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Impact of Water Treatment Processes on Selected Heavy Metals Concentrations in Drinking Water Within Katsina Metropolis.

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Abstract

The research focused on the impact of water treatment processes on selected heavy metals concentrations in drinking water within Katsina metropolis. Water samples were collected from taps, sachets and Ajiwa dam raw waters and analyzed for Pb, Cu, Fe, Ni, Mn, Zn and Mg using atomic absorption spectrophotometer (AAS). The solid residues filtered from the treated samples were also analyzed using x-ray fluorescence (XRF) method. The result obtained from the water analysis shows that Cu concentration determined between (0.862-17.232) µg/L with the highest concentration below WHO limit in Ajiwa dam raw water, Pb concentration determined between (0.000-109.63) µg/L with the highest concentration above WHO limit in Ajiwa dam raw water, Ni concentration was detected in almost all the water samples, with the concentration between (0.000-0.72) µg/L, all the concentrations were below WHO limit, Mn concentration determined between (16.554-66.234) µg/L with the highest concentration within WHO limit in Ajiwa dam raw water, Zn concentration determined between (47.286-58.122) µg/L with the highest concentration within WHO limit in tap water, Mg concentration determined between (102.5-213.77) µg/L with the highest concentration within WHO limit in Ajiwa dam raw water. While the amount(%) of isolated element shows that Si(42.51), O(25.39), K(0.24), Ca(1.16), Ti(0.16), Mn(0.04), Fe(1.19), Cu(0.02), Zn(0.009), Ag(0.40), Ba(0.31), Ce(0.03), Nd(0.002), Eu(0.03), Re(0.04), Cl(1.14) and S(0.22) with Silicon with the highest percentage and Neodymium with the least percentage value. Analysis of variance (ANOVA) shows that Pb (p-value 0.000), Cu (p-value 0.000), Fe (p-value 0.000), Ni (p-value 0.490), Mn (p-value 0.007), Zn (p-value 0.000) and Mg (p-value 0.046). This results show that the concentrations of heavy metals analyzed were either removed or drastically reduced to tolerable level or standard limit set by WHO for safe drinking water through series of water treatment processes and this render the water in the areas safe for drinking for now.

Key Words
Ajiwa Dam Raw Water
Concentratio
Heavy Metals
Sachet Water
Tap Water
WHO

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1. Introduction

Heavy metals are elements with a specific gravity that is at least 5 times the specific gravity of water. [8], [10], [15].Using a density as a defining factor, heavy metals are those elements with a specific density of $5g/cm^3$ or more [6]. They can also be defined as chemical elements with the density greater than $4g/cm^3$ found in all kinds of soils, rocks and water in terrestrial and freshwater ecosystem [12]. Furthermore, heavy metals can be referred to as any metallic element that has a relatively high density and is toxic even at low concentrations [1]. Generally, metals enter into aquatic environment through atmospheric deposition, erosion of geological milieu or due to anthropogenic activities caused by industrial effluents, domestic sewage and mining waste [1], [2], [4], [5], [10].

Water is among the most essential substances needed to sustain human, animals, and plants life [13].Water is needed for drinking, cooking, bathing, washing of domestic and human waste etc. [9]. It is the major constituent of the body, in fact water account for about 70 -80% of weight of most tissues like muscles, brain, liver, e t c. The average water content of all the body as a whole is about 61% in a normal adult [3].

2.Materials and Methods

Analytical grade reagents and deionized water were used throughout the study. Water samples were analyzed using Atomic Absorption spectrophotometer (AAS) while the solid residues were analyzed using x-ray fluorescence (XRF) and the results of the water samples analyzed were compared with WHO [14] standard limits.

Glass wares were thoroughly washed with detergent and rinsed with distilled water and later dried in an oven at 105°C.

2.1 Materials

Sample bottle, Beaker, Funnel, Filter paper, Stirrer, Wash bottle, Micro pipette, Evaporation pots, Measuring cylinder (10, 100 and 1000) cm^3, Volumetric flask (100 and 1000) cm^3, Spatula, Sand bath, Hot plate/stove.

2.2 Methods

2.2.1 Sampling of Sachet Water

Water samples were collected in well cleaned 5 liter polythene plastic containers, the sample containers were rinsed with their respective water sample before filling each with the sample.

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The sachet water were purchased from the popularly patronized brands at different locations of the study area, two sachet out of every bag of the same brand of water were sampled and total of 20 sachets were transferred into 5 liter plastic containers so as to form a representative of the whole. The same procedure was applied to other brands in all the study areas.

2.2.2 Sampling of Tap water

Tap waters were collected three times daily, at an interval of 3 hours; the tap water was allowed to run for some minutes before filling the sample containers so as to obtain a composite sample as recommended by [11].

Table 1. Identification of Sampling Sites

S.No	Sampling sites from Katsina and Batagarawa local government	Sample Identification
1	Kambarawa sachet	KS
2	Kofar Sauri sachet	KSS
3	Dutsen safe sachet	DSS
4	Tudun matawalle sachet	TMS
5	Tap water	TW
6	Ajiwa tap water	ATW
7	Ajiwa Dam raw water	ADW

2.2.3 Sample Digestion

The water samples were first boiled, and followed by decantation. About 5 liters of each sample were measured and transferred to the cleaned pot for evaporation, till the volume of the sample reached about 30 ml, then transferred into a Pyrex beaker and evaporated to dryness. The resulting residue was then leached with 30 cm^3 of 0.5 mol/dm^3 of HNO_3 and filtered into 30 ml sample bottle. 25 cm^3 of this solution were used for the determination of (Pb, Cu, Ni, and Fe) and 5 cm^3 was diluted up to six times and later used for the determination of (Mn, Mg, Zn).

Furthermore; the residues obtained from each sample were then mixed up together, and 2g was weighted and analyzed using x-ray fluorescence (XRF) method.

2.2.3.1 Preparation of Stock Solutions

1) Lead 1000 mg/L: 1.5986 g of ($Pb(NO_3)$) were dissolved into 1000 cm^3 flask and made to the mark with 0.5M HNO_3

2) Manganese1000 mg/L: 2.2923 g of $MnCl_2$ were dissolved into 1000 cm^3 flask and made to the mark with 0.5M HNO_3

3) Iron 1000 mg/L: 2.7189 g of $FeSO_4$ were dissolved in1000 cm^3 flask and made to the mark with 0.5M HNO_3

4) Copper 1000 mg/L: 4.4966 g of $CuSO_4.7H_2O$ were dissolved into 1000 cm^3 flask and was made to the mark with 0.5M HNO_3

5) Magnesium 1000 mg/L: 5.00 g of $MgSO_4$ were dissolved into 1000 cm^3 flask and was made to the mark with 0.5M HNO_3

6) Zinc1000 mg/L: 2.0858 g of $ZnCl_2$ were dissolved into 1000 cm^3 flask and was made to the mark with 0.5M HNO_3.

7) Nickel 1000 mg/L: 4.0499 g of $NiCl_2.6H_2O$ were dissolved into 1000 cm^3 flask and was made to the mark with 0.5M HNO_3

2.2.3.2 Calibration standards for the metals

1) Preparation of 100 ppm Standard Solution:

10 cm^3 of 1000 ppm multi elemental stock solution were transferred into 100 cm^3 flask and made to the mark with 0.5M HNO_3.

2) Preparation of 2.5 ppm Standard Solution:

2.5 cm^3 of 100 ppm multi element stock solution was transferred into 100 cm^3 flask and made to the mark with 0.5M HNO_3. The absorbance reading for the metals i.e.(Pb, Fe, Cu, Ni, Mn, Zn and Mg) were taken using atomic absorption spectrophotometer (AAS).

2.3. Study Area

The Katsina State is located in Northern Nigeria and lies between latitude of 12 ° 59' 26.95'' N and longitude of 7° 36' 6.37'' E with an estimated area of 24, 1929 km^2 and estimated population of 3, 878, 344 as of 1991 census. It shares the borders from east with Kano State and Jigawa States, from the west with Zamfara state, and from the north with Niger Republic. [7]. The state is among the few states in Nigeria where both the rainy and dry season farming take place.

3. Results and Discussion

1) Lead: As shown in the figure 1, the lead concentration ranged between (0.000 – 109.63) µg/L. with the highest concentration value in Dam water sample. Lead was not detected in both the tap and sachet water samples analyzed. It was observed that the concentration of lead in the dam water was above WHO standard limit for drinking water, which was further screened through water treatment processes. The presence of lead at higher concentration in Ajiwa dam water may be as a result industrial wastes, household effluent, use of fertilizers for farming activities dissolution of the metals from it naturals sources in the water.

2) Copper: As shown in fig.2, the concentration of copper ranged between (0.862-17.232) µg/L with the highest concentration value in the Ajiwa dam raw water and the low concentration in the sachet water samples. It was observed that the amount of copper concentrations in all the water samples analyzed were within WHO limit for drinking water.

Furthermore, it can be seen that there was descending order in the in copper contractions from Ajiwa dam raw water to Ajiwa tap water and the samples of sachet waters analyzed

Copper is an essential element for the wellbeing of humans and other living organisms, it enters into water through household plumbing copper pipes and dissolution from its main sources. Exposure to copper in an excess dose may cause serious health problems such (vomiting, diarrhea, nausea, headache, e.t.c) and cause some changes in taste that may affect water acceptability by consumers.

3) Nickel: As shown in the figure 3 above, the nickel concentration ranged between (0.000-0.72) µg/L. It can be seen that there were reasonable concentrations of nickel observed between Ajiwa dam raw water and tap waters. Meanwhile, the concentrations of nickel in all the water samples analyzed were within WHO standard limit for drinking water.

Nickel is usually needed for humans and other living organisms. This metal finds its way into the water by leaching through water pipes, and when taken above acceptable limit may leads to serious health challenges and possible death.

4) Iron: As shown in the figure 4, iron was detected in all the water samples analyzed. The concentration of iron ranged between (3.972-2.3828) µg/L. The highest concentration was observed in the ajiwa dam raw water and the low concentration in the sachet water samples.

Iron may be present in the dam water at higher concentration due to some domestic and other industrial effluents. Furthermore, the presence of iron the tap and sachet waters may be contributed by the use of iron coagulants or the corrosion of iron pipes during distribution or in the borehole piping. However, the amount of iron in the tap and sachet waters may seem minimal as a result of water treatment processes they had undergone.

Iron is an essential element in human nutrition, no guideline value was proposed for iron in drinking water, because it is not of health concern at the levels found in drinking water, But its presence in an excess level may change the taste of the water, which may affect the water acceptability by the consumers.

Table 2. Result of samples analyzed for heavy metals in (µg/l)

Heavy metals (µg/L)	Pb	Cu	Ni	Fe	Mn	Zn	Mg
WHO 2011 Limits (µg/L)	10	2000	70	NG	NG	NG	NG
P-Values	*	0.000	0.490	0.000	0.007	0.000	0.046
KS	0.000	0.000	0.000	7.944	16.554	0.000	129.786
KSS	0.000	0.000	0.000	7.944	16.554	0.000	102.498
DSS	0.000	0.000	0.72	3.972	33.114	0.000	157.074
TMS	0.000	0.864	0.72	7.944	16.554	0.000	161.286
ADW	109.626	17.232	0.72	238.278	66.234	47.286	217.95
ATW	0.000	8.616	0.72	31.77	49.674	58.122	194.874
TW	0.000	8.616	0.72	31.77	49.674	58.122	213.774

NG: No Guideline

Table 3. Results of the solid residue analyzed

Element	Amount (%)
Si	42.51
O	25.39
K	0.24
Ca	1.16
Ti	0.16
Mn	0.04
Fe	1.19
Cu	0.02
Zn	0.009
Ag	0.40
Ba	0.31
Ce	0.03
Nd	0.002
Eu	0.03
Re	0.04
Cl	1.14
S	0.22

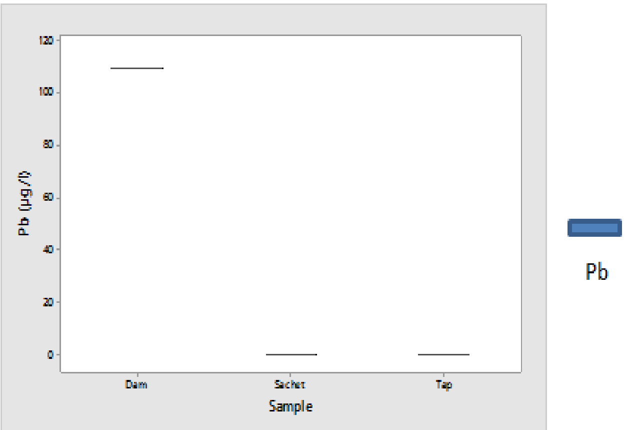

Fig.1.Distribution of lead concentration in water samples from different sources

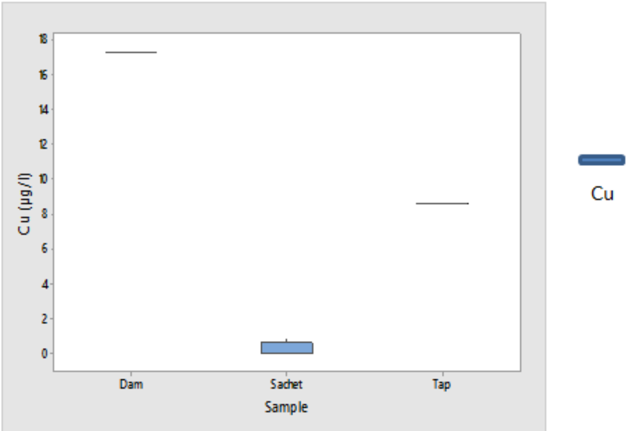

Fig.2. Distribution of copper concentration in water samples from different sources

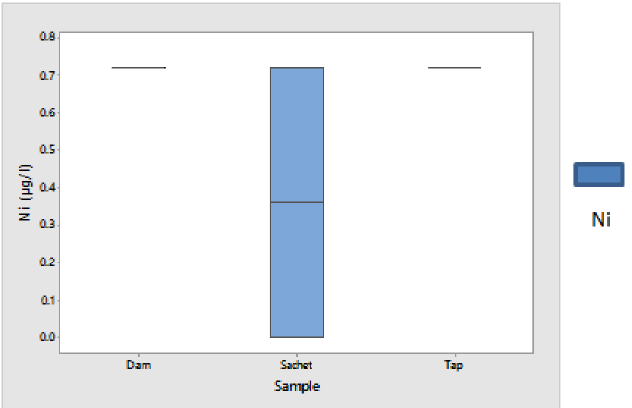

Fig.3. Distribution of nickel concentration in water samples from different sources

5) Manganese: As shown in the figure 5, manganese was detected in all the water samples analyzed. Manganese concentration ranged between (16.554-66.234) µg/L, with the highest manganese concentration observed in the Ajiwa dam raw water and the low manganese concentration was observed in the sachet water samples. There was no guideline value proposed for manganese because it is not of health concern at the level found in the drinking water.

Manganese is naturally occurring and essential for human life and other living organisms, but its presence in an excess level in water may cause changes in color and taste, which indeed affect the water acceptability by the consumers.

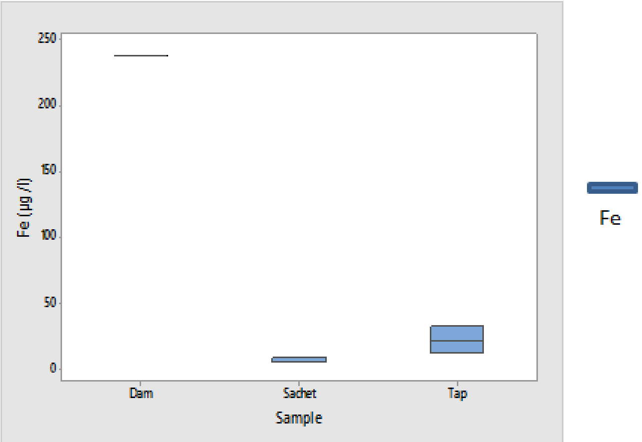

Fig.4: Distribution of iron concentration in water samples from different sources

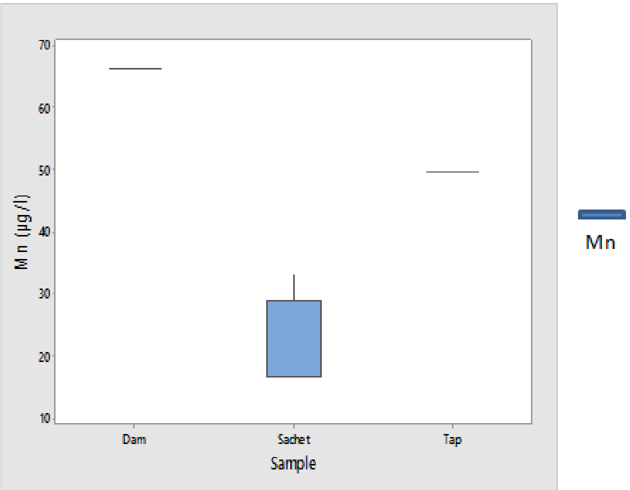

Fig.5.Distribution of manganese concentration in water samples from different sources

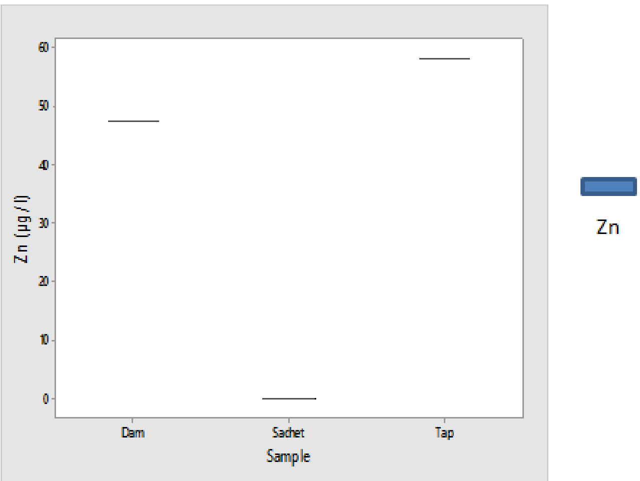

Fig.6. Distribution of zinc concentration in water samples from different sources

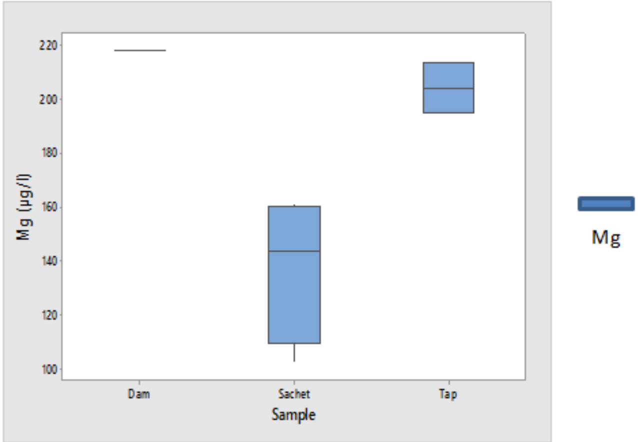

Fig.7. Distribution of magnesium concentration in water samples from different sources

6) Zinc: As shown in the figure 6, zinc was not detected in all the sachet water samples analyzed. The concentration of zinc ranged between (47.286-58.122) µg/L, with the highest zinc concentration observed in the tap water samples. The presence of zinc at higher concentrations in the tap waters may be contributed largely from the corrosion of pipes or dissolution from it natural source. Zinc is among the essential element need for human wellbeing. There is no formal guideline value established for zinc in drinking water. However, drinking water containing zinc at level above 3000 µg/l may not be acceptable to consumers and may tends to cause some health disorder, but its concentration levels found in this work were all within tolerable limit

7) Magnesium: Magnesium was detected in all the water samples analyzed. The magnesium concentration ranged between (102.5-213.77) µg/L. The highest magnesium concentration was observed in the dam raw water sample. Magnesium is part of the essential elements need by human body, but its ions are known to be the major contributor to the water hardness. Even though there was no health base guideline given for magnesium concentrations in the water; however, the degree of hardness in water may affect its acceptability to the consumers in terms of taste and house hold uses.

The high level of magnesium in Ajiwa dam raw water may be attributed from the minerals containing magnesium like Dolomite $CaMg(CO_3)_2$, $MgCO_3$, magnesium washed from rocks or by farming activities.

8) Amount (%) of the isolated elements determined in the solid residue: As shown in the figure 8 , the amount of elements determined showed that, some elements such as Si and O are present at highest percentage values, while other elements such as Ti, Mn, S, K, Zn, Ba, Cu, Ca, Nd, Ce, Ag, Re, Eu, Fe and Cl are detected in trace amount. Even though within the literature investigated, there is no formal guideline values for these elements in the residues emanated from the heavy metals digestion. However, it can be seen from the results that the amount of heavy metals/or elements in the residues are detected in trace amount which does not affect the quality of the water in the study area, Furthermore; pollution prevention is better than any technique that may reduce or eliminates the quantity or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation, it is therefore advised that laboratory personnel and governmental agencies should use pollution prevention techniques to minimize waste generation.

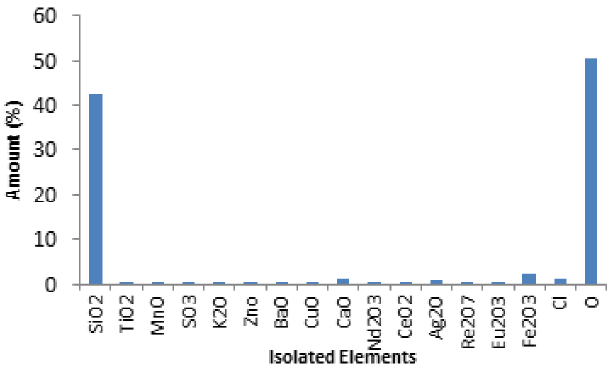

Fig.8. Amount (%) of Elements obtained from x-ray fluorescence

9) Analysis of Variance (ANOVA): ANOVA results shows that lead (P-Value 0.000), iron (P-Value 0.000), zinc (P-Value 0.000), copper (P-Value 0.000), manganese (P-Value 0.007) and magnesium (P-Value 0.046). Apart from nickel (P-Value 0.490); most of the results showed that in each of the heavy metal analyzed from respective water samples, have their means significantly different from each other, and the variation may be attributed considering the fact that most of the elements analyzed are abundant in nature and their concentrations may differ from one area to another. It can also be caused by both differences in the physical and chemical factors.

4. Conclusion

From the results obtained, it can be concluded that heavy metals are found not only in raw waters but also in tab and sachet waters. The application of water in human life is not over emphasized; thus it can include domestic, agricultural and industrial. Heavy metals could also be found to have many health challenges and the remedy to such problems could be every one's job in the society. This could be achieved by minimizing discharge of harmful chemicals into water bodies that might accumulate and caused the above mentioned health problems. It is recommended that concentration of other metals in drinking water in the area and/or other physical parameters need to be investigated as the metals concentration in the water are affected by diversified factors such as P^H, temperature, conductivity and organic matter contents, etc.

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