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Characterization of Water Quality on University Campus

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Authors' contributions

This research was carried by between both authors. Author DFO designed the study, performed the statistical analysis and wrote the protocol the first draft of the manuscript. Author MCE managed the analysis and literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Introduction: Safe drinking water is vital to all human and living organisms.
Aim and Study Location: This study appraised untreated water within the Federal University of Petroleum Resources, Effurun (FUPRE) campus with a view to ascertaining their potability.
Methodology: The samples were analyzed using the America Public Health Association (APHA), standard protocol
Results: The pH indicated that the water were acidic with pH values from 3.50 ± 0.04 to 5.73 ± 0.08. Total iron exceeded the stipulated WHO limit of 0.3 mg/L in some of the locations with concentration varying from 0.232 ± 0.01 to 0.963 ± 0.04. The heavy metal load was relatively low and within regulatory limits.
Conclusion: The study concluded that water should not be consumed without treatment due to the non-conforming parameters. In addition, waters with a non-conformance contributed by feacal coliform (*E coli*) or any other microbial entities should be avoided since serious health water-related diseases (cholera, typhoid, dysentery and diarrheal) may set if consumed.

Keywords: Contamination; health implications; safe water; water consumptio.

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1. INTRODUCTION

Water is the most precious currency of all times and it is important to all human, living organisms, ecological systems, food production and for economic development. Water is consumed daily by human and there is no creature on Earth that can survive for a long time without water. However, the water we drink daily may not be potable (safe) due to impurities or contaminants that may be present in it [1]. In most regions in Nigeria and Delta State in particular, the government public water supply has seized to function for decades and, this has made residents and institutions to provide water for themselves by digging their privately owned boreholes, which is used by the residents, students and staff for consumption, utility, laboratory experiments and other assays [2]. With the main aim to quench their thirst, most people consume water from these untreated water sources without thoughts of the harm or risk such water may pose [3]. The World Health Organization (WHO) has estimated that approximately 3.4 million persons die yearly from drinking polluted water, which is about 9,300 deaths daily [4].

With the recent outbreak of the corona virus (COVID-19), there has been an increase in the demand for water both for consumption and sanitation as a measure to ensure good health and hygiene amongst other domestic purposes. The WHO has reported previously that there will be water shortage in most regions of the world with the rural communities being the most vulnerable. The lack of access to adequate safe water supply has contributed to illnesses and death resulting from water related diseases such as cholera, typhoid, dysentery and diarrheal [5].

On an average, a person needs approximately 54 liters of safe water each day to meet their daily metabolic, hygiene and domestic needs. The quantity of water needed for drinking is 4 L/person/day and in addition, 40 L of water will be required for bathing, washing, flushing and hygiene. These together will amount to 44 L while an additional 10 L will be required for daily cooking making a total of 54L/person/day of water needed by an individual for drinking, bathing, washing, hygiene and cooking. Similarly, in an institution, considering a hostel room of 4 occupants, it means that they will require a total of 54 x 4 L = 216 L /day while in a hostel housing 100 occupants that will mean 21600 L / day. For regions or areas with short water supply, this estimated quantity of daily demand could be a huge challenge and serious burden on residents and institutions since government does not provide water coupled with incessant power outage to supply water to reservoirs, hence some individuals may have to walk or trek / travels several miles / kilometers in quest for water to meet their daily demands.

Sustainable quality water and sanitation for all is goal #6 of the United Nations sustainable development agenda with a set of 17 sustainable development goals (SDGs) that needs to be achieved by the year 2030. Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs [6]. With a few years to achieving the sustainable development goals, one begins to wonder if this is feasible considering the fact that nothing has been put in place to provide water to the citizens and institutions.

In public government institutions (universities), it is the responsibility of the university authority to provide water for students and staff for their basic use and needs. Even when such water are provided, they are consumed untreated and this could be detrimental to the health and wellbeing of the University community since consumption of polluted or contaminated waters could lead to an outbreak of disease causing ailments such as dysentery, typhoid, cholera and diarrhea.

The study was carried out to evaluate the physico-chemical, inorganics and biological characteristics of some selected ground water Within the Federal University of Petroleum Resources, Effurun, (FUPRE) campus with a view of ascertaining their potability. This is because water is not treated and is used extensively for drinking, sanitation, experiments and other domestic purposes in the hostels, offices and laboratories.

2. MATERIALS AND METHODS

2.1 Sampling Locations

The sampling locations were within the campus of Federal University of Petroleum Resources, Effurun (FUPRE) located in Uvwie Local Government Area of Delta State, Nigeria. Federal University of Petroleum Resources, Effurun was established in March 2007 under a Federal Government of Nigeria initiative to build a specialized University to produce unique high level manpower and relevant expertise for the oil and gas industry. FUPRE was the first of its kind in Africa and sixth in the world of such petroleum Universities. FUPRE organizes its academic activities in various departments in college of science (COS) and college of engineering and technology (COT).

2.2 Water Sampling

A total of fifty four (54) water samples were collected from nine (9) sampling points within FUPRE campus. The exact sampling coordinates are presented in Table 1. Parameters indicated in Table 2 were analyzed for physico-chemical, inorganics and microbial analysis. Ex-situ determination was carried out in the laboratory of the Departments of Chemistry, Environmental Management and Toxicology, FUPRE and FatLab, Ibadan.

2.3 Determination of Metals in Samples

Two hundred and fifty (250) mL of well-mixed water sample was accurately measured and transferred into a beaker. Five (5) mL of concentrated nitric acid (HNO_3) was measured and added to the beaker containing the water sample. The sample was heated on a hot plate at a temperature between 90 and 95^oC until the volume reduced to approximately 15-20 mL. The beaker was removed from the heat, allowed to cool and was filtered. The filtrate was poured into a 25 mL volumetric flask and the final volume adjusted to the mark with double distilled water. The preferred metals in the samples were analyzed using the atomic absorption spectrophotometer (AAS), Shimadzu AA-7000.

2.4 Determination of Feacal Coliform (*Esherichia coli* count)

The multiple tube fermentation technique (#9222A) expressed as most probable number (MPN)/ml was used to determine feacal coliform (*E. coli* count) [7].

2.5 Quality assurance / Quality control

One of the primary responsibilities of the authors was to ensure that results were accurate (with low bias and high precision) and this work was accomplished using a well-defined quality assurance / quality control (QA/QC) procedure. Samples for physico-chemical analysis were collected using a 2 litre pre-conditioned polyethylene containers which were rinsed three (3) times with the samples to be collected while that of microbial analysis was collected using pre-sterilized McCartney bottles. Samples were collected after 2 minutes of consistent flow of water from the outlet tap. Samples for physico-chemical and microbial analyses were preserved in an ice chest at to 4^oC while samples for metal analysis were preserved with 2 mL of 1:1 nitric acid (HNO_3). *In situ* measurements were taken for pH, temperature, electrical conductivity, TDS and turbidity in order to maintain the sample integrity due to their relatively unstable condition and rapid deterioration beyond their respective holding times. All instrument for the in-situ and ex-situ analysis were duly calibrated to ensure accuracy and precision. Reagents and chemicals used were of Analar / American Chemical Society (ACS) grade and were of good quality. In addition, results obtained were subjected to statistical analysis and abnormal data were treated as outliers and only data within the linear range of standards were accepted. The QA/QC procedure covered all aspects of activities from sampling to accurate preservation techniques through laboratory analysis to data validation and verification.

3. RESULTS

The results from this study are highlighted in Tables 3 – 4 and Fig. 2.

3.1 Mean Physico-chemical, Metals and Microbial Characteristics of the Waters

The mean results for pH for all the water samples analyzed in Table 3 were below the specified WHO/DPR/FMEnv range of 6.5 to 8.5. The pH were acidic with values ranging from 3.50 ± 0.04 (health centre) to 5.73 ± 0.08 (Girls' Hostel B1). The waters could be considered fresh based on the relatively low total dissolved solid (TDS) and salinity concentrations. Values obtained ranged from 18 ± 1 to 47 ± 0.3 mg/L for TDS and 4.99 ± 0.01 to 7.99 ± 0.3 mg/L for salinity. The concentrations for total iron exceeded the stipulated limit of 0.3 mg/L in some locations with concentrations varying from 0.232 ± 0.01 to 0.963 ± 0.04 mg/L. Lead and cadmium were below the measuring instrument detection limit of 0.001 mg/L. The results for copper and zinc was within the stipulated limits for all locations. All the samples analyzed were free from feacal coliform (*E.coli*) bacteria contamination.

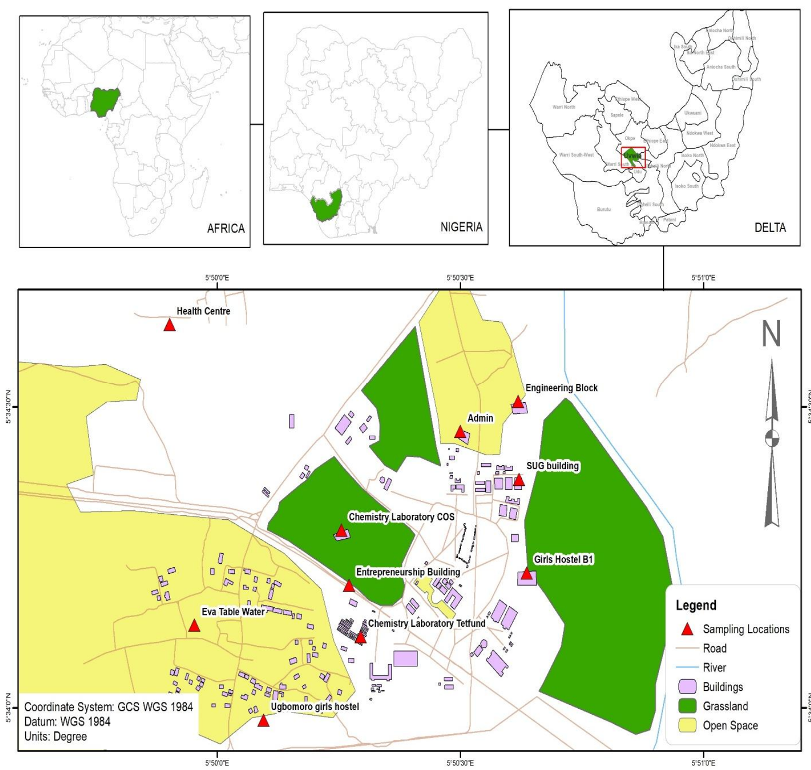

Fig. 1. Geologic map of FUPRE showing the sampling locations

Table 1. Coordinates for the sampling location*

Sampling Location	Latitude	Longitude
Girls Hostel B1	N5^{0}56′ 90.37″	E5^{0}84′ 27.38″
Engineering block	N5^{0}57′ 25.77″	E5^{0}84′ 36.55″
SUG building	N5^{0}57′ 13.37″	E5^{0}84′ 37.78″
Ugbomoro girls hostel	N5^{0}56′ 94.08″	E5^{0}83′ 65.23″
Entrepreneurship building	N5^{0}56′ 96.38″	E5^{0}84′ 01.25″
Chemistry laboratory COS	N5^{0}56′ 95.5″	E5^{0}80′ 55.6″
Administrative building(Admin)	N5^{0}57′ 23.48″	E5^{0}84′ 22.12″
Health centre	N5^{0}57′ 87.5″	E5^{0}83′ 92.39″
Chemistry laboratory Tetfund	N5^{0}56′ 79.45″	E5^{0}83′ 85.37″
Eva Table water (control)	N05^{o} 32′ 39.22″	E005^{o} 45′ 36.96″

** Refer to Fig. 1*

Table 2. Analytical methods for parameters analyzed in this study

Parameters	Analytical Methods
pH	pH, (APHA 4500 H^+
Temperature, ^{o}C	Thermometer (APHA, 2550-B)
Total dissolved solids (TDS), mg/L	TDS (APHA 2540-C)
Chloride (Cl^-) content, mg/L	Mohr's Argentometric method (APHA 4500 Cl-B)
Conductivity, µS/cm	Conductivity (APHA 2510 B)
Total hardness	EDTA titrimetric method (APHA 2340 C)
Turbidity	Nephelometric Method: (APHA – 2130-B)
Metals	Atomic Absorption Spectrophotometer (AAS)
Determination of Total Coliform Bacteria	Multiple Tube Test (APHA 9222A)

Source: APHA, (2017)

Table 3. Mean results of the physico-chemical and microbial analysis

Parameters	WHO Limit	DPR	FMEnv	Hostel B1	Engineering building	SUG building	Ugbomro girls hostel	Entrepreneurship building	Chemistry lab (COS)	Admin building	Health centre	Chemistry lab tetfund	Eva Water
pH	6.5-8.5	6.5-8.5	6.5-8.5	5.73 ± 0.08	4.44 ± 0.1	3.85 ± 005	4.51 ± 0.01	4.37 ± 0.07	3.97 ± 0.03	3.71 ± 0.01	3.5 ± 0.04	3.92 ± 0.2	6.81 ± 0.09
Temperature (°C)	N/A	25	25	28.0 ± 0.4	28.4 ± 0.4	28.7 ± 0.2	28.7 ± 0.2	28.5 ± 0.3	28.7 ± 0.3	28.9 ± 0.4	29.0 ± 0.3	29.0 ± 0.4	26.6 ± 0.04
Electrical Conductivity	2500	N/A	N/A	95 ± 0.2	51 ± 0.4	40 ± 0.3	42 ± 0.5	46 ± 0.4	71 ± 1	35 ± 0.5	66 ± 1	40 ± 0.5	85.4 ± 8.4
Total Dissolved Solid (mg/L)	1500	N/A	2000	47 ± 0.3	26 ± 1	19 ± 0.4	21 ± 1	23 ± 0.2	35 ± 0.4	18 ± 1	32 ± 0.5	20 ± 0.2	42.7 ± 2.3
Turbidity NTU	5	N/A	10	0.31 ± 0.01	0.46± 0.04	0.5 ± 0.06	0.7 ± 0.05	0.57 ± 0.01	0.1 ± 0.01	0.36 ± 0.01	0.42 ± 0.01	0.75 ± 0.02	0.15 ± 0.02
Chloride (Cl^-) content mg/L	200	N/A	600	5.99 ± 0.21	4.99 ± 0.3	7.99 ± 0.3	6.94 ± 0.04	4.99 ± 0.2	6.94 ± 0.04	4.99 ± 0.31	4.99 ± 0.01	5.95 ± 0.05	14.7 ± 0.82
Total Suspended Solid (mg/L)	N/A	N/A	N/A	0.7 ± 0.08	0.92± 0.02	0.82± 0.02	1.2 ± 0.04	0.68 ± 0.01	0.3 ± 0.02	0.75± 0.03	0.59± 0.02	1.0± 0.03	<1.00 ± 0.0
Total Hardness mg $CaCO_3$/L	500	N/A	N/A	18 ± 0.1	16 ± 0.1	10 ± 0.5	4.00 ± 0.02	12 ± 1	10 ± 0.5	8 ± 0.5	10 ± 0.2	14 ± 0.6	17.00 ± 0.50
Calcium, mg of $CaCO_3$/L	75	N/A	N/A	10.00 ± 0.03	8.00 ± 0.04	4.00 ± 0.02	1.6 ± 0.01	6.00 ± 0.03	4.00 ± 0.02	3.2 ± 0.02	4.00 ± 0.03	6.00 ± 0.04	6.81 ± 0.06
Magnesium, mg of $CaCO_3$/L	30	30	N/A	4.00 ± 0.01	2.40 ± 0.01	0.8 ± 0.02	0.48 ± 0.01	1.4 ± 0.02	0.8 ± 0.02	0.48 ± 0.01	0.8 ± 0.02	1.6 ± 0.02	1.69 ± 0.02
Microbiological *E coli* count (MPN/mL)	0	Nil	Nil	0	0	0	0	0	0	0	0	0	0

FEPA, [8]; DPR, [9]; WHO, [10]

Table 4. Mean results for heavy metals

Parameter, mg/L	WHO Limit	FME Standard	DPR standard	Hostel B1	Engineering building	SUG building	Ugbomro girls hostel	Entrepreneurship building	Chemistry lab (COS)	Admin building	Health centre	Chemistry lab tetfund	Eva Water
Iron	0.3	0.3	0.3	0.564± 0.05	0.274± 0.02	0.232±0.01	0.240± 0.05	0.963±0.04	0.343± 0.07	0.263± 0.02	0.364± 0.03	0.282± 0.05	<0.001
Copper	2	1.5	1.5	0.276±0.03	0.109±0.01	0.616±0.03	0.421± 0.03	0.316±0.09	1.040± 0.2	0.207± 0.03	0.178± 0.01	0.408±0.14	<0.001
Zinc	5	3	3	1.321±0.3	0.361± 0.04	0.379±0.02	0.152± 0.01	0.287±0.04	0.418±0.1	0.366±0.02	0.123±0.01	0.156± 0.02	<0.001
Cadmium	0.005	N/A	N/A	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	0.01	N/A	N/A	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

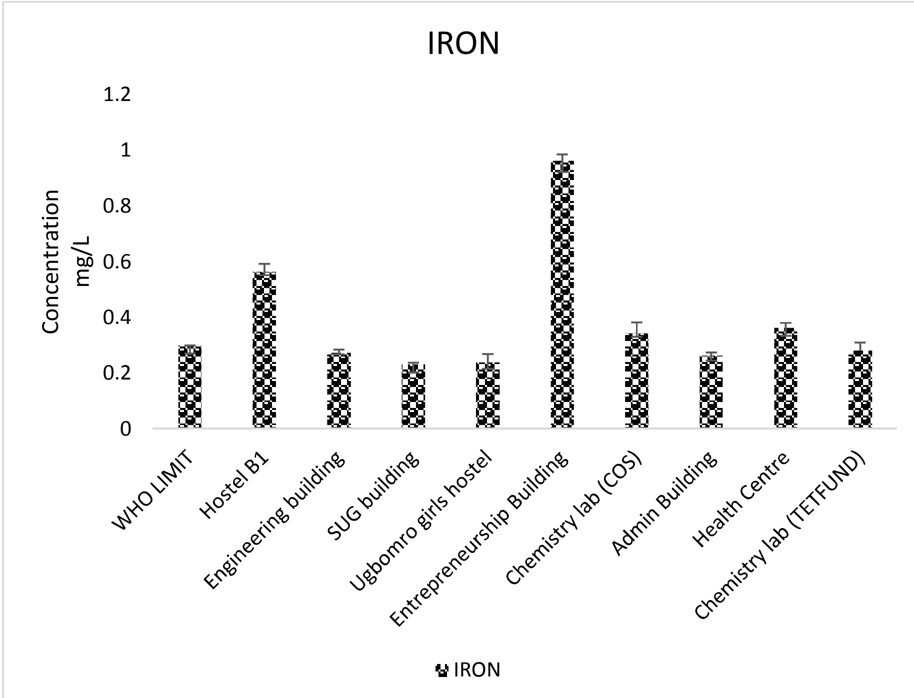

Fig. 2. Average concentrations ± SE of iron

4. DISCUSSION

Water is life, however lack of potable water has been a challenge in most regions of the world. Water of acceptable quality is needed by all to sustain a healthy and hygienic life and this include water for drinking and other domestic functions [11]. Water that is safe to drink should be clear and free of particles, odour or taste. Visual observation or assessment cannot be used to adjudge water free from pollutants or is potable [12].

In this study, water sources at hostel B1 and engineering building had concentrations of iron beyond the permissible limit which could be as a result of rusty pipes distributing water to its source. Rusty pipes distributing water to different facilities within a university can release metals like iron, manganese, zinc, into water supply lines in addition to algal build up in the storage tanks, giving the water a metallic or salty taste [13]. The effects of consuming untreated waters daily with high level of non-conformance could be significant as this can induce several water borne (cholera, typhoid, dysentery, diarrheal) and other health challenges including gastrointestinal disorder, acidosis, and other related ailments [14] [5].

Some major reasons why the populace in the university community (staff and students) consume untreated or contaminated water without choice of option include: dehydration, desperation, expensive cost of table waters and the only central water source available for use. Similarly, most staff and students may not have the necessary awareness that such water may contain harmful pathogens that could lead to an outbreak of disease and health crisis including cholera, typhoid, dysentery and diarrheal upon consumption and since they do not have an alternative means of water supply [15].

Most tertiary institutions have a central borehole, which distributes water to different facilities (hostels, laboratories, offices, utilities), therefore, there is the tendency for contamination along the distribution channels. Similarly, most university authorities do not conduct chemical and microbial laboratory testing to ascertain potability of such water. In addition, it is important to note that most often than not the quality of water distributed to the laboratories for use in geological, chemical, physical, biological and microbial analysis are not usually tested before use in the laboratories for the different experiments.

The pH of all water from all sampling locations in this study were acidic. It is worthy to note that when such water are used in the laboratory, experiment results may be compromised negatively even when distilled or deionized water are used for certain experiments, most especially, if the experiment is pH dependent or have other conditions in the standard operating procedure for such parameters. The water quality may also adversely influence some bioassays, while some biological organisms (fish, shrimps, clamps) that may be used for bioassay may not survive the relatively low pH and metal conditions during their acclamation period before such assays are conducted, which may either reduce or enhance the growth and development of some these species. In addition, microbiological assay may equally be at risk from such water even when double distilled. In a similar view, using such water for medical testing could be a challenge if not prudently checked as medical results may be compromised or influenced negatively. It would also be proper to ensure that water used in the laboratories (distilled or deionized) should be adequately tested before use in assays so as to prevent erroneous results in such experimental results. Screening of water in the university would ensure water potability, protection, safety and sustainability, which are essential since water is the most valuable resource of man [16] [15] [17].

5. CONCLUSION

We conclude that the water analyzed can be suited domestic purposes rather than drinking due to the relatively low pH and high iron content. Thus, for water analyzed in this appraisal to be safe for drinking as well as laboratory purposes, it should be treated using the following options depending on the non-conforming parameter:

- pH filters
- Ion exchangers (resins)
- biosand filters or clay (ceramic) pot filters
- carbon dot nanoparticles-zero valent iron ZVI nanoparticles (CD-NPs-ZVI -NPs)

Based on the results from this study, we recommended the following:

- The management of Federal University of Petroleum Resources Effurun and other bodies in water quality management [Institute of Professional Analysts of Nigeria (IPAN), Water Board Management, Federal Ministry of Environment (FMEnv), Nigerian Industrial Standard (NIS) and International Organization for Standardization (ISO)] should ensure that public serving boreholes are subjected to water quality tests so as to ascertain its quality before consumption and use in laboratory and for other domestic functions.
- Monitoring of water in the institution should be done periodically.
- The location of the boreholes should be such that the drainage or sewer systems does not seep or interfere with the underground water supply, as this would help to forestall any infiltration of sewage.
- There should be legislations and standards to ensure that the quality of water consumed by individual is regulated and enforced by the relevant authorities,

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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