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Research Article

Comparative Analysis of Physicochemical Properties of Some Selected Water Sources in Ekiti State, Nigeria -

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ABSTRACT

The physicochemical properties of some selected water sources within a quarry site at locations (L1, L2, L3, and L4) in Afao-Ekiti were investigated using standard analytical methods. At the quarry site the following parameters were undertaking (pH, total dissolved solids, the total hardness, phosphate, electrical conductivity, chloride, and fluoride and nitrate) and were all within the World Health Organization (WHO) permissible limits for drinking water. However, the metal samples investigated also fell within WHO permissible limits for drinking water except for iron (L3) and manganese (L4). These results showed that water sources in this environment were not contaminated and fit for human consumption. This study also investigates the suitability of water for drinking purposes based on Water Quality Index (WQI) estimated. The Communities within the studied area require alternative sources of potable water for drinking and domestic purposes other than the previous model.

Keywords: Physicochemical; Heavy metals; Water; Quarry; Contamination

INTRODUCTION

According to Efe et al. [1], it has been reported in most cities, towns, and villages in Nigeria, that valuable man-hour was spent on seeking and fetching water, often of doubtful quality from distant sources. About 1.1 billion people lack access to drinking water supply [2]. Water in its pure state is acclaimed key to health and one of the most abundant and generally essential to life. Water according to Upong and Okon [3] covers about 97% volume on earth's surface, 0.8% underground, 0.009% in inland freshwaters such as lakes, while 0.00009% is contained in rivers [4]. Consequently, water is one of the keynotes that has contributed solely to live, without the presence of water no reaction can take place in the body system, water constitutes the major functional mechanism that generalizes life availability. According to Muyi [5], man requires a steady and accessible supply of water because man can go without food for twenty-eight days, but only three days without water because water serves as an emulsifier, and dissolution in the body system.

Water pollution is a global problem that needs to be solved urgently and has a significant impact on the efficiency of sustainable cities [6]. Rudimentary household water rations have been suggested at 50 liters per person per day apart from the water needed in the gardens [7]. The water we drink is needed for cell function and its volume rations, any decrease in our daily water intake will affect the efficiency of cells and other body activities [8]. In addition to water intake by humans and for health necessities, water is also needed in agriculture, industrial, recreational and other purposes. In most religions, water is considered a purifier and makes life unique [9]. Every usage of water is essential, however, water for human sanitation and consumption is considered to have the highest social and economic importance since the health of people has a direct influence on all other activities [10].

Groundwater is already used extensively in Nigeria through wells and boreholes [4]. Groundwater is the water underneath the surface where all the hollowness in the rocks and soil are filled. Wells, boreholes, and springs originate from groundwater. A borehole is generally hydraulic structured, properly designed and constructed to permit the economic withdrawal of water from an aquifer. It is a narrow well drilled with the machine. Borehole water, unlike well water, it is obtained from a borehole drilled into the aquifer or underground water zone, which is usually a fully saturated subterranean zone, some distance below the water table purposely to suit the comfort of the people dwelling and their habitat [11]. Borehole water like water from any other source is not ultimately pure. Its purity varies depending on the geological conditions of the soil through which the groundwater flows and some anthropogenic activities. Until this present age, the groundwater has been thought of as being a standard for any form of water purity itself [12].

According to Ukpong and Abaraogu [13], groundwater usage is based on the hypothesis that it precludes from the atmosphere and hence less susceptible to pollution. However, groundwater is sometimes vulnerable to quality problems that may have serious impacts on human health [4]. But water as reported by Umara et al. [14], is the most precious natural needs of life after oxygen, and "key" to health, it should be qualitative before being used. Any polluted waters, irrespective of the pollutants, if consumed, may lead to a variety of diseases, such as cholera, typhoid, dysentery, skin, and mental disorders, etc.

To safeguard the health of people to the barest minimum of dreadful experiences of drinking, and/or use of low-quality waters, it is essential that the quality of water should be monitored with a view to finding a lasting solution to health problems related to the use and drinking of low-quality waters. Both solid and liquid wastes materials dumped either on the soil surface or buried, decompose to produce leachate that penetrates the aquifers and contaminate the groundwater thereby raising the potential toxicity of the water to consumers. Nowadays, surface dumping and burying of both industrial and domestic waste are common practices among rural and urban dwellers to which most people or inhabitants do not pay much attention. However, the quality of good water depends principally on the element(s) present in it as it percolates the underground surface. The world health organization WHO sets a quality guideline for drinking water and recommends that the properties of drinking water should fall within the acceptable limit specified in this guideline. The research work is aimed at assessing the quality parameters of water collected from the quarry site in Afao-Ekiti, Ekiti State, Nigeria.

Water Quality Index (WQI) is a valuable and unique rating to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment techniques to meet the concerned issues. However, WQI depicts the composite influence of different water quality parameters and communicates water quality information to the public and legislative decision-makers. In spite of the absence of a globally accepted composite index of water quality, some countries have used and are using aggregated water quality data in the development of water quality indices. Attempts have been made to review the WQI criteria for the appropriateness of drinking water sources. Besides, the present article also highlights and draws attention towards the development of a new and globally accepted "Water Quality Index" in a simplified format, which may be used at large and could represent the reliable picture of water quality [15].

MATERIALS AND METHODS

Sampling sites

Afao-Ekiti is located in Irepodun Local Government Area of Ekiti State. The settlers are predominantly peasant farmers and the major industrial activities sited in the area are quarry due to the availability of rocks. The rural folks in the area depend on hand-dug wells and boreholes for the sources of water for drinking and domestic purposes.

For this study, three water samples were collected at the IBD IMPLEX LTD quarry site and control sample from Afao town. (Sample A, N $7^0 41^1 4.3296^{11}$, E $5^0 15^1 44.37^{11}$ at elevation 113.0m) were taken in blast site, (Sample B, N $7^0 41^1 49.3296^{11}$, E $5^0 15^1 44.37^{11}$ at elevation 376.0m) from borehole in front of the quarry office which is almost 500m away from blasting site and (Sample C, N $7^0 41^1 4.8732^{11}$, E $5^0 18^1 45.6948^{11}$ at elevation 374.0m) were taken from milling site which was about 1 kilometers away from the quarry site. Sample D (N $7^0 42^1 23.6484^{11}$, E $5^0 19^1 16.7772^{11}$ at elevation 372.0m) were taken from hand-dug manual drilled borehole encamped with a manual pump as control sample which was about 2-kilometer to the quarry site located at Afao township.

Sample collection and analysis

The samples were collected at four different sampling points with 2000ml plastic containers. The portion of the water sample for metal analysis was treated with 1ml of Hydrochloric acid (Hcl) in a 500ml sample bottle to arrest microbial activities while those for non-metal analysis were freshly refrigerated in a cooler packed with, ice blocks to avoid microbial action affecting their concentration.

The physicochemical properties of the water samples were determined using standard analytical methods. The pH, Colour, Temperature, Total alkalinity, Turbidity, Conductivity, Total hardness, Total Dissolved Solids (TDS), Total Suspended Solids (TSS) were analyzed. The heavy metal concentration was estimated using the Atomic Absorption Spectrophotometric (AAS) method after acid digestion. Sodium and potassium were determined with a flame photometer using a direct aspiration method [16]. The data generated were compared with the World Health Organization [17] standards for drinking water.

DATA ANALYSIS

Statistical analysis was carried out using analysis of variance (ANOVA) and compared for significance at $P < 0.05$ using SPSS package version 21.

RESULTS AND DISCUSSION

The result in table 1 shows the physicochemical properties of water sources compared with the World Health Organization [17] standards for drinking water. The water at Afao-Ekiti quarry site was found to have lower total alkalinity value ranging between 1.0 and 1.3 mg/L and the pH range of 6.88 to 7.75 (slightly acidic to slightly alkaline). Phosphate, fluoride, sulphate, chloride, and nitrate were below the stipulated WHO range. This showed that the water samples in this area are suitable for drinking and agricultural purposes. The temperature of the water samples was between 26.3°C and 27.1°C. Turbidity value between 3 and 7 NTU, respectively. The values of electrical conductivity ranged between 18.13 and 89.18μs/cm. All the colors were moderately clear except that of L3. Total dissolved solids ranged between 8.07 and 15.59 mg/L. In L1, L2, and L4, the values of turbidity were in agreement with WHO except in L3 which a result of quarry activities around the vicinity was. The hardness of the groundwater is influenced by the presence of carbonates and bicarbonates of calcium and magnesium, sulphates, chlorides, nitrates. The hardness in the analyzed samples ranged from 100 to 211.5 mg/L. The chloride concentration in all the samples analyzed was found to be within the permissible limits. A high chloride content may harm the metallic pipes and structure. Excess of chloride in groundwater imparts salinity in the water and affects human consumption. The alkalinity of groundwater was due to the presence of carbonates, bicarbonates, and hydroxides. The concentration of fluorides present was within the acceptable WHO limits. Fluoride ions have dual importance in water supplies, a high concentration of fluoride causes dental fluorosis, while a concentration lesser than 1.0 mg/L results in dental caries. The water samples in the study area can be considered as safe for drinking since the fluoride content in the samples was lower than 1.5mg/L (Table 1). Sulphates ions originated in natural water due to oxidation of sulphite ores or gypsum and other sulphur bearing ores. However, ingestion of water containing a high concentration of sulphate can have laxative effects, which is enhanced when sulphate is consumed in combination with magnesium. Sulphate values in all the samples analyzed are well within the limits. Nitrates are believed to occur in groundwater mainly due to leaching

Table 1: Physicochemical properties of water sources in Afao-Ekiti.

Physicochemical parameters	L1 (Quarry Water)	L2 (Borehole Office)	L3 Blasting	L4 (Hand Dug Well)	WHO (2003)
pH	7.09	6.88	7.75	6.91	6.5-8.5
Temperature (°C)	26.8	26.3	27.1	26.4	25-30
Colour	Clear	Clear	Dirty	Clear	Clear
Turbidity (NTU)	5	4	7	3	5
Electrical Conductivity (μs/cm)	27.5	18.13	38.62	89.18	250
Total Dissolved Solids (mg/L)	12.68	8.07	28.31	15.59	250-500
Alkalinity (mg/L)	1.3	1.3	1	1	600
Chloride (mg/L)	7.83	8.97	7.6	8.1	250
Nitrate (mg/L)	0.1	0	0	0	10
Fluoride (mg/L)	0	0	0.01	0	1.5
Sulphate (mg/L)	1.43	2.35	2.42	0.47	500
Phosphate (mg/L)	0.05	0.07	0.07	0.02	5
Total Hardness (mg/L)	141	100	211.5	131.9	150-500
Calcium Hardness (mg/L)	125	89	196	85	75
Magnesium Hardness (mg/L)	16	11	15.5	46.9	50
Potassium (mg/L)	0.7	0.6	0.5	0.5	200
Sodium (mg/L)	3	2.8	2.2	2.5	200
Copper (mg/L)	0.04	0.02	0.04	0.04	2
Zinc (mg/L)	0.46	0.01	0.23	0.55	3
Lead (mg/L)	0.01	Nd	0.01	Nd	0.01
Nickel (mg/L)	Nd	Nd	Nd	Nd	1
Cadmium (mg/L)	Nd	Nd	Nd	Nd	0.003
Iron (mg/L)	0.3	0.02	12.6	0.3	0.3
Chromium (mg/L)	0.05	Nd	0.02	Nd	0.05
Manganese (mg/L)	0.22	0.02	0.46	0.53	0.5

from soil organic matter, leaching of fertilizers applied to the soil, while leachates from refuse dumps and industrial discharge also contribute to presence of nitrate. In excessive amounts, it contributes to the illness of infant methemoglobinemia or blue baby syndrome. The concentration of nitrates in the analyzed groundwater samples is well within the permissible WHO limits.

The results of heavy metals examined in this study showed a wide difference from the two sampling points (2km away from the quarry site) which could be a result of specks of dust from the quarry sites [18]. It may also be due to anthropogenic influence trending in the society such as small-scale entrepreneur activities which include open-air solid waste combustion, farming, quarrying, and smoke from automobiles [18,19]. A report of Ikem et al. [20], Vinodhini and Narayanan [21], and Agbafor et al. [22] indicated that high level of heavy metals could relatively leads to increase serum liver enzymes, kidney function parameters and reduction in haemoglobin level packed cell volume and Red Blood Cells. Therefore, from this study, it was evident that of all the metals investigated, samples from L1 and L3 sites should be properly monitored because, in the future, there may be an increase in the level of lead which could later result in health-related hazards for the dwellers. The level of non-metallic ion such as nitrate, chloride, phosphate, and fluoride of the potable waters could be associated with dissociation of their metallic compounds, oxidation of other forms of the compounds, high degree organic pollution, and type of minerals in the bedrock, eutrophication, agricultural activities and use of detergents [23,24]. High nitrate concentration above 10mg/l is dangerous to pregnant women and could as well poses a serious health threat to infants less than 3 to 6 months of age because of its ability to cause methaemoglobinaemia or blue baby syndrome in which blood loses its ability to carry sufficient oxygen [25] while high fluoride level in drinking water may lead to reduction in total erythrocyte, haemoglobin percentage, haematocrit value, protein content and then fluorosis [26] but from this study, it was clearly shown that all the physicochemical parameters were in line with international standards.

WATER QUALITY INDEX (WQI)

The water quality index reveals some interesting and important information about the quality of groundwater in the study area. The recommended limit of WQI for drinking water is 100. WQI of all sites has been found between 70 to 90%, therefore, it can be said that the quality of groundwater in the study area is satisfactory for drinking purposes.

CONCLUSION

This study has provided data on the level of physicochemical properties of water from the quarry site and Afao-Ekiti community. Considering the results obtained from the investigations, the following conclusions were drawn: sulphate, nitrate, and phosphate concentrations met the WHO standards and all heavy metals analyzed fell within the WHO limits. The heavy metal concentrations of samples of water from locations L1, L2, L3, and L4 were all within the set limit by WHO, except iron and manganese for L3 and L4 respectively. Significant differences existed among the results of fluoride, total hardness, calcium hardness, magnesium hardness across all the samples at $p > 0.05$ confidential limit whereas the results of phosphate showed significant difference at $p > 0.01$ confidential limit. This implies that the potable water in Afao-Ekiti is confirmed

Table 2: Physicochemical properties of water sources in Afao-Ekiti.

	pH	Temp	Turbidity	EC	TDS	Alkalinity	Cl^-	NO_3^-	F^-	SO_3^{-2}	PO_4^{-3}	TH	CH	MH	K	Na
pH	1															
Temp	0.923	1														
Turbidity	0.942	0.924	1													
EC	-0.158	-0.203	-0.468	1												
TDS	0.93	0.824	0.755	0.213	1											
Alkalinity	-0.491	-0.312	-0.169	-0.749	-0.771	1										
Cl^-	-0.712	-0.858	-0.601	-0.269	-0.781	0.53	1									
NO_3^-	-0.111	0.271	0.098	-0.334	-0.268	0.577	-0.328	1								
F^-	.974*	0.812	0.878	-0.1	0.934	-0.577	-0.584	-0.333	1							
SO_3^{-2}	0.51	0.357	0.685	-0.825	0.215	0.28	0.171	-0.173	0.547	1						
PO_4^{-3}	0.477	0.363	0.681	-0.879	0.16	0.367	0.168	-0.071	0.494	.994**	1					
TH	.968*	0.927	0.852	0.063	.976*	-0.629	-0.845	-0.072	0.927	0.278	0.244	1				
CH	.990*	.957*	.975*	-0.258	0.88	-0.376	-0.722	0.016	0.937	0.543	0.525	0.948	1			
MH	-0.326	-0.338	-0.608	.984*	0.039	-0.619	-0.159	-0.256	-0.276	-0.898	-0.94	-0.103	-0.416	1		
K	-0.354	-0.047	-0.051	-0.626	-0.605	0.905	0.148	0.87	-0.522	0.079	0.184	-0.417	-0.218	-0.507	1	
Na	-0.692	-0.425	-0.432	-0.423	-0.858	0.907	0.419	0.714	-0.81	-0.145	-0.05	-0.729	-0.583	-0.261	0.92	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

unpolluted with organic and inorganic substances and therefore fit for drinking. It is therefore recommended that standard measures be taken by the appropriate authorities to ensure proper treatment of the waters to safeguard the health consumers. An analysis of this nature should be carried out regularly. Water users should also be on the watch and to report every high level of any physical or chemical properties to the appropriate authorities to sustain water quality for consumption.

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