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AN ASSESSMENT OF DRINKING WATER QUALITY IN PRIVATE HOSTELS AROUND UNIVERSITY OF BENIN, BENIN CITY, EDO STATE, NIGERIA

UNA EVALUACIÓN DE LA CALIDAD DEL AGUA POTABLE EN LOS ALBERGUES PRIVADOS DE LA UNIVERSIDAD DE BENIN, CIUDAD DE BENIN, ESTADO DE EDO, NIGERIA

AVALIAÇÃO DA QUALIDADE DA ÁGUA PORTÁVEL EM ALBERGUES PRIVADOS DA UNIVERISIDADE DE BENIN, CIDADE DE BENIN, NIGÉRIA

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ABSTRACT
Livability and comfortability in private hostels in Nigeria to a large extent depend on the quantity and pollution-free water for students' utilization. A shortfall in quantity and quality of water in the university community and surrounding hostels normally exposes students to various degrees of water stress and other vulnerabilities with serious implications on personal sanitation and hygiene. This paper evaluates drinking water pollution in three private hostels around the University of Benin, Benin City, Edo State, Nigeria. Field-based and laboratory analysis was deployed to investigatethe concentration of 18 water pollutants namely: carbon dioxide, chloride, alkaline, conductivity, pH, hardness, total dissolvedsolids, total suspended solids, total solids, manganese, calcium, zinc, copper, potassium, cadmium, iron, total aerobic count and coliform.Unacceptable levels of water pollution and quality indicators particularly in copper, cadmium, iron, and coliform were found across the sampled private hostels while other parameters met theWorld Health Organization limit making the water relatively suitable for consumption. Besides, there was no spatial variation of water pollution indicators across the sampled private hostels. The need to sustain the concentration of these indicators cannot be over-emphasized to avert water-related diseases that are harmful to the health of man. The paper recommends that students residing at private hostels should cultivate the habitsof treating water before consumption using the commonest methods of boiling and filtration to guarantee their health security and wellbeing.

Keywords: Water; Pollution; Quality; Indicators; Private Hostels; UNIBEN

RESUMEN
La habitabilidad y la comodidad en los albergues privados de Nigeria dependen en gran medida de la cantidad y la calidad del agua libre de contaminación que utilicen los estudiantes. La escasez de agua en cantidad y calidad en la comunidad universitaria y los albergues circundantes normalmente expone a los estudiantes a diversos grados de estrés hídrico y otras vulnerabilidades con graves consecuencias para el saneamiento y la higiene personal. En el presente documento se evalúa la contaminación del agua potable en tres albergues privados situados en los alrededores de la Universidad de Benin, en la ciudad de Benin, Estado de Edo (Nigeria). Se desplegaron análisis de campo y de laboratorio para investigar la concentración de 18 contaminantes del agua, a saber: dióxido de carbono, cloruro, alcalino, conductividad, pH, dureza, total de sólidos disueltos, total de sólidos en suspensión, total de sólidos, manganeso, calcio, zinc, cobre, potasio, cadmio, hierro, total de recuento aeróbico y coliformes. Se encontraron niveles inaceptables de contaminación del agua e indicadores de calidad, en particular de cobre, cadmio, hierro y coliformes, en los albergues privados muestreados, mientras que otros parámetros cumplían con el límite de la Organización Mundial de la Salud, lo que hacía que el agua fuera relativamente apta para el consumo. Además, no hubo variación espacial de los indicadores de contaminación del agua en los albergues privados muestreados. Nunca se insistirá lo suficiente en la necesidad de mantener la concentración de estos indicadores para evitar las enfermedades relacionadas con el agua que son perjudiciales para la salud del hombre. El documento recomienda que los estudiantes que residen en albergues privados cultiven los hábitos de tratar el agua antes de su consumo utilizando los métodos más comunes de hervirla y filtrarla para garantizar su seguridad sanitaria y su bienestar.

Palabras Clave: Agua; Contaminación; Calidad; Indicadores; Albergues privados; UNIBEN

RESUMO
A habitabilidade e o conforto em albergues privados na Nigéria dependem, em grande medida, da quantidade e da água livre de poluição para a utilização dos alunos. Uma queda na quantidade e qualidade da água na comunidade universitária e nos albergues circundantes normalmente expõe os alunos a vários graus de estresse hídrico e outras vulnerabilidades com sérias implicações no saneamento e higiene pessoal. Este artigo avalia a poluição da água potável em três albergues privados em torno da Universidade de Benin, localizada em Benin, Estado de Edo, Nigéria. A análise de campo e de laboratório foi implantada para investigar a concentração de 18 poluentes de água, a saber: dióxido de carbono, cloreto, alcalino, condutividade, pH, dureza, sólidos dissolvidos totais, sólidos suspensos totais, sólidos totais, manganês, cálcio, zinco, cobre, potássio, cádmio, ferro, contagem aeróbia total e coliformes. Níveis inaceitáveis de poluição da água e indicadores de qualidade, particularmente cobre, cádmio, ferro e coliformes, foram encontrados nos albergues privados amostrados, enquanto outros parâmetros atenderam ao limite da Organização Mundial de Saúde, tornando a água relativamente adequada para consumo . Além disso, não houve variação espacial dos indicadores de poluição da água nos albergues privados da amostra. A necessidade de manter a concentração desses indicadores não pode ser superestimada para evitar doenças relacionadas à água que são prejudiciais à saúde humana. O trabalho recomenda que os alunos que residem em albergues particulares cultivem os hábitos de tratar a água antes do consumo, utilizando os métodos mais comuns de fervura e filtração para garantir sua segurança sanitária e bem-estar.

Palaras-chave: Água; Poluição; Qualidade; Indicadores; Albergues privados; UNIBEN

1. INTRODUCTION

In the 21st Century march towards the eradication of illiteracy and quest towards achieving qualitative higher education, the private sector has played asignificant role in educational development around the world. In many sub-Saharan African countries including Nigeria, the key area of public-private partnership in educational development is in the provision of reasonably priced temporary residents in the form of hostel accommodation for students. However, for hostel accommodations to be comfortable and act to support competitive learning for students (PHILIP et al., 2018), essential ancillary utilities and services including the provision of potable water supply has to be in place. Typical Nigerian students need comfortable and affordable hostel accommodations located within a reasonable distance from the University Campus, together with adequate security, uninterrupted electricity, and water supply. A shortfall in quantity and quality of water in the university community and surrounding hostels normally exposes students to various degrees of water stress and other vulnerabilities with serious implications on personal sanitation and hygiene.

Nevertheless, although students in higher institutions are in some way contented with some hostel accommodations built around university areas and operated under public-private partnerships (BABATUNDE; PERERA, 2017), Nigeria ivory towers are still bedeviled with moribund hostel accommodations with ensuing water quality challenges. This has paved easy entrance of private sector developers in students' estate development and water supply business. Many other vital services are also in awful circumstances (ABDULLAHI et al., 2017). Apart from the insufficient quantity and irregularity of water (AZUBUIKE, 2018), more worrisome is the continual deterioration of the quality of water provided in Nigeria privately operated students hostels. Lower than recommended water quality standards in private hostels around many tertiary institutions have been reported (OGUNDE et al., 2017; NWANEKEZIE; MENDIE, 2019). In the University of Benin, Benin City, Edo State, the story is not only unpalatable but ghastly to the extent that students residing on-campus and off-campus have protested against the awful circumstances, water quality and quantity in their hostels (The Guardian, 2019).

It suffices to note that copious studies have been undertaken across various disciplinary domains in Benin City, Edo State and elsewhere in an attempt to unravel the suitability as well as the portability of water for drinking and other uses. Erah *et al* (2002) examined water quality from six boreholes and three manually dug wells and found that the water was heavily polluted with heavy metals, elements and microbial organisms. Agatemor et al (2007) investigated water quality in the University of Benin (UNIBEN) water distribution network and found that even though the water was portable for human consumption, pH and total coliform count (TCC) were above recommended levels. Akpoveta et al (2011) assessed the quality of water in selected locations in Benin City and Agbor and discovered that although the sampled water sources met established standards for drinking, the water was heavily polluted with calcium and manganese.

Oshoma et al (2018) investigated the bacteriological and physico-chemical parameters of borehole water in storage tanks in Benin City, Edo State. The study found that water samples from storage tanks were polluted with dangerous microorganisms, physical and chemical elements which made the water unsuitable for human consumption. Oria-Usifo et al (2018) assessed the quality parameters of water samples from boreholes in the municipal area of Oredo, Benin City. The study reported higher than set limits of pH, nitrate and coliform organisms in sampled water whereas the physical and chemical elements were within standard limits. Foka et al (2018) examined water quality indicators in four boreholes located within heavily populated vicinities in Benin City. It was uncovered that the water was polluted with coliform bacteria which were also above established boundary whereas nearly all the physical and chemical water quality indicators fell under a tolerable edge.

Ogbeifun et al (2019) also examined water quality parameters in nine locations in Benin City and found that water pollutants were within acceptable limits. Ezenweani and Ezenweani (2019)

carried out drinking water quality assessment on five locations in Ugbowo, Benin City and found that 80% of the water samples from the study locations were suitable for human consumption. This was attributed to the water quality parameters falling within acceptable limits whereas 20% of the microbial concentrations were beyond stipulated levels. As it could be seen, literature evaluating drinking water pollution and quality in private hostels in Benin City particularly and around UNIBEN are lacking. Attempt should be made speicifally to identify key pollutants in water sources used by students residing in private hostel and compare such indicators with laid down standards. In drinking water quality literature, the World Health Organization (WHO) guidelines, the United States Environmental Protection Agency (USEPA), Department of Petroleum Resources (DPR), National Food and Drug Administration and Control (DAFDAC), the Nigerian Standard for Drinking Water Quality (NSDWQ) and Standards Organization of Nigeria (SON) have widely been used (OMOLE; ISIORHO, 2011; OGUNDE et al., 2017; OSHOMA et al.,2018; ORIA-USIFO et al., 2018; OGBEIFUN et al., 2019).

Notwithstanding the need for students in private hostels to use unpolluted water in food preparation, portable water is also required for drinking, sanitation and personal hygiene. Also regrettably is the fact that most water sources are not located within the private hostels' premises. Students residing in private hostels who spent quality time searching for water are likely to miss their classes. Those who end up attending lectures after a long period have been utilized in fetching water end up being tired, thus losing concentration. Poor academic performance (British Psychological Society, BPS, 2012), increased rate of absenteeism (HUNTER et al., 2015) as well as dehydration and reduced cognitive abilities have been correlated with poor water quality and intake among students (CHARD et al., 2019). In private hostels around UNIBEN, Benin City, the primary source of water for consumption and other purposes at all times of the year is raw groundwater abstracted through boreholes and hand-dug wells.

Presently, the potability as well as the drinkability of the water provided at the privately owned students' hostels around UNIBEN is still unclear. It is, therefore, not only apt and expedient but essential to evaluate the physical, chemical and microbial indicators of the water sources vis-à-vis established guidelines with the view to ascertaining its portability for students' consumption. The aim of the study reported in this paper, therefore, was to assess the drinking water pollution in private hostels around University of Benin, Benin City, Edo State, Nigeria. It was also hypothesized that there is no spatial variation of water pollution indicators across the sampled private hostels.

2. MATERIALS AND METHODS

2.1. Study Area

This study was carried out in the surrounding areas of UNIBEN Main Campus in Ugbowo, Benin City, Edo State, Nigeria.The location map of UNIBEN and its environs is presented in Figure 1. UNIBEN Main Campus is situated between latitudes 6^{O} 22' 30'' – 6^{O} 25' 30''North of the Equator and longitudes 5^{O} 35' 31'' – 5^{O}38' 33''East of the Greenwich along Lagos – Sagamu Expressway in Benin City.

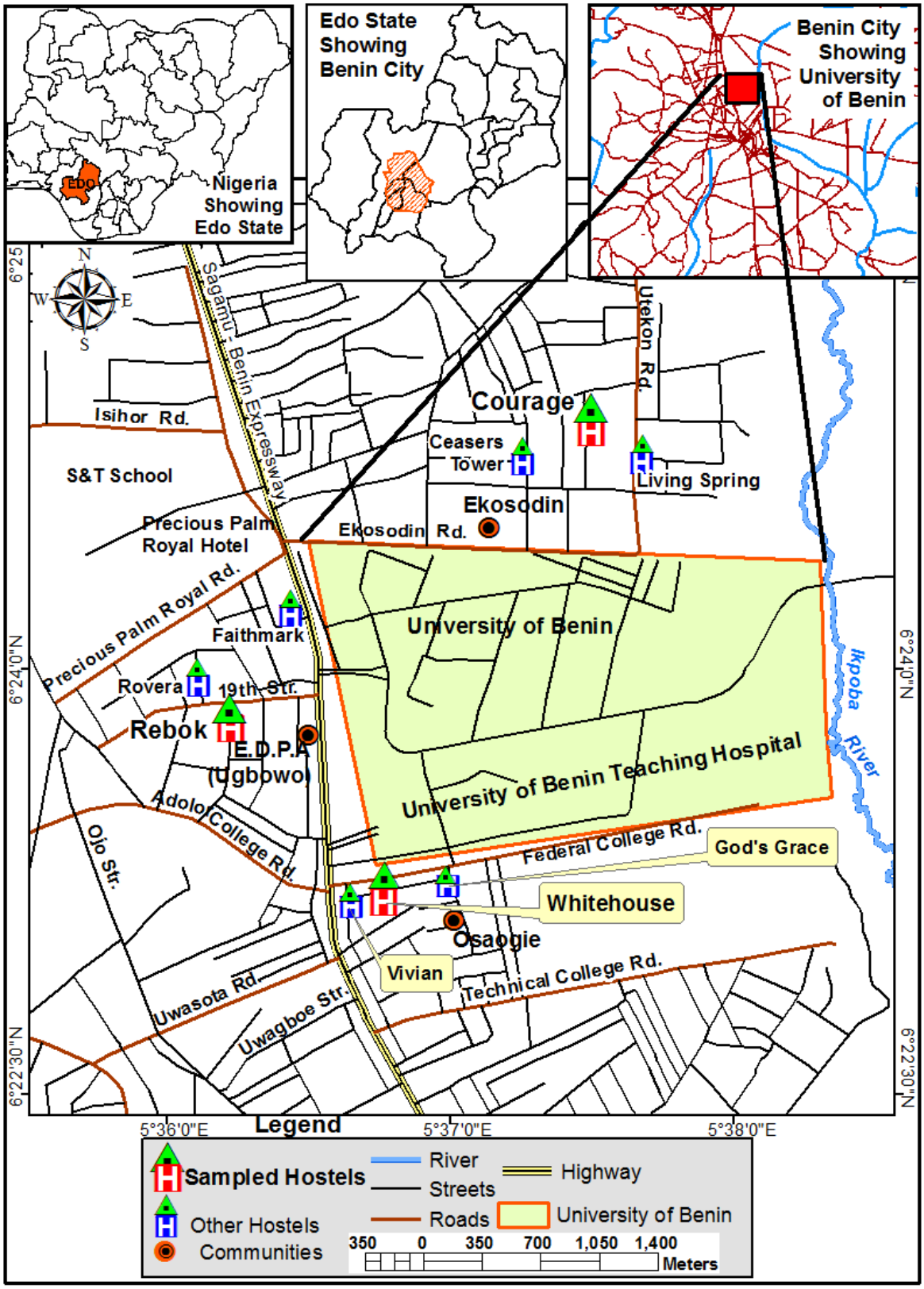


Figure 1: UNIBEN and its environs showing sampled private student hostels

UNIBEN is bounded in the north by Ekosodin Community, in the east by Ikpoba River, in the south by Osasogie Community and the western side is Ugbowo which is also one of the host communities. UNIBEN is one of Nigeria's second generation federal universities established in 1970

with "*Knowledge for Service*" as the *Motto* with the *Vision* "*To establish a model institution of higher learning which ranks among the best in the world and responsive to the creative and innovative abilities of the Nigerian people*". The university started as an Institute of Technology and was accorded the status of a full-fledged University by National Universities Commission (NUC) on 1st July, 1971. In his Budget Speech in April 1972, the then Military Governor of Mid-Western State, Col. S. O. Ogbemudia (who also doubled as the Visitor to the University) formally announced the change of name from the Institute of Technology to the University of Benin. On 1st April, 1975 the University at the request of the State Government, was taken over by the Federal Government and became a Federal University.

Today, the University has continued to grow from strength to strength with several Faculties, Departments, Institutes and Units. Following NUC's directives, the University experimented with the Collegiate System in 1991/92 and 1992/93 (https://uniben.edu/about-us.html).

In January 2006, the Federal Government approved the takeoff of the College of Petroleum and Gas Engineering of the University of Benin at Effurun, near Warri, in Delta State, with the initial population of 100 students in two departments; Petroleum Engineering and Gas Engineering. The University offers courses at various levels: Postgraduate, Undergraduate, Diploma and Certificate. Presently, the total student enrollment stands at over 40,000 made up of both full-time and part-time students shared among the various Faculties. In 1985, Grace Alele-Williams became Nigeria's first female vice-chancellor when she was appointed to head the University of Benin. She served as its vice-chancellor until 1991. The University is also famous for ground-breaking research works with other universities around the world and with both local and international bodies such as USAID, Ford Foundation, UNCF (United Negro College Fund), RMRDC (Raw Materials Research & Development Council of Nigeria) amongst others in the areas of Agriculture, Public Health and Engineering to name a few (UNIBEN, undated).

Students' population in 2018/2019 academic session stood at 45,968 with 22,577 male and 23,391 female, undergraduate full time (male = 17,965; female = 18,187), undergraduate part time (male = 2,018; female = 3,181) and postgraduate (male = 2,594; female = 2,023). The university also has 1,829 academic staff and 5,412 non teaching in her payroll as at the end of 2017/2018 academic session (UNIBEN Information and Communication Technology Unit, 2019). There are nine hostels namely: Medical, NDDC, Queen Idia (Hall 1), Tinubu (Hall 2), Hall 3, Hall 4, Keystone (Hall 5), Hall 6 and Akimbola (Postgraduate). It is the inadequacy of these hotels to accommodate all the students that prompted the development of private hostels off-campus around the neighbouring communities.

The climate of UNIBEN and environs falls within the Humid Tropical with frequent influence of tropical continental and maritime air masses. The high-resolution time-series (TS) gridded climatic data of month-by-month variation in climate (version 4.03 from January 1901 - December 2019) released by the University of East Anglia-Climatic Research Unit, Harris and Jones (2019) indicate that temperature is as low as 21.6^{O}C in January and as high as 34.2^{O}C in February in Ugbowo. Rainfall pattern is bi-modal with the first peak of 315.9mm in July with a short dry season in August and the second peak of 309mm in September and a total about 1961mm per annum.

Remotely sensed data from METEOSAT Earth Observation Satellites launched by EUMETSAT (Network of 31 European National Meteorological Services) Satellite Application Facility on Climate Monitoring (CM SAF) (SAHA et al., 2014), also showed that annual evapotranspiration is about 40.6mm with the highest value of 4mm observed in December and lowest value of 2.7mm noticed in July. Mean annual relative humidity is about 82%, average surface solar radiation is 213.4Wm-2 with the highest value of 247.7Wm-2 observed in February and the lowest value of 167Wm-2 noticed in August. Mean wind speed is about 4meters per second and may sometime exceed 10 meters per second in peak rainy season.

The relief of Ugbowo where UNIBEN campus is located is characterized by a gentle landscape with amean elevation of about 11meters above mean sea level (AMSL) in the eastern flank and 107meters AMSL in the western edge. The soil is reddish which is typical of laterite with a

considerate amount of clay intermixed with fine textured sandyloam characteristics (SUNDAY; CHIDI, 2019). The natural vegetation of Ugbowo has been greatly altered giving way to light vegetation along Ikpoba River wetlands and grasses intermixed with homestead gardens and built-up areas. Other isolated ornamental trees with an average height of about 20meters and an estimated mean canopy diameter of 22meters can still be found in the area. Many horticultural gardens located along Uselu Lagos expressway also contribute to the beautiful scenery of Ugbowo.

2.2. Datasets, Sampling, Methods of Analyses

This study deployed the investigational method to illuminate water quality indicators of private hostels near UNIBEN. These include carbon dioxide (CO_2), chloride (CL), alkaline (ALK), conductivity, pH, hardness, total dissolvedsolids (TDS), total suspended solids (TSS), total solid (TS), manganese (Mn), calcium (Ca), zinc (Zn), copper (Cu), potassium (K), cadmium (Cd), iron (Fe), total aerobic count (TAC) and coliform. Three private students' hostels were randomly selectedto monitor the water quality such that they were evenly spread across the north, south and western flanks of UNIBEN. The private hostels include Courage in Ekosodin community, Whitehouse found in Osasogie community and Rebok located in Ugbowo as seen in Figure 1.

Quality assurance/quality control was an integral part of all aspects of the sample preservation, data coding and manipulation, handling and analytical methods. A sample chain of custody forms was utilized for the registration and tracking of samples in the laboratory. The quality assurance programme put in place includes preservation of samples in 10% buffered formalin which helped to maintain sample integrity and prevent sample deterioration during sample handling and laboratory analyses. Only standard and commonly accepted laboratory methods were applied. These standard procedures adopted in water sample retrieval and laboratory analysis were in line with the requirements specified by WHO, the American Society for Testing and Materials (ASTM), United States Environmental Protection Agency (USEPA), American Public Health Association (APHA), DPR, DAFDAC, NSDWQ and SON.

Three water samples were retrieved from three sampled private hostels for laboratory investigation mid-weekend in January 2020. In-situ analyses were immediately carried out to determine the following parameters with short holding time; temperature, pH, turbidity, and Free (residual) chlorine. Water samples for microbiology analysis (TAC and coliform) were collected in 200ml plastic containers, acidified with 10% HNO_3 stored in cooler at 4°C+0.2°C and immediately transported to the laboratory for analysis using the techniques described in Ogunde et al (2017), Oshoma et al (2018), Oria-Usifo et al (2018) and Ogbeifun et al (2019).

For this study, the WHO (2011) standard for drinking water was adopted for comparison with the water quality in the three sample stations in private hostels around UNIBEN.The cartographic technique of charts was deployed to communicate the findings.This has the advantage of giving a glance or virtual impression about water quality information. Also, analysis of variance (ANOVA) was the statistical approach deployed in the testing of the null hypothesis which states that "*there is no significant spatial variation in water pollution indicators across the sampled private hostels*". ANOVA was computed in Statistical Package for Social Science (SPSS) version 22 based on Hays (1981) with the expression in equation 1 as:

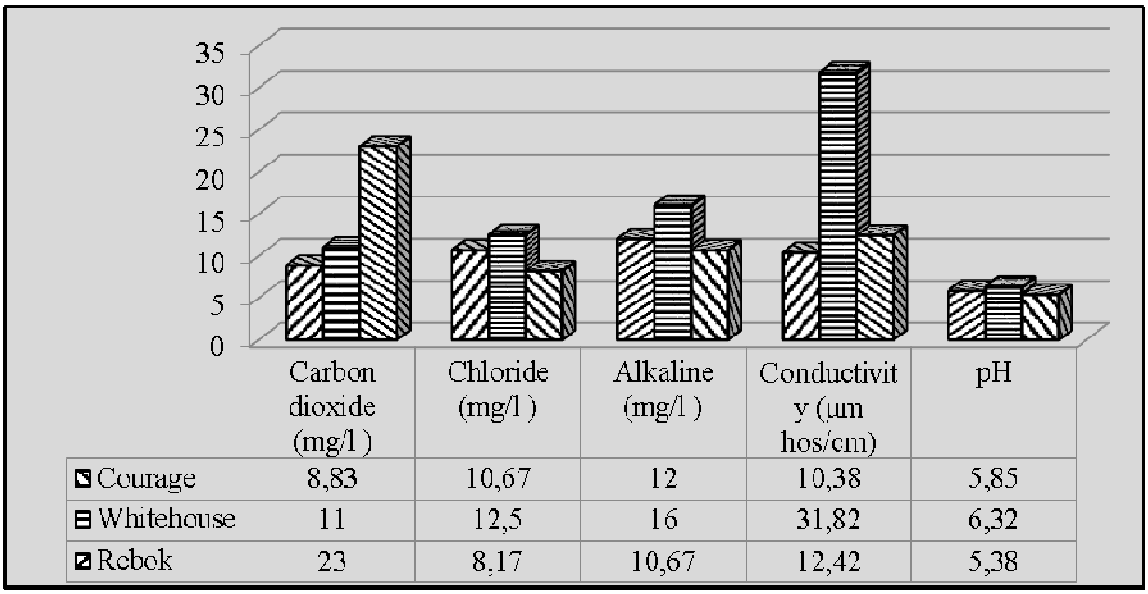
$$H_0: \mu_1 = \mu_2 = \mu_3 = \cdots = \mu_k \quad \ldots\ldots (1)$$

Where:
μ = mean of water pollution quality indicators at different sites;
k = the number of water pollution and quality indicators.

3. RESULTS AND DISCUSSION

3.1. Level of Carbon Dioxide, Chlorine, Alkaline, Conductivity and Ph

Carbon dioxide, chlorine, alkaline, conductivity and pH were among the water pollution and quality indicators isolated from water samples across the three sampled private hostels near UNIBEN in Benin City and their concentration is presented in Figure 2. As it could be seen, the highest concentration of CO_2 (23mg/l) was discovered in Rebok Hostel while the lowest quantity of 8.83mg/l was found in Courage Hostel with Whitehouse Hostel recording 11mg/l. Nevertheless, these values were comparatively lower than the 50mg/l specified by WHO (2011). It has been reported that the presence of carbon-dioxide in water may have negative effects depending on the water pH. If the water has a high pH value, the carbonic acid will act to neutralize it, but if the water is acidic, the carbonic acid will make it even more acidic (WHO, 2010a).



	Carbon dioxide (mg/l)	Chloride (mg/l)	Alkaline (mg/l)	Conductivity (µm hos/cm)	pH
Courage	8,83	10,67	12	10,38	5,85
Whitehouse	11	12,5	16	31,82	6,32
Rebok	23	8,17	10,67	12,42	5,38

Figure 2: Distribution of Water Pollutants in Sampled Students' Private Hostels near UNIBEN in Benin City (Carbon dioxide, chlorine, alkaline, conductivity and pH)

Regarding chlorine, the highest quantity of 116mg/l was discovered in Whitehouse Hostel while the lowest quantity of 10.67mg/l was established in Rebok Hostel with Courage Hostel recording the median value of 12mg/l. In any case, these values were relatively lower than the 100mg/l stipulated by WHO (2011). The existence of chloride in water samples indicates that thechemical used in water treatment was chlorine related which is not dangerous to human health. This finding corroborates earlier reports of Owolabi et al (2014) although the range was between 5-32mg/l from water samples collected from student hostels of Osun State University, Main Campus, Osogbo, Osun State. The current level of chlorine also indicates increased portability of water as reported by Asadu (2016). Regarding pH, the highest value of 6.32 was found in Whitehouse Hostel while the lowest quantity of 5.38 was discovered in Rebok Hostel with Courage Hostel having a median value of 5.85. The pH values found in this study were below the acceptable limit of 6.5-8.5 which agrees with previous study by Ogeleka et al (2014) when evaluating the status of borehole water in Warri, Delta State. Lower than the acceptable limit in pH is normally a wakeup call for the treatment of such water before consumption to avoid the associated adverse health implications.

Concerning alkaline, the highest level of 12.5mg/l was discovered in Whitehouse Hostel while the lowest quantity of 8.17mg/l was found in Rebok Hostel with Courage Hostel recording the median value of 12.5mg/l. These values were comparatively lower than the alkalinity level of 20-45mg/l reported by Owolabi (2014) from water samples collected from student hostels of Osun State University, Main Campus, Osogbo, Osun State. All the same, these values were relatively lower than the 200mg/l stipulated by WHO (2011). Toxicity of alkaline in water is very rare but shortfall or excess can be moderated with adjustment in the level of pH (WHO, 2010b).Concerning conductivity, the highest amount of 31.82µm hos/cmwas discovered in Whitehouse Hostel while the lowest quantity of 10.38 µm hos/cmwas found in Courage Hostel whereas Rebok Hostel recorded the median value of 11.42µm hos/cm. Again, these values were reasonably lower than the 100mg/l stipulated by WHO (2011). Lower than the regulated level of conductivity in water samples had earlier been reported by Ogbeifun et al (2019) who stated that conductivity is driven by water temperature and extreme values can affect the odor, taste and often result in digestive system disturbance.

3.2. Level of Hardness, Manganese and Calcium

The results of the concentration of hardness, manganese and calcium obtained from the laboratory analyses of water pollutants and quality indicators isolated from water samples across the three sampled private hostels near UNIBEN in Benin City is presented in Figure 3. As it could be seen, the highest concentration of hardness (27.83mg/l) was found in Whitehouse Hostel while the lowest quantity of 21mg/l was found in Rebok Hostel with Courage Hostel recording 21.83mg/l. Nevertheless, these values were comparatively lower than the 100mg/l stipulated by WHO (2011). This finding agrees with that of Iyasele & Idiata (2011) who reported lower than the recommended limit of hardness in boreholes water samples in Edo North, Edo State. In contrast, 66.7% of the water samples investigated by Owolabi et al (2014) in student hostels in Osun State University, Main Campus, Osogbo, Osun State was higher than WHO (2011) limit.

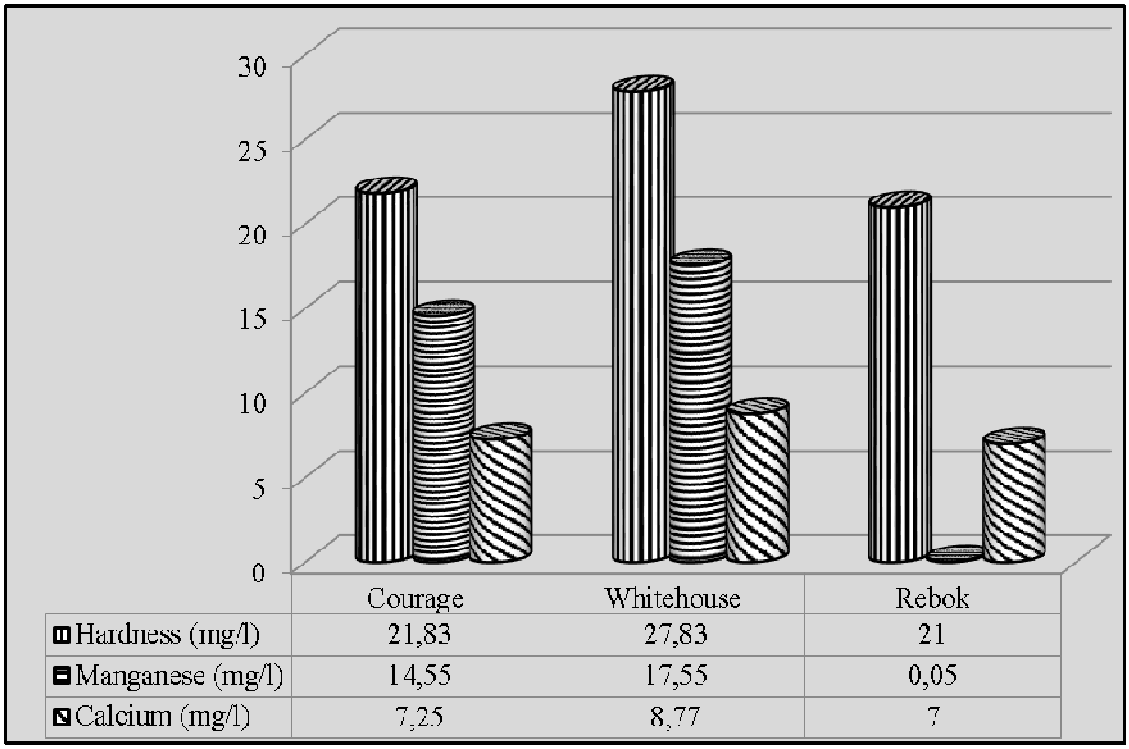
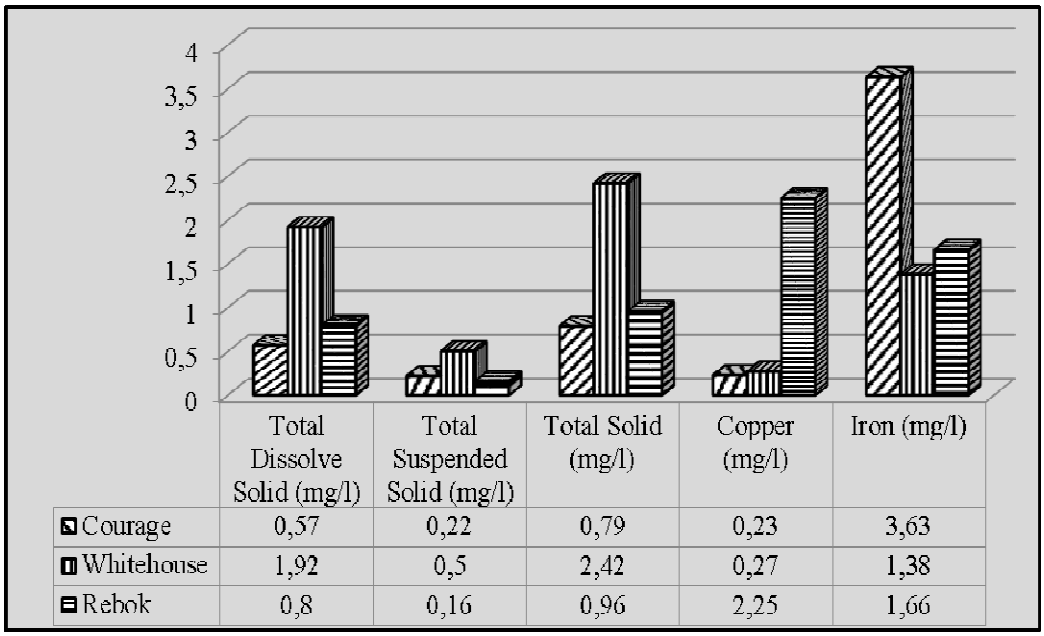


Figure 3: Distribution of Water Pollutants in Sampled Students' Private Hostels near UNIBEN in Benin City (hardness, manganese and calcium)

Similarly, the highest value of manganese (17.55mg/l) was discovered in Whitehouse Hostel while the lowest quantity of 0.05mg/l was found in Rebok Hostel with Courage Hostel recording 14.55mg/l. Apart from thewater sample collected from Rebok Hostel, samples collected from Courage and Whitehouse Hostels were comparatively higher than the 0.05-0.5mg/l specified by WHO (2011). This finding however contradicts the result of Ogbeifun et al (2019) in all the nine water samples retrieved from Oredo, Egor and Ovia North East parts of Benin City.Concerning calcium, the highest level of 8.77mg/l was discovered in Whitehouse Hostel while the lowest quantity of 7mg/l was found in Rebok Hostel with Courage Hostel recording the median value of 7.25mg/l. The values from Courage and Rebok Hostels were comparatively lower than 7.5mgl fixed by WHO (2011) while thewater sample from Whitehouse Hostel was above the limit. Lower concentration of calcium had earlier been reported by Agatemor and Okolo (2007) while evaluating water quality parameters in UNIBEN water distribution network.

3.3. Level of Total Dissolved Solid, Total Suspended Solid, Total Solid, Copper and Iron

Another set of water pollution and quality indicators investigated from the three private hostels near UNIBEN were total dissolved solids, total suspended solids, total solids, copper and iron and the results are shown in Figure 4. The level of total dissolved solids (TDS) in Courage Hostel was 0.57mg/l, Whitehouse Hostel (1.92mg/l) while RebokHostel was 0.8mg/l. This result is comparatively lower than values of 12mg/l to 43 mg/l reported by Adegbite et al (2018) in Egbeta community, Ovia North East LGA, Edo State. Despite everything, these values were relatively lower than the 500mg/l recommended by WHO (2011).With reference to the level of total solids (TS), Courage Hostel recorded 0.22mg/l, Whitehouse Hostel (0.5mg/l) while Rebok Hostel was 0.16mg/l which were slightly lower than the range of 1.66±0.01 to 6.097±0.01mg/l reported by Ogbeifun et al (2019) across nine locations in Benin City. Be that as it is, these values were within the acceptable limit set by WHO (2011).



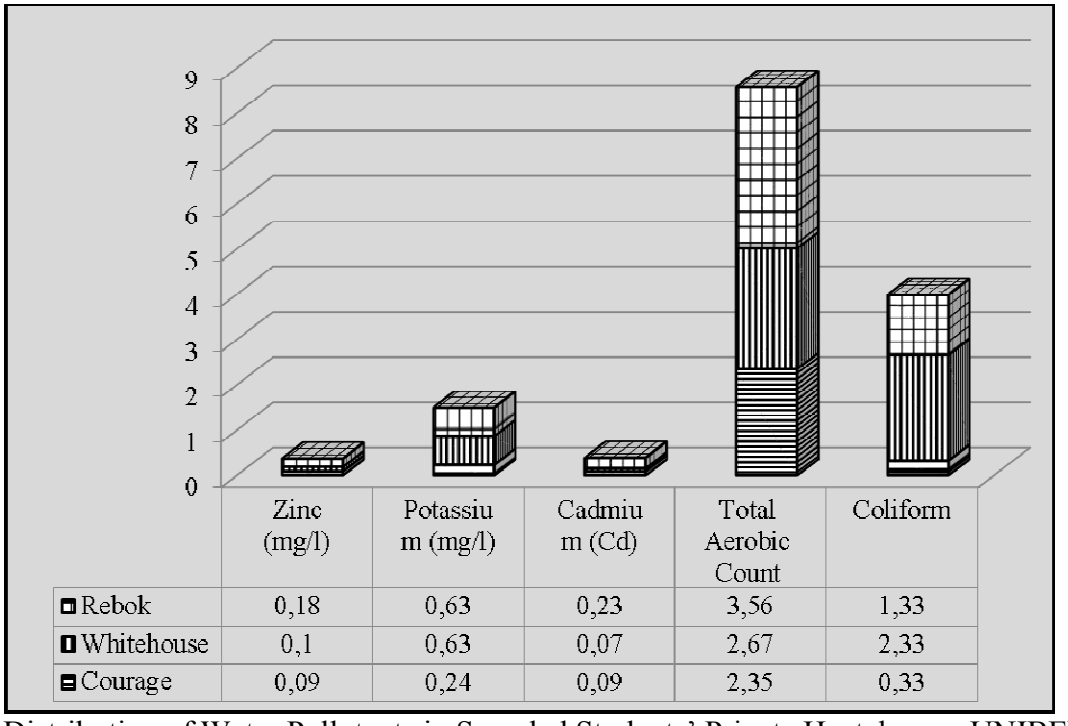
	Total Dissolve Solid (mg/l)	Total Suspended Solid (mg/l)	Total Solid (mg/l)	Copper (mg/l)	Iron (mg/l)
Courage	0,57	0,22	0,79	0,23	3,63
Whitehouse	1,92	0,5	2,42	0,27	1,38
Rebok	0,8	0,16	0,96	2,25	1,66

Figure 4: Distribution of Water Pollutants in Sampled Students' Private Hostels near UNIBEN in Benin City (Total dissolved solids, total suspended solids, total solid, copper and iron)

Regarding the concentration of copper (Cu), it was 0.23mg/l in water sample retrieved from Courage Hostel, 0.27mg/l in Whitehouse Hostel and 2.25mg/l in Rebok Hostel: these were slightly lower than the range of 1.66±0.01 to 6.097±0.01mg/l reported by Ogbeifun et al (2019) across nine locations in Benin City. Nevertheless, these values were within the acceptable limit set by WHO (2011). It is also clear that, the water sample at Rebok Hostel was highly polluted with Cu since it was above the acceptable limit of 1.0 mg/l, hence, unfit for human consumption. Copper contaminated water could pose health hazards such as abdominal pains, nausea, vomiting, diarrhoea, headache and dizziness as reported by Chinwe et al (2010). Copper poisoning principally influences the formation of liver cirrhosis known as non-India childhood cirrhosis (WHO, 2011). Similarly, the observed quantity of iron (Fe) discovered in Courage Hostel was 3.63mg/l, Whitehouse Hostel recorded 1.38 mg/l whereas Rebok Hostel had a value of 1.66 mg/l which were higher than WHO (2011) set limits of 0.003 and 0.30 mg/l. This result on Fe agrees with the finding of Ogeleka et al (2014) who reported a somewhat obvious level higher than set standard in Warri, Delta State.

3.4. Level of Zinc, Potassium, Cadmium, Total Aerobic Count and Coliform

Other sets of water pollution and quality indicators investigated from the three private hostels near UNIBEN were zinc, potassium, cadmium, total aerobic count and coliform and the results are shown in Figure 5. The observed values of zinc (Zn) concentration, which ranged from 0.09mg/l in Courage Hostel, 0.1mg/l in Whitehouse Hostel to 0.18mg/l in Rebok Hostel were within the set limit of 5mg/l.This result on Zn is consistent with the values of 0.01±0.00 -0.65±0.02mg/l noticed in water samples assessed by Ogbeifun et al (2019). Zinc is an essential element needed for the maintenance of metabolic activities in the human body system (CHINWE et al., 2010). Besides, the observed values of value for potassium concentration, which ranged from in 0.24mg/l in Courage Hostel, 0.63mg/l in Whitehouse Hostel to 0.63mg/l in Rebok Hostel and were within the acceptable standard of 1.0 mg/l. Conversely, the observed values for cadmium (0.09 – 0.23 mg/l) were above the set limits of 0.



	Zinc (mg/l)	Potassium (mg/l)	Cadmium (Cd)	Total Aerobic Count	Coliform
Rebok	0,18	0,63	0,23	3,56	1,33
Whitehouse	0,1	0,63	0,07	2,67	2,33
Courage	0,09	0,24	0,09	2,35	0,33

Figure 5: Distribution of Water Pollutants in Sampled Students' Private Hostels near UNIBEN in Benin City (zinc, potassium, cadmium, total aerobic count and coliform)

Furthermore, the observed values of total aerobic counts (2.35 – 3.56Log 10cfu/ml) of the water samples were high. It has been reported that, a high aerobic count does not itself present a risk to the water supply system. The presence of biofilms in the drinking water distribution system may play a role in the presence of potential pathogens in drinking water pipes. This contamination can occur due to defective joints, rusted pipelines crossing over the sewage pipes and low/high pressure in the pipelines (MAES et al., 2019). For water to be wholesome, it should not present any risk of infection or contain unacceptable contamination of chemicals hazardous to health and should aesthetically be acceptable to consumers.

Also, the observed values of coliform counts (0.33 - 2.33log10cfu/ml) were higher than the set standard of 0.0. This could have been due to mixing-up of water and sewage where the water pipes are broken. Being indicator organisms of faecal contamination and the causal organisms of many water-borne diseases, it is, therefore, pertinent to treat the water with physical and/or chemical methods before deployed for domestic uses. Students from these private hostels draw their drinking water from these locations and this could lead to an outbreak of water-borne infections if treatment options are not employed.

3.5. Hypothesis Testing

Nevertheless, to further buttress empirically, the spatial variability of water pollution and quality indicators across the sampled private hostels, the study hypothesized the absence of spatial variability and this was tested using the ANOVA.As it could be seen in Table 1, although the Sum of Squares between Groups was 16.669, Mean Square of 8.335 and F-values between groups 0.130,the p-value in the Sig column was higher than 0.05 specified for the study. Hence, the alternate hypothesis was rejected while the null hypothesis was adopted, meaning that there is no significant spatial variation in water pollution and quality indicators across the sampled private hostels.

Table 1: ANOVA result of spatial variability of water pollution and quality indicators in private hostels near UNIBEN, Benin City

Water Sample (All Hostels)	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	16.669	2	8.335	.130	.879
Within Groups	3080.282	48	64.173		
Total	3096.951	50			

However, to ensure that the ANOVA result did not occur by chance, and to avoid Type I error, multiple comparisons was executed across the water samples in the locations using TUKEY test and the result is presented in Table 2. Although the Mean Difference (I-J) of water sample in Courage Hostel, when compared with that of Sample 2 (Whitehouse Hostel), was -1.422 and that of water sample in Whitehouse Hostel with Courage Hostel was 1.422, no value in the *Sig*. column was less than 0.05 confidence limit set for the test. TUKEY test, therefore, confirmed that the ANOVA result earlier computed did not occur by chance, but was statistically not significant. Thus, at 95% confidence level, the null hypothesis which states that “there is no spatial variation of water pollution indicators across the sampled private hostels” was adopted.

Table 2: Tukey HSD Result of Multiple Comparisonsof spatial variability of water pollution and quality indicators in private hostels near UNIBEN, Benin City

(I) Hostels	(J) Hostels	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Sample 1	Sample 2 (Whitehouse Hostel)	-1.422	2.801	.868	-8.20	5.35
(Courage	Water Sample (All Hostels)	-.750	2.670	.957	-7.21	5.71
Hostel)						
Sample 2	Sample 1 (Courage Hostel)	1.422	2.801	.868	-5.35	8.20
(Whitehouse	Water Sample (All Hostels)	.672	2.801	.969	-6.10	7.45
Hostel)						
Water Sample	Sample 1 (Courage Hostel)	.750	2.670	.957	-5.71	7.21
(All Hostels)	Sample 2 (Whitehouse Hostel)	-.672	2.801	.969	-7.45	6.10

4. FINAL CONSIDERATIONS

The issue of water pollution and poor quality in the typical university environment in Nigeria may be surprising considering the maintenance of excellence, highest standards, quality and globally acceptable practices inherent in these citadels of learning. Unacceptable levels of water pollution and quality indicators particularly in copper, cadmium, iron and coliform were found across the sampled private hostels near UNIBEN, Benin City. This study also found that other water pollution and quality parameters met WHO limit making the water relatively unsuitable for public consumption. Besides, there was no spatial variation of water pollution indicators across the sampled private hostels.The need to bring down the concentration of these indicators within WHO acceptable limits cannot be over-emphasized to avert water-related diseases that are harmful to the health of man.

The paper recommends that students residing at private hostels should cultivate the habits of treating water before consumption using the commonest methods of boiling and filtration to guarantee their safety and wellbeing. There is also the need for the formulation of university water pollution and quality policy guidelines which specifies regular water treatment and quality monitoring and made available to private hostel accommodation providers. Massive sensitization of students and private hostels developers on the health implications of using and providing water with questionable and degrading quality should also be carried out by the university management.

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