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# Physical and Chemical Quality Assessment of Water Used for Drinking and other Domestic Purposes in Okada Town, Edo State

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**Abstract:** *This study assessed the pertinent physical and chemical quality of selected water sources in Okada Town, Ovia North-East L.G.A. of Edo State Nigeria, to ascertain their compliance or otherwise, with Nigerian Industrial Standard (NIS): Nigerian Standard for Drinking Water Quality, European Union (EU) and World Health Organization (WHO) threshold limits using standard analytical methods. The following Water quality parameters were examined: pH, electrical conductivity, colour, turbidity, total suspended solids (TSS), total dissolved solids (TDS), dissolved oxygen, biological oxygen demand, chemical oxygen demand, HCO3-, Nitrite, Nitrate, and Sulphate. Others are Sodium, Potassium, Calcium, Magnesium, Iron, Manganese, Zinc Copper, Lead, Nickel, and Lead. The samples were found to be within the standard for the physical parameters: colour, taste, total suspended solids, total dissolved solids, turbidity, and electrical conductivity. The chemical quality parameters of all the water samples were found to be within standards for clean and safe drinking water and so are considered safe for human consumption; but for the fact that the pH values of all the five water samples (BHA, BHB, BHC, BHD & SW) were all below 6.5, ranging from 5.22-5.75. This suggests that all the water samples are acidic and therefore, need to be treated to render them fit and safe for consumption.*

**Keywords:** *Physico-Chemical Analysis, Drinking Water Quality, Borehole Water, Water Sources*

## INTRODUCTION

Water is among the basic natural sources of wellbeing essential for the continued existence of both plants and animals on earth (Ojo, Bakare, & Babatunde, 2005; Afolabi, T. A., Ogbuneke, & Ogunkunle, 2012; Kowther & Suaad, 2007). Although the major chunk of the earth's surface (71%) is made up of water (Tyler, 1991; Gleick, 2006), only 1% is accessible for human consumption (Lefort, 2006). Water found in lakes, streams, rivers, ponds, shallow aquifers, oceans, seas, ice caps, and glaciers, etc. is termed surface water (Chandra *et al.,* 2012), while groundwater is said to be Water that occurs below the water table and supplies springs, wells, and borehole (Jalali, 2005).

Ehlers and Kraft (2001) assert that unpolluted and uncontaminated water is odorless, colorless, and tasteless, but as a consequence of human and animal activities, it is usually contaminated with solid and human waste, effluents from chemical industries, and dissolved gases. Owamah (2019) posits that groundwater is the main water source for domestic and sometimes industrial uses in Nigeria, and it is mostly accessed through boreholes and shallow wells and used directly, without any form of quality testing or treatment. It is generally believed by rural dwellers that groundwater is clean and poses no threat to human health (Masoud *et al.*, 2018). On the other hand, Kowsalya *et al.* (2010) assert that the quality of drinking water has become greatly affected due to pollution of freshwater sources (rivers, lakes, and oceans). Studies by Mayback *et al.* (1989) reports that pollution of freshwater sources has occurred mainly due to three major reasons: contamination by excess nutrients from sewage wastes from industries, mining, and agriculture. Drinking-Water sources are polluted by chemicals from industrial processes and agrochemical applications while physical contaminants result from erosion and (WHO 2004) disposal of solid wastes. Other sources of groundwater pollution are the improper application of fertilizers, pesticides, insecticides, herbicides, animal manures, stormwater drains that discharge chemicals to groundwater, careless disposal, and or storage of wastes (USEPA,2002). Worldwide, Water-related issues continue to be one of the main causes of health problems (Envuladu, *et al.*, 2012).

Human health depends to a large extent on quality safe and clean water available in adequate quantities (Khatoon & Pirzada, 2010; Oyedeji, Olutiola, & Moninuola, 2010; Peh, Sorsa, & Halamic, 2010). Furthermore, previous studies have shown that lack of access to safe and adequate water supply in part is responsible for illness and death mostly in children (Ishaku *et al.*, 2011). Public health protection and maintenance vitally depend on water quality control (Ishaku *et al.*, 2011). Groundwater constitutes the main source of domestic water supply in Okada since pipe-borne water is completely absent. Because the quality of drinking water is of paramount importance to human wellbeing, regular and periodic monitoring of water quality must be given the highest priority. The objective of this study was to investigate pertinent physical and chemical qualities of water samples from boreholes and streams in Okada Town, create public awareness of its status, and recommend possible remedies.

## MATERIAL AND METHOD

### A. Study Area

Okada Town is the administrative headquarters of Ovia North East Local Government Area of Edo State, with an area of 2,301km$^2$ and a population of 153,849 according to the 2006 census. It lies on the geographical coordinates of 6°44'0'' North, 5°23'0'' East in DMS (Degree Minutes Seconds). Okada is a warm-weather region with a subsequent high rate of consumption of drinking water.

### B. Sample Collection

Samples of water were collected from boreholes in four different areas in duplicate through a simple random sample selection of wells and from the only stream running through the town giving a total of five samples which were ultimately analyzed. The samples were coded BHA, BHB, BHC, BHD (for samples from boreholes), and SW (samples from stream water).

### C. Sample Preservation and Treatment

The samples were then taken to the laboratory and refrigerated at standard conditions (at 4 °C). All the apparatuses used for analysis were properly washed and rinsed and also all reagents used were of analytical grade. Standard methods of analyses were employed in the various physical and chemical parameter determination.

### D. Physical Analysis

Taste and odour of the samples were evaluated subjectively using 3-member laboratory specialized technicians alongside the researcher and standard operating procedure on water analysis as specified by NIS (2017). Colour was determined by using the Lovibond comparator (Oni, 1997). The total suspended solids (TSS) content and turbidity of each water sample were determined with the HACH portable colorimeter (Model DR/350) as described by APHA (1998). Conductivity was determined with a conductivity meter as described by APHA (1998) and the total dissolved solids (TDS) was determined by the Gravimetric method (APHA, 1998).
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#### E. Chemical Analysis

The pH of each water sample was determined by using the HACH pH meter (Hanna 8424) after standardization with buffer solution. Chloride was determined by the silver nitrate titrimetric method as described by APHA (1998). Phosphate was determined by the molybdate spectrophotometric method described by APHA (1998). Nitrate was determined by the spectrophotometric sodium salicylate method described by APHA (1998). Sulfate was determined by a titrimetric method described by APHA (1998). All other tests were done according to APHA (1998).

#### F. Determination of Metals

Traces metal (Manganese, Copper, Lead, Zinc, Chromium, Nickel, and Vanadium) concentrations were determined by the atomic absorption spectrophotometer (ass model-solar 969 unicam series) according to APHA (1998). Potassium, Sodium, Magnesium, and Calcium and were determined by standard AOAC (1984) methods, using the flame photometer. Iron was determined by a colorimetric method and ferrover iron powder pillow reagent was used as described by the HACH colorimeter manual.

## RESULTS AND DISCUSSION

### A. Selected Physical and Aggregate Parameters

Results of the selected physical parameters obtained in the four boreholes and one water sample are presented in Table 1.

Table-1 Selected physical properties of investigated bottled water brands from Okada Town

| S/N | Parameter | Water Sample/Standard | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | BHA | BHB | BHC | BHD | SW | RANGE | MEAN | WHO | NIS |
| 1 | Colour (TCU) | 5 | 5 | 5 | 5 | 5.7 | 5-5.7 | 5,14 | 15 | 15 |
| 2 | Total dissolved solids (TDS) (mg/L) | 22.5 | 26.3 | 26.2 | 25.1 | 54.8 | 22.5-54.8 | 30.98 | 500 | 500 |
| 3 | Electrical conductivity (µS/cm at 250°C | 45.8 | 57.9 | 52.6 | 50.3 | 108.7 | 45.8-108.3 | 63.06 | 1000 | 1000 |
| 4 | Turbidity (NTU) | 0 | 0 | 0 | 0.8 | 0 | 0-0.8 | 0.16 | 5 | 5 |
| 5 | Total suspended solids (TSS) (mg/L) | 0 | 0 | 0 | 1.4 | 0 | 0-1.4 | 0.28 | <30 | 30 |
| 6 | Taste | UTS | UTS | UTS | UTS | UTS | - | - | UTS | UTS |
| 7 | Odour | UTS | UTS | UTS | UTS | UTS | - | - | UTS | UTS |

UTS= Unobjectionable taste

**B. Colour, Odour, Taste, Total Suspended Solids, and Turbidity**

Result of the physical analysis (Table 1) show that all the water samples had the same colour content (5TCU), which was within the acceptable value of WHO/NIS of less than 15TCU. Neither odour nor taste was detected in any of the samples. 80% of the samples (BHA, BHB, BHC, and SW) had a turbidity value of 0 NTU and BHD representing 20% had a turbidity value of 0.8NTU which is far below the 5NTU stipulated by NIS and WHO. For total suspended solids, only BHD had a value of 1.4mg/L, meaning that all the samples conformed with existing standards whose threshold value is 30mg/L. These results suggest that based on the above parameters alone, all water obtained from the four boreholes and stream are not turbid and therefore, good for human consumption. The presence of particles such as silt, clay, and other forms of living micro-organisms and non-living materials found in water results in degradation in clarity (Rputheti, Okigbo, & Advanapu, 2008).

**C. EC and TDS**

Table 1 shows that the electrical conductivity (EC) of the samples ranged between (45.8-108.3µS/cm), having an average value of 63.06µS/cm. Sample SW had the highest electrical conductivity of 108.3µS/cm which is 9.3 times less than the NIS and WHO standard. EC is important because it is a measure of cations that affect the taste in no small way, and thus has a significant impact on the user acceptance of the water as potable (Rozoska, 1980; WHO, 2004). It was observed that the TDS values, on the other hand, appeared in the range of 22.5-54.8 mg/L with the mean of 30.98 mg/L. It is also observed 100% of the water samples (BHA, BHB, BHC, BHD & SW) had TDS values which were approximately half the magnitudes of their corresponding EC values. These kinds of coincidences among the EC and TDS values may point to a direct relationship between the two parameters.

## D. Result of Chemical Analysis

Table-2 Selected chemical properties of investigated water samples from Okada Town

| S/n | Parameter | Sample | | | | | Statistic | | Quality Standard | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BHA | BHB | BHC | BHD | SW | RANGE | MEAN | WHO | EU | NIS |
| 1 | pH | 5.38 | 5.75 | 5.43 | 5.54 | 5.22 | 5.22-5.75 | 5.46 | 6.5-8.5 | N/A | 6.6-8.5 |
| 2 | $Cl^-$(mg/L) | 8.6 | 4.4 | 9.9 | 7.1 | 8.1 | 4.4-9.9 | 7.62 | <250 | 250 | 250 |
| 3 | $PO_4^{2-}$ (mg/L) | 0.28 | 0.21 | 0.19 | 0.38 | 0.76 | 0.19-0.76 | 0.36 | <50 | N/A | 50 |
| 4 | $NO_3^-$ (mg/L) | 0.51 | 0.12 | 0.23 | 0.60 | 0.56 | 0.12-0.60 | 0.40 | <50 | 50 | 50 |
| 5 | $SO_4^{2-}$. (mg/L) | 0.46 | 0.36 | 0.28 | 0.33 | 5.63 | 0.28-5.63 | 1.41 | <10 | 250 | 100 |
| 6 | Iron (mg/L) | 0.21 | 0.14 | 0.26 | 0.91 | 0.18 | 0.14-0.91 | 0.34 | N/A | 0.02 | N/A |
| 7 | $K^+$ (mg/L) | 0.19 | 0.2 | 0.86 | 0.78 | 1.11 | 0.19-1.11 | 0.63 | <200 | N/A | 200 |
| 8 | $Na^+$ (mg/L) | 2.16 | 2.11 | 1.59 | 3.26 | 3.14 | 1.59-3.26 | 2.45 | <200 | 200 | 200 |
| 9 | $Ca^{2+}$ (mg/L) | 3.57 | 2.47 | 3.68 | 5.79 | 6.14 | 2.47-6.14 | 4.33 | <100 | N/A | 100 |
| 10 | Magnesium ((mg/L) | 1.35 | 1.57 | 1.29 | 2.03 | 2.55 | 1.29-2.55 | 1.76 | <0100 | N/A | 100 |
| 11 | Dissolved Oxygen (mg/L) | 7.1 | 6.2 | 6.8 | 6.2 | 5.8 | 5.8-7.1 | 6.42 | 6.0 | 5 | 8.0 |
| 12 | BOD (mg/L) | 0.8 | 0.2 | 0.5 | 4.5 | 3.1 | 0.2-4.5 | 1.82 | <10 | N/A | 10 |
| 13 | COD ((mg/L) | 9.3 | 7.2 | 8.0 | 14.0 | 29.6 | 7.2-29.6 | 13.62 | <50 | N/A | 50 |
| 14 | $HCO_3^-$ (mg/L) | 6.1 | 18.5 | 6.1 | 80.5 | 36.5 | 6.1-80.5 | 29.54 | <200 | N/A | 200 |
| 15 | N02 (mg/L) | 0.01 | 0.009 | 0.012 | 0.032 | 0.018 | 0.009-0.018 | 0.016 | <3 | 0.5 | 0.1 |
| 16 | Mn (mg/L) | 0.01 | 0.02 | 0.06 | 0.09 | 0.04 | 0.01-0.09 | 0.044 | <0.4 | 0.05 | 0.2 |
| 17 | Cu (mg/L) | 0.009 | 0.004 | 0.007 | 0.018 | 0.009 | 0.004-0.018 | 0.0094 | <1.0 | 2.0 | 1.0 |
| 18 | Pb (mg/L) | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | <0.01 | 0.01 | 0.01 |
| 19 | $Zn^{2+}$ (mg/L) | 0.65 | 0.74 | 0.39 | 1.0 | 0.42 | 0.39-1.0 | 0.695 | <5 | | 3 |
| 20 | Chromium | 0 | 0 | 0 | 0 | 0 | 0 | - | <0.01 | 0.05 | 0.05 |
| 21 | Nickle | 0 | 0 | 0 | 0 | 0 | 0 | - | <0.01 | 0.02 | 0.02 |
| 22 | Vanadium | 0 | 0 | 0 | 0 | 0 | 0 | - | <0.01 | N/A | 0.01 |

## E. Chlorine, Phosphate, Nitrate, Nitrite, Phosphate, Sulphate, and pH.

From Table 2, Chlorine concentrations were found to be in the range 4.4-9.9 mg/l. The average concentration being 7.62mg/l. All the brands had values far lower than the 250 mg/l (WHO, 1983) permissible limit. Small amounts of chlorides are required for normal cell functions in plant and animal life (Igwemmar, Kolawole, & Okumoye, 2013).

Phosphate concentrations were found to range from 0.19-0.76 mg/l, with a mean of 0,36mg/L. All the samples had values far lower than 50mg/l (WHO, 1983) permissible limit. The concentration of nitrates in the water samples varies from a minimum of 0.012mg/l (Brand BHB) to a maximum of 0.60mg/l (Brand BHD) with an average concentration of 0.40mg/L. All of which are far below the WHO standard of 50mg/l. In general, vegetables are the main source of nitrate intake when the level in drinking water is below 10 mg/l. When nitrate level in drinking water exceeds 50 mg/l, drinking water becomes the main source of total nitrate intake. Water that is contaminated with nitrate proves harmful especially to infants causing methemoglobinemia otherwise called infantile cyanosis or blue baby syndrome if consumed (WHO, 2017). The average Nitrite concentration in the water samples was 0.016mg/l and the lowest was 0.009mg/l(BHB) with the w3highest being 0.018mg/l(SW). All the brands had values far lower that 851n 3mg/l (WHO, 1983), the lowest permissible limit for drinking water. pH is a measure of hydrogen ion concentration in water. Its values recorded in this work were between (5.22 – 5.75) as shown in table 1. This means that all the samples are acidic.100% of the samples (BHA, BHB, BHC, BHD, and SW) fall below 6.5 and therefore, outside the (WHO, 1983) permissible limit for portable water are there is a need to treat such water to render it fir and safe for human consumption. The pH value is an important index of acidity or alkalinity and the concentration of hydrogen ions in water (Murugesan, Ramu, & Kanna, 2006).

### F. Iron, Potassium, sodium, Calcium, Zinc, Manganese, Copper, Chromium, Cadmium, Nickel, Lead and Vanadium

A look at Table 2 shows that the concentration of iron in the water samples varied from a minimum of 0.14mg/L (BHB) to a maximum of 0.91mg/L (BHD). The Iron concentration in all the samples is below the NIS/WHO standard. The minimum daily requirement of iron is ranged from about 10 to 50 mg/day (FAO/WHO, 1988). It is vital in oxygen transport in the blood of all vertebrates and some invertebrate animals. Potassium concentrations were found to range of 0.19mg/l(BHA) to 1.11mg/l(SW). The average concentration being 0.63mg/l. All the brands had values far lower than the 200mg/l (WHO, 1983) permissible limit. The value of calcium was found in the range of 2.47mg/l to 6.14 mg/l. The average is 4.33mg/l. The values are below the 100 mg/l recommended by (WHO, 1983). Excess calcium contributes to the formation of kidney and bladder stones. Calcium plays a significant role in blood clotting, muscular contraction, and some enzymes assisting in metabolic processes. It functions as a coordinator among inorganic elements, such that when K, Mg, or Na are present in quantities beyond a particular limit in the body, Calcium assumes a corrective role (Fleck, 1976). Calcium also contributes to the hardness of water and may cause problems with laundering, washing, and bathing. The concentration of magnesium in the battled water samples varied from 1.29 mg/l(BHC) to a maximum of 2.55 mg/l (SW). The average concentration was 1.76 mg/L. All of which are far below the WHO standard of 100 mg/l. The concentration of Zinc in the water samples varied from 0.39 mg/l(BHC) to a maximum of 1 mg/l (BHD). All of which are far below the WHO/NAFDAC standard of 5.0 mg/l and 3 mg/L respectively. The trace metals Chromium, Cadmium, Lead, and Vanadium were not detected.

## CONCLUSION

Since ancient times humans have understood the importance of clean drinking water and have devised different techniques to improve its quality. Safe drinking water is first a public health issue and at the same time a human rights issue.

From this study, it can be said that borehole and stream water in Okada does have the quality of portable water-based on physicochemical analysis of most parameters evaluated, but because the pH values of all the water samples fall outside the WHO and NIS recommended range of 6.5- 8.5(indicating acidity, albeit slight), it can be concluded that overall Okada borehole and stream waterfall short of national and international standards, and can therefore constitute a health hazard. It is recommended that Okada ground and surface water should be processed to correct the pH before domestic consumption can be considered safe. The government at all levels should make a concerted effort to at least systematically provide potable water to the teeming population.

## CONFLICT OF INTEREST

We hereby state that no conflict of interest will arise in any form from the publishing of this research work.

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