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Determination of some trace elements in water samples within kano metropolis

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ABSTRACT

This research was conducted for the sole purpose of measuring the concentration of some trace metals in some water samples within Kano Metropolis. For this purpose, twenty each of different water samples were randomly collected to serve as the subject of the study. These water samples comprised of bore hole water samples, sachet water samples, packaged bottled water samples, pump water samples and well water samples. Atomic Absorption spectrophotometer (AAS) was used to determine dissolved analytes in aqueous samples after suitable filtration, evaporation and acid preservation. Prior to analysis, the water samples were pre-concentrated and the residue dissolved in O.IM HNO_3. The analytes measured include Copper, iron, lead, Zinc and arsenic. The highest concentration of iron and lead was detected in bottled water; borehole contains the highest concentration of Copper while the highest concentration, of Zinc was detected in pump water. Cadmium was not detected in any of the water samples while arsenic was highest in well water. The concentrations of iron, zinc and copper metals were found to be below World Health Organization limit in some samples, while arsenic in some samples were found to be outside the permissible limit. It was therefore concluded that proper water treatment procedure which will reduce the metals above safe limit should be embarked on, which will eliminate the accumulation of toxic waste in both human and animals.

Key words: water, iron, lead, arsenic, copper, samples.

INTRODUCTION

Water is one of the most essential elements to life on Earth. In its purest form, it's odorless, colorless and tasteless but due to human and animal activities, it is usually contaminated with solid and human waste, effluents from chemical industries and dissolved gases [1].Water contaminated by sewage is estimated to kill about two million children every year [2]. The acid rain is another major water contaminant. In addition, water contains some amount of mineral constituents which iron Fe, magnesium Mg, lithium Li, zinc Zn, copper Cu, chromium Cr, nickel Ni, cobalt Co, vanadium V, arsenic As, molybdenum Mo, selenium Se, lead Pb and so many others [3]. The presence of toxic metals such as lead and Cadmium in the environment has been a source of worry to environmentalists, government agencies and health practitioners [4]. This is mainly due to their health implications since they are non-essential metals of little or no benefit to humans [5, 6]. Many of these minerals are required micronutrients such as copper and selenium [7]. Concentrations of trace elements in water vary because of physiological, environmental and other factors [8]. Some trace elements have several roles in living organism. Some are essential components of enzymes where they attract substrate molecules and facilitate their conversion to specific end products [9]. In excessive concentrations, however trace elements can negatively affect growth, reproduction and other biological functions. A safe and portable drinking water should conform to certain standard set by World Health Organization (WHO) [10]. The quality required of water varies with the use to which the water is to be put [11]. Some people prefer bottled water to sachet water as they believe that it is hygienically prepared. Some people drink only bore hole water or well water as it is the only available source especially in rural areas where bottled and sachet are not produced or too expensive to buy. The objective of this work is to determine the concentration of these trace metals in some water sample within Kano metropolis.

MATERIAL AND METHODS

Reagents and Glass Wares

Reagents of AnalaR grade were used, and and distilled water were used throughout the study. The apparatus and glass wares were thoroughly washed and oven dried. Pre-concentration of the samples were carried out and the residue was leached with O.I.M HNO_3 acid (AnalaR) Solution. This solution was used for the determination of Fe, As, Cu, Pb, and Zn using Atomic Absorption spectrophotometer (AAS).

Source of material and study area

Twenty different water samples were randomly collected to serve as the subject of the study. These water samples comprised of bore water samples, sachet water samples, package Bottled water samples, pump water samples and well water samples. Kano city in northern Nigeria (Lat: N 1159[degrees] 981', Long: E 008[degrees] 31.491') has forty four local government areas but the sampling was conducted within the main Kano municipal local government area.

Analysis of water samples: Water samples were analysed using Atomic Abs o r p t i o n Spectrophotometer (AAS). From each 2 litre plastic water sampled, 150ml of water was taken, this was preserved by adding 1.0ml conc. HNO_3 pooled and then stored in a refrigerator to stabilize the metals for up to 2 weeks. From the pool 100 ml water sample was filtered and concentrated to about 60ml in 100ml standard flask to which 5.0ml HNO_3 was added. This was made up to 100ml mark with de-ionized water followed by elemental analysis with Unicom 969 Atomic Absorption Spectrophotometer (AAS) using 1% HNO_3 as blank. The metal concentration was read off from a standard curve.

Metal concentration, mg/l = A x B/C

Where
A = Concentration of metal in digested solution (mg/l)
B = Final volume of digested solution (ml)
C = Sample size
The use of AAS was based on Beer-Lambert's law:

Log Io/It = (abc) (1)

Where:
Io = Intensity of incident light
It = Intensity of transmitted light
a = Molar absorptivity
b = Thickness of medium
c = Concentration

Thus, the concentration and the logarithmic of the transmittance are proportional.

The procedures employed are as indicated in the AAS manufacturer's manual.

Statistical analysis
The data collected were subjected to one way analysis of variance using the Statistical Package for the Social Sciences (SPSS) version 16.

RESULT AND DISCUSSION

The table 1 shows the mean scores, along with the corresponding standard error, the minimum and maximum observation for each of the metals' concentrations found in the water samples Fe, Cu, As, Zn and Pb were all detected at varying degrees in all the collected water samples except Cadmium; it was therefore omitted from the table and statistical test.

For Iron, the observed f-value was 2.971 with a probability level of 0.045 ($P \leq 0.05$). The highest concentration of iron was found in bottled water and was significantly different from the concentration found in the water samples from other water sources. Between the other sources (Borehole, sachet, pump and well) of water no significant difference was observed in the concentration of Iron in their water samples. Iron is one of the earth's most plentiful resources, making up at least five percent of the earth's crust. Rainfall seeping through the soil dissolves iron in the earth's surface and carries it into almost every kind of natural water supply, including well water. Although iron is present in our water, it is seldom found at concentrations greater than 10 milligrams per liter (mg/1) or 10 parts per million (ppm). Iron is not considered hazardous to health. In fact, it is essential for good health because it transports oxygen in your blood. In the United States, most tap water probably supplies less than 5 percent of the dietary requirement for iron. Under Department of Natural Resources (DNR) rules, iron is considered a secondary or "aesthetic" contaminant. The present recommended limit for iron in water, 0.3 mg/I (ppm), is based on taste and appearance rather than on any detrimental health effect. Private water supplies are not subject to the rules, but the guidelines can be used to evaluate water quality [12]

No significant difference in the amount of copper between the different sources of water in terms of concentration. The observed p-value was 0.089 ($P > 0.05$). Copper concentration was found to be more in water samples from wells. It was closely followed with samples from borehole and pump water samples. Bottled water was found to have the least concentration and was closely followed by samples from sachet water. No significant difference was observed in the concentration found in the different samples. Copper compounds are also used as an agricultural pesticide, and to control algae in lakes and reservoirs. Drinking water normally contributes approximately 150 ug/day. Immediate effects from drinking water which contains elevated levels of copper include vomiting, diarrhea, stomach cramps, nausea.

Table 1: Mean scores of the metal concentration in the water samples

Metal	Water sources	Mean±SE	Minimum	Maximum
Iron	Borehole	4.36±0.874(µg/L)^{b}	2.00(µg/L)	7.35(µg/L)
	Sachet	3.48±0.807(µg/L)^{b}	1.27(µg/L)	5.74(µg/L)
	Bottled	8.02±1.682(µg/L)^{a}	1.92(µg/L)	12.22(µg/L)
	Pump	3.58±1.141(µg/L)^{b}	1.17(µg/L)	7.21(µg/L)
	Well	4.65±0.501(µg/L)^{b}	3.43(µg/L)	5.73(µg/L)
Copper	Borehole	4.21±1.705(µg/L)^{a}	0.36(µg/L)	8.70(µg/L)
	Sachet	2.28±1.089(µg/L)^{a}	0.20(µg/L)	5.50(µg/L)
	Bottled	0.82±0.389(µg/L)^{a}	0.10(µg/L)	2.30(µg/L)
	Pump	4.14±1.375(µg/L)^{a}	0.82(µg/L)	8.30(µg/L)
	Well	5.49±1.016(µg/L)^{a}	2.30(µg/L)	7.90(µg/L)
Lead	Borehole	0.09±0.038(µg/L)^{c}	0.01(µg/L)	.20(µg/L)
	Sachet	0.93±0.217(µg/L)^{ab}	0.22(µg/L)	1.41(µg/L)
	Bottled	1.93±0.217(µg/L)^{a}	1.33(µg/L)	2.44(µg/L)
	Pump	1.09±0.330(µg/L)^{ab}	0.25(µg/L)	2.10(µg/L)
	Well	1.17±0.387(µg/L)^{ab}	0.00(µg/L)	2.10(µg/L)
Zinc	Borehole	8.82±6.901(µg/L)^{a}	0.38(µg/L)	36.31(µg/L)
	Sachet	7.71±2.439(µg/L)^{a}	1.39(µg/L)	15.31(µg/L)
	Bottled	2.81±0.743(µg/L)^{a}	1.29(µg/L)	5.40(µg/L)
	Pump	6.28±0.616(µg/L)^{a}	4.81(µg/L)	7.89(µg/L)
	Well	0.44±0.272(µg/L)^{a}	0.00(µg/L)	1.13(µg/L)
Arsenic	Borehole	8.21±1.798(µg/L)^{b}	2.05(µg/L)	12.00(µg/L)
	Sachet	7.37±1.516(µg/L)^{b}	3.62(µg/L)	11.00(µg/L)
	Bottled	1.71±0.365(µg/L)^{a}	0.56(µg/L)	2.72(µg/L)
	Pump	7.10±1.495(µg/L)^{b}	3.50(µg/L)	11.50(µg/L)
	Well	9.68±1.287(µg/L)^{ab}	5.40(µg/L)	12.00(µg/L)

Note: Means with same letters are not significantly different at 0.05 level of significance

The seriousness of these effects can be expected to increase with increased copper levels or length of exposure. Children under one year of age are more sensitive to copper than adults. Long-term exposure (more than 14 days) to copper in drinking water which is much higher than 1,000 ug/I has been found to cause kidney and liver damage in infants. Other persons who are highly susceptible to copper toxicity include people with liver damage or Wilson's disease [12]. However, the copper level in all the water samples was below WHO Limit (i.e 200 µg/L) for copper [13].

Significant difference was observed in the lead concentration in the different sources of the water samples. The observed f-value was 6.119 with a p-level of 0.002 ($P < 0.05$). The highest concentration of lead was detected in Bottled water and was significantly different from the concentration in other samples of water from well, pump, sachet and borehole. Water sample from borehole had the least lead concentration of lead and was significantly different from concentrations found in other water samples from pump, well, and sachet sources. Between pump, well and sachet water samples, no significant difference was observed in the concentration of lead. However, the concentrations observed from the samples are below the maximum limit of 10.0µg/L for lead and 3000 µ g/l for iron set by WHO [13]. The United States Environmental Protection Agency has classified Pb as being potentially hazardous and toxic to most forms of life [14]. It has been found to be responsible for quite a number of ailments in humans such as chronic neurological disorders especially in fetuses and children. Automobile exhaust fumes have been reported to account for about 50% of the total inorganic Pb absorbed by human beings [15]. Other inputs of Pb into the environment are from used dry-cell batteries, from sewage effluent, runoff of wastes and atmospheric deposition.

For zinc, no significant difference was observed in the concentrations found in the water samples from the different sources. The observed f-value was 1.121 while the level of significance was 0.374 ($P > 0.05$). In natural surface waters, the concentration of zinc is usually below 10 µg/litre, and in groundwaters, 10–40 µg/litre [16]. In tap water, the zinc concentration can be much higher as a result of the leaching of zinc from piping and fittings[17]. Taking too much zinc into the body through food, water, or dietary supplements can also affect health. The levels of zinc that produce adverse health effects are much higher than the Recommended Daily Allowances (RDAs) for zinc of 15 mg/day for men and 12 mg/day for women. If large doses of zinc (10-15 times higher than the RDA) are taken by mouth even for a short time, stomach cramps, nausea, and vomiting may occur. Ingesting high levels of zinc for several months may cause anemia, damage the pancreas, and decrease levels of high-density lipoprotein (HDL) cholesterol. [18]
Mean Iron content of bottle water is high

The result of test indicated that there were significant differences in the arsenic concentration in the water samples analyzed as shown in Table 1. The observed f-value for the test was 4.785 at 4.20 degree of freedom. The probability of level of significance was 0.007 ($P < 0.05$). The mean arsenic concentrations in the water from the different sources along with their standard errors are shown in the table 1. The result of the analysis shows that water from bottled samples had less arsenic concentration and was significantly different from the water from Borehole, Sachet, Pump and Well sources. Though the observed arsenic concentration in all the seven samples were found to be lower than the WHO threshold limit of 10.0µg/L [13] but water from the wells were found to be above the WHO limit in most cases. The aggregate mean was however found to be within the limit as indicated in the table. In the statistical test, no significant difference was observed between water from Borehole, Sachet packs, Pump and well sources. The maximum level of arsenic was detected in borehole and well water ie 12.00 µg/L whereas the minimum concentration was found in bottled and sachet water. The presence of high concentration of arsenic in drinking water in excess of acceptable limit recommended by WHO (10.0 µg/L) can be attributed to industrial effluents, dissolution of arsenic containing minerals in water, bioaccumulation of arsenic in the body of the fish along the food chain, geo-thermal activity etc [19].

CONCLUSION

It was observed that the copper and zinc concentration in all the same had no significant difference, the arsenic concentration in well water was higher than that recommended by WHO, the lead and iron content in bottled water is high and which could be directly detrimental to the health of the aquatic ecosystem and indirectly to man. Continuous consumption of some of these metals from water could lead to their accumulation and eventually death, hence continual assessment and enlightment is highly essential.

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