COMPARATIVE ASSESSMENT OF THE PHYSICOCHEMICAL AND HEAVY METAL LEVELS IN POTABLE WATER SOURCES IN AWKA AND NNEWI METROPOLIS.

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Abstract

Studies were carried out to determine the physicochemical parameters and heavy metal levels in the potable water samples in Awka and Nnewi metropolis using standard operational procedures and instrumentation. The mean levels of the physicochemical parameters and metals analyzed in the water samples in Awka metropolis were; 6.16 – 6.48,16.22 – 21.33µS/cm, 11.28 – 13.90mg/l, 17.76 – 19.17mg/l, 26.09 – 29.29mg/l, 44.39 – 53.68mg/l, 73.91 – 101.78mg/l, 60.11 – 80.16mg/l, 0.010 – 0.015mg/l, 0.025 – 0.034mg/l, 0.001 – 0.003mg/l, 0.003 – 0.006mg/l, 0.003 – 0.005mg/l and 0.001 – 0.005mg/l for pH, electrical conductivity, total dissolved solids, total suspended solids, total solids, water hardness, sulphates , chlorides, nitrates, phosphates, Cu, Fe, Pb, Zn and Sb respectively. The mean levels of the physicochemical parameters and metals analyzed in the water samples in Nnewi metropolis were, 6.05 – 6.40, 16.20 – 20.77µS/cm, 9.18 – 10.47mg/l, 13.62 – 19.55mg/l, 20.85 – 28.84mg/l, 42.27 – 54.91mg/l, 73.35 – 86.75mg/l, 56.73 – 72.67 mg/l, 0.013 – 0.017mg/l, 0.014 – 0.028mg/l, 0.001 – 0.002mg/l, 0.004 – 0.005mg/l, 0.002mg/l and 0.001 – 0.003mg/l for pH, electrical conductivity, total dissolved solids, total suspended solids, total solids, water hardness, sulphates, chlorides, nitrates, phosphates, Cu, Fe, Pb, Zn and Sb respectively. The physicochemical parameters and heavy metal concentrations of the water samples in the two studied environments were within their respective WHO recommended permissible limits for a drinking water quality. The levels of the metals in the water samples in the studied environments were statistically insignificant (at $p < 0.05$) except Zn in water samples in Nnewi metropolis. The levels of pH, electrical conductivity, total dissolves solids, nitrates and phosphates in the water samples in the two studied environments were significantly insignificant at $p < 0.05$.

Keywords: Heavy metals, physicochemical properties, water and pollution.

Introduction

Water is an essential component of life and is regarded as a universal solvent [25]. Water is one of the most important and abundant compounds of the ecosystem. All living organisms on earth need water for their survival and growth [20]. As of now, only earth is the planet having about 70% of water. Water plays a significant role in maintaining the human health and welfare. It is indispensable for man's existence on earth as about two-thirds of the human body consists of water and requires between one to seven (1 – 7) litres of water for its appropriate functioning to avoid dehydration [17]. Clean drinking water is now recognized as a fundamental right to human beings. Around 780 million people worldwide do not have access to clean and safe water and 2.5 billion people do not have proper sanitation [23]. As a result, around 6.8 million people die each year due to water related diseases and disasters [18].

Water could be obtained from ground water and surface sources [16]. The ground water sources include boreholes, and hand dug of wells while surface water sources include rivers, streams and lakes. Accordingly, no matter the sources of water, it is consumed and used on a day to day basis. The quality of water depends on its physical, chemical and biological characteristics, which determines its utility for different purposes [4]. Water fit for human consumption is referred to as potable or drinking water and should be of safe quality, which entails that it does not present any significant health risk over lifetime consumption [28]. Although water is essential for life, it also remains an important source of disease transmission and a major case of mortality in developing countries because of limitations in access and quality [14]. Water quality and suitability for use are determined by its taste, odour, colour and concentration of organic and inorganic matters [23]. Pollution of water bodies are usually caused by chemical and microbial contaminants which leads to water borne infections and diseases [26]. The potential sources of water contamination are geological conditions, industrial and agricultural activities and water treatment plants [23]. Also rapid urbanization of rural areas, industrialization and population growth have been the major causes of stress on the environment leading to problems like human health problems, eutrophication and fish death, coral reef destruction and biodiversity loss [8].Improper disposal of industrial and agricultural effluents which is most common in major African urban and rural centre's has led to heavy contamination of the available fresh water resources reducing the volume of safe agriculture, domestic, irrigation and drinking water. These contaminants can affect the clarity and chemical constituents of the water source.

Essentially, they can distort the quality of the water and even add odour thereby impacting negatively on human and economic activities [27]. One major contaminant of water sources from the environment is heavy metal. Heavy metals are significant environment pollutants and their toxicity is a problem of increasing significance for ecological, evolutionary, nutritional and environmental reasons [12]. The most commonly found heavy metals in waste water include arsenic, cadmium, chromium, copper, lead, nickel and zinc, all of which cause risks to human health and the environment [13]. Heavy metals toxicity can result in damaged or reduced mental and central nervous function, lower energy levels and damage to blood composition, lungs, liver, kidneys and other vital organs [15]. Long term exposure may result in slowly progressing physical, muscular and neurological degenerative processes that mimic Alzheimer's disease, Parkinson disease, multiple sclerosis and even cancer [12]. Microbial contamination of water due to pathogenic organisms is another most important problem for water quality management and another important factor for pollution of water sources [24]. These pathogenic micro-organisms come from various ways like the release of effluents from waste water, house drainage and surface run-off.

In Nigeria, access to safe drinking water and hygienic sanitation facilities still pose challenge to its rapidly growing population of more than 180million people [5]. Awka and Nnewi metropolis are popular municipalities in Anambra state, with very many water sources. However, the quality and suitability of the various water sources in these areas are being increasingly challenged by intense anthropogenic activities. Because of the wide application of the various water sources in the two (Awka and Nnewi) metropolis in both drinking and other domestic activities, studies were carried out to determine the physicochemical and heavy metal levels of the various water sources consumed by the people.

Materials and Methods

Seventy (70) water samples comprising of (20 boreholes, 20 wells, 20 rainwater reservoirs and 10 stream water) were randomly collected from different parts of Awka and Nnewi metropolis. Water samples were collected with clean polyethylene containers. All the reagents used were of analytical grade.

Analysis: The physicochemical analysis of the waters samples were conducted following the standard analytical procedures [6]. Also, heavy metals were assayed in the water samples using flame atomic absorption spectrometer [7]. The data obtained was analyzed for mean and standard deviation using MS-Excel and t-test analysis carried out using SPSS 18.0 version at 95% level of confidence.

Results and Discussion

Table 1: Physicochemical properties of water samples in Awka metropolis

Parameter	Borehole	Well	Rain	Stream	T test P value	WHO STD
pH	6.48 ± 1.08	6.31 ± 0.83	6.24 ± 0.52	6.16 ± 0.40	0.26	6.5 – 8.5
Electrical conductivity (µS/cm)	16.22 ± 1.96	20.86 ± 2.14	21.33 ± 1.71	17.55 ± 0.79	0.09	500
Total dissolved solids (mg/l)	11.28 ± 0.65	12.60 ± 0.82	12.14 ± 0.57	13.90 ± 0.44	0.17	250
Total suspended solids (mg/l)	17.76 ± 0.80	22.45 ± 2.04	18.65 ± 0.71	19.17 ± 1.43	0.41	250
Total solids (mg/l)	29.29 ± 2.40	27.38 ± 1.66	26.09 ± 0.83	28.04 ± 1.53	0.55	250
Water Hardness (mg/l)	44.39 ± 3.07	47.35 ± 2.84	45.47 ± 1.54	53.68 ± 3.57	0.03	70
Sulphate (mg/l)	101.78 ± 5.31	96.02 ± 1.35	94.32 ± 2.02	73.91 ± 2.55	0.01	250
Chloride (mg/l)	80.16 ± 1.78	69.44 ± 1.08	67.15 ± 1.16	60.11 ± 1.20	0.01	200
Nitrate (mg/l)	0.010 ± 0.00	0.013 ± 0.001	0.011 ± 0.000	0.015 ± 0.001	1.14	10
Phosphate	0.026 ± 0.001	0.034 ± 0.005	0.030 ± 0.001	0.025 ± 0.001	1.02	2

Table 2: Physicochemical properties of water samples in Nnewi metropolis.

Parameter	Borehole	Well	Rain	Stream	T test P value	WHO STD
pH	6.13±0.54	6.30± 0.78	6.40± 0.80	6.05± 0.42	0.88	6.5 – 8.5
Electrical conductivity (µS/cm)	16.20± 1.13	18.58± 2.04	17.21±0.69	20.77± 0.53	0.11	500
Total dissolved solids (mg/l)	9.18 ± 0.40	8.86± 0.51	10.04 ± 0.68	10.47± 0.35	0.25	250
Total suspended solids (mg/l)	13.62±1.20	19.55 ±0.72	17.84± 0.89	19.05±0.64	0.02	250
Total solids (mg/l)	20.85±1.58	27.39±0.93	28.84± 0.85	26.50± 1.25	0.03	250
Water Hardness (mg/l)	42.27±2.08	51.80± 2.13	46.84± 1.30	54.91±1.85	0.02	70
Sulphate (mg/l)	86.75±3.44	73.35± 1.48	78.92±1.32	76.14±1.55	0.02	250
Chloride (mg/l)	62.14±2.09	72.67±0.95	64.11±2.12	56.73±0.91	0.03	200
Nitrate (mg/l)	0.013± 0.000	0.017± 0.002	0.014± 0.001	0.015 ± 0.001	1.92	10
Phosphate	0.028± 0.002	0.022± 0.001	0.024± 0.003	0.014± 0.001	0.56	2

pH: pH is most important in determining the corrosive nature of water. It serves as an index to denote the extent of pollution by acidic or basic waste [10]. Table 1 shows that the mean pH values for borehole, well, rain and stream water samples in Awka metropolis were 6.48, 6.38, 6.24 and 6.16 respectively. The mean values of the pH of the water samples were statistically insignificant at $p < 0.05$. Table 2 shows that mean pH values for borehole, well, rain and stream water samples in Nnewi metropolis were 6.13, 6.30, 6.40 and 6.08 respectively. The pH of the water samples in Nnewi metropolis were equally statistically insignificant at $p < 0.05$. The results further shows that the pH of the various water sources in both Awka and Nnewi metropolis were within the recommended WHO permissible limits for a potable, drinking water [28].According to [11], the pH of a water body is very important in the determination of water quality since it affects other chemical reactions such as solubility and metal toxicity.

Comparison of the pH values in Tables 1 and 2, shows that water samples (borehole, well and stream) from Nnewi metropolis were at a lower pH than those from Awka metropolis. This could be due to differences in anthropogenic activities within the studied environments. The results of this study was in agreement with pH values of 6.29 – 6.43 reported by [18], in borehole water samples in Nsukka Urban Area of Enugu State.

Electrical Conductivity

The electrical conductivity of the various water sources in Awka metropolis were 16.22µS/cm for borehole water, 20.86µS/cm for well water, 21.33µS/cm for rain water and 17.55µS/cm for stream water as shown in Table 1. The order of decrease of the conductivity of the water samples in Awka metropolis was: rain >well >stream >borehole.

Table 2 shows that the mean electrical conductivity of the various water sources in Nnewi metropolis were 16.20µS/cm for borehole water, 18.55µS/cm for well water, 17.21µS/cm for rain water and 20.77µS/cm for stream water. The order of decrease in electrical conductivity of the water sources in Nnewi metropolis was: stream > well > rain > borehole. The mean levels of the electrical conductivity of the water samples from the two studied environments (Awka and

Nnewi) were found to be statistically insignificant and within the WHO, recommended permissible for a drinking water quality.
[23], stated that electrical conductivity is a good and rapid method of measuring the total dissolved ions and is related to the total solids on a water sample. Hence a high value of electrical conductivity is an indication of high level of dissolved solids which could render water unfit for human consumption. The values of the electrical conductivity for water samples obtained in this research were far below 225.67 – 1353µS/cm reported by [3], in hand dug wells in Gambari, Ogbomoso, Oyo State.

Total dissolved solids: Table 1 shows that the mean values of the total dissolved solids in water samples in Awka metropolis were 11.28, 12.60, 12.14 and 13.90 mg/l for borehole, well, rain and stream respectively. The order of decrease of the total dissolved solids in the water samples was: stream > well > rain > borehole. For water samples in Nnewi metropolis, Table 2 shows that the mean values of the total dissolved solids decreased in the following order; stream > rain > borehole > well with values of 10.47, 10.04, 9.18 and 8.86mg/l respectively.
The mean levels of the total dissolved solids in the various water sources in the two studied environments were within the recommended permissible limits for a drinking water quality and shows no significance difference at $p < 0.05$. [16] obtained higher values of 24.6 – 27.6mg/l in well water samples in Wukari local government area of Taraba State than reported in this study. According to [10], total dissolved solids indicates the salinity behaviour of water and that its levels in a water body is due to vegetable decay, evaporation, disposal of effluent and chemical weathering of rocks. Comparing the values in Table 1 and 2, it can be observed that their was higher value of total dissolved solids in the various water sources in Awka metropolis than Nnewi metropolis.
Total suspended solids: Table 1 shows that the mean values of total dissolved solids in the water samples in Awka metropolis decreased in the following order: well > stream > rain > borehole high values of 22.45, 19.17, 18.65 and 17.76 mg/l respectively. In the same vein, Table 2 shows that the mean values of the total suspended solids in water samples in Nnewi metropolis were 13.62mg/l for borehole, 19.55mg/l for well, 17.84mg/l for rain and 19.05 mg/l for stream. The order of decrease of total suspended solids in the water samples was: well > stream > rain > borehole. The levels of the total suspended solids in the various water sources in the two studied environments were found to show no significant difference at $p < 0.05$. The levels of total suspended solids in the water samples in the studied environments were within the recommended permissible limits for a drinking water quality.
[20] stated that total suspended solids is a very useful parameter indicating the presence of suspended particles (ions) and solids in a water body and increases due to increase in decaying vegetation. Research have shown that increased level of suspended solids results in increased turbidity, lower photosynthesis and decrease in dissolved oxygen [2]. Comparing the values of Tables 1 and 2 shows that the water samples in Awka metropolis were found to be of higher values than those in Nnewi metropolis.

Total solids:

The total solids is a very useful parameter indicating the chemical constituents of a water body [18]. Table 1 shows that the mean values of the total solids in water samples in Awka metropolis decreased in the following order: borehole > stream > well > rain with values of 29.29, 28.04, 27.38 and 26.09mg/l respectively. Table 2 shows that the mean values of total solids in water samples in Nnewi metropolis decreased as follows: rain > well > stream > borehole with values of 28.84, 27.39, 26.50 and 20.85mg/l respectively. Statistical analysis of the levels of the total solids in the water samples from Awka metropolis was insignificant while the water samples in Nnewi metropolis were significant at $p < 0.05$. The levels of the total solids in the water samples in the two studied environments were within the recommended permissible limits.

Water hardness:

Table 1 shows that the mean values of water hardness in water samples from Awka metropolis were; 44.39mg/l for borehole, 47.35mg/l for well, 45.47mg/l for rain and 53.68mg/l for stream. The values of the water hardness in the water samples decreased in the following order; stream > well > rain > borehole.

Table 2 shows that the mean values of water hardness in water samples from Nnewi metropolis were, 42.27, 51.80, 46.84 and 54.91mg/l for borehole, well, rain and stream respectively. The hardness of the water samples decreased in the following order; stream > well > rain > borehole. Statistical analysis of the values of the water hardness in the water samples in the two studied environments shows significance different at $p < 0.05$. The levels of water hardness in the water samples were within the WHO recommended permissible limits for a drinking water quality. The mean values of the water hardness in the water samples (stream, rain and well) from Nnewi metropolis were found to be higher than that in Awka metropolis.

According to [28], hardness of water is not a health hazard but its value should remain below permissible limits to restore the test of water. The values of the water hardness obtained in this study was lower than 15 – 438mg/l reported by Okoro *et al.*, (2017) for well water samples in Nsukka urban area in Enugu State.

Sulphates:

Table 1 shows that the mean levels of sulphates in water samples in Awka metropolis were 101.78 mg/l for borehole, 96.02mg/l for well, 94.32mg/l for rain and 73.9mg/l for stream. The order of decrease of sulphates in the water samples was as follows; borehole > well > rain > stream.The mean values of sulphates in the water samples in Nnewi metropolis decreased in the following order: borehole > rain > stream >well with values of 86.75, 78.92, 76.14 and 73.35mg/l respectively as shown in Table 2. The values of sulphates in water samples from the two studied environment were statistically significant ($p < 0.05$). The levels of sulphates in the water samples from the two studied environments were within the recommended permissible limits for a safe, drinking water quality. Comparison of the results of Tables 1 and 2 for sulphates shows that higher values were obtained in borehole, well and rain water samples in Awka metropolis than Nnewi metropolis. High concentrations of sulphates in drinking water can have a laxative effect when combined with calcium and magnesium, the two most common constituents of hardness. [3] reported that high concentrations of sulphate in drinking water can cause gastric intestinal irritation. The mean values of sulphates reported in this study were higher than 0.00 – 6.33mg/l obtained by [3], in hand dug wells in Gambari, Ogbomoso, Oyo State.

Chlorides:

The order of decrease of chloride levels in water samples in Awka metropolis were as follows: borehole > well > rain > stream with values of 80.16, 6944, 67.15 and 60.11 respectively as shown in Table 1. The mean level of chlorides in water samples in Nnewi metropolis decreased in the following order: well > rain > borehole > stream, with values of 72.67, 64.11, 62.14 and 56.73mg/l respectively as shown in Table 2.

The chloride levels in water samples in the two studied environments were statistically significant at $p < 0.05$ and within the recommend permissible limits for a drinking water quality. Higher values of chlorides were found in water (borehole, rain and stream) samples in Awka metropolis than in Nnewi metropolis. This could be attributed to variation in the geological and climatic conditions and anthropogenic activities within the studied environments [23]. The results of this study compared favourably with 64.98 – 78.61mg/l reported by [18], in borehole water sources in Nsukka-Urban Area Enugu State.

Nitrates:

The presence of nitrate in water indicates the presence of fully oxidized organic matter [16]. [23], stated that the presence of nitrate in water is attributed mainly to agricultural lands, discharge of household and municipal sewage from the market place and other effluents containing nitrogen sources. Table 1 shows that the mean levels of nitrates in water samples in Awka metropolis decreased in the following order: stream > well > rain > borehole with values of 0.015, 0.013, 0.011 and 0.010mg/l respectively.

Table 2 shows that the mean levels of nitrates in water samples in Nnewi metropolis were, 0.013mg/l for borehole, 0.017mg/l for well, 0.014mg/l for rain and 0.015mg/l for stream. The levels of nitrates decreased in the following order: well > stream > rain > borehole. The statistical analysis of the levels of nitrates in water samples in Awka and Nnewi metropolis shows no significant differences at $p < 0.05$. The water samples contained nitrates at levels within the recommended permissible limits for a drinking water quality.

Phosphates:

According to [19], the deposition of phosphorus in a body of water occurs by mechanism such as sedimentation of phosphorus minerals, adsorption/precipitation of phosphorus with inorganic compounds and uptake of phosphorus from the water column by algal and other microbial communities.

Table 1 shows that the mean levels of phosphates in water samples in Awka metropolis decreased as follows; well > rain > borehole > stream, with values of 0.034, 0.030, 0.026 and 0.025mg/l respectively. The mean levels of phosphates in water samples in Nnewi metropolis decreased in the following order: borehole > rain > well > stream with values of 0.028, 0.024, 0.022 and 0.014mg/l respectively as shown in Table 2.

The levels of phosphates in the water samples in the two studied environments were statistically insignificant at $p < 0.05$ and within the recommended permissible limits for a drinking water quality. [18] obtained higher values of 0.6 – 1.3mg/l for phosphates in borehole water sources in Nsukka Urban Area of Enugu State than reported in this study.

Table 3: Mean concentration of metals in water samples in Awka Metropolis

Metal	**Borehole(mg/l)**	**Well(mg/l)**	**Rain(mg/l)**	**Stream(mg/l)**	**T test P value**	**WHO STD**
Cu	0.046±0.011	0.001 ± 0.000	0.003± 0.001	0.001± 0.000	0.07	1.00
Fe	0.011±0.003	0.004±0.001	0.003±0.001	0.004± 0.001	0.6	1.00
Pb	0.006± 0.001	0.004± 0.001	0.003±0.001	0.004±0.001	1.05	0.05
Zn	0.003±0.000	0.005 ±0.001	0.004±0.001	0.003± 0.000	0.83	5.00
Sb	0.005±0.001	0.002± 0.000	0.002± 0.000	0.001 ± 0.000	0.47	1.000

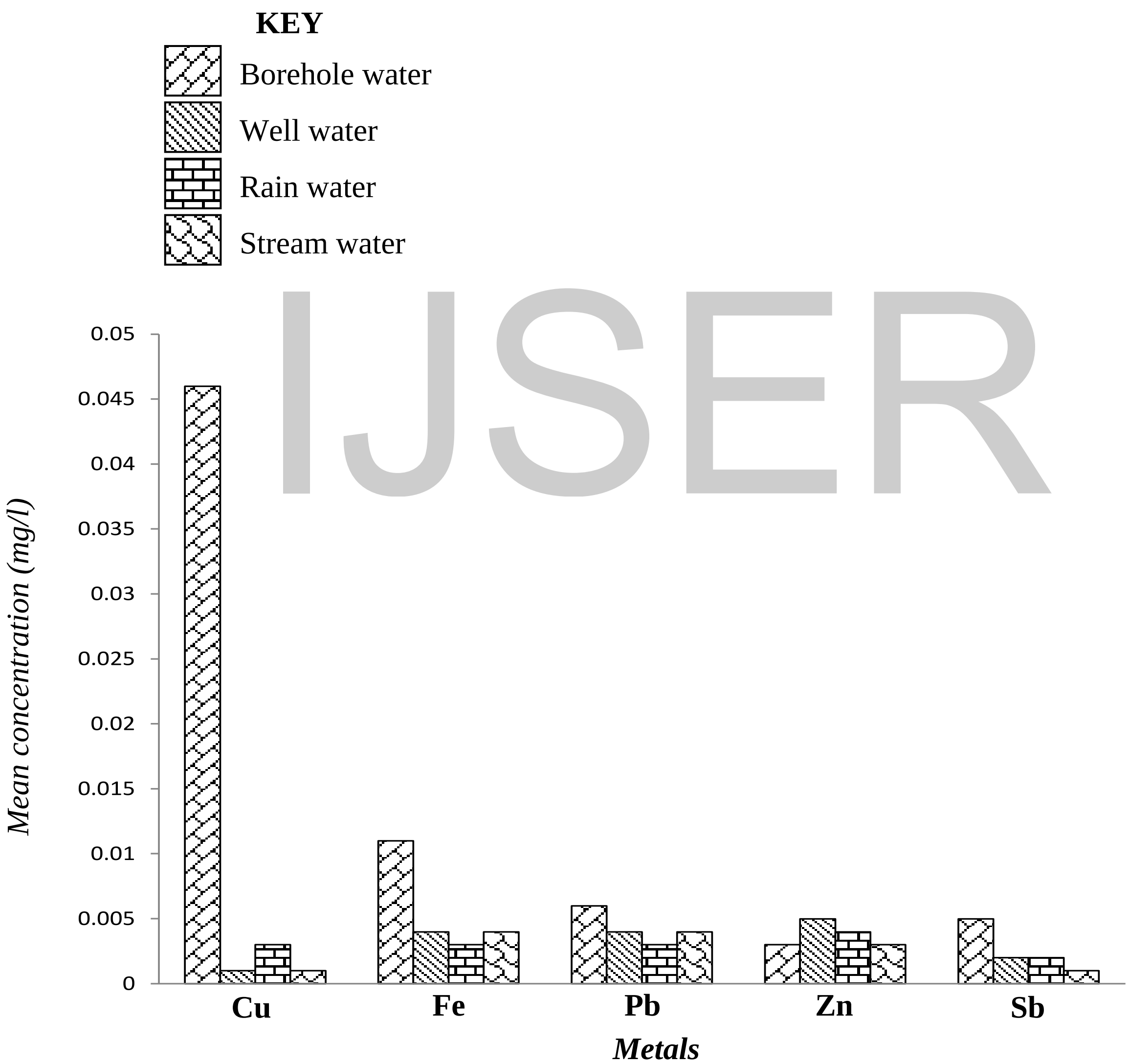

Fig 1: Bar chart representation of the metal concentrations in water samples in Awka metropolis.

Table 4: Mean concentration of metals in water samples in Nnewi Metropolis

Metal	Borehole(mg/l)	Well(mg/l)	Rain(mg/l)	Stream(mg/l)	F test P value	WHO STD
Cu	0.002± 0.000	0.001 ± 0.000	0.002± 0.001	0.001 ± 0.000	1.60	1.00
Fe	0.004±0.001	0.005± 0.002	0.004± 0.001	0.004 ± 0.001	1.12	1.00
Pb	0.005± 0.001	0.006± 0.002	0.002± 0.000	0.002± 0.000	0.91	0.05
Zn	0.036± 0.008	0.003± 0.001	0.005± 0.001	0.002± 0.000	0.03	5.00
Sb	0.003± 0.001	0.001± 0.000	0.001± 0.000	0.002± 0.000	0.57	1.00

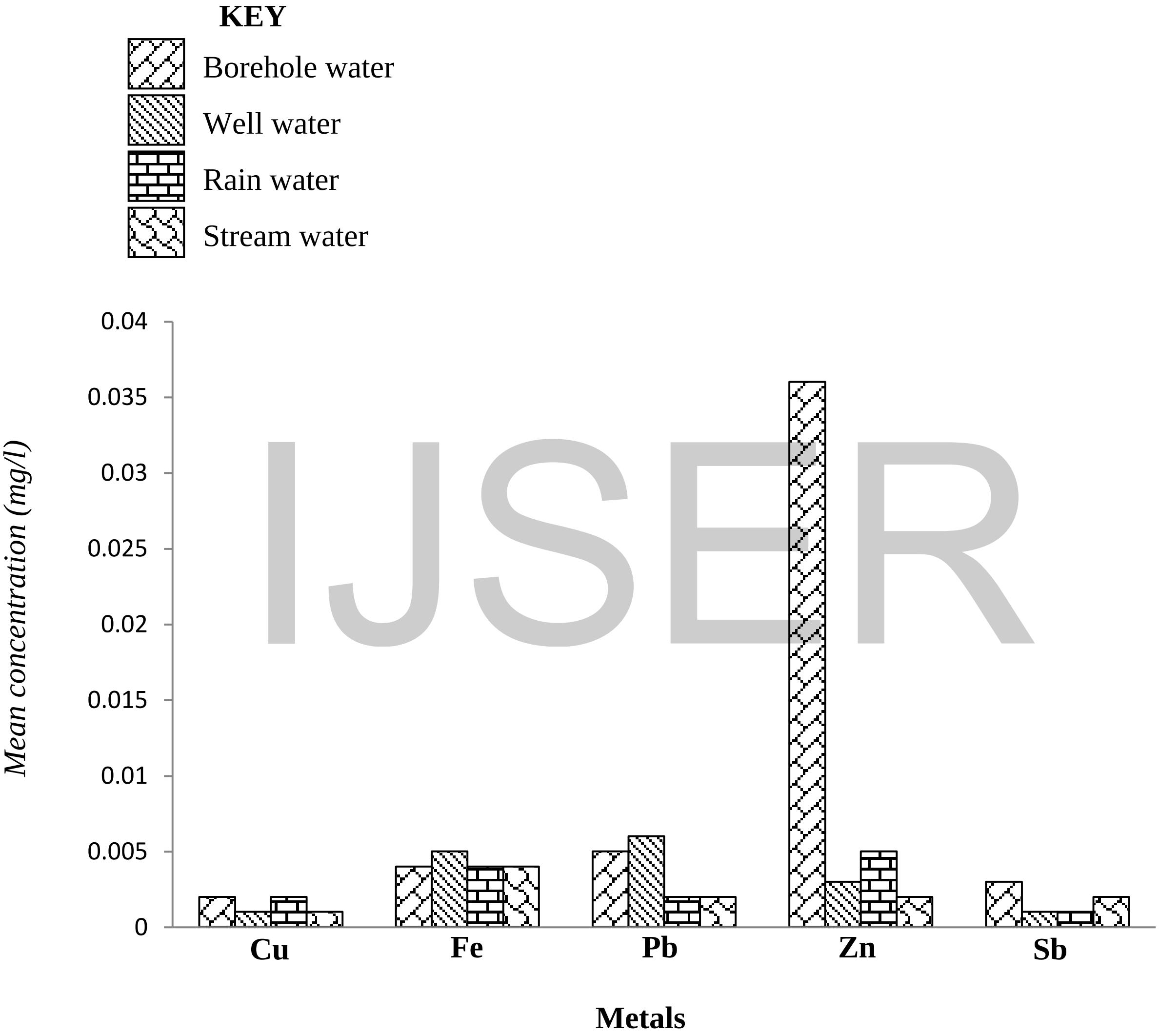

Fig 2: Bar chart representation of the metal concentrations in water samples in Nnewi metropolis.

Copper:

According to [1], contamination of drinking water with high level of copper may lead to chronic anaemia. [9], equally reported that copper in excess in drinking water could impart a bitter taste to the water and promote the corrosion of galvanized iron and steel fittings.

Table 3 shows that the mean concentration of copper in the water samples in Awka metropolis decreased as follows: borehole > rain > well, stream with values of 0.046, 0.003 and 0.001mg/l respectively.

Table 4 shows that the mean levels of copper in the water samples in Nnewi metropolis were 0.002mg/l for borehole, 0.001mg/l for well, 0.002 mg/l for rain and 0.001mg/l for stream. The metal decreased in the water samples in the following order; borehole, rain > well, stream as shown in Fig 2.

The levels of the metal in the water samples in the two studied environments were statistically significant (at $p < 0.05$) and within the recommended permissible limits for a drinking water quality. The values reported in this study was higher than 0.0007 mg/l obtained by [16] for copper in ground water sources in Wukari local government area of Taraba State.

Iron:

Iron is the fourth most abundant element by mass in the earth crust. In water, it occurs mainly in ferrous or ferric state [3]. It is an essential and non-conservative trace element found in significant concentration in drinking water because of its abundance in the earth's crust. The shortage of iron causes anemia and prolonged consumption of drinking water with high concentration of iron may lead to liver disease called haermosiderosis [21].

Table 3 shows that the mean levels of iron in the water samples in Awka metropolis as follows; borehole > well, stream > rain with values of 0.011, 0.004 and 0.003mg/l respectively.

Table 4, Fig 2 shows that the mean concentrations of iron in water samples in Nnewi metropolis were; well > borehole, rain, stream with values of 0.005 and 0.004mg/l respectively.

The concentrations of the metal in the water samples in the studied environment were not significant at $p < 0.05$ and within the permissible limits for a drinking water quality. Higher values of 0.163 – 0.285ppm were obtained by [18] in borehole water sources in Nsukka Urban area of Enugu State than reported in this study. The concentrations of iron in water samples in Awka metropolis compared very well with that in Nnewi metropolis except borehole water.

Lead:

Lead is the most significant of all the heavy metals because it is toxic and harmful even in small amounts [12]. High concentration of lead in the body can cause death or permanent damage to the central nervous system, the brain, liver and kidneys [3].

Table 3 shows that the mean levels of lead in water sample in Awka Metropolis decreased in the following order; borehole > well, stream > rain, with values of 0.006, 0.004 and 0.003mg/l respectively.

Table 4 shows that the mean levels of lead in water samples in Nnewi metropolis decreased as follows: stream > well > borehole > rain, with values of 0.007m 0.006, 0.005 and 0.002mg/l respectively.

The concentrations of the metal in the water samples were statistically insignificant at $p < 0.05$ and within the recommended permissible limits for a drinking water quality. Tables 3 and 4 shows that the levels of lead in the water samples (stream and well) in Nnewi metropolis were slightly higher than the water samples in Awka metropolis.

Zinc:

Zinc is one of the most important trace elements that play a vital role in the physiological and metabolic process of many organisms. Nevertheless, higher concentrations of zinc can be toxic to the organism [22]. Table 3 shows that the mean concentrations of zinc in water samples in Awka metropolis were 0.003mg/l for borehole, 0.005mg/l for well, 0.004mg/l for rain and 0.003mg/l for stream. The metal decreased in the water samples in the following order: well > rain > borehole, stream as shown in Fig 1.

Table 4, Fig 2 shows that the mean levels of zinc in the waters samples in Nnewi metropolis decreased in the following order: borehole > rain > well > stream, with values of 0.036, 0.005, 0.003 and 0.002 mg/l respectively.

Statistical analysis of the concentrations of zinc in the water samples in Awka metropolis showed no significance difference (at $p < 0.05$) while zinc in water samples in Nnewi metropolis were statistically significant.

The levels of the metals in the water samples in the two studied environments were within the WHO recommended permissible limits for a drinking water quality.

Antimony:

Table 3 shows that the mean levels of antimony in the water samples in Awka metropolis decreased as follows: borehole > well, rain > stream, with values of 0.005, 0.002 and 0.001mg/l respectively. The mean values of antimony in the water samples in Nnewi metropolis decreased in the following order; borehole > stream > well, rain with values of 0.003, 0.002 and 0.001mg/l respectively as shown in Table 4, Fig 2.

The levels of antimony in the water samples in the studied environments were within the recommended permissible limits for a drinking water quality. Statistical analysis of the metal in the water samples revealed no significant difference at $p < 0.05$. [3], stated that excess antimony can interfere with absorption of dietary iron which can result in iron deficiency (anaemia) and can equally cause bacterial growth in water.

Conclusion

The study shows that the levels of the physicochemical parameters and heavy metals analyzed in the water samples in Awka and Nnewi metropolis were within their respective recommended permissible limits for a drinking water quality. Higher values of the physicochemical parameters were predominantly observed in the stream and well samples in the studied environments with rain water samples having the least values. There was equally a predominant observation of higher values of metals in the borehole and well water samples in the two studied environments than in the other studied water samples.

Almost two-third of the physicochemical parameters and heavy metals were present at higher concentrations in the water samples in Awka metropolis than in Nnewi metropolis. The differences observed in the levels of the physicochemical parameters and metals in the two studied environments could be attributed to climatic, geographical and geologic variations as well as human and industrial activities.

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