IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 7, Issue 11 Ver. I. (Nov. 2014), PP 74-81
www.iosrjournals.org

Quality Assessment of the Changes in the Physico-Chemical Parameters in Pipe-Borne Water Supplied In Kano Metropolis, Nigeria.

*[1]Abdullahi Zakari, [1]Victoria Abiola Ikudayisi and [2]Shafa'atu I. Giwa
[1](Department of Pure and Industrial Chemistry, Bayero University, Kano, Nigeria)
[2](Department of Biochemistry, Usmanu Danfodiyo University, Sokoto, Nigeria)

Abstract: *This research was embarked upon to assess the changes in the physical and chemical properties of piped-borne water supplied in Kano metropolis from the treatment plants(challawa and tamburawa plants), along the distribution lines to the various points of use. Samples of piped water were collected from selected points of use (zones) including raw and treated water from the treatment plants and analyzed for selected physical parameters- pH, alkalinity, conductivity, turbidity, total dissolved solids, total suspended solids and chemical parameters –chlorides, sulphates, nitrates, nitrites and trace metals which includes sodium, potassium, calcium, magnesium, lead, cadmium, chromium, manganese, iron, nickel, zinc, and copper. The results show that all the physical parameters were within the world health organization WHO acceptable limits with the exception of turbidity and total suspended solids of sharada zone with 208 NTU and 193mg/L respectively. All the chemical parameters were within the thresholds limits including all the metals analyzed which were present in concentrations permitted by the WHO for a quality drinking water. Mean concentration of some of the metals were found as follows:* ***Pb*** *(0.0021± 0.0005) mg/L,* ***Fe*** *(0.0024± 0.0005,* ***Zn*** *(0.0017± 0.0005) mg/L,* ***Cu*** *(0.0038± 0.0008) mg/L,* ***Ca*** *(0.0430± 0.00078) mg/L and* ***Mg*** *(0.0224± 0.0064) mg/L. The study indicates that despite all the parameters meeting the WHO laid out standards, the purification processes and distribution lines (pipes) need to be reviewed periodically and checked thoroughly for possible contamination and ways to prevent it so as to achieve wholesome drinking water for the general public.*

Key words: *Pipe borne water, physico-chemical parameters, WHO, Kano metropolis.*

I. Introduction

All life forms on earth depend upon water [1]. Each human being needs to consume several litres of fresh water daily to sustain his or her life. [1].It is in fact the second important resources to human life after air. Man can survive longer without food than without water. water is also needed for agriculture, manufacturing processes and domestic needs [2].As an important constituent of biotic community, it occurs naturally on the land, below its surface, in the atmosphere and in biomass [3]. Throughout history, the quality of drinking water has been a factor in determining human welfare [4].It is clear that water pollution should be a concern of every citizen. Water accounts for about 70% of the weight of a human body. Out of the estimated 1,011million km^3 of the total water present on earth, only 33,400 m^3 is available for drinking, agriculture, domestic and industrial consumption. The rest of the water is locked up in ocean as salt water, polar ice-cap and glaciers and underground [5].Water plays a significant role in the continuity of life due to its unique qualities.

Water plays an important role in the world economy, as it functions as a solvent for a wide variety of chemical substances, industrial cooling and transportation. More than 70% of freshwater is consumed by agriculture [6]The quality of water and its effect are characterized by its physical and physico-chemical properties [3]. The problems associated with chemical constituents of drinking water arise primarily from their ability to cause adverse health effects after prolonged periods of exposure, of particular concern are contaminants that have cumulative toxic properties, such as heavy metals and substances that are carcinogenic [7].

The need for qualitative drinking water is now a global problem, as access to a secure, safe and sufficient source of fresh water is a fundamental requirement for the survival, well being and socio economic development of humanity. A safe and portable drinking water should conform to certain standard set by World Health Organization(WHO) .The quality required of water varies with the use to which the water is to be put[8].

Kano city (latitude 12° 02'N, longitude 08°30'E, in northern Nigeria is one of the largest and most populous city in Nigeria. The population of the city is estimated at over ten million during the 2006 national population census. It is the commercial nerve centre of northern Nigeria. The high population is brought about by the much economic and industrial activities occurring in the city [9]. Owing to increasing industrialization one hand and exploding population on the other hand, demands of water supply have been increasing tremendously. However, the menace of water borne diseases and epidemics still threaten the well being of the population, especially in a developing country like Nigeria. Therefore the quality as well as the quantity of clean water supply is of vital significance for the welfare of mankind [5]. The need for better treated water has lead to the dependence, by a section of the populace in the city on public treated pipe borne water as the only available source of treated water as a matter of priority. Since government in this part of the world is responsible for providing treated water and bearing in mind the inconsistencies and complacency of government agencies saddled with such task, there is the need for time to time monitoring of the treatment processes employed at both the old water treatment plant (challawa treatment plant) and the new tamburawa plant. Atomic Absorption Spectrometry (AAS), a widely used technique for quantification of metal species, has proved to be a powerful tool for trace element determination in a variety of materials in terms of the enhanced sensitivity, efficient matrix removal, high sampling frequency and low cost of equipment [10].This research work examined the changes in the physico-chemical properties of the piped water supply distributed for use from both plant to the various points of use in different zones of Kano city.

II. Materials And Methods

2.1 Materials

In the preparation of the reagents, chemicals of analytical grade purity and deionized water were used. All glass wares were cleaned by immersion in 10% nitric acid overnight and were washed with detergent before rinsing with de-ionized water. Samples of water were collected in clean 10 litres capacity plastic containers from ten samplings zones in Kano city including the water treatment plants and labeled. The taps were allowed to run for at least two minutes before filling the container which has been rinsed severally with the water to be collected and the temperature was checked immediately. Each sample was collected three times at an interval of about 5 hours to form a representative of the whole water for that particular area or zone [11].

2.2 Methods

2.2.1Sample Treatment for Metals Determination

Each of the 5.0 liters samples was evaporated to dryness using Pyrex beaker and hot plate. The residues were digested with $50cm^3$ of $0.25moldm^{-3}$nitric acid and transferred into $120cm^3$ plastic containers and then analyzed using atomic absorption spectrometry (AAS) [11].

2.2.1determination Of Other Parameters

2.2.1.1pH

The pH of the water samples was determined by using JENWAY digital pH meter. The pH meter was switched on and allowed to stand for 5 minutes for stabilization of the meter, followed by the calibration of the meter by dipping the electrode (probe) into buffer 4 solution, the knob of the meter was adjusted until an accurate reading was observed, the probe was washed with distilled water and wiped with clean tissue paper, then buffer 7 solution was also used for proper calibration. After the calibration process, the probe was washed and wiped dry before it is dipped into the water sample; readings were taken when the pH meter was stabilized.

2.2.1.2 Turbidity

The turbidity of the water samples was determined using DR/890 HACH Colorimeter [12] and was set according to the manufacturers' manual. The colorimeter which has been thoroughly cleaned was switched on for about 5 minutes and programmed into turbidity measurements. A sample blank (doubly distilled water), contained inside the blank cuvette was used to calibrate the instrument, after which the turbidity of the water sample, also contained in the sample cuvette was determined and recorded.

2.2.1.3 Conductivity

The conductivity of the water samples was determined using HACH conductivity meter. The instrument was thoroughly cleaned and switched on for about 5 minutes, and then it was set according to the manufacturers' manual. The meter was also calibrated by dipping the electrode (probe) into the blank (doubly distilled water). The electrode was wiped properly and was dipped into the water sample contained in a beaker. The readings were recorded when they are stabilized.

2.2.1.4Alkalinity

The alkalinity of each water sample was determined by titration. 100mL of each water sample was taken into a conical flask, 2-3 drops of phenolphthalein indicator was added, followed by another 2-3 drops of methyl orange indicator. The water was then titrated with 0.1M Hydrochloric acid; the orange solution observed was boiled at100˚C, cooled and then titrated again with 0.1M Hydrochloric acid, a pink solution showed the end point of the titration and the volume of acid used were recorded. The volume of acid used is the total alkalinity of the water sample.

2.2.1.5 Total dissolved solids

The total dissolved solids in the water samples was determined using DR/890 HACH Colorimeter[12] and was set according to the manufacturers' manual. The colorimeter which has been thoroughly cleaned was switched on for about 5 minutes and programmed into total dissolved solids measurements. A sample blank (doubly distilled water), contained inside the blank cuvette was used to calibrate the instrument, after which the total dissolved solids in the water sample, also contained in the sample cuvette was determined and recorded.

2.2.1.6 Total suspended solids

The total suspended solids in the water samples were determined using DR/890 HACH Colorimeter [12] which was set according to the manufacturers' manual. The colorimeter which has been thoroughly cleaned was switched on for about 5 minutes and programmed into total suspended solids measurements. A sample blank (doubly distilled water), contained inside the blank curvette was used to calibrate the instrument, after which the total suspended solids in the water sample, also contained in the sample cuvette was determined and recorded.

2.2.1.7 Sulphates, Nitrates and Nitrites

Nitrates and Nitrites as (NO_3N and NO_2N) were determined by the cadmium metal method [12]. The cadmium metal in the added reagents (Nitra Ver 4 and Nitri Ver 4) reduces all the nitrates and nitrites while sulphate was determined by using Sulfa Ver standard methods (addition of Sulfa Ver 5) [12]

2.2.1.8 Chlorides

The chloride of the water samples was determined by taking 100ml of each sample,, 1ml of K_2CrO_4 indicator was added and then titrated with standard $AgNO_3$ until a pinkish yellow end point was observed. The result was evaluated by calculation.

III. Results And Discussion

In the analysis of pipe borne water in Kano metropolis, Kano city was divided into only ten (10) zones due to limited supply of the piped-borne water by the government through the water treatment plants, from where samples were taken and analyzed in triplicates. The analysis covered pH, total dissolved solids, total suspended solids, conductivity, alkalinity, nitrates, nitrites, sulphates, chlorides and trace metals.

The chart for pH is as shown in Fig.-1. pH value of drinking water set by the World Health Organization WHO [13] ranges from 6.5-8.5. The pH of both raw waters is slightly alkaline (above 8.00) due to various substances such as salts, dissolved solids but after the treatment processes, the addition of chlorine (chlorination process after the addition of lime to correct the pH) at the distribution points raises the pH of the water making the water to be slightly acidic (6.00-6.90) so as to kill all the microorganisms in the pipes and pumps along the distribution line to the points of use and this process reduces the acidity making the water to be neutral (7.00-7.50). All the water samples analyzed were neutral with the exception of Zoo road zone which was acidic (5.75). This suggests that the pH of the water was not corrected with lime as at when released from the distribution point due to lime unavailability in the treatment plant (Tamburawa treatment plant) as at the time of the analysis.

As for the turbidity, this parameter is absent in most of the water analyzed especially the water collected at the points of use with the exception of Sharada zone as shown in the distribution pattern in Fig.-2. This suggests that the water collected at various points of use are very clear that is, absence of suspended solids, and that Sharada zone water was not purified and treated before it was released at the distribution point in Challawa treatment plant. Challawa raw water and Tamburawa raw water also show high turbidity which suggests pollution of the water body which results to presence of particles and high coloration of the water.

Fig.3 is the chart depicting the alkalinity in the water samples. A careful study of the alkalinity values show variations in the total alkalinity of the water samples from the raw water along the distribution line to the samples of water collected at points of use, with University new campus having the highest value (97.5) which suggests the dissolution of the pipes due to ageing and intrusion from leakages from broken pipes but all the values still conform with the WHO standards.

The chart illustrating the conductivity of the various water samples is as shown in Fig.4. All the water samples analyzed have conductivity values that fall within the World Health Organization permissible limits with University new campus water having the highest value ($196.00\mu Scm^{-1}$) and Sharada zone having the lowest value ($107.20\mu Scm^{-1}$), hence the waters are safe for drinking and for other purposes.

The pattern for total dissolved solids of the water samples is as shown in Fig.5. The World Health Organization standard for maximum value for total dissolved solids in drinking water is 1200mg/L. The total dissolved solids for both raw waters (Challawa and Tamburawa waters) fall within the permissible limit for total dissolved solids. This is an indication that the raw waters are not contaminated beyond limits with various substances such as minerals, salts and ions which will lead to reduction in the purification and treatment costs and energy. The total dissolved solids in all the water collected at various points of use are also within the permissible range. Their concentrations are within 50mg/L to 120mg/L which suggests that the waters collected at different zones are safe for drinking and for other purposes.

Most of the water analyzed has no suspended solids as shown in the chart in Fig.6. Both raw waters (Challawa and Tamburawa waters) show high concentration of suspended solids with 256.00mg/L and 103mg/L respectively as they may be contaminated with various domestic wastes from different activities carried out by the nearby communities. It was also observed that Challawa treated water contains small amount of suspended solids which suggest ineffective purification processes by the treatment plant. The high concentration of suspended solids observed in Sharada zone was also due to unpurified water released by Challawa treatment plant to serve the zone which was as a result of obsolete apparatus and machineries used in the treatment plant.

As for Nitrates, Nitrites, Sulphates and Chlorides, the chart depicting the distribution pattern of these parameters is shown in Figs.7, 8, 9 and 10 respectively. These parameters get into the raw water body from environmental pollution such as sewage, agricultural activities (uses of fertilizers), highway refuse disposal and all other domestic activities from the nearest communities surrounding the water and small concentrations are passed into treated water after purification. A potential hazard caused by nitrates in water may be the formation of carcinogenic nitrosamines in the human digestive system by the conversion of nitrate to nitrite [14]. All the water samples analyzed show the presence of all these parameters in concentrations that are far below the maximum limits (50mg/L for nitrates, 250mg/L for both sulphates and chlorides) set by the World Health Organization, this suggests that the raw water and the treated water are all free from excess contamination as a result of pollution due to the above mentioned activities hence safe for consumption.

With respect to the alkaline and alkali earth metals the metals analyzed under this category are Sodium, Potassium, Calcium and Magnesium. The variation in results of analysis of these metals is illustrated by Fig.11. It was observed that these metals are present in the water samples in concentrations that are far below the World Health Organization standards rendering the water very soft. Sodium (0.0077±0.0018 mg/L) does not show any variation from the treatment plant to points of use in homes but its concentration in Challawa water is slightly more than the water supplied from Tamburawa treatment plant with Challawa raw water having the highest concentration (0.0116±0.00165 mg/L) and Tamburawa raw water with the lowest (0.0056±0.00253 mg/L). Potassium (0.019±0.0060 mg/L) increases considerably in treated water from 0.0188mg/L in both raw waters to 0.0304mg/L and 0.0217mg/L for Challawa treated water and Tamburawa treated water respectively which is due to the formation of chlorides as a result of chlorination. The potassium concentration decreases along the distribution line to the points of use with values that comply with the WHO drinking water standards. Calcium and magnesium which are essential elements to the body are also present in lower concentration of 0.0430±0.0078 mg/L and 0.0224±0.0064 mg/L respectively, when compared to the WHO standards. These concentrations are due to the efficient water softening process employed in the treatment plants to remove hardness from the water with the exception of Sharada zone having the lowest concentration (0.0261±0.00417 mg/L and 0.0247±0.00305 mg/L respectively) because of absence of purification and treatment processes before the distribution to the points of use.

The chart in Fig.12 depicts the various concentrations of selected heavy metals like Lead, Cadmium, Chromium and Manganese .All these metals are present in all the water samples analyzed and their concentrations are far below the WHO threshold limits for drinking water. This result, for the present study agrees with similar reports by other authors [15]. Lead being a very toxic metal has a mean value of 0.0021±0.0005mg/L compared to 0.01mg/L which is the maximum limit concentration in drinking water permitted by WHO. Other authors have reported a higher value for lead in drinking water beyond the permissible limits allowed by the WHO [16]. The concentration of lead in both raw water and treated water does not vary with points of use which suggest that the purification processes does not include removal of metal ions and the slight increase along the distribution line to the points of use suggests that lead pipes(which has been discouraged globally) are being used to convey the water, which results to lead ions dissolution in the water and give rise to increase in concentration with University old campus having the highest concentration (0.0031±0.00045mg/L) and it can also be added from contaminated soil through broken pipes. Cadmium, chromium and manganese are also present in raw water, treated water and water collected at various points of use in lower concentration compared to WHO standards for drinking water. This suggests that these metals are present in the surface water (raw water) and are not removed during purification processes. Their concentrations are 0.0020±0.0008 mg/L, 0.0014±0.0005 mg/L and 0.0021±0.0005 mg/L respectively. However, all these metals are present in very low concentration which satisfies the WHO threshold limits of the metals; hence the water is safe for drinking and for other purposes. The chart in Fig.13 shows the various concentrations of other heavy metals like Iron, Nickel, Zinc and Copper. Khan et al,[13] reported higher values for these metals above the WHO permissible limits. However for the present study, these metals are present in the water samples in concentration that are within the WHO drinking water standards and agrees with that reported by [15]. Iron which is an essential metal required by the circulatory system in the body has a mean concentration of 0.0024±0.0005mg/L and its concentration in all the water samples ranging from the raw water to water from various points of use does not vary. The concentration of copper in raw water increases to a significant concentration in treated water and the increment rises at all the points of use. This suggest that impure chemicals which contain copper as impurity are used in the treatment processes leading to increase in concentration of copper in the treated water and copper ions from old pipes used in the conveyance of the water dissolved in it which also give rise to increased concentration along the distribution line to points of use with University old campus having the highest mean concentration (0.0054±0.00090 mg/L). Nickel and zinc are also present in concentration which is acceptable by the World Health Organization standards and there is no variation in their concentration from the raw water to water collected at points of use. This suggests that the surface waters (raw waters) are not contaminated with these ions and there is no addition of these metals to the water through purification processes and conveyance (pipes).

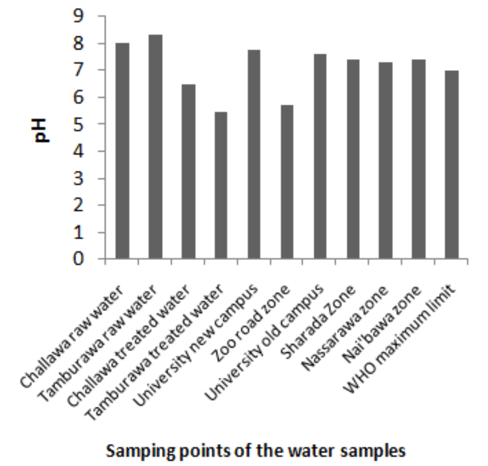

Fig. 1: pH variation with the sampling points

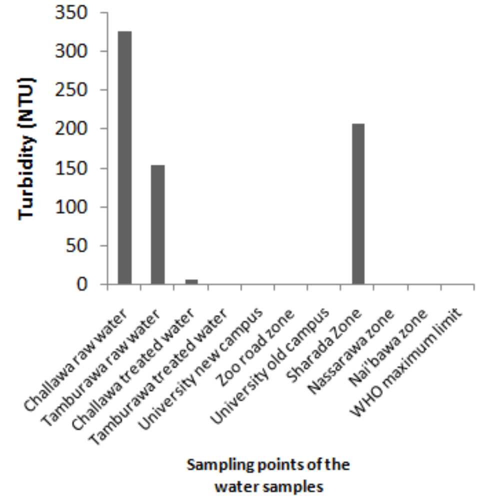

Fig. 2: Turbidity variation with sampling points

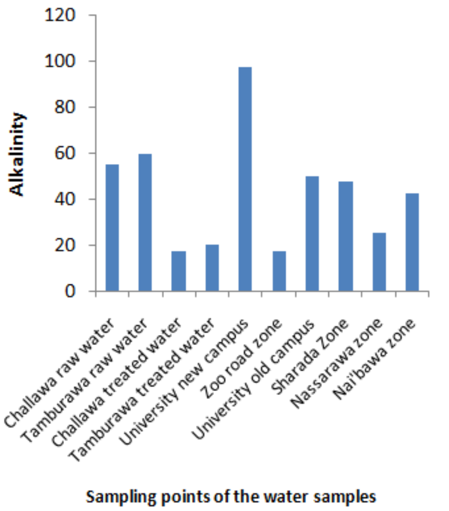

Fig.3: Alkalinity variation with sampling points

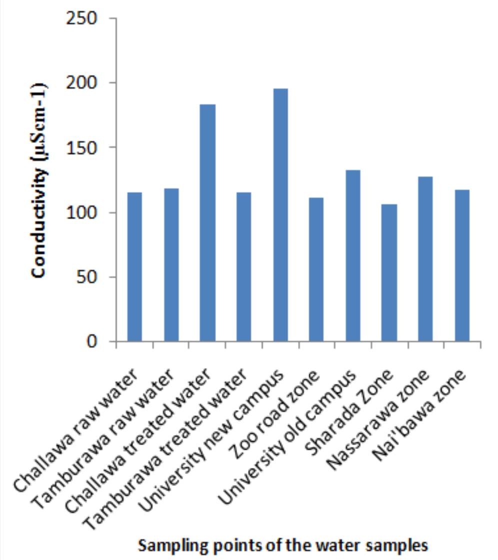

Fig. 4: Chart showing conductivity of the water samples

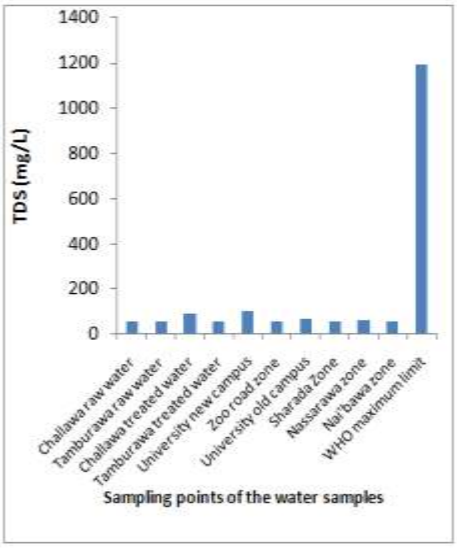

Fig.5: Chart showing total dissolved solids in the water samples.

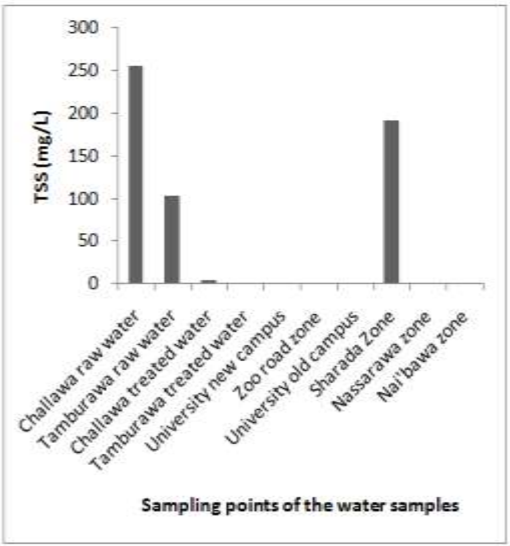

Fig.6: Chart showing total suspended solids in the water samples.

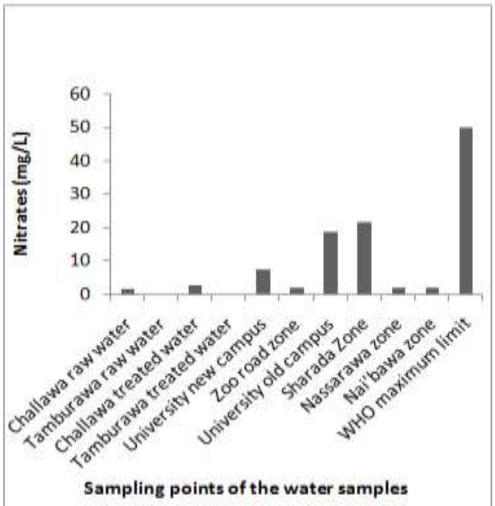

Fig. 7: Chart showing variation of nitrates in the water samples.

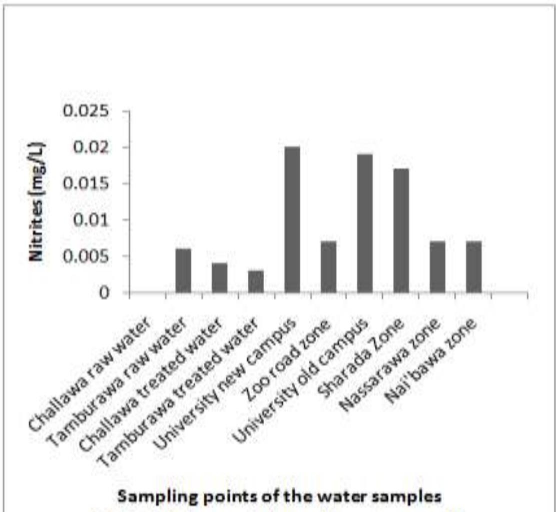

Fig.8: Nitrites variation with water samples

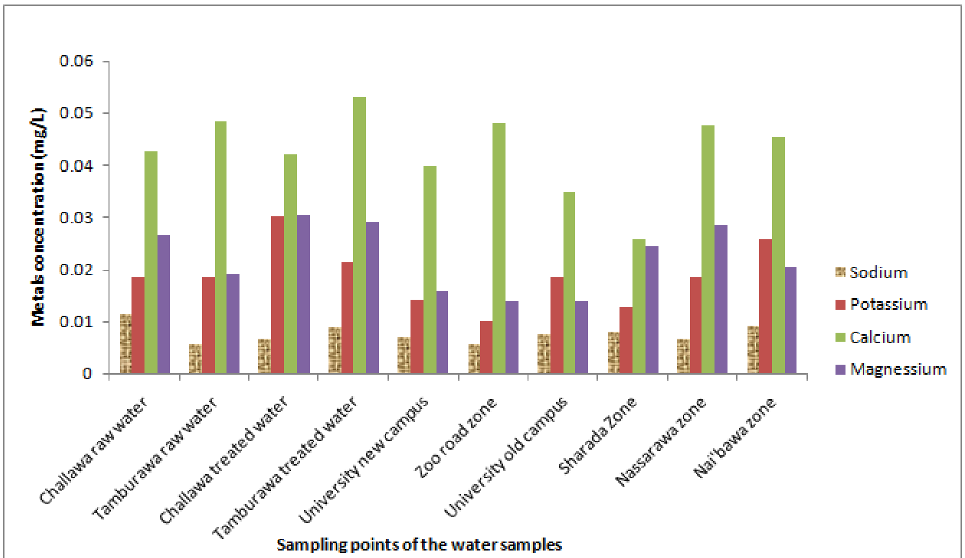

Fig.11: Variation of alkai and alkaline earth metals with sampling points

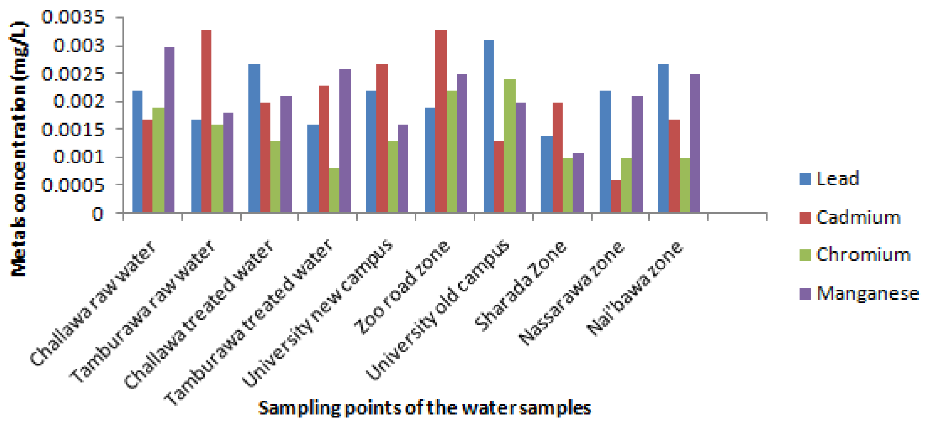

Fig.12: Lead, cadmium, chromium& manganese variation with sampling points

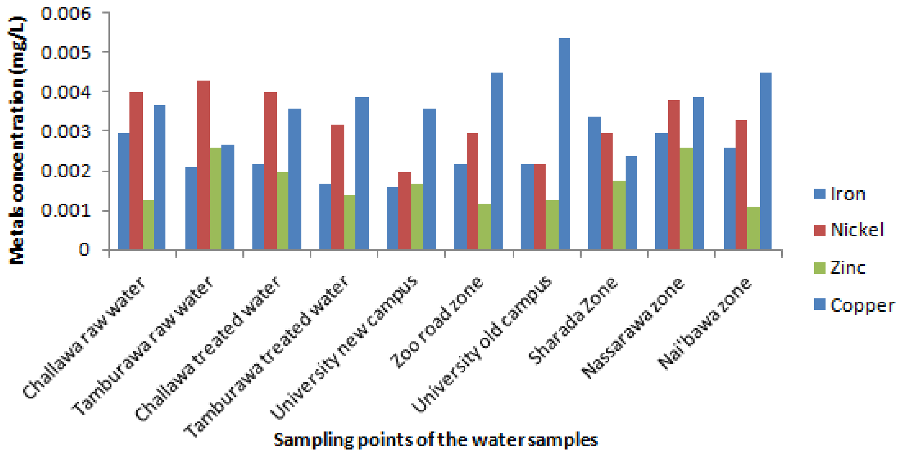

Fig. 13: Iron, nickel, zinc& copper variation with sampling points

IV. General Discussion

The assessment of the changes in the physico-chemical parameters in piped water in Kano metropolis involves the analysis of water samples starting with the raw water from the rivers (Challawa river and Tamburawa river), then the purified water that is ready for distribution in the treatment plant and finally water at each points of use where consumers collect it for industrial and domestic uses. There are lots of changes that occur in each step from the purification processes to the distribution lines (pumps and pipes) which can make water safe or unsafe for drinking and for other uses. Treatment processes in treatment plants contribute a lot to most of these changes as different chemicals used contribute to presence of some parameters in which their concentration in the water determine how safe they can be to the general public. There are other factors that contribute to these parameters which include old and worn out pumps and pipes which result into ions dissolution into the treated water, breakage and leakage of pipes which attract impurities from soil matter and nearby vegetation resulting into contamination of the treated water, lead pipes which has been discouraged worldwide are still been used in Kano metropolis result into the presence of lead ions in the water though in concentration that is far below the maximum permissible limits by World Health Organization. The two water treatment plants (especially Challawa plant) also contribute to the contamination of the water by the addition of ions through using impure chemicals and obsolete machines, and sometimes distributing the water for public use without proper treatment due to unavailability of treating chemicals such as lime.

V. Conclusion

The scope of this research work is limited to physical parameters such as pH, alkalinity, conductivity, turbidity, total dissolved solids, total suspended solids and chemical parameters such as sulphates, chlorides, nitrates, nitrites and trace metals including sodium, potassium, calcium, magnesium, lead, cadmium, chromium, manganese, iron, nickel, zinc and copper in piped-borne water supplied in Kano metropolis. All the physical and chemical parameters analyzed in the water samples were all within the World Health Organization (WHO) and Standards Organization of Nigeria (SON) [16] limits, hence making piped-borne water in Kano metropolis safe for drinking and other purposes. However, the treatment plants (Challawa and Tamburawa) need review and upgrading so as to improve the quality of water being supplied to the metropolis, also the government need to supply all the necessary requirements to the treatment plants for proper and uninterrupted production of wholesome water with maximum purity to the general public. Further research work can be done on other physical and chemical parameters such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), phosphates, microbiological activities and other trace metals such as aluminium, cobalt and so on, to further determine the wholesomeness and purity of the piped-borne water, the changes occurring along the distribution lines and its effects on the water quality and finally, the efficiency of the purification and treatment processes of the treatment plants supplying water to Kano metropolis.

Reference

[1] Baird, C**.** Environmental chemistry, Second edition (W.H Freeman and company 1999)..

[2] M.D Said and WLO Jimoh. Measurement of some physical parameters in some water samples. Biosci. Reas. Comm .21(3), 2009, 133-136**.**

[3] Narayanan, **.P.** Environmental Chemistry, Second edition 2007.

[4] Bhatia S. C. Environmental chemistry, First edition, (CBS Publishers & Distributors New Delhi India, 2008).

[5] Dara S, S**.** A textbook of Environmental Chemistry and pollution control, Second edition (S. Chand & CompanyLtd 2009).

[6] Khan Sher Ali, Zahoor Ud Din, Ihsanullah & Ahmad Zubair. Levels of selected heavy metals in drinking water of Peshawar city. International journal of science and nature.IJSN 3(2),2011, 648-652.

[7] Uduma A.U. Physicochemical Analysis Of The Quality Of Sachet Water Consumed In Kano Metropolis, American Journal of Environment, Energy and Power Research, 2(1), 2014, 01-10.

[8] Ogbonna O, Jimoh W.L, Awagu E. F. and Bamishaiye E.I. Determination of some trace elements in water samples within Kano metropolis. Advances in Applied Science Research, 2 (2): 2011, 62 -68.

[9] Dan azumi, S and Bichi, M.H, Industrial pollution and implication on source of water supply in Kano, Nigeria International journal of engineering and technology, IJET-IJENS, 10(1), 2010, 101-110

[10] Fang, Z. Flow Injection Atomic Absorption Spectrometry, (West Sussex, England ,John Wiley and Sons Ltd. 1995)

[11] Jimoh, W.L.O and Sholadoye, Q. O: Trace Elements as Indicators of Quality of Drinking Water in Offa Metropolis, Kwara State, Nigeria. Bayero Journal of Pure and applied Sciences. 4(2), 2011, 103-108.

[12] HACH. Water analysis handbook. Third edition (Loveland, Colorado, USA HACH Company, 1997).

[13] World Health Organization Guidelines for Drinking-water Quality, Fourth Edition; 2011, 155-160

[14] O'Neill, P**.** Environmental Chemistry, Second edition, (Chapman & Hall 1993).

[15] J.C. Akan , V.O. Ogugbuaja , F.I. Abdulrahman and J.T. Ayodele ,. Determination of Pollutant Levels in Water of River Challawa and in Tap Water from Kano Industrial Area, Kano State, Nigeria. Research Journal of Environmental Sciences, 1: 2007,211-219.

[16] Orewole, M.O., Makinde, W.O., Adekalu, K.O., Shittu, K.A**.** Chemical Examination of Piped Water Supply in Ile- Ife in South Nigeia, Iran. J .Environ. Health. Sci. Eng., 4(1) 2007, 51-56.

[17] Standard Organization of Nigeria .Nigerian Industrial Standard: Nigerian Standard for Drinking Water Quality, NIS 554: 2007