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Groundwater qualityin Okitipupa township of Ondo State, Nigeria

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This study was conducted to assess the quality of groundwater in Okitipupa (Okpa), the head quarter of Okitipupa local government area of Ondo State, Nigeria. Physico-chemical parameters were determined using standard methods while metals were determined using Atomic Absorption Spectrophotometer. The pH range (Mean ± SD) are 8.5- 11.2 (10.1 ± 0.9), the Electrical Conductivity range are 1095- 1932 (1503 ± 211) µSCm^{-1}, the TDS range are 657 – 1159 (902 ± 126) mgL^{-1}, the chloride concentration range are 220- 299 (276 ± 18.5) mgL^{-1}, the Sulphate range are 80.7 – 260 (201 ± 53.5) mgL^{-1} and Nitrate range 10.1-92 (35.1-19.6) mgL^{-1}. The metal index (MI) was used to assess the level of metal contamination in comparison with WHO maximum acceptable concentration (MAC). The calculated MI values of metals (Fe, Cr, Pb, Cu and Ni) ranged from 1.47- 46.3. The results show that the overall quality of water decreases as MI >1 is a threshold of warning. Improved sanitation and treatment of groundwater meant for drinking is necessary.

Key word: Groundwater, Okitipupa, metal index, anions, Ondo State.

INTRODUCTION

Groundwater contamination occurs when man made products such as gasoline, rock salts and chemicals get into groundwater and cause it to become unsafe and unfit for human use (Groundwater Foundation, 2008). Water is an excellent solvent athat contains a lot of dissolved chemicals which moves through rocks and subsurface soil. It has a lot of opportunity to dissolve substances as it moves through rocks and subsurface soil. For that reason groundwater will often have more dissolved substances than surface water. Even though the ground is an excellent mechanism for filtering out particulate matter such as leaves, soil still dissolved chemicals and gases can still occur in a large enough concentration in groundwater to cause problems. In developing countries, the provision of safe and clean drinking water supply schemes is considered to be the key responsibilities of the government because people have limited access to safe drinking water (Nawab et al., 2015). Many inorganic contaminants are toxic and pose a great health and environmental concern in quite low concentrations.

Heavy metals are considered as environmental contaminants because of its persistence, toxicity and bio- accumulative nature in the environments (Pekey et al., 2004). Water containing several types of toxic metals may cause different types of health problems like respiratory and cancers in humans (Kavcar et al., 2009). The metal Index (MI) was defined as the sum of metal

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concentration divided by maximum acceptable concentration (MAC) (Gabriella and Renso, 2004). The higher the concentration of a metal compared to its MAC value, the worse the quality of the water. The objective of the present study is to assess the physicochemical parameters of groundwater in Okitipupa Township and compare MI values to ascertain its suitability for human consumption.

MATERIALS AND METHODS

The Study Area: Okitipupa town lies between Latitude 5.125°N Longitude 4.008°E and Latitude 8.042°N Longitude 6.011°E. It is the headquarter of Okitipupa local government of Ondo State, Nigeria. It has an area of 63 sqkm^2 and a population of 233,565 at 2006 census (NPC, 2006). It is bounded in the North by Odigbo Local government, East by Irele Local government, South by Ilaje Ese Odo Local government and West by Ogun State. The inhabitants are mainly Yoruba of Ikale ethinic group while agriculture is the main occupation.

Sample collection and preservation

Well water samples were collected from twenty one locations across Okitipupa. Water samples were collected into a cleaned polythene bottles of one liter capacity which were rinsed with water to be sampled before collection. A cleaned polyvinyl chloride (PVC) rope was attached to a drawer made up of high density polyethylene (HDPE) bucket which was used to draw water from the wells.

Sample analysis

The physico-chemical parameters such as pH, Temperature, Electrical Conductivity (EC) and position of the wells were measured on the field using the following instruments. Hand-held 2000VWR Scientific meter for pH, Thermo Orion model conductivity meter (USA made) was used to measure the conductivity and TDS of the water. Samples meant for metal analysis were preserved with 5 mL concentrated nitric acid per liter. Samples for anions were kept in ice, transferred to the laboratory and analyzed immediately. The concentration of anions were determined using standard methods (APHA, 1998). The salicylate method was used for nitrate determination, turbidimetry method was used for sulphate determination, Vanado-molybdo-phosphoric acid method was used for phosphate determination and Indophenol colorimetric method was used for ammonium concentration determination. Cecil UV-Visible Spectrometer was used for the measurement. The chloride and alkalinity were determined by Mohr's method and titration methods respectively. Samples were digested in aqua- regia and analyzed for trace elements using a Perkin Elmer Atomic Absorption Spectrophotometer.

Chemicals and Reagents: All glassware and polyethylene bottles were washed, rinsed with doubly distilled water and soaked in 10% HNO_3 (v/v) for 72 h. The glass wares were rinsed again three times with doubly deionized water and finally dried in oven before use. All reagents were of analytical grade and the water used was doubly deionized water. Nitric acid (65% Suprapur, Merck, Darmstadt, Germany) was used for cleaning glassware and for preservation of water samples.

Statistical Analysis: Microsoft Excel was used for data entry and descriptive statistics (range, mean, standard deviation). SPSS 18.0 was used to generate the Pearson correlation data.

RESULTS AND DISCUSSION

The range of physicochemical parameters and metallic elements in groundwater of Okpa were presented in Table 1 while the concentration of metallic element from different locations were presented in Table 2. The metal Index were presented in Table 3 while Pearson correlation of metals were presented in Table 4.

Physicochemical parameter

The range of pH are 8.5-11.2 in groundwater of Okitipupa township of Ondo State (Table 1). Ten percent of the samples were found to be very close to 8.5, the maximum recommended by World Health Organization (WHO, 2008). This is in variance to 6.8-7.7 that was reported in Punjab Pakistan [9]. The Electrical Conductivity (EC) in This is in variance to 6.8-7.7 that was reported in Punjab Pakistan (Mahar et al., 2013). The Electrical Conductivity (EC) in Okitipupa groundwater ranged from 1095 - 1932 µScm^{-1} with the mean value of 1503 ± 211 µScm^{-1}.

The WHO recommended EC value in drinking water was 250 µScm^{-1}. The high value recorded may be due to dissolved ions of the salty nature of the water. Total Dissolve Solid (TDS) from Okitipupa groundwater ranged from 657 - 1159 mgL^{-1} with the mean value 902 ± 126 mgL^{-1}. Based on TDS content, groundwater are classified into desirable for drinking (up to 500 mgL^{-1}), permissible for drinking (500-1000 mgL^{-1}), useful for agricultural purposes (up to 3000 mgL^{-1}) and unfit for drinking and irrigation (above 3000 mgL^{-1}) (Davis and De-Wiest, 1963). Eighty one percent of groundwater samples collected from Okitipupa are within permissible for drinking level while 19 % are useful for agricultural purposes.

Chloride concentration in Okitipupa groundwater ranged from 220-299 mgL^{-1} with the mean value of 276 ± 18.5 mgL^{-1}. The WHO recommended limit of 250 mgL^{-1} in drinking water were exceeded by 86% of the samples. Phosphate concentration in groundwater samples from Okitipupa ranged from 3.5- 41 mgL^{-1} with a mean value of 7.4 ± 2.1 mgL^{-1}. Sulphate concentration in groundwater samples from Okitipupa town ranged from 80.7 - 260 mgL^{-1} with a mean value of 201± 53.5 mgL^{-1}. Ten percent (10%) of the groundwater samples collected has sulfate concentration greater than WHO limit of 250 mgL^{-1}. The high level of SO_4^{2-} may be due to run off from agricultural land where fertilizers is applied to the land which might have contaminated the groundwater. Nitrate concentration in groundwater samples from Ore ranged from 10.1 - 92 mgL^{-1} with a mean value of 35.1 ± 19.6 mgL^{-1}. The results indicated that none of the samples exceeded the WHO limit of 50 mgL^{-1} in drinking water. Previous studies reported similar nitrate concentration and was correlated it with land use pattern (Gardner and Vogel, 2005). Nitrate in groundwater is of great concern because of it causes met-hemoglobinemia in infants while the

Table 1. Range of physicochemical parameters and metallic elements in groundwater of Okpa.

Elements/Parameter	Min	Max	Mean	WHO
pH	8.5	11.2	10.1±0.900	6.50-8.50
Conductivity (µSCm^{-1})	1095	1932	1503±211	250
TDS(mgL^{-1})	657	1159	902±126	250
Cl $^{-}$(mgL^{-1})	220	299	276±18.5	250
PO_4^{3-} (mgL^{-1})	3.5	41	7.40±7.79	-
SO_4^{2-} mgL^{-1})	80.7	260	201± 53.5	250
NO_3^{-}(mgL^{-1})	10.1	92	35.1±19.6	0.05
Cd(mgL^{-1})	0.001	0.035	0.0098±0.002	0.003
Fe(mgL^{-1})	0.012	0.315	0.112±0.103	0.300
Cr(mgL^{-1})	0.003	0.044	0.0208±0.013	0.050
Cu(mgL^{-1})	0.071	0.681	0.4201±0.224	2.00
Pb(mgL^{-1})	0.001	0.006	0.004±0.003	0.01
Ni(mgL^{-1})	0.005	0.057	0.028±0.014	0.020

Table 2. Metallic elements in groundwater of Okpa.

Locations	Cd(mgL^{-1})	Fe(mgL^{-1})	Cr(mgL^{-1})	Cu(mgL^{-1})	Pb(mgL^{-1})	Ni(mgL^{-1})
Okpa1 n=4	0.001±0.001	0.212±0.001	0.0133±0.001	0.611±0.01	0.0103±0.003	0.027±0.002
Okpa 2 n=4	0.005±0.001	0.309±0.004	0.029±0.004	0.534±0.009	0.0013±0.00	0.026±0.001
Okpa3 n=4	0.002±0.00	0.068±0.002	0.0037±0.00	0.652±0.017	0.0047±0.00	0.024±0.00
Okpa 4 n=4	0.003±0.001	0.015±0.00	0.0243±0.00	0.074±0.002	0.0083±0.00	0.04±0.00
Okpa 5 n=4	0.021±0.001	0.0533±0.022	0.031±0.00	0.152±0.0312	0.011±0.00	0.021±0.00
Okpa 6 n=4	0.003±0.002	0.101±0.037	0.04±0.004	0.614±0.00	0.002±0.00	0.007±0.001
Okpa 7 n=4	0.016±0.001	0.028±0.014	0.004±0.00	0.305±0.027	0.0067±0.00	0.054±0.002

Key: Okpa1- garage, Okpa2- Bagudu str, Okpa 3-Ayonio str, Okpa 4-ofedepe, Okpa 5-Idepe, Okpa 6-Igbodigbo, Okpa 7-Erinje/ NDDC quarters.

Table 3. Metal Index (MI) in Okpa groundwater.

Elements/Parameter	? i	MACi	MI = ? i/ MACi
Cd(mgL^{-1})	0.139	0.003	46.3
Fe(mgL^{-1})	0.779	0.300	2.59
Cr(mgL^{-1})	0.145	0.050	2.9
Cu(mgL^{-1})	2.94	2.00	1.47
Pb(mgL^{-1})	0.044	0.01	4.4
Ni(mgL^{-1})	0.199	0.020	9.95

primary sources of groundwater nitrate are domestic sewage disposal and fertilizer.

Metallic elements

Cadmium concentration in Okpa groundwater ranged from 0.001- 0.035 mgL^{-1} with the mean value of 0.0098 ±0.002 mgL^{-1}. Twenty nine percent of the samples exceeded WHO limit of 0.003 mgL^{-1}. The highest Cd concentration value were recorded from Idepe area (Okpa 5) (Table 2). High Cd concentration may be due to discharge from waste or by leaching from sewage laden landfills. It may also be attributed large use of polyvinyl plastics, nickel-cadmium batteries, insecticides, motor oil, and disposal of slugde in dumpsites. Chronic exposure to Cd lead to anemia, anosmia, cardiovascular diseases and renal failure (Holl et al., 2002). High values were recorded from two locations (Okpa 5 and Okpa7) with the mean values of 0.021±0.001 and 0.016±0.001 mgL^{-1} respectively (Table 2). Results from previous studies shows Cd concentration range in groundwater of Punjab which were lower than the range obtained from the present study (Mahar et al., 2013).

Table 4. Correlation of metals in groundwater of Okpa.

Cd		Fe	Cr	Ni	Pb	Cu
Cd	1					
Fe	0.033	1				
Cr	0.813**	0.227	1			
Ni	-0.306	-0.305	-0.631**	1		
Pb	-0.158	-0.384	-0.218	0.278	1	
Cu	-0.248	0.558**	-0.127	-0.492*	-0.542*	1

Iron concentration in Okpa groundwater ranged from 0.012-0.315 mgL^{-1} with the mean value of 0.112 ± 0.103 mgL^{-1}. Previous study reported iron concentration in the Sahelian region of Northern Ghana, West Africa with higher range but lower in mean value than the results from the present study (Cobbina et al., 2012). Fourteen percent of the Fe concentration in well water samples from Okpa exceeded WHO limit of 0.3 mgL^{-1}. In most wells, rusty well cover used could also be a possible source of iron in these well. Turbidity, taste, discoloration, deposits and growth of iron-bacteria could be widespread in wells with high iron concentration.

Chromium concentration in Okpa groundwater ranged from 0.003-0.044 mgL^{-1} with the mean value of 0.021 ± 0.013 mgL^{-1}. None of the samples exceeded WHO limit of 0.05 mgL^{-1}. The results from the present study is similar to what was reported in previous study of groundwater in Riyadh region of Saudi Arabia (Abdulrahman et al., 2011). Copper concentration in Okpa groundwater ranged from 0.071- 0.681 mgL^{-1} with the mean value of 0.420 ± 0.224 mgL^{-1}. None of the samples exceeded WHO limit of 2.0 mgL^{-1}. This is similar to results obtained in groundwater of Iwo and Ikonifin of Osun State, Nigeria (Gbadebo et al., 2015). The Pb concentration in Okpa groundwater ranged from 0.001 – 0.006 mgL^{-1} with the mean value of 0.004± 0.003 mgL^{-1}. Thirty eight percent exceeded the WHO limit of 0.01 $mgL^{-1.}$ The difference is due to improper waste disposal which eventually pollute groundwater resources. This results is in agreement with the study that reported lead as one of the elements in the groundwater samples of Kwahu west district of Ghana that is above the safety limits recommended by WHO (Nkansah et al., 2010). Lead can initiate hypertension, tiredness, irritability, anemia behavioral changes and impairment of intellectual functions in affected population that consume those groundwater samples. Nickel concentration in groundwater of Ore ranged from 0.005-0.057 mgL^{-1} with the mean value of 0.028 ±0.014 mgL^{-1}. Fourteen percent of the groundwater samples exceeded WHO limit of 0.02 mgL^{-1}. Ni concentration in groundwater up to 0.20 mgL^{-1} was reported in the past. Nawab et al. (2013) reported highest Ni concentration in groundwater of Shangla, Pakistan to be 0.064 mgL^{-1} (Nawab et al., 2015) Combustion of fuel as well as municipal waste are possible sources of Ni in groundwater.

Metal index

The metal index for drinking water was preliminary defined as MI = ?Ci/MACi, where Ci is the concentration of each element in solution and MAC is the maximum allowable concentration (Gabriella and Renso, 2004). The MI in Okpa groundwater for Cd, Fe, Cr, Cu, Pb and Ni are 46.3, 2.59, 2.9, 1.47, 4.4 and 9.95 respectively (Table 3). If the concentration of a certain element is higher than the respective MAC value, the water cannot be used. The presence of several elements with concentrations smaller than but close to the respective MAC values will also decrease overall quality of water because of additive effect. Thus MI greater >1 is a threshold of warning even in the case where Ci < MACi for all elements.

Pearson correlation of metals

Significant positive correlation P < 0.05 was recorded between Cd and Cr (r = 0.813), Fe and Cu (r = 0.558) (Table 4).Negative correlation was recorded between Cr and Ni (r = -0.631), between Pb and Cu (r = -0.542). Inter-element positive correlation matrix of metals indicated a common source of contamination, however, negative correlation shows that the sources are different.

Conclusion

Groundwater in Okpa contain dissolved ions and most especially chloride level was very high. The metal index showed that cumulative effect endanger human health as MI >1 is a threshold of warning. Improved sanitation may reduce the danger but treatment of groundwater meant for drinking is necessary.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Abdulrahman A, Abdullah IA, Mujahid AK (2011). Assessment of Trace

Metals in Groundwater Sources Used for Drinking Purposes in Riyadh Region. International Journal of Water Resources and Arid Environments1(1):05-09.
APHA (1998). American Public Health Association Standard methods for the examination of water and waste water, 19th Edition. APHA, AWWA, WEF. Washington DC. p 4-67:99-144.
Cobbina SJ, Nyame FK, Obiri S (2012). Groundwater Quality in the Sahelian Region of Northern Ghana, West Africa Research Journal of Environmental and Earth Sciences 4(4):482-491.
Davis SN, De-Wiest RJM (1963). Hydrogeology. New York. Wiley P 463.
Gabriella T Renso C (2004). Heavy metals in drinking waters from mount Aminata (Tuscany Italy). Possible risk from Arsenic for public health province of Sirena. Science of the Total Environment. 327:41-51.
Gardner KK, Vogel RM (2005). Predicting Ground Water Nitrate Concentration from Land Use. Ground Water 43(3):343-352.
Gbadebo AM, Ayedun H, Moses AI (2015). Hydrogeochemical assessment of groundwater in Iwo, Ikonifin and Ife-Odan, Osun and Oyo states, Southwest Nigeria. Environmental Earth Sciences 73:3633-3642.
Groundwater Foundation GF (2008). Sources of groundwater contamination. Wwwgroundwater.org/gi/sources of gwcontain.htm. Accessed on 15th Feb. 2009.
Holl WH, Bartosch CH, Zhao X, He S (2002). Elimination of trace heavy metals from drinking water using weakly basic anion exchange. Jahrgang Heft 3:5-20.
Kavcar P, Sofuoglu A, Sofuoglu SC (2009). A health risk assessment for exposure to trace metals via drinking water ingestion pathway. International Journal of Hygiene and Environmental Health 212(2):216-227.
Mahar MT, Khuhama MY, Baloch MA,Tahangir TM (2013). Health risk assessment of heavy metals in groundwater, the effect of evaporation ponds on distillery spent wash: Acase study of Southern Punjab Pakistan. World Appllied Science Journal 28(11):1748-1756.
National Population Commision (NPC) (2006). National Population Commision Official Gazette.
Nawab J, Ali S, Rauf A, Ur Rehman U, Khan AA, Sajjad M, Khan W (2015). Health risk associated with heavy metals via consumption of surface and groundwater in District Shangla, Pakistan. Journal of Himalayan Earth Sciences 48(2):62-73.
Nkansah MA, Boadi NO, Badu M (2010). Assessment of quality of water from hand dug wells in Ghana. Environmental Health Insights 4:7-12.
Pekey H, Karaka D, Bakoglu M (2004). Source apportionment of heavy metals in surface waters of a polluted stream using multivariate statistical analyses. Marine Pollution Bulletin 49:809-818.
WHO (2008).World health Organisation. Guidelines for drinking water quality (3rd Ed incorporating the 1st and 2nd Addenda) volume 1 recommendation .Geneva http:// . Accessed on 19th August 2009.