	*Pseudomonas* sp	3(8.82)	2(8)
9	*Chromobacter* sp	2(5.88)	-
10	*Citrobacter* sp	1(2.94)	3(12)
11	*Serratia* sp	-	2(8)
12	*Klebsiella* sp	-	2(8)

Table 4a. Physico-chemical characteristics for borehole water samples at wet and dry seasons

LOCATION	Temperature (^oC)		pH		Pb(mg/l)		Cu(mg/l)		Mn(mg/l)		SO_4^{2-}(mg/l)		NO_3^-(mg/l)	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Eastern By-pass	27.00	29.15	7.06	6.90	0.01	0.03	1.46	1.42	0.14	0.25	214.70	161.60	16.61	13.10
Omuigwe Aluu	27.05	29.00	6.23	7.15	0.00	0.02	0.03	1.39	0.07	0.46	65.45	116.00	1.15	3.37
Eagle Island	28.35	29.00	6.23	6.59	0.00	0.00	0.03	1.31	0.07	0.48	6.55	1.40	1.15	7.33
Ogu Waterside	27.20	28.30	6.21	6.81	0.00	0.02	0.01	1.34	0.01	0.09	4.83	145.50	3.55	12.35
Cemetery waterside	27.00	28.70	7.95	7.40	0.01	0.02	1.32	0.66	0.36	0.45	281.95	265.95	30.80	22.10
Mean	27.32	28.83	6.74	6.97	0.00	0.02	0.57	1.22	0.13	0.35	114.70	138.09	10.65	11.65
Range	(27.00-28.35)	(28.30-29.15)	(6.21-7.95)	(6.59-7.40)	(0-0.01)	(0-0.3)	0.01-1.46)	(0.66-1.42)	(0.01-0.36)	(0.09-0.48)	(6.55-281.95)	(1.40-265.95)	(1.15-30.80)	(3.37-22.10)
Rumuolumeni (Control)	26.70	28.05	6.47	7.05	0.00	0.00	0.06	0.01	0.12	0.04	1.04	80.17	2.70	4.65

Table 4b. Physico-chemical characteristics for well water samples at wet and dry seasons

LOCATION	Temperature (°C)		pH		Pb(mg/l)		Cu(mg/l)		Mn(mg/l)		SO_4^{2-}(mg/l)		NO_3^-(mg/l)	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Eastern By-pass	28.10	29.25	6.77	7.21	0.30	0.00	13.22	9.40	1.90	2.04	366.27	328.58	121.12	13.61
Omuigwe Aluu	27.45	28.85	6.37	6.51	0.00	0.00	10.80	8.35	0.64	1.25	262.50	132.45	2.91	5.80
Eagle Island	27.30	28.65	6.16	6.22	0.00	0.00	12.25	0.07	0.80	0.12	1.64	27.90	7.68	3.53
Ogu Waterside	28.35	29.05	7.05	7.83	0.05	0.00	5.35	0.01	0.85	0.02	199.35	11.03	10.85	3.89
Cemetery waterside	26.10	28.05	6.60	6.71	0.25	0.10	3.90	2.50	0.54	1.15	149.80	25.05	16.40	23.30
Mean	23.46	28.77	6.59	6.90	0.12	0.02	9.10	4.07	0.95	0.92	195.91	105.00	31.792	10.03
Range	(26.1-28.35)	(28.25-29.25)	(6.16-7.05)	(6.22-7.83)	(0.00-0.30)	(0-1.0)	(3.90-13.22)	(0.01-9.40)	(0.54-1.90)	(0.02-2.04)	(1.64-366.27)	(11.03-328.58)	(2.91-121.12)	(3.53-23.25)
Rumuolumeni (Control)	27.50	28.00	6.80	6.71	0.00	0.00	0.05	0.04	0.09	0.12	195.95	0.76	5.75	5.12

Table 4c. Physico-chemical characteristics for soil samples at wet and dry seasons

LOCATION	Depth	Temperature (oC)		pH		Pb(mg/kg)		Cu(mg/kg)		Mn(mg/kg)		SO42-(mg/kg)		NO3-(mg/kg)	
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Eastern By-pass	0	29.00	29.20	8.29	8.72	12.70	31.00	25.4	5.70	25.40	74.80	933.40	984.10	123.50	175.00
	50	28.20	27.40	7.83	8.00	16.90	17.2	28.10	3.10	28.10	70.00	688.90	690.00	132.40	136.70
	100	27.00	25.00	8.17	8.00	9.20	4.00	22.80	0.70	22.80	67.10	668.90	690.00	13.20	62.10
Omuigwe Aluu	0	28.50	28.00	8.45	8.61	7.50	21.00	41.60	15.10	41.60	36.00	68.90	174.20	31.80	108.00
	50	27.10	27.00	8.27	8.40	6.20	11.00	38.20	10.10	38.20	25.90	137.80	171.00	35.30	82.5
	100	26.00	26.00	7.20	8.00	4.10	8.30	33.40	15.00	33.40	20.00	68.90	52.00	30.90	51.00
Eagle Island	0	29.00	29.20	7.00	7.53	4.80	8.00	39.80	0.40	39.80	12.80	757.80	688.90	39.20	185.30
	50	28.00	28.40	6.88	8.61	3.90	5.50	29.00	0.30	29.00	10.50	826.70	1033.30	39.70	44.10
	100	27.00	28.00	6.30	8.79	2.60	1.40	34.00	0.20	34.00	1.00	964.40	895.60	38.20	52.90
Ogu Waterside	0	27.50	28.20	7.10	8.51	44.00	51.10	25.20	4.20	25.20	18.30	786.00	447.80	103.00	141.20
	50	26.20	27.70	7.00	8.41	21.00	17.6	23.2	3.90	23.20	16.60	724.00	861.10	63.70	132.40
	100	25.00	26.00	4.90	8.56	13.20	10.00	2.00	2.50	20.00	12.70	683.00	688.90	14.40	123.5
Cemetery waterside	0	29.10	29.50	5.00	7.50	63.00	73.00	35.00	13.20	35.00	42.00	155.00	213.00	130.00	192.00
	50	28.40	28.50	5.70	7.00	35.00	42.10	24.00	4.00	24.00	25.00	82.00	67.00	87.90	111.10
	100	28.00	27.40	6.10	6.10	12.40	15.00	25.00	15.00	25.00	10.00	72.00	92.00	62.00	77.20
Mean		27.60	27.70	6.946	8.05	17.10	21.08	28.45	6.23	29.65	29.51	507.85	516.59	63.01	111.67
Range		(25.00-29.10)	(25.00-29.50)	(4.90-8.45)	(6.10-8.79)	(2.60-63.00)	(1.40-73.00)	(2.00-41.60)	(0.20-15.00)	(20.00-41.60)	(1.00-74.80)	(68.90-964.0)	(67.00-1033.30)	(13.20-132.40)	(44.10-192.00)
Rumuolumeni (Control)	0	27.50	28.00	7.70	7.63	10.00	1.00	8.00	4.70	8.00	21.50	166.00	344.50	7.00	185.30
	50	26.20	27.20	7.00	6.20	6.50	0.60	2.00	1.90	2.00	18.20	73.00	413.30	3.40	8.20
	100	25.00	26.10	6.80	6.02	2.00	0.40	0.10	0.50	0.10	16.90	54.00	310.00	1.00	4.10
Mean		26.23	27.10	7.17	6.62	6.12	0.62	3.27	2.37	3.37	18.87	97.67	355.93	3.80	65.87
Range		(25.00-27.50)	(26.10-28.00)	(6.80-7.00)	(6.02-7.63)	(2.00-10.00)	(0.40-1.00)	(0.10-8.00)	(0.50-4.70)	(0.10-8.00)	(16.90-21.50)	(54.00-166.00)	(310.00-413.30)	(1.00-7.00)	(4.10-185.30)

Table 5a. Particle size data of soil samples from six sampling sites during the wet season

Soil Location	Sample depth (mm)	% Passing Sieve Size Number						D_{10} (mm)	K ($\times 10^{-2}$ cm/s)
		2mm	1mm	0.5mm	0.25mm	0.106mm	0.053mm		
Eastern By-Pass	0	96.82	89.18	78.00	40.91	17.09	7.73	0.06	0.36
	50	97.10	89.95	79.81	44.97	17.21	12.86	0.04	0.16
	100	87.22	79.45	53.20	39.63	19.60	4.82	0.08	0.64
Omuigwe Aluu	0	83.91	65.50	53.79	28.20	12.12	5.24	0.13	1.69
	50	88.13	72.78	67.47	28.96	8.63	2.74	0.12	1.44
	100	94.38	84.16	76.64	37.81	12.04	7.32	0.18	3.24
Eagle Island	0	96.18	76.79	62.38	24.29	13.78	1.54	0.11	1.21
	50	96.50	89.42	72.25	32.83	15.75	9.58	0.09	0.81
	100	90.20	75.02	64.49	27.23	11.41	4.02	0.09	0.81
Ogu Waterside	0	98.90	90.50	79.10	40.40	16.10	2.90	0.08	0.64
	50	88.38	79.43	66.38	43.52	24.48	6.10	0.06	0.36
	100	92.17	79.21	67.12	29.78	12.38	4.10	0.09	0.81
Cemetery Waterside	0	90.39	77.40	60.94	39.63	22.34	5.40	0.06	0.36
	50	93.40	79.89	53.83	18.55	8.49	2.30	0.16	2.56
	100	95.84	76.14	49.06	29.75	12.64	5.26	0.09	0.81
Rumuolumeni (Control)	0	98.30	92.28	76.34	37.32	19.17	2.80	0.11	1.21
	50	99.39	94.60	56.53	31.19	18.12	1.31	0.12	1.44
	100	99.74	92.81	76.21	39.08	18.56	1.96	0.12	1.44

Table 5b. Particle size data of soil samples from six sampling sites during the dry season

Soil Location	Sample depth (mm)	% Passing Sieve Size Number						D_{10} (mm)	K ($\times 10^{-2}$ cm/s)
		2mm	1mm	0.5mm	0.25mm	0.106mm	0 .053mm		
Eastern By-Pass	0	89.66	74.87	62.18	28.24	18.91	10.25	0.05	0.25
	50	96.33	82.85	74.37	39.02	21.60	8.14	0.06	0.36
	100	92.35	74.02	63.35	30.43	13.79	9.61	0.08	0.64
Omuigwe Aluu	0	93.83	81.67	67.75	32.75	17.33	9.42	0.06	0.36
	50	89.70	72.10	65.00	21.60	7.70	3.40	0.11	1.21
	100	97.80	84.40	57.80	32.40	6.00	3.40	0.10	1.00
Eagle Island	0	90.20	78.70	49.80	14.60	50.30	2.10	0.19	3.61
	50	94.00	84.90	59.80	24.20	6.30	3.50	0.15	2.25
	100	93.30	86.30	65.10	30.7	11.10	6.70	0.09	0.81
Cemetery Waterside	0	98.07	90.61	79.30	42.81	15.96	5.53	0.12	1.44
	50	89.43	76.46	57.07	20.05	6.32	2.66	0.11	1.21
	100	97.00	88.45	77.45	43.00	26.18	7.82	0.06	0.36
Ogu Waterside	0	96.20	87.90	67.20	29.60	6.70	3.10	0.14	1.96
	50	94.00	85.20	65.40	25.90	6.90	3.60	0.14	1.96
	100	79.50	70.20	51.60	19.80	4.50	2.50	0.16	2.56
Rumuolumeni (Control)	0	98.80	95.80	82.70	45.20	18.40	8.50	0.06	0.36
	50	99.52	99.00	91.90	61.90	33.10	19.50	0.02	0.04
	100	99.85	99.10	92.30	63.40	35.50	21.10	0.02	0.04

The permeability of the soil was calculated using the Hazen's formula

$K=cd_{10}2$

Where K = hydraulic conductivity (cm/s)

C= constant (for k in cm/s and d_{10} in mm, c = 1).

d_{10} = effective diameter (mm) defined as diameter such that 10% by weight of the porous matrix consists of grains smaller than it.

The soil is permeable in the study areas with permeability values ranging from 0.16×10^{-2} cm/s - 3.24×10^{-2} cm/s for the wet season and 0.04 cm/s - 3.61 cm/s for the dry season.

The permeability does not follow any specific trend with depth at both seasons.

Table 6. Coefficient of Permeability (K)

Level	Range
High	Over 10^{-1}cm/sec
Medium	10^{-1} to 10^{-3} cm/sec
Low	10^{-3} to 10^{-5} cm/sec
Very low	10^{-5} to 10^{-7} cm/sec
Practically impermeable	Less than 10^{-7}

Terzaghi, K and Peck, R. B. (1967).

Table 7. WHO standard for drinking water quality

Parameter	WHO (Maximum permissible limit mg/l except pH and Temperature)
pH	6.5 -8.5
Temperature (^oC)	5-50
Nitrate	45
Sulphate	250
Manganese	0.4
Copper	1.0
Lead	0.01
Microbiological parameters	WHO limits (cfu/ml)
Total heterotrophic bacterial count	500
Salmonella sp count	0
Shigella sp count	0
Vibrio sp count	0
Total coliform count	1-10 (cfu/100ml)
Faecal coliform count	0 (cfu/100ml)

Table 8. Average Chemical Parameter for Soil Samples

Parameter	Accepted Standards	
	Bowen	Kabata
Cu	0.002	0.013
Mn	0.008	0.3
Pb	0.001	0.004

Bowen, H.J. M (1979). Environmental Chemistry of Elements, London.

through 0-100cm depth during the wet and dry , as in table 4c, were higher than the concentrations at the control sites and also higher than the average metal content of soil as reported by Bowen(1979). This shows that the soils are contaminated to hazardous proportions. The reduction of the concentrations at the control sites suggests that the contamination on the control site is not from a dumpsite (it doesn't have any dumpsite close to it), rather it could come from other sources like copper; coming from the parent igneous rocks or from areas where copper ores are found and worked, or from sewage; manganese, coming from the parent igneous and sedimentary rocks, iron, steel, battery manufacture and coal burning areas; lead, coming from discharge to the atmosphere from car-exhaust fumes due to the use of tetraethyl lead as an anti-knock ingredient, acid water passing through old lead pipes, fuel reservoirs in filling stations in the area, the use of batteries, pigments, dyeing and glass. The high concentration levels at the other sites clearly indicate that the contamination came from the dumpsite.

Soil contaminated by copper, lead and zinc are not suitable for food production (Alloway, 1990; Smith 1996; Anikwe and Nwobodo, 2002) as increased heavy metal content in soil can increase its plant uptake to the detriment of its consumers. Therefore, these soils are not suitable for agriculture. Particle size data of soil samples of the different location and season were as shown in Tables 5a-b and from there, the permeability of the soil samples were calculated. The permeability (K) values of the soil samples are of the order of magnitude of 10-3cm/sec for the wet and dry seasons except at the control site during the dry season which has an order of 10-4cm/sec. This order of 10-3cm/sec is classified as high or medium and is typical of sandy soils. The soil at the control site at the dry season is classified as low. This classification is based according to Terzaghi and Peek (1967). These soil types are bound to allow the infiltration of elements deeper and deeper into the soil with time. These results therefore made these water and soil samples unacceptable when compared to the control water and soil samples which were collected from a site that had no dumpsite.

The results showed that seasonal influence can affect microbial proliferation as the total bacterial counts on the different media were highest during the dry seasons. This could be as a result of some organisms being washed down into the soil or away from the dumpsites during the wet periods.

Conclusion

This study found out that soils in the study area are contaminated to hazardous levels by anions and metals especially copper, manganese and lead and so are unsuitable for food production. The underground water system in this area was not affected by these dumps at both seasons, rather the wells were contaminated as a result of their being shallow and open, factors that contribute to their not being potable for drinking. Seasonal influence has effect on the number of microorganisms in the soil. It can therefore be concluded, that since the soil types are permeable and can allow the passage of substances through it with time that the underlying groundwater will be affected with time with substances from the waste dumps through leaching and other types of substance movements. There is an important need to increase the awareness of the community towards preventive and treatment approaches to minimize the dangers associated with the use of contaminated water and soil. There is therefore, an important need to increase the awareness of the community towards preventive and treatment approaches to minimize the dangers associated with the use of contaminated water and soil and indiscriminate dumping of refuse in the city.

REFERENCES

Abah, S. O. and Ohimain, E. I. 2010. Assessment of dumpsites rehabilitation potential using the integrated risk based approach: a case study of Eneka, *Nigeria. Journal of World Applied Sciences*,8:436-442.

Abdulrafiu, O. M., Adeleke, A. K. and Lateef, O. G. 2011. Quality Assessment of Groundwater in the Vicinity of Dumpsites in Ifo and Lagos, Southern Nigeria. *Advances in Applied Science Research,*2(10): 289-298.

Adebara, S. A., Afolayan, A., Omajali, D.I. and Olatunji,A.A. 2016. Assessment of the Effect of solid waste Dumpsite on Groundwater in Osogbo and Ede Metropolis, Osun, Nigeria. *International journal of Engineering Technologies and Management Research*, 3(2): 1-21.

Adejumo, T.O. 2014. Microbial and Physicochemical Analysis Of Five Major Dumpsites and Nearby Water Sources. *Journal of Environment and Earth Science*, 4(15): 165-177.

Akpoborie, T., Egbo, S.H.O., Ebenuwa, C.C. and Emeshili, E.M. 2008. Comparative Study of the Satchet Water in Asaba Metropolis, South-South, Nigeria. Proceedings of *International Conference of the Chemical Society Of Nigeria*,

Alloway, W. H. 1990. Agronomic Controls over the Environmental Cycling of Trace Elements. *Advances in Agronomy*,20: 235-249.

Anikwe, M. A. N. and Nwobodo, K.C.A. 2002. Long Term Effect of Municipal Waste Disposal on Soil Properties and Productivity of Sites for Urban Agriculture in Abakaliki, Nigeria. *Bioresource Technology*, 83: 241-250.

APHA 1995. Standard Methods for the Examination of Water and Waste Water. 19th ed. *American Public Health Association*, Pp 525-987.

Arora, D.R. 2004. Textbook of Microbiology. 2nd edition C.B.S.Publishers and distributors, New Delhi, India. p686.

Babatunde, B.B., Vincent–Akpu, I.F., Woke, G. N., Atarhinyo, E., Aharanwa, U.C., Green, A.AF. and Isaac-Joe, O. 2013. Comparative Analysis of Municipal Solid Waste (MSW) Composition in Three Local Government Areas in Rivers State, Nigeria. *African Journal of Environmental Science and Technology*, 7(9): 874-881.

Bennet, R.W. and Lancette, G. A. 1992. Principles and Practice of Infectious Diseases. 7th edition , Church Hill Livingstone, *Philadelphia,* Pp 3495-3526.

Bowen, H.J.M. 1979. Environmental Chemistry of the Elements. Academic Press, London.

David, O. M. and Oluyege, A. O. 2014. Effect of Open Refuse Dumpsite on the Quality of Underground Water used for Domestic Purposes in Ado-Ekiti. A Public Health Awareness study. *Journal of Environment and Ecology*,5(2): 1-9.

Edward, C. 1990. Microbiology of Extreme Environments. 2nd ed. Open University Press. Milton, Keynes.

Eze, V.C., Omeh, Y.N. and Ugweye, C. D. 2013. Microbiological and Physico-chemical Assessment of Soil Contaminated with Lairage Effluent in Umuahia, Abia Stata, Nigeria. *Journal of Pharmacy and biological sciences*, 8(2): 50-56.

Hagerty, D. J., Pavoni, J. L. and Heer, J. E. 1973. Solid Waste Management. Van Nostrand Reinhold, New York.

Harrigan, W. F. and McCance, M. E. 1966. Laboratory methods in Microbiology. Academic press London.

Holt, J. G., Krieg, N. R., Sneath, P.H.A., Staley, J.T.S. and William, S. T. 1994. Bergey's Manual of Determinative Bacteriology (9th. ed.). Williams and Wilkins, Baltimore.

Igoni, A. H., Abowei, M. F .N., Ayotamuno, J. M. and Eze, C. L. 2007. Effect of Total Solids Concentration of Municipal Solid Waste in Anaerobic Batch Digestion on the Biogas Produced. *Journal of Food, Agriculture and Environment*, 5: 333-337.

Jawad, A. AL-Shereideh, S. A., Abu-Rukah, Y. and Qadat, K. 1998. Aquifer Groundwater Quality. *Science of the Total Environment*,128: 69-81.

Kashef, A. I. 1987. Groundwater Engineering . McGraw-Hill Book company. New York. p512.

Linton, W. C. and Dick, M. H. 1990. General Microbiology and Immunology, 8th edition, *Philadelphia*, Pp120-125.

Longe, E. O. and Balogun, M. R. 2010. Groundwater Quality Assessment Near a Municipal Landfill, Lagos, Nigeria. *Research Journal of Applied Sciiences, Engineering and Technology*, 2 (1): 39-44.

Moffat , D. and Linden, O. 1996. Perception and Reality: Assessing Priorities for Sustainable Development in Niger Delta. *Ambi.,* 24: 527-538.

Nadeem, K., Farhan, K. and IIyas, H. 2016. Waste Amount Survey and Physico-chemical Analysis of Municipal Solid Waste Generated in Gujranwala-Pakistan. *International Journal of Waste Resources*, 6(1): 1-8.

Nyanagababo, J. T. and Hamya, J. W. 1986. The Decompositi on of Lead, Cadmium, Zinc and Copper from Motor Traffic on Brachiarla Erimi and Soil along a Major Road in Kampala City . *International journal of Environmental studies*, 27: 115-119.

Obire, O., Nwaubeta, O. and Adue, S. B. N. 2002. Microbial Community of a Waste Dumpsite. *Journal of Applied Science and Environmental Management*, 6(1): 78-83.

Oko, J. O., Aremu, O. A., Odoh, R., Yebpella, G. and Shenge, G. A. 2014. Assessment of Water Quality Index of Borehole and Well Water in Wukari Town, Taraba State, Nigeria. *Journal of Environment and Earth Science*, 4(5):1-9.

Okpokwasili, G. C. and Ogugbue, C. J. 2006. Solid Waste Disposal Systems in Nigeria: The Merit, Demerits and Sustainable Investment Opportunities. In 4th Annual Conference of the Nigerian Senate on the Environmental Solid Waste Management in the 21st Century Nigeria. Hotel Presidential, Port Harcourt.

Osunkiyesi, A. A. 2012. Physico-chemical Analysis of Ogun River (water samples) within Two Locations (Akiro-Olugbade and Lafenwa) in Abeokuta, Nigeria. African *Journal of Biomedical Research*,11: 285-290.

Ozebo, V. C., Saheed, G. and Olufemi, A. I. 2014. Physico-chemical Properties of Soil samples and Dumpsite Environmental Impact on Groundwater Quality in South Western Nigeria. *The African Review of Physics*, 9(0015): 103-114

Pavoni, J.L., Heer, J. E. and Hagerty, D. L. 1975. Handbook of Solid Waste Disposal, Materials and Energy Recovery. van Nostrand Reinhold Company, New York.

Pelczar, M. J. (Jr), Chan, E. C. S. and Krieg, N. R. 1993. Microbiology: Concepts and Applications. McGraw-Hill Inc. New York.

Pushpendra, S. B., Anjana, S., Akhilesh. K.P., Priyanka, P. and Abhishek, K. A. 2012. Physico-chemical Analysis of Groundwater near Municipal Solid Waste Dumpsite in Jabalpur. *International Journal of Plant, Animal and Environmental Sciences*,2(1): 217-222.

Slomczynska, B. and Slomczynski, T. 2004. Physico-chemical and Toxicological Characteristics of Leachetes from MSW Landfills. *Polish Journal of Environmental Studies*, 13(6): 627-637.

Smith, C. J., Hopmans, P. and Cook, F. J. 1996. Accumulation of Cr, Pb, Cu, Ni, Zn and Cd in Soil following Irrigation with Untreated Urban Effluent in Australia. *Environmental Pollution*, 94: 317-323.

Terzaghi, K. and Peek, R. B. 1967. Soil Mechanics in Engineering Practice. 2nd edition. John Wiley and sons.

Ugochukwu, S., Giwa, F.J. and Giwa, A. 2015. Bacte riological Evaluation of Sampled Satchet Water sold in Samaru-Zaria, Kaduna State, Nigeria. *Journal of Basic and Clinical Sciences*,12 (1): 6-12.

Ugwoha, E. and Emete, K. C. 2015. Effects of Open Dumpsite Leachetes on Groundwater Quality: A Case Study of Alakahia Dumpsite in Port Harcourt, Nigeria. *Journal of Environmental Studies*,1(1):1-8

Wemedo, S. A., Ekpemadu, J. C. and Ekweozor, I. K. E. 2004. Bacterial Quality of Oriobojo Stream in Isiokpo, Ikwerre Local Government Area of Rivers State, Nigeria. *Journal of Nigerian Environmental Society*, 2(2): 192-195.

WHO, 2002. Water Sanitation and Hygiene. World Health Organization, Geneva.

WHO, 2004. Guidelines for Drinking Water Quality. 3rd ed. Vol 1 Recommendation, Geneva.

Williams, J. O. and Hakam, K. 2016. Microorganisms Associated with Dumpsites in Port Harcourt Metropolis, Nigeria. *Journal of Ecology and Natural Environment*, 8(2): 9-12.

****