INVESTIGATION INTO ENVIRONMENTAL POLLUTION AND ITS EFFECT ON POTABLE WATER IN OSUN STATE COLLEGE OF EDUCATION, ILESA AND ITS ENVIRONMENT

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Abstract: This study was carried out to investigate the effect of environmental pollution on quality of potable water in Osun State College of Education, Ilesa and its environment. The physicochemical parameters (pH, DO, TDS, EC, total hardness, acidity, alkalinity, nitrates, and sulphates) were determined using standard techniques while the levels of metals (Pb, Al, Cu, Fe, and Zn) were determined using Atomic Absorption Spectrophotometry. The study findings indicated that most of the investigated physicochemical parameters were in compliance with the WHO permissible limits. Results also showed that Pb was undetected while Fe had the highest concentration of 0.84±0.11 mg/L in the water samples. Water quality indices were generally less than 100, indicating the suitability of the water samples for drinking. Health risk assessment equally showed that oral and dermal exposure to the water samples would pose no immediate non-carcinogenic health risks based on the HQ values less than 1. However, long term exposure should be avoided to prevent bioaccumulation of these metals.

Keywords: Health risk; Metals; Physicochemical parameters; Potable water; Water quality

Introduction

The earth's surface is occupied by about 70-80% water by weight. The significance of potable water cannot be overemphasized as it is required for metabolic processes as well as other related activities (Haftu and Sathishkumar 2020). The water composition of the earth emanates predominantly from two sources; salt water and fresh water, with the former contributing 67% and the latter 3% to make up 70% total water composition. The available fresh water resources comprising of rivers, aquifers, and lakes are being directly used by living organisms on the earth's surface. However, the available fresh water resources are not sufficient to meet the global water supply due to the presence of about 8 billion people living on the earth (Bishnoi and Arora 2007; Haftu and Sathishkumar 2020). The result of this restricted access to potable water supply is a reduction in life expectancy and public health (Chabukdhara *et al.* 2017).

In addition to the limited water supply relative to global population, the presence of contaminants emanating from increased industrialization and urbanization has led to an impairment in water quality across the globe (Haftu and Sathishkumar 2020). Variations exist in water quality depending on source and location; however, anthropogenic influences of manufacturing processes and improper refuse disposal are predominantly responsible for elevated levels of contaminants in the environment (Martin *et al.* 2015).

Specifically, groundwater represents a vital source of water for industrial, agricultural, domestic, and drinking purposes (Shakerkhatibi *et al*. 2019). The quality of groundwater is dependent on factors such as population growth, drought, urbanization, agricultural activities, industrial activities, and geological factors (Hajizadeh *et al*. 2017). While groundwater usage offers reduced exposure to waterborne microorganisms, the presence of inorganic pollutants such as heavy metals is on the increase (Bacquart *et al*. 2015; Aghapour *et al*. 2016). Heavy metals are among significant parameters that are considered whilst assessing the quality of water for drinking purposes (Malakootian *et al*. 2016).

Heavy metals are sometimes essential metals or toxic metals depending on their nutritional value and/or toxicity. The essential metals such as Fe, Co, Mn etc. are needed in minute quantities for proper body functioning (Muhammad *et al.* 2019). The deficiency of these essential metals in the human body can result in deficiency effects while elevated levels can also result in health problems (Alves *et al*. 2018). On the other hand, the toxic metals such as Cd, Pb, As etc. are extremely hazardous even in minute quantities. They are generally associated with health problems such as hypertension, anorexia, heart diseases, and cancer (Jadoon *et al*. 2019; Qian et al. 2020). These metals are considered hazardous due to their toxicity, persistence, and bioaccumulation in several environmental media (Gashkina *et al*. 2020; Xie *et al*. 2020).

The threat posed to the potable water supply of the study area is presumed to emanate from the direct and/or indirect introduction of both organic and inorganic chemicals into the environment. Due to the paucity of data on the study area, the present study therefore aims to assess the water quality of Osun State College of Education and its environment, identify the possible sources of these contaminants and recommend appropriate remediation strategies for cleanup.

Methodology

Study Area

The Osun State College is situated along Osu/Ibodi road in Ilesa East Local Government Area. It covers an area of about 1500 sq m. It is located within the Tropical climate zone of West Africa. It has average rainfall of 1000-1250 mm usually from March to October and a mean relative humidity of 75% to 100%. The area has tropical vegetation with a double rainfall maximum characterized by two high rainfall peaks, with a short dry season and a longer dry season falling between and after each peak. The first rainy season begins around March and last to the end of July with a peak in June, this rainy season is followed by a short dry break in August known as the August break which is a short dry season lasting for two to three weeks in August. This break is broken by the short rainy season starting around early September and lasting to Mid-October with a peak period at the end of September. The ending of the short rainy season in October is followed by long dry season. This period starts from late October and lasts till early March with peak dry conditions between early December and late February (McKnight and Darrel, 2000). The school is non-residential for both staff and students, most students reside outside in villages around the campus namely; Imola, Ibodi, Arimoro and Ido Ijesa. The major source of potable water in the campus is sachet water produced by the institution. Well water in the college is used for cleaning purposes and laboratory use. Well water and sachet water are basically used for drinking and domestic purposes in the villages around the campus.

Sampling

For the purpose of this study, Osun State College of Education and its environment was divided into four Zone; zone A, B, C and D will be the Campus, Imola, Ido-Ijesa and Ajibade respectively. For sample collection, the three sample sources in zone A were Sachet water produced by the college (both treated and untreated), Mr. Bee sachet water and Ayomaya sachet water all of which were the major sachet water available within the campus and around the zones. Three wells whose water is being used for drinking and domestic purposes were randomly selected in each of the other zones (B, C and D) as the sample sources, thus a total of twelve water sample was collected.

Material and Method

The samples were collected in sterilized polythene bottles of one litter capacity for physical parameter measurements while for metals, the samples were collected in 2.5 L Winchester bottles (immediately acidified with 5 ml of dilute HCl).

Unstable parameters such as electrical conductivity (EC), pH, total dissolved solid (TDS) and dissolved oxygen (DO) were measured at the sampling site. Metal concentration (Iron, Zinc, Copper, aluminium and Lead were analysed using Atomic Absorption Spectroscophy method (AAS) while other parameters in the samples, Alkalinity, SO_4^- and NO_3^- were analysed by using standard techniques (Anonymous, 1976).

Results and Discussion

Physicochemical Parameters of Water Samples

The determined physico-chemical parameters comprising of colour, odour, pH, dissolved oxygen, total dissolved solids, electrical conductivity, total hardness, acidity, alkalinity, nitrates, and sulphates are presented in Table 1. The analyzed physico-chemical parameters were compared with the safety guidelines of the World Health Organization (WHO).

Table 1: Physicochemical Parameters of Water Samples

zone	Abbrev	Samples /sample location	Colour odour	pH	DO Mg/L	TDS	EC µS/cm	Total Hardness (as CaCO3)	Acidity in mg/L	alkalinity in mg/L	Nitrates mg/L	Sulphate mg/L
A	CT	College Venture water (CVL)..treated	Colourless Odourless	7.0	2.0	80	170	54	21.76	63.0	2.12	1.15
	CR	College Venture water (CVL). Raw	Colourless Odourless	6.3	3.8	160	320	76	18.80	130.0	3.40	2.54
	DT	Dr Bee Pure water (treated)	Colourless Odourless	7.0	1.6	00	00	28	29.64	31.6	1.53	1.91
	AT	Ayomaya pure water (treated)	Colourless Odourless	6.8	0.2	110	230	45	22.60	35.7	2.74	2.10
B	YH	Alleluyah Hostel Nov	Colourless Odourless	6.7	4.1	70	130	60	21.32	98.4	42.92	43.45
	OH	Olomania hostel	Colourless Odourless	5.9	3.4	230	440	82	34.96	125.2	35.12	54.33
	AH	Abanise Villa	Colourless Odourless	5.9	3.7	60	130	44	25.76	58.6	53.15	52.85
C	GA	God is Able Hostel	Colourless Odourless	5.7	0.9	60	130	38	14.56	64.8	28.45	39.56
	JJ	J.J. House	Colourless Odourless	6.0	1.5	20	50	38	19.88	68.8	33.55	47.50
	ES	Eli's Shop	Colourless Odourless	6.3	1.6	150	320	100	21.56	172.8	48.35	20.22
D	AP	Ajibade (Near Paragon)	Brownish Odourless	6.7	2.5	60	120	42	21.28	105.6	67.30	11.90
	LH	Lydia Hostel	Colourless Odourless	6.1	5.3	70	80	38	8.36	163.9	38.90	26.00
	RS	Rcf Sec	Colourless Odourless	7.0	5.8	50	120	44	16.40	38.7	44.34	33.75

Colour and Odour

The studied water samples were observed to be colourless and odourless except for only one of the water samples that had a brownish colour. Drinking water colouration has been attributed to the presence of coloured organic matter (specifically fulvic and humic acids) (WHO 2011). A possible contamination of the water source emanating from the introduction of industrial effluents and/or presence of metallic impurities or corrosion products of iron may strongly influence the colour of the water sample (WHO 2011). However, the study results showed that most of the water samples complied with the WHO safety guideline that drinking water should have no visible colour.

pH

pH represents one of the most important parameters of water quality, although it usually has no direct impact on the consumers (Kumar et al. 2011). In this study, the pH of the water samples ranged from 5.9- 7. Only about 46% of the water samples were found to be within the permissible limits (6.5-8.5) set by the WHO. The remaining water samples were found to have acidic pH values. The leaching of agro-effluents emanating from geochemical processes and farmlands may be responsible for the observed acidic-pH values of the water samples (Egbueri 2019). Acidic-pH water has the potential to cause corrosion. If the corrosion is not minimized, it can result in adverse effects on appearance and taste (WHO 2011).

Dissolved Oxygen

Dissolved oxygen (DO) is vital to aquatic life particularly for respiration. It also helps in maintaining the effect of organic wastes via a self-purification mechanism (Al-Shujairi 2013). The results of the present study indicated that the DO values ranged 0.2-5.8 mg/L. About 85% of the water samples had DO values less than the critical limit of 5 mg/L. Low DO values are usually associated with water systems undergoing a high rate of organic decomposition (Mishra et al. 2009). The low DO values may also be a reflection of the water temperature because warmer waters contain relatively depleted oxygen content than cool waters (Keller 2011). This depleted dissolved oxygen content could bring about the microbial reduction of sulphate to sulphide and nitrate to nitrite (WHO 2011).

Total Dissolved Solids

In water, total dissolved solids (TDS) comprise of bicarbonates, carbonates, phosphates, chlorides, and nitrates of manganese, magnesium, and sodium, etc. (Mahananda 2010). In this study, the TDS values ranged from 0-230 mg/L. This showed that the water samples were in agreement with the permissible limits set for TDS in drinking water (1000 mg/L) by the WHO. TDS values of water samples higher than the permissible limit are considered unpalatable for drinking (WHO 2011).

Electrical Conductivity

Electrical conductivity (EC) measures the extent of dissolution of ionic substances in water (Yilmaz and Koc 2014). In this study, the EC values ranged from 0-440 µS/cm. Electrical conductivity is a function of total dissolved solids and temperature (Egbueri 2019). The studied water samples have EC values less than the permissible limit of 1000 µS/cm (NIS 2007). Water samples with high EC values are considered unfit for consumption (WHO 2011). The relatively observed low EC values of the water samples may be attributed to minimal solute dissolution in the water samples.

Total hardness

Hardness caused by calcium is reflected in the excessive use of soap to cause foaming in water. The values of total hardness of the studied water samples ranged from 28-100 mg/L. These values are within the acceptable limit of 200 mg/L for total hardness in drinking water (BIS 2012). High values of total hardness may bring about high consumption of soap. Scale deposition in distribution system, treatment works, tanks, and pipelines in buildings is also an aftereffect of high water hardness (WHO 2011).

Acidity and Alkalinity

The total acidity values of the studied water samples ranged from 8.36-34.96 mg/L while the values of alkalinity of the water samples ranged from 31.6-172.8 mg/L. All the values recorded for alkalinity of the samples are within the permissible limit of 200 mg/L. Alkalinity is primarily due to carbonate, bicarbonate and hydroxide contents presence over the permissible limit gives undesirable taste to water

Nitrates

As a form of nitrogen, nitrate is essential for the growth, reproduction, and survival of organisms. In the present study, the levels of nitrate ranged from 1.53-67.3 mg/L. About 77% of the water samples were within the allowable limit (45 mg/L) of nitrates in water (BIS 2012). Nitrate level in water samples is a reflection of the aerobic decomposition of organic nitrogeneous matter present in the water (Pal and Maiti 2018).

Sulphates

In this study, the sulphate levels of the water samples ranged from 1.15-54.33 mg/L. For domestic water use, the recommended limit for sulphate ion is 250 mg/L (WHO 2011). All the water samples had sulphate levels below the recommended limit. Generally, the natural occurrence of sulphate ion in water is on the account of mineral leaching. However, discharge of domestic sewage and industrial wastes into waterbodies may lead to an upsurge in its concentration (Manivasakam 2005). The observed sulphate levels confirmed the suitability of the water samples for drinking and other domestic uses.

Metal Levels of the Water Samples

The levels of metals (Al, Cu, Fe, Zn, and Pb) in the water samples are presented in Table 2. The levels of Al in the water samples ranged from 0.01-0.64 mg/L. Levels of Cu in the water samples ranged from 0.01-0.06 mg/L. The concentration of Fe in the water samples ranged from 0.02-0.84 mg/L while the concentration of Zn in the water samples ranged from 0.01-0.24 mg/L. In all the water samples, Pb was not detected. About 31% of the water samples had Al levels above WHO permissible limit, 23% of the water samples had Fe levels about permissible limit while none of the water samples had Cu and Zn levels exceeding the WHO permissible limit. Although contamination of drinking water sources by heavy metals is a public concern due to their persistence, biomagnification, toxicity, bioaccumulation, and indestructibility (Cao *et al.* 2018), the studied metals in the present study which may have emanated from fuel combustion, mining, and other industrial processes (Rajeshkumar et al. 2018) are believed to have not found their way into the water samples. The presence of these metals in levels lower than permissible limit makes the water samples suitable for drinking and other domestic purposes.

Table 2: Levels (mg/L) of Metals of the Water Samples

Zone	Abbrev	Samples /sample location	Al mg/L	Cu mg/L	Fe mg/L	Zn mg/L	Pb mg/L
A	CT	College Venture water (CVL)..treated	0.02 ± 0.04	0.04 ± 0.12	0.02 ± 0.00	0.01 ± 0.01	ND
	CR	College Venture water (CVL). Raw	0.03 ± 0.01	0.02 ± 0.00	0.11 ± 0.06	0.07 ± 0.02	ND
	DT	Dr Bee Pure water (treated)	0.01 ± 0.00	0.01 ± 0.05	0.14 ± 0.12	0.04 ± 0.02	ND
	AT	Ayomaya pure water (treated)	0.16 ± 0.02	0.02 ± 0.07	0.15 ± 0.17	0.06 ± 0.04	ND
B	YH	Alleluyah Hostel Nov	0.1 ± 0.12	0.01 ± 0.10	0.13 ± 0.01	0.07 ± 0.05	ND
	OH	Olomania hostel	0.31 ± 0.04	0.01 ± 0.01	0.14 ± 0.02	0.17 ± 0.10	ND
	AH	Abanise Villa	0.18 ± 0.15	0.03 ± 0.02	0.84 ± 0.11	0.12 ± 0.01	ND
C	GA	God is Able Hostel	0.26 ± 0.18	0.04 ± 0.05	0.72 ± 0.18	0.11 ± 0.06	ND
	JJ	J.J. House	0.21 ± 0.03	0.01 ± 0.02	0.54 ± 0.10	0.01 ± 0.15	ND
	ES	Eli's Shop	0.19 ± 0.07	0.03 ± 0.06	0.14 ± 0.12	0.24 ± 0.14	ND
D	AP	Ajibade (Near Paragon)	0.64 ± 0.03	0.03 ± 0.11	0.17 ± 0.07	0.02 ± 0.02	ND
	LH	Lydia Hostel	0.12 ± 0.14	0.06 ± 0.05	0.26 ± 0.25	0.03 ± 0.01	ND
	RS	Rcf Sec	0.18 ± 0.00	0.02 ± 0.05	0.22 ± 0.01	0.07±0.01	ND
WHO Permissible limit			0.2	1	0.3	1	

Source Identification of Physicochemical Parameters and Metals in Water Samples

The source identification of the physicochemical parameters and metals in the water samples was carried out by using hierarchical cluster analysis and principal component analysis. Hierarchical cluster analysis was used to determine the group the various parameters based on their mean similarities. As shown in Figure 1, three major clusters were observed. Group A showed clustering relationship between alkalinity and total dissolved solids, Group B showed clustering relationship between acidity and total hardness, while Group C showed clustering relationship between Cu, Zn, Al, Fe, dissolved oxygen, pH, acidity, nitrates, and sulphates. The latter group showed the closest clustering relationship. The close clustering relationship of the parameters indicated similar sources. A major observation is the non-existent relationship between total dissolved solids and parameters associated with anthropogenic sources such as nitrates, copper etc. This indicated that the source of total dissolved solids in the water sources is probably geogenic rather than anthropogenic (Egbueri 2019).

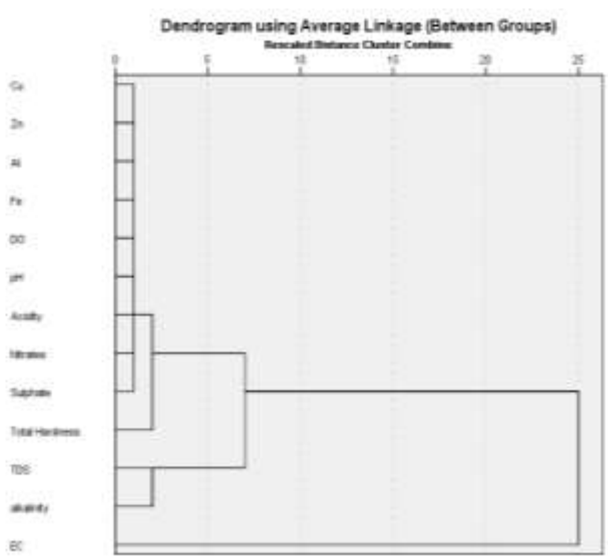

Figure 1: Hierarchical cluster analysis of physicochemical parameters and metals in water samples

Principal component analysis is a tool used to reduce the complexity and dimensionality of a data set. Eigen values greater than 1 were selected and varimax rotation with Kaiser Normalization was used as the method of rotation. As shown in Table 3, five principal components (PC) explaining 89.28% of the total data variance were identified. The component plot of the rotated components is presented in Figure 2. PC 1 explaining 32.78% of the total data variance had significant factor loadings of 0.947, 0.943, 0.937, 0.765, and 0.716 by total hardness, total dissolved solids, electrical conductivity, Zn, and alkalinity, respectively. This relationship is probably due to the erosion activity of schistose rocks with sulphide seams attribute (Emenike et al. 2017). PC 2 contributing 22% to the total data variance exhibited factor loadings of 0.908, 0.767, and -0.741 by Fe, sulphate, and pH, respectively. The negative correlation of pH with Fe and sulphate was noted. The positive correlation of Fe and sulphate may be a reflection of the ions dissolved in water, indicating common sources for these ions (Kükrer and Mutlu 2019). PC 3 with factor loadings of -0.501, -0.912, and 0.832 by alkalinity, Cu, and acidity, respectively contributed 14.99% to the total data variance. PC 4 (explaining 10.5% of total data variance) had high factor loadings of 0.945 and 0.857 for Al and nitrates respectively. Dissolved oxygen with high factor loading of 0.945 contributed 9.01% to total data variance and stood as the sole factor in PC 5. This reflected a non-correlation with the other water parameters and this factor can be attributed to natural processes (Kükrer and Mutlu 2019). The natural processes involved could be soil leaching and/or surface runoff (Mutlu and Uncumusaoğlu-Aydın 2018).

Table 3: Principal Component Analysis of Physicochemical Parameters and Metals in Water Samples

	Component				
	1	2	3	4	5
Total Hardness	.947	-.084	.087	-.007	.100
TDS	.943	-.062	.086	-.012	-.044
EC	.937	-.053	.161	-.013	-.098
Zn	.765	.364	.152	.108	-.018
Alkalinity	.716	-.028	-.501	.208	.233
Fe	-.319	.908	-.083	.126	-.104
Sulphate	.065	.767	.230	.323	.377
pH	-.483	-.741	.318	.079	-.011
Cu	-.036	.066	-.912	.046	-.067
Acidity	.280	-.010	.832	.002	-.249
Al	.037	.022	-.006	.945	-.224
Nitrates	.050	.286	-.100	.857	.363
DO	.009	.052	-.129	-.011	.955
Eigen values	4.262	2.86	1.95	1.366	1.172
% data variance	32.78	22	14.99	10.5	9.01
Cumulative %	32.78	54.78	69.77	80.27	89.28

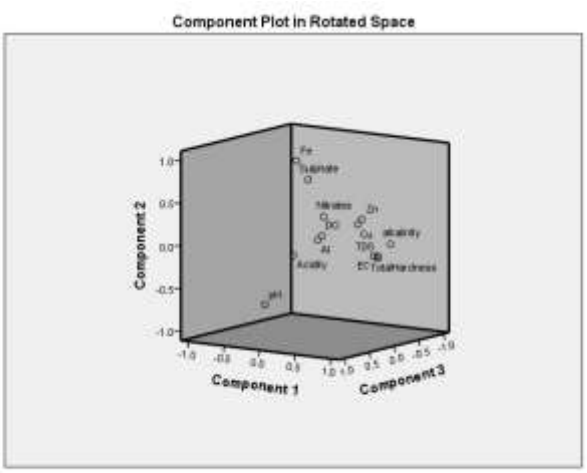

Figure 2: Component plot of physicochemical parameters and metals in water samples

Water Quality Index of Water Samples

Water quality index is a reflection of composite influence of water quality parameters such as physicochemical parameters and metals (Meng *et al.*, 2016) and this was used in a bid to providing a comprehensive picture of water quality. For the physicochemical parameters and metals, the sum of weights was 30.09 and all the other parameters are presented in Table 4. Variations existed in the water quality index of the studied samples. Only about 46% of the studied water samples had excellent quality, the remaining 54% had good water quality.

Table 4: Water quality index of water samples

	pH	TDS	Total Hardness	Nitrates	Sulphate	Al	Cu	Fe	Zn	WQI
CT	0.124	0.021	0.017	0.007	0.0006	0.013	0.002	0.008	0.0003	19.717
CR	0.111	0.042	0.025	0.012	0.001	0.02	0.001	0.048	0.002	26.615
DT	0.124	0	0.009	0.005	0.001	0.006	0.0006	0.062	0.001	21.086
AT	0.12	0.029	0.014	0.010	0.001	0.108	0.001	0.066	0.001	35.449
YH	0.118	0.018	0.019	0.158	0.023	0.067	0.0006	0.057	0.002	46.745
OH	0.104	0.061	0.027	0.129	0.028	0.210	0.0006	0.062	0.005	63.058
AH	0.104	0.015	0.014	0.196	0.028	0.122	0.001	0.372	0.003	86.004
GA	0.101	0.015	0.012	0.105	0.021	0.176	0.002	0.319	0.003	75.776
JJ	0.106	0.005	0.012	0.123	0.025	0.142	0.0006	0.239	0.0003	65.643
ES	0.111	0.039	0.033	0.178	0.010	0.129	0.001	0.062	0.007	57.52
AP	0.118	0.015	0.013	0.248	0.006	0.434	0.001	0.075	0.0006	91.645

LH	0.108	0.018	0.012	0.143	0.0138	0.081	0.003	0.115	0.0009	49.857
RS	0.124	0.013	0.014	0.163	0.017	0.122	0.001	0.097	0.002	55.713

Health Risk Assessment of Metals in Water Samples

The risk assessment models for metals developed by USEPA were used in assessing the non-carcinogenic health risks associated with exposure to the water samples (Iqbal and Shah 2013). The results of health risk assessment of metals in the water samples upon exposure by children and adults are presented in Tables 5 and 6 respectively. Potential adverse health effects could arise if the hazard quotient (HQ) of a metal exceeds unity. In contrast, minimal hazards are associated with exposure to a metal contaminant if its hazard quotient is below unity. However, the results indicated that there are no non-carcinogenic health risks emanating from oral and dermal exposure of the studied metals in the water samples. The HQ values observed in this study were lower than those reported by Emenike *et al.* (2017). The oral route represented the principal exposure pathway for the studied metals due to its relatively high HQ values. The study results also indicated that children were the more vulnerable population to the studied metals in the water samples.

Table 5: Health risk assessment of metals in water samples upon exposure by Children

	Oral									Dermal								
	CDI				THQ				TTHQ	CDI				THQ				
	Al	Cu	Fe	Zn	Al	Cu	Fe	Zn		Al	Cu	Fe	Zn	Al	Cu	Fe	Zn	
CT	1.27E-05	2.56E-05	1.28E-05	6.39E-06	1.27E-05	6.39E-04	4.26E-05	2.13E-05	7.16E-04	7.15E-09	1.43E-08	7.16E-09	3.58E-09	7.15E-08	5.96E-07	5.11E-08	4.77E-08	7.67E-07
CR	1.91E-05	1.28E-05	7.03E-05	4.47E-05	1.91E-05	3.2E-04	2.34E-04	1.49E-04	7.22E-04	1.07E-08	7.16E-09	3.94E-08	2.51E-08	1.07E-07	2.98E-07	2.81E-07	3.34E-07	1.02E-06
DT	6.39E-06	6.39E-06	8.95E-05	2.56E-05	6.39E-06	1.6E-04	2.98E-04	8.52E-05	5.5E-04	3.57E-09	3.58E-09	5.01E-08	1.43E-08	3.57E-08	1.49E-07	3.57E-07	1.9E-07	7.33E-07
AT	1.02E-04	1.28E-05	9.59E-05	3.84E-05	1.02E-04	3.2E-04	3.19E-04	1.27E-04	8.69E-04	5.72E-08	7.16E-09	5.37E-08	2.15E-08	5.72E-07	2.98E-07	3.83E-07	2.86E-07	1.54E-06
YH	6.39E-05	6.39E-06	8.31E-05	4.47E-05	6.39E-05	1.6E-04	2.77E-04	1.49E-04	6.5E-04	3.57E-08	3.58E-09	4.65E-08	2.51E-08	3.57E-07	1.49E-07	3.32E-07	3.34E-07	1.17E-06
OH	1.98E-04	6.39E-06	8.95E-05	1.09E-04	1.98E-04	1.6E-04	2.98E-04	3.62E-04	1.01E-03	1.1E-07	3.58E-09	5.01E-08	6.09E-08	1.1E-06	1.49E-07	3.57E-07	8.11E-07	2.42E-06
AH	1.15E-04	1.92E-05	5.37E-04	7.67E-05	1.15E-04	4.79E-04	1.78E-03	2.55E-04	2.64E-03	6.44E-08	1.07E-08	3.01E-07	4.3E-08	6.44E-07	4.47E-07	2.14E-06	5.72E-07	3.81E-06
GA	1.66E-04	2.56E-05	4.6E-04	7.03E-05	1.66E-04	6.39E-04	1.53E-03	2.34E-04	2.57E-03	9.3E-08	1.43E-08	2.58E-07	3.94E-08	9.3E-07	5.96E-07	1.84E-06	5.25E-07	3.89E-06
JJ	1.34E-04	6.39E-06	3.45E-04	6.39E-06	1.34E-04	1.6E-04	1.15E-03	2.13E-05	1.46E-03	7.51E-08	3.58E-09	1.93E-07	3.58E-09	7.51E-07	1.49E-07	1.38E-06	4.77E-08	2.32E-06
ES	1.21E-04	1.92E-05	8.95E-05	1.53E-04	1.21E-04	4.79E-04	2.98E-04	5.11E-04	1.41E-03	6.80E-08	1.07E-08	5.01E-08	8.59E-08	6.8E-07	4.47E-07	3.57E-07	1.14E-06	2.63E-06
AP	4.09E-04	1.92E-05	1.09E-04	1.28E-05	4.09E-04	4.79E-04	3.62E-04	4.26E-05	1.29E-03	2.29E-07	1.07E-08	6.09E-08	7.16E-09	2.29E-06	4.47E-07	4.34E-07	9.54E-08	3.26E-06
LH	7.67E-05	3.84E-05	1.66E-04	1.92E-05	7.67E-05	9.59E-04	5.54E-04	6.39E-05	1.65E-03	4.29E-08	2.15E-08	9.31E-08	1.07E-08	4.29E-07	8.94E-07	6.64E-07	1.43E-07	2.13E-06
RS	1.15E-04	1.28E-05	1.41E-04	4.47E-05	1.15E-04	3.2E-04	4.68E-04	1.49E-04	1.05E-03	6.44E-08	7.16E-09	7.88E-08	2.51E-08	6.44E-07	2.98E-07	5.62E-07	3.34E-07	1.83E-06

Table 6: Health risk assessment of metals in water samples upon exposure by Adults

	Oral									Dermal								
	CDI				THQ				TTHQ	CDI				THQ				
	Al	Cu	Fe	Zn	Al	Cu	Fe	Zn		Al	Cu	Fe	Zn	Al	Cu	Fe	Zn	
CT	2.34E-06	4.7E-06	2.35E-06	1.17E-06	2.34E-06	1.17E-04	7.82E-06	3.91E-06	1.32E-04	4.68E-09	9.37E-09	4.68E-09	2.34E-09	4.68E-08	3.9E-07	3.34E-08	3.12E-08	5.01E-07
CR	3.52E-06	2.35E-06	1.29E-05	8.22E-06	3.52E-06	5.87E-05	4.3E-05	2.73E-05	1.33E-04	7.02E-09	4.68E-09	2.58E-08	1.64E-08	7.02E-08	1.95E-07	1.84E-07	2.18E-07	6.68E-07
DT	1.17E-06	1.17E-06	1.64E-05	4.7E-06	1.17E-06	2.94E-05	5.47E-05	1.56E-05	1.01E-04	2.34E-09	2.34E-09	3.28E-08	9.37E-09	2.34E-08	9.76E-08	2.34E-07	1.24E-07	4.8E-07
AT	1.87E-05	2.35E-06	1.76E-05	7.05E-06	1.87E-05	5.87E-05	5.87E-05	2.34E-05	1.6E-04	3.74E-08	4.68E-09	3.51E-08	1.41E-08	3.74E-07	1.95E-07	2.5E-07	1.87E-07	1E-06

YH	1.17E-05	1.17E-06	1.53E-05	8.22E-06	1.17E-05	2.94E-05	5.08E-05	2.73E-05	1.19E-04	2.34E-08	2.34E-09	3.05E-08	1.64E-08	2.34E-07	9.76E-08	2.17E-07	2.18E-07	7.67E-07
OH	3.63E-05	1.17E-06	1.64E-05	2E-05	3.63E-05	2.94E-05	5.47E-05	6.65E-05	1.87E-04	7.26E-08	2.34E-09	3.28E-08	3.98E-08	7.26E-07	9.76E-08	2.34E-07	5.3E-07	1.58E-06
AH	2.11E-05	3.52E-06	9.86E-05	1.41E-05	2.11E-05	8.81E-05	3.28E-04	4.69E-05	4.85E-04	4.21E-08	7.03E-09	1.97E-07	2.81E-08	4.21E-07	2.92E-07	1.4E-06	3.74E-07	2.49E-06
GA	3.05E-05	4.7E-06	8.45E-05	1.29E-05	3.05E-05	1.17E-04	2.81E-04	4.30E-05	4.73E-04	6.09E-08	9.37E-09	1.69E-07	2.58E-08	6.09E-07	3.9E-07	1.2E-06	3.43E-07	2.54E-06
JJ	2.46E-05	1.17E-06	6.34E-05	1.17E-06	2.46E-05	2.94E-05	2.11E-04	3.91E-06	2.69E-04	4.91E-08	2.34E-09	1.26E-07	2.34E-09	4.91E-07	9.76E-08	9.03E-07	3.12E-08	1.52E-06
ES	2.23E-05	3.52E-06	1.64E-05	2.82E-05	2.23E-05	8.81E-05	5.47E-05	9.39E-05	2.59E-04	4.45E-08	7.03E-09	3.28E-08	5.62E-08	4.45E-07	2.92E-07	2.34E-07	7.49E-07	1.72E-06
AP	7.51E-05	3.52E-06	2E-05	2.35E-06	7.51E-05	8.81E-05	6.65E-05	7.82E-06	2.38E-04	1.49E-07	7.03E-09	3.98E-08	4.68E-09	1.49E-06	2.92E-07	2.84E-07	6.24E-08	2.13E-06
LH	1.40E-05	7.05E-06	3.05E-05	3.52E-06	1.4E-05	1.76E-04	1.01E-04	1.17E-05	3.04E-04	2.81E-08	1.41E-08	6.09E-08	7.03E-09	2.81E-07	5.85E-07	4.35E-07	9.36E-08	1.39E-06
RS	2.11E-05	2.35E-06	2.58E-05	8.22E-06	2.11E-05	5.87E-05	8.61E-05	2.73E-05	1.93E-04	4.21E-08	4.68E-09	5.15E-08	1.64E-08	4.21E-07	1.95E-07	3.68E-07	2.18E-07	1.2E-06

Conclusion

The present study investigated the suitability of potable water in Osun State College of Education and its environment. Physicochemical parameters were measured and the levels of selected metals were determined in the water samples. This was with a view to estimating the water quality as well as studying the effect of environmental pollution on water quality. The results of the study indicated that most of the physicochemical parameters had values within the permissible limits of regulatory agencies. The water quality indices of the water samples showed that they were of good and excellent quality for drinking. Health risk assessment indicated that there were no immediate potential non-carcinogenic health risks associated with oral and dermal exposure to the water samples. However, frequent and long-term exposure to the water samples might encourage the build-up of the metals in the body. Appropriate purification and/or remediation strategies should be developed to clean up these metals in the studied water samples.

Conflict of Interest

The authors declare that there is no conflict of interest

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