

Physico-Chemical and Bacteriological Screening of Household Water Supplies in Selected Communities in Edo State, Nigeria

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Abstract

Over 70% of the earth crust is filled with water but access to potable water remains a global challenge. This study focused on ascertaining the level of potability of borehole water in Edo State, Nigeria, for human consumption. Two hundred and forty-three (243) borehole water samples were collected from nine sampling sites and analyzed for physical (pH, total solids, DO, COD and BOD), chemical (NO_3 , SO_4 , PO_4 , chloride and metallic ions) and bacteriological (total bacteria count and total coliform count) properties. The results were compared with standards prescribed by the World Health Organization and Federal Ministry of Environment, Nigeria. The values of all the physicochemical parameters of the borehole water analyzed in the study were below the limits recommended by FME and WHO. The bacteriological analysis of the water revealed that the total bacterial count ranged from 1.78 ± 0.33 to $3.92 \pm 0.32 \times 10^3$ cfu/ml while coliform counts ranged from 0.65 ± 0.32 to $2.75 \pm 0.20 \times 10^3$ cfu/ml. These values were above acceptable limits. Thus, the borehole water from the studied localities across the three senatorial districts are not considered fit for consumption and it is therefore recommended that home water purification such as boiling and filtration should be practiced among the inhabitants before consumption.

Keywords: water, physicochemical, parameters, borehole, potability

Резюме

Както е известно, над 70% от земната кора е покрита с вода, но въпреки това достъпът до питейна вода остава глобално предизвикателство. Това проучване е насочено към установяване нивото на преносимост на сондажната вода в щат Едо, Нигерия за консумация от човека. Двеста четиридесет и три (243) проби от сондажна вода са събрани от девет места и анализирани за техните физични (pH, общо твърди вещества, DO, COD и BOD), химични (NO_3 , SO_4 , PO_4 , хлорид и метални йони) и бактериологични (общ брой бактерии и общ брой колиформи) свойства. Резултатите са сравнени със стандартите, предписани от Световната здравна организация (СЗО) и Федералното министерство на околната среда (ФМОС), Нигерия. Стойностите на всички физикохимични параметри на сондажната вода, анализирани в проучването са под препоръчаните от ФМОС и СЗО граници. Бактериологичният анализ на водата показва, че общият бактериален брой варира от 1.78 ± 0.33 до $3.92 \pm 0.32 \times 10^3$ cfu/ml, докато колиформният брой варира от 0.65 ± 0.32 до $2.75 \pm 0.20 \times 10^3$ cfu/ml. Тези стойности са над допустимите граници. Ето защо, сондажната вода от изследваните находища в трите изследвани сенатски района не се счита за годна за консумация. Поради това се препоръчва на жителите преди консумация домашната вода да се пречиства чрез преваряване и филтриране.

Introduction

Despite the fact that 71% of water makes up the earth surface, a great number of the world's population lack access to potable water, which has contributed greatly to global outbreaks of diseases (Kelmendi *et al.*, 2018; Duressa *et al.*, 2019). According to the WHO (2017), approximately 30% of people all over

the world lack access to potable water. In addition, over six million deaths have been reported in the developing countries, resulting from illnesses caused by water-borne diseases (TWAS, 2002). The United Nations has been tasked with the responsibility of improving water quality but discharge of industrial and domestic effluents into water bodies has

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made it difficult to deliver potable water for man's consumption (Duressa *et al.*, 2019). The WHO and other donor organizations have collaborated with governments of most developing countries using various government intervention strategies to provide potable water through community water supply systems. However, the strategies have not been effective as a result of the ever-increasing human population, has led to inadequacy and inconsistency in the community water supply. The threats posed by the inadequacy and inconsistency in the community water supply have led the public to seek for alternative potable water sources whose availability does not guarantee potability (Emmanuel-Akerele and Francis, 2021). Nigeria is one of the countries in the world that has unsafe water supplies especially in the rural communities. Given the low quality of drinking water in Nigeria, millions of people have been trapped in the cycle of poverty and ill health, often rendering them unable to work or go to school due to water-related diseases, which are preventable (Adeyinka *et al.*, 2014). About 90 million people in Nigeria do not have access to safe drinking water and about 130,000 children under the age of five die every year from preventable waterborne diseases. Therefore, lack of access to safe water supply is a serious threat to the country (Adeyinka *et al.*, 2014). Boreholes, rivers, streams and wells are the water sources in most communities in Edo State. These water sources are posing a threat to public health as a result of source contamination, as fertilizer and pesticides used for farming are washed into the water bodies. Most of the cases of waterborne diseases are not always reported, except outbreaks of infectious diseases from hospital settings. Quality assessment of groundwater in Edo State has indeed been undertaken by some researchers (Adegbite *et al.*, 2018; Ogbeifun *et al.*, 2019). However, these studies have either been limited to specific locations/towns or hand-dug wells and not across the State. The objective of this study was to assess the quality of borehole water across the State with respect to the potable status following the collapse of the public water supply scheme on the basis of the three senatorial districts that make up Edo State in the State and characterizing its potability with regards to WHO guidelines.

Materials and Methods

Study Area

This research work was carried out in Edo state, Nigeria. Edo State is located between latitude 6°50'N, longitude 6.00'E and 152 meters' elevation

above the sea level. It has 18 local government areas (LGAs) in the three senatorial districts. A multi-stage sampling method was adopted with the Senatorial districts as primary. The secondary stage was the random selection of 3 local Government Areas from each Senatorial district, thereby bringing it to a total of 9 sampling stations across the state. The selected local government areas were Etsako west, Etsako Central, Etsako East, Ikpoba-okha, Oredo, Egor, Esan West, Owan West, Esan Central, Etsako East and Etsako West (Fig. 1).

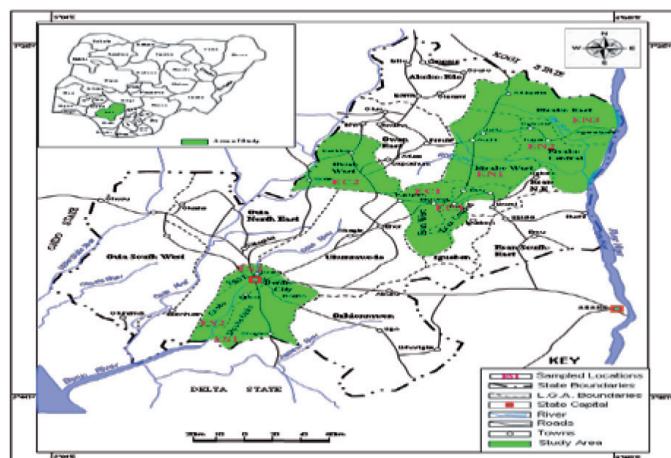


Fig. 1. Map of Edo State showing the sampling sites across the senatorial district

Sample collection

A total of 243 borehole water samples were collected directly from three different sampling borehole locations within the selected local government areas between January and August 2018 using sterile glass reagent bottles (250 ml). The bottles were filled with the borehole water, labelled and transported in an ice-packed container to the laboratory within 4 h of collection for physicochemical and bacteriological analysis.

Physicochemical analysis of the water samples

Physicochemical parameters and heavy metal compositions of the borehole water samples were carried out at the Nigerian Institute for Palm Oil Research (NIFOR) Benin City, Edo State, Nigeria. Samples were analysed following the procedures laid down by the World Health Organization (WHO). The pH, salinity and electrical conductivity, total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD), and chemical oxygen demand (COD) were determined at the point of collection using the HANNA combo (H198130) instrument by connecting the electrodes to each meter submerged in a clean beaker containing the sample according to the manufacturer's instruction. Other parameters such as nitrate,

sulphate chloride, phosphate, calcium, magnesium, sodium, iron, zinc, and copper were analysed at the chemistry laboratory section of the Nigerian institute for palm oil research (NIFOR). The presences of heavy metals were examined in a process whereby samples were digested with a concentration of 55% of nitric acid using an Agilent (240) FS flame atomic-absorption spectrophotometer (USA). This was achieved after the equipment was calibrated with set up standard solutions. Reagents and chemicals used for the study were of laboratory grade and used without additional purification processes (APHA, 1998).

Bacteriological analysis of the borehole water samples

Enumeration of total viable and faecal coliform counts was carried out using membrane filtration technique (Habash and Johns, 2009). A sterilised membrane filter of pore size (0.45µm) was used to filter 100 ml of each sample. The filter paper was then placed on solidified Membrane Lactose Glucoronide agar (MLGA) plate and then inverted. The plates were incubated at 37°C for 20 h and at 44.5°C for 24 h, respectively, for enumeration of total coliform and thermo-tolerant fecal coliforms (ASTM, 2012). Plates showing green and yellow colonies were counted as total coliform while plates showing green with yellow colonies were counted as thermo-tolerant fecal coliforms using a colony counter and expressed as Colony Forming Units (CFU) per 100 ml. Further tests were carried out using morphological, biochemical, and molecular techniques for proper identification of the isolates.

Statistical analysis

All analyses were performed in triplicates. The data were recorded as means $\pm$ standard deviation and analyzed using Microsoft Excel. One-way ANOVA was used to analyze the significant differences between their means. Differences between means at 5% significant level (P -value < 0.05) were considered.

Results and Discussion

The results of the physicochemical analysis of the borehole water samples from the nine sampling sites that cuts across the three senatorial districts in Edo State, Nigeria are presented in Table 1. They showed that there was no significant difference in the pH of all the borehole water in the sampling sites.

This slight acidic pH of all the borehole water samples was below the limits (6.5-8.5) recommended by local and International regulatory bod-

ies. This could be due to the presence of dissolved mineral leached into the water table. Ogbeifun *et al.* (2019) reported similar findings in respect to borehole water in Benin City, Edo State. The recorded values for electrical conductivities and total dissolved solids were below the limit (1000 µS/cm and 500 mg/l) recommended by local and International regulatory bodies. This showed that there is low dissolved inorganic salt in the water table. Electrical conductivity is related to the ionic content of the water, a function of the total dissolved solids concentration. Similar low electrical conductivity and total dissolved solids was reported in samples from Edo State (Iyasele and Idiata, 2011; Ogbeifun *et al.*, 2019). The BOD and COD values recorded in this study were not statistically significant in all the borehole water from the sampling sites (Table 1).

The recorded values were below the recommended limits. The highest mean $\pm$ SE values of BOD (2.93 ± 0.37) and COD (16.24 ± 0.24) were recorded in Edo Central. This can be attributed to the low organic material dissolved in borehole water (Efe *et al.*, 2005; Nduka *et al.*, 2008; Ogbeifun *et al.*, 2019). The results in Table 1 also show that there were significant differences in the nitrate content of all the borehole water in the sampling sites, although the values were generally below the recommended limit (10 – 20 mg/l). This revealed that there is low organic and inorganic material in the area that could contaminate the water table. Such results were in line with Ogbeifun *et al.* (2019) and Okereke *et al.* (2014), who reported low nitrate content in their study. The mean $\pm$ SE of the phosphate and sulphate in this study recorded as 1.46 ± 0.35 and 1.28 ± 0.24 were below the limit (5 mg/l and 2 – 3.5 mg/l) recommended by local and international regulatory bodies. The mean value of the phosphate and sulphate does not show any significant differences in all the borehole water from the sampling sites. The recorded mean $\pm$ SE values of the phosphate and sulphate were 1.46 ± 0.35 and 1.28 ± 0.24 , respectively, which were below the limit recommended by local and International regulatory bodies. This could be due to low contamination levels of these parameters in the source water.

The results in Table 2 showed the mean values of the metals and heavy metal ions contents of the borehole water samples from the nine sampling sites. Moreover, there was no significant difference in the zinc, iron, manganese, magnesium, calcium, chloride, carbonate contents of all the borehole water in the sampling sites. The mean $\pm$ SE values were below the limit recom-

Table 1. Physical and Chemical properties of the borehole water sample

Location/ Source	pH	EC μS/cm	TDS mg/l	DO mg/l	BOD mg/l	COD mg/l	PO ₄ mg/l	NO ₂ mg/l	SO ₄ mg/l
Edo North 1	5.26 ±0.27	286.82 ±0.42	137.42 ±0.14	5.91 ± 0.22	2.13 ±0.23	10.24 ±0.05	0.82 ±0.22	1.39 ±0.16	0.97 ±0.25
2	5.46 ±0.13	287.24 ±0.25	138.23 ±0.44	5.01 ± 0.06	1.63 ±0.41	9.39 ±0.09	0.16 ±0.43	0.72 ±0.26	0.10 ±0.14
3	5.60 ±0.42	286.42 ± 0.56	136.62 ±0.12	6.81 ± 0.51	2.63 ±0.02	11.09 ±0.11	1.48 ±0.11	2.06 ±0.55	1.84 ±0.08
Edo South 1	5.30 ±0.55	170.32 ± 0.42	85.53 ±0.15	5.74 ± 0.32	2.41 ±0.23	15.00 ±0.40	1.56 ±0.47	3.15 ±0.22	1.77 ±0.45
2	5.07 ±0.15	170.71 ± 0.33	86.26 ±0.42	6.24 ± 0.10	2.74 ± 0.25	15.30 ±0.32	1.23 ±0.36	3.61 ±0.56	2.09 ±0.27
3	5.51 ±0.26	170.36 ± 0.42	84.93 ±0.24	5.16 ± 0.18	2.08 ±0.27	14.70 ±0.12	1.89 ±0.43	2.69 ±0.32	1.45 ±0.06
Edo Central 1	5.41 ±0.44	116.83 ± 0.34	56.92 ±0.22	6.03 ± 0.31	2.93 ±0.33	16.24 ±0.02	2.01 ±0.56	3.89 ±0.09	1.11 ±0.40
2	5.86 ±0.38	117.35 ± 0.24	57.52 ±0.54	5.31 ± 0.12	3.54 ±0.22	15.74 ±0.47	2.33 ±0.27	3.04 ±0.29	0.72 ±0.30
3	4.96 ±0.54	116.36 ± 0.37	56.44 ±0.43	6.75 ± 0.23	2.32 ±0.55	16.74 ±0.22	1.69 ±0.30	4.74 ± 0.09	1.50 ±0.17
P- Value	0.8423	0.0934	0.1024	0.4834	0.2643	0.2334	0.0702	0.0000 ⁺	0.4543
FME Limits	6.5-8.5	1000	500	3.0	30	60	5.0	10	2.0
WHO Limits	6.5-9.0	1000	500	6.4	40	80	5.0	< 20	3.5

P-value significant at > 0.05

mended by local and international regulatory bodies. This could be due to the low level of dissolved metallic ions leached into the water underground table water since these ions are not known to be present in the study area. This finding was similar to the findings of Enuneku *et al.* (2018), who reported a low value of some trace metals in borehole water proximal to dumpsites, Benin City, Nigeria. The significant value of copper recorded in this study could be attributed to the wearing away of the pipes or brass taps leached from coatings into the water distribution channel. This metallic ion is known to cause serious gastrointestinal disorder and irritations, but its mean $\pm$ SE value of 0.13 ± 0.26 was below the limits (0.5 – 1.5) recommended by local and international regulatory bodies, which makes the water safe for consumption.

This finding was in agreement with Odiana and Edosomwan, 2019, Adekola *et al.* (2012), and Okereke *et al.* (2014), who reported low value of copper in borehole water from Edo State, Yola, Adamawa State and Uturu, Abia State.

Figures 2 and 3 present the bacteriological analysis of the borehole water collected from the different sampling sites in cfu $\times 10^3/100$ ml. The results showed that Edo North 2 had the highest TBC, which ranges from 3.60×10^3 to 4.24×10^3 while Edo South 3 had the lowest TBC, which ranges from 1.45×10^3 to 2.11×10^3 , respectively. Similar-

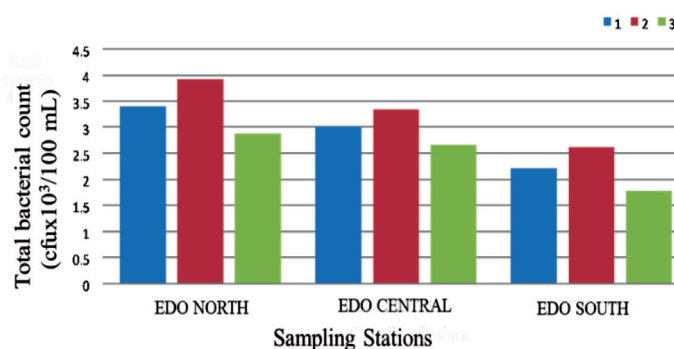


Fig. 2. Total bacterial count of the sampling locations within senatorial districts

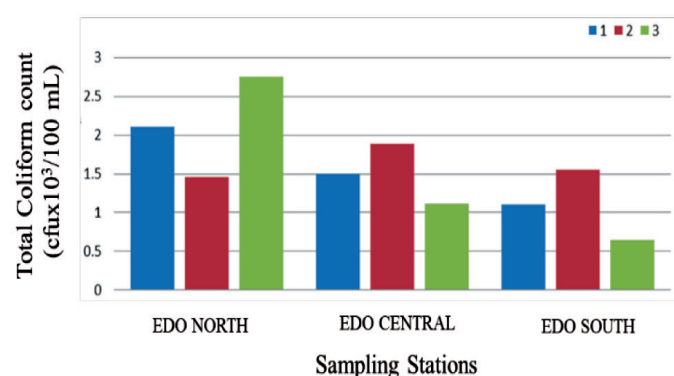


Fig. 3. Total coliform count of the sampling locations within senatorial districts

ly, Edo North 3 had the highest TCC which ranges from 2.55×10^3 to 2.95×10^3 while Edo South 3 had the lowest TCC, which ranges from 0.33×10^3 to 0.97×10^3 respectively.

Table 2. Concentration of metal ions (mg/l) in borehole water by sampling sites (M $\pm$ SE)

Location/ source	Zn	Cu	Fe	Mn	Ca	Na	Mg	Cl	HCO ion
Edo North 1	0.19 ± 0.50	0.03 ± 0.30	0.52 ± 0.23	0.04 $\pm$ 0.32	4.15 ± 0.20	1.83 ± 0.20	1.39 $\pm$ 0.08	56.64 ± 0.05	41.01 ± 0.44
2	0.18 ± 0.44	0.04 ± 0.15	0.42 ± 0.34	0.04 $\pm$ 0.02	3.19 ± 0.23	1.03 ± 0.34	0.41 $\pm$ 0.12	57.43 ± 0.10	41.23 ± 0.33
3	0.20 ± 0.52	0.02 ± 0.42	0.62 ± 0.09	0.05 $\pm$ 0.48	5.11 ± 0.54	2.63 ± 0.52	2.37 $\pm$ 0.02	55.85 ± 0.55	40.79 ± 0.12
Edo South 1	0.26 ± 0.06	0.03 ± 0.34	1.08 ± 0.16	0.17 $\pm$ 0.09	2.29 ± 0.21	1.14 ± 0.25	0.76 $\pm$ 0.30	52.08 ± 0.31	33.84 ± 0.17
2	0.25 ± 0.31	0.04 ± 0.09	1.17 ± 0.51	0.16 $\pm$ 0.16	3.18 ± 0.39	1.04 ± 0.09	0.99 $\pm$ 0.06	51.18 ± 0.07	34.74 ± 0.21
3	0.27 ± 0.25	0.02 ± 0.50	1.00 ± 0.25	0.17 $\pm$ 0.18	1.39 ± 0.22	1.24 ± 0.01	0.53 $\pm$ 0.03	52.98 ± 0.23	32.94 ± 0.16
Edo Central 1	0.44 ± 0.20	0.31 ± 0.35	1.35 ± 0.37	0.05 $\pm$ 0.32	2.36 ± 0.14	0.91 ± 0.48	0.83 $\pm$ 0.27	58.01 ± 0.41	34.90 ± 0.35
2	0.43 ± 0.28	0.08 ± 0.11	3.25 ± 0.50	0.04 $\pm$ 0.28	1.57 ± 0.50	1.31 ± 0.28	0.43 $\pm$ 0.52	57.13 ± 0.44	34.30 ± 0.08
3	0.45 ± 0.09	0.56 ± 0.08	1.44 ± 0.22	0.06 $\pm$ 0.37	3.15 ± 0.09	0.51 ± 0.11	1.23 $\pm$ 0.06	58.89 ± 0.30	35.50 ± 0.03
P- Value	0.0634	0.0000*	0.0902	0.1010	0.1403	0.2975	0.2722	0.9345	0.6732
FME Limits	15	1.5	0.3	0.5	200	100	150	600	< 20
WHO Limits	- 15	0.5 – 1.5	0.1-1.0	0.05- 0.5	- 200	200	- 150	- 600	- 30

P-value significant at > 0.05

These values of the TBC and TCC recorded in this study were above the recommended zero limits for drinking water (WHO, 1985). This could be attributed to contamination of the underground water table by leached sewage as septic tanks, latrines and soakaways are sited in closed proximity to the borehole in the study area. Such a high value of TBC and TCC is of great public health importance as consumption of microbiologically unfit water poses a menace of disease outbreak within a large number of human populations. This finding was in agreement with Onajite *et al.* (2018), Chidinma *et al.* (2016), Olajubu *et al.* (2014), Nwachukwu *et al.* (2013), Emmanuel-Akerele and Francis (2021), and Obi *et al.* (2011), who reported high number of total coliform and pathogenic bacteria in borehole water samples in Edo State and some parts of Nigeria.

Conclusion

From the findings above it can be said that despite the low physicochemical properties of the borehole water across the state, the waters are not safe for consumption because of the risk of water-borne diseases that may be linked to the high TBC and TCC recorded in the study. Thus, it is recommended that home water purification such as boiling and filtration should be practiced among the inhabitants before consumption. Also, sewage dis-

posing tanks soakaways and latrines should be sited at least 50 m away from the borehole in order to reduce sewage contamination of the borehole water.

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