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Physicochemicalwater quality within Okposi Okwuand Uburu Salt Lakes, Ebonyi State, Nigeria

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Abstract
Natural processes and human activities including anthropogenic sources may increase the level of physicochemical qualities of ground and surface water in environment. Physico – chemical qualities of water sources within Okposi Okwu and Uburu area were investigated using standard technique to ascertain if the water samples were safe for drinking. The qualities measured include temperature, pH, turbidity, total dissolved solid (TDS), electrical conductivity (Ec), nitrates (NO_3^-), sulphate (SO_4^{-2}), phosphate (PO_4^{-3}), chloride Cl^-, sodium (Na), lead (Pb), copper (Cu), cadmium (Cd), chromium (Cr), nickel (Ni), arsenic (As) and cyanide (CN). Fresh water quality was observed in all the samples; with neutral pH recorded in Atta stream, Asu river, borehole water samples in both localities. Water samples from Atta stream and Asu river were more turbid than borehole water, traceable to human activities. Findings further revealed safe physicochemical qualities for sachet water, while arsenic (As) and cyanide (CN) concentrations were the major heavy metal pollutants of borehole water from Okposi Okwu and Uburu, Atta stream and Asu river samples investigated; therefore unfit as drinkable water, traceable to water – rock interaction, lithology, salt water intrusion, agrochemical runoff among other human and anthropogenic sources in the localities. To ensure high quality of drinkable water sources in the localities, bacteriological assessment and further treatment were suggested to minimize acute problem of water related diseases which are prevalent to human being.

Keywords: *Heavy metals, ground water, physicochemical qualities, surface water, World Health Organization safety standards*

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I. Introduction

Water pollution is a global public health threat which places human and aquatic lives at risk. Water related diseases are possibly responsible for increase in illnesses and death in developing countries asdecrease in daily portable water intake may affect the efficiency of cells and other activities of the body. Major sources of natural water include rain water (precipitation), surface water (river, stream, ponds, lakes, oceans) and ground water (well, borehole and spring). Surface water, where they exist in most urban and rural areas in the developing countries especially in Nigeria, are drinkable, use for irrigation, and domestic purposes while ground water is the major water source for public drinkable water supply both in developed and developing countries. Hydrologic cycle connects surface and ground water sources therefore; contaminants may be shared between the sources.

Despite ongoing efforts by governments, civil society and international community, over a billion people do not have access to improve drinking water sources (UNICEF,2008) [1]. In a bid to promoting healthy living among the inhabitants of a locality, the need to study the drinkable water quality is essential. In Nigeria, agencies like the National Agencies for Food and Drug Administration and Control (NAFDAC), Standard Organization of Nigeria (SON), Nigeria Industrial Standard (NIS), Nigerian Standard for Drinking Water Quality (NSDWQ) and international organizations including World Health Organization (WHO) U.S. Environmental Protection Agencies (USEPA) have suggested some physico – chemicalguidelines for drinking water quality above which health risk maybe expected.

In the study of the elemental composition and distribution of common fertilizers in Nigeria, [2] had established that arsenic and lead concentrations were 3 and 2.5 times higher than the respective world fertilizer metal standards.[3], in Nigeria, had reported the presence of lead, arsenic, nickel cobalt, copper and cyanide in Single Super Phosphate fertilizer (SSP) and Nitrogen Phosphorus Potassium (NPK) fertilizers. It was identified in Ohaozara Local Government Area in Ebonyi State that the commercial and subsistent farmers employ

agrochemicals such as chemical fertilizers, pesticides and herbicides to boost and improve crop yields. Prolong use of agrochemicals on farmland may increase the elemental composition and run – off from agrochemicals may wash into and contaminate surface water.

Furthermore, due to the occurrence of saline lakes at Okposi Okwu and Uburu area, fresh and portable water sources may be a serious challenge in the area considering salt – water intrusion. The major sources of drinkable water and for other uses in the area about 2 km away from the two lake water are boreholes, Atta stream found in Okposi Okwu and Asu River found in Uburu. In most cases, they are consumed without further treatment and may be unfit for drinking. Sachet waters certified by NAFDAC, consumed in Okposi Okwu and Uburu area were suspected to be unfit as drinkable water.Changes in reproductive functions of adult male rats administered water and salt samples from Okposi and Uburu Nigerian Salt Lakes was reported [4]. Surface and ground water quality was reported within WHO guidelines in Ikwo, Ebonyi State, Nigeria [5]. Comprehensive data and information on the physico – chemical qualities of various water sources within salt lake communities for drinking and other purposes was needed to be updated in the study area. The study therefore investigated some physico – chemicalqualities of drinkable and domestic water sources from Okposi Okwu and Uburu salt lake areas in Ebonyi State comparing the results with studies carried out in Salt Lake Community in Nasarawa State in Nigeria, local and international guidelines for drinking water quality.

II. Materials And Methods

2.1 The study location

Okposi Okwu and Uburu in Ohaozara Local Government Area (LGA), Ebonyi State Nigeria lies between latitude 6^0 02′ 20″ N to 6^0 02′ 60″ N and longitude 007^0 48′ 37″ E to 007^0 44′ 53″ E located within the Lower Benue Trough. [6] and[7] had contributed significantly to the details of the general geology of the study area as the lithology in the locality of the salt lakes varies with location; while Okposi is a mud filled depression surrounded by sandstone exposures, Uburu salt lake area consist of sandstone beds with intercalation of fine grained bands of silts and shale. The bedrock of the area is made up of sedimentary rocks which belong to the Asu River group of Albian age. The fracture system within the bedrock has been reported to be responsible for the occurrence of brine in the region [8]. The well – developed fold and fractures of the Lower Benue Trough form host of lead – zinc mineralization predominant in the area and also serve as channel for the salt groundwater [9 – 10]

2.2 Sample collection and preparation

Boreholes, stream and river water considered were about 2 km away from the the salt lakes while the sachet water investigated were the common brands sold in the area. 2 L plastic containers thoroughly rinsed with dilute HCl and thereafter with little quantity of water samples were used for the collection of water samples and for each, about 1% air space was left for thermal expansion. Water samples were collected during the dry season when demand for drinking water is relatively high. Using stratified random sampling technique, thirty six (36) water samples were investigated in all, comprising of eighteen (18) water samples in each locality; three (3) samples each were drawn from the two brands of sachet water registered by NAFDAC in the two localities. The water samples were acidified at the point of collection with 20 ml of concentrated trioxonitrate (VI)acid (HNO_3) in order to avoid adsorption of the heavy metals on the walls of the containers and transported to Nigerian Institute of Science Laboratory Technology (NISLT) in Ibadan Oyo State, Nigeria for the physico – chemical analyses.

2.3 Physico – chemicalanalyses

The temperature was measured at the site using mercury in glass thermometer in degree Celsius by dipping the thermometer into the water samples and recording the stable reading. The pH, total dissolved solids (TDS), electrical conductivity (Ec) were determined using HANNA meter (HI 9828) which was calibrated with standard buffer solution of pH which ranged from 4.0 – 9.0. The probe was dipped into the container of the water samples until a stable reading was obtained and recorded. The turbidity was determined using HACH Spectrophotometer (DR/2000). The nitrate, phosphate and sulphate were read in JENWAY UV/Visible spectrophotometer (6506). Chloride ion was determined by Argentometric titration method. Sodium, lead, arsenic, nickel, chromium, cyanide, copper and cadmium concentrations were measured using atomic absorption spectrophotometer (AAS). Table 1 and Table 2 respectively compare the mean physico – chemicalcharacteristics of water sources in Okposi Okwu and Uburu area with local and international drinking water safety standards.

Table 1: Comparison of mean physico – chemicalcharacteristics values of borehole, Atta stream and sachet water used at Okposi Okwu area with drinking water safety standards.

Physico – chemical characteristics	Borehole water	Atta stream	Sachet water	WHO[11]	NIS [12]	NSDWQ [13]
Temperature (^{0}C)	27.20±0.634	26.10±0.471	25.77±0.170	25 – 30	Ambient	25 - 30
pH	7.70±0.160	7.5±0.094	6.87±0.052	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5
Turbidity (NTU)	3.90±4.810	42.17±35.926	0.50±0.016	5.0	5.0	5.0
TDS (mg/L)	19.20±1.344	46.8±1.067	10.5±0.294	500	500	500
Ec (µS/cm)	38.30±2.687	93.5±1.979	21.8±0.216	1000	1000	1000
Nitrate (mg/L)	ND	0.03±0.024	2.3±0.082	50.0	50.0	50
Phosphate (mg/L)	0.16±0.233	0.037±0.025	0.02±0.008	5.0		
Sulphate (mg/L)	ND	ND	0.013±0.005	500	100	
Chloride (mg/L)	30.72±5.285	397.04±20.054	12.53±1.302	250		250
Sodium (mg/L)	25.28±0.615	257.20±6.203	3.13±0.826	200		
Lead (mg/L)	ND	ND	0.006±0.005	0.01	0.01	0.01
Arsenic (mg/L)	0.01±0.005	0.01±0.004	ND	0.01	0.01	
Nickel (mg/L)	ND	ND	ND	0.07	0.02	-
Chromium (mg/L)	ND	ND	0.003±0.005	0.05	0.05	0.05
Cyanide (mg/L)	0.03±0.023	0.012±0.004	ND	0.003	0.003	0.003
Copper (mg/L)	0.01±0.015	0.003±0.005	0.13±0.047	2.0		1.0
Cadmium (mg/L)	ND	ND	ND	0.003	0.003	0.003

ND: Not detected. NTU: Neophlometric Turbidity Unit

Table 2: Comparison of mean physico – chemicalcharacteristics values of borehole, Asu River and sachet water used at Uburu area with drinking water safety standards.

Physico – chemical characteristics	Borehole water	Asu River	Sachet water	WHO[11]	NIS [12]	NSDWQ [13]
Temperature (^{0}C)	28.5±0.5	29.0±0.577	25.83±0.170	25 – 30	Ambient	25 – 30
pH	7.6±0.129	7.6±0.138	7.02±0.058	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5
Turbidity (NTU)	17.0±10.154	21.13±7.685	0.54±0.06	5.0	5.0	5.0
TDS (mg/L)	24.8±6.368	27.54±6.369	10.76±0.170	500	500	500
Ec (µS/cm)	49.66±12.710	62.0±14.782	21.9±0.262	1000	1000	1000
Nitrate (mg/L)	0.016±0.012	0.018±0.016	2.43±0.262	50.0	50.0	50.0
Phosphate (mg/L)	0.006±0.015	0.097±0.102	0.013±0.005	5.0		
Sulphate (mg/L)	ND	ND	0.013±0.005	500	100	
Chloride (mg/L)	16.42±5.009	85.08±49.798	14.10±0.355	250		250
Sodium (mg/L)	5.48±0.320	56.28±3.942	3.33±0.036	200		
Lead (mg/L)	ND	ND	0.003±0.005	0.01	0.01	0.01
Arsenic (mg/L)	0.015±0.008	0.016±0.007	ND	0.01	0.01	
Nickel (mg/L)	ND	ND	ND	0.07	0.02	-
Chromium (mg/L)	ND	ND	0.006±0.005	0.05	0.05	0.05
Cyanide (mg/L)	0.04±0.034	0.023±0.122	ND	0.003	0.003	0.003
Copper (mg/L)	ND	0.01±0.008	0.13±0.047	2.0		1.0
Cadmium (mg/L)	ND	ND	ND	0.003	0.003	0.003

ND: Not detected. NTU: Neophlometric Turbidity Unit

III. Results and Discussion

Table 1 compared the results obtained in water sources investigated at Okposi Okwu area with the guidelines for drinking water quality suggested by [11 – 13]while Table 2 compared the results obtained in water sources investigated at Uburu area with the suggested [11 – 13] guidelines for drinking water quality.

3.1 Temperature

Table 1 and Table 2 showed the mean water samples for Atta stream, Asu river and borehole water in both Okposi okwu and Uburu area were in good agreement the guidelines for drinking water quality. Asu river had the highest result, 29.0±0.577 ºc while the lowest result, 26.10±0.471 ºc was found in Atta stream among the borehole and surface water investigated. These results slightly differ with 25.83±0.170 ºc and 25.77±0.170 ºc obtained in sachet water drinkable in Okposi Okwu and Uburu area respectively as observed from the Tables 1 and 2.

3.2pH

pH concentration measures the acidic (1 – 6), neutral (7) or alkaline (7 – 14) concentration of a medium. Observation from Table 1 and Table 2 revealed that except for sachet water consumed in Okposi Okwu which was acidic in nature, other water sources in Okposi Okwu and Uburu were found to be neutral. These results were within the guidelines for drinking water quality [11 – 13].

3.3 Turbidity

Turbidity limits transparency due to suspended solid particles such that light cannot penetrate deeply into water column. It is measured in Neophlometric Turbidity Unit (NTU). Observation from Table 1 and Table 2 revealed that Atta stream, Asu river, Uburu borehole and Okposi Okwu borehole water samples recorded the mean results of 42.17±35.926 NTU, 21.13±7.685 NTU, 17.0±10.154 NTU and 3.90±4.810 NTU respectively which were about 8 times, 5 times, 3 times higher respectively than the guidelines for drinking water quality [11 – 13], except for Okposi Okwu borehole water.

3.4 Total dissolved solids (TDS) and electrical conductivity (Ec)

Total dissolved solid (TDS) describes the inorganic salt and small amount of organic matter present or dissolved in water. The major constitutes are calcium, magnesium sodium and potassium cations, carbonate, hydrogen carbonate, chloride, sulphate and nitrate anion. Conductivity measures the ability of aqueous solution to carry electric current and it is affected by the geology of area through which water flows. It is measured in micro siemens per centimeter (μS/cm). Electrical conductivity of a particular solution depends on three factors namely: the number of ions, charge on an ion or ionic charge and velocity of ions [14]. Higher electrical conductivity indicates a higher amount of dissolved salts present in water.

Electrical conductivity (EC) increases as concentration of ions in water samples increases and is related to TDS content of water. TDS and conductivity are used to evaluate fresh water quality; water sources with TDS lower than 1000mg/L is regarded as fresh water. All the water samples analyzed revealed fresh water sources since there were all far below the guidelines for drinking water quality [11 – 13] as observed from the Table 1 and Table 2. The mean concentration results for TDS and ECdiffered with the study carried out by [15] in the salt lake community of Nasarawa State, Nigeriawhich wererespectively above WHO guidelines for drinking water quality [11].

3.5 Nitrate, phosphate and sulphate

Nitrate, phosphate and sulphate are major contaminant in agricultural areas were agrochemicals are used to enhance and protect crop yield. Their sources in surface and ground water may also be due to natural mineralization. As observed from Table 1 and Table 2, in general all the water samples analyzed for nitrate, phosphate and sulphate were respectively belowthe guidelines for drinking water quality[11 – 13], which implies that soil and agricultural runoff, detergent and other possible sources of phosphate concentration have not significantly contaminated the surface water sources. The mean concentration results agreed with [14] study in the salt lake community of Nasarawa State, Nigeria which were below[11] guidelines for drinking water quality. Furthermore, borehole concentrations in this study showed that phosphate constituent of the aquifer material was minimal.

3.6 Chloride and sodium

High sodium chloride concentration in water is an indication of salinity. It was observed in Table 1 and Table 2 that sodium and chloride concentrations in borehole water and Atta stream found in Okposi Okwu area were higher than corresponding results in Uburu area. Relatively higher sodium and chloride concentration observed in Atta stream than corresponding the guidelines for drinking water quality [11 – 13],are responsible for objectionable salty taste. This could be an indication of salt water intrusion to Atta stream. Among all the water samples investigated, the lowest results were obtained in Sachet water sold in the Okposi Okwu and Uburu area.

3.7 Lead, arsenic, nickel, cadmium chromium, cyanide and copper

Arsenic (As) and cyanide (CN) concentrations were the major heavy metal pollutants of borehole water from Okposi Okwu and Uburu, Atta stream and Asu river samples investigated. The results as observed from Table 1 and Table 2 exceeded the guidelines for drinking water quality [11 – 13], while lead, nickel, cadmium, chromium and copper concentrations in the investigated water samples were found belowthe guidelines for drinking water quality [11 – 13].Unlike [16], Ground Water Quality Index (GWQI) was not investigated in all the samples to reveal excellent, good, fair and poor categories or classes of ground water quality.

IV. Conclusion

Some physico – chemicalstudy of the borehole water, water samples from Atta stream and Asu river in at Okposi Okwu and Uburu area and NAFDAC certified sachet water sold in the area were carried out using standard analytical method. In general, sachet water samples were physico – chemicallysafe as drinkable water while samples of borehole water from Okposi Okwu, borehole water from Uburu, Asu river and Atta stream were considered unsafe due to concentrations of heavy metals of arsenic and cyanide comparable with local and international guidelines for drinking water quality. There is need to create awareness about the present situation

in the study areas and further investigation, employing larger samples for purpose of generalization. The study suggests further treatment of water samples by the consumers before consumption so as to reduce the possible risk of health challenges.

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