ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 6 | Issue: 7 | July 2020 || Journal DOI: 10.36713/epra2013 || SJIF Impact Factor: 7.032 ||ISI Value: 1.188

HEAVY METAL POLLUTION INDEX AND SAFETY CONCERNS OF BOREHOLE WATER LOCATED PROXIMALLY TO DUMP SITES IN YENAGOA, BAYELSA STATE

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ABSTRACT

Heavy metals pollution index of borehole water located proximal to dumpsites were investigated in yenagoa metropolis. This was done to determine the degree of heavy metal intrusion into portable waters and its effects on human health. Nine (9) Boreholes (3/area) located proximally to each of the dumpsites were sampled for heavy metals using 50 ml empty plastic bottles. Samples were collected in triplicates and twenty seven (27) plastic bottle samples were collected. Water samples were taken to the Institute of Pollution Studies (IPS) laboratory Port Harcourt and analyzed for Iron (Fe), Chromium (Cr), Cadmium (Cd), Lead (Pb) and Nickel (Ni). The Electro spectrophotometric method was used to detect and determine heavy metal prevalence. Data were analyzed for means, standard deviation and analyses of variance (ANOVA) with the aid of SPSS version 20 software. Heavy metal pollution index (HPI) was also conducted for the borehole water from the sampled locations. Results reveal that Fe content in the sampled ranged from 0.28mg/l - 0.38mg (Tombia>Opolo>Greenvilla). Cr values ranged between 0.004mg/l – 0.02mg/l (Tombia=Opolo>Greenvilla). Cd concentration ranged 0.036mg/l -0.50mg/l. Pb concentration ranged between 0.035mg/l – 0.18mg/l and Pb concentration ranged between 0.036mg/l – 0.18mg/l. All parameters exceeded the WHO limit for safe drinking water except Cr which was below limit. Heavy metal pollution index (HPI) reveals that: Tombia (461.23), Greenvilla (127.84) and Opolo (50.40). Tombia and Greenvilla exceeded the threshold value of 100. Based on the findings from this research, only borehole water from Opolo was below the threshold (50.40). Therefore the consumption or use of water from Tombia and Greenvilla for cooking or drinking are hazardous and portends grave danger as it can result in organ or systemic damage to humans.

KEY WORDS: ***Heavy metal, Pollution index, Borehole, Dumpsite, Water, Yenagoa***

1. 0 INTRODUCTION

It is paradoxical that about a decade after the United Nations announced its attainment of the millennium developmental goal (MDG) of the provision of safe drinking water to at least 88% of the worlds inhabitants, over three-quarters of Africa are still without access to safe drinking water. Safe drinking water or potable water is water of sufficiently high quality that it can be consumed or used without risk of immediate or long term harm.

In Yenagoa the problem of access to safe drinking water is further compounded by the absence of a waste management policy and a waste containment plan (Alagoa et al, 2020). Waste dumpsites and human housing compete for space in neighborhoods that are epitomes of slums and lack basic city planning. Heavy metals from dumpsites seep into ground water and present in borehole waters located proximally to these dumpsites.

Heavy metals in drinking water presents a health risk if consumed without treatment, therefore there is a need to monitor heavy metals characteristics of boreholes in Yenagoa. The use of heavy metal pollution index as a tool to gauge the safety of drinking water is gaining increase recognition in environmental research. This will provide useful information for government and other stakeholders for the enactment of statutes and the protection of human life.

2.0 MATERIALS AND METHODS

2.1 Borehole Sample Collection

Borehole water samples were collected from nine (9) Boreholes in different areas located strategically in Tombia, Opolo and Greenvilla areas, Yenagoa. Water samples were collected in triplicates with clean empty 50ml table water containers and transported under cool conditions to the Institute of Pollution Studies (IPS) laboratory of the Rivers State University of Science and Technology, Port Harcourt. A total of twenty seven (27) water samples were taken for investigation. Sampling sites were selected based on their closeness to highly populated neighborhoods and high degree of commercial patronage.

2.2 Water Analysis for Heavy metals

Water samples were analysed for the Heavy Metals Fe, Cu, Cd, Pb, Cr and Ni using model 210VGP of the Basic Scientific Atomic Absorption Spectrophotometer series with Air Acetylene gas mixture as Oxidant. The results were recorded in mg/L.

2.3. Statistical Analysis

Mean and standard deviation were calculated for all the investigated heavy metals. Analysis of Variance (ANOVA) was employed to determine the degree of variability or interrelatedness of the different borehole facilities of all the measured parameters, and the means separated using the Turkey HSD Post HOC test at a probability level of P=0.05 or 95% confidence limit. The weighted arithmetic average of the concentrations was used to calculate HPI values using the equation given by Mohan et al. (1996). Analysis was aided using the SPSS@ Statistical software 20.

3.0 RESULT

Table 1: Location of Sampling sites in Yenagoa

S/N	Location		LATITUDE	LONGITUDE
1	Tombia	TBH1	N4^{0}56'59.92"	E6^{0}21'11.643"
2		TBH2	N4^{0}56'57.42"	E6^{0}20'8.0682"
3		TBH3	N4^{0}56'56.85"	E6^{0}20'9.578"
4	Opolo	OPBH1	N4^{0}56'43.362"	E6^{0}19'51.58"
5		OPBH2	N4^{0}56'52.13"	E6^{0}19'59.77"
6		OPBH3	N4^{0}59'29.00"	E6^{0}19'42.34"
7	Greenvilla	GVBH1	N4^{0}56'38.99"	E6^{0}19'39.67"
8		GVBH2	N4^{0}56'37.80"	E6^{0}19'38.83"
9		GVBH3	N4^{0}56'32.88"	E6^{0}19'30.38"

Source: Field work, 2020. TBH –Tombia borehole (1-3), OPBH- Opolo borehole (1-3), GVBH- Greenvilla borehole (1-3).

Table 2: Comparison of mean heavy metals in Borehole water with WHO standards

Heavy metals (mg/l)	Study area/WHO standard. Tombia	Opolo	Greenvilla	WHO
Fe	0.384^a±0.037	0.34^{ac}±0.021	0.28^{bc}±0.027	0.30
Cr	0.004^b±0.0000	0.004^b±0.000	0.020^b±0.026	0.05
Cd	0.502^c±0.409	0.036^c±0.02	0.039^c±0.018	0.003
Pb	0.18^d±0.28	0.035^d±0.01	0.063^d±0.037	0.015
Ni	0.037^e±0.027	0.036^e±0.016	0.056^e±0.006	0.020

Source: Field work, 2020. WHO (2011). Means with the same letter superscript along the same rows are not significantly different (P>0.05).

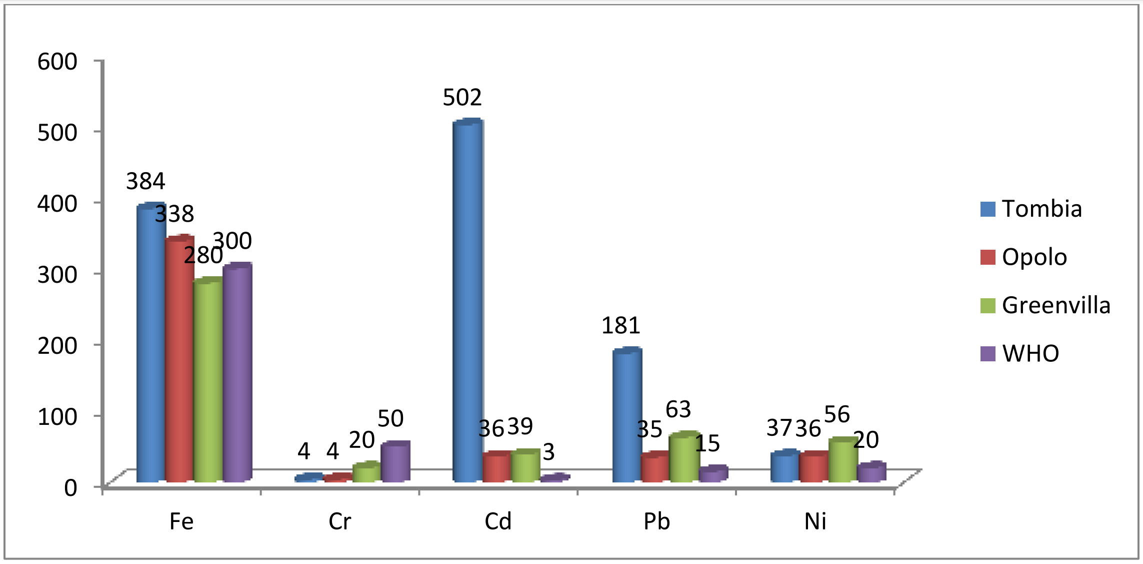

Fig. 1: Mean concentration of heavy metals in all sample stations

Table 3: Heavy metal pollution Index (HPI) for Tombia Borehole water

Heavy Metals	Mean Conc.	Highest permitted value for drinking water (*Si*)	Desirable maximum value (*Ii*)	Unit weightage (*Wi* = *1*/*Si*)	Sub index (*Qi*)	*Wi* × *Q*
Fe	384	300	300	0.0033	-	-
Cr	4	50	100	0.02	192	3.84
Cd	502	3	3	0.33		-
Pb	181	15	20	0.066	3220	212.52
Ni	37	20	20	0.05	-	
Total	-			0.469		**216.32**

***Wi* = 0.469. *Wi* × *Q* = 216.32 HPI = 461.23**

Table 4: Heavy metal pollution Index (HPI) for Opolo Borehole water

Heavy Metals	Mean Conc.	Highest permitted value for drinking water (*Si*)	Desirable maximum value (*Ii*)	Unit weightage (*Wi* = *1*/*Si*)	Sub index (*Qi*)	*Wi* × *Q*
Fe	338	300	300	0.0033	-	-
Cr	4	50	100	0.02	192	**3.84**
Cd	36	3	3	0.33	-	-
Pb	35	15	20	0.066	300	**19.8**
Ni	36	20	20	0.05	-	-
Total				0.469		**23.64**

***Wi* = 0.469. *Wi* × *Q* = 23.64 HPI = 50.40**

Table 5: Heavy metal pollution Index (HPI) for Greenvilla Borehole water

Heavy Metals	Mean Conc.	Highest permitted value for drinking water (Si)	Desirable maximum value (Ii)	Unit weightage ($Wi = 1/Si$)	Sub index (Qi)	$Wi \times Q$
Fe	280	300	300	0.0033	-	-
Cr	20	50	100	0.02	160	**3.2**
Cd	39	3	3	0.33	-	-
Pb	63	15	20	0.066	860	**56.76**
Ni	56	20	20	0.05	-	-
Total				0.469		**59.96**

Wi = 0.469. $Wi \times Q$ = 59.96 HPI = 127.84

Table 6 :Prescribed limits for heavy metals concentration in drinking water

Standards	Pb	Fe	Zn	Mn	Cd	Co	Cu	Cr	Ni
ICMR(mg/l)	0.1	0.3	5	0.1	0.01	NA	0.05	0.05	0.02
CPC(mg/l)	0.1	3	5	2	2	NA	2	2	3
WHO(mg/l)	15	300	300	100	3	40	50	50	20
EPA(mg/l)	15	300	300	50	3	-	100	100	-

Source: David et al (2013). WHO - World Health Organization EPA- Environmental Protection Agency ICMR – Indian Council of Medical Research. CPC-Consumer Protection Council

4.0 DISCUSSION

This study observed heavy metal parameters of Fe, Cd, Pb and Ni are above that of threshold limits of WHO (2011) in borehole water in the study stations. Except for Cr which was below the suggested internationally permissible limit. Similar result was obtained by Chika and Prince (2020). They observed heavy metal concentrations of Ni and Pb are above the permissible limit and also noted lower concentrations of Cr as compared to the permissible limit in drinking water from different sources in Ikorodu LGA of Lagos State. In contrast to the findings of this study, David et al, (2013) observed that the concentration of the heavy metals Mg, Ca, Mn, Fe and Cd in samples of drinking water monitored in Ago-Iwoye, Ogun State were significantly lower than the WHO permissible limit. They further observed non-detectable concentration of Zn, Cu, Pb, and Cr in the water samples.

In this study, Fe concentration in borehole water ranged between 0.28mg/l – 0.384mg/l with Tombia having the highest concentration and Greenvilla having the least concentration (Table 1 and Fig.1). Higher levels of Fe observed in Tombia may be due to deposition of metallic waste waters and leachate coming from the phone and the computer village situated nearby. Milivojec et al (2016) observed increase levels of Fe due industrial waste water and leachate coming from landfills. There is a significant higher concentration of Fe than the permissible limit. Another reason for the significant high concentration of Fe is due to the fact that Fe is easily derived from marshy environment and also from acidic soils (Imasuen and Egai, 2013). The geology of the areas could probably be the source of Fe in the water from such boreholes. Higher levels of Fe at these borehole sites could be due to the fact that Fe seeped through soil into water aquifers.

Fe is an essential element to the human body therefore high concentrations as observed in this study may not pose a significant threat to human health.

Cr concentrations in this study ranged from 0.0041mg/l – 0.019mg/l with the lowest value at Opolo and the highest at Greenvilla. There were no significant differences between sampled locations (P>0. 05). All sample location displayed lower levels of Cr than the permissible limit. Cr is a trace heavy metal usually found in surface and ground water occasionally. Sources of Cr include discharges from steel and pulp mills; erosion of natural deposits *etc.* One reason for the low level of Cr may be due to the fact that Cr is a metal of low bio-geochemical mobility.

Cd concentration in this study ranged between 0.036mg/l – 0.501mg/l with the highest value in Tombia and the lowest in Opolo boreholes. There is no significant difference (P>0.05) between study locations of borehole water. Cd concentration exceeded the international permissible limit. Cd is usually found in effluents from industries producing batteries, phosphate fertilizers, mining and other inorganic products. Effluents from industries like battery making, dye making, pigment making, alloy making are the major sources of Cd into the water bodies (Rao et al, 2004). The location of dumpsites near residential dwelling, market places and E-waste generating centres may be the reason for this appreciable rise above the permissible and desirable limits.

Pb concentration in borehole water ranged from 0.034mg/l to 0.181mg/l with maximum value at Tombia and a minimum value at Opolo. There is no significant difference (P>0.05) in concentrations between all three borehole locations (Tombia, Opolo and Greenvilla). The value of Pb in this study exceeds the permissible limits for Pb concentration in drinking water. (WHO, 2011). This result is consistent with the result of Milivojec et al (2016) who also observed higher than permissible concentrations of Pb in water samples.

One reason for this high concentration of Pb may be due to the presence of dumpsites near borehole water sources. Pb gets into the surface and ground water through municipal wastes, mining activities, plumbing, paint residue and burning of coal. Another source of Pb in the water is the very high concentration of Pb in soil which diffuses through the soil solution into ground water and surface water (Hardman et al, 1994).

Ni concentration in borehole water ranged from 0.0361mg/l to 0.056mg/l with a maximum in Greenvilla and a minimum in Opolo. There is no significant difference (P>0.05) in concentrations between all three borehole locations (Tombia, Opolo and Greenvilla). Ni toxicity sources are cocoa plant foods (nuts) and hydrogenated oils. Stainless steel manufacturing, electroplating, coal and oil combustion also release Ni as their effluents. Industries dealing with electrical equipment and household appliances, catalysts, pigments, batteries (NiCad) are also sources of Ni contamination in the water bodies. In this study, the presence of Ni in quantities above the permissible value may be as a myriad of the diverse kinds of materials found in the dumpsites and waste streams in the study area.

Heavy metal pollution index (HPI) for borehole water in all the sampled locations (Tombia, Opolo and Greenvilla) indicate that Tombia has 461.23, HPI index for Opolo is 50.40 while the HPI index for Greenvilla is 127.84. This shows that Tombia>Greenvilla>Opolo in HPI.

This result is indicative that the HPI of Tombia and Greenvilla borehole water exceed the critical value of HPI of 100 (Prasad and Singita, 2008; Prasad and Mondal, 2008) which imply that the water is unacceptable for drinking without treatment. On the other hand the HPI of Opolo was below the critical value of 100 suggesting that the water is safe for drinking.

In this study, the HPI values observed in Tombia and Greenvilla may be due to landfill leachates, domestic sewage and industrial waste waters in the study area.

In conclusion, the findings have revealed that there is a direct correlation between dumpsite and heavy metals in proximal borehole waters in the study area. The HPI also suggest that apart from Opolo area, the borehole waters from Tombia and Greenvilla area are unacceptable for drinking without treatment.

5.0 CONCLUSION

The determination of heavy metals in portable waters such as in borehole water is very critical because of its overriding importance on public health issues. This study has assessed the heavy metals in borehole water located proximally to these dumpsites in Yenagoa. The heavy metals studied are Fe, Cr, Cd, Pb and Ni in borehole water. The heavy metal pollution index (HPI) in all the sampled locations (Tombia, Opolo and Greenvilla) was calculated. HPI index for Tombia is 461.23. HPI index for Opolo is 50.40 while the HPI index for Greenvilla is 127.84. This shows that Tombia>Greenvilla>Opolo. The HPI index of Tombia (461.23) and that of Greenvilla (127.84) exceeded the internally accepted threshold value of 100, while the HPI value of Opolo (50.40) was lower than the threshold value.

This study therefore concludes that borehole water in Tombia, Opolo and Greenvilla Yenagoa are greatly affected by heavy metal intrusions from dumpsite. It is unsafe to drink borehole waters from Tombia and Greenvilla because of the grave consequences of organ or systemic damage from heavy metal poisoning.

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ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 6 | Issue: 7 | July 2020 || Journal DOI: 10.36713/epra2013 || SJIF Impact Factor: 7.032 ||ISI Value: 1.188

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