Boreholes Water Quality and Human Health Risk Assessment in Rivers State University, Port Harcourt, Nigeria.

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ABSTRACT
Assessment of boreholes water quality at Rivers State University was conducted by analyzing water sample for chemical and microbiological contaminations. The results obtained were compared with the permissible limits for drinking water established by the World Health Organization (WHO), Standard Organisation of Nigeria (SON). The water had high microbial counts and human pathogen, thus not suitable for drinking consumption without treatment. The mean and maximum values of 109 cfu/ml and 3000 cfu/ml respectively were obtained against WHO 2006 standard limit of 100cfu/ml for E.Coli. Similarly, the mean and maximum values of 8.6MPN/ml and 210MPN/ml respectively were obtained against SON 2007 limit of 10MPN/ml and WHO, 2006 limit of 0-2MPN/ml. Coliform levels exceeding the standard limits are indicative of water system that is infested with human pathogens. These results were compared with records of disease prevalence at Rivers State University medical centre to determine any relationship with the number of persons becoming ill from drinking contaminated water and possible outbreak of water borne diseases attributable to human pathogens. Health records show that 610, 1010 and 1728 cases of malaria fever where reported between Year 2019 and 2021 . Similarly, 18, 63, and 107 cases of typhoid fever respectively, where also reported during the same period. Furthermore, diarrhoea, dysentery and cholera had an average of 4 cases each during the record period. Consequently, the study recommends the utility of commonly used and potable drinking water treatment technologies that guarantee treatment of multiple contaminant types in order to avert chronic health effects. Furthermore, the management of the Rivers State University should set up a surveillance programme to monitor the quality of the so-called "pure water" predominantly consumed by the students.

Key words: Boreholes water quality, chemical and microbiological contaminants, disease prevalence.

1.INTRODUCTION

Groundwater is the traditional source of water in the Niger Delta region of Nigeria. It is also a main component of the hydrological cycle. The hydrologic cycle is an interactive and interconnected with other components of the cycle, such as surface runoff, infiltration amongst others. Groundwater is perceived as a high quality source of water, with no attempt for treatment in most cases before consumption. Recently, the quality of groundwater has been declining as a result of chemical and microbial contaminants posing health risk of cancer, cardiovascular, adverse productive outcomes, amongst other health effects and causing water born diseases. According to [1], good quality drinking water is a cornerstone of public health. UNICEF and World Health Organization (WHO), 2011 observed that 13% of the world population lacked access to improved drinking-water sources in 2008, and almost 10% of the total burden of disease worldwide could be prevented by improving drinking-water supply, sanitation, hygiene, and the management of water resources, according to [2]. Furthermore, [**3**] reported that among other diseases, water diseases cause diarrhoea, which kills nearly one million people every year. Most of the causalities are children under the age of five [4, **5].** [6, **7]** reported that about 130,000 deaths in Nigeria among children are attributable water – borne infections and the burden of diarrhea attributable deaths among under – 5 children have been reported to be 150,000 per year. In terms of sanitation, the population of Nigerians without access to potable water is about 35% according to [**8]**. While, it is the Niger Delta, it was estimated that less than 20 to 40% of rural communities and only 45 to 50% of urban communities have access to safe drinking water, see [**9]**. The ability to improve drinking water quality and human health through research, technology and protection programmes is dependent on our willingness to invest in drinking water. In order to assess the impact of groundwater consumption on human health at the Rivers State University; this study was conducted with the following objectives: (i) Collection of data on chemical and microbial parameters from archive of the Institute of Pollution Studies (IPS) of the Rivers State University (RSU), Port Harcourt (ii) Compare the data with specific standards recommended by SON, WHO (iii) Collation of data on disease prevalence from Rivers State University Medical Centre (iv) Compare (ii) and (iii) above to determine if the number of persons becoming ill from health risks and water borne diseases will be correlated to determine the trend and (v) make recommendations to the management of Rivers State University for implementation of research findings. The study will provide substantial health, economic and social benefits which may be summarized as: the overview of health benefits ranges from the reduction of the mortality rate of children and thus increasing the life expectance, the reduction of the rate of suffering and hardship caused by water related diseases, minimized cost of medical treatment and increased productivity. Secondly, the improved quality of water supply produces economic benefits which include: the reduction in the time required to collect and transport water, improved opportunities for keeping livestock or growing subsistence crops and the production of improved fire fighting capacity. Finally, the accessibility to safe drinking water will enhance social benefits as this will be evident in the family and social development in the sense that time will be used for more meaningful activities like educational programs instead of searching of water for consumption bearing in mind that time is money.

2. Materials and Methods

2.1Study Area and Site Description

The main campus of the Rivers State University is situated in Port Harcourt City. Port Harcourt lies within latitudes 4^{o} 43' 07" and 4^{o} 54' 32" N and longitudes 6^{o} 56' 04" and 7^{o} 03' 20"E. The mean annual rainfall is over 2500mm, with a mean annual temperature of 30^{o}C and a population of over 3 million persons. The study area shown in Figure. 1 is located within Port Harcourt metropolis in the Niger Delta sedimentary basin of Nigeria. Port Harcourt is covered on the surface by the Benin Formation which is otherwise call the Coastal Plain Sands. The Benin Formation is Miocene to Recent in age , according to [**10]**. It has variable thickness which may be up to 1,400 metres in some areas, see [**11]**. This Formation is underlain in the subsurface by the petroleum bearing Agbada and Akata Formations. The soil zone of the Benin Formation is mainly lateritic, and beyond this zone the Formation consists of thick friable sands with some intercalations of clay beds. These sands are mostly medium-to-coarse-grained, pebbly, moderately sorted with local lenses of fine grained sandstone and sandy clay[**12]**.

The domination of loose sands in the Benin Formation makes the ground in Port Harcourt porous and permeable to wastes on the soil surface. This is because during the rainy season, rainwater will cause leachates from the wastes to percolate downwards and pollute the groundwater over time. Most boreholes in Rivers State University rarely exceeds 120 metres (360ft) in depth, as shown in Table 1.

2.2 Sample Collection and Collation of Archival Data

Primary and secondary data were employed in the study. The primary data were obtained from the field experiment (i.e. water analysis result) while the secondary data were collated from IPS, RSU data bank. The total of sixty-six over-head tanks or borehole stations were identified within the university campus, out of which twenty six were randomly selected for the study as in Figure 1.

Samples for physic-chemical analysis were collected in 1.5-litre plastic bottle while those for microbiology were collected in sterile McCartney bottle. All the samples were preserved in iced cool box and transported to the laboratory for analyses. Table 1 shows the sampling points and GPS Co-ordinates.

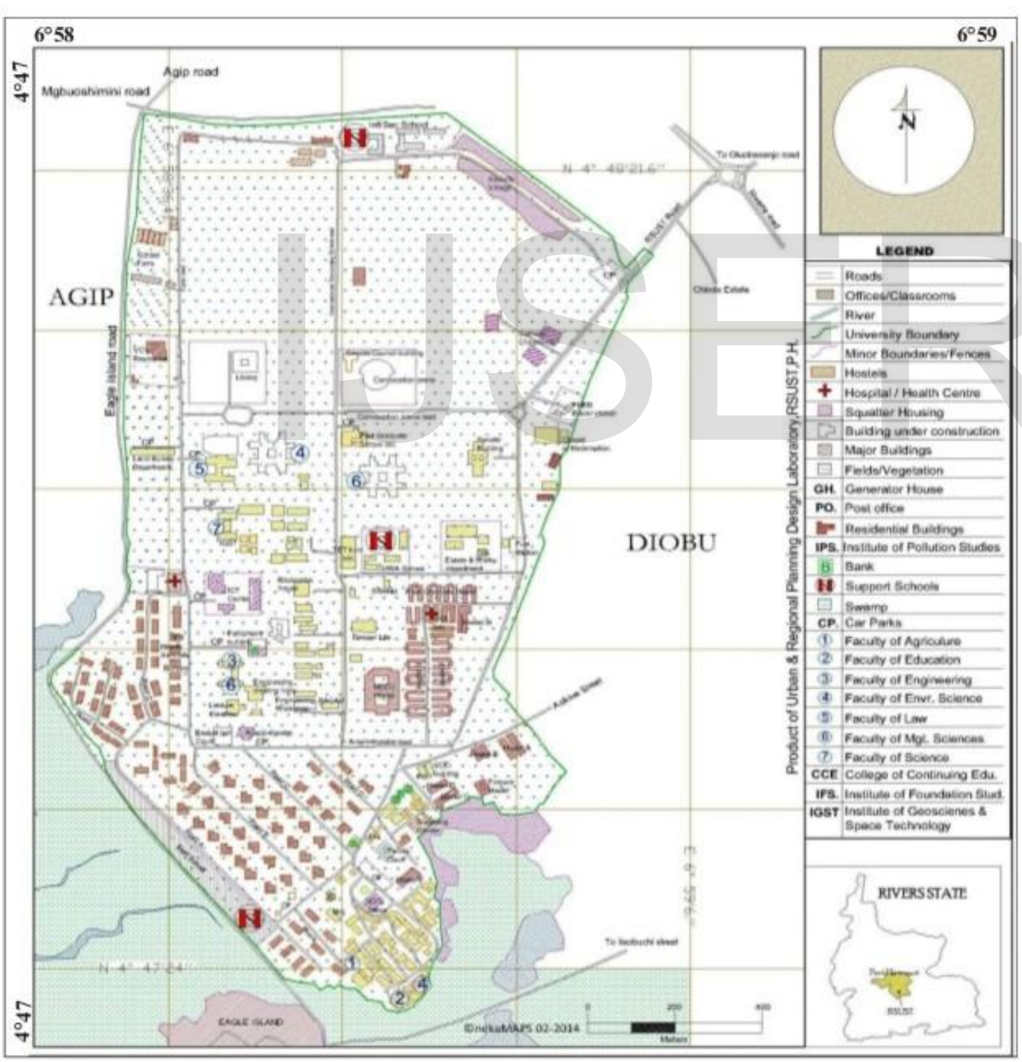


Figure 1: Map of the Study Area

Table 1: Location of boreholes and GPS co-ordinates

No.	Station Name	Code	Depth (ft)	GPS N	GPS E	Area

No.	Station Name	Code	Depth (ft)	GPS N	GPS E	Area
1	RSU water Station	UBH 1	280-300	4^0 47' 23.2"	6^0 58' 46.4"	SW
2	Institute of Pollution Studies	UBH 2	140-150	4^0 47' 21.2"	6^0 58' 48.0"	SW
3	Staff School	UBH 3		4^0 47' 27.3"	6^0 58' 36.1"	SW
4	Prof. Nimi Briggs Hospital	UBH 4		4^0 47' 48.8"	6^0 58' 35.8"	SW
5	NDDC Hostel	UBH 5		4^0 47' 41.9"	6^0 58' 52.1"	SE
6	Faculty of Law	UBH 6		4^0 47' 57.8"	6^0 58' 41.6"	NW
7	Vice Chancellor's lodge	UBH 7		4^0 47'07.9"	6^0 58' 34.2"	NW
8	RSU Agric Farm	UBH 8	360	4^0 47' 18.9"	6^0 58' 37.1"	NW
9	Diplomat Mushroom Farm	UBH 9		4^0 47' 22.5"	6^0 58' 47.3"	NW
10	International Sec Sch (ISS)	UBH 10		4^0 47' 24.4"	6^0 58' 52.9"	NE
11	Main Gate Car Park	UBH 12^{11}		4^0 47' 13.4"	6^0 58' 08.5"	NE
12	Council Unit	UBH 13		4^0 47' 06.6"	6^0 58' 49.8"	NE
13	RSU Admin Building	UBH 14		4^0 47' 56.7"	6^0 58' 59.2"	NE
14	Estate & Works Department	UBH 15	360	4^0 47' 51.6"	6^0 58' 57.4"	NE
15	UWA Daycare	UBH 16		4^0 47' 52.1"	6^0 58' 54.2"	NE
16	Fisheries Aquaria	UBH 19		4^0 47' 19.4"	6^0 58' 51.7"	SE
17	Institute of Education	UBH 20		4^0 47' 14.3"	6^0 58' 53.4"	SE
18	Road G Flat 9A	UBH 21		4^0 47' 41.9"	6^0 58' 30.5"	SW
19	Road G Flat 9B	UBH 1	NA	4^0 47' 42.0"	6^0 58' 29.9"	SW
20	Biological Science Lab	UBH 2	NA	4^0 47' 49.6"	6^0 58' 45.8"	NW
21	Sick Bay	UBH 3	NA	4^0 47' 45.0"	6^0 58' 54.7"	SE
22	Road F Flat 7A	UBH 4	NA	4^0 47' 42.5"	6^0 58' 35.1"	SW

2.3Laboratory Analyses

The parameters analysed in the laboratory may be categorize as follows; (a) **Chemical parameters:** Total hardness, total alkalinity, Turbidity, CO_3^{2-} **,** HCO_3^- **,** NO_3^- **,** SO_4^{2-} Cl^- PO_4^{3-} **(b) Metals: Ca, Mg, Na, K** PO_4^{3-} **(c) Microbiology**: THB, TCB and FCB. Except otherwise stated, the laboratory methodologies used were taken from *Standard Methods for the Examination for Water and Wastewater* published by American Public Health Association (APHA), 1985) and American Society for Testing & Material (ASTM, 1999). Summary of these methods used are shown in Table 2.

Table 2: Summary of Analytical Methods.

No	Parameter	Method
1	Turbidity	Nephelometer
2	Hardness	EDTA Titration
3	Alkalinity	Titration
4	Chloride, Cl^- (mg/1)	ASTM D 512
5	Sulphate, So_4^2 (mg/l)	Turbidimetric
6	Phosphate, PO_4^{-3} (mg/1)	APHA 4110
7	Nitrate, NO_3 (mg/1)	Brucine
8	Bicarbonate	Titration
9	Carbonate	Titration
10	Calcium	EDTA Titration
11	Magnesium	Calculation
12	Sodium	Flame Photometry
13	Potassium	Flame Photometry

3. Results and Discussion

3.1 Results

The minimum, maximum, mean and standard deviation values of the physico-chemical as well as microbiological properties of groundwater samples within the Rivers State University from year 2019 to 2021 are presented in Table 3. Table 3 also contains the Standard Organisation of Nigeria (SON) and World Health Organisation (WHO) standard limits for drinking water (SON, 2007) and WHO, 2006).

Table 3: Ranges and Means of RSUST Groundwater Quality July & September 2013

No.	Parameters	Min	Max	Mean	+SD	SON (2007)	WHO (2006)
1	pH	4.09	6.77	4.93	0.58	6.5-8.5	6.5—8.5
2	Temperature (^0C)	26.4	30.3	28.3	1.2	NS	NS
3	Conductivity (μS/cm)	20	407	103	102	1000	1200
4	Salinity (%)	<0.01	0.2	0.03	0.06	NS	NS
5	TDS (mg/l)	12	274	67	67	500	600
6	Turbidity (NTU	<0.05	<0.05	<0.05	<0.05	5	5
7	Chloride, Cl-(mg/l)	<1.0	12.3	2.9	2.8	250	250
8	Sulfate, SO_4^2 (mg/l)	<1.0	15.5	2.4	3.0	100	250
9	Phosphate, P_4^{3-}(mg/l)	<0.05	1.90	0.05	0.29	NS	Ns
10	Nitrate, NO_3^- (mg/l)	0.30	6.20	2.65	1.35	50	50
11	Alkalinity (mg/l as $CaCO_3$)	2	8	3.8	1.8	100	100
12	Carbonate, CO_3^{2-}(mg/l)	0	0	0	0	NS	NS
13	Bicarbonate HOD_3^- (mg/l)	4	16	7.5	3.7	NS	NS
14	Hardness (mg/l as $CaCO_3$)	<0.1	34.6	8.0	7.8	150	200
15	Calcium, Ca^{2+} (mg/l)	<0.08	9.2	1.7	1.9	NS	NS
16	Magnesium , Mg^{+2} (mg/)	<0.05	2.8	0.9	0.8	0.2	NS
17	Sodium, Na^+ (mg/l)	<0.01	44.62	11.21	13.02	200	200
18	Potassium, K^+(mg/l)	<0.01	11.88	1.50	2.64	NS	NS
19	THB I(cfu/ml)	Nil	3000	109	570	NS	<100
20	TCB (MPN/100ml)	Nil	210	8.6	43.6	10	0-2
21	FCB (MPN/100ml)	Nil	Nil	Nil	Nil	0	0

Note: <0.05 = Less than detection limit; NS = Not Specific

Table 4: Summary Data on Disease Prevalence: 2019 to 2021

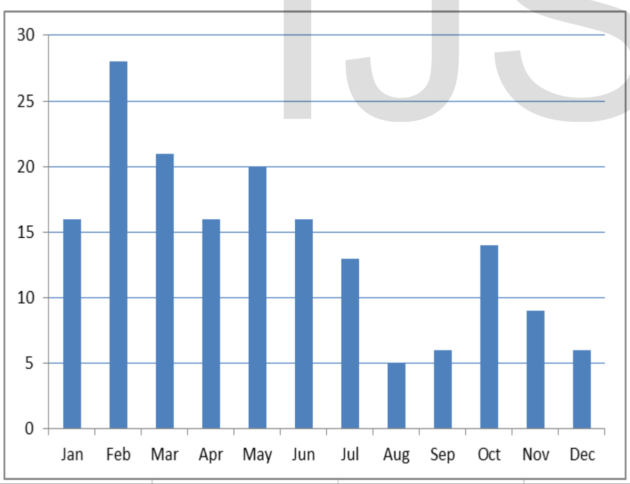
S/N	Items	2019	2020	2021
1.	Diarrheal	3	4	4
2.	Dysentery	1	0	4
3.	Cholera	1	0	3
4.	Typhoid	18	63	107
5.	Malaria	610	1010	1728

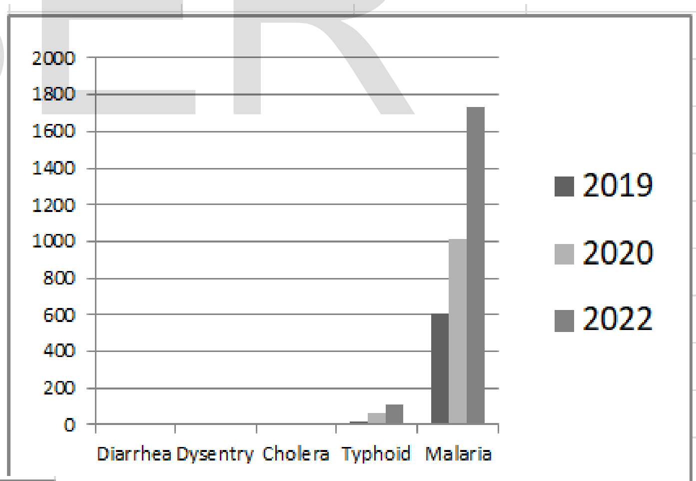
Source: Medical Centre, Rivers State University

Table 4 presents the survey of disease prevalence or pattern using data collated from the Medical centre, RSU. Diseases that manifest as a result of contact and use of poor quality water are called water-borne diseases. These include diarrhea, cholera, typhoid, dysentery, malaria, etc. The order of disease prevalence is malaria, typhoid, diarrhoea, dysentery and cholera. Figure 2, shows a graphical plot of the total number of cases during the study period; 2019-2021. Figures 3 and 4 show the monthly distribution of typhoid and malaria respectively from 2019 to 2021.

Figures 3 and 4 show that more cases of persons becoming ill due to typhoid and malaria respectively in the dry season than during the rainy season. In the case of malaria this may be attribution of stagnation of water in the drainage system and higher temperature which in combination promotes the breeding of plasmodium mosquitoes.

Table 3 shows that the minimum, maximum and mean values of the parameters are substantially below the limiting standards of SON, 2007 and WHO, 2006. The mean and maximum values of 109 cfu/ml and 3000 cfu/ml respectively were obtained against WHO 2006 standard limit of 100cfu/ml for E.Coli. Similarly, the mean and maximum values of 8.6MPN/ml and 210MPN/ml respectively were obtained against SON 2007 limit of 10MPN/ml and WHO, 2006 limit of 0-2MPN/ml. coliform levels exceeding the standard limits are indicative of water system that is vulnerable to human pathogens. The human health problems attributable to pathogens are: diarrhea, typhoid, cramps, nausea and vomiting. This illness can lead to more serious health problems or even death for people with undeveloped or weakened immune systems such as children and elderly. The pH values of the groundwater in the study area are below the standard limits 0f (6.5 – 8.5) for WHO and SON for drinking water quality. Water with a pH value less than 7 is termed acidic. Acidity in groundwater is attributable to free carbon dioxide or industrial pollution. Water with low PH values is normally corrosive. The presence of THB and TCB is indication of human pathogens and unsuitable for human consumption unless it is chlorinated. Table 4.3 shows the existence of strong correlation between parameters. For example, TDS strongly correlates with Conductivity, Salinity, Chloride, Hardness, Calcium, Magnesium, Sodium and Potassium.





2: Disease Prevalence In RSU, Port Harcourt, Nigeria.

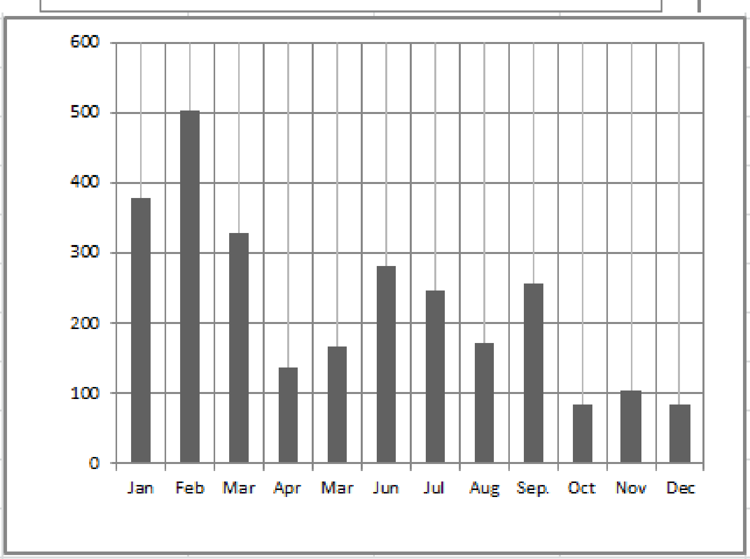


Figure 4: Monthly Distribution of Malaria for 2020&2021

3.2 Discussion

The mean and maximum values of 109 cfu/ml and 3000 cfu/ml respectively were obtained against WHO 2006 standard limit of 100cfu/ml for E.Coli. Similarly, the mean and maximum values of 8.6MPN/ml and 210MPN/ml respectively were obtained against SON 2007 limit of 10MPN/ml and

WHO, 2006 limit of 0-2MPN/ml. Coliform levels exceeding the standard limits are indicative of water system that is vulnerable to human pathogens. The human health problems attributable to pathogens are: diarrhea, typhoid, cramps, nausea and vomiting. These diseases may lead to more serious health problems or even death for

people with undeveloped or weakened immune systems such as children and elderly.
These results were corroborated with records of disease prevalence from the University medical centre. Health records shows 610, 1010 and 1728 cases of malaria where reported in 2019, 2020 and 2021 respectively. Similarly, 18, 63, and 107 cases of typhoid where also reported in 2019, 2020 and 2021 respectively, also diarrhoea, dysentery and cholera had an average of 4 cases each during the record period. The findings in this study agree with NDDC (2020) which reported the severity ranking of water borne diseases in the Niger Delta region as follows: Malaria 39%, Typhoid 17.82 %, Cholera 16.51%, Dysentery 8.40%, and Diarrhoea 5.05%. Furthermore, the values of physic – chemical obtained also agree with the Nigerian country – wide values of groundwater quality reported by [13]

4. CONCLUSION AND RECOMMENDATIONS

4.1 CONCLUSION

The suitability of borehole water quality for human consumption at Rivers State University main consumption was studied in this paper. The study was conducted using chemical, metal and microbiological parameters from twenty six (26) boreholes. The results shows that all parameters were below the maximum contaminant levels (MCLs) set by SON (2007) and WHO (2006) guidelines except E. coli and total coliform which exceeded the MCLs. These results imply the borehole water quality is chemically suitable for human consumption, except E. coli and total coliform which exceeded the MCLs. The study also investigated the possible association between human pathogens and disease prevalence using records from the University medical centre. The result of disease prevalence during the study period revealed that Malaria had 3348 cases, the typhoid 188 cases, cholera- 4 cases, Dysentery-5 cases and Diarrhoea-11 cases. The presence of microbial contaminants exceeding MCLs highlights the importance of routing monitoring of boreholes water quality to protect public health.

4.2 RECOMMENDATIONS

(i) It is important that RSU community recognise the effects of their lifestyles on boreholes water quality and the level of treatment that is required to allow safe drinking water to flow from their taps.
(ii) The drinking water quality stakeholders; the departments and the Medical centre must work together through research, education and update the university community on the dangers of water-borne diseases.
(iii) The bottling and packaging water companies must treat their waters to limiting standards like the standard organisation of Nigeria (SON) and World Health Organisation before releasing them for public consumption.
(iv) The management of the University should conduct periodic assessment of bottled water consumed within the University for compliance. In case of non-compliance, the culprits should be punished by banning their products.
(v) Boreholes should be properly constructed and maintained to avoid surface contaminants influencing the borehole water quality.

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