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Drinking Water Quality in an Induction Camp at Oyo State, Nigeria: A Preliminary Assessment

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Authors' contributions

This work was carried out in collaboration between all authors. Author JBE managed the literature searches, wrote the protocol, participated in bench work and wrote the first draft of the manuscript. Author NAOO designed the study and made significant contribution to the manuscript. Authors AII, IEM, ENN, FMU and OPU participated in sample collection, bench work and made significant contribution to the manuscript. All authors read and approved the final manuscript.

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Short Communication

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ABSTRACT

Physicochemical and microbial characterization of a groundwater source in an induction camp sited in Oyo state, Nigeria was conducted between April, 2016-June, 2016, to determine its fitness for drinking using standard analytical methods. The water quality index derived mainly from the physicochemical parameters revealed that drinking water samples were of poor quality. Total heterotrophic counts were found to be within the range of (16-70) $x10^2$ CFU/ml and (15-75) $x10^2$ CFU/ml before and after the orientation exercise respectively, which were above the recommended standard of $5x10^2$ CFU/ml for treated water as specified by United States Environmental Protection Agency (USEPA). Total coliform was observed to be positive only at some sampling points. *Escherichia coli* and *Staphylococcus aureus* were also isolated at sampling points P1 and P2 (6 CFU/ml and 1 CFU/ml respectively). No fungal and Salmonella-Shigella organisms were observed

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in all the samples. The results revealed that it is necessary to improve on the treatment technique for the drinking water source and also advice participants on the need to maintain adequate hygiene during camping period.

Keywords: Physicochemical assessment; microbial characterization; water quality index; Nigeria.

1. INTRODUCTION

Untreated groundwater could pose serious health threat to people drinking it. Likewise, treated water if not properly monitored could be further contaminated especially during distribution [1]. In Nigeria, greater percentage of groundwater is used for domestic purposes and it requires certain degree of purity to prevent outbreak of diseases. Such diseases may result in acute illness caused by pathogens, chemicals or toxins [2]. Groundwater contamination may be caused by certain anthropogenic activities which introduce foreign agents into the aquifer, thereby shifting the natural equilibrium to the detriment of the end users. Such activities include mainly poor waste disposal methods as well as increased industrial activities such as mining arising from industrialization and urbanization [3,4]. The aetiology of most disease outbreak from drinking water arises mostly as a result of the proximity of the aquifer to the source of contaminant which may be from point or non-point sources [5]. Previous study has documented several cases of groundwater contamination leading to disease outbreak like skin rashes, cholera and typhoid resulting in hospitalization and fatal in extreme cases [2]. The presence of faecal coliforms in a water supply is a proof of faecal contamination and is therefore a definite indication of the risk that pathogens may be present [6]. Contaminated drinking water supply following chlorination indicates application of inadequate treatment or contamination was introduced during the distribution process [6].

In investigating the contamination level of drinking water, the quality may be envisaged. Sometimes, it may be difficult to provide a general picture of the water quality from the levels of each parameter. The overall quality of water at a certain location and time based on several physicochemical parameters can be assessed over a hundred point scale referred to as Water Quality Index (WQI). The result obtained from this model is reliable only if the basic parameters that account for water quality are included. The main objective of WQI is to convert a complex water quality data into information that is understandable and useable by the public [7].

The study location (Fig. 1) situated at Iseyin town in Southwest of Nigeria is an induction camp that host about three thousand people biannually for the purpose of volunteer service. Observation of rashes among other mild ailments on the skin of some participants was a concern that led to this scientific enquiry (Fig. 2). Consequently, the physicochemical characteristics and the microbial load of the drinking water samples were determined before and after the camping period to determine the quality of the drinking water. This may help for a root-cause analysis of the problem in order to address them properly for the safety of participants in subsequent occasions.

2. MATERIALS AND METHODS

2.1 Study Area and Place of Sample Analysis

Ground water samples were collected from an induction camp situated at Iseyin town (Fig. 1) before and after the camping exercise and analysed between April, 2016 – June, 2016 in Environmental and Biotechnology laboratory, Department of Microbiology, University of Ibadan, Oyo State, Nigeria and Analytical laboratory, Department of Chemistry, University of Ibadan, Oyo State, Nigeria.

2.2 Sample Collection

Plastic containers for physicochemical analysis were pre-treated by soaking in 0.05 M hydrochloric acid overnight and then rinsed with distilled water and air- dried in the laboratory. Sample containers were re-rinsed with the sample water at each sampling point and then corked tightly. Water samples for microbial analysis were collected in autoclave-sterilized glass containers. The exterior part of the tap was properly cleaned with a tissue to remove dirt. The tap was allowed to flow at a maximum rate during which the nozzle was sterilized with an ignited cotton wool soaked in ethanol. The flow

rate of the tap was reduced and the sample was filled leaving an air space to facilitate shaking during inoculation. Water samples were collected from three main sources supplying water to the kitchen (P1), female (P2) and male lodges (P3). Samples collected from the three main sources before and after the induction program were analysed.

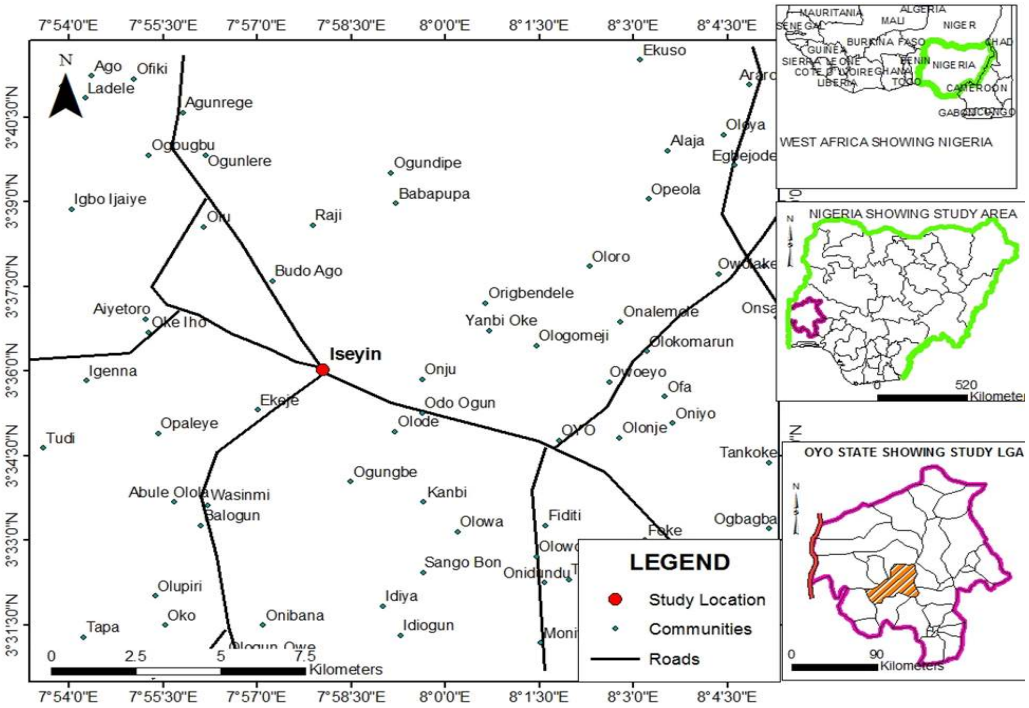

Fig. 1. Map showing the study location

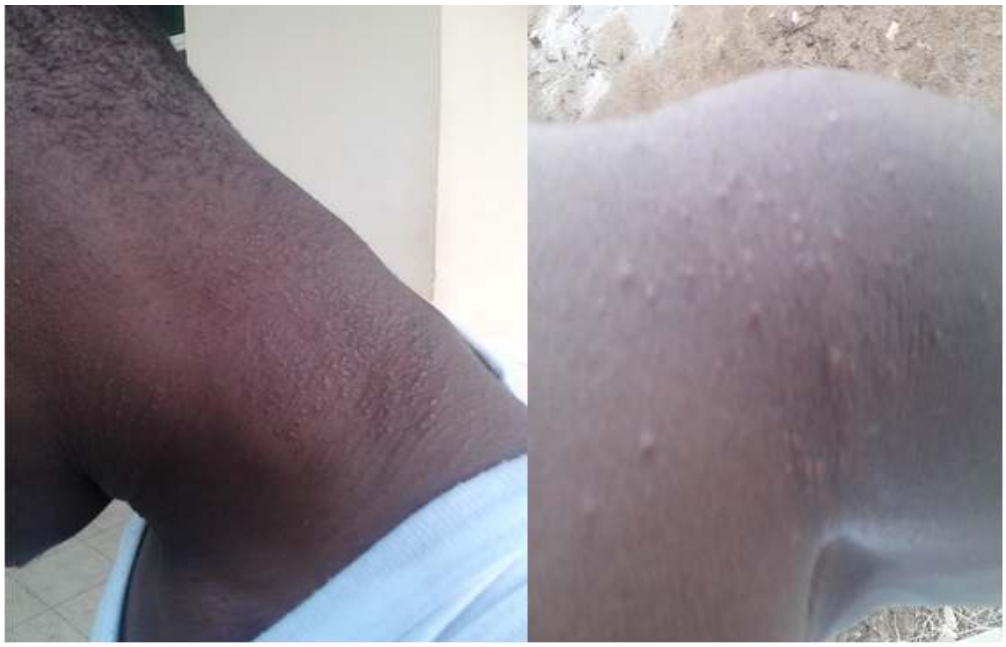

Fig. 2. Rashes on the skin of some of the affected participants

2.3 Physicochemical and Microbial Analysis of Water Samples

Sixteen physicochemical parameters were analysed using standard methods described by the American Public Health Association [8]. Dissolved oxygen (DO), temperature and pH were determined on site. DO was determined with the aid of a DO meter (Jenway DO_2 probe, model 9200), Temperature and pH were also determined using a thermometer (Hanna Instruments, HI 99300) and a pH metre (Jenway, 3510) respectively. Turbidity was determined by taking the absorbance at 520 nm using UV spectrophotometer (Spectrum lab 7525), while conductivity was determined using a portable conductivity meter (Hanna Instruments, HI 99300). Total dissolved solid (TDS) and Total suspended solid (TSS) were determined in the laboratory by gravimetric method, Total hardness, acidity, alkalinity, Ca and Mg hardness were determined by titrimetric technique. Salinity was determined using Conductometer (Hanna Instruments). Chloride was determined by argentometric method [9], sulphate and nitrate by spectrophotometric method [10] using UV spectrophotometer (Spectrum lab 7525) and absorbance were recorded at 450 nm and 500 nm respectively. Bacteriological analysis was carried out using the pour plate technique reported by [8].

2.4 Determination of Water Quality Index

The WQI of the water samples was assessed using the equation as reported by [11]:

$$WQI = \sum \frac{qn\,Wn}{Wn}$$

Where qn is the quality rating for the nth parameter and Wn is the unit weight for nth parameter. A further derivation of qn and Wn is available elsewhere [11]. The water quality status for each index level is presented in Table 1.

Table 1. Water quality status for each index level

Water quality index level	Water quality status
0-25	Excellent water quality
25-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Unsuitable for drinking

Source: [11,7]

3. RESULTS AND DISCUSSION

The results of the physicochemical characteristics, WQI data as well as microbiological parameters obtained before and after the induction program are presented in Tables 2 and 3 respectively.

The temperature determined varied from 28.0-29.5℃ as stipulated by [12], with no significant changes before and after the induction program. Temperature is an important parameter of water quality since it affects the amount of dissolved oxygen present. Excluding other factors, cold water holds more oxygen than warm water because the amount of oxygen that will be dissolved increases with decrease in temperature [10]. Although changes in pH of drinking water is reported to have no direct adverse effect on health, pH levels below 6.5 in an aquifer can initiate corrosion in pipes, thereby releasing toxic metals [10,13]. The pH values for the water samples were within the permissible limit of 6.5-8.5 and 6.5-9.5 as specified by [12] and [1] respectively, except the water being supplied to the male lodge (P3) which had a pH of 6.30 and 6.25 before and after the induction program respectively. This shows the need for regular monitoring of the aqua source as increased acidity of drinking water below the permissible limit is capable of having indirect health effects by enhancing the survival of pathogenic organisms as well as metal solubilization [14,15,9]. The water at the study area was clear and showed no turbidity, which could be attributed to the extremely low suspended solids present (TSS range: 0.42 mg/l- 3.47 mg/l). Although high turbidity is often a sign of poor water quality, crystal clear water is not an indication of good water quality as it may be as a result of high acidity [16]. TDS values were also low (47.7-58.3) compared to the permissible limit of 500 as recommended by [12] and may be as a result of the low content of inorganic salts such as chlorides, nitrates and sulphates as well as the cations (Ca and Mg) when compared to their respective permissible values. Hardness in natural water is caused by the presence of carbonates (Ca and Mg) and bicarbonates. Their amounts in the environment depend on the type of rocks and the rate of disintegration. Mg hardness associated with sulphate ions has laxative effect on persons unaccustomed to it [7]. In this study, the hardness levels were all within the recommended standard by World Health Organization.

Table 2. Physicochemical characteristics and microbiological parameters of water samples before official commencement of the induction program

Parameters	P1	P2	P3	WHO	USEPA
Physicochemical parameters					
Temperature (℃)	28.50	29.00	29.00	20.0-30.0	-
pH	6.60	6.70	6.30	6.5-8.5	6.5-9.5
TDS (mg/l)	48.90	47.70	47.60	500.0	
Conductivity (µS)	92.00	86.90	89.10	400.0	2500.0
Salinity (mg/l)	0.05	0.05	0.05	-	12.0-38.0
Acidity (mg/l)	10.00	20.00	20.00	-	
Alkalinity (mg $CaCO_3$/l)	80.00	60.00	60.00	-	400.0
Total hardness (mg $CaCO_3$/l)	24.00	36.00	40.00	300.0	-
Turbidity (FTU)	0.00	0	0	5.0	-
Ca (mg $CaCO_3$/l)	8.00	8.00	8.00	75.0	-
TSS (mg/l)	3.70	1.60	0.48	500.0	-
Mg (mg $CaCO_3$/l)	2.88	6.72	7.68	50.0	-
Sulphate (mg/l)	10.00	10.00	2.00	500.0	250.0
Chloride (mg/l)	8.00	8.00	8.00	-	250.0
Nitrate (mg/l)	BDL	BDL	BDL	50.0	50.0
DO (mg/l)	2.03	1.22	2.44	-	-
WQI parameters					
∑Wnqn	52.34	53.12	56.73	-	-
∑Wn	0.99	0.99	0.99	-	-
Water Quality Index	52.87	53.65	57.30	-	-
Bacteriological parameters					
Total Heterotrophic Count ($x10^2$CFU/ml)	16.00	14.00	70.00	-	5.0
E. coli Count (CFU/ml)	0.00	0.00	6.00	-	0.0
Staphylococcus Count (CFU/ml)	0.00	1.00	0.00	-	0.0
Total Coliform Count (MPN/100 ml)	< 2	< 2	2.00	-	0.0
Salmonella-Shigella Count (CFU/ml)	0.00	0.00	0.00	-	0.0
Total Fungal Count	0.00	0.00	0.00	-	0.0

Water quality indices calculated gave 52.87, 53.65 and 57.30 for P1, P2 and P3 respectively, with extreme value observed at P3. This implies poor water quality as all the values lie within WQI range of 51-75 (Table 1). Furthermore, the proximity of the data to the lower boundary of the WQI range for poor water quality implies that some effort is required to obtain good water quality at the study location by applying efficient water treatment methods and maintaining proper sanitary conditions to ensure improved dissolved oxygen levels required for optimal health [17,18]. The quality of the drinking water was further reduced after the orientation programme as indicated by increase in WQI values which increased from 52.87- 59.69, 53.65- 57.63 and 57.30- 59.02 for P1, P2 and P3 respectively. This suggests contamination of the drinking water due to improper management of the water resource by the participants. This serves as a caution to the participants on the need for adequate hygiene. Furthermore, it may be interesting to inquire if there would be further aging of contaminants over a longer period after camping.

The total heterotrophic count (THC) which provides a general bacterial density in water sources could serve as a check for water treatment efficiency. It has been established that bacterial counts for treated water should contain no more than 500 bacterial colonies per milliliter [1]. Bacterial counts for the sample water were above this permissible value revealing the relatively low efficiency of the treatment measures and require improvement. *Staphylococcus aureus* was observed in the water source supplied to the female lodge (P2) which was further observed to increase after the induction exercise. Total fungal counts and Salmonella-Shigella counts were all negative for all the samples. Total coliform counts which gives a clue of faecal contamination of an aqua

Table 3. Physicochemical characteristics and microbiological parameters of water samples at the close of the induction program

Parameters	P1	P2	P3	WHO	USEPA
Physicochemical parameters					
Temperature (℃)	28.00	29.00	29.50	20.0-30.0	-
pH	6.40	6.50	6.25	6.5-8.5	6.5-9.5
TDS (mg/l)	57.30	50.80	49.50	500.0	-
Conductivity (µS/cm)	119.00	88.70	90.10	400.0	2500.0
Salinity (mg/l)	0.05	0.05	0.05	-	12.0-38.0
Acidity (mg/l)	20.00	20.00	20.00	-	
Alkalinity (mg$CaCO_3$/l)	60.00	55.00	60.00	-	400.0
Total Hardness (mg/$CaCO_3$)	32.00	38.00	40.00	300.0	-
Turbidity (FTU)	0	0	0	5.0	-
Ca (mg $CaCO_3$/l)	12.80	8.00	8.00	75.0	-
TSS (mg/l)	0.42	0.60	0.50	500.0	-
Mg (mg $CaCO_3$/l)	4.61	6.52	7.95	50.0	-
Sulphate (mg/l)	18.00	15.00	2.00	500.0	250.0
Chloride (mg/l)	8.00	8.00	8.00	-	250.0
Nitrate (mg/l)	BDL	BDL	BDL	50.0	50.0
DO (mg/l)	1.22	1.22	2.24	-	-
WQI parameters					
∑Wnqn	59.09	57.05	58.43	-	-
∑Wn	0.99	0.99	0.99	-	-
Water Quality Index	59.69	57.63	59.02	-	-
Bacteriological parameters					
Total Heterotrophic Count ($x10^2$CFU/ml)	20.00	15.00	75.00	-	5.0
E. coli Count (CFU/ml)	0.00	0.00	5.00	-	0.0
Staphylococcus Count (CFU/ml)	0.00	0.00	2.00	-	0.0
Total Coliform Count (MPN/100 ml)	2.00	4.00	5.00	-	0.0
Total Fungal Count (CFU/ml)	0.00	0.00	0.00	-	0.0

source was observed only in P3 representing water supplied to the male lodge before official opening of the induction program. Further isolation of *Escherichia coli* (6 CFU/ml) was obtained at this aqua source confirming faecal contamination. After the induction program, all the samples were observed to be positive to coliform with the highest count of 5 MPN/100 ml at P3 and *Escherichia coli* (5 CFU/ml) was further observed at the same sampling point only indicating further contamination during the course of the program. It is required that treated water should contain no faecal coliforms at all [1]. Although faecal organisms are not intrinsically pathogenic, their presence especially *E. coli* are a clear indication that enteric pathogens may be present as they possess low infective dose [19]; hence, it is required that all treated drinking water sources should be completely free of faecal bacteria. This could possibly be the reason for the observed dermal infection which requires improved treatment measures to prevent acute or fatal cases.

4. CONCLUSION

The study was carried out as a preliminary assessment of the drinking water quality in an induction camp at Oyo state based on water quality index model and microbial characterization. The results reveal poor water quality as well as faecal contamination. Hence, there is need to improve on the treatment technique and possibly install point of use and

point of entry systems specifically designed to remove harmful microorganisms and toxic elements to ensure that pathogens as well as chemical contaminants are completely eliminated. It is also necessary to advise participants on the need to keep the drinking water sources clean to prevent exposure to harmful contaminants. This will serve as a benchmark of environmental safety for participants in subsequent occasions.

5. RECOMMENDATION

A further research that will incorporate parameters that affect the dynamics of the microorganisms as well as risk assessment of the contaminants over a long period of time at the study site is highly recommended.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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