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Physicochemical, mineral and heavy metal compositions of four water sources within and outside Evangel University, Akaeze Take-Off Campus, Okpoto in Ebonyi State, Nigeria

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Abstract

Water pollution involves the introduction or leakage of toxic substances into water bodies thereby making them unsafe for consumption due to the resultant adverse effect on health. The study evaluated the physicochemical properties, minerals, and heavy metal contents of four water sources used for drinking, bathing, washing, and so on, by inhabitants of Okpoto community living around Evangel University (EU) Take-off Campus, Okpoto, Ebonyi State Nigeria. Two of the water sources were a bore hole and a stream within EU Campus, while the other two were collected from a hand pump and another stream outside EU Campus. Standard methods were used to determine the physicochemical properties, mineral and heavy metal contents of the four water samples. The results showed normal pH values for EU bore hole and stream only, lower values were obtained for total hardness, dissolved oxygen (DO), chemical oxygen demand (COD) and biological oxygen demand (BOD) in the four samples compared to the World Health Organization (WHO), Federal Environmental Protection Agency (FEPA) and United States Environmental Protection Agency (EPA) standards for drinking water. Also, lower than the standard values were found in minerals like magnesium, chloride, nitrate, phosphate and sulphates, and heavy metals like iron and copper in the four water sources. Chromium concentrations in the samples were higher than the standards except in EU bole hole. Cadmium was not found in EU bore hole and stream. The results showed that the borehole and hand pump were safer for drinking and cooking than the two streams, with EU bore hole being better. However, none of the four water sources met all the WHO, FEPA and EPA standards for drinking water. Hence, further purification processes such as boiling, filtration, addition of water guards, and so on, should be carried out to make the water sources safer for consumption.

Keywords: Evangel University, Water sources, Physicochemical properties, Mineral contents, Heavy metal contents

Introduction

Water is one of the most important of all natural resources known on earth. It is important to all living organisms, most ecological systems, human health, food production and economic development [1]. Many congenital diseases such as goiter and cancer have been associated with presence of high concentration of a chemical or its inadequate supply in water [2]. Currently, about 20 % of the world's population lacks access to safe drinking water, and more than 5 million people die annually from illness associated with safe drinking water or inadequate sanitation[3]. If everyone had safe drinking water and adequate sanitation services, there would be 200 million fewer cases of diarrhea and 2.1 million fewer deaths caused by diarrheal illness each year [3]. As water is one of the most important compounds of the ecosystem, but due to increased human population, industrialization, use of fertilizers in the agriculture and man-made activity; the natural aquatic resources are causing heavy and varied pollution in aquatic environment leading to pollute water quality and depletion of aquatic biota. It is therefore necessary that the quality of drinking water should be checked at regular time of interval, because due to use of contaminated drinking water, human population suffers from diverse water borne diseases.

It is difficult to understand the biological phenomena fully because the chemistry of water reveals much about the metabolism of the ecosystem and explain the general hydro-biological relationship [4]. Water is one of the principal natural resources for the survival of mankind. With the ever-increasing population and simultaneously decrease of surface water resources, groundwater resources have become more important. A number of water quality parameters are measured to determine water quality. These parameters include physical properties such as pH, total suspended solids, temperature, and chemical properties like chemical oxygen demand, (COD), biological oxygen demand (BOD), dissolved oxygen [5].

Evangel University, Akaeze (EUA) is a private University owned by the Assemblies of God Nigeria. The take-off Campus of the University is presently located at Kilometre 48, Enugu-Abakaliki Expressway, Okpoto, Ebonyi state, Nigeria. Okpoto is situated in the northeast of Okopoto-Agu. It is a village in Ishielu Local Government Area of Ebonyi State, Nigeria. It is a village where people live, school and work. Okpoto has a Latitude of 6º 21' 41" N and a Longitude of 7º 51' 50" E. It's Latitude and Longitude dec. is 6.36139,7.86394 with an Elevation of 109 metres (358 feet). The study was carried out on four water sources in Okpoto, comprising of a bore hole and a stream in Evangel University Campus, and a hand pump and another stream outside the University Campus, which indigenes of Okpoto community living around the University fetch for drinking, cooking washing and so on. There was need to ascertain the safety of these water sources for drinking and cooking owing that Okpoto is endowed with some natural deposits such as minerals, including rocks where limestone and gravels are quarried. There has not been any prior research on the physicochemical, mineral and heavy metal compositions of the water sources in Evangel University, Akaeze, Okpoto Campus and its immediate environment. Hence, this study is aimed at bridging this gap.

Materials and Methods

Equipment: The equipment used in the study include: atomic absorption spectrophotometer (BUCK 210 VGP), spectrophotometer (JENWAY 7315), hot plate, electronic weighing balance (Golden-mettler U.S.A), BOD incubator, conductometer (Metla tolledo), pH-meter (metla tolledo meter model 210), refrigerator (Haier thermocool; HTF-429H), ceramic crucible, heating mantle, retort stand, spatula, burette, pipette, beakers, Kjeldahl flask, Erlenmeyer flask, volumetric flasks, conical flask, measuring cylinder.

Chemicals/ Reagents: The chemicals/ reagents used in the study were of analytical grades: bromocresol green, silver nitrate ($AgNO_3$), manganese (ii) salt, iodide-azide, hydroxide, sodium thiosulphate ($Na_2S_2O_3$), manganese sulphate, sulphuric acid, tin (ii) chloride, ammonium molybdate, sodium hydroxide (NaOH), ammonium chloride, ferrous ammonium sulphate, phenanthroline ferrous sulphate, potassium dichromate ($K_2Cr_2O_7$), sulphamic acid (NH_2SO_3H), eriochrome black T, EDTA, phenol disulphonic acid, barium chloride, calcium carbonate ($CaCO_3$), alkali-iodide-azide, alkaline potassium iodide solution, calcium chloride ($CaCl_2$), starch indicator, ammonia buffer solution, nitric acid (HNO_3), phosphoric Acid (H_3PO_4), hydrochloric acid (HCl).

Methods

Collection of Water Samples

Four water samples were respectively collected from four different water sources in Okpoto community of Ishielu Local Government Area, Ebonyi State, Nigeria. Two samples were from a borehole and a stream within Evangel University, Akaeze (EUA), Okpoto Take-off Campus; while the other two samples were from a hand pump and a stream outside, but close to the University Campus. The fresh sample of each water source was collected in a clean 75 cl bottle and adequately covered and used for the various analyses. Samples were collected in August 2022.

Physio-Chemical Analyses

The physicochemical parameters (pH, total acidity, total alkalinity, total solid (TS), total dissolved solid (TDS), total suspended solid (TSS), dissolved oxygen (DO), chemical oxygen demand (COD) and biological oxygen demand (BOD)) were determined based on AOAC Official Methods as reprinted by Williams [6].

Determination of Minerals and Heavy Metals

The minerals and heavy metals (potassium, magnesium, phosphorus, iron, copper, lead, chromium, cadmium and arsenic) were determined using Atomic Absorption Spectrophotometer (AAS) after acidic digestion [6], while chloride, nitrate and sulphate were determined based on AOAC Official Method as reprinted by Williams [6].

Statistical Analysis

The statistical analysis of the results obtained was done using SPSS version 23. Means were compared by one-way Analysis of Variance (ANOVA) followed by Ducan's multiple range test procedures of SAS software version 9.1. All the results obtained were expressed as mean ± Standard Deviation (S.D.) of three replicates of each sample, and the differences between means were regarded as significant at $P < 0.05$.

Results

Physicochemical Properties

Table 1 shows the results of the physicochemical properties of four water sources within and outside Evangel University Campus of Okpoto community in comparison with the World Health Organization (WHO) [7], Federal Environment Protection Agency (FEPA) [8] and United States Environmental Protection Agency (EPA) [9] standards for drinking water. The pH of EU bore hole (7.04) and stream (6.43) were within the WHO, FEPA and EPA pH standards for drinking water, while the hand pump (5.73) and stream (5.96) outside EU were lower than these standards. The conductivities of the four samples were below the WHO standard of 1000 µS/cm. The conductivity of the hand pump was highest at 800 µS/cm followed by the two streams at 600 1000 µS/cm and least by that of the bore hole (300 1000 µS/cm). While their acidities were above the 50 mg/l recommended level for EPA, their alkalinities were within the normal values for WHO and EPA standards of 50 – 500 mg/l. The values of total hardness were 151.20 and 90.07 mg/l for EU bore hole and stream, 120.18 and 54.97 mg/l for hand pump and stream outside EU Campus, which were below the WHO standard of 199 – 200 mg/l. For total solid

(TS), only the hand pump with 5430.33 mg/l was up to and above WHO value of 5000 mg/l but far above EPA value of 500 mg/l. Next is EU bole hole with TS of 431.00 mg/l which is close but less than EPA value. Total dissolved solids (TDS) were highest in EU stream (2625.67 mg/l), followed by EU bore hole (1036.33), outside EU stream (995.00 mg/l) and hand pump (778.00 mg/l). While only EU stream was up to 2000 mg/l FEPA value, others were over 500 mg/l WHO and EPA values. None of the water samples was up to FEPA (30 mg/l) and EPA (80 mg/l) values for total suspended solids but were all less than 1.00 mg/l which is comparable to 0 mg/l of WHO. The values of dissolved oxygen (DO) and chemical oxygen demand (COD) for the four samples were less than the standard values for FEPA and EPA. However, apart from EU stream, the values of the biological oxygen demand (BOD) for the samples were higher than the EPA value of 4 mg/l but were all lower than 50 mg/l of FEPA.

Mineral Contents

Table 2 shows the result of the mineral contents of the various water samples within and outside EU Campus Okpoto community. The potassium concentrations for the four water samples were close to the WHO of 0 mg/l. The concentrations of magnesium, chloride, nitrate, phosphate and sulphates were lower than WHO, FEPA and EPA standards. While phosphorus concentrations in all the four samples were above 0.1 mg/l EPA standard, only that of EU bole hole (10.17 mg/l) was up to and above the FEPA standard (5 mg/l).

Heavy Metal Contents

The results of heavy metal contents of four water sources within and outside Evangel University Campus of Okpoto community are presented in Table 3. The concentrations of iron and copper in the four water sources were lower than the WHO, FEPA and EPA standards; although appreciable levels of iron were found in the hand pump (0.14 mg/l) and EU bore hole (0.13 mg/l) when compared to the WHO and EPA standards of 0.3 mg/l. The concentration of lead was normal in EU bore hole (0.01 mg/l), followed by the stream (0.02 mg/l) and hand pump (0.05 mg/l) outside EU, while EU stream (0.51 mg/l) contained the highest level compared to 0.01 mg/l standard of WHO and FEPA. Chromium concentrations were higher in the water samples except in EU bole hole (0.05 mg/l) compared to WHO standard (0.05 mg/l); while the hand pump is next in low chromium content (0.08 mg/l). Cadmium was not found in EU bore hole and stream, whereas equal concentrations of 0.01 mg/l were respectively recorded in the hand pump and stream outside EU Campus, which are in line with FEPA standard (0.01 mg/l) but higher than the WHO (0.003 mg/l) and EPA (0.005 mg/l) standards. The concentrations of arsenic in all the samples were higher compared to the WHO (0.01 mg/l), FEPA (0.1 mg/l) and EPA (0.0 mg/l) standards.

Table 1: Physiochemical properties of four water sources within and outside Evangel University Campus in Okpoto community of Ishielu LGA, Ebonyi State, Nigeria

Parameters	Evangel University (EU) Campus		Outside EU Campus		WHO	FEPA, 1991	EPA, 2009
	Bore Hole	Stream	Hand Pump	Stream			
pH	7.04 ± 0.03	6.43 ±0.03	5.73 ± 0.09	5.96 ± 0.09	6.6 - 8.0	6.00-9.00	6.00-8.50
Conductivity (µS/cm)	300 ± 5.00	600 ± 10.00	800 ± 5.00	600 ± 10.00	1000		
Acidity (mg/l)	113.65 ± 2.90	85.00 ± 5.00	122.17 ± 2.02	26.67 ± 2.89	0	NA	50
Alkalinity (mg/l)	338.00 ± 2.00	16.00 ± 1.00	120.00 ± 5.00	48.00 ± 2.00	30 - 500	NA	30 - 500
Total Hardness (mg/l)	151.20 ± 0.44	90.07 ± 0.40	120.18 ± 0.79	54.97 ± 0.14	199 - 200		
TS (mg/l)	431.00 ± 1.00	216.67 ± 3.06	5430.33 ± 5.03	300 ± 5.00	5000	NA	500
TDS (mg/l)	1036.33 ± 2.52	2625.67 ± 2.08	778.00 ± 3.00	995.00 ± 5.00	500	2000	500
TSS (mg/l)	0.18 ± 0.00	0.20 ± 0.00	0.47 ± 0.00	0.26 ± 0.00	0	30	80
DO (mg/l)	2.15 ± 0.02	3.11 ±0.02	2.06 ± 0.03	2.49 ± 0.06	0	5	6.0 - 8.0
BOD (mg/l)	5.54 ± 0.19	3.65 ± 0.05	7.44 ± 0.01	12.01 ± 0.03	0	50	4
COD (mg/l)	19.61 ± 0.06	12.42 ± 0.04	27.40 ± 0.05	12.66 ± 0.10	0	80	250

The values are expressed as mean ± SD (n = 3)

Table 2: Mineral contents four water sources within and outside Evangel University Campus in Okpoto community of Ishielu LGA, Ebonyi State, Nigeria

Parameters	Evangel University (EU) Campus		Outside EU Campus		WHO	FEPA, 1991	EPA, 2009
	Bore Hole	Stream	Hand Pump	Stream			
Potassium (mg/l)	0.01 ± 0.01	0.05 ± 0.01	0.06 ± 0.02	0.10 ± 0.02	0		
Magnesium (mg/l)	0.31 ± 0.04	0.29 ± 0.02	0.33 ± 0.03	0.25 ± 0.03	27-30	20	30
Phosphorus (mg/l)	10.17 ± 0.35	0.89 ± 0.02	0.65 ± 0.03	0.87 ± 0.03	0	5	0.1
Nitrate (mg/l)	0.06 ± 0.02	0.16 ± 0.02	0.23 ± 0.02	0.09 ± 0.01	5	20	10
Chloride (mg/l)	5.82 ± 0.04	121.94 ± 0.10	77.95 ± 0.06	39.98 ± 0.03	250	600	250
Sulphate (mg/l)	0.57 ± 0.03	0.72 ± 0.03	4.86 ± 0.11	0.63 ± 0.03	250	500	200

The values are expressed as mean ± SD (n = 3)

Table 3: Heavy metal contents four water sources within and outside Evangel University Campus in Okpoto community of Ishielu LGA, Ebonyi State, Nigeria

Parameters	Evangel University (EU) Campus		Outside EU Campus				
	Bore Hole	Stream	Hand Pump	Stream	WHO	FEPA, 1991	EPA, 2009
Iron (mg/l)	0.13 ± 0.01	0.00 ± 0.00	0.14 ± 0.01	0.02 ± 0.01	0.3	20	0.3
Lead (mg/l)	0.01 ± 0.00	0.51 ± 0.02	0.05 ± 0.00	0.02 ± 0.01	0.01	0.01	0
Chromium (mg/l)	0.05 ± 0.01	0.18 ± 0.02	0.08 ± 0.03	0.20 ± 0.01	0.05		
Copper (mg/l)	0.20 ± 0.02	0.05 ± 0.02	0.05 ± 0.02	0.10 ± 0.02	2	1.3	1.3
Arsenic (mg/l)	2.19 ± 0.07	2.02 ± 1.18	4.13 ± 0.02	0.53 ± 0.01	0.01	0.1	0
Cadmium (mg/l)	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	0.01 ± 0.01	0.003	0.01	0.005

The values are expressed as mean ± SD (n = 3)

Discussion

Environmental pollution, including natural deposits and human activities such as indiscriminate waste disposal and agricultural practices affect the water sources used for drinking, washing and other activities. The present study examined the physicochemical properties, minerals, and heavy metal contents of four water sources used for drinking, bathing, washing, and so on, by people living in Okpoto community around Evangel University (EU) Take-off Campus. The pH of EU bore hole (7.04) and stream (6.43) were within the WHO, FEPA and EPA pH standards for drinking water, while the hand pump (5.73) and stream (5.96) outside EU were lower than these standards. The pH of water is related to carbonate and bicarbonate ions present in it [10]. Therefore, the lower pH values of the hand pump and stream outside EU Campus could be due to the presence of carbonate and bicarbonate ions present in the rocks and minerals in Okpoto-Ishielu environment encountered during the drilling of the hand pump and those washed into the flowing stream during the quarrying of rocks in the community respectively. Alteration of physiological pH is detrimental to health. Due to the moderate acidity of the streams, freshwater organisms (such as snail and earthworm) will survive in the water [11]. The pH values of EUA borehole and stream are comparable with those of Ishiagu stream (7.50) and well (6.80) respectively but differ with those of Ugwuja stream and well at 5.80, which are water sources in two communities in Ebonyi State [12]. The acidities of the four water samples were above the 50 mg/l recommended level for EPA, while their alkalinities were within the normal values for WHO and EPA standards of 50 – 500 mg/l. The higher alkalinities of EU bore hole and the hand pump outside EU Campus could possibly be as a result of deposited alkaline-containing minerals in the soil leached into the water bodies [13].

The total hardness of the all the samples were below the WHO standard of 199 – 200 mg/l. It was highest in EU bore hole followed the hand pump, EU stream and least in the stream outside EU. This trend in the total hardness is similar to the result of the total acidity but dissimilar to that of pH of the four samples. Hardness of water can affect washing and cooking leading to wastage of soaps and furring of cooking utensils respectively. For total solids (TS), only the hand pump with 5430.33 mg/l was up to and above WHO value of 5000 mg/l but far above EPA value of 500 mg/l. Next was EU bole hole with TS of 431.00 mg/l which is close but less than EPA value. Water with too low levels of total solids can reduce the efficiency of wastewater treatment plants, as well as the operation of industrial processes that use raw water [11]. Our result is similar to that of Edwin *et al.* [12]. Total dissolved solids (TDS) were highest in EU stream, followed by EU bore hole, outside EU stream and hand pump). While only EU stream was up to 2000 mg/l FEPA value, others were over 500 mg/l WHO and EPA values. None of the water samples was up to FEPA (30 mg/l) and EPA (80 mg/l) values for total suspended solids but were all less than 1.00 mg/l which is comparable to 0 mg/l of WHO. TDS and TSS indicate pollution in water, with high TDS levels suggesting the presence of pollutants [12]. Low TSS levels show that sample is of good quality [14]. The presence of high level of total dissolved solids (TDS) and total suspended solids (TSS) in water sources shows that materials are carried in suspended form by the water body and suggests that the water is polluted[11]. High levels of TSS in the stream could affect the amount of light that enters the streams and will therefore affect the survival of plants and photosynthetic bacterial in the stream. The high level of TDS could be attributed to the fact that moderate amounts of soluble anions and cations were present in the water samples [11].

The values of dissolved oxygen (DO) and chemical oxygen demand (COD) for the four samples were less than the standard values for FEPA and EPA. However, apart from EU stream, the values of the biological oxygen demand (BOD) for the samples were higher than the EPA value of 4 mg/l but were all lower than 50 mg/l of FEPA. Low level of dissolved oxygen in water is a sign of contamination and is an important factor in determining water quality, pollution control and treatment process[15]. High values of chemical oxygen demand (COD) and biochemical oxygen demand (BOD) is an indication of polluted water and signifies the presence of organic, inorganic and oxygen demanding pollutants in the water bodies [16, 17]. Our results for BOD and COD are in variance with a previous study that showed higher values for these parameters [12].

The mineral contents showed that the potassium concentrations for the four water samples were close to the WHO of 0 mg/l. The concentrations of magnesium, chloride, nitrate and phosphate were lower than WHO, FEPA and EPA standards. While phosphorus concentrations in all the four samples were above 0.1 mg/l EPA standard, only that of EU bole hole (10.17 mg/l) was up to and above the FEPA standard (5 mg/l). A proper plasma potassium level is essential for the normal heart functioning. Potassium ions also take part in the normal functioning of skeletal muscle fibers and are needed for many enzyme reactions [18]. Magnesium is necessary in the maintenance of bone growth and integrity and is involved in the regulation of the cardiac cycle and the functioning of muscles and nerves. Deficiency diseases are hypomagnesaemia and neuromuscular irritability. Toxicity symptoms are hypotension, respiratory failure, and cardiac disturbances [19, 20]. Also, magnesium serves as a cofactor of different enzymes, including some glycolytic enzymes [21]. Availability of magnesium in the water sources are often due to deposits of magnesite, dolomite among other salts in the area, which can be washed or leached from the soil into water [22]. Chloride is necessary to maintain the composition of blood and the formation of hydrochloric acid. It regulates the acid-base balance and the osmotic pressure. Deficiency symptoms include alkalosis and failure to thrive in infants. Toxicity symptoms include an increase in the extracellular volume and hypertension [23]. High concentration of nitrate (> 10 mg/l) is dangerous for pregnant women, it also poses a dire threat to infants (< 3 – 6 months) health as it leads to the formation of methemoglobinemia, also known as blue baby syndrome which is the inability of the blood to carry sufficient oxygen [14]. Traces of phosphates increase the tendency of growth of troublesome algae in the water and their presence in the water sources may be attributed to agricultural activities [24]. Phosphorus is an essential component of ATP, DNA and phospholipids [25].

The concentrations of iron and copper in the four water sources were lower than the WHO, FEPA and EPA standards; although appreciable amounts of iron were found in the hand pump and EU bore hole when compared to the WHO and EPA standards. Iron and copper are components of rocks but are normally washed into water bodies. Although they are required in low concentration, iron and copper are cofactors of some enzymes. Deficiency of iron results to anemia. Excess iron can lead to the development of cirrhosis, skin pigmentation, and hemochromatosis [26]. Copper-containing proteins like ceruloplasmin contribute to the absorption of iron in the gastrointestinal tract. Copper deficiency can cause hypochromic anemia. Copper toxicity manifests as hepatolenticular degeneration and biliary cirrhosis [27].

Lead level was only normal in EU bore hole (0.01 mg/l), followed by the stream and hand pump outside EU, while EU stream contained the highest level compared to the WHO and FEPA standards of 0.01 mg/l. The high level of lead in EU stream could be as a result of lead mining around Okpoto community that leaked into the flowing stream from a long distance, while that of the hand pump could be as a result of little lead deposit underground. Lead is dangerous to health as it can lead to disruption of the biosynthesis of haemoglobin and anemia, an increase in blood pressure, kidney damage, miscarriages etc. It is also implicated in brain damage, declined fertility in men, disruption of the nervous system, etc [10]. Therefore, EU stream is not safe for drinking. Chromium concentrations were higher in the water samples except in EU bole hole that meets the WHO standard, then followed by the hand pump. Chromium is a toxic metal occurring in water and groundwater from natural and anthropogenic means. Microbial interaction with mineral-containing rocks together with geogenic processes release Cr (VI) in natural environment by chromite oxidation [28]. Also, Cr (VI) pollution is largely related to several Cr (VI) industrial applications in the field of energy, chemicals and metals productions, and subsequent managements of waste and wastewater. In water, chromium mainly occurs in two oxidation states Cr (III) and Cr (VI) and related ion forms depending on pH values, redox potential, and presence of natural reducing agents [28]. Public concerns with chromium are mostly related to hexavalent compounds due to their toxic effects on humans, animals, plants, and microorganisms. Depending on dose, level and duration of exposure, chromium risks for human health range from skin irritation to DNA damages and cancer development [28]. Hence, the requirement of Cr for drinking water is insignificant. Our study revealed that there were high chromium levels in the two streams, making them inadequate for consumption.

Cadmium was not found in EU bore hole and stream, whereas equal concentrations of 0.01 mg/l were respectively recorded in the hand pump and stream outside EU Campus, which are in line with FEPA standard (0.01 mg/l) but higher than the WHO (0.003 mg/l) and EPA (0.005 mg/l) standards. The amount of cadmium in water is naturally small. It enters water through diffusion after release from car exhaust. Once in air it spreads with the wind and settles into the ground or surface water as dust. Cadmium is not beneficial to the human system [29] and the toxic effects include renal dysfunction, myocardia dysfunction, obstructive lung disease, cadmium pneumonitis, bone defects [30]. Arsenic levels in all the water samples were higher compared to the WHO, FEPA and EPA standards. Low amount of arsenic was recommended probably because of its toxic health effects such as inhibition of the enzyme pyruvate dehydrogenase, the enzyme that convert pyruvate to acetyl CoA and this could lead to coma and subsequently death [12]. The possible source of arsenic in the water sources is its natural deposits on earth crust [31]. Our results on heavy metal contents of the four water sources are consistent with the work of Edwin *et al.* [12] except for higher lead levels recorded in their water samples. Our previous studies showed the effects of physicochemical properties, mineral and heavy metal compositions on agricultural soil and their impact on cassava samples from Ebonyi State, Nigeria [32, 33].

Conclusion

The study investigated the physicochemical, mineral and heavy metal compositions of four water sources within and outside Evangel University (EU), Akaeze take-off Campus, Okpoto in Ebonyi State, Nigeria, comprising of a bore hole and a stream within EU Campus and, a hand pump and a stream outside the Campus. The results showed that the borehole and hand pump were safer for drinking and cooking than the two streams, with EU bore hole being better. However, none of the four water sources met all the WHO, FEPA and EPA standards for drinking water. Hence, further purification processes such as boiling, filtration, addition of water guards, and so on, should be carried out to make the water sources safer for consumption.

Conflict of Interests: The authors declare no conflict of interests.

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