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Effects of Physicochemical Properties and Heavy Metals level in Tap Drinking Water on Human Health at Urban Katsina, Nigeria

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Abstract

This study was aim to determine the effects of physicochemical properties and heavy metals level in tap drinking water samples collected from ten different locations on human health in Urban Katsina, Katsina State. Nigeria. A total of 20 (10 each) Tap water samples were collected during dry and wet seasons of the year 2013. The gross appearance, pH, EC, Turbidity, Hardness, Calcium (Ca), Chlorine (Cl) and the concentration of lead (Pb), Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu) were analyzed using standard analytical techniques. The results of analysis gave the physicochemical properties with range as follows: pH (5.3 – 7.7), conductivity (89 - 877 ohm/cm), turbidity (5 – 712 ntu), hardness (72 – 600 mg/l), Ca (0.2 – 18.75 mg/l) and Cl (-0.2 – 15.3 mg/l). The pH values were generally acidic while turbidity and hardness especially in most of the sampling locations were higher than the permissible levels set by the World Health Organization (WHO, 2004) for portable water. The concentration of heavy metals (mg/l) was found in the following

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ranges: Pb (0.04 – 0.3), Fe (0.04 – 0.44), Mn (0.05 – 1.48), Zn (0.03 – 0.19), and Cu (0.08 – 1.86). Lead and iron were detected in most of the Tap water samples and Manganese was detected only in one sampling location. Zinc and Copper, in all the two seasons, were within the maximum permitted levels of drinking water standard by SON (2007) and WHO (2004). Thus, all the tap water samples studied here are considered not safe for drinking from the Lead and Iron (some), i.e. have direct effects on human health. All these heavy metals detected in the tap water vary from one location to another. This could be associated with the leaching from rusting in the old galvanized metal pipe-work in the distribution channel.

Keywords: Physicochemical properties, Heavy metals, Tap Water, Urban Katsina, Nigeria

INTRODUCTION:

Water is a very important resource in Urban Katsina and the issue of water and its use has been a subject of so much research inquiry. Urban Katsina lies between N120 411 4511 to N130 401 5011 and E0070 311 1011 to E0070 411 4511 in Katsina State (Figure 1). Urban Katsina is located at the centre of Hausa plains, at the extreme Northern part of the Nigeria. Urban Katsina bounded with Kaita from the North, Jibia to the west and Batagarawa from the south while it is bounded by Rimi to the east. Urban Katsina is part of the headquarters of Katsina Local Government Area and it is also the capital of Katsina State. It has a total area of about 2,448km2.

At the 2002 World summit on sustainable development in Johannesburg (South Africa), great concern was expressed about the 1.1 billion people in the world who do not have access to safe drinking water (Cech 2005). Nigeria is known to be endowed with abundant water resource, but the availability of portable water for drinking is a problem in many parts of the country. The availability of good quality water is an indispensable feature for preventing disease and improving quality of life (Dinrifo et al., 2010). Water quality deals with the physical, chemical and biological characteristics in relation to all other hydrological properties.

The abundance of organic compounds, toxic chemicals, radionuclides, nitrites and nitrates in drinking water may cause adverse effects on the human health such as cancer, other human body malfunctions and chronic illnesses (Ikem et al., 2002). Therefore, it is essential to constantly monitor water quality used for drinking purposes. Zhao et al. (2002) noted that contamination of tap water with heavy metals has a considerable impact on the world population health. Hence, drinking water must be considered as a finite resource that has limits and boundaries to its availability and suitability for use.

In Urban Katsina, tap water is one of the forms of portable water people drink. The agency incharge of provision of tap water in the study area is Katsina State Water Board (KTSWB), whose supplies the water via piping system to some areas within its supply network in urban Katsian. The water is pumped from the Ajiwa dams which is then treated and distributed. Even if it complies with regulation standards as it leaves the plant, several investigations have demonstrated that tap water quality (both physicochemical and microbiological) deteriorates as it moves from the treatment

FIG. 1 : MAP OF KATSINA STATE SHOWING URBAN KATSINA AS THE SELECTED STUDY AREA

plant to the system extremities (AWWA, 1998; Powell et al., 2000; Rodriguez and Se´rodes, 2001). It has been clearly established that these variations are closely associated with the of water residence time throughout the distribution system (Ozdemir, 1999).

Hence, tap drinking water was considered among the safest for human consumption. However, there is a proper lack of care which affect the current quality of received water to the extent that some tap water are bringing out brownish water or sometimes the taste is very bad and offensive. In the light of the reported cases of water borne disease across the study area one wonders whether this water source is really safe. Previous research works in the State and outside the State on municipal drinking water quantity and quality; Ruma and Inkani (2012), Umar (2003), Idris (2011), Kiyawa (2009) and Maipandi (1998) etc made efforts in assessing the water quality situation.

The availability of good quality water is an indispensable feature for preventing disease and improving quality of life (Dinrifo et al., 2010). Water quality deals with the physical, chemical and biological characteristics in relation to all other hydrological properties (Shinde at al., 2010). Therefore to safeguard the health of people and to reduce the barest minimum the problems of water born disease, it is essential to analyzed the quality of tap water in Urban Katsina and monitored it with the view to have finding solution to health problems associated with drinking water in an area.

Hence, the aim of this research is to determine the effects of tap drinking water quality on human health in Urban Katsina, Katsina

State, Nigeria. In specific terms, the study seeks to realize the following objectives: Determine the level of some physicochemical parameters and heavy metals in the area; Compare these levels with International Standard of World Health Organization (WHO, 2004) and to look at the implication of these levels of tap water quality on human health in the study area.

MATERIALS AND METHODS

Standard analytical methods were employed in the determinations of the physicochemical properties of the tap water samples. Heavy metals levels were determined using Atomic Absorption Spectrophotometer (AAS) methods after wet digestion. The graphing method of Beer's law or Spectrophotometric Analysis was used to calculate the concentrations (mg/l) of the heavy metals in the tap water samples. The tap water samples were collected in nitric acid washed plastic bottles. After collections, nitric acid (0.2%) was added as a preservative (WHO, 2004). The entire plastic bottle sample were marked and labeled for each of the tap water the, sampling location and date of sampling. The collected samples was preserved in ice-block containing plastic coolers and transported to the laboratory for analysis.To prevent samples contamination with trace metals, all the glassware and plastic containers have been treated with 0.01M HNO3 and rinsed with distilled water. Using purposive sampling technique, ten (10) sampling points (Figure 2) i.e. Filin Samji Quarters (FSQ), Tudun Wada Quarters (TWQ), Kofar Durbi Quarters (KDQ), Kofar Marusa Quarter (KMQ), Sabuwar Unguwa Quarters (SUQ), Kofar Kaura Quarters (KKQ), Kofar Sauri Quarters (KSQ), Police

Compound Quarters (PCQ), Yar'adua Quarters (YQ) and Saulawa Quarters (SQ), were identify and ten (10) samples apiece in both dry and wet seasons respectively of tap drinking water was collected in the year 2013 and analyzed.

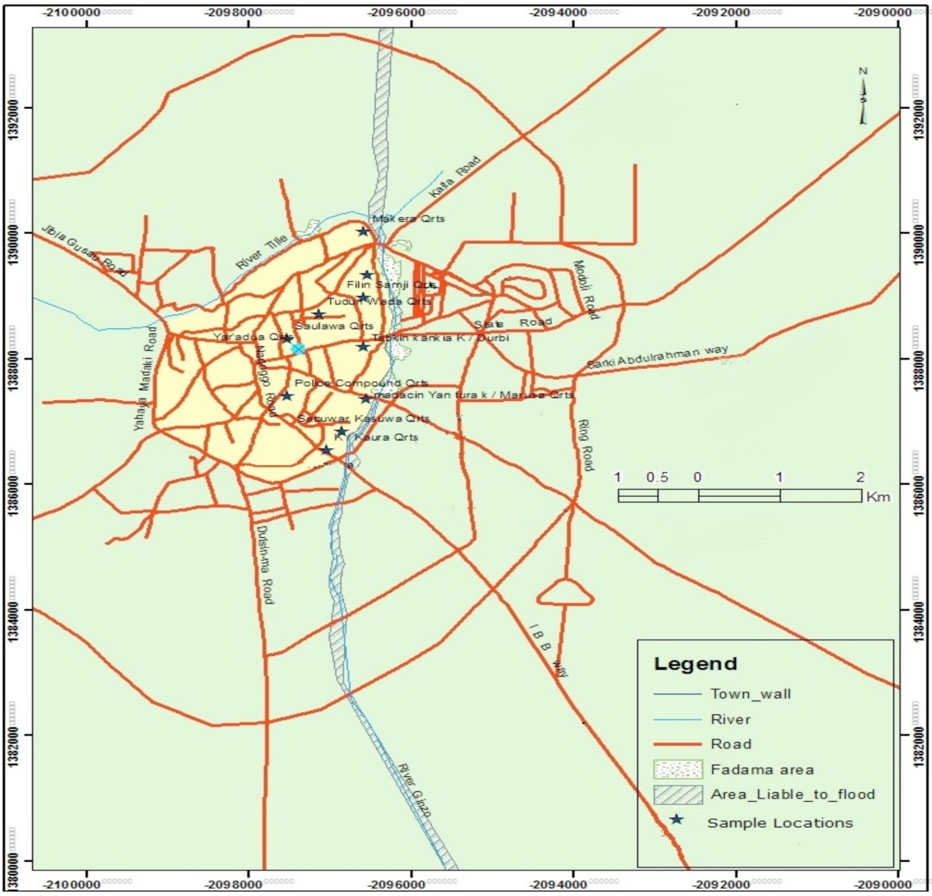


Figure 2: Map of Urban Katsina Shown Sample Locations

The method used for the determination of physico-chemical parameters was described by A.O.A.C. (2005). Analysis for heavy metal levels determination was achieved by measuring 100ml of each water sample into a beaker and 5cm3 of concentrated HNO3 was added. The solution was evaporated to near dryness on a hot plate, making sure that the sample does not boil. The beaker containing the residue was cooled. 5ml of conc. HNO3 was further added and returned to the hot plate until digestion was completed (Ahn et al., 1996; Anonymous 1995). Two milliliter of conc. HNO3 was added and the beaker warmed slightly to dissolve the residue. The digested sample was filtered and the filtrate made up to 50cm3 marks with deionized water. The metal levels of the sample were determined using Atomic Absorption Spectrophotometer following the manufacturer's manual.

RESULTS AND DISCUSSION

The physicochemical parameters obtained from analysis of tap water samples from Urban Katsina were presented in Table 1. In all the water samples, pH values ranged between 5.4 - 6.9 (dry season) and 5.3-7.7 (wet season) with an average value of 6.4±0.4 and 6.8±0.7 in dry and wet season respectively. The pH of tap water samples from the study area is higher in wet season (in most locations) than those obtained in dry season. The highest pH value was observed in Kofar Durbi Quarters (KDQ) with 7.7 (Figure 3). This influence that seasonal variation influences the pH values in Urban Katsina. Compare average value of the pH with the WHO (2004) and SON (2007) standard, the tap water is within the pH maximum permitted levels for drinking.

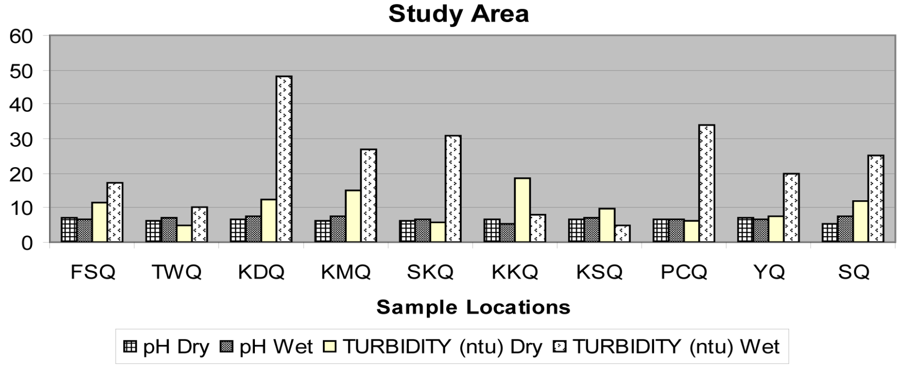
Table 1: Physicochemical parameters values in dry and wet season of tap water samples

Sampling Points	pH Dry	pH Wet	EC (ohm/cm) Dry	EC (ohm/cm) Wet	Turbidity (ntu) Dry	Turbidity (ntu) Wet	Hardness (mg/l) Dry	Hardness (mg/l) Wet	Ca (mg/l) Dry	Ca (mg/l) Wet	Cl (mg/l) Dry	Cl (mg/l) Wet
FSQ	6.85	6.63	95	114	11.5	17	184	120	15.32	4.84	-0.3	1.6
TWQ	6.28	7.25	567	336	5	10	712	264	14.72	0.2	0.4	0.2
KDQ	6.68	7.7	95	126	12.5	48	216	120	10.28	0.4	-0.2	15.3
KMQ	6.35	7.35	95	106	15.02	27	232	104	13.71	0.61	0.3	-0.9
SKQ	6.25	6.47	95	101	5.65	31	344	80	10.28	1.21	0.1	2.8
KKQ	6.5	5.3	95	120	18.7	8	280	96	11.9	0.4	0.5	1.5
KSQ	6.43	6.84	95	95	9.8	5	248	104	12.1	1.01	-0.2	3.9
PCQ	6.4	6.6	117	89	6	34	136	72	9.88	1.01	-0.8	1
YQ	6.9	6.46	119	90	7.5	20	168	112	9.68	2.82	-0.7	3.5
SQ	5.4	7.52	877	109	12	25	600	104	18.75	2.02	-0.2	10.2
Average	**6.4**	**6.8**	**225**	**126.6**	**10.37**	**22.5**	**312**	**117.6**	**12.67**	**1.45**	**-0.11**	**3.91**
Std. Dev.	**0.4**	**0.7**	**258**	**70**	**4.22**	**12.61**	**182**	**51**	**2.8**	**1.36**	**0.42**	**4.77**

The Electric Conductivity ranged between 95 - 877 and 89 – 336 ohm/cm. On the average values the electric conductivity (EC), turbidity, total hardness, calcium and chlorine of dry and wet season tap water samples are: 225±258 ohm/cm - 127±70 ohm/cm; 10.37±4.22 - 22.5±12.61 ntu; 312±182 - 118±51 mg/l; 12.67±2.80 - 1.45±1.36 mg/l and -0.11±0.42 - 3.91± 4.77 mg/l respectively.

A critical look at these results revealed that the values of turbidity (figure 3), in the study area are higher in the wet than in dry season. This would be as result of the old steel pipes used in the distribution, which sand mud and other dirt's get accumulated in the disconnected pipes through run-off in the rainy season.

Figure 3: pH and Turbidity levels in the Tab Water of the Study Area



Saulawa Quarters (SQ) with 877 ohm/cm and Tudun Wada Quarters (TWQ) with 567 ohm/cm have the highest values of EC (figure 4), while Police Compound Quarters (PCQ) with 89 ohm/cm has lowest EC concentration. Also in the entire tap water sample collected in the ten sampling locations of the study area, hardness of the water is highest in dry than in the wet season (figure 4).

Figure 4: EC (uS/cm) and Hardness (mg/l) Levels in the Tab Water of the Study Area

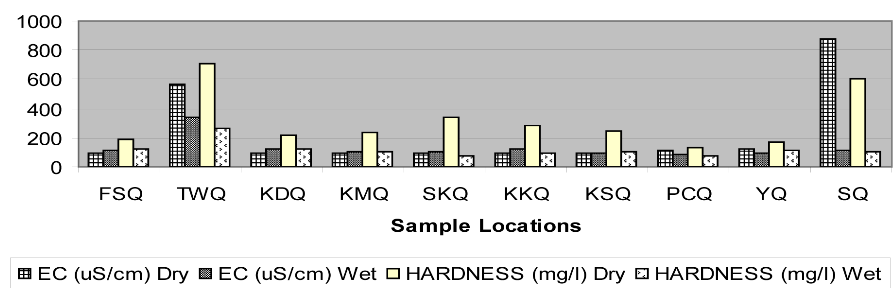
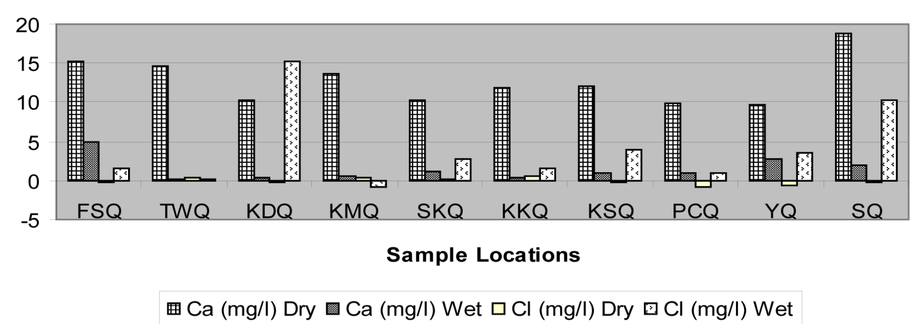


Figure 5; show the values of Ca and Cl levels in the tap water of the Urban Katsina. Ca and Cl concentrations are both high in the dry than wet season. Also Saulawa Quarters (SQ) tap water has high content of Ca (18.75 mg/l), while Tudun Wada Quarters (TWQ) has lowest content of 0.2 mg/l of Ca. Chlorine concentration in the ten tap water samples analyze in the study area, shows that, Kofar Durbi Quarters (KDQ) has the highest Cl value of 15.3 mg/l (figure 5).

Figure 5: Calcium (mg/l) and Chlorine (mg/l) levels in the Tab Water of the Study Area



However, physicochemical properties (i.e. pH, EC, Ca, and Cl) of the tap water at both season were within the routes met the WHO (2004) specifications. The WHO standard for pH, EC, Turbidity, Hardness, Ca and Cl are 6.5-8.5, 400 ohm/cm, 5ntu, 250mg/l, 25mg/l and 5mg/l respectively. However, levels of both season of turbidity and dry season of hardness were higher than the WHO (2004) and SON (2007) specification for drinking water.

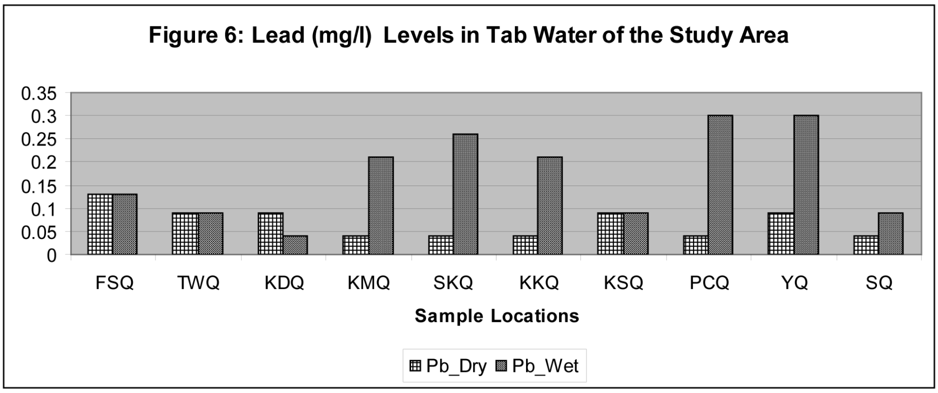
From the result in Table 2; lead and iron were detected in most of the tap water samples. Lead was detected above the permissible limits in all the two season tap water samples while iron detected in dry season tap water samples only. Zinc and copper were not detected at all in any of the samples.

Table 2: Heavy Metals Concentration in Taps Water

Sampling Points	Heavy Metals Concentration (mg/L) in Dry and Wet Season									
	Pb Dry	Pb Wet	Fe Dry	Fe Wet	Mn Dry	Mn Wet	Zn Dry	Zn Wet	Cu Dry	Cu Wet
FSQ	0.13	0.13	0.11	0.11	0.15	0.15	0.05	0.03	0.93	0.76
TWQ	0.09	0.09	0.22	0.15	0.15	0.1	0.08	0.03	0.76	0.51
KDQ	0.09	0.04	0.26	0.07	0.1	0.05	0.13	0.08	0.25	0.42
KMQ	0.04	0.21	0.22	0.04	0.1	0.15	0.13	0.03	0.59	0.08
SKQ	0.04	0.26	0.33	0.04	0.2	0.1	0.19	0.05	0.08	0.59
KKQ	0.04	0.21	0.33	0.07	0.1	0.1	0.08	0.05	0.08	0.51
KSQ	0.09	0.09	0.37	0.07	0.05	0.05	0.13	0.03	1.27	0.68
PCQ	0.04	0.3	0.4	0.04	0.15	0.15	0.16	0.05	1.86	0.59
YQ	0.09	0.3	0.37	0.11	0.1	0.2	0.16	0.03	0.93	0.59

Source: Field work, 2013

The concentration of lead in dry and wet season ranged between 0.04 - 0.13 and 0.03 - 0.04 mg/l with average values of 0.07±0.03 and 0.17±0.09 mg/l respectively (table 2). The highest concentration (0.13 mg/l) was obtained in Filin Samji Quarter both the two season (figure 6). This could be associated with human activities such as the use of chemicals and old steel pipes used in the tab water distribution. In addition to this, manganese was found only in Saulawa Quarters dry season tap water while iron was found in most of the dry season samples. The concentrations of iron and manganese in dry and wet



season ranged between 0.11 - 0.44 and 0.04 - 0.15 mg/l; 0.05 - 1.48 and 0.05 - 0.2 mg/l (figure 7) with average values of 0.31±0.10 and 0.07±0.04 mg/l; 0.26±0.4 and 0.12±0.05 mg/l respectively. In the WHO (2004) guidelines, minimum or maximum permissible limits set for Fe and Mn are 0.3 mg/l and 0.4mg/l respectively. Also in the literature value of 0.3 mg/l for Fe (SON 2007) has been suggested as the accepted minimum since iron is one of the essential elements for human metabolism. In this regard, it is clear that the water samples analysed have levels of Fe (dry season sample) that is above the required maximum permitted for drinking water (figure 6). On the average, the concentration of Zinc (0.13±0.04 and 0.04±0.02 mg/l), and Copper (0.72±0.53 and 0.56±0.2 mg/l) in all the two season, values vary from one location to another (figure 8). Thus, Mn, Zn and Cu are all within the maximum permitted levels of drinking water standard by SON (2007) and WHO (2004).

The pH, Electric Conductivity (EC), Turbidity and Hardness of the drinking water have no direct adverse effect on human health. However, drinking waters with pH lower than 4 have a sour taste and above 8.5 an alkaline bitter taste. In this study area, the tap water pH and EC of the ten sampling locations have mean values that are within the permissible limit. The WHO limits turbidity for drinking water is 5ntu while for hardness is 250mg/l. Hardness of water which

Figure 7: Iron (mg/l) and Manganase (mg/l) Levels in Tab Water of the Study Area

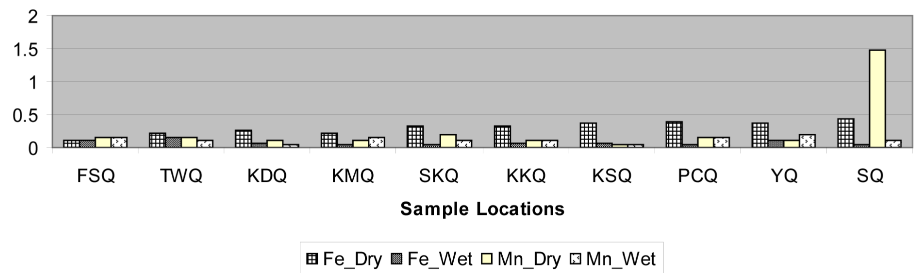
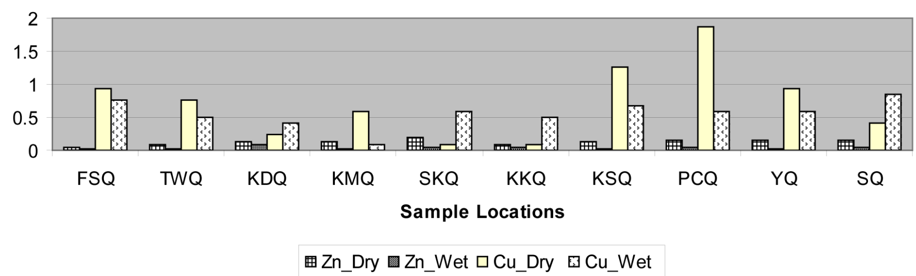


Figure 8: Zinc (mg/l) and Copper (mg/l) Levels in the Tab Water of the Study Area



is due to the presence of calcium and magnesium salts in water, does contribute towards total calcium and magnesium human dietary needs, which has a beneficial effect on bone structure. Over 90% of the tap water in the ten sampling locations has turbidity values above the WHO permissible limit. WHO prescribed 25mg/l as a limit for Ca and 250mg/l for Cl in drinking water. But according to WHO (2004) Calcium concentration above 25mg/l can cause depresses the function of muscles and nervous tissues. Also chlorine concentrations higher than 250 mg/l are considered to be at risk for human health and may cause unpleasant taste of water, leading to consumer complaints. Thus, all the tap water samples studied here are considered as safe for drinking from the Calcium and Chlorine point of view.

In humans, lead, Iron, Manganese, Zinc and Copper metal in drinking water can results a wide range of effects depending upon the level and duration of exposure. The effect of lead on the heart is indirect and occurs via the autonomic nervous system; it has no direct effect on the myocardium. Adverse health effects of Pb include various cancers, toxic to central and peripheral nervous systems, neurological and behavioural effects (WHO, 2004). The elevated amounts of Mn may cause apathy, irritability, headache, insomnia as well as gastrointestinal irritation and respiratory disease (WHO, 2004). However, the major adverse effects of elevated concentrations of Fe and Mn are associated with aesthetic nuisances such as staining of laundry, unpleasant odor and taste. Zinc concentration in drinking water has no direct health effect on human health. Copper is an essential nutrient, but at high doses it has been shown to cause stomach and intestinal distress, liver and kidney damage, and anemia (USEPA, 1983). Also, WHO (2004) has explained that despite Cu being an essential element for human health, elevated concentrations may result in serious liver and/or kidney damage, gastrointestinal distress and, in a lesser scale, vomiting and nausea.

The WHO drinking water guideline set the limit for these metals at 0.01 mg/l for Pb, 0.3 mg/l for Fe, 0.4 mg/l for Mn, 5 mg/l for Zn and 2.0 mg/l for Cu as the maximum permissible. In the ten tap drinking water samples analyzed over the ten sampling locations, have values of Pb, and Fe that are above the minimum permissible limit set by WHO (2004) for drinking water. Thus, all the tap water samples studied here are considered not safe for drinking from the Lead and Iron (some), while they are safe for drinking from the Manganese, Zinc and Copper point of view.

CONCLUSION

In conclusion, physicochemical parameters and levels of heavy metals in all the tap water samples were compared with World Health Organization standard for drinking water (WHO, 2004). The pH, EC, Hardness (wet season) Ca, Cl, and Fe (wet season), Mn, Zn, and Cu of the tap water samples values are within the acceptable limits (WHO, 2004) for safe drinking water. While the values of turbidity and Pb in both seasons; hardness (dry season), and Fe (dry season) are above the maximum permitted for a safe drinking water set by WHO (2004). Thus, all the tap water samples studied here are considered not safe for drinking from the turbidity and Pb (both seasons); hardness and Fe (dry season only) i.e. have direct effects on human health. While the tap water is safe for drinking from Manganese, Zinc and Copper point of view. Very erratic changes in the metal levels were observed in the tap water sample at some sampling points which have been related to leaching from the corroded pipe work and also contamination from run-off into damaged pipe networks. Based on the result obtained the values of physiochemical parameters and heavy metals of the tap water samples were found to vary within (season) and between (season) at different sampling points in Urban Katsina.

In order to minimize the variation of the physiochemical parameters and improve the tap water quality, frequent and improved supervision of the distributed taps systems and repairs and maintenance especially of the pipes are also essential for intermittently operated system. In addition to this, it's also recommended that, bacteriological assessment of this tap water should be carried out to be sure if the water is safe bacteriological contamination.

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