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A COMPARATIVE ANALYSIS OF PHYSICAL AND CHEMICAL QUALITY OF SURFACE WATER AND RAINWATER IN LAU METROPOLIS, TARABA STATE, NIGERIA

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Abstract: Drinking water quality is an essential measure of quality of life. This study examined a comparative analysis of the physical and chemical quality of surface and rainwater in Lau Metropolis, Taraba state, by identifying factors responsible for physical and chemical qualities and suggesting a better water body source for domestic use and health well-being.

The study was carried out in September 2022, using a purposive sampling technique. Statistical data analysis of Pearson correlation and Chi-square test of mean values were used. The parameters analyzed were pH, Temperature, Electrical conductivity, Turbidity, Colour, and Total Alkalinity. Total Hardness, TDS, Cd, Fe, Zn, Cu and Pb. Laboratory test methods used were ASTM and APHA. The result showed that Harvested Rainwater met specification in all tested parameters except Fe with a concentration of 0.625mg/l as against NSDWQ and WHO's specification of 0.30mg/l. However, Surface water did not meet NSDWQ and WHO specifications in Turbidity, Colour, Fe, and Cd with values of 32.7NTU, 15.17TCU, 0.814mg/l, and 0.013mg/l respectively. The maximum permissible limit by NSDWQ and WHO for Turbidity, Colour, and Cd are 5.0NTU, 15.0TCU, and 0.003mg/l respectively. High Fe content in both water samples could be attributed to contact with dissolved gases from biomass burning, transportation sources, and crustal materials. Land use activities, erosive ability of soil, and stormwater runoff could be responsible for surface water pollution. This study recommends that HRW should be used due to its quality. However, Fe content in HRW can removed domestically by Fe removal filters, it requires less effort and resources. Surface water treatment is expensive.

Keywords: Atmosphere, Properties, Quality, Storm

1.1 Introduction

As one of the most valuable resources to man and living organisms, water is essential for the sustenance of life on earth and this is exemplified by its diversified uses such as washing, irrigation, cooking, and drinking. Thus, water is life and its quality is an essential measure of the quality of life (Oboh and Agbala, 2017). The freshwater resources of Nigeria constitute about 12.4% of its total surface area (Dimowo, 2013). Poor water quality usually becomes a major constraint on development, if not adequately considered within a given development program. This is because water resource conditions are complementary to many development inputs. But domestic use, agricultural production, industrial activities and other factors can alter the chemical and physical characteristics of water in ways that can threaten ecosystem integrity and human health.

Rivers provide life-saving services worldwide with diverse categories of flora and fauna (Gupta, Pandey and Hussain 2009). The quality of any water system reflects the inter-play of biotic and abiotic conditions existing in such environments (Ali and Khairy, 2012). Rivers and lakes provide most of earths' freshwater resources and enormous benefits in both domestic and irrigational activities of man (Dirican, 2015). The foreign particles (pollutants) accumulate to contaminate the sources of water rendering it unhealthy for use and consumption. Pollutants are particles either in liquid or solid form that changes the quality of water (Akpan and Ajayi, 2016). Rainwater, overland flow, soil water, and groundwater mix together in river channel to become stream flow. The magnitude of the contribution from each of these pathways will determine the stream flow chemistry. Various studies have shown that all kinds of water have their own chemistry, which can be changed as water moves from one storage area to another (Allan, Moss, Le-Roax, Phoenix and Sonke, 2020; Xenopolous, Barnes, Boodoo and Butman, 2021). Therefore, the water chemistry at the ultimate recipient source area will be a comprehensive reflection of the chemistry of the different constituent water and their flow pathways (Sterte, Lidman, Balbarini, Lindborg and Laudon, 2021).

Pollution of river is a global problem. In India for instance, Ojutiku, Habibi, Kolo and Oyero, (2016) reported that about 70% of the available water is polluted. Water pollution is a major global problem and as industrialization spread across the globe, so is the challenge associated with it. Fertilizers and pesticides are major contributors to water pollution, Nitrates from fertilizers are a common chemical pollutant of water. Heavy metals, sulphates, nitrates, chlorides, phosphates, carbonates, ammonia, pesticides, phenols, soaps, detergents are the common chemical pollutants. Nowadays, many regions face problems of scarcity and low quality of surface water. In order to find solution to the problem, an alternative that has been increasingly practiced is rainwater harvesting (Stahn and Tomini, 2017). However, risks from these hazards can be minimized by good design and practice of Rainwater Harvesting methods (Khalid, Abbas and Sahid, 2015). The chemical composition of rainwater is highly dependent on the concentration of air pollutants and particulate matter from the atmosphere; being an indicator of the air quality and helping to understand the relative contribution of different sources of atmospheric pollutants in the atmosphere. In this premise, a comparative study of surface and rainwater quality will enhance better understanding of water quality for consumption in Lau metropolis.

Statement of the Problem

One of the most recent problems in developing countries like Nigeria is the shortage of clean water, particularly in rural communities that rely on rivers as their main source of domestic water supply. In most cases, people depend on alternative means of supply such as rainwater harvesting, collection from rivers, streams, and any available water body, channeling runoff to ponds and other storage facilities, and purchasing from water vendors. Considering the roles that surface and rainwater play in the Lau area and the increasing human activities, the need for constant monitoring and assessment of the quality of such water sources becomes highly imperative. In most cases, the river Benue which passes through Lau, is far away from some inhabitants, and rainwater on the other hand is seasonal, while the cost of constructing water storage facilities throughout the dry season is a challenge in the study area.

This study, therefore, offers a measure of hope for identifying and management of water resources. Water pollution has continued to generate unpleasant implications for health and economic development in Nigeria and the developing World in general, the consequences of which include 4.6 million deaths from diarrhea and a sizeable number of casualties from ascariasis. As the river runs through its course, the water quality is greatly affected by land use and other human activities in the area. Considering the roles that river Lau and rainwater play in the water supply to the inhabitants of their immediate environments, the increasing human activities around them and poor conditions of both surface and rainwater in Lau metropolis necessitated the need for comparative analysis to determine better water sources in the area. This gives room for the provision of alternatives. Reversing the damage done to any water body is usually complicated and expensive.

Aim and Objectives

The main objective of this study is to examine the Comparative Analysis of the Physical and Chemical Quality of Surface Water and Rainwater in Lau Metropolis, Taraba State, Nigeria. The specific objectives are to;

- To identify the physical and chemical qualities of surface and rainwater in the study area
- To determine factors responsible for physical and chemical qualities of surface and rainwater in the study area; and
- To suggest a better water body source for domestic use, economic and health wellbeing.

2. Review of Related Literature

Harvested rainwater is physically, chemically, and microbiologically polluted, (Zdeb, M, Justyna Z and Dorota, 2016). WHO (2015) reported that in Africa, water scarcity is a threat to sustainable development and it has been estimated that by 2030, 75 to 250 million people will be living in water stressed areas. In Nigeria, where over 65 million people lack access to clean water and sanitation, with that number skyrocketing to 90 million in 2015. Regarding the quantitative question of rainwater, Oboh, and Agbala, (2017), found out that, rainwater has several advantages about some of its physical and chemical parameters when compared to surface water because of its less turbidity. The report also showed that meteorological factors, characteristics of the particles, and characteristics of the roof, such as its geometry, its material and its cleanliness, can make the quality of rainwater runoff vary spatially. Thus, water is life and its quality is an essential measure of the quality of life. According to Bruce, Thulane and Gwebu, (2017), rooftop rainwater harvesting is the interception of rainwater from rooftop catchments and storing it in surface or subsurface reservoirs. Rainfall is pure and clean when it is released from the clouds, but it is polluted upon reaching the atmosphere and the intercepting surface.

Population growth and the expansion of urban and industrialized areas have put great pressure on water resources (Luizzo, *et al*, 2016). On urbanization and land use, Nuiss and Siedentop (2021), opined that many environmental difficulties that countries are undergoing are resulting from the growing rapidity of change in land use; and one of the critical facts about land use changes is that the effects may be long-lasting and sometimes unalterable. The report concluded that some changes are a result of natural processes, but human activities are accountable for many of the environmental challenges we are currently facing.

Abubakar and Ajadike (2023), reported that higher concentrations of rainwater chemical constituents could be due to atmospheric accumulation of pollutants, gases, and particulate matter with increasing urbanization. This could have contributed to environmental pollution and thereby affecting the quality of rainwater which could also pose risks to people's health who depend on this source of water supply. The study concludes that location is a determinant of variability in rainwater properties.

Similarly, in the rural environment where industrial activities are low, the production of gases such as carbon monoxide, hydrogen sulphide, and hydrocarbons barely affects the quality of rainwater. Wind-blown dirt, leaves, fecal droppings from birds and other animals, insects, and contaminated litter in the catchment areas due to the influence of urbanization can be a source of contamination of rainwater (Emmanuel, 2018).

Based on using rivers by some communities in Nigeria, Victor, Emmanuel, Usman, George, and Obinna, (2022) observed that, in Igah communities in Kogi state, delivery of pipe-borne water was not readily available to satisfy the water supply needs of the people. Besides, River Maboro, the major river in Olamaboro, and other smaller streams within the Igah communities are far away from the inhabitants. Therefore, many households resort to rainwater as their alternative source for their water needs. Rivers are among the most degraded ecosystems on earth (Best, 2019). Water quality is impaired due to human activities such as urbanization and agriculture and currently, only 23% of the earth's largest rivers flow uninterrupted to the ocean (Grill *et al.*, 2019).

One of the most recent problems in developing countries like Nigeria is the shortage of clean water, particularly in rural communities that rely on rivers as their main source of domestic water supply. The deteriorating quality of water threatens sustainable living in these communities and it is, therefore, a reason for worry (Omoigberale *et al*., 2013).

Edegbene *et al.*, (2012) reported that rivers are fast deteriorating which could be attributed to anthropogenic activities. Water quality assessment generally involves analysis of physical chemical, biological, and microbiological parameters and reflects on the abiotic and biotic status of the ecosystem. Fertilizers and pesticides are major contributors to water pollution, Nitrates from fertilizers are a common chemical pollutant of surface water. Heavy metals, Sulphates, Nitrates, Chlorides, Phosphates, Carbonates, Ammonia, Pesticides, Phenols, Soaps, and detergents are the common chemical pollutants of surface water (Ojitiku, Habibu, Kolo, and Oyero, 2016).

3. Methodology

Study Area

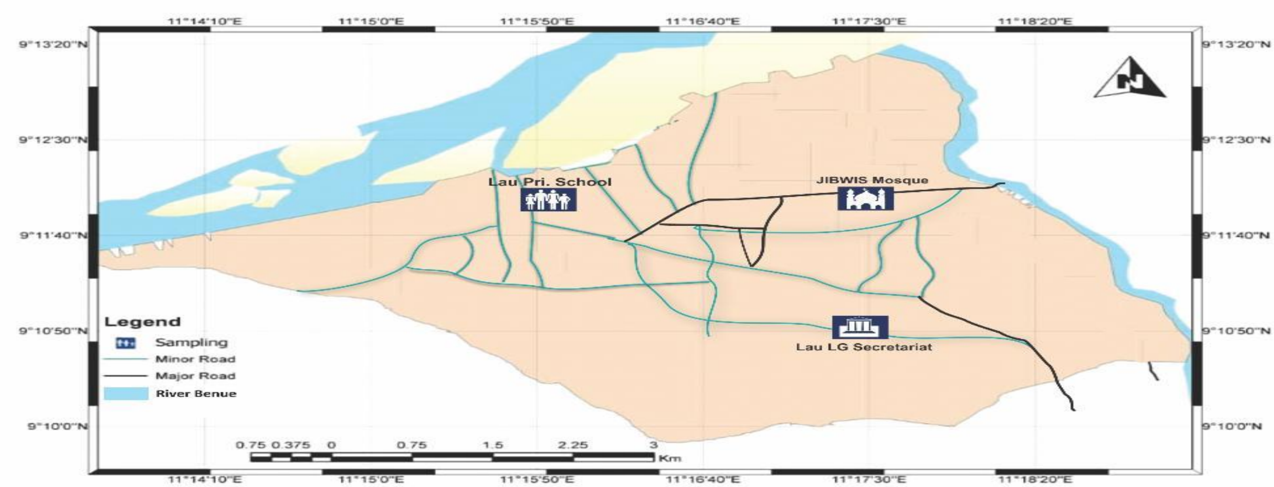

Fig. 1: Lau Metropolis Map, Showing the sample points
Source: Ministry of Land and Survey, Jalingo

Figure 1: Lau Metropolis Map, showing the sample Points

The study area lies between Latitudes 9^{0}13" and 9^{0}11"N of the equator and longitudes 11^{0}18" and 11^{0}14"E of Greenwich meridian (from fig. 1). It is bordered to the East by Zing Local Government area (LGA), to the West by Karim Lamido LGA, to the North by Numan in Adamawa state and to the South by Jalingo and Yorro LGAs of Taraba state as shown in the figure 1. The study area has estimated population of 96,590 individuals (NPC, 2006), it is dominated by the Mumuye, Hausas, Fulani's and yangdang. who are predominantly farmers and fishermen.

Lau is located along the Western River banks of the Benue River and it is the Local Government Headquarters of Lau. River Benue is a major tributary of the Niger River, it's about 1,400km long. Its source is from the Adamawa Plateau, Cameroun, flowing West through Garoua and Lagdo Reservoir into Nigeria, passing through

Jimeta to Numan, Lau, Mayo Ranewo, Ibi and Makurdi before eventually meeting the River Niger at Lokoja, Kogi State, providing enormous opportunity for farming, fishing and other domestic activities (Barau, *et al*, 2020). By this, river Benue forms the major source of water in the study area. The climate is one which alternate between wet and dry season, mean average rainfall of 1020mm and maximum temperature of about 42°C. Fishing, farming, and marketing are the major occupation of the people in the area. The town has large markets for fish. People come from far and wide to buy fish in large quantities (Usmani *et al*, 2017). The inhabitants also plant food crops such as, yam, rice, millet, maize and beans.

Sample collection and Analysis

Prior to sampling, sample containers were soaked with 10% HNO_3 for 24hours, well rinsed with water, distilled water and with sample before sample collection took place (Olowo, 2011; Hassan *et al*, 2020).

HRW Sample: Harvested Rainwater (HRW) were collected three times in September, 2022 from three locations; JIBWIS central mosque, local government secretariat and Lau Nursery school. Samples were taken from plastic and concrete tanks. A composite sample was made for HRW.

SW Sample: Three samples were taken from the river (surface water), using purposive sampling method. They are A, B and C. The surface water samples A and B were taken about 50m apart and 5m from river shore. Sample C was taken at about 40m away from the shore of the river. A composite sample of surface water sample was made. The two composite samples (Rainwater and Surface water) were wrapped in a black cellophane bag to prevent oxidation and placed in a cooler box packed with iced chips (cooler box). The samples were transported to laboratory for tests. The following parameters were tested: pH, Temperature, color, EC, TDS, Turbidity, Total Alk, Total Hardness, Cu, Cd, Zn, Pb and Fe. American Society for Testing and Materials (ASTM) and American Public Health Association (APHA) test methods were used.

Results for Temperature, pH, Electrical conductivity and TDS were obtained from PC TESTER 35, using corresponding probes. Each probe was standardised using standard solution. For TA and TH, titrimetric method was used. For color, LOVIBOND colorimeter apparatus was used, while for metals (Fe, Pb, Cu, Cd, Zn) analyses, FAAS (Flame Atomic Absorption Spectrophotometer) was used (SHIMADZU 6300 model) was used. A light beam from a hollow cathode lamp of the same element as the target metal is radiated through the flame, and the amount of absorbed light is measured by the detector. Concentration was displayed on the monitor in mg/l.

4. Results

Table 1: Result of Harvested and Surface water

	Parameter	**Water sample**		**NSDWQ**	**WHO**
S/N		**HRW**	**SW**		
1	Temperature (^{0}C)	25.0	25.0	Ambient	Ambient
2	pH	6.75	7.47	6.5 - 8.5	6.5 - 8.5
3	Colour TCU	5.0	**15.1**	15.0	15.0
4	Electrical. Cond. (µ/cm)	15.61	125.1	1000	1000
5	TDS (mg/l)	10.5	84.0	500	500
6	Turbidity (NTU)	1.2	**32.7**	5.0	5.0
7	Total Alkalinity(mg/l)	2.78	6.58	-	-
8	Total Hardness (mg/l)	3.86	32.29	150	200
9	Lead (mg/l)	<0.001	<0.001	0.01	0.01
10	Iron (mg/l)	**0.6252**	**0.8138**	0.30	0.30
11	Zinc (mg/l)	0.0221	0.8962	3.0	3.0
12	Cadmium (mg/l)	<0.001	0.0125	0.003	0.003
13	Copper (mg/l)	0.0523	0.1373	1.0	1.0

(Fieldwork, 2022)

Key: Bolded values were above the specification of WHO and NSDWQ, 2015

Discussion

PH - The data table showed that the water samples from the study area had mean pH values of 6.75 and 7.47 respectively for HRW and SW. This implies that the HRW is acidic, while the SW is alkaline. The HRW acidity is due to the reaction of rainwater with atmospheric carbon dioxide, Sulphur dioxide, or Nitrogen dioxide to produce carbonic, sulphuric, or Nitric acids as was even found by (Zhang *et al*, 2020). The alkalinity of surface water is due to organic matter in combination with catchment sources of alkaline origin. It comes from run-off through agricultural farmlands since the study area is agricultural. The result disagrees with the findings of Omokoro *et al*, (2019), on the Isiokpo River in River's state with pH values of 5.60, 5.60, and 6.80 from three different locations. However, the result from this work supports the findings of Godwin, Andesikuteb, Ezra, and Abubakar (2020) on river Kaduna with a mean value of 8.08. The study concluded that it could be due to agricultural run-off and industrial effluents. However, HRW result was acidic. This phenomenon occurs mainly due to dependence on fossil fuels, which has resulted in acid rain formation (Zhao *et al*, 2019). Rainwater acidity is an indication of activities of industries, high vehicular transportation and high commercial activities as asserted by Ubuoh *et al*, (2012), Siti *et al*, (2020) and Zheng *et al*, (2017). Since the study area is a riparian and agricultural zone, fishing and fish smoking, farming, commercial activities and bush burning could have contributed to low (acidic) pH of rainwater. Another reason could be due to wind trajectory action that could have carried particles far away from the source as supported by Ayeki *et al*, (2019) and Vincent *et al*, (2016). The mean values of pH were within MPL of WHO and NSDWQ of 6.5 to 8.5.(figure 2).

Color: Colored water gives the appearance of being unfit to drink, even though the water may be safe for public use. Color is an indication of presence of organic substances such as algae and humid substances (Anyadike and Obeta, 2013). From table 1, HRW and SW had mean color values of 5.0 and 15.1 TCU respectively. The color of surface water is above WHO and NSDWQ MPL of 15.0TCU. This could be due to human activities such as agriculture, waste disposal method, storm effect as well as paved surfaces along the river banks in wet season. This submission is supported by John *et al*, (2020), who stated that water color is also linked to water quality and can be related to the amounts of sediments, algae and dissolved organic matter in water.

Turbidity - The turbidity result showed 1.2 and 32.7NTU for HRW and SW respectively. HRW value was within the WHO and NSDWQ MPL of 5.0NTU as shown in table 1 and figure 2. However, SW had its turbidity value above the standards. This could be attributable to storm run-off, agricultural activities, domestic wastes disposal and erosion that must have washed away the surrounding top soil in to the river. This assumption agrees with findings of Omokoro, Nadie and Akani (2019), who obtained turbidity of 88.49NTU in Kaduna River. Similarly, Waziri *et al*, (2012), studied rainwater and runoff characteristics in University of Maiduguri campus, Nigeria, the average turbidity for the 5 sites studied were 5.21NTU. Barau *et al*, (2020), opined that turbidity of surface water could be due to motor-wheels of engine boats which continuously agitate the water there by increasing turbidity.

Temperature –The temperature of 25^0C is a laboratory measured temperature for samples. Temperature affects some of the important chemical and physical characteristic and properties such as density, thermal capacity and weight. It also affects sample measurement when using Borosilicate cylinders. This temperature recorded is within WHO′s MPL of 20-30^0C as reported by Azuonwu *et al*, (2017). Barau *et al*, (2020) reported the temperatures of 24.1 and 32.0^0C from 2 sites in Lau surface water between July 2017 and February, 2018.

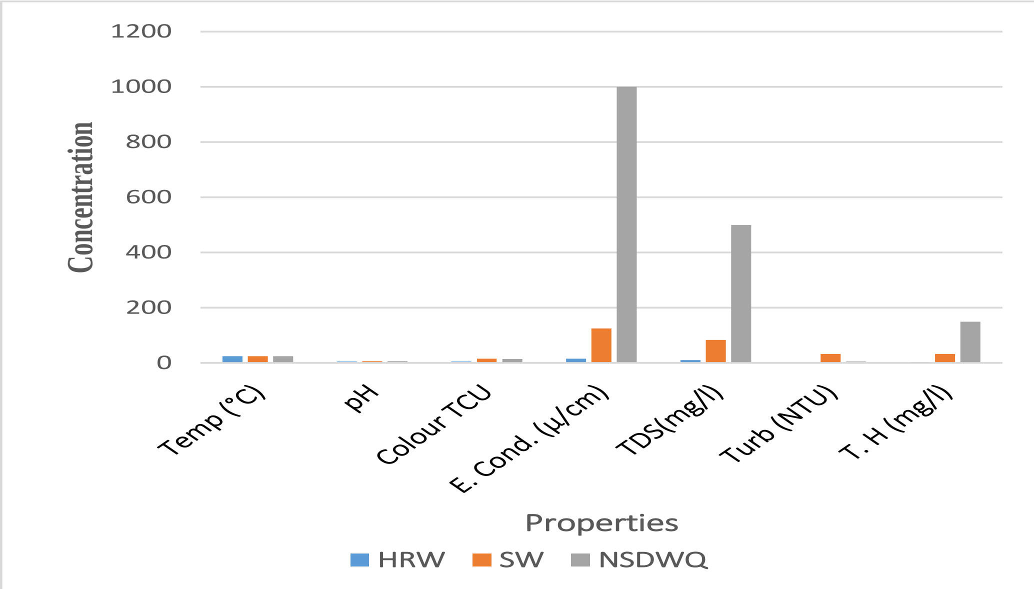

Figure 2: Showing Comparison between HRW and SW Properties

Electrical Conductivity- EC depends on dissolved ions (Kur, Alaanyi and Awuhe, 2019) and nutrient load of run-offs from farms (Oseji *et al*, 2020). EC of HRW and SW were 15.61 and 125.1µs/cm respectively, lower than 1000µs/cm, MPL by NSDWQ and WHO (figure 2). It has no direct significance concerning the health of humans (Ayeki *et al*, (2017), however, the higher conductivity in SW could be attributed to erosion and land use activities in the study area, which agrees with Omokar and Nedie, (2019). Low EC is an indication of low dissolved ions in rainwater. It could be attributed to low commercial and other human activities. Higher mean value of EC in SW could mean higher human activities such as farming (Zhang *et al*, 2017), and run-offs particularly farming activities in an area (Oseji *et al*, 2020), or meteorological condition that could have washed the drains and water channels carrying particles to the river body (John *et al*, 2020).

TDS - Mean values in HRW and SW were 10.5 and 84.0mg/l respectively. The figures were within the NSDWQ and WHO MPL of 600mg/l and 500mg/l respectively. However, SW has highest TDS (84.0mg/l). The reason could be due to rainstorm effect of wet season and erosive capacity of storm on river banks. Low TDS in HRW could be a reflection of low anthropogenic activities and lack of industrial presence. This assumption agrees with Belonwu *et al*, (2016). Increased surface runoff of rivers flow could erode rivers banks adding to the sediments and contaminants. (Anyadike and Obeta, 2013).

Total Alkalinity- It measures the resistance of the solution towards the pH changes due to the presence of an acid. The total alkalinity of HRW and SW were 2.78 and 6.58mg/l respectively, they were within NSDWQ and WHO MPL of 300-500mg/l (Agbaire and Obi, 2009). SW had higher alkalinity than HRW. This could mean that river water had more capacity to resist change in pH than HRW. Ojituku, *et al* (2016), studied river Kaduna water, the September result showed the alkalinity of 25.5mg/l, higher than the study area. The higher value could be attributed to increased farming activities especially fertilizer run-off and urbanization in the area (Grill *et al*, 2019), as well rainfall intensity (Ubuoh, 2017 and Abubakar and Ogbu, (2023).

Hardness - Hard water is usually defined as water, which contains a high level of Ca and Mg ions. It is the measure of the concentration of the multivalent cations, primarily it is equivalent to the Ca and Mg concentrations of the water (Ababio, 2007). Ca and Mg ions are soluble in water but they constitute hardness. HRW and SW had the mean values of total hardness as 3.86 and 32.29mg/l respectively. These values are within NSDWQ and WHO MPL of 150 and 200mg/l respectively. The values are in agreement with Oseji *et al*, (2019) on water quality of river Illushi in Edo state. The mean value was 26.82mg/l. Similarly, Ewulonu *et al,* (2019) reported the mean value of 18.57mg/l from fresh surface water in Isiokpo community, River state.

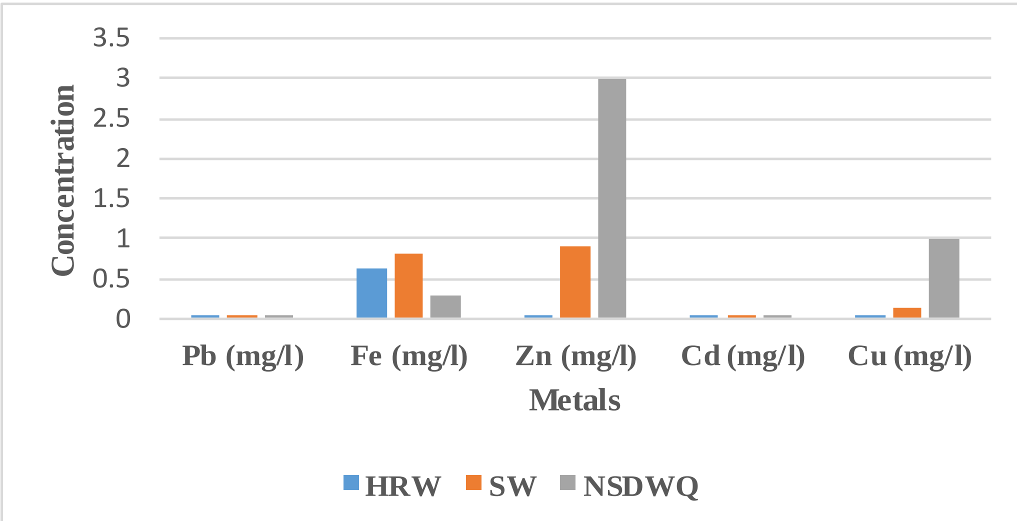

Figure 3: Comparison in Metal Concentration in HRW and SW

Iron – The data has shown HRW and SW had the Fe level of 0.6252 and 0.8138mg/l respectively. All the values were above WHO and NSDWQ MPL of 0.30mg/l. the result is unlike river Ethiope in Delta state with mean Fe content of <0.001mg/l in the wet season (Agbaire and Obi, 2009). This could be due to intercepting effect of storm water and land use activities in the area (Bruce *et al*, 2017). This opinion is supported by Subodh, (2021). Sources of Fe in rainwater could be through crustal source, quarrying and construction activities and could be from combustion of fossil fuels (Francis, 2018 and Adeyeye, 2019).

Lead- HRW and SW had the mean values of <0.001mg/l in all of the samples (Table 1). The values were within WHO and NSDWQ MPL of 0.01mg/l. Presence of Pb in HRW is an indication of atmospheric pollution with combustion of petroleum products and crustal activities. (Subodh, 2021). Ubuoh, *et al*, (2012) found out that the mean Pb range of rainwater in Akwa-Ibom state was between 0.12-0.90mg/l, with high industrial presence, such as oil exploration industries. Although, the result was expected to be higher in Akwa-Ibom state due the oil exploration, low Pb value could be due to effects of rainfall intensity as asserted by Abubakar and Ogbu, (2023). SW received run-off which contains sediments, from surroundings thereby affecting colour and other metals such as Pb. David *et al*, (2020) reported mean Pb concentration of Lau and Mayo Ranewa, along river Benue as 0.014 and 0.015mg/l respectively. These values were above that of study area. This could be due to fluctuating rainfall events and variations in farming and other human activities.

Cd- Cd contamination in water can be through natural erosion of Cd containing rocks, industrial dusts, fertilizer as in phosphate rocks. HRW and SW Cd mean values were <0.001 and 0.0125mg/l respectively, as shown in figure 3. SW value was higher than WHO and NSDWQ of 0.003mg/l, this could be attributed to erosive ability of rivers banks and effects of weathering, especially during wet season as supported by Anyadike and Obeta (2013). It could also be due to poor waste management and heavy use of fertilizer and pesticides, being an agrarian community (Calistus *et al*, 2023). However, Arif *et al*, (2019), reported with respect to rainwater, the comparative concentration of Cd in Jordan, Mexico and India as 52.0, 80.5mg/l and <0.001 respectively. These are industrial areas with high concentrations of Cd in rainwater. Result from the study area (<0.001), is an indication of less emissions of chemical pollutants as a result lack of industrial presence and could be attributed to minimal human activities.

Zinc – Zn has not been considered poisonous, in terms of health protection. Its inflow into surface water could be due to agrochemicals from farm lands. HRW and SW had mean values of 0.0221 and 0.8962mg/l respectively as compared with WHO and NSDWQ standards of 3.0mg/l. Zinc impacts colour to water body. All the values are within WHO and NSDWQ MPL, as shown in figure 3. This low concentration of Zn could be an indication of minimal industrial and commercial activities in the study area. This agrees with Godwin *et al*, (2020) on Zn level in Kaduna River (0.775mg/l), which is similar to what is obtained in study area. However, Kaduna River result was obtained in February, dry season when the Zn level could have been higher due to effect low water volume of the river. David *et al*, (2020) obtained mean Zn level in Lau and Mayo Ranewa as 4.75 and 4.22mg/l respectively, between July 2017 and February 2018. The study attributed the Zinc source to agro allied chemicals from farm lands in the area. Zn in HRW could come from roof and storage facilities.

Cu –HRW and SW had the mean values of 0.0523 and 0.1373mg/l respectively, below WHO and NSDWQ MPL of 1.0mg/l as shown in figure 3. There was no Cu contamination in rainwater and surface water in the study area. Godwin *et al*, (2020), studied river Kaduna in February 2015, where he obtained 0.285mg/l as Cu concentration. This was higher than the study area with Cu concentration of 0.1373mg/l. This low level of Cu in the study area could be due to rainwater intensity in wet season as asserted by Godwin *et al*, (2019) on quality of rainwater in Benin City.

5. Summary

The sample analyses were not in-situ, hence the temperature recorded were experimental. The HRW samples met standards of WHO and NSDWQ in all tested physical and chemical parameters (13) except for Fe, where it had mean value of 0.6252mg/l as against 0.30mg/l standard for both WHO and NSDWQ-2007. While surface water did not meet specification for Turbidity, Color, Fe and Cd, with values of 32.7NTU, 15.1TCU, 0.8138 and 0.0125mg/l respectively. However, where all the water samples met specification, the mean values for SW were found to be significantly higher, such as in EC, TDS, Total Alkalinity, Total hardness, Zn and Cu. Statistically, there was significant difference in physical and chemical qualities of water samples between HRW and SW in the study area.

The high content of Fe in HRW could be due to contact with different dissolved atmospheric gases from biomass burning, vehicular and engine boats emissions, dusts and waste disposal methods in the area. River Benue in Lau is impacted in some way by land use activities, particularly agriculture that generated pollutants and storm water run-off, and by loss of the natural filtering capacity of wetlands and forests around the water channels leading to the river.

Conclusion

The study showed that HRW has better physical and chemical water qualities compared to SW in the study area. SW did not meet WHO and NSDWQ standards in Color, Turbidity, Fe and Cd. This could be due to storm run-off effect. Turbidity affects appearance and aesthetic of drinking water quality. Cd is a heavy metal which has adverse effect on health particularly on kidney malfunctioning. High intake of Fe can cause liver and kidney diseases. HRW did not meet WHO and NSDWQ standards in Fe, this could be due to atmospheric emissions, crustal effect and other human activities. The high Fe content could have contributed to high color concentration.

Fe can be removed from domestic water supply system by using Iron removal filter. It has additional advantage of removing color and turbidity. This finding therefore, concludes that HRW is preferable for consumption, when compared to Surface water in Lau metropolis. Although rainwater is not available through-out the year, large cisterns and dug wells could be built to store large quantity of harvested water. In addition, Fe removal requires less effort and resources. Quality of water is a very important factor with regards to the possible options for its use. Without any doubt, inadequate quantity and quality of water have serious impact on sustainable development**.** With poor access to potable water provision and lack of water infrastructure, rainwater provides the basic water alternative to the study area.

Recommendations

Rainwater is the most easily accessible source of water as proved by the result obtained. During rainwater harvesting, first flush of water from roof and gutters should be diverted. A system should be installed to prevent first flush from going into a storage tank. It is necessary to avoid blockage due to debris, leaves, sand, filters should be regularly cleared and cleaned. The water in the storage tanks should be checked regularly for any change in its physical qualities, such as Color and Odour. Storage tanks should be treated by adding disinfecting agent such as chlorine. Gutters, pipes, tank inlets and filters should be cleaned regularly.

For human settlements, improved awareness on sanitation is required. People should be taught on proper way to dispose wastes. Inhabitants should be informed about health hazards on indiscriminate waste disposal methods. Cottage industries and irrigation farmers should treat waste before discharge into the river. Good water treatment plant should be setup to treat water from River Benue before consumption. This is to eliminate the contaminants such as color, sediment and heavy metals. Regular water treatment and inspection will improve drinking water quality.

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