ASSESSMENT OF THE QUALITY OF MUNICIPAL WATER IN SOKOTO STATE

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ABSTRACT

Sokoto water board is the organization responsible for the supply of portable safe water for domestic uses for the inhabitants of Sokoto metropolis. There is a need for monitoring the supplied water from the inlet and exit to ascertain that the residents are getting safe water for domestic uses. This project is concerned with the assessment of the quality of the raw water supply to the water board, treated water coming from the storage tank to the consumers and the water at the customers' points in the metropolis. Samples of water were collected from 10 selected areas in each of Sokoto North, Sokoto South and Wamakko local governments, and one from the intake raw water and the exit treated water from water board for laboratory analyses. The results of the analyses showed that the hardness of the raw water was 50, while that of the treated water is 1, but the hardness of the water collected from various areas of the three local governments were higher than the treated water collected from the water board, some are even higher than that of raw water. And the same thing is the sulphur contents, color, odor and taste, this indicates that the water gets contaminated before reaching the end users. The water board needs to pay serious attention to some of their old facilities that are used for water distribution so as to improve the quality of water supplied.

Keywords: Hardness, Treatment, Water, Distribution, Sokoto, Metropolis

INTRODUCTION

Water (H_2O) is a transparent fluid that makes up the streams, lakes, oceans, rain, snow, fog, dew, and the cloud of the world and majority of the fluids of organisms is made of water. Water is a chemical compound that contains two atoms of hydrogen and one atom of oxygen that are connected by covalent bonds. Water is a liquid at room temperature and standard atmospheric pressure, but it often co-exists in the solid state, (ice); and gaseous state, (water vapor). (Crocket, 2015).

Safe drinking water is essential to humans and other life forms, although no calories or organic nutrients are provided by it. Access to safe drinking water has improved over the last decades in almost every part of the world, but approximately over one billion people still lack access to clean water (Kuppers et al., 2014). There is a remark relationship between access to safe water and gross domestic product per capita (Iess et al., 2014). However, it has been estimated that by 2025 more than half of the world population will be facing water-based vulnerability (Dubnov-Raz, Constantini, Yariv, Nice and Shapira, 2011). Another report, issued in November 2009, suggests that by 2030, water demand will exceed supply by 50% in some part of the world (Dennis et al., 2010). Water functions as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation. (Dubnov-Raz et al., 2011 and Gleick & Palaniappan, 2010).

Sources of water

The following are some common sources of water (Mekonnen and Hoekstra, 2010):

1. **Groundwater:** Soil and rock layers naturally filter the ground water, that might have to fall as rain sometimes ago, to a high degree of clarity, which does not require additional treatment besides adding chlorine or chloramines as secondary disinfectants. Underground water may emerge as springs, artesian springs, or may be extracted from boreholes or wells. Depending on the strata through which the water has flowed, some mineral elements may be present including chloride, and bicarbonate. There may be a requirement to reduce the iron and manganese content of this water to make it acceptable for drinking, cooking, and laundry use. Primary disinfection may also be required.
2. **Upland lakes and reservoirs:** Lakes generally located in the headwaters of river systems, upland reservoirs are usually sited above any human habitation and may be surrounded by a protective zone to restrict the opportunities for contamination. Bacteria and pathogen levels are typically low, but some bacteria, protozoa or algae will be present. Where uplands are forested or peaty, humic acid can color the water, which makes the pH very low, as such, require adjustment.
3. **Rivers, canals and low land reservoirs:** These are low land water bodies, which are often considered contain high bacteria, algae, suspended solids and a variety of matters dissolved in them. They required treatment before they can be safe for drinking.
4. **Atmospheric water.** These comprise of water vapors, clouds, dew, fog, snow, which after proper condensation falls back as water for human uses. Atmospheric
5. **Rainwater.** This is water from the atmosphere that falls to the earth surface.
6. **Desalination.** Seawater can be treated for uses by distillation or reverse osmosis.
7. **Surface Water:** Freshwater bodies that are open to the atmosphere are called surface water, such as streams, rivers, springs, ponds, and lakes. Underground water can give rise to surface water.

WATER TREATMENT

Water treatment is a procedure that is used to remove existing water contaminants or reduce their concentration so that the water becomes fit for its desired end-use, which include drinking, washing, bathing, industrial uses, medicinal uses and various others. Waste water can be treated, and it will be made safe for man uses (Mekonnen and Hoekstra, 2010).

The processes below are the ones commonly used in water purification plants. Some or most may not be used depending on the scale of the plant and quality of the raw (source) water.

Pre-treatment

1. **Pumping and containment:** - Water is pumped from its source or directed into pipes or holding tanks for future treatment. To avoid contamination of water, appropriate infrastructures must be made from suitable materials and constructed so that accidental contamination does not occur (Osegovic *et al.*, 2009).

2. **Screening: -** This is the first step in purifying surface water. It is done to remove large debris such as sticks, leaves, rubbish and other large particles, which may interfere with subsequent purification steps. (Cicek, 2013).
3. **Storage: -** Water from rivers, streams, and other sources can be collected and stored in Bankside reservoirs for periods between a few days and many months to allow natural biological purification to take place if treatment is by slow sand filters. Storage reservoirs water supply to be maintained during drought and transitory pollution incidents in the source river (Cicek, 2013).
4. **Pre-chlorination: -** Chlorination of incoming water is done to minimize the growth of some harmful organisms on the pipework and tanks. This has been stopped because of the potential adverse quality effects (Cicek, 2013).

A combination selected from the following processes is used for municipal drinking water treatment worldwide (Mekonnen and Hoekstra, 2010).

- Pre-chlorination to control algae and stop organic growth.
- Removal of dissolved iron and manganese through aeration together with pre-chlorination.
- Flocculation coagulation.
- Improvement coagulation and for thicker flocculation formation by the use of coagulant aids, known as polyelectrolytes.
- Removal of suspended solids trapped in the flocculation by sedimentation process.
- Remove particles from water through filtration.
- Removal of salt from the water desalination processes.
- Killing of bacteria by Disinfections.

pH Adjustment

Pure water has a neutral pH close to 7 (neither alkaline nor acidic). Sea water can have pH values that range from 7.5 to 8.4 (moderately alkaline). Fresh water can have widely varying pH values depending on the geology of the drainage basin or aquifer and the influence of contaminant inputs (acid rain). If the water is acidic (pH lower than 7), the pH can be raised by adding essential chemicals like lime, soda ash, sodium hydroxide. Stripping dissolved carbon dioxide from the water (forced draft degasification) can be an effective way to raise the pH for highly acidic waters (Mekonnen and Hoekstra, 2010).

Coagulation and Flocculation

One of the first steps to assist in the removal of suspended particles in water in a conventional water purification process is the addition of chemicals, which contribute in water turbidity and color. (Muckelbauer et al., 2013).

Sedimentation

Sedimentation basin (clarifier or settling basin) is a large tank with low water velocities, allowing flocculation to settle to the bottom. It is where water enters into as its exits the flocculation basin.

The sedimentation basin is best located close to the flocculation basin, so the transit between the two processes does not permit settlement or flocculation break up. Sedimentation basin outflow is usually over a weir so that only a thin top layer of water far away from sludge flows out (Mekonnen and Hoekstra, 2010).

Sludge Storage and Removal

A layer of sludge is formed on the floor as particles settle to the bottom of a sedimentation basin. The amount of sludge generated is often 3 to 5 percent of the total volume of water to be treated. This call for the removal from time to time. The sedimentation basin may be equipped with mechanical cleaning devices that continually clean its bottom, or the basin can be periodically taken out of service and cleaned manually. This adds to the operating cost of a water treatment plant (Cicek, 2013).

Flocculation Blanket Clarifiers

Particulates are removed by trapping them in a layer of suspended flocculation as the water is forced upward in a sub category of sedimentation. The main merit of flocculation blanket clarifiers is that they occupy little space than conventional sedimentation. The setback is that efficiency of particles removal can vary owing to changes in influent water quality and flow rate (Mekonnen and Hoekstra, 2010).

Dissolved Air Flotation

Dissolved air flotation (DAF) is often used for water supplies that are particularly vulnerable to unicellular algae blooms and supplies with low turbidity and high color that do not settle out easily. Water flows to DAF tanks, after coagulation and flocculation processes. Air diffusers on the tank bottom create fine bubbles that attach to flocculation resulting in a floating mass of strong flocculation. They are removed from the surface, and clarified water is withdrawn from the bottom of the DAF tank (Muckelbauer et al., 2013).

Filtration

After separating most floc, the water is filtered as the final step to remove remaining suspended particles and unsettled floc (Muckelbauer *et al.*, 2013).

Rapid Sand Filters

Rapid sand filters are the most common type of filter with larger space between them than the suspended particles. This property is to prevent clogging of the filter quickly. Most particles pass through surface layers but are trapped in pore spaces or adhere to sand particles. Sand often has a layer of activated carbon or anthracite coal above it, which water moves through vertically. The top layer removes organic compounds, which contribute to taste and odor (Mekonnen and Hoekstra, 2010).

PROBLEM OF THE RESEARCH

The quality of water for the domestic and industrial application cannot be over emphasized. The quality of water supply by Sokoto State Water Board is not encouraging. It is usually colored, taste, and hard when used for washing. This is the motivated this research to find out the causes of the poor quality of the water distributed by water board to recommend possible solutions.

AIM AND OBJECTIVES

The aim of the research is to assess the quality of water supply by water to Sokoto Metropolis
The objectives of the research are:

i. To analyze water collected from ten selected areas from each of the three local governments that surround the metropolis
ii. To analyze the clarity of the water collected
iii. To analyze the taste of the water collected.
iv. To find out the pH values of each of the water collected.
v. To find out the hardness of the water collected.
vi. To find out the iron contents of each water collected
vii. To find out the sulphur contents of the water collected

SIGNIFICANCE OF THE RESEARCH

The importance of water quality to human life can never be over emphasized. Save drinking water contributes a lot to the wellbeing of man. On contrary impure or dirty water can cause several complications to man, such as cholera, dysentery, typhoid fever, etc. This research will help in improving the quality of water supply to Sokoto metropolis for the purpose of combating the menace of epidemic disease arising from the unclean water supply by the water board.

SCOPE AND LIMITATION

The Three local governments that surround Sokoto Metropolis – Sokoto North, Sokoto South, and Wamakko – were selected and demarcated into ten areas each and water were collected from each area randomly to represent other areas not included. This is to reduce the limit the number of water to be collected and reduce the cost and labor of the research

RESEARCH METHODOLOGY

Samples of water were collected from the various areas as shown in table 1 below.

Table 1: Samples of Water Collected from the various areas for Test

S/No	Area	Sample of water collected
1	Raw Water from Water Board	1
2	Outlet Treated water from Water Board	1
3	Sokoto North Local Government	10
4	Sokoto South Local Government	10
5	Wamakko Local Government	10
	TOTAL	**32**

The samples of water were sent to the lab for test on the following areas: pH, tested using pH electrode; Turbidity, tested using turbidimeter; Temperature, tested using thermometer; Hardness, tested using titration with EDTA; Iron contents, tested using o-phenanthroline and atomic absorption spectrometer; Sulphur contents, tested using ion chromatography; Odour, tested using personal assessment and Taste, tested using personal assessment.

RESULTS AND DISCUSSION

Below are the results of the analyses carried out in the water collected from the water board, raw and treated water and those from the selected areas of the three local governments of the metropolis.

Results of the Analysis of Water Collected from Water board

The analyses of the samples of water collected from the raw and treated waters from the water board is as shown below:

Table 2: Analyses of Raw and Treated Water Collected from the Water Board

SN	Area Water Collected	pH	Turbidity (NTU)	Temp. (ºC)	Hardness (mg)	Colour	Odor	Taste	Iron (mg)	Sulphur (mg)
1	Raw Water	6.9	15	29	50	Muddy	Foul	Abject	0.02	80
2	Treated Water	6.8	1	29	8	Clear	Odour less	Tasteless	0.01	1

From table 2 above, it can be observed that the raw water feed to the reservoir of the water board has a pH value of 6.9, a turbidity of 15 NTU, hardness of 50mg/l, muddy in colour, a foul taste, abject taste, 0.02mg/l iron content and 80 mg/l sulphur content. After treated the pH value became 6.8, turbidity reduced to 1NTU, hardness reduced to 8mg/l, the water became clear, odorless and tasteless, with iron content reduced to 0.01mg/l and sulphur content to 1mg/l.

According to WHO (2004), the treatment was up to standard, and it is safe for domestic use.The above results show that the raw water itself has a pH of the approved range 6.5 to 8.5, the turbidity was far above the standard of 5 – 1 NUT (WHO, 2004), hardness was within the recommended value of 50 mg/l for soft water (WHO, 2004), iron contents was below the range of the standard of 0.05 – 0.3mg/l and sulphur contents were above the recommended value (WHO, 2004 and Brikke, 2000).

After the treatment, the pH was still within the acceptable standard of 6.8; the turbidity was brought to 1NUT which is WHO standard of domestic water, the hardness was as well brought very low (8mg/l), even though the raw water was within the acceptable hardness. Iron contents were reduced to 0.01 and sulphur contents from 80mg/l to 1mg/l, which was a good result.

Results of the Analysis of Water Collected from Various Areas in Sokoto North

The results of the analysis of the water collected from the various areas in Sokoto north local government are as displayed in table 3 below. From the table, it can be observed that there is

fluctuation in the values of pH of the various water collected from different areas of the local government. Turbidity and hardness also follow the same trend as in the case of pH, even though all the three are within the WHO acceptable standard. But the required results is to have almost the same quality of water with the treated water fed from the water board.
The graphical displacement of the information is shown in figure 1 below.

Table 3: Analyses of Waters Collected from Different Areas of Sokoto North Local Government

SN	Area Water Collected	pH	Turbidity (NTU)	Temp. (°C)	Hardness (mg)	Colour	Odour	Taste	Iron (mg)	Sulphur (mg)
1	Marnawa	6.8	2	30	5	Fair	Little	Inoff	0.1	8
2	Maniru Road	6.5	5	30	8	Fair	Little	Inof	0.2	2
3	Alkammawa	6.4	4	30	20	Coloured	Little	Inoff	0	1
4	Gidadawa	7.1	3	30	10	Coloured	Little	Inoff	0	5
5	Bazza Area	7.2	2	30	30	Muddy	Little	Inoff	0.1	0
6	Kofar Rini	7.8	1	30	55	Muddy	Little	Inoff	0.3	0
7	Kofar Marke	8.1	1	30	60	Muddy	Little	Inoff	0	2
8	Kofar Taramniya	6.9	1	30	5	Fair	Little	No	0.3	6
9	Takardawa	5.9	5	30	1	Fair	Little	No	0	8
10	Kofar Bai	7.6	0	30	2	Fair	Little	Little	0	2

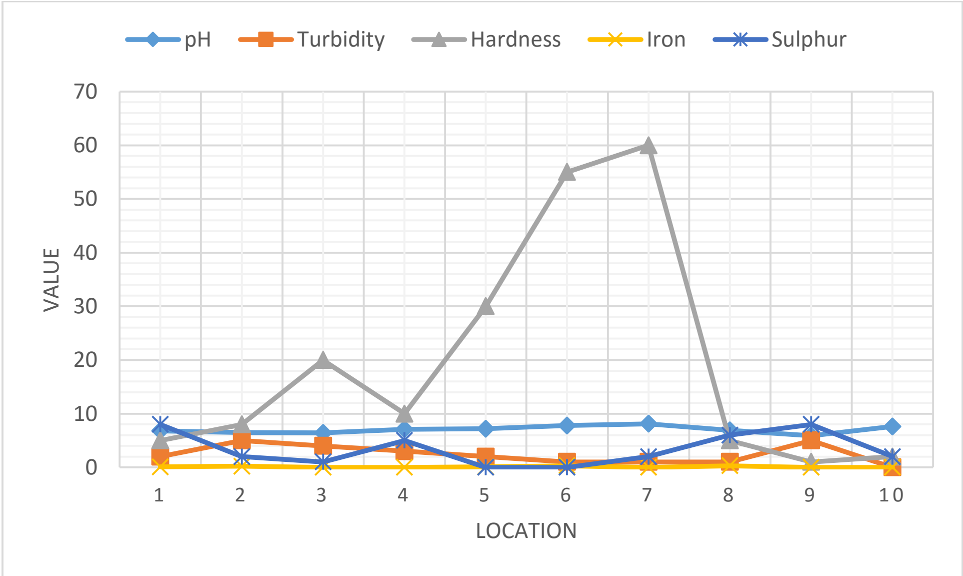

Fig. 1: Variation of various Properties Measured from the Water Collected from different Locations of Sokoto North Local Government

It can be observed from the figure above that the quantities measured fluctuated from station 1 to 10. With stations 6 and 7 having the higher hardness of 55 and 60 respectively. This could be as a result of rusting pipes or infiltration on pollutants into the pipes through leaked points. In the case of Turbidity, pH, Iron contents and sulphur contents, the variation is not so clear, most especially in the case of the pH, which is very close to each other.

Results of the Analysis of Water Collected from various Areas in Sokoto South

Below is the data obtained from the analysis of the water collected from the various locations in Sokoto south local government. The graphical representation of the information is shown in figure 2 below. From the table it can be observed that the pH, Turbidity, and Hardness values are within the acceptable range of safe drinking water. Only sulphur contents are unacceptable in some places.

Table 4: Analyses of Waters Collected from Different Areas of Sokoto South Local Government

SN	Area Water Collected	pH	Turbidity (NTU)	Temp. (ºC)	Hardness (mg)	Colour	Odour	Taste	Iron (mg)	Sulphur (mg)
1	Mabera	6.9	1	30	50	Clear	Little	Inoff	0.1	10
2	Nakasari	7.1	1.5	30	20	Clear	No	No	0.05	6
3	M/Jelani	7.3	2	30	30	Coloured	No	No	0.2	8
4	Kofar Atiku	7.5	2.5	30	15	Coloured	No	No	0	12
5	Gabi area	7.6	3	30	25	Coloured	No	No	0	20
6	Majema U/Rogo	7.9	3	30	10	Coloured	Little	Inoff	0	5
7	R/Dorowa	7.0	1	30	5	Clear	Little	Inoff	0.4	2
8	Kwane road	7.1	4	30	6	Clear	No	Inoff	0	5
9	Marna area	6.8	5	30	8	Clear	Little	Inoff	0	6
10	Tudun wada	6.9	4	30	5	Clear	No	Inoff	0	8

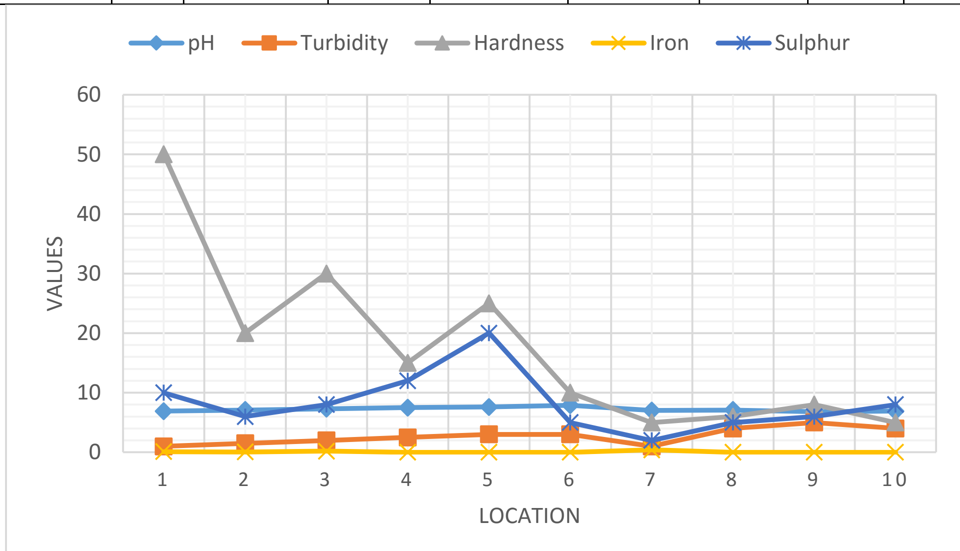

Fig. 2: Variation of various Properties Measured from the Water Collected from different Locations of Sokoto South Local Government

From the graph in figure 2 above, it can be observed that there is wide variation in the hardness; specifically, that of station 1, has the highest and station 10 has the least. So also is the sulphur contents, in which station 5 has the highest value, and station 7 has the least. The pH, Turbidity and Iron contents are of the similar version from station 1 to 10, though there are some disparities, they are negligible. Which shows that there is addition along the way as the water flows from the water board to the various stations, such as dirt in the pipes, wearing of the pipes, and infiltration of pollutants into the pipes at leaked points.

Results of the Analysis of Water Collected from various Areas in Wamakko

The results of the test conducted on the waters collected from different stations in Wamakko local government are as shown below. One can observe the various quantities varied from station to station, indicating that there have been additions of some particular foreign product, which contaminate the water before it gets to the various locations.

Table 5: Analyses of Waters Collected from Different Areas of Wamakko Local Government

SN	Area Water Collected	pH	Turbidity (NTU)	Temp. (ºC)	Hardness (mg)	Colour	Odour	Taste	Iron (mg)	Sulphur (mg)
1	Arkilla SLC	6.2	3	30	50	Clear	No	Inoff	0.1	25
2	G/Salenke	7.1	5	30	65	Sky blue	No	Inoff	0.1	30
3	Five-star area	7.0	6	30	90	Cleare	Little	Abj	0.2	20
4	G/man Ada	8.1	4.5	30	60	Coloured	Little	Inoff	0.2	5
5	Gawon Nama	7.5	7.1	30	86	Clear	Little	Abj	0.3	3
6	UDUTHS	8.3	3	30	70	In obj.	No	Abj	0.5	2
7	Dingyadi Road	7.5	2	30	50	In obj.	No	Inoff	0	5
8	Gidan Yashi	6.8	5	30	60	In obj.	No	Inoff	0	8
9	Fada area	7.2	6	30	55	In obj.	Little	Inoff	0.2	10
10	Guiwa area	7.0	4	30	65	Clear	Little	Abj	0.3	6

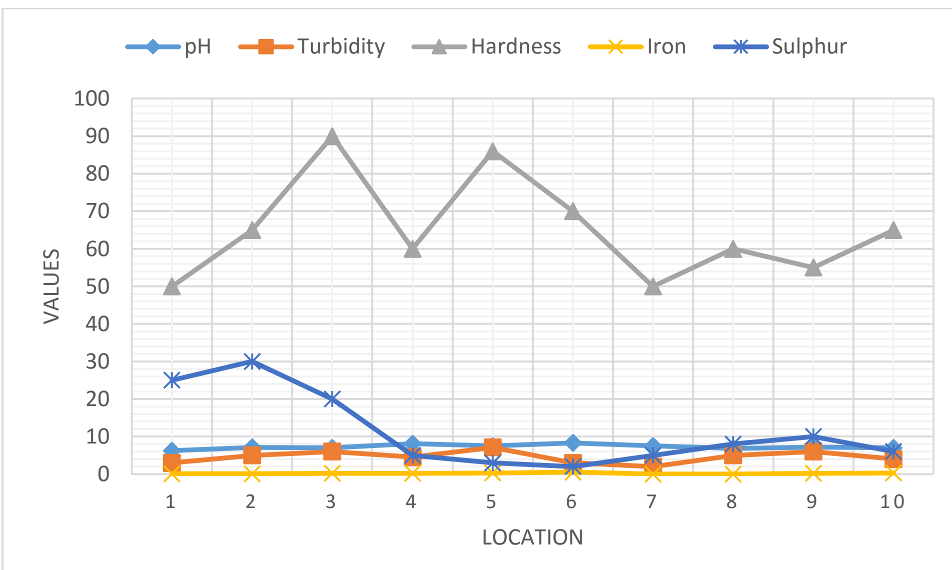

Fig. 3: Variation of various Properties Measured from the Water Collected from different Locations of Wamakko Local Government

It can be observed from the figure 3 above that the hardness of the waters collected from various differs widely from one place to another, with location 3 having the highest hardness value and five followed closely. Similarly, sulphur contents of the waters change as well. The highest value is from location 1 and closely followed by station 2, and station 4 was the least. The pH, Turbidity and Iron contents do not differ much as the other two parameters above (i.e., Hardness and Sulphur contents).

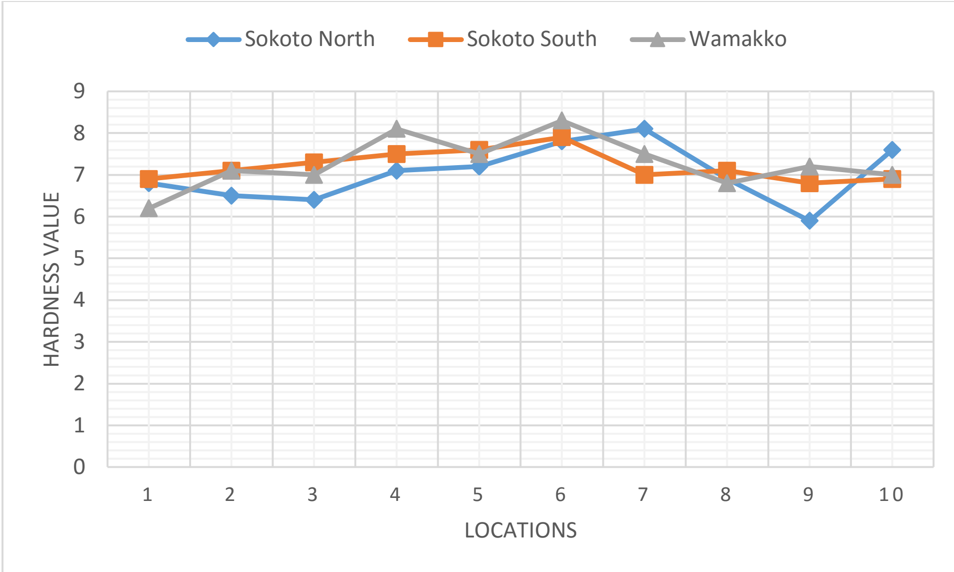

Fig. 4: pH Values of Waters Collected from Different Locations in the Three Local Government Compared.

From figure 4 above, it can be observed that there is no remarked difference in pH, from the waters collected from a different station in the three local government. Although some of the pH values are more than those of the raw water and treated water of 6.9 and 6.8 respectively.

Figure 5 below shows the hardness values of the many waters collected from the various stations in the three local governments. It can be observed that Wamakko local government stations' waters have a higher hardness than those from Sokoto North and South. The least for Wamakko being from station 7, which lower than that of Sokoto North station seven only. Sokoto North waters have the least hardness from stations 1 to 4, while from stations 5 to 7 Sokoto South has the least hardness. Sokoto north and south waters have an equal hardness in stations 8, while Sokoto North waters have the least hardness in stations 9 and 10.

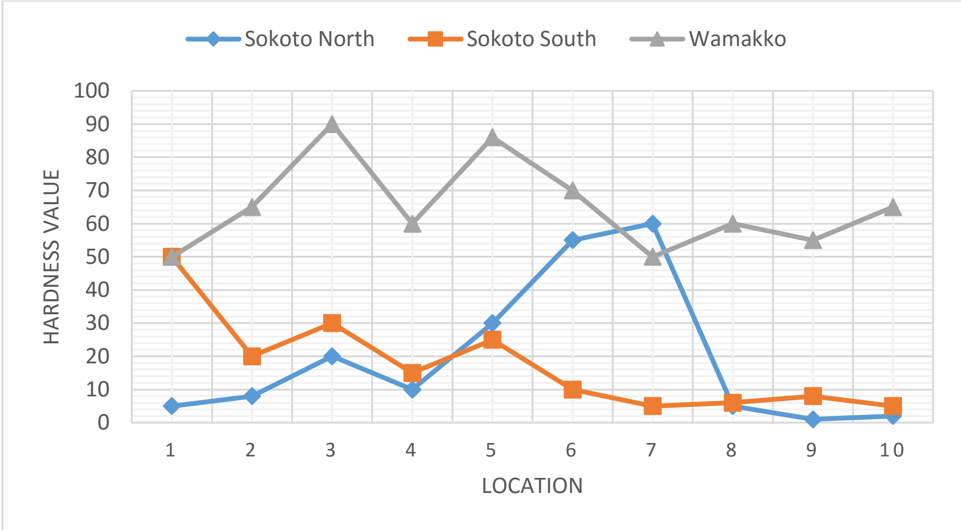

Fig.5: Hardness Values of the Waters Collected from Different Locations of the Three Local Governments.

The disparities in the values of the hardness indicate that foreign matters have been entering into the water as it leaves water board to the various stations. Because the treated water has a hardness value of 8, which was obtained after treated raw water with a hardness value of 50, the various values obtained from the different stations of the three local governments show infiltrations or inclusions of foreign matters into the water in the pipes.

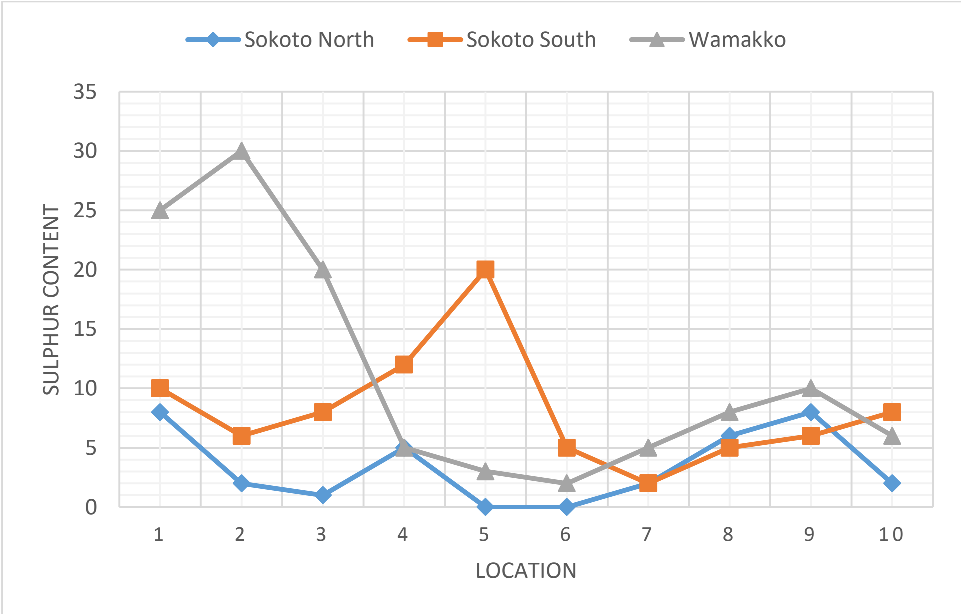

Fig. 5: Sulphur Contents of the Waters Collected from Different Locations of the Three Local Governments.

From figure 5 above, it can be observed that the sulphur contents from the waters from the various **stations** differ across the three local government. From stations 1 to 10, it shows that

Wamakko has the highest for stations 1 to 3, while Sokoto North has the least for the three stations. At station 4 Sokoto South has the highest, while Sokoto North and Wamakko have the least. Sokoto South have the highest at stations 5 and 6, while Sokoto north has the least in the two stations. While Wamakko has the highest in stations 7, 8 and nine as Sokoto south is highest in station 10. Sokoto north and south are least in station 7, Sokoto south is least in stations 8 and 9, and Sokoto north is the least in station 10.

It is observed that there are a lot to do to meet up with provision of portable water by Sokoto state water board. Most of the water supplied to the various homes are not save for domestic applications because of contamination either due to dirt in the pipes or infiltration of pollutants at leaked points of the pipes.

The treated water from leaving water board to the various points of consumptions was in accordance with WHO standard for safe water for domestic use (WHO, 2004). But the point of concern is changes observed at the various points that the waters were collected for testing.

CONCLUSION

After analyzing the results the Laboratory tests, the following conclusion was reached at:

- The quality of water needs to be improved upon to meet the standard of safe water for domestic application, and even industrial use.
- There were dissolved iron contents into the water as it leaves water board to the end consumers
- There are very many variations in the hardness of the waters collected from the various stations of the three local governments, which shows that there are additions of chemical like $CaCO_3$ along the way
- The colors of the waters shows contamination with muddy materials as well as dirt in the pipes carrying the waters
- The taste of the water indicates the contamination of the water along way before reaching the final consumer
- Some acidic contaminants have been contaminating the waters as they being conveyed from the water board to the various stations
- The pipes that supply water to various areas are too old as such need replacement or proper care need to be taken to reduce the introduction of foreign materials into the water.

RECOMMENDATIONS

- The existing pipelines conveying waters from water board to various parts of the metropolis should be examined and clear of dirt.
- Those pipes that are not cleanable should be changed with new ones to prevent contamination of waters.
- Iron pipes should be properly galvanized to avoid iron inclusions into the water due to surface erosion.

- Additional and more advanced laboratory facilities should be provided to help get better analyses of water in order to meet up with world standard.

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