Determination of the concentration of heavy metals in borehole wateraroundUniversity of Cross River State (UNICROSS)refuse dump site, Calabar, Nigeria

Abstract

The contamination of ground water from the infiltration of leachates into aquifers and health risks on residents drinking from boreholes around dumpsites, informed this study on the levels of heavy metals in the boreholes around University of Cross River State (UNICROSS) dumpsite. Borehole water samples were aseptically collected from 3 boreholes at 50, 80, and 200 meters respectively from the dumpsite into a one liter sampling bottle and preserved in an ice chest. The samples were then analyzed for heavy metals using Atomic Absorption Spectrophotometer. The values obtained were compared with WHO permissible standards for drinking water. The mean concentration of Pb (0.614 ± 0.008), Cd (0.399 ± 0.053), As (0.023 ± 0.002), and Co (0.002 ± 0.001 mg/l) in the borehole water were significantly higher than WHO permissible limits, while the concentration of Cr (0.002 ± 0.001) and Ni (0.056 ± 0.004) were significantly lower than the WHO permissible limits. The increasing trend of heavy metals in the borehole water was Cr = Co < As < Ni < Cd <Pb. Due to the health risks associated with drinking water contaminated with heavy metals, we recommend that Government should relocate the dumpsite far away from its current location.

Key words: Dump sites, borehole, heavy metals, solid waste.

1.0 INTRODUCTION

Water is pervasive and drinking water of good quality is crucial to human physiology and the presence of man relies significantly upon the accessibility of water. A typical man (53 kg - 63 kg body weight), needs around 3 liters of water and food day to day to keep up with great wellbeing(Onweluzo and Akuagbazie, 2010) and consequently, water is depicted as the most irreplaceable substances throughout everyday life (Okonko *et al.*, 2008). In certain spots, accessibility of water is basic, restricted, and sustainable. Deficiency of water could prompt sickness flare-ups and financial misfortune, subsequently, water is a need; it is a special fluid and without it life is unimaginable. Water assumes an essential part in the legitimate working of the world's environment. Man involves water for different purposes which incorporate drinking, transportation, modern and homegrown use, water system of farming, entertainment, fisheries, and garbage removal, quarrying, among others (Tiimub *et al.*, 2015 and Shittu *et al.*, 2008). In emerging nations, human populace increment has prompted a colossal strain on the arrangement of safe drinking water (Umeh *et al.*, 2005). Perilous water is a worldwide general wellbeing danger, setting people in danger for a large group of diarrheal and different sicknesses as well as synthetic inebriation(Hughes and Kaplan, 2012). The majority of the new water bodies all around the world are getting dirtied, accordingly diminishing the convenience of water (Chandra *et al.*, 2012).

Open waste dump is a land disposal site through which all types of wastes are disposed-off in a manner that does not protect the environment. They breed vectors of disease, reduce the aesthetic values of the environment, cause nuisance, and produce leachate which infiltrate into the hydrogeological system (Arisi *et al.*, 2015). Different Sources such as garbage, spoilt foodstuffs, electronic goods, painting waste, used batteries among others, when dumped with municipal solid wastes raise the concentration of heavy

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metals in dumpsites. Dumping devoid of the separation of hazardous waste can further elevate noxious environmental effects (Arisi *et al.*, 2015). Environmental impact of land filling of municipal solid waste can usually result from the run-off of the toxic compounds into surface water and groundwater(Arisi *et al*., 2015), which eventually leads to water pollution as a result of percolation of leachate (Udofia *et al.*, 2016). These metropolitan waste unloading areas are assigned spots not as expectedly planned or developed. Subsequently, squanders unloaded throughout the years bio-degenerate and produce leachates that eventually become point wellspring of contamination into soil and groundwater (Udofia *et al*., 2016). At the point when precipitation happens, the permeating water (leachates) disintegrates numerous natural and inorganic salts which might be shipped to local springs bringing about the adjustment of the water quality. The consequences of the dumpsite on groundwater hydrology is that leachates from dumpsite penetrates into the ground and furthermore move towards groundwater stream subsequently defiling the groundwater along its way (Udiba *et al.*, 2015).

Underground water contamination have turned into a worry in Nigeria, because of expanded urbanization and industrialization. Squander released in dump destinations contains a ton of metals, synthetic substances, and miniature life forms which are fit for contaminating ground waters. The UNICROSS dump site is found near residential areas of the institution and it goes throughpressure from the consistent dumping of waste from the inhabitants. In addition, the major erosion control channel passes through the institution which most times causes floods within the university community during heavy downpour.The fears of the underground leaching of the waste to the environment and it's potential impact on human health at large is the reason for undertaking this studies to assess the possible impact of solid waste dumps on ground water quality and ascertain the current water quality status of boreholes water in the vicinity of UNICROSS community to specifically evaluate the concentration of heavy metal (Hg, Pb, Cr, Cd, As, Ni, Co) and to examine how safe drinking of the borehole water around the dump site is, by comparing its heavy metal levels with the WHO acceptable limits.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study area is situated at University of Cross River State, Calabar, between longitude 8^{o}15' E and 8^{o} 25' E and latitude 4^{o}84'N and 4^{o} 54' N under Calabar-South Local Government Area, near the popular Ekpo-Abasi junction.The area is located in the sub-equatorial belt characterized by the wet and dry seasons. The wet season starts in April and finishes in November with a peak in June and July, while the dry season begins from December and finishes in March (Obialor and Ayim, 2021). The vegetation is notwithstanding, impacted by exercises like farming, development, and urbanization. Aside from the wind system, other climatic boundaries, for example, mean yearly precipitation and temperature, worldwide radiation,reflections coefficient to make reference to a couple, likewise, impact the region (Monechot, 2009). Three boreholes were chosen for the evaluation. Borehole 1 is found 50 meters from the dumpsite, borehole 2 is 80 meters from the dumpsite, and borehole 3 is 200 meters from the dumpsite. The WHO acceptable limits of every heavy metal was assigned as the control**.**

2.2 Collection of Water Samples for Heavy Metal Analysis

The technique for sample collection and analysis was espoused from America Public Health Association [13]. Water samples (n = 9) for the study were collected from three

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boreholes around the study area for a period of three (3) months(January, June, and November 2021), covering for both wet and dry seasons.

The samples were aseptically collected. The mouth of the tap was cleaned with methylated spirit using cotton wool and flushed before collection of samples. The water samples were collected into sterilized sampling bottles, sterilized with 99% ethanol soaked in cotton wool. The water was allowed to run to waste for about 3 to 5 minutes before collection and the water samples was collected into sterile 500ml bottle and covered tightly. The water samples were then preserved in an ice chest immediately after collection, before transporting them to Ministry of Science and Technology laboratory, Uyo for analysis of mercury, lead, chromium, cadmium, arsenic, nickel, and cobalt utilizing Atomic Absorption Spectrophotometer.

2.3 Analysis of Water for Heavy Metals

Heavy metals concentration in water was determined using an atomic absorption spectrophotometer (Perkin Elmer, 2280 model). To 50ml of unfiltered water sample in a 500ml Taylor flask, 0.51 ml of concentrated sulphuric acid was added. This was boiled to get white fumes, and allowed to cool, and 1.0ml of 60% $HClO_3$ and 5.0ml of concentrated HNO_3 were then added. The resulting mixture was then digested until a clear digest is obtained. This digest was allowed to cool, before being filtered using No 44 Watt man paper into 500ml volumetric flask, and the digest was analyzed Using Atomic Absorption Spectrophotometer for heavy metals in mg/L (El-Sayed *et al.*, 2011).

2.4 Statistical Analysis

Data collected was subjected to descriptive statistics (mean, standard deviation, and ranges). Analysis of variance (ANOVA) was used to test for the level of the significance difference in the heavy metals concentration between each bore-hole water compared to the control at 0.05 level of significance and at their relevant degrees of freedom. All statistical analysis was carried-out using Predictive analytical soft-ware (PASW) version 20.

3.0 RESULTS AND DISCUSSIONS

The results of the concentration of heavy metals in borehole water near UNICROSS dumpsite is presented in Table 1 below. The highest concentrations of all the heavy metals were recorded in borehole 1, while the least concentrationswas recorded in borehole 3. The mean concentration of lead, cadmium, arsenic, and cobalt (borehole 1 and borehole 2) in each boreholes were significantly higher than the control ($p<0.05$), while the concentration of chromium and nickel were significantly lower than the control ($p<0.05$). Mercury was not detected in all boreholes during the study. The mean concentrationof heavy metals in the water from boreholes under study are 0.614 ± 0.008, 0.002 ± 0.001,0.399 ± 0.053, 0.023 ± 0.002, 0.056 ± 0.004, 0.002 ± 0.001 mg/l for lead, chromium, cadmium, arsenic, nickel, and cobalt respectively. The heavy metals concentration in water from the boreholes had an increasing trend of Cr = Co < As < Ni < Cd <Pb.

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TABLE 1. Concentration of heavy metals in borehole water around CRUTECH dumpsite during the study

Heavy metals (mg/l)	Control (WHO, 2006)	Boreholes around CRUTECH dumpsite			
		Borehole 1	Borehole 2	Borehole 3	Mean
Hg	-	BDL	BDL	BDL	BDL
Pb	0.01^{a}	0.622 ± 0.001^{b} (0.622 – 0.623)	0.611 ± 0.008^{b} (0.604 – 0.620)	0.607 ± 0.007^{b} (0.600 – 0.615)	0.614 ± 0.008 (0.600 – 0.623)
Cr	0.05^{a}	0.002 ± 0.000^{b} (0.002 – 0.002)	0.001 ± 0.001^{b} (0.001 – 0.002)	BDL	0.002 ±0.001 (0.001 – 0.002)
Cd	0.003^{a}	0.433 ± 0.002^{b} (0.432 – 0.435)	0.389 ± 0.070^{b} (0.308 – 0.433)	0.376 ± 0.062^{b} (0.304 – 0.416)	0.399 ± 0.053 (0.304 – 0.435)
As	0.01^{a}	0.026 ± 0.001^{b} (0.025 – 0.027)	0.024 ± 0.001^{b} (0.023 – 0.025)	0.021 ± 0.001^{b} (0.020 – 0.022)	0.023 ± 0.002 (0.020 – 0.027)
Ni	0.07^{a}	0.061 ± 0.001^{b} (0.060 – 0.062)	0.056 ± 0.004^{b} (0.052 – 0.060)	0.052 ± 0.002^{b} (0.050 – 0.054)	0.056 ± 0.004 (0.050 – 0.062)
Co	0.001^{a}	0.003 ± 0.000^{b} (0.002 – 0.003)	0.002 ± 0.001^{b} (0.002 – 0.003)	0.001 ± 0.001^{a} (0.001 – 0.002)	0.002 ± 0.001 (0.001 – 0.003)

Values are in mean ± standard deviation, ranges are in parenthesis ( )
Values with different superscript in each borehole compared to the control are significantly different ($p<0.05$)

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4.0 Discussion

The disposal of wastes in UNICROSS dumpsitepose potential healthdanger to people and has the ability to pollute the borehole water situated around the dumpsite because of uncontrolled penetration of leachate from the squanders (Taylor and Allen, 2006). Essentially, the deterioration of most waste produces methane, which is equipped for causing fire flare-up, green house emanation as well as the development of solid leachate, which dirty surface and groundwater assets (Salawu *et al*., 2014). To this end, this study examines, interestingly the degrees of heavy metals in borehole water from boreholes near dumpsites in UNICROSS, in order to anticipate the potential health risks of drinking from these boreholes, essentially because these boreholes are the only source of water which residents of this locality rely on for their daily activities such as; drinking, washing items, irrigation water for all the vegetable farms scattered round the institution. Assessing the quality of this water by comparing heavy metal concentrations with international water quality standards is therefore absolutely necessary to safeguard human life.

This study uncovered variations in the levels of heavy metals between the boreholes near the dumpsite. This could be because of the distinction in the amount of leachates which penetrated into the ground water (Eni *et al.,* 2014). The variations in the concentration of heavy metals between the boreholes could be because of the distinction in the depth of boreholes, distance of the boreholes from the dumpsite, unearthingstrategy utilized in penetrating the boreholes, and the hydrological soil layers (Alonge, 1991), and structure of waste arranged (Afolayan, *et al*.,2012).The concentration of lead, cadmium, arsenic, and cobalt(borehole 1 and 2) in the boreholes around the dumpsites were higher than that of the control. This denotes that the levels of the aforementioned heavy metals in boreholes around the dumpsite were raised by the infiltration of contaminants and leachates of thedumpsites. The higher concentration of aforementioned heavy metals in the boreholes could be attributed to the solid waste disposed in the dumpsite which over time biodegrade and add their metallic content to the soil (Oni, *et al.,* 2010). It could also be as a result of the ability of dumpsites to transfer significant levels of toxic and persistent metals into the soil environment, which thereafter infiltrate into ground water(Udosen *et al.,* 2006). From this study, borehole 1 had the highest concentration of lead, chromium, cadmium, arsenic, nickel, and cobalt, and this could be as a result of its closeness to the dumpsite and as such receive higher quantity of leachates(Luter *et al.*,2011).

The mean cadmium, lead, chromium, nickel, and cobalt concentration in the boreholes examined were lower than the findings from similar studies on the pollution status of heavy metals in ground water system around open dumpsites in Abakaliki urban (Arisi *et al*.,2015) the heavy metals concentration in Uyo metropolis (Akpabio and Ekpo, 2013), the threats of contaminants in boreholes along IkotEffanga dumpsite, Calabar Municipality, Nigeria (Ivon *et al.,* 2017). The variations in the levels of heavy metals between the boreholes for the present study and those of the other studies compared could be due to the difference in age of the dumpsites, depth of the ground water, its distance from the dumpsite, excavations technique used in drilling the boreholes and the hydrological soil strata. It could also be as a result of difference in composition of wasteand geographical location. Underground water contamination is the function of waste management strategies and season(Afolayan *et al.,* 2012). The differences in

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contamination level of underground water could also be due to the differences in leachate percolation, chemical composition of leachate, rainfall, depth and distance of the boreholes from the dumpsite (Jhamnani et al., 2009 and Eni et al., 2011). Lead was the highest contaminant in the borehole waters around the UNICROSS dumpsite, and this denotes that the composition of the waste commonly deposited in the dumpsite are dominated by lead.The mean concentration of lead, cadmium, arsenic, and cobalt in the boreholes around the UNICROSS dumpsitewere above the WHO acceptable limit for drinking water indicating unsafe levels capable of causing severe health issues to consumers. For example, the ingestion of Arsenic at unsafe levels could cause skin, lung, bladder, and kidney disorders. Lead ingested at unhealthy level could causeneuro-developmental effects, hypertension, impaired fertility, and anaemia. Unsafe levels of cadmium and cobalt could cause kidney disorders (WHO, 2006).

5.0 CONCLUSION

Solid waste disposed in exposed dumpsite is usually subjected to series of complex biochemical and physical processes, which lead to the production of both leachate and gaseous emissions. When leachate leaves the dumpsite and reaches the water table, it results in borehole contamination. This study revealed that the citing of boreholes around the UNICROSS dumpsite could pose serious health threat to residents. To this end, it is recommended that Government moves the dumpsite far away from its current location to prevent the contamination of ground water and possible outbreak of various water-borne diseases and death. Also, Government should insist on consistent treatment of borehole waters by owners, so as to prevent any possible outbreak of diseases.

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