EVALUATION OF SOME TOXIC HEAVY METALS AND BACTERIAL LOAD FROM SELECTED SOURCES OF DRINKING WATER IN OZUOBA, RIVERS STATE, NIGERIA

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Received: 12th January, 2024
Accepted: 21st February, 2024
Published: 28th February, 2024
Available: https//www.nmlsj.org
Publisher: ScholarlyFeed

Cite as: Azike CA, Agi VN, Ben-Chioma AE, Ekesiobi SU, Thompson IN, Nwanosike IP. Evaluation of some toxic heavy metals and bacterial load of selected sources of drinking water in Ozuoba, Rivers State, Nigeria. Nexus Med Lab Sci J. 2024; 1(1):15-24

Abstract

The provision of safe drinking water is an important Public Health goal. The aim of this study is to evaluate some heavy metals and bacterial load in some selected sources of drinking water in Ozuoba, Rivers State, Nigeria. Three different water sources from different locations in Ozuoba were analyzed. The brand names of the water used are Lasien bottled water, Cway bottled water, Lucid bottled water, Zoey sachet water, Minaso sachet water and Einpac sachet water. The borehole water sources were collected from different households in the Ozuoba community. The concentration of lead, cadmium, chromium and bacterial load (total coliform, fecal coliform and *Escherichia coli* count) were estimated in bottled water, borehole and sachet water sources using atomic absorption spectrophotometer (AAS) in the laboratory. Graph pad version 8.02 was used to statistically analyze the results obtained. T-test and ANOVA were used to compare the significant difference at p≤0.5. The results obtained show that Total coliform and Esherichia coli were significantly (p-value < 0.05) present in the sachet water and bottled water. There was significant difference in the Total coliform, fecal coloform and *Esherichia coli* in the bottled water, borehole water and sachet water at p <0.05. Lead, cadmium and chromium concentrations in bottled water were 0.003mg/L, 0. 0005mg/L and 0.000633mg/L respectively; the borehole water source contained 0.0005mg/L of lead, 0.0007mg/L of cadmium, and 0.00766mg/L of chromium. These concentrations are below the World Health Organisation (WHO) and Network and Information Systems (NIS) detection limits. Hence, the water sources under study are considered safe sources of drinking water from the findings.

Keywords: *Hospitalization, Monkeypox, Polymerase Chain Reaction.*

INTRODUCTION

Water is a clear, colourless, tasteless liquid composed of hydrogen and oxygen. It is an indispensable natural resource used on a daily basis for various purposes. Humans use water from various sources for a variety of daily activities, including household, agricultural, and manufacturing purposes. According to Igbeneghu and Lamikanra in 2014, water is used for drinking, bathing, medication, industrialization, processing of food, recreation and other uses. However, each of the aforesaid uses has its own unique water quality categorization that determines its fittingness [1, 2, 3, 4].

An environment can be polluted or contaminated. Water pollution occurs when unwanted materials (with potentials to threaten human and other natural systems) find their way into Rivers, lakes, wells, streams, boreholes or even reserved fresh water in homes and industries [5]. Large quantities of heavy metals are being released into rivers worldwide due to global rapid population growth and anthropogenic activities [6].

Waterborne disease cause about 3.4 million deaths every year making it the leading cause of morbidity and mortality all-over the world [7]. People around including the Ozuoba community do not have safe drinking water and that has resulted into myriad of water borne diseases, heavy metal poisoning and toxicity. The quest for a safe drinking water free from any form of contamination cannot be overemphasized. Worldwide, about a billion people have no access to safe drinking water and 2.6 billion people lack proper sanitation, which results to 1.8 million people dying yearly from water related diseases, with about 90% of children under the age of 5 years mostly in developing countries being infected [8].The general idea is that drinking water should be totally free from microorganisms but this is not usually the case especially processed packaged water being the area of concern which is not free from microorganisms. Production of quality water product is increasingly difficult, because the demand for water is high. Implementing universal standard for drinking water is not being followed to the latter, due to differences in sociological conditions, varying climates, and other specific circumstances found all over the world.

MATERIALS AND METHODS

Sample collection: A total of nine (9) Water specimens collected and used in this experiment were grouped into three: bottle water, sachet water and borehole water. The bottle water specimens collected in this group, consisted of Lasien bottle water, Cway bottle water, and Lucid bottle water. The bottle water specimens were bought at three different retail locations in Ozuoba. The borehole water specimens were collected at different household locations in Ozuoba. The sachet water consisted of Zoey sachet water, Minaso bottle water and the Einpac sachet water. The sachet water sources were bought at different retail locations.

Sample Analysis

Determination of Lead, Arsenic, Cadmium, Copper and Zinc in water using APHA 3111C Method.

Principle: This is based on acid digestion. The mixture of the concentrated acids (perchloric acid, nitric acid and sulphuric acid), causes the matrices of the organic and inorganic samples to be destroyed or dissolved and the whole sample to be brought into solution, the heating causes the acid digestion to speed up as to improve the digestion quality. Subsequently, Atomic absorption spectrophotometry (AAS) allows the concentrations of the elements to be determined in the filtrates.AAS quantitatively measures the concentrations of elements present in a liquid sample. It utilizes the principle that elements in the gas phase absorb light at very specific wavelengths which gives the technique excellent specificity and detection limits. The sample may be an aqueous or organic solution; it may even be solid provided it can be dissolved successfully. The liquid is drawn in to a flame where it is ionized in the gas phase. Light of a specific wavelength appropriate to the element being analyzed is shone through the flame; the absorption is proportional to the concentration of the element. Quantification is achieved by preparing standards of the element.

Procedure
One hundred milliliters (100 ml) of the acid preserved sample was transferred into a beaker and 5 ml of concentrated nitric acid (HNO3) was added, then 2 grams of henger granules were added to the solution sample to minimize spatter. The solution was then placed on a hot plate in a hood at a temperature of 95 ºC to achieve a slow boil. The slow boiling allowed evaporation and then the solution was continuously heated while concentrated nitric acid was added until a light coloured, cleared solution was observed signifying completion of digestion. The solution was removed from the hood and allowed to cool off. After the solution was allowed to cool, the solution in the beaker was then filtered into a 100ml volumetric flask by the use of a Whatman 42 filter paper. The bottom of the beaker was rinsed with distilled water and emptied into the filter paper. The volume of the filtrate was then completed to 100 ml of the volumetric flask. The solution was transferred into a 100 ml plastic container for atomic absorption spectrophotometer analysis of the heavy metals. The AAS was adjusted according to the operating procedure and optimized using air-acetylene gas flame. The absorbance of the sample solution was analysed under the same condition as the calibration standard.

Preparation of Standard Calibration Curve
The standard stock was diluted with 5% nitric acid in series of dilutions to make 0.5ppm, 1.0ppm, 1.5pm and 2.0pmm standard concentrations and then the absorbance of these standard concentrations were recorded which were for the calibration standard (by plotting the absorbance against the calibration standards).

Determination of Total Coliform in Drinking Water
Method: (APHA 9221-B) by Most Probable Number (MPN) Presumptive Test
Principle: In the presumptive test a series of 9 or 12 tubes of lactose broth are inoculated with measured amounts of water to see if the water contains any lactose-fermenting bacteria that produce gas. If, after incubation, gas is seen in any of the lactose broths, it is presumedthat coliforms are present in the water sample. This test is also used to determine the most probable number (MPN) of coliforms present per 100 ml of water.
Procedure
Three (3) double strength lactose broth (DSLB) tubes and 6 single strength lactose broth (SSLB) tubes withdurham tubes inserted in eachwere aligned and labeled according to the amount of water that was dispensed in each tube, 10ml, 1.0ml and 0.1 ml respectively. Ten(10) ml of DSLB media was transferred into the DSLB test tubes, and 10 ml of SSLB media was transferred into the SSLB tubes. The water samples in bottle were mixed by shaking several times, then a 10 ml pipette was used to transfer 10 ml of water sample to one DSLB tube and two SSLB tubes, this was kept aside as the first set. For the second set, a 1.0ml pipette was used to transfer the water sample into another one DSLB tube and two SSLB tubes. For the third set, a 1.0ml pipette was used to transfer 0.1ml of the water sample into one DSLB and two SSB tubes. The sets of tubes were then kept in the incubator for 24 hours. After 24 hours of incubation, the tubes were examined for 10 % gas and more. The MPN/100 ml was determined by referring to the MPN index table and data were recorded.

Determination of Fecal Coliform in Drinking Water Using most probable number (MPN) method: Complete test
Principle: In the presumptive test a series of 9 or 12 tubes of lactose broth are inoculated with measured amounts of water to see if the water contains any lactose-fermenting bacteria that produce gas. If, after incubation, gas is seen in any of the lactose broths, it is presumedthat coliforms are present in the water sample. This test is also used to determine the most probable number (MPN) of coliforms present per 100 ml of water.
Procedure
From the positive test tubes in the determination of total coliforms, 10 ml, 1 ml and 0.1ml was transferred into newly prepared MacConkey broths of single and double strength and then Durham tubes were then inserted. The tubes were then placed in the incubator at $45^{0}C$ for 24 hours. After the 24 hours' incubation, the tubes were examined and the number for each set of tube with ≥ 10 % gas. The fecal coliform (MPN/100ml/L) was determined by

referring to the MPN index table. Positive test indicates the presence of *Esherichia coli*

Determination of *Esherichia Coli* in Drinking Water using APHA 9221-F

Principle: In this method *E. coli* are defined as coliform bacteria that possess the enzyme β-glucuronidase and are capable of cleaving the fluorogenic substrate 4-methylumbelliferyl-β-D-glucuronide (MUG) with the corresponding release of the fluorogen when grown in EC-MUG medium at 44.5°C within 24 ± 2 h or less.

Procedure

From the previews test, all the presumptive fermentation tubes that showed growth, gas and acidity within 48 hour of incubation to the *Escherichia coli* test, were collected and gently shaken using an applicator stick, after gently shaking, the contents were then transferred into EC-MUG broth and incubated in a water bath at 45 ºC for 24 hours and the tubes examined for growth by the use of fluorescence with a long wavelength UV lamp (6 W). Positive test for *E. coli* gave blue light when compared with the positive control; the negative control did not show any blue light.

Statistical Analysis

All data obtained from the laboratory analysis was computed in a Microsoft sheet, statistical analysis was done by graph pad prism 8.02. The results were expressed in mean and standard deviations, students' T-test and one-way ANOVA was used to compare the means of the parameters and regression analysis was used to determine the correlations of the parameters investigated.

RESULTS

The result of the frequency distribution of heavy metals and bacterial load compared to WHO/ NIS, is presented in Table1.

Table 1: Frequency Distribution of Heavy Metals Detected in different Water Types by WHO/ Detection Limit

Parameters	Water Type	Detection Range	Frequency	Percent
Lead Group (mg/l)	Bottled Water	≤WHO Detection Limit (0.01mg/l)	3	100.0
		>WHO Detection Limit (0.01mg/l)	0	0.0
	Borehole Water	≤WHO Detection Limit (0.01mg/l)	3	100.0
		>WHO Detection Limit (0.01mg/l)	0	0.0
	Sachet Water	≤WHO Detection Limit (0.01mg/l)	1	33.3
		>WHO Detection Limit (0.01mg/l)	2	66.7
Cadmium (mg/L)	Bottled Water	≤WHO Detection Limit (0.003mg/l)	3	100.0
		>WHO Detection Limit (0.01mg/l)	0	0.0
	Borehole Water	≤WHO Detection Limit (0.003mg/l)	3	100.0
		>WHO Detection Limit (0.01mg/l)	0	0.0
	Sachet Water	≤WHO Detection Limit (0.003mg/l)	3	100.0
		>WHO Detection Limit (0.01mg/l)	0	0.0
Chromium (mg/L)	Bottled Water	≤WHO Detection Limit (0.05mg/l)	3	100.0
		>WHO Detection Limit (0.01mg/l)	0	0.0
	Borehole Water	≤WHO Detection Limit (0.05mg/l)	3	100.0
		>WHO Detection Limit (0.01mg/l)	0	0.0
	Sachet Water	≤WHO Detection Limit (0.05mg/l)	1	33.3
		>WHO Detection Limit (0.05mg/l)	2	66.7

The result of the general frequency distribution of the heavy metals and bacterial load is presented in Table 2

Table 2: General Frequency Distribution of Heavy Metals and Microbial Load in Water

Parameter	Detection Limit	Frequency	Percent
	Heavy Metals		
Lead Group (mg/l)	≤WHO Detection Limit (0.01mg/l)	7	77.8
	>WHO Detection Limit (0.01mg/l)	2	22.2
	Total	9	100.0
Cadmium (mg/L)	≤WHO Detection Limit (0.003mg/l)	9	100.0
	>WHO Detection Limit (0.01mg/l)	0	0.0
Chromium (mg/L)	≤WHO Detection Limit (0.05mg/l)	7	77.8
	>WHO Detection Limit (0.05mg/l)	2	22.2
	Total	9	100.0
	Microbial Parameters		
Total Coliform Count	≤WHO Detection Limit (0.00 MPN/100mL)	6	66.7
	>WHO Detection Limit (0.00 MPN/100mL)	3	33.3
	Total	9	100.0
Fecal Coliform Count	≤WHO Detection Limit (0.00 MPN/100mL)	6	66.7
	>WHO Detection Limit (0.00 MPN/100mL)	3	33.3
	Total	9	100.0
***E. coli* Count**	≤WHO Detection Limit (0.00 MPN/100mL)	3	33.3
	>WHO Detection Limit (0.00 MPN/100mL)	6	66.7
	Total	9	100.0

Lead content in bottled water and sachet water, showed no significant difference with the NIS detection limit at p>0.05, the lead content in borehole water was significantly different from the NIS detection limit at p<0.05. the lead content was lower than the NIS detection limit, Cadmium content in the bottled water, borehole and sachet water was significantly different from the NIS detection limit at p<0.05. Total coliform and *Esherichia coli* were significantly present in the sachet water and bottled water. The result is presented in Table 2b.

The result of the means and standard deviations of lead, cadmium, chromium, total coliform, fecal coliform and *Esherichia Coli* is presented in Table 3.

Table 2b: Comparative difference between NIS Detection Limit and Parameters of different Water Types

Water Type	Mean	NIS Limit	T test	df	p-value
Lead (Mg/L)					
Bottled Water	.0032000±.00415812	0.01	-2.833	2	.105
Borehole Water	.0005000±.00010000		-164.545	2	.000
Sachet Water	.1276000±.20154325		1.011	2	.419
Cadmium (mg/L)					
Bottled Water	.0005333±.00025166	0.003	-16.977	2	.003
Borehole Water	.0007000±.00020000		-19.919	2	.003
Sachet Water	.0007000±.00026458		-15.057	2	.004
Chromium (mg/L)					
Bottled Water	.0006333±.00030551	0.01	-53.104	2	.000
Borehole Water	.0007667±.00015275		-104.696	2	.000
Sachet Water	.0606667±.04966219		1.767	2	.219
	Microbial Parameters				
Total coliform (MPN/100ml)					
Bottled Water	1.7333333±.25166115	10	-56.895	2	.000
Borehole Water	11.6000000±5.12640225		.541	2	.643
Sachet Water	2.6333333±1.61735381		-7.889	2	.016
Fecal Coliform (MPN/100ml)					
Bottled Water	.00000000±.00000000	0	---	---	---
Borehole Water	2.516667±1.30416001		3.342	2	.079
Sachet Water	.00000000±.00000000	---	---	---	---
Esherichia Coli (MPN/100ml)					
Bottled Water	1.6000000±.13228757	0	20.949	2	.002
Borehole Water	.0000000±.00000000	---	---	---	---
Sachet Water	1.6166667±.10408330		26.903	2	.001

Note: --- t-test cannot be computed because standard deviation equals zero . NS=Not Significant=p>0.05; Sig=Significant=p<0.05

Table 3: Descriptive Statistics of Heavy Metals and Microbial Parameters based on Water Type

Water Type	Parameters	N	Minimum	Maximum	Mean	Std. Error	Std. Deviation Statistic
Bottled Water	**Heavy Metals**						
	Lead (Mg/L)	3	.00070	.00800	.0032000	.00240069	.00415812
	Cadmium (mg/L)	3	.00030	.00080	.0005333	.00014530	.00025166
	Chromium (mg/L)	3	.00030	.00090	.0006333	.00017638	.00030551
	Microbial Parameters						
	Total coliform (MPN/100ml)	3	1.50000	2.00000	1.7333333	.14529663	.25166115
	Fecal Coliform (MPN/100ml)	3	.000000	.000000	.00000000	.000000000	.000000000
	Esherichia coli (MPN/100ml)	3	1.45000	1.70000	1.6000000	.07637626	.13228757
Borehole Water	**Heavy Metals**						
	Lead (Mg/L)	3	.00040	.00060	.0005000	.00005774	.00010000
	Cadmium (mg/L)	3	.00050	.00090	.0007000	.00011547	.00020000
	Chromium (mg/L)	3	.00060	.00090	.0007667	.00008819	.00015275
	Microbial Parameters						
	Total coliform (MPN/100ml)	3	6.80000	17.00000	11.6000000	2.95972972	5.12640225
	Fecal Coliform (MPN/100ml)	3	1.550000	4.000000	2.51666667	.752957133	1.304160011
	Esherichia coli (MPN/100ml)	3	.00000	.00000	.0000000	.00000000	.00000000
Sachet Water	**Heavy Metals**						
	Lead (Mg/L)	3	.00080	.36000	.1276000	.11636105	.20154325
	Cadmium (mg/L)	3	.00040	.00090	.0007000	.00015275	.00026458
	Chromium (mg/L)	3	.00700	.10500	.0606667	.02867248	.04966219
	Microbial Parameters						
	Total coliform (MPN/100ml)	3	1.65000	4.50000	2.6333333	.93377966	1.61735381
	Fecal Coliform (MPN/100ml)	3	.000000	.000000	.00000000	.000000000	.000000000
	Esherichia coli (MPN/100ml)	3	1.50000	1.70000	1.6166667	.06009252	.10408330

The means of the of the lead, cadmium, lead, chromium, total coliform, fecal coliform and Esherichia coli were compared for significant difference in the bottled water, borehole water and sachet water; There was no significant difference in the means of the lead concentrations in the bottled water, borehole water, and sachet water. There was no significant difference in the means of lead concentrations in the bottled water, borehole water, and sachet water. There was no significant difference in the means of the chromium concentrations in the bottled water, borehole water and sachet water at p>0.05. There was significant difference in the Total coliform, fecal coloform and Esherichia coli in the bottled water, borehole water and sachet water at p <0.05. The result is presented in Table 4.

Table 4: ANOVA (Mean Comparison) of Heavy Metals and Microbial Parameters by Water Type

Parameters	Water Type	Mean±SD	F-value	df	p-value	Remark
Heavy Metals						
Lead (Mg/L)	Bottled Water	0032000±.00415812	1.168	8	.373	NS
	Borehole	.0005000±.00010000				
	Sachet Water	. 1276000±.20154325				
Cadmium (mg/L)	Bottled Water	.0005333±.00025166	.481	8	.640	NS
	Borehole	0007000±.00020000				
	Sachet Water	.0007000±.00026458				
Chromium (mg/L)	Bottled Water	.0006333±.00030551	4.374	8	0.07	NS
	Borehole	.0007667±.00015275				
	Sachet Water	.0606667±.04966219				

Microbial Parameters (MPN/100ml)						
Total coliform	Bottled Water	1.7333333±.25166115	9.249	8	0.02	Sig
	Borehole	11.6000000±5.12640225				
	Sachet Water	2.6333333±1.61735381				
Fecal Coliform	Bottled Water	.00000000±.000000000	11.171	8	0.01	Sig
	Borehole	2.51666667±1.304160011				
	Sachet Water					
Esherichia Coli	Bottled Water	1.7333333±.25166115	273.912	8	0.00	Sig
	Borehole	.0000000±.00000000				
	Sachet Water	1.6166667±.10408330				

Sig=Significant=p<0.05; NS=Not Significant=p>0.00

DISCUSSION

Distribution of Heavy Metals and Microbial load in Drinking Water

The frequency distribution of the heavy metals in the three different sources of drinking water supplies compared with the WHO detection limit is described as follow: the lead content of the bottled water was below the WHO detection limit (bottled water Lead:0.003200 mg/L < WHO Lead : 0.01 mg/L) , making the bottle safe source of drinking water in the context of lead, also, the distribution of lead in borehole water was below the WHO detectable limit (borehole water Lead:0.005 mg/L <WHO Lead: 0.01 mg/L) making the borehole water 100 percent safe for drinking compared to WHO permissible limit, in the sachet water, the Lead content was 66.33 greater than the WHO detection limit, this may not be safe for drinking (sachet water Lead:0.127600 mg/L > WHO Lead :0.01 mg/L).

Cadmium in bottle water was found to be 100 percent free in distribution which is safe for drinking (bottled water cadmium: 0.0005mg/L < WHO cadium: 0.003mg/L), also the cadmium in the sachet water was found to be 100 percent free in distribution when compared with WHO detectable limit (sachet cadmium:0.0007 < WHO cadmium: 0.003mg/L). The cadmium concentration was lower than the WHO permissible limit, making all the three water samples safe for drinking in the context of cadmium. For chromium, the bottled water and borehole water was 100 percent lower than the WHO permissible limit except for the sachet was which had chromium content greater than the WHO detection limit (Sachet water chromium:0.126700mg/L > WHO chromium:0.01mg/L), the sachet water may not be safe for drinking.

The findings in the study with respect to the three heavy metals, was compared with that of other authors in Nigeria. In the study done by Bolawale & Adelusi in the year 2017 in Lagos State Nigeria, they identified Lead, chromium and cadmium in bottle water to be below the WHO permissible limit in drinking water [9]. The study also agrees with another study where lead and cadmium were identified to be lower than the WHO and NIS detectable limit [10], but disagrees with their finding on chromium which was present in bottled and sachet water as against this study where the amount of chromium was lower than the WHO and NIS detectable limit. This discrepancy may be as a result of contamination of machine used in the bottling company.

The fecal coliform distribution in this study, agrees with the findings recorded in Ibadan where fecal colifom and *Escherichia coli* in bottle water were below the NIS limit except for one bottle water that was contaminated [11]. Oyedeji and his team in the study carried out in Ibadan also reported the presence of fecal coliform and *Escherichia coliform* of varying number isolated from sachet water which is not safe for drinking, this was also the finding in sachet water in this study.

In this study, the borehole water and sachet water are not safe for drinking as there was

100 percent of fecal coliform and *Escherichia coli* in the drinking water. The reason for these contaminations could be as a result of unhygienic conditions in the production of the sachet water while the underground water may be due to accumulation of refuse dumb in the environment, stagnant water or flooding of the environment. A similar work also done by another researcher identified presence of total coliform in borehole water [12]. In this study, the bottle water and sachet water were rated 100 percent unsafe for drinking due to the identification of *E. coli* in both sources, however the borehole water was identified 100 pecent below the WHO limit for *Esherichia coli.*

Comparative Analysis of Heavy Metals and microbial load across the three Drinking Water Source

Based on distribution, bottled water and sachet were 100 percent safe for drinking while borehole water was identified to be 66.6% contaminated with coliform. In terms of fecal coliform distribution, the three water supplies were 100% safe for drinking while in the distribution of *Esherichia coli*, only borehole water was identified to be 100% safe while bottle water and sachet was 0.0% unsafe. When the Lead metal was compared in the three different sources of drinking water, the Lead content was 0.00% in the bottle and borehole water and bottle water but was 66.6% present in the sachet water making sachet water unsafe for consumption. All the three water supplies were 0.00% distributed making the three sources good for drinking in the context of cadmium. Chromium was 0.00% distributed in the bottle and borehole water but 66.8% distributed in the sachet water. The sachet water is not safe for drinking in the context of chromium.

In comparison of the mean ± SD of the heavy metals value, they tend to be in the order of lead>chromium>cadmium and Total coliform>*Esherichia coli*>fecal coliform in bottled water while in borehole water, Cadmium=chromium>lead and total coliform>fecal coliform>*Esherichia coli.* In sachet water: lead>chromium>cadmium and Total coliform>fecal coliform>*Esherichiac coli.* When compared across the three sources of drinking water, in terms of lead concentration; sachet water> bottled water>borehole water, in terms of cadmium concentration, boreholewater=sachet water> bottled water, in terms of chromium concentration; sachet water>borehole water>bottle water. In terms of total coliform; bore hole water > sachet water>bottled water this could be to hipping of refuse dumb, flooding of contaminated water, stagnant water containing dead animals. In terms of fecal coliform, borehole water > sachet water = bottled water this could be due to improper sewage disposal. In terms of *Esherichia coli*; bottled water= sachet water >borehole water this could be due to contamination of surfaces and materials used in the production of the water supplies, or the machines are contaminated as well as the hygienic conditions of the workers.

Comparative Analysis of Observed Results with WHO and NIS Detection Limit.

When the lead concentrations in the three water samples were compared there was no significant difference in bottled water and sachet water but the lead in borehole water was significantly below the WHO and NIS limit. Ozuoba soil and underground water may not be contaminated with lead because the area is not known for automobile works and chemical industries. The bottle water and sachet water may not be directly produced in Ozuoba, they are only supplied to the area, hence the difference in lead concentrations. The cadmium in the three sources of water was significantly lower than the WHO limit at $p<0.05$. The concentration of chromium in the three water sources was significantly below the WHO limit. The total coliform fecal in the three water sources showed significant difference in bottle water which was below the WHO limit while the total coliform in sachet and borehole water showed no significant difference. *Esherichia coli* was significantly high in the bottled and sachet water when compared with the NIS limit.

Conclusion

Lead and cadmium were observed to be below WHO and NIS detectable limit in the bottled water, borehole water and sachet water; however, chromium was also below WHO and NIS detectable limit in bottled water and borehole water but was higher than the WHO permissible limit in sachet water. *Esherichia coli* were detected above the WHO limit in bottled water and sachet water. Coliform was above the WHO limit in borehole water. Total coliform was identified to be above the WHO permissible limit in borehole water. Only Chromium showed correlation with bacterial load in the analysed drinking water source. The bottled water, borehole water and sachet water are not 100% safe for drinking as they are contaminated with varying amount of the investigated parameters. In terms of the heavy metal content in the water, this may differ due to difference in geographical locations, auto mechanical workshop activities, flooding, and industrial activities in the locations

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