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BACTERIOLOGICAL AND PHYSICOCHEMICAL ANALYSIS OF DRINKING WATER SOURCES IN SOME PARTS OF NNEATO IN UMUNNEOCHI LOCAL GOVERNMENT OF ABIA STATE, NIGERIA

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ABSTRACT

Many rural dwellers who drink water fetched from springs, rivers, and streams are at risk of experiencing waterborne diseases. This study investigated the bacteriological and physicochemical quality of drinking water sources in selected parts of Nneatọ in Umunneochi local government area of Abia state. A total of four water samples were obtained from ọhịị Ezioba spring (OES), ọhịị Ụmụacha stream (OUS), Iyi mbara river (IMR), and Obulụlọ river (OLR). The microbiological evaluations carried out on the water samples include total heterotrophic bacterial count (THBC) and total coliform count (TCC). Bacterial isolates were identified using conventional standard microbiological techniques. Physicochemical properties analysed include pH, conductivity, acidity, colour, chloride, magnesium, calcium, iron, suspended solids, turbidity and total hardness The result of the study revealed that the total heterotrophic bacterial count (THBC)for OES, OUS, IMR and OLR were 1.0×10^5 CFU/ml, 1.5×10^5 CFU/ml, 1.9×10^5 CFU/ml and 2.0×10^5 CFU/ml, respectively. The highest THBC was obtained in OLR while the lowest was encountered in OES. Total coliform count (TCC) of the water samples – OES, OUS, IMR, OLR were 28, 36, 710 and 1100 MPN/100 ml, respectively. OES has the lowest TCC while the highest TCC was observed in OLR. The percentage occurrence of the bacterial isolates includes Staphylococcus aureus (13.33%), Salmonella sp. (13.33%), Escherichia coli (13.33%), Klebsiella sp. (13.33%), Vibrio cholerae (13.33%), Enterobacter aerogenes (13.33%), Pseudomonas sp. (10%), and Shigella sp. (10%). The physicochemical properties were within the World Health Organization (WHO) limit, with the exception of colour (slightly clear), conductivity (500-685 µs/cm), acidity (0.4-0.8), and pH (4.02-5.30). THBC and TCC were equally above the WHO and National Agency for Food and Drug Administration and Control (NAFDAC) stipulated limits for water safety. The outcome of this study reveals that the sampled water sources were heavily contaminated with potential pathogenic bacteria and feacal matters as well as other agricultural waste materials. Thus, the water sources are unsafe for drinking and other domestic purposes. Therefore, public health enlightenment campaign through allforms of media, provision of alternative water sources such as borehole water with a treatment plant for the residents of Nneato town will avert the outbreak of waterborne diseases.

Keywords: Bacteriological quality, water, coliforms, pathogens, pollution, water scarcity

INTRODUCTION

Water is the second most vital need behind oxygen that sustain human life on earth (Ndubuisi *et al*., 2019; Chinyere *et al*., 2023). Two different sources of water in our planet are ground water stored beneath the surface of earth's aquifer, and surface water such as ponds, lakes, oceans etc. (Anyanwu and Ihediwa, 2015; Kiliç, 2021). Although the earth surface is dominated by 70% water, only 2.5% of it is freshwater. The rest have a high salinity, which makes it unsuitable for drinking, and domestic use (Isukuru *et al*., 2024). Out of approximately 3% fresh water, only 1% can be utilized as potable water, while 2% is not accessible because it exists as glaciers and polar ice caps (Anyanwu and Ihediwa, 2015; Wogu *et al*., 2023).

Despite the abundance of water on earth, water scarcity remains a big challenge to the global population. It is estimated that 3 billion persons worldwide will not have access to fresh water in 2050 (Manetu and Karanja, 2021). One of the fundamental human rights is the accessibility to clean and safe water (Atif *et al*., 2024). By 2030, it is expected that the human population denied access to basic sanitation, clean and safe will be reduced, in line with the goal 6 of the Sustainable Development Goals (SDGs), championed by the United Nations (Adamu *et al*., 2022). Growing world population, industrialization, extensive agricultural practices, and indiscriminate discharge of all kinds of waste into water bodies result in water pollution. Certainly, it has negative environmental and economic consequences (Goncharuk, 2013; George and Efiom, 2018; Eze *et al*. 2021). Water pollution has greater damaging effect in the environment compared to air and land pollution (Isukuru *et al*., 2024). The consequences of water scarcity, poor sanitation, and lack of access to safe water for drinking is worst in the undeveloped and developing countries, unlike the developed countries (Allaq *et al*., 2023; Shayo *et al*., 2023; Obueh et al., 2024).

Out of estimated population of 220 million Nigerians, more than 66 million persons lack access to pipe-borne water (Adamu *et al*., 2022; Imam *et al*., 2023). According to Okereke *et al*. (2022), the population of Nigerians who have access to drinking water is only 19%. It is alarming that only 42% of urban and semi-urban dwellers in Nigeria could make use of safe water daily, compared to 71% of rural dwellers (Isukuru *et al*., 2024). Consequently, several cases of water-related diseases caused by pathogenic bacteria, protozoa, and viruses occur among the population, majority of them unreported due to self-medication. The common diseases associated with drinking water contaminated with pathogens include cholera, typhoid, hepatitis, and dracunculiasis. Also included are viral diseases such as polio, hepatitis A, and hepatitis E infections (Forstinus *et al*., 2016).

Untreated water from rivers and streams are the main sources of drinking water in most rural communities in developing countries (Akinnibosun and Ugbawa, 2017). This ugly situation is largely responsible for the high rate of waterborne diseases and related health issues, which could lead to death in extreme cases (Some *et al*., 2021). Sadly, a lot of rural dwellers still believe that fetching drinking water from a flowing river and stream does not predispose them to diseases, having been the source of drinking water since they were born. Globally, streams and rivers are predisposed to fecal contamination (Ogeniyi, 2023). According to United Nations International Children's Emergency Fund (UNICEF), 26.5 % of Nigerians defecate in open places. This unhealthy practice contributes in polluting surface water bodies (Ogole and Oyelana, 2020). Illnesses linked to water are grouped into three categories namely water-borne illnesses, water-washed disease, and water-based disease (Forstinus *et al*., 2016; Oleiwi *et al*., 2020). Of the three groups, water-borne illnesses mainly as a result of poor sanitation, poor hygienic practices, and drinking untreated water is of critical importance

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(Manetu and Karanja, 2021). Globally, it is estimated that 2.2 million deaths occur annually out of 2.1 billion persons across the world that lack access to drinking water that is safe and clean (Shayo *et al*., 2023). The World Health Organization (WHO) estimated that 80% of human diseases reported across the world is associated with drinking unsafe water (Goncharuk, 2013).

The quality of drinking water in the three senatorial zones in Abia State, namely Abia North, Abia Central, and Abia South, were carried out by Okereke *et al*. (2022). The water sources include spring, stream, borehole, lake, and rain water. However, the study did not involve all the Local Government Areas (LGA) in Abia North Senatorial zone. Umunneochi LGA was excluded in the study. In other parts of the State, Wogu *et al*. (2023) assessed the quality of different sources water for drinking and domestic uses. In recent years, the population of people living in Nneato community, Umunneochi LGA has been on the increase (Ekene *et al*., 2023). Due to lack of access to treated borehole water, majority of the residents depend on *ọhịị* Ezioba spring water, *ọhịị* Ụmụacha stream, *Iyi mbara* river, and Obulụlọ river, as their sources of domestic and drinking water. Both stream and river have the same meaning, except in their sizes. Stream is smaller in size compare to river (Ndubuisi *et al*., 2019). They are categorized as surface water. On the other hand, spring water flows to the surface from groundwater, occasioned by the recharge of surface water (Balogun *et al*., 2013). According to Anyanwu and Ihediwah (2015), the intersection of ground surface and water supply give rise to spring. Bathing, washing of clothes, and other human activities are banned in the section of the *ọhịị* Ezioba spring, strictly for fetching drinking water. Imo river flows across many communities, where runoff from flood, and bushes where open defecation occurs, contaminate the flowing water before reaching Nneato. Despite the fact that the stream and rivers are flowing, relying on them for drinking water and other domestic use could pose a health risk to the community. Therefore, this study is aimed at assessing the bacteriological and physiochemical quality of water sources in some parts of Nneato in Umunneochi Local Government Area of Abia State.

MATERIALS AND METHODS

Description of source of water sample

The study area is Eziama Nneato in Umunneochi Local Government Area (LGA), Abia State. Figure 1 shows a google map of the study area (Ire *et al*., 2024). Four selected water sources which include *ọhịị* Ezioba spring water, *ọhịị* Ụmụacha stream, *Iyi mbara* river, and Obulụlọ river were sampled for analysis. Imo River source is located in Umudike Umuaku Community in Umunneochi Local Government Area of Abia state which cuts across three states (Abia, Imo, and Rivers). The *ọhịị* Ezioba spring water, located at Ndaji ugwu, *ịkpa* Ezịọba in Eziama, Nneato, is the source of *ọhịị* Ụmụacha stream. The spring water, rivers, and stream serves as sources of water for domestic uses and recreation. The predominate occupation of indigenes of Nneato is farming. The predominate occupation of the indigenes of Nneato is farming with an estimated population figure of 30,023 (Ezulike *et al*., 2017).

Sample collection

Four (4) sterile universal plastic bottles were gently lowered inside the spring, river, and stream until it was half-filled. The water collected was used to rinse the container before water samples was collected. The sampling bottle was lowered inside the water body to a depth of about 5 cm, was held in the neck and positioned upwards facing the flowing water until the container was filled. Immediately, the bottles were tightly corked and labeled. They were transferred into ice pack inside plastic coolers, and transported to the Laboratory for analysis.

Fig. 1. Google map of Umunneochi where the spring, stream, and rivers are located (Ire *et al*., 2024).

Sample preparation

The water samples were shaken vigorously before the cork was removed. One millilitre (1 ml) of each sample was transferred into 9 ml sterile peptone water in a test tube to obtain 10^{-1} dilution. With the aid of a sterile pipette, 1 ml from the stock solution was transferred into another test tube containing 9 ml sterile peptone water. Stepwise transfer into 9 ml sterile peptone was done using a sterile pipette for each transfer until 10^{-3} dilution was reached. A set of test tubes were dispensed with 9 ml sterile peptone water.

Determination of total heterotrophic bacterial count

A sterile pipette was used to transfer 0.1 mL of the diluted sample from dilution 10^{-2} and 10^{-3} into a solidified sterile nutrient agar. Each sample was inoculated in duplicates using the spread plate technique. The inoculated plates were inverted, and incubated at 37 ^{o}C for 48 hours. The number of colonies in each culture plate was counted, and the result was expressed in CFU/ml.

Determination of total coliforms

The most probable number (MPN) method described by Salman and Hamad (2011) with a slight modification was used to determine the total coliform count (TCC) of the water samples. It involves three stages namely the presumptive test, confirmed test, and complete test.

Identification of bacterial isolates

The bacterial isolates were identified using Gram staining, motility and biochemical tests which include catalase, oxidase, indole, citrate, triple sugar iron, methyl red and Voges-Proskauer test (Isu and Onyeagba, 2002; Shoaib *et al*., 2020).

Physicochemical analysis

Test for odour

Theodour of the water samples was tested using the procedure described by Adekanmi*et al.* (2020). Twenty millilitre (20 ml) of the water sample was poured into a beaker that has been properly cleaned. The water sample inside the beaker was agitated vigorously to check whether there is frothing. After 2 minutes, the water sample was allowed to settle. The water sample inside the beaker was

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observed under a bright light to check whether there was presence of particulate matter. The beaker was raised very close to the nose to test whether the water sample inside it has odour.

Test for colour

The same sample of water tested for odour was used to test the colour. The water sample inside the beaker was observed under a bright light and the colour observed was noted.

Determination of pH

The pH meter was calibrated using buffer 7.0 and 4.0. Thereafter, the pH electrode was inserted into the water sample and left for 15 minutes to stabilize. The reading in the pH meter was recorded. The procedure was repeated and the average was recorded (Akpen*et al*., 2018).

Determination of calcium

The calcium content of the water samples was determined using the procedure described by Abdullahi *et al*. (2019). Exactly 50 ml of water sample was measured and poured inside a conical flask. Thereafter, 2 ml of 1.0 N NaOH and aliquot of meroxide indicator was added. The mixture was titrated with 1 M ethylenediamine tetra acetic acid (EDTA). The concentration of calcium in the water samples expressed in mg/L was calculated using the formula below:

$$\text{Calcium (mg/L)} = \frac{ml\ of\ EDTA\ x\ N\ x\ 40.08\ x\ 1000}{ml\ of\ sample}$$

Where: ml of sample = 50 ml; normality of EDTA = 0.1 M

Determination of magnesium

The concentration of magnesium in the water sample was determined by subtracting the value of calcium content from that of total hardness (Abdullahi *et al*., 2019).

Determination of chloride

The method described by Abdullahi *et al*. (2019) was adopted. It involves the use of silver nitrate titrimetric method. Exactly 100 ml of each water sample was poured into a conical flask. Three drops of 10% potassium chromate indicator was added to the sample. The mixture was titrated against 0.02 N silver nitrate until a reddish tinge colour was observed which indicate the end point. The control (blank) used for the titration is distilled water. The concentration of chloride in the sample was calculated using the formula below:

$$\text{Cl (g/L)} = \frac{(A-B)\ x\ N\ x\ 35.45}{Volume\ of\ sample} \quad \text{x } 1000$$

Where: A-Titre value of sample

B – Titer value of distilled water

N-Normality of silver nitrate

Determination of iron

What is contained in the HACH DR/2000 spectrophotometer manual was followed in line with the FerroVer method. Before testing the sample, adjustment of the meter to mg/Fe Fv´ was made. The method described by Akpen *et al*. (2019) was adopted. Deionized water measuring 25 mL was poured in the sample cell i.e. the blank, positioned in the cell holder, and the display adjusted to 0.00 mg/L Fe Fv. Exactly 25 mL of the water sample was poured in another sample cell. Thereafter, what is contained inside one FerroVer reagent powder pillow was emptied inside the water sample and swirled to ensure proper mixing.

Total suspended solid

This test was performed was performed using a spectrophotometer. Twenty five milliliter (25 ml) of the water sample was dispensed into a curvette and placed in the light chamber. The absorbance of the sample was read using the spectrophotometer at wavelength 810 nm and distilled water as the blank.

Total acidity

Exactly 25 ml of the water sample was measured, and phenolpthalene was used as an indicator acid. The sample was titrated against 0.02 M of NaOH and colour change was observed.

Conductivity

A conductivity meter was used to determine the conductivity of the water samples using the procedure described by Abdullahi *et al*. (2019). Distilled water was used to rinse the probe of the conductivity meter before it was inserted into the water sample. It was allowed to remain inside the water sample for 2 minutes before taken the readings.

Turbidity

A potable turbidity meter (Model TN-100/T-100) was used to determine the turbidity of the water samples following the instruction in the manual. Distilled water was used to calibrate the meter. Thereafter, the water sample was carefully position inside the cell holder. One finger was used to press the enter key which commanded the equipment to measure the turbidity of the water sample. The reading observed was recorded in NTU (Akpen *et al.*, 2018).

Total dissolved solids

The total dissolved solids in the water samples were determined using HACH TDS/Conductivity meter. About 100 ml of the water sample was poured into a beaker. The electrode probe of the TDS meter was rinsed with deionized water before it was inserted into the water sample. After 2-3 minutes, the reading in the display screen was recorded in mg/L (Abdullahi *et al.* 2019).

Total hardness

The procedure describe by Abdullahi *et al.* (2019) was adopted. It involved the use of titrimetric method. Exactly 50 ml of the water sample was poured into a 250 mml Erlenmeyer flask and 1 ml of NH_4Cl-NH_4OH buffer solution was added. The mixture was gently mixed. Thereafter, 8 drops of Eriochrome Black-T indicator was added to the mixture and titrated with ethylenediamine tetra acetic acid (EDTA) solution. At the end point, the solution changed from wine-red colour to blue.

$$\text{Total hardness (mg/L)} = \frac{(A)\ X\ N\ x\ 1000}{Sample\ volume\ in\ ml}$$

Where: A = Titre value; N= Normality of EDTA; Sample volume is 50 ml

RESULTS

This study revealed that the *ọhịị* Ezịọba spring had the lowest bacterial count (1.0×10^5 CFU/ml), while the highest bacterial count (2.0×10^5CFU/ml) involved Obulụlọ river (Figure 2). Total coliform count of water from the different sources is presented in Table 1. The result shows that Obulụlọ river had the highest total coliform count (1100 MPN/100 ml), followed by *Iyi mbara* river (710 MPN/100 ml), while *ọhịị* Ezịọba spring had the lowest coliform count (28 MPN/100 ml).

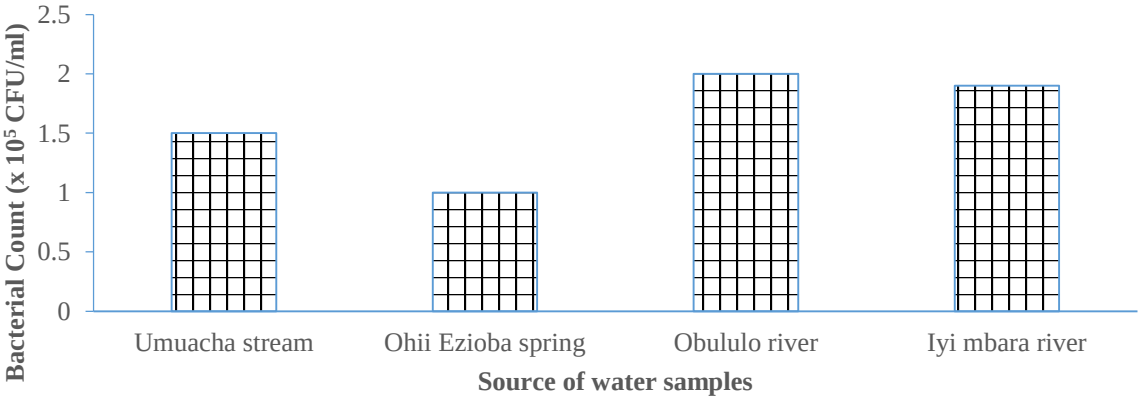

Fig. 2. Total heterotrophic bacterial count of water from different sources.

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Table 1: Total coliform count of water samples.

Sample code	MPN/100 ml	WHO Std. (MPN/100 ml)	EPA Std. (MPN/100 ml)
OUS	36	0	0
OES	28	0	0
OLR	1100	0	0
IMR	710	0	0

Key: OUS- *Ọhịị* Ụmụacha stream; OES-*Ọhịị* Ezịọba spring; OLR- Obulụlọ river; IMR- *Iyi mbara* river; MPN-Most probable number; WHO-World Health Organization; EPA-Environmental Protection Agency

Table 2 shows the bacterial species isolated from the water samples. The result indicated that the *Ọhịị* Ezịọba spring, *Ọhịị* Ụmụacha stream, Obulụlọ river, and *Iyi mbara* river harbour similar bacteria species. The result from this study shows that 6 out of 8 bacterial species were present in the four water sources. They include *Staphylococcus aureus, Salmonella* sp., *Escherichia coli*, *Klebsiella* sp., *Vibrio cholerae*, and *Enterobacter aerogenes*. However, *Pseudomonas* sp. and *Shigella* sp. isolated from the rivers and stream were absent in *Ọhịị* Ezịọba spring.

Table 2: Bacterial species isolated from the water samples

Isolates	Sample OUS	Sample OES	Sample OLR	Sample IMR
Staphylococcus sp.	+	+	+	+
Salmonella sp.	+	+	+	+
Shigella sp.	+	-	+	+
Escherichia coli	+	+	+	+
Enterobacter aerogenes	+	+	+	+
Pseudomonas sp.	+	-	+	+
Klebsiella sp.	+	+	+	+
Vibrio cholerae	+	+	+	+

Key: OUS- *Ọhịị* Ụmụacha stream; OES-*Ọhịị* Ezịọba spring; OLR- Obulụlọ river; IMR- *Iyi mbara* river; + indicate the presence of bacterial specie; - indicate the absence of bacterial specie

Table 3 shows the physicochemical properties of water samples obtained from the water samples. The results for all the physicochemical properties of *Ọhịị* Ezịọba spring had the lowest values compared with the stream and two rivers, with the exception of acidity and iron content. On the contrary, water sample from Obulụlọ river and *Iyi mbara* river had the highest values in all the physicochemical parameters, with the exception of pH, total suspended solids, acidity, Ca^{2+} hardness, and iron content.

Table 3: Physicochemical properties of water samples.

Parameters	Sample OUS	Sample OES	Sample OLR	Sample IMR	WHO Standard
pH	5.30	4.02	5.11	5.03	6.5-8.5
Conductivity (µs/cm)	670	500	685	600	500
Colour	Slightly clear	Slightly clear	Slightly clear	Slightly clear	Clear

Odour	No odour	No odour	No odour	No odour	No odour
Turbidity (NTU)	0.4	0.04	0.46	0.36	5
TDS (mg/L)	375	360	380	390	500
TSS (mg/L)	85	65	80	77	1000
Acidity	0.4	0.8	0.8	0.7	0.3
Total hardness	82	75	100	100	500
Ca^{2+} hardness	40	35	40	40	75
Mg^{2+} hardness	42	40	60	50	20-125
Chloride (mg/L)	8.8	6.4	82	80	250
Iron (mg/L)	0.2	0.3	0.3	0.3	0.3

Key: OUS- *Ọhịị* Ụmụacha stream; OES-*Ọhịị* Ezịọba spring; OLR- Obulụlọ river; IMR-*Iyi mbara* river; TDS-Total dissolved solids; TSS-Total suspended solids; WHO-World Health Organization; NTU-Nephelometric turbidity unit

DISCUSSION

The total heterotrophic bacterial count (THBC) of water sample from *Ọhịị* Ụmụacha stream (1.5 x 10^5 CFU/ml) is higher than theresult reported by Okonko *et al*. (2008) in a related study. According to the researchers, the THBC of Somorin and Alabata stream is 1.5-1.9 x 10^4CFU/ml and 1.0-1.2 x 10^4 CFU/ml, respectively. The coliform count of Somorin stream (44 MPN/100 ml) ishigher than the *Ọhịị* Ụmụacha stream (36 MPN/100 ml). This is not the case with the Alabata stream (24 MPN/100 ml). This result could be attributed to bathing that takes place inside the river and farming activity going on close to the river. On the contrary, water samples from *Ọhịị* Ezịọba spring had the lowest total coliform count (TCC) and total heterotrophic bacterial count (THBC) of 28 MPN/100 ml and 1.0 x 10^5 CFU/ml, respectively. In a related study, Balogun *et al*. (2013) reported that during the peak of rainy season, Omi-Iduspring and Arae spring had the highest and lowest THBC of 4.0 x 10^6 and 0.47 x 10^6 CFU/ml, respectively. During the peak of dry season, Isunpaiye spring and Agadagidi spring had the highest and lowest THBC of 0.84 x 10^6 and 0.14 x 10^6 CFU/ml, respectively. In terms of TCC of the spring water samples determined during the rainy season using the multiple tube fermentation technique, the researchers also reported that the Isunpaiye spring and Agadagidi spring had the highest (76±2.1 MPN/100 ml) and lowest (5.1±2.1 MPN/100 ml) values, respectively. During the dry season, Omi-Idu Spring and Agadagidi spring had the highest (60±1.3 MPN/100 ml) and lowest (5.1±2.6 MPN/100 ml) values, respectively.

The ban enforced by the community against bathing, washing clothes, processing of local foods such as *abacha*, and other human activities at the takeoff point of the *Ọhịị* Ezịọba spring, except fetching the water for drinking, could be responsible for the low THBC and TCC reported in this study. The pollution of these water bodies could also be as a result of farming activities and human traffic around the location of these water bodies as some of them are located along the major roads in Nneato. However, the THBC and TCC of the spring, stream, and rivers in this study exceeded the WHO and EPA limit (Bukar *et al*., 2015). The National Agency for Food and Drug Administration and Control (NAFDAC) stipulate that the maximum total heterotrophic bacterial count of drinking water is 104 CFU/ml (Abasiekong *et al*., 2016). According to the guideline stipulated by the regulatory body, thermotolerant coliform bacteria must not be detected in 100 ml of drinking water (Edema *et al*., 2011). The Nigeria Standard of Drinking Water Quality (NSDWQ) requirement for safe water is 10 total coliform count per 100 ml of water (Isa *et al*., 2013). The presence of coliforms and

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potential pathogenic bacteria in the water makes it unsafe for drinking. In a related study, Eze *et al*. (2021) reported that fecal coliform count of Onuiyieke river in Imo state, exceeded the WHO limit (0.5 MPN/100 ml).

Bacterial species isolated from the spring water, stream, and two rivers are *Staphylococcus* sp., *Salmonella* sp., *Escherichia coli, Enterobacter aerogenes, Klebsiella* sp., *Vibrio cholerae, Shigella* sp., and *Pseudomonas* sp. The presence of these organisms in the drinking water consumed by residents of Nneato community is a public health risk. According to Otorkpa (2019), these microorganisms have been reported in the drinking water sources in Nigeria. All the microorganisms isolated from the water samples are coliforms, except *Vibrio cholera* and *Pseudomonas* sp. According to the WHO guideline, the absence of total coliforms is a requirement for water to be safe for drinking. The presence of coliforms in the water samples is an indication that other microorganisms reported in this study could be pathogenic (Meride and Ayenew, 2016).

Klebsiella sp. is associated with urinary tract infections (UTIs), septicemias, and soft tissue infections. *Staphylococcus aureus* is commonly implicated in pleuropulmonary bacteremia, infective endocarditis, osteoarticular, skin and soft tissue. *Enterobacter aerogenes* are usually present in the gastrointestinal tract of humans. Generally, the bacterium is not responsible for disease condition in healthy individuals, but the bacterium could cause opportunistic infections. The presence of *Escherichia coli* in drinking is an indicator of feacal contamination. Although most strains of *E. coli* are not harmful, *E. coli* O157:H7 could manifest severe symptoms in humans which include vomiting and diarrhea. *Salmonella typhi* is responsible for typhoid fever frequently reported by many Nigerians. The disease is spread by drinking water and eating food contaminated with the bacterium. Globally, it is estimated that 16 million cases and 600,000 deaths occur annually due to typhoid fever. *Shigella* sp. is the causative agent of shigellosis. Globally, the estimated number of cases and casualties recorded every year is 163 million and 1.1 million, respectively. *Vibrio cholerae* is a bacterium responsible for cholera. *Pseudomonas aeruginosa* is implicated in blood stream infections which could lead to death. Immunocompromised individuals are predisposed to infection caused by this bacterium (Otorkpa, 2019).

The pH of the water samples within the range of 4.02-5.30 did not meet the WHO standard. This result is in agreement with the report by Okereke *et al.* (2022). The researchers reported that the average pH of different sources of water from Abia north, Abia central, and Abia south senatorial zones is 5.12±0.950, 5.45±0.737, and 4.49±0.550, respectively. The WHO guideline in terms of pH is not based on health, rather to minimize corrosion during distribution of water in pipes to various homes.

Physical observation of the water samples show that it has a slightly clear colour. This result did not conform to the WHO standard, that potable water should be clear. A slightly clear water is a sign that the water is unfit for drinking. On the contrary, a clear water does not mean it is safe for drinking, without carrying out further analysis.

The chemical parameters of all the water samples which include total dissolved solids, total suspended solids, turbidity, total hardness, Ca^{2+} hardness, Mg^{2+} hardness, chloride, and iron content were within the WHO limit. This result is substantially in agreement with the report by Okereke *et al.* (2022). The acidity and conductivity of water samples from *Ọhịị* Ụmụacha stream and *Ọhịị* Ezịọba spring were below the WHO limit, respectively. This is contrary to the result reported for water samples from other sources.

CONCLUSION

Drinking water from the *Ọhịị* Ụmụacha stream, *Ọhịị* Ezịọba spring, Obulụlọ river and

Iyi *mbara* river is slightly clear and harbours potentially pathogenic organisms. Most of the physicochemical parameters of the rivers and stream are within the WHO standard. Although the total heterotrophic bacterial count, total coliform count, and most of the physicochemical parameters of *Ọhịị* Ezioba spring stream had lower values compare with the rivers, the four water sources are not fit for drinking. It is imperative that human activities in the water and surrounding environment should be highly regulated the microbial contamination which ultimately led to water pollution. Moreso, open defecation around the location of these spring, stream and rivers should be totally prohibited with adequate enlightenment campaign through intentional media campaigns (traditional and social media) on the health hazards posed by such attitude.

Furthermore, government and non-governmental agencies should take urgent steps to provide a borehole and water treatment plant for residents in Nneatọ town, in order to provide alternative potable water for the populace. This will help to discourage them from fetching water from the rivers and stream for drinking and other domestic purposes. These strategies and interventions will avert the potential outbreak of waterborne diseases in the community and save lives.

Competing interests

The authors declare that no competing interest exist.

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