March 2013. Vol. 2, No.4 ISSN 2305-8269

International Journal of Engineering and Applied Sciences

www.eaas-journal.org

ASSESSMENT OF HEAVY METAL STATUS AND BACTERIA POPULATION IN MUNICIPAL BOREHOLE WATER IN LANDFILL AND NON-LANDFILL AREAS IN CALABAR MUNICIPALITY, CROSS RIVER STATE, NIGERIA.

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ABSTRACT:

Landfill leachate are the major ground water pollutant that affect the quality of drinking water due to the seepage of toxic substance from E-wastes, house-hold wastes, mechanic wastes, other agricultural wastes etc. This study was aimed at assessing the status of heavy metal and bacteria population in municipal borehole water in landfill and non-landfill areas in Calabar. Twelve boreholes were sampled in the landfill areas such as Atimbo, Anantigha, Ibom layout and GOM (Goldie, Orok-Orok and Mount-Zion) while the other twelve boreholes were also sampled in the non-landfill areas in Atimbo, Anantigha, Ibom layout and GOM. The water samples were collected and analyzed for the presence of heavy metals and microbial load. The result for the presence of heavy metals shows that there were no significant difference ($p>0.05$) in the iron content of the borehole water samples in the landfill and non-landfill areas, while the manganese and ammonium content of the landfill areas were significantly ($p<0.05$) higher than that of the non-landfill areas. The result on the microbial analysis showed that the bacterial populations in the landfill borehole water samples were higher than those of the non-landfill areas. The following microorganisms were identified in the water samples *Escherichia coli*, *Streptococcus sp*, *Salmonella sp*, *Shigella sp* and *Vibrio sp*. However, the result of this study implies that borehole water samples in landfill areas are unsuitable for human consumption and occupant in landfill areas should avoid drinking water from these boreholes since it can interfere with the normal state of health.

Key words: Assessment, Heavy metal, Borehole water, Landfill, Municipality

INTRODUCTION

Aluminum contamination of groundwater could come from the disposal of aluminum containing materials such as aluminum foil, antiperspirants cans and ceramics in municipal landfills. Exposure to this contaminant could manifest in flatulence, headaches, dry skin, weak and aching muscles, memory loss, Alzheimer's disease and Parkinson disease. Aluminum works by blocking the electric discharge of nerve cells which reduce the activity of the nervous system. Arsenic is sometime present in municipal waste. It is usually in the form of rat poison, paints beer, pesticide and fungicides. It acts in the body to inhibit enzymes, anorexia, dermatitis, stomatitis, hair loss and jaundice. Arsenic is also a carcinogen, causes kidney damage and leads to a decrease in growth and mental ability (Lenntech 2004). Cadmium is generated from fungicides and welding material. It causes anemia, cancer, cerebral hemorrhage, liver cirrhosis, hypoglycemia and infertility Cadmium directly damages nerve cells it, affects bones and joints leading to arthritis and osteoporosis (Young, 2005). Copper found in municipal landfills comes from disposed copper cookware, fungicides, and copper pipes. The symptoms of

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copper accumulation include acne, allergies, insomnia nausea, premenstrual symptoms, yeast infections, mood swings, depression, cystic fibrosis, anxiety, phobias and estrogen dominance. A build up of copper can result in hyperactivity in acoustic children (Noland, 2003). The sources of iron in municipal waste dumps include materials made from iron. The symptoms of iron accumulation in the body are anger, constipation, high blood pressure, Parkinson disease; hepatitis and heart failure. It leads to hemochromatosis (iron over load). It increases the possibility of stroke and memory loss (Ogwegbu and Muhanga, 2005). Lead is another source of contamination generated from food cans, with lead soldering seals, batteries, and e-waste. In the body, rather than calcium, lead is incorporated into the bone. It causes hyperactivity, fatigue, and causes deficiencies of other minerals such as zinc, calcium and manganese. It can also inactivate thyroxine thereby inhibiting the uptake of Iodine (Ogwegbu and Muhanga, 2005). Mercury is often found in hospital waste. Mercury affects health by accumulating in the kidney and inhibits ATpase thereby impairing energy production in body cells and as a result, there is degeneration of nerve fibers (Hauser and Hauser, 2008). Nickel is generated from batteries, wire and electrical parts. Steady ingestion (exposure to nickel) can lead to cancer especially of the lungs and nasal sinus (Hauser and Hauser, 2008). This presence study was aimed at assessing the presence of heavy metals and bacterial population in some selected landfills and non-landfills areas in Calabar.

MATERIALS AND METHODS

Study Site

The study was carried out in the Department of Genetics and Biotechnology, University of Calabar, while the physicochemical and bacteriological analyses of the water samples were carried out in Cross River State Water Board Corporation (CRSWBC), Cross River State, Nigeria.

3.2 Sample Collection

Groundwater samples were randomly collected from twenty four boreholes across the Calabar metropolis. Twelve of these boreholes consist of the landfill locations in Atimbo, Anantigha, Ibom layout and GOM while the other twelve consist of the non-landfill locations in Atimbo, Anantigha, Ibom layout and GOM. The global positioning systems (GPS) for the boreholes in the four locations are recorded in Table 1. The samples were collected according to WHO guidelines (WHO, 1983). The procedure for borehole water sample collection started with a reconnaissance survey to the areas. This was to help in identifying functional boreholes in landfill and non-landfill areas. Functional borehole was conceptualized as one that is frequently in use with high level of usage greater than 50 persons per day. Through this approach, 24 functional boreholes in landfill and non-landfill areas were identified, and water samples randomly collected. Water samples were collected in 2.0 litre plastic bottles; before the collection of water samples, the borehole were allowed to pump for 18 minutes so that water with a constant temperature and pH, representing that from the aquifer was collected. Water samples were collected at the borehole heads. Prior to sample collection, all plastic bottles were rinsed thrice with the borehole water. After sampling, the containers were tightly covered, labeled and taken to the laboratory for analysis.

Table 1: Global Positions of studied sites

Location	Latitude	Longitude	Altitude (m)above sea level
Atimbo	$4^0$58 ˋ10 ˋˊ	8^0 22ˋ4 ˋˊ	28
1	$4^0$58 ˋ5 ˋˊ	$8^0$21 ˋ55 ˋˊ	30
2	4^0 58ˋ9 ˋˊ	8^0 22 ˋ4ˋˊ	21
3	4^0 58 ˋ7 ˋˊ	8^0 21 ˋ7 ˋˊ	33
4	$4^0$58 ˋ7 ˋˊ	$8^0$22 ˋ4 ˋˊ	35

March 2013. Vol. 2, No.4 ISSN 2305-8269

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5	$4^0$58ˊ7ˊˊ	$8^0$22ˊ4ˊˊ	33
6	$4^0$58ˊ9ˊˊ	$8^0$22ˊ4ˊˊ	33
Anantigha	$4^0$55ˊ5ˊˊ	$8^0$18ˊ9ˊˊ	28
1	$4^0$58ˊ7ˊˊ	$8^0$19ˊ21ˊˊ	27
2	$4^0$55ˊ11ˊˊ	$8^0$19ˊ51ˊˊ	29
3	4ˊ55ˊ8’	$8^0$18ˊ57ˊˊ	28
4	$4^0$55ˊ0ˊˊ	$8^0$19ˊ1’	28
Ibom Layout			
1	$4^0$57ˊ59ˊˊ	$8^0$20ˊ1’	63
$2	$4^0$57ˊ57ˊˊ	$8^0$20ˊ5’	72
3	$4^0$57ˊ53ˊˊ	$8^0$20ˊ1’	63
4	$4^0$57ˊ55ˊˊ	$8^0$20ˊ10’	73
5	$4^0$57ˊ58ˊˊ	$8^0$20ˊ9’	73
6	$4^0$57ˊ55ˊˊ	$8^0$20ˊ8’	73
GOM			
1	$4^0$56ˊ4ˊˊ	$8^0$20ˊ18’	69
2	$4^0$56ˊ35ˊˊ	$8^0$20ˊ16’	53
3	$4^0$$57^6$ˊ41ˊˊ	$8^0$20ˊ18’	74
4	$4^0$56ˊ38ˊˊ	$8^0$20ˊ4’	71
5	$4^0$57ˊ41ˊˊ	$8^0$20ˊ12’	70
6	$4^0$56ˊ41ˊˊ	$8^0$20ˊ18’	70

NB
Longitude and Latitude are measured as degree (^{0}), minutes (‘) and Seconds (ˊˊ)

 ISSN 2305-8269

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Heavy metal analysis of borehole water samples

Heavy metals analysis was done using the Atomic Absorption Spectrophotometry for chemical parameters. The following parameters were analyzed:

3.4.1.1 Copper

Procedure: 5ml of the water sample was placed in a WTW Spectrophotometer reaction cell and 5 drops of copper reagent cu-ik: added into it, and shaken. A reaction time of 5 minutes was allowed before reading was taken in the spectrophotometer at 420um wave length.

3.4.1.2 Nitrite

Procedure: 5ml of the water sample was placed in a test tube and 1 microspoonful of nitrate reagent no2- and shaken to dissolve. After 10 minutes, the concentration was determined using the spectrophotometer, at a wave length of 40um.

3.4.1.3 Ammonium

Procedure: 5ml of the water sample was placed in a test tube and 0.60ml of ammonium reagent nh4-1 was added using a syringe. 1 level microspoonful of ammonium reagent nh4-2 was also added, shaken and allowed to stand for 5 minutes. Ammonium concentration was then determined using the spectrophotometer at a wavelength of 520nm

3.4.1.4 Manganese

Procedure: 5ml of the water sample was placed in a test tube and 4 drops of manganese reagent mn-1 was added and shaken. 2 minutes thereafter, 2 drops each of Manganese reagents mn-2 and mn-3 were added, shaken and allowed to stand for another 2 minutes before reading the Manganese concentration from the spectrophotometer at a wavelength of 520nm.

3.4.1.5 Lead

Procedure: 5ml of the water sample was placed in a reaction cell and 5 drops of lead reagent pb-1k was added and mixed. The concentration of Lead was determined in the spectrophotometer at a wavelength of 620nm

3.4.1.6 Cyanide

Procedure: 5ml of the water sample was added into a reaction cell and shaken vigorously. 1 (one) level microspoonful of cyanide reagent cn-3k was added and also shaken to dissolve the powder. A reaction time of 10 minutes was allowed and then the cyanide concentration read from the spectrophotometer at a wavelength of 620nm.

3.4.1.7 Chromate

Procedure: 6 drops (0.6ml) of Chromate reagent cr-3k was added to a reaction cell and shaken to mix. This was allowed to stand for 1 minute and then 5ml of the water sample added and shaken also to mix. This was again allowed to stand for another 1 minute and the chromate concentration read from the spectrophotometer at a wavelength of 560nm.

3.4.1.8 Iron

Procedure: 5 ml of the water sample was placed in a test tube and 0-30ml of Iron reagent fe-1 was added, shaken and allowed to stand for 3 minutes. The iron concentration was then determined at a wavelength at 420nm in the spectrophotometer.

3.4.1.9 Zinc

Procedure: 0.5 ml of Zinc reagent Zn-1k was placed in a reaction cell and mixed, and then 0.5ml of the water sample was added and shaken to mix. Finally, Zinc reagent Zn-2k was added, shaken and allowed to stand for 15 minutes. The zinc concentration was determined at a wave length of 720um.

3.4.2 Microbial analysis

3.4.2.1 Bacteriological tests (Total and Feacal Coliforms)

Method: the method used is the membrane filtration method.

Materials used: Erlenmeyer flask, vacuum pump, measuring cylinders, forceps, alcohol, Petri dishes, media for culturing (MF-C, agar base, Endo Agar), incubator (BICASA model), autoclave (AND England), colony counter (Stuart Scientific).

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Procedure: All the glass wares and the media used were sterilized in an autoclave at 121^{0}C for 15 minutes. The media used, (endo and MF-C agar) were prepared according to manufacturer's instructions before sterilization. The media were poured into sterile glass Petri dishes and allowed to cool and solidify. The filtration unit was mounted on the Elenmeyer flask and fastened with a clamp, then a membrane filter was carefully picked with a forceps and placed on the filtration unit and 100ml of the water sample was measured using the measuring cylinder and poured into the filtration unit. The vacuum pump was then turned on and the water was filtered out into the Erlenmeyer flask. The membrane filter was carefully removed with a sterile forceps (dipped in alcohol) and placed on the molten medium. Incubation was done at 37^{0}C for Total Coliforms and 44^{0}C for Feacal Coliforms for 24 hours. The cultures were then harvested and the colonies counted with a colony counter and the colony counts appropriately noted. This procedure was repeated for all the samples.

3.4.2.1 Isolation of *Salmonella/Shigella* species

The *Salmonella*/*Shigella* agar (SSA) was prepared according to the manufacturer's direction and 0.1 ml aliquot of each water sample was transferred onto the surface of the dried sterilized SSA plates. The plates were inoculated in triplicate and incubated at 37°C for 24 to 48 h. Thereafter, pure cultures were obtained by sub-culturing onto freshly prepared SSA plates and pure colonies were identified using biochemical reactions.

3.4.2.2 Isolation of *Vibrio* species

The thiosulphate citrate bile salt (TCBS) agar was prepared and poured into sterilized Petri dishes. It was allowed to solidify, after which, 0.1 ml of each water sample was transferred onto the dried agar plates in triplicate using a 1 ml pipette and spread evenly with a sterile hockey stick. It was incubated at 35°C for 24 to 48 h. After incubation, yellow colonies were counted and thereafter identified using biochemical reactions.

3.4.2.3 Isolation of total culturable heterotrophic bacteria

The spread plate method was used. Ten-fold serial dilution of each water sample was prepared aseptically in sterile physiological saline up to 10^{-3} and 0.1 ml aliquot of each dilution was plated on dried nutrient agar plates in triplicate. All incubations were conducted at 35°C for 24 h under aerobic conditions and plates containing 30 to 300 colonies were selected and counted. The number of colony-forming units per ml (cfu/ml) was calculated by multiplying the number of colonies by the dilution factor.

3.4.2.4 Identification of isolates

The cultural, morphological and biochemical characteristics of the respective isolates were compared with the criteria in Bergey's manual of Determinative Bacteriology (1994). The biochemical tests used in the identification and characterization of the isolates include: gram staining, motility, indole production, methyl red-voges proskauer, citrate utilization, oxidase, catalase, coagulase and sugar fermentation tests.

3.5 Experimental design and Statistical analysis

The experiment design for the study was a 2x4 factorial experiment in a completely randomized design. The factor 1, represent the borehole locations while factor 2, represent the sample locations.

The data collected were subjected to a two way analysis of variance (ANOVA). Significant means were separated using least significant difference (LSD) test.

RESULTS

Heavy metals contents in boreholes

Iron (Fe)

There was presence of iron in all the borehole water samples in the landfill and non-landfill areas. The presence of these heavy metal shows no significant difference (p>0.05), thus this implies that all water samples contain the same concentrations of iron.

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Lead (Pb)

The result indicated that all the water samples except borehole water from Anantigha landfill area did not contain lead. The concentration of the lead found in Anantigha borehole water sample was 0.07±0.01mg/l.

Zinc (Zn)

The presence of zinc was only detected in Atimbo and Anantigha landfill areas at a concentration of 0.03±0.05 and 0.05±0.02mg/l respectively, all other borehole water samples zinc was not detected.

Copper (Cu)

Copper was detected at a concentration of 0.03±0.01mg/l in Anantigha borehole water samples in the landfill areas but absent in other borehole water samples.

Manganese (Mn)

The result obtained showed that there were significant difference in the manganese concentration found in the borehole water samples from the landfill and non-landfill areas. It was however observed that water sample from Anantigha landfill area contained the highest concentration of manganese with mean value of 0.21±0.02 followed by borehole water samples from Atimbo 0.11±0.01, Ibom layout 0.14±0.01mg/l, GOM 0.13±0.01mg/l in the landfill area respectively, Anantigha 0.13±0.03mg/l, Ibom layout 0.08±0.01mg/l and GOM 0.09±0.01mg/l in the non-landfill areas respectively, thus showing no significant difference ($p>0.05$) between them, while water samples from Atimbo non-landfill area has the lowest concentration of manganese with mean value of 0.03±0.01mg/l.

Aluminum (Al^{3+})

The presence of aluminum was detected in borehole water samples from Atimbo and Anantigha landfill areas at a concentration of 0.02±0.01mg/l and 0.82±0.22mg/l respectively, other water samples tested for did not contain aluminum

Ammonium

The result obtained showed that they were significant difference ($p<0.05$) in the concentration of ammonium found in the borehole water sample in the landfill and non-landfill areas. The borehole water sample in Anantigha landfill area had the highest concentration of ammonium with a mean of 0.93±0.19 followed by borehole water samples from Atimbo 0.55±0.02mg/l, GOM 0.42±0.02 in the landfill areas respectively and Anantigha 0.59±0.02mg/l in the non-landfill areas showing no significant difference ($p>0.05$). The concentration of ammonium in Atimbo non-landfill areas was found to be 0.3±0.01mg/l.

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			Landfill			Non landfill			
Parameters	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH8	WHO
Iron (mg/l)	1.24^a±0.03	1.17^a±0.12	1.43^a±0.04	1.52^a±0.06	1.18^a±0.40	0.97^a±0.03	0.76^a±0.10	0.66^a±0.03	0.30
Lead (mg/l)	ND	0.07±0.01	ND	ND	ND	ND	ND	ND	0.01
Zinc (mg/l)	0.03±0.01	0.05±0.02	ND	ND	ND	ND	ND	ND	3.0
Copper(mg/l)	ND	0.03±0.01	ND	ND	ND	ND	ND	ND	2.0
Manganese (mg/l)	0.11^b±0.01	0.21^a±0.02	0.14^b±0.01	0.13^b±0.01	0.03^c±0.01	0.13^b±0.01	0.08^b±0.01	0.09^b±0.01	0.50
Aluminium (mg/l)	0.02±0.01	0.83±0.22	ND	ND	ND	ND	ND	ND	0.2
Ammonium (mg/l)	0.55^b±0.02	0.93^a±0.19	0.16^d±0.02	0.42^b±0.02	0.30^c±0.01	0.59^b±0.01	0.08^d±0.01	0.17^d±0.03	0.5
Cyanide (mg/l)	ND	0.002±0.01	ND	ND	ND	ND	ND	ND	
Chromate (mg/l)	ND	0.001±0.00	ND	ND	ND	ND	ND	ND	

Table 2: Heavy metal contents in Boreholes water

Means with the same case letter along the horizontal array signified no significant difference ($p>0.05$)

Key: ND, not detected; BH1Atimbo borehole in landfill area; BH2, Anantigha borehole in landfill area; BH3, Ibom layout borehole in landfill areas; BH4, GOM boreholes in landfill areas; BH5, Atimbo boreholes in non-landfill areas; BH6, Anantigha borehole in nonlandfill areas; BH7 Ibom layout boreholes in non-landfill areas; BH8, GOM boreholes in non-landfill areas.

ISSN 2305-8269

International Journal of Engineering and Applied Sciences

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Microbial analysis of borehole water in landfill and non-landfill areas

The result of the microbial analysis showed that the total heterotrophic bacterial counts in the borehole water samples were as followed: Atimbo borehole water sample contain $2.8x10^2$cfu/ml, Anantigha borehole water sample contains $3.8x10^2$cfu/ml and GOM borehole water samples contains $2.1x10^2$cfu/ml in the landfill areas respectively.

The result also shows that the faecal coliform count in the borehole water samples were as follows: Atimbo borehole water $3.4x10^2$cfu/ml, Anantigha $8.63x10^2$cfu/ml, Ibom layout $2.43x10^2$cfu/ml and $3.3x10^2$cfu/ml in the landfill areas respectively, while Anantigha borehole in the non-landfill areas contain $2.0x10^2$cfu/ml. No counts were obtained in other samples.

Table 3: Microbial analysis of boreholes

Locations	THB (CFU/ml)	Total coliform (MPN/ 100ml)	Faecal coliform cfu/ml	Vibro sp cfu/ml	Shigella sp cfu/ml	Salmonella sp cfu/ml
BH1	$2.8x10^2$	103	$3.4x10^2$	$2.2x10^2$	$2.8x10^2$	ND
BH2	$3.8x10^2$	950	$8.63x10^2$	$2.72x10^2$	$3.56x10^2$	$2.91x10^2$
BH3	ND	47	$2.43x10^2$	ND	ND	ND
BH4	$2.1x10^2$	98	$3.3x10^2$	ND	$2.0x10^2$	ND
BH5	ND	ND	ND	ND	ND	ND
BH6	ND	32	$2.0x10^2$	ND	ND	ND
BH7	ND	ND	ND	ND	ND	ND
BH8	ND	ND	ND	ND	ND	ND

Key: ND, Not detected

 ISSN 2305-8269

International Journal of Engineering and Applied Sciences

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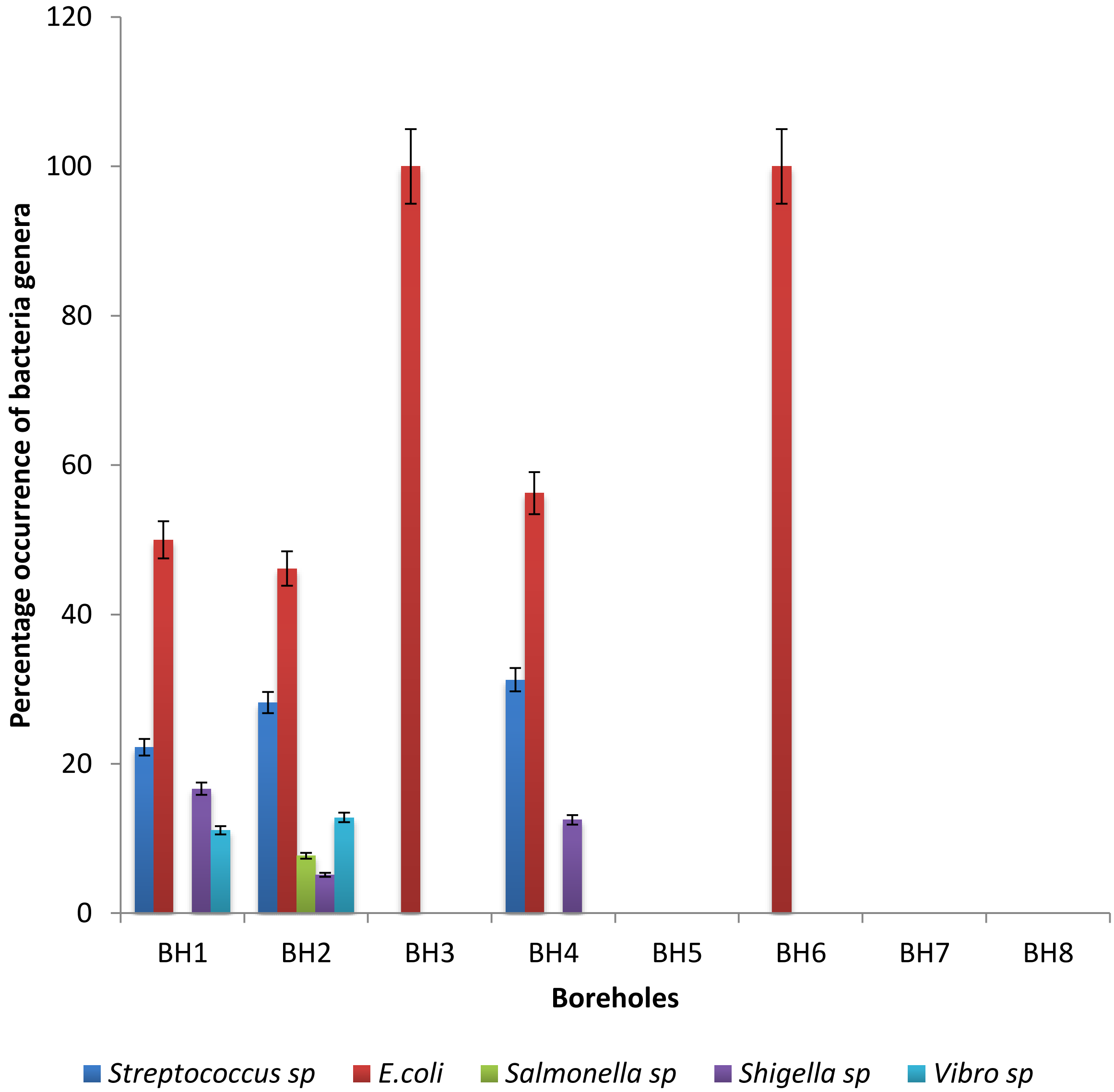

FIG 1: Percentage occurrence of bacterial genera

DISCUSSIONS

Heavy metal content in borehole water

Manganese concentrations in the landfill and non-landfill borehole water samples were below the WHO standard for drinking water of 0.5mg/l. Udom *et al*., (1998) reported that manganese concentration above 0.1mg/l stains laundry and sanitary wares, while above 0.2mg/l in drinking water causes neurological disorder. However, the values obtained in Anantigha borehole water in the landfill areas presented a manganese concentration of 0.21mg/l. water samples from the non-landfill contain low concentrations of manganese which thus, implies that water samples from the borehole has good taste and would not promote the growth of algae in reservoirs or collection tank (Nwankwoala *et al*., 2002., Njar *et al*., 2012). Some recent studies have reported associations between increased levels of manganese in drinking water and cognitive behavioral problems in children Bouchard *et al*., (2007). The nature of cellular damage caused by manganese has been attributed to its capacity to generate cytotoxic levels

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of radicals and Manganeses related neurodegradation (Dobson *et al*., 2004).

Iron is common water contaminants that pose no health hazards. Its presence in water results in staining as well as offensive taste and appearance. Iron cause reddish-brown staining of laundry, porcelain, dishes, utensils and glassware. Industrial effluent, acidmine drainage, sewage and landfill leachate may also contribute iron to local groundwater in these study it was observed that the iron level in the landfill areas exceeded the WHO standard of 1.0mg/l. the non-landfill areas also significantly contain high concentration of iron especially Atimbo non-landfill area. Iron levels above 0.3mg/l tend to stain laundry. Obiri-Danso *et al*., (2003) found that iron was present in bottle water but at a concentration within the WHO standard (WHO, 1993).

Zinc is considered non-toxic, but excess amount can cause system dysfunctions that result in impairment of growth and reproduction (Nolan, 2008). The clinical signs of zinc have been reported to include vomiting diarrhea, bloody urine, icterus (yellow mucus membrane), liver failure, kidney failure and anemia (Duruibe *et al*., 2007). Zinc was detected in Atimbo and Anantigha boreholes in the landfill areas in a minute amount below the WHO standard of 2mg/l. however; zinc was not detected in Ibom layout, GOM and the non-landfill areas. The low amount of Zinc in the boreholes water samples implies that the water do not have caustic taste.

Lead was only detected in minute amounts in Anantigha boreholes in the landfill areas which concentration was below the WHO standard for drinking water. Lead is the most toxic of the heavy metals. Human exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure. High level of human exposure to lead could result in toxic biochemical effects in humans which in turn cause problems in synthesis of haemoglobin, effects on the kidneys, gastrointestinal tract, joints and reproductive system, and acute or chronic damage to nervous system (Leuntech, 2011).

Copper and chromate were detected in small amount below the WHO standard for drinking water in Anantigha borehole water around the landfill areas. Other samples tested zero for copper and chromate, the presence of copper in drinking water is often detected from copper pipes and additives made to control algal growth. Chromium is used in metal alloys and pigments for paints, cement, paper, rubber and other materials. Exposure to chromate in low-level could result in irritation of skin and cause ulceration, while long term exposure could result in kidney, liver damage, damage to circulatory and nerve tissue. The presence of these element in Anantigha borehole water could impose health danger due to their numerous effect.

Cyanide was also observed in the borehole water sample in Anantigha landfill areas at a low level as compared with the WHO standard. The short-term effect of cyanide have been found to be rapid breathing, tremors and other neurological effects while the long term effects have been found to be weight loss, thyroid effects and nerve damage. Almost all the boreholes water samples tested free of cyanide except that of Anantigha that contain a little amount.

Microbiological analysis of the borehole water samples

The presence of coliform bacteria in the borehole water samples, as observed in this study is a source of great concern. These bacteria have been associated with a number of health problems such as cholera, vomiting and diarrhea (Prescott, 2002). Ngeudo-tongsi (2011) in his studies reported the presence of coliforms, faecal coliforms and pathogens (*Esherichia coli*, *Streptococcus* and *Pseudomonas*, *Salmonella*) in large numbers which was attributed to emanation of these species from some sources such as seepages from septic tanks into household drinking water supply, unhealthier latrine systems which have exceeded their expected life span or post treatment contamination along the distribution line. The presence of these indicator organisms in drinking water sources may provide an indication of water borne problems and is a direct threat to human health and is a matter of serious concern. The presence of high bacteria population in Atimbo, Anantigha and GOM boreholes water in the landfill areas is an indication that the water is highly polluted and not good for human consumption. However, the pollution of these water sources may be as a result of the landfill activities which might have leached some of the harmful chemicals into the ground water level. For sustainability of human health occupant of such areas should avoid drinking from boreholes close to dumpsite, septic tanks in order to avoid chronic diseases that might arise through the consumption of such water.

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