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Investigation of Heavy Metals Level in selected Boreholes around the Vicinity of some Cemeteries in Benin City, Nigeria

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ABSTRACT: Groundwater pollution by heavy metals such as lead, copper, nickel and iron is one of the major environmental issues of concern which has developed into a widely studied area. In this study, attempt was made to investigate the level of heavy metals in selected boreholes around the vicinity of cemeteries in Benin City. Seventy-two (72) samples of groundwater were taken from boreholes in 9 stations around the three cemeteries in Benin City on monthly basis. The samples were analysed for 7 heavy metals, in accordance with standard procedures. The heavy metals include; Zinc, Lead Iron, Copper, Cadmium, Nickel and Mercury. From the results of the study, a variation in the mean concentration of zinc was observed. The mean concentration of zinc in site 1 was 0.450mg/l, for site 2, it was 0.140mg/l and for site 3, it was 1.0533mg/l. For iron, mean concentration was 0.072mg/l in site 1. For site 2, mean concentration of iron was 2.140mg/l and for site 3, mean concentration of iron was 0.560mg/l. It was further revealed based on the results that mean value of heavy metals in groundwater around cemeteries in Benin City were generally lower during dry season compared to wet season. In addition, result of computed pollution index (Pi) revealed that the heavy metal with the highest potential to pollute groundwater is Cadmium, with Pi of 0.5333 and 0.400 representing dry season and wet season respectively.

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Water is a critical resource in the sustenance of all forms of life. It has also been described as a universal solvent, which is highly essential in all sectors of the economy, including agriculture, domestic use, industrial sector, and in sewage disposal. This all-important fluid constitutes 64% of the human body (Environment Agency 2004). Water fit for human consumption is called potable water (Kudesia and Kudesia 2008). Economic development, increase in human population, and extensive agricultural activities exert heavy pressure on water, making it relatively scarce. In areas where surface water like rivers, springs and lakes that produce fresh waters are lacking, groundwater becomes the major source (Kupchella and Hylan 1992). Groundwater is sourced from geologic zones in the ground called aquifers. Aquifers are a body of rock or regolith, sufficiently permeable to conduct economically significant quantities of groundwater to springs and wells (Skinner and Porter 1995). Groundwater is simply water located beneath the ground surface in soil pore spaces and in the fractures of rock formations (Adeyeye and Abulude, 2004). It is about 20% of the world's fresh water supply and it is about 0.61% of the entire world's water which includes the oceans and permanent ice (Asadi et al., 2007). The real source of groundwater is the infiltration of precipitation into the ground, following rainfall (Skinner and Porter 1995). So, aquifers are recharged by rainfall. Rainfall is known to facilitate the mobilization of contaminants into groundwater during percolation. Groundwater can be contaminated from a number of point-sources such as leaks of hazardous wastes from underground storage tanks and leachates from landfills. It can also be contaminated from diffuse source such as seepage of organic and inorganic compounds from agricultural fields. Once contaminated, groundwater is almost impossible to cleanse unlike surface water that undergoes self-purification, over time and space (Chakrabotty et al., 2004; Cave et al., 2004). Environment Agency (2004) has said that groundwater has been identified as the most potentially vulnerable receptor of pollutants from cemeteries. According to Ucisik and Rushbrook (1998), decayed corpses in cemeteries may cause groundwater contamination. Rim-Rukeh (2009) and Kudesia and Kudesia (2008) have identified toxic heavy metals to include Cadmium, Lead and Mercury. Non-toxic heavy metals are Manganese, Cobalt, Iron Copper and Zinc. All such parameters at various concentrations are potential pollutants to groundwater. Where a cemetery is built on a soil of low porosity and low permeability underlain by a saturated geologic zone above 50m thick, percolated decomposition products from it can be prevented from reaching the groundwater beneath (Environment Agency, 2004). This zone inhibits seepage of decomposition products into groundwater. The processes involved in this attenuation of contaminants include filtration, adsorption biodegradation and chemical oxidation (Pedley and Guy, 1996). In a study on Groundwater

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Contamination from Cemeteries in Portugal, Rodrigues and Pacheco (2003) found out that cemeteries may contribute to groundwater contamination only on the condition that animal remains are buried within 250m of the cemetery. They also said that soil geology and aquifer types are key variables in groundwater contamination from cemeteries. Kiptom and Ndambuki (2012) found out in Langas district in Kenya that groundwater abstracted closer than 48m to pit latrines were contaminated. The objective of the investigation of heavy metals level in selected boreholes around the vicinity of cemeteries in Benin City, Nigeria was to evaluate the damages done to groundwater quality as a result of human decomposition and also to monitor the compliance of residents to the environmental laws regulating the siting of boreholes around the vicinity of cemetery

MATERIALS AND METHODS

Benin City, the capital of Edo State, Nigeria which is the study area is located in the rain forest zone, with geographical coordinates of latitudes $6^{o}\,17^{1}$ N, $6^{o}\,26^{1}$ N and longitudes $5^{o}\,35^{1}$ E, and annual mean temperature of 27.5ºC (Ikhuoria, 1987). It has two main seasons, wet and dry; from April to November and November to April respectively, with an annual mean rainfall of about 2095mm (Ikhile and Olorode 2011). In matters of hydrogeology, Benin City lies on the Benin Formation, with an aquifer of mean depth of 136m (Ikhile and Olorode 2011). Schools, hospitals, markets and cemeteries are among the social services provided in the City. Figure 1 shows the digitized map of the study area.

Location of sample stations: Three sample stations were located at each of the three cemeteries in Benin City. At each cemetery, two sample stations were located at different distances within 100m radius of the cemetery and a third, outside the 100m radius, which served as the control. The coordinate of the sample stations were obtained by means of the Global Positioning System (GPS) and distances were determined by scaling from the plotting of the points against their cemeteries.

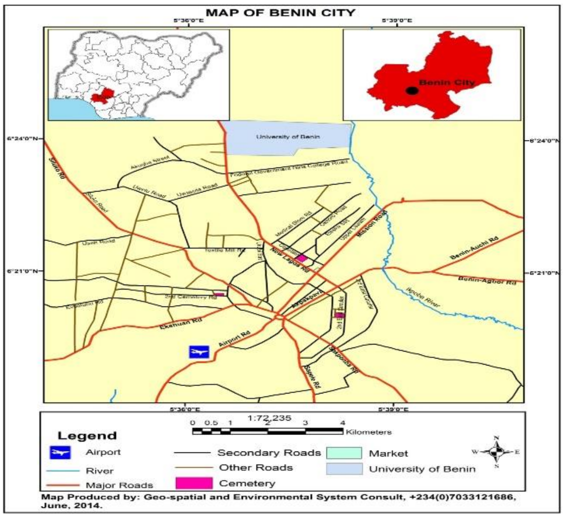

Fig 1: Map of Benin City showing the cemeteries

Groundwater samples were collected from boreholes in each of the 9 sample stations for 4 months in dry season (Nov and Dec 2012; Jan and Feb 2019). The sampling was replicated in wet season (May, June, July and Sept 2019). Means of the 4 readings in each station, at each cemetery, in each season were taken. Details of the sampling stations, their coordinates and distances from the cemeteries are presented in Table 1

Table 1: Description of sampling locations

Station Description	Stn.	Coordinates (m) Northing (X)	Easting (Y)	Distance (m)
First Cemetery (site 1)	1	257986	356522	8
	2	258241	356664	94
	3	258380	356766	240
Second Cemetery (site 2)	1	258943	353523	5
	2	259010	353435	40
	3	259222	353394	250
Third Cemetery (site 3)	1	260664	355555	45
	2	260698	355499	140
	3	260990	355155	570

Analysis of samples: The water samples were analysed in triplicates to obtain the mean value and standard deviation of each water quality test parameters. The samples were labelled properly and stored in air tight, clean and dried plastic containers. At every point of collection, the clean, dried plastic containers were rinsed two to three times with the borehole water to be sampled before collection. The collected samples were then kept in a refrigerator before analysis. Heavy metals present in the water samples was determined using Atomic absorption spectrometer (UNICAM 969). The source of radiation is a hollow lamp, which contains a cathode constructed of the same metals being analysed. This emits the wavelength characteristic of the metal and a different lamp is required for each metal. The light from the lamp is directed through a flame and onto monochromator, which selects the preferred analytical wavelength. The light monochromator is detected by a photomultiplier tube and converted to an electrical signal.

Table 2: Chemical Characteristics of Groundwater around Cemeteries in Benin City (Dry Season)

S/ No	Parameter	WHO Std. (mg/L)	Site 1 New Benin Cemetery				Site 2 Second East Circular Cemetery				Site 3 Oliha Quarters Cemetery			
			Min	Max	Mean	Std dev.	Min	Max	Mean	Std dev.	Min	Max	Mean	Std dev.
1	Zinc	3.0	0.30	0.60	0.45	0.161	0.12	0.16	0.14	0.02	0.78	1.23	1.0533	0.240
2	Lead	0.01	0.002	0.006	0.004	0.0020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	Iron	0.30	0.04	0.13	0.072	0.0058	1.27	3.19	2.14	0.973	0.38	0.79	0.56	0.2095
4	Copper	1.0	0.012	0.035	0.0233	0.0115	0.003	0.013	0.0065	0.0056	0.01	0.03	0.02	0.010
5	Cadmium	0.003	0.0	0.0	0.0	0.0	0.0	0.001	0.00067	0.00058	0.0	0.001	0.00067	0.00058
6	Nickel	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	Mercury	0.001	0,0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3: Chemical Characteristics of Groundwater around Cemeteries in Benin City (Wet Season)

S/No	Parameter	WHO Std (mg/L)	Site 1 New Benin Cemetery				Site 2 Second East Circular Cemetery				Site 3 Oliha Quarters Cemetery			
			Min	Max	Mean	Std dev.	Min	Max	Mean	Std dev.	Min	Max	Mean	Std dev.
1	Zinc	3.0	0.67	1.68	1.13	0.511	0.89	2.42	1.697	0.768	1.03	1.48	1.25	0.225
2	Lead	0.01	0	0	0	0	0	0	0	0	0	0	0	0
3	Iron	0.30	0.01	0.025	0.0187	0.0078	0.011	0.16	0.0687	0.080	0.01	0.020	0.0167	0.0058
4	Copper	1.0	0.012	0.035	0.0233	0.0115	0.003	0.013	0.0097	0.0058	0.00	0.030	0.017	0.015
5	Cadmium	0.003	0.001	0.0014	0.00117	0.0002	0.002	0.002	0.0018	0.0003	0.00	0.001	0.00067	0.00058
6	Nickel	0.02	0.010	0.013	0.011	0.0017	0.001	0.002	0.00143	0.0005	0.0	0.002	0.00117	0.00104
7	Mercury	0.001	0	0	0	0	0	0.0001	0.00003	0.00006	0	0	0	0

The sample is aspirated in acetylene-air flame where the water is evaporated and the metal containing compounds are volatilized and dissociated into ground state atoms. The ground state atoms absorb the radiation from the hollow cathode lamp and are excited to higher energy levels, the concentration level of the parameter is displayed on the computer.

RESULTS AND DISCUSSION

Descriptive Statistics of the heavy metal composition of the samples are presented in Tables 2 and 3. World Health Organization (WHO) (2011) drinking water quality was used as the standard. Results have shown that the heavy metals analysed fell comfortably within the WHO permissible limits. .Parameters that recorded zero in dry season was Nickel and Mercury. In wet season, Lead only, recorded zero in all the stations. It showed lower values, compared to those obtained by Akpovita *et al.,* (2011) in a similar work on borehole water around selected locations Benin City and Agbor respectively. Mercury had a mean ± standard deviation of 0.00003 ± 0.00006 mg/l in station 4 at Second Cemetery and remains the only station in which mercury was recorded in the entire study. This was however the closest station to cemetery boundary in the study, with a distance of 5m away from the cemetery. The trace of Hg in this station may be attributed to the porosity of the soil which allows leachate from human decomposition to infiltrate into the underlying aquifer. Toxic heavy metals such as zinc (Zn), cadmium (Cd), nickel (Ni) and mercury (Hg) exhibited increase in values from dry to wet season. Mean ± standard deviation values of Zn in all the stations were 0.548 ± 0.043 mg/l and 1.326 ± 0.041 mg/l for dry and wet seasons respectively. Though the mean values of Zn were below the WHO standard, they were higher than the results obtained by Akpovita *et al.,* (2011), from borehole water in Benin City and Agbor, Delta State, with a range of 0.10 – 0.12 mg/l. Mean ± standard deviation values of Cd for both dry and wet seasons were 0.0016 ± 0.0032 mg/l and 0.0012 ± 0.0006 mg/l respectively. Cd values were however lower than ones obtained by Akpovita e*t al.,* (2011) in a similar work, with a range of 0.003 – 0.006 mg/l. For Ni, mean ± standard deviation was zero during the dry season and 0.0045 ± 0.005 mg/l in wet season. These values were lower than one reported by Akpovita *et al.,* (2011). Lead exhibited a different pattern from other heavy metals, as it showed decrease in values from dry to wet season.

It recorded zero in all the stations except Third Cemetery with 0.004 ±0.002 mg/l, in dry season. Lower values of Pb were obtained in the same similar work on groundwater in Benin City by Akpovita et al., (2011), with a range of 0.013 – 0.015 mg/l. The low level of heavy metals in all the stations, especially in dry season, is attributed to the paucity of rainfall in dry season which discourages the percolation of potential contaminants into groundwater. In the process of downward descent, potential contaminants in groundwater are attenuated by the processes of filtration, adsorption and ion exchange (Okokoyo and Rim-Rukeh 2004). To better understand the pollution dynamics of boreholes around the vicinity of cemeteries, the water pollution index of the waters samples were calculated. Pollution index (Pi) is expressed as a function of the concentration of individual parameter as against the baseline standard (Akpoveta *et al.,* 2011). It is normally expressed as:

$$P_i = \left(\frac{C}{S}\right)$$

Where; Pi is the pollution index, C is the concentration of the parameter (test result) and S is the standard for the parameter (WHO standard). The critical value of Pi is 1.0. All values greater than 1 shows significant level of pollution. Conversely, Pi values less than 1 indicates no pollution. The computed pollution indices is presented in Table 4.

Table 4 Mean of Parameters Tested and Pollution Indices

Parameter	WHO Std (S) (mg/l)	Test Result (C) (mg/l)		Pollution Index (Pi)	
		Dry Season	Wet Season	Dry Season	Wet Season
Zinc	3.00	0.548 ±0.428	1.359± 0.541	0.1827	0.442
Lead	0.010	0.0.0022±0.0001	0.0000	0.220	0.000
Cadmium	0.003	0.0016±0.0032	0.0012±0.006	0.533	0.400
Nickel	0.020	0.0000	0.0045±0.005	0.000	0.225
Mercury	0.001	0.0000	0.00001±0.000	0.000	0.010
Copper	1.00	0.0162±0.0112	0.0167±0.0014	0.0162	0.0167
Iron	0.36	0.924±0.001	0.0344±0.048	0.1028	0.0964

Results have shown that the pollution indices followed the pattern of test results between dry and wet seasons at the three cemeteries. Values of Pi in dry season were generally lower than wet season as revealed in Table 4. This is an indication that contamination by heavy metals of groundwater around cemeteries in Benin City is higher in wet season than in dry season The Pi of Mercury and Nickel was zero in dry season as well as Lead in wet season. The mean values of Iron (a non-toxic heavy metal) increased in dry season with 0.924 mg/l over wet season with 0.034 mg/l. Research has shown that the three toxic heavy metals that would contributed most to the groundwater contamination in descending order of Pi, in dry season are; Cadmium, Lead and Zinc, with Pi of 0.5333, 0.220 and 0.182, respectively. Wet season values of Pi for all the stations were 0.442, 0.400 and 0.225 for Zinc Cadmium and Nickel respectively. Of all the heavy metals studied. Cadmium featured as the parameter with highest potential to contaminate groundwater.

Conclusion: Groundwater around cemeteries in Benin City is generally not at the risk of heavy metals pollution, as the test results have shown that they fall comfortably within the WHO permissible levels. Nevertheless, Human activities like smelting, production of paints and printing that generates traces of heavy metals that can further spike their concentration should be avoided in areas where groundwater is abstracted, to forestall possible contamination.

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