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RESEARCH ARTICLE

Analysis of River Water Quality and its Implications on Crop Production in Kufana, Kaduna State, Nigeria

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ABSTRACT

This study analyzed river water quality and its implications on crop production in Kufana with the aim of establishing the level of pollution of the river's water quality in regard to crop production. To achieve the desired aim of the study intended to identify the types of crops cultivated, determine the characteristics of the physicochemical parameters of the river water, and compare the concentration levels of the variables to the Food and Agriculture Organization Standard (FAO 2018), as well as to determine the effect of these variables on the crops cultivated using water from the river. Related literature on water qualities for irrigation, water quality index, and models was reviewed; an empirical review was also considered in the study. Water samples were collected from rivers Ugo, Kufana, and Issa Gbari. Ten (10) parameters were tested, which comprise Calcium, Magnesium, Chloride, Carbonate, Bicarbonate, Sulphate, pH, Conductivity, TDS, and Temperature. Analysis of Variance (ANOVA) was the major statistical tool used in testing the hypotheses. The tool was used to test whether the water of the rivers is not polluted, as such, does not have any effect on crop production. Result from the study revealed that Calcium (0.70mg/l, 2.20mg/l and 1.30mg/l), Chlorine (23mg/l, 18.99mg/l and 16.99mg/l.), pH (6.58mg/l, 6.80mg/l 6.25mg/l), electrical Conductivity (58.80 Ds/m, 144.80 Ds/m and 111.30 Ds/m) and TDS (29.30mg/l 72.10mg/l, 55.80mg/l) were within the acceptable limit of WHO and FAO, while Magnesium (0.30mg/l, 1.50mg/l), Bicarbonate (24mg/l, 12mg/l and 14mg/l), Sulphate (18mg/l, 24mg/l and 14mg/l) and Temperature (28.800C) were not within the acceptable limit. Carbonate was not detected in the three rivers. The results of the study equally revealed a variation in the physico-chemical variables and water quality. The study concluded that since the rivers Ugo, Kufana and Issa Gbari are used for irrigating farms during the dry season, in order to avoid bioaccumulation of toxic pollutants in the agricultural products, farmers should be encouraged to use biofertilizers and biopesticides to avoid soil, surface water and groundwater contamination.

Keywords: *Water quality; River; Pollution; Irrigation; Kufana*

1. INTRODUCTION

Water is an essential resource in the production of most types of goods and services, including food, energy and manufacturing. Water supply quantity and quality at the place where the user needs it must be reliable and predictable to support financially sustainable investments in economic activities (United Nations World Water Development Report (UNWRSD), 2015).

About 71% of the earth's surface is covered by water, mostly in oceans and other large water bodies, with 1.6% of the water underground in aquifers and 0.001% in the air as vapour, clouds and precipitation. Over 97% of the total water supply is contained in the oceans and other saline bodies of water and is not readily usable for most purposes. (Hussein et al.,2016).

Food and Agriculture Organization (FAO, 2019) revealed that Agriculture is the single largest user of freshwater resources, using a global average of 70% of all surface water supplies. Except for water lost through evapotranspiration, agricultural water is recycled back to surface water and/or groundwater. However, agriculture is both cause and victim of water pollution. It is a cause through its discharge of pollutants and sediment to surface and/or groundwater, through net loss of soil by poor agricultural practices, and through salinization and waterlogging of irrigated land.

Irrigation practices have played an important role in increasing agricultural production and productivity so as to meet the ever-increasing food, fibre, etc. demands of the growing population. Water resources like rivers and streams serve as a source of irrigation water, while crossing different territories. Irrigated agriculture, however, has only been linked to the availability of water in physical terms, while the quality of water is significantly important for sustainable agricultural production. However, the latter has often been neglected until the situation where most irrigated agriculture is heavily dependent on lower water quality and less desirable sources elsewhere in the world (FAO, 1985; Islam and Shamsad, 2009).

River water quality is related to several factors including geology, climate, land use, and man activities. Many naturally occurring chemicals in river water come from dissolving rocks, soil, and decaying plant material. River water can be contaminated; human activities can increase the concentration of naturally occurring substances like salts, minerals, and nitrate (Hassan and Tavir, 2018).

Patil and Patil (2017) examined water from River Amalner in Jalgaon district, Maharashtra, India for different chemical parameters and found contamination in a majority of the cases, caused by influx of industrial and domestic wastewater. A study was conducted to assess the water quality parameter of Molla and Fitsume (2017) studied the Irrigation water quality of River Kulfo and its implication in irrigated agriculture, South West Ethiopia and the studied revealed that, the concentration of calcium cation (21 g/L) is the highest concentrated followed by sodium (8.3g/L), magnesium (5 g/L) and potassium (1.8 g/L) is the least concentrated in the River, the concentration level of the chloride ion was (25 mg/L). More importantly, both the electrical conductivity and the sodium adsorption ratio are relatively low, implying the water is non-saline and can safely be used for irrigation.

In Nigeria, the rate of urbanization characterized by high population concentration, increase in industrial and agricultural activities coupled with environmental pollution, degradation and indiscriminate disposal of all kinds of wastes are perceived to pose serious pollution threats with all its concomitant health hazards on river water quality, especially in urban areas (Ajala,2015, Abayomi, 2016, Ocheri, 2016, Adelana and Abayomi, 2017, Amadi, 2018 and Kehinde, 2019). Therefore, this study intends to analyze river water quality and its implications on crops production in Kufana with a focus on determining the effect of these variables on crops, cultivated using water from the rivers.

On that note, this study aims to establish the level of pollution of the rivers' water quality in regard to crop production. To achieve this aim, the study intends to pursue the following specific set of objectives to: identify the types of crops cultivated using water from the river.; determine the characteristics of the physico-chemical parameters of the river water; compare the concentration levels of the variables to the Food and Agriculture Organisation Standard (FAO 2018); determine the effect of these variables on the crops cultivated using water from the river.

H_0: The water of the rivers is not polluted, as such do not have any effect on crop production.

2. MATERIALS AND METHODS

Study Area

Kajuru Local Government Area is domiciled in Kaduna State, Northwest Nigeria, and is located on latitude 9^0 59N and 10^0 55N and Longitude $7^0$34E and 13E, with its headquarters at Kajuru town. Kajuru LGA is bordered by the Igabi, Chikun, Kauru, Zangon Kataf, and Kachia LGAs. Several towns and villages make up Kajuru LGA, and these include Maiyola, Kajuru, Kalla, Kasuwar-Magani, and Iri. The estimated population of Kajuru LGA is put at 247,888 inhabitants. (Rimau, 2011)

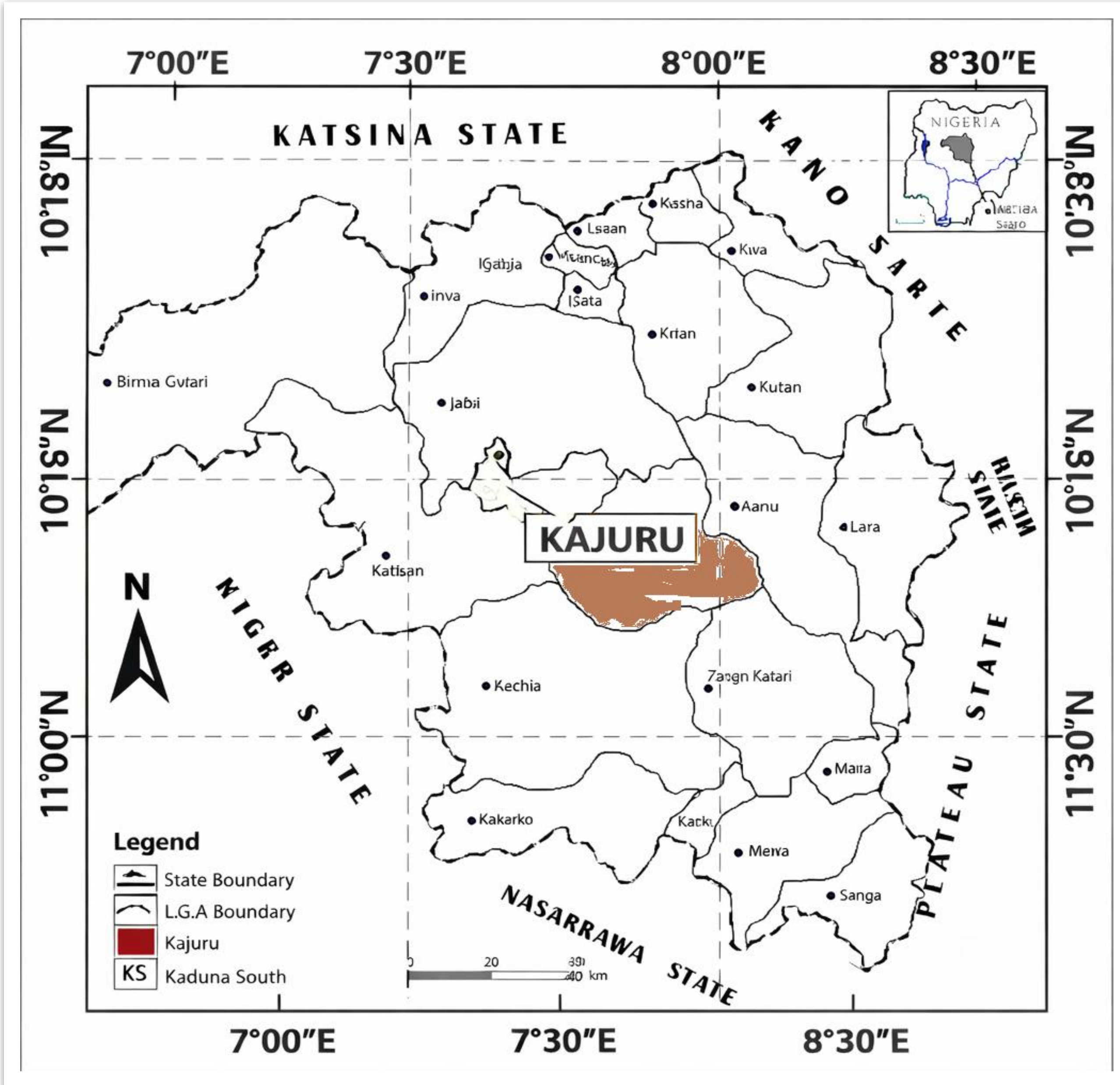

Figure 1. Map of Kaduna State showing Kajuru Local Government

According to Köppen's classification of climate, Kajuru Local Government belongs to the Aw, which is marked by distinct wet and dry seasons. The most important climatic variables in the study area include temperature, rainfall, and relative humidity. The study area experiences high temperatures all year round, which is a characteristic of the tropics. The mean daily temperature in the area can be as high as 34 °C between months of March and May. Temperature could be as low as 20 °C during December to January. This low temperature is intensified by humidity due to the dry harmattan wind.

The study area has two seasons as earlier mentioned. These two seasons are determined by two prevailing air masses blowing over the area at different periods during the year. One of the air masses is the north-easterlies, which is a continental air mass that sets in from the month of November and lasts to early March. During this period, precipitation is very low or absent. The air mass is dry and dust-laden. The second air mass is the southwesterlies, which begins to set in from late March and ends around October. During this period, precipitation and humidity are very high, and rainfall exceeds 1,300mm a year. The maximum rainfall is experienced in the month of August; during this time, rainfall is usually very heavy with thunderstorms. The relative humidity ranges between 65% and 70% in the rainy season and between 18% and 38% in the dry season (Chori, 2013).

The area is part of the extension plains of northern Nigeria. The general relief of the area is fairly plain, with isolated rock outcrops of inselbergs found in the area, thus creating undulations. The inselbergs are granitic in origin, formed from underlaid basement complex rocks. Depressions are found along the water courses where streams occur. The study area is drained by a network of streams that find their source mostly in the isolated hilly areas found around (Rimau, 2011).

The area under study is found on the extensive crystalline basement complex of northern Nigeria. The basement complex rocks are intrusive igneous rocks which have been in existence since Precambrian time. According to the Food and Agriculture Organization (F.A.O) soil classification, Kajuru local government area is made up of ferruginous tropical soil which is derived from intensive weathering and granitization of the basement, which itself comprises mostly migmatites, gneiss, granite, and schist. These soils are generally well-drained and mostly sandy-loam and loamy soils in plains, while in the valleys, there are deposits of hydromorphic soils, which occupy the flood plains of the rivers. The soils in the area are rich in mineral content and therefore support the high agricultural productivity in the area (Rimau, 2011).

Kajuru local government area belongs to the northern Nigeria-Guinea savannah zone based on vegetation classification. The vegetation here suffers from anthropogenic disturbance through the cutting down of trees for fuel wood, cultivation, and construction works. Also, animal grazing is very high, coupled with seasonal bush burning, which is prominent during the dry season. The vegetation has been reduced to grasses, shrubs, and parkland; few tall trees are found, mostly along watercourses. The parkland trees are found in the open cultivated land, with shrubs found almost everywhere except areas where cultivation is being practiced. Common trees found in the area include *Isoberlinia doka*, African locust bean, gao tree, African mahogany, mango, and several others. There is also a large expanse of green grass, especially during the wet season. This supports a large population of cattle and other herbivorous animals during the wet season. The common grass species are *Albiziazygia*, *Tridax procumbens*, and *Landolphia spp* among others. During the rainy season, the grasses are green but turn brownish during the dry season (Abaje, Sawa, Iguisi and Ibrahim, 2016).

Two days reconnaissance survey of the study area was undertaken with the purpose of familiarizing the researcher with the study area, the land use within the area, as well as the actual location of these rivers. This was undertaken from 10th to 11th of January 2021. It was observed that land uses in the area include residential, rain-fed agriculture, and transportation and irrigation activities take place along the banks of the rivers. The points at which the water sample would be collected were also selected.

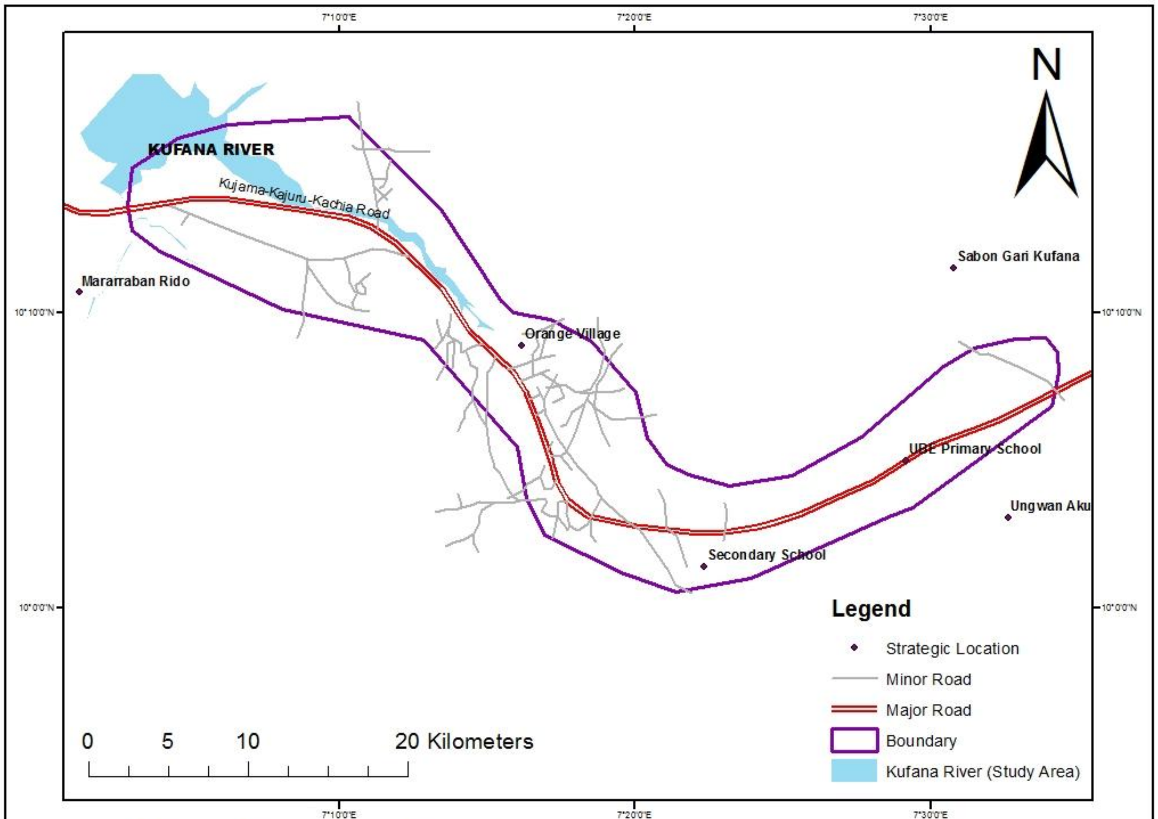

Figure 3.2: Map of Kufana Showing Kufana River
Source: Kaduna Geographic Information Service, 2021

Figure 2. Showing the Sampling Site

Sample and Sampling Techniques

The selection of the sampling points was dictated by accessibility. This was to ease difficulties that might be encountered during the course of sample collection, even though the samples were taken during the peak of the dry season, that is, on 23rd March 2021. It is during this period that farmers used the rivers for irrigational activities. The sampling points were selected away from possible situations that may influence the true quality of the samples. (Achuthan, Abdullah and Mahamoud 2005).

Instrument for Data Collection

The water samples were collected and stored in 750-ml high-density polyethylene bottles (HDPE) for laboratory analyses. All water samples were kept at 4°C until they were analyzed using standard methods APHA.

Procedure for Data Collection

The traditional grab-sampling method involving on-the-spot collection of water samples for quality analysis was used. The water samples were collected from rivers Ugo, Kufana, and Issa Gbari. Water samples were collected at the selected points on the rivers in pre-washed 2-litre plastic containers. The water from each sample point was used to rinse the container before collecting the sample, and two samples were collected for the study (Nworgu 2006).

Laboratory Analysis of Water Samples

The water samples were transported using a cold box to the Kaduna State Water Corporation Central Laboratory, where they were preserved before Analysis. The samples were preserved by cooling to $4^{o}c$ to prevent any reaction. The samples were tested for PH, Magnesium, Sulphate, Calcium Chloride, and bicarbonate, among others, and these were determined by using the American Public Health Association (2005) methods for wastewater examination 21^{st} Edition.

pH of the samples was measured using an electromagnetic method. The pH meter was warmed for 3 minutes. The electrode was removed, rinsed with fresh distilled water, and wiped with soft tissue. The pH meter was calibrated using the pH 4, 7, and 10 Calibration Standard Solution. The water electrode was then rinsed with sample to be measured and inserted into the sample, the "ON" pH knob and the temperature reading taken on the scale. The electrode was rinsed again with distilled water and stored immersed in the distilled water.

Calculation mg/L = log $H_3O^+ = 10^{-PH}$ …………………………………………………….. (1)

Chloride

Chloride was measured by argentometric titration of 100mg/l sample using 0.141mol dm^{-3} silver nitrate ($AgNO_3$) in the presence of 1 mL potassium chromate indicator (K_2CrO_4), at a pH of 7-8. At the endpoint, the colour changes from yellow to pinkish-yellow, and the chloride concentration was computed by calculation as follows:

mg /L Chloride = (A-B) x N/Vol. of sample used x 35, 450…………………… (2)

Where,

A = sample titrate value; B = Blank titrate and N = 0.0141

Carbonates

It is used to predict the additional sodium hazard associated with CaCO3 precipitation involve calculation of carbonate. Carbonate is another alternative measure of the sodium content in relation to calcium and magnesium. This can be calculated as:

RSC = (CO3 2- + HCO3-) – (Ca2+ + Mg+2) …………………………………………… (3)

Where all concentrations are in meq/L.

Magnesium

A colorimetric method was used; in this method, iron was detected at the wavelength of 510 nanometers (nm), while magnesium was detected at 525nm

Calculation:

$Mg + 2HCl$ - $MgCl_2 + H_2$…………………………………………………………………………………………… (4)

Sulphate

Spectrophotometric method was in this method, sulphate and iron are precipitated as $BaSo_4$in acidic media with hydrochloric acid (HCl) and barium chloride. The absorption of light by this precipitate suspension is measured at 420nm.

Calculation

Mg/l $So_{4=}$ $mgso_4$ x 100/ml sample. ………………………………………………… (5)

Electrical Conductivity and Total Dissolved Solids (EC and TDS)

Were determined using a Wagtech WE30120 Conductivity/TDSmeter. The analyses were conducted by submerging the probe into the water sample in a plastic beaker to minimize any electromagnetic interference, stirring once, and allowing the reading to stabili

ze. Calibration of the EC/TDS meter was conducted daily using a compatible EC standard solution

(12.88ms/cm). Temperature of the water samples was measured with the EC/TDS meter, because the EC value was automatically compensated for temperature.

Manganese

A colorimetric method was used; in this method magnesium was detected at the wavelength of 525nm.

$Mn + 2 NO_3^- + 8H^+ \longrightarrow 3 Mn^{2+} + 2 NO (g) + 4H_2O$………………………… (6)

Temperature

Temperature was determined by using a dry–bulb thermometer directly from the sampling point. Readings were expressed in degrees Celcius (^oc).

Calculation:

$k = C + 273.15$ where ………………………………………………………. (7)

C = the temperature in Celsius scale

K = Temperature in the Kelvin scale

Method of Data Analysis

Data collected were presented in tables and were analyzed using descriptive and inferential statistical tools. The descriptive statistical tool used was charts. All data collected were coded into the Statistical Package for Social Science (SPSS) v20. Hypotheses formulated were tested using Analysis of Variance (ANOVA) at a 0.05 level of significance.

The mean formula;

$$X = \frac{\sum F\overline{X}}{\sum n} \quad \text{where}$$

X is the arithmetic mean

$\sum fx$ is the sum of frequency and rating scale (x)

$\sum f$ is the sum of the frequency

3. RESULTS AND DISCUSSION

The data were presented in tables and charts. Tests of variation between the physical and chemical parameters were conducted using Analysis of Variance (ANOVA) with the aid of Statistical Package for Social Science (SPSS). Three rivers were sampled (i.e., Ugo, Kufana, and Issa Gbari).

Table 1. Concentration of Physical and Chemical Parameters in the Three Rivers

PARAMETERS	UNIT	RIVER UGO	RIVER KUFANA	RIVER ISSA GBARI
Calcium	mg/l	0.70	2.20	1.30
Magnesium	mg/l	0.30	0.00	1.50
Chlorine	mg/l	24.00	18.99	16.99
Carbonate	mg/l	0.00	0.00	0.00
Bicarbonate	mg/l	24.00	12.00	14.00
Sulphate	mg/l	18.00	24.00	14.00
pHis	H+	6.58	6.80	6.25
Electricity Conductivity	dS/m	58.80	144.80	111.30
TDS	mg/l	29.30	72.10	55.80
Temperature	^oc	28.80	28.80	28.80

Table 1 above gives analyses of the physical and chemical concentrations of the ten (10) parameters in river Ugo, river Kufana and Issa Gbari. The laboratory results revealed the concentration of calcium in rivers Ugo, Kufana, and Issa Gbari with 0.70mg/l, 2.20mg/l and 1.30mg/l respectively. There is a concentration of magnesium 0.30mg/l in River Ugo and 1.50mg/l in River Issa Gbari.

Chlorine was also concentrated in the three rivers, 23mg/l in River Ugo, 18.99mg/l in River Kufana and 16.99mg/l in river Issa Gbari. Carbonate was not found in the three rivers, with the result showing 0.00. Bicarbonate is also concentrated in the rivers, 24mg/l in River Ugo, 12mg/l in River Kufana and 14mg/l in river Issa gbari.

18mg/l of sulphate is concentrated in River Ugo, 24mg/l in River Kufana, and 14mg/l in River Issa Gbari. pH is highly concentrated in the three rivers, 6.58mg/l is concentrated in river Ugo, 6.80mg/l in river Kufana, and 6.25mg/l in river Issa Gbari. Electrical conductivity is highly concentrated in river Ugo with 58.80Ds/m, 144.80Ds/m in river Kufana, and 111.30Ds/m in river Issa Gbari

29.30mg/l TDS is concentrated in River Ugo, 72.10mg/l in River Kufana and 55.80mg/l in river Issa gbari. The three rivers (Ugo, Kufana and Issa gbari has a concentration of temperature range of 28.80^{0}C.

Table 2. Mean, Variance and Standard Deviation of the Concentration Levels of the Parameters

PARAMETERS	RIVER UGO	RIVER KUFANA	RIVER ISSA GBARI	$\bar{X}$	V	SD
Calcium	0.70	2.20	1.30	1.40	0.38	0.62
Magnesium	0.30	0.00	1.50	0.60	0.30	0.55
Chlorine	24.00	18.99	16.99	19.99	8.69	2.95
Carbonate	0.00	0.00	0.00	0.00	0.00	0.00
Bicarbonate	24.00	12.00	14.00	20.00	32.00	5.66
Sulphate	18.00	24.00	14.00	18.67	16.89	4.11
pH	6.58	6.80	6.25	6.54	0.15	0.23
Conductivity	58.80	144.80	111.30	104.97	1252.17	35.39
TDS	29.30	72.10	55.80	52.4	311.09	17.64
Temperature	28.80	28.80	28.80	28.80	0.00	0.00

Table 2 shows that the concentration level of calcium has a mean of 1.40mg/l, variance 0.38, and standard deviation 0.62; magnesium has a concentration level of 0.60, 0.30, and 0.55 of mean, variance, and standard deviation, respectively. The mean, variance, and standard deviation of chlorine are 19.99, 8.69, and 2.95. The mean, variance, and standard deviation of the concentration levels of carbonate are 0.00. The mean, variance, and standard deviation of the concentration levels of bicarbonate are 20.00, 32.00, and 5.66. Sulphate has a concentration level of 18.67, a mean, 16.89 variance and 4.11 standard deviation. pH also has the concentration levels of 6.54 mean, 0.15 variance, and 0.23 standard deviation. The mean concentration level of conductivity is 104.97, variance 1252.17, and standard deviation of 35.39. TDS has a mean concentration level of 52.4, 311.09 variance and 17.64 standard deviation. Temperature concentration levels of mean of 28.80 and 0.00 variance and standard deviation.

Table 3. Mean values of Parameters in Relationship with FAO and WHO Standard

PARAMETERS	$\bar{X}$	WHO STANDARD	REMARK	FAO STANDARD	REMARK
Calcium	1.40	≤ 20	Acceptable	0 -20	Acceptable
Magnesium	0.60	0.05	Not acceptable	0 - 5	Acceptable
Chlorine	19.99	250	Acceptable	0 -30	Acceptable
Carbonate	0.00	≤ 1	Void	0 - .1	Void
Bicarbonate	20.00	0-10	Not acceptable	0 - 10	Not acceptable
Sulphate	18.67	5	Acceptable	0 - 20	Acceptable
pH	6.54	6.5-8.5	Acceptable	6.5 – 8.5	Acceptable
Conductivity	104.97	1000	Acceptable	0 - 30	Acceptable
TDS	52.4	<1000	Acceptable	0 - 2000	Acceptable
Temperature	28.80	25	Acceptable	30	Acceptable

Table 3 gives an analysis of the mean values of the parameters in relation to FAO and WHO standards. The table shows that the calculated mean value of calcium is 1.40 < 20 of the limits set by the WHO and FAO standards, which means that base on the result calcium is concentration in the rivers does no harm to crops. Magnesium has a mean value of 0.60 > 0.05 of WHO Standard and less than the acceptable limit of FAO. This implies that it is within the acceptable limit of FAO and not within the acceptable limit of WHO. The mean value of chlorine is 19.99 < 250/0-30 acceptable limits of WHO and FAO Standard of water quality for irrigation. The mean value of carbonate is 0.00, which signifies that the parameter is not present in the rivers. Bicarbonate has a mean value of 20.00 > 0-10 WHO and FAO Standard for water quality, which signified that the element value is not acceptable for irrigation. Similarly, the table equally revealed that the mean values of sulphate, pH, conductivity, TDS and temperature are 18.67, 6.54, 104.97, 52.4 and 28.80 respectively. These values are all within the acceptable limits set by WHO and FAO. Consequently, the results indicate that the level of pollution in the rivers is minimal though calls for careful usage of contaminant around the sample sites by farmers.

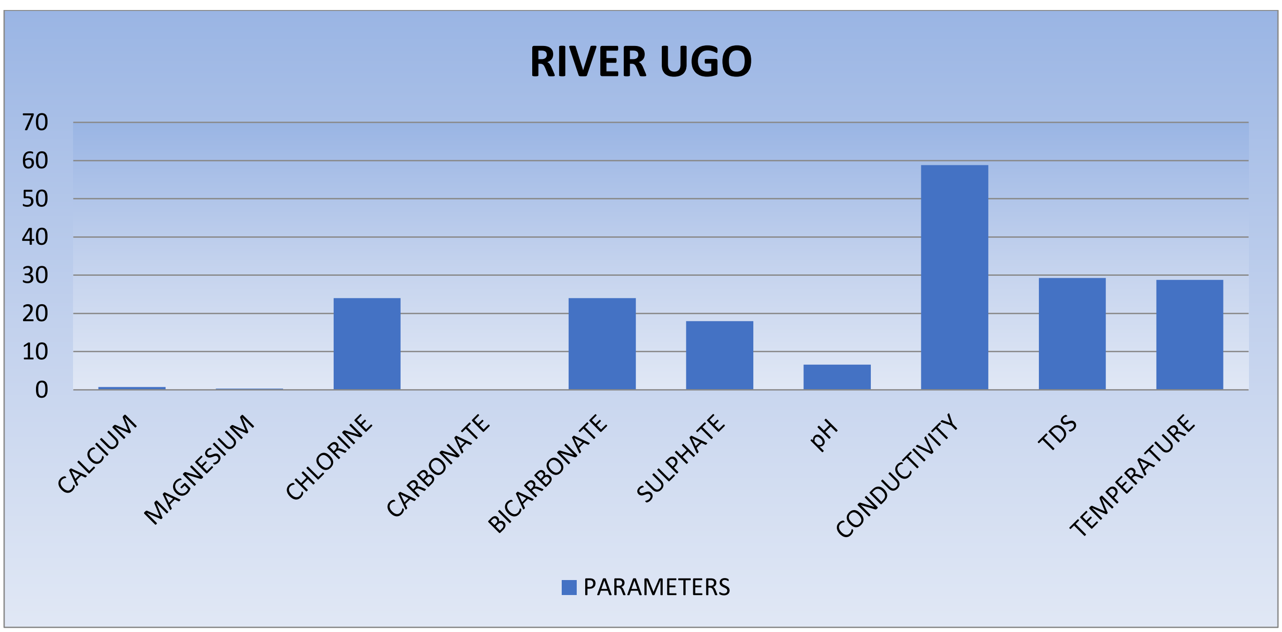

Figure 3. Concentration of the Tested Parameters in River Ugo

Figure 3 presents analyses of the concentration level of ten (10) parameters in River Ugo. The table revealed that calcium is 0.7mg/l, magnesium 0.3mg/l chlorine 24.003mg/l, carbonate 0.003mg/l, sulphate 18.00, pH, 6.58, conductivity 58.8ds/m, TDS 29.33mg/l and temperature 28.80°C

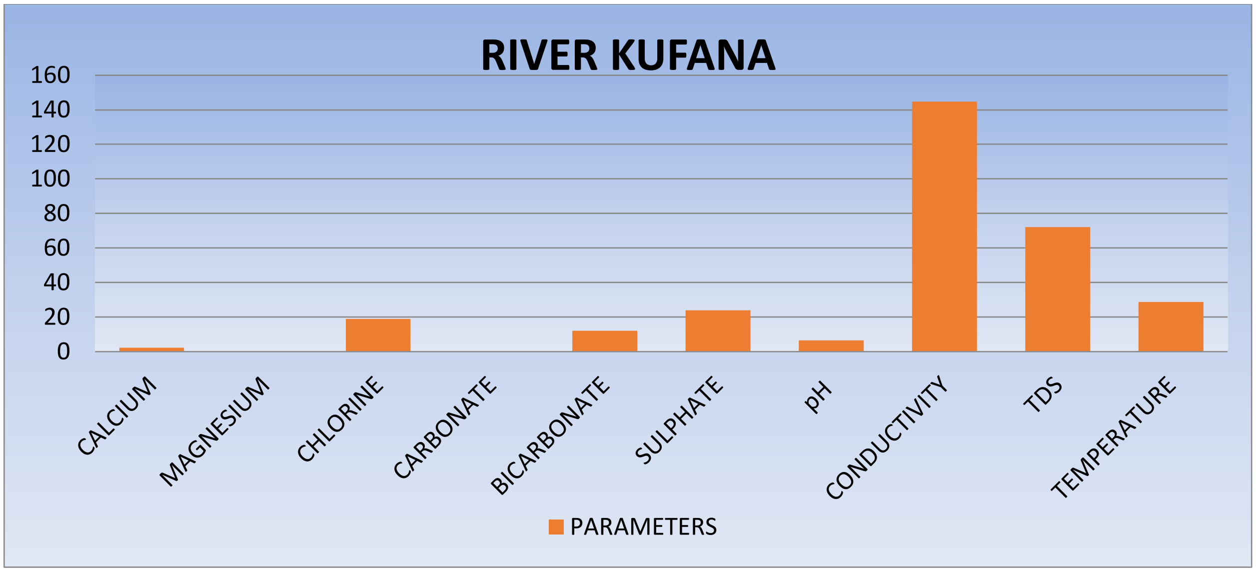

Figure 4. Concentration of the Tested Parameters in River Kufana

The concentration of the ten (10) parameters in River Kufana is presented in Figure 4. The concentration level of calcium is 2.23mg/l, magnesium 0.00V chlorine 18.993mg/l, carbonate 0.003mg/l, bicarbonate 123mg/l, sulphate 24.003mg/l, pH, 6.58, conductivity 144.8ds/m, TDS 72.13mg/l and temperature 28.80°C.

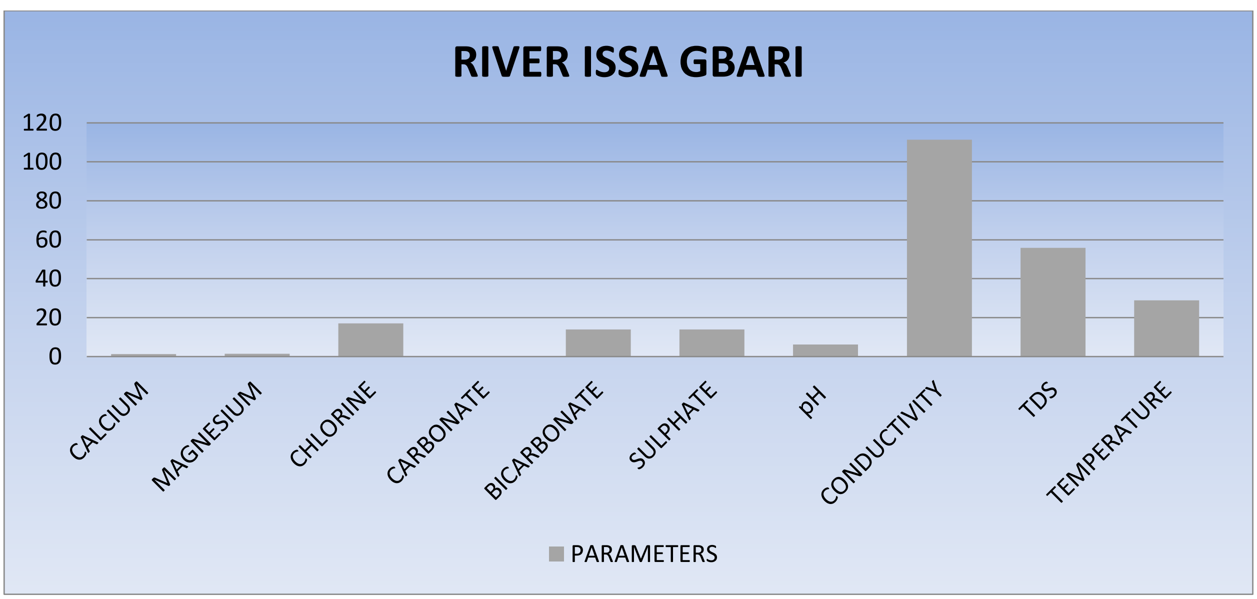

Figure 5. Concentration of the Tested Parameters in River Kufana

Figure 5 gives analyses on the concentration of the ten (10) parameters in River Kufana. The figure revealed that the concentration level of calcium is 1.303mg/l, magnesium 1.503mg/l, chlorine 16.993mg/l carbonate 0.00V, bicarbonate and sulphate 14.003mg/l respectively; pH 6.25, conductivity 111.3, ds/m TSD 55.8, temperature 28.8°C.

Table 4. Measured Parameters in Relation to WHO and FAO Standards

PARAMETERS	UNIT	RIVER UGO	RIVER KUFANA	RIVER ISSA GBARI	WHO STANDARD	FAO STANDARD
Calcium	mg/l	0.70	2.20	1.30	≤ 20	0 -20
Magnesium	mg/l	0.30	0.00	1.50	0.05	0 - 5
Chlorine	mg/l	24.00	18.99	16.99	250	0 -30
Carbonate	mg/l	0.00	0.00	0.00	≤ 1	0 - .1
Bicarbonate	mg/l	24.00	12.00	14.00	0-10	0 - 10
Sulphate	mg/l	18.00	24.00	14.00	5	0 - 20
pH		6.58	6.80	6.25	6.5-8.5	6.5 – 8.5
Conductivity	dS/m	58.80	144.80	111.30	1000	0 - 30
TDS	mg/l	29.30	72.10	55.80	<1000	0 - 2000
Temperature	^{o}c	28.80	28.80	28.80	25	30

Table 4 below gives analyses on the measured parameters in relation to the World Health Organization and the Food and Agriculture Organization. The table revealed that the concentration of calcium (mg/l) in River Ugo is 0.703mg/l, River Kufana 2.203mg/l and 1.303mg/l in River Issa Gbari. Similarly, the concentration of calcium in Ugo River is lower compared to Kufan and Issa Gbari, as shown in Table 6. The measured parameters in the three rivers are all within the acceptable levels of WHO and FAO standards, which implies that the level of pollution is low and the water quality is suitable for irrigation.

The concentration level of magnesium is shown in the second item in Table 4. The table shows that the concentration level of magnesium in Ugo River is 0.303mg/l; Kufana River is 0.003mg/l and 1.503mg/l in Issa Gbari River. Kufana River has no concentration, while Ugo River has a lower concentration compared to 1.503mg/l of Issa Gbari River. The concentration levels of the parameters of the two rivers, where the parameter is concentrated, are all within the acceptable level of WHO and FAO water quality standards. Therefore, the result obtained revealed that the rivers are free from pollutants.

The concentration level of chlorine revealed that River Ugo, Kufana, and Issa Gbari have concentrations of 24.003mg/l, 18.993mg/l and 16.993mg/l < 250/0-30 WHO and FAO water quality standard respectively. This implies that the water quality of the rivers is within the acceptable standard of the organizations. However, Issa Gbari River has the lowest concentration of chlorine, while Ugo River has a higher concentration of chlorine.

The table shows that there is no concentration of carbonate in the three rivers. This is as a result of low contamination of the rivers by farmers and effluent.

The concentration level of bicarbonate in the table revealed that Ugo has the highest concentration of bicarbonate, with 24.003mg/l follow by Issa Gbari 14.003mg/l and Kufana River 12.003mg/l. The concentration of the parameter in the three rivers is above the acceptable limit of 0-10 WHO and FAO, implying that the level of pollutants is very high in the rivers; therefore, the quality of the water in the rivers is not acceptable for irrigation.

The concentration of sulphate in River Ugo 18.003mg/l and in River Issa Gbari is 14.003mg/l < 5/0-20 acceptable level of the WHO and FAO water quality standard, while River Kufana has a high concentration 24.003mg/l > 5/0-20 acceptable levels of the two organizations. The result signified that River Ugo and Issa Gbari are fit for irrigation, while River Kufana is not because of the high concentration of pollutants.

The pH concentrations in the rivers are 6.58, 6.80, and 6.25 < 6.5-8.5 WHO and FAO water quality standard. This implies that the level of acidity in the rivers is within the acceptable limit, thereby making the water fit for irrigation.

The level of Conductivity concentration in River Kufana is high, measured 144.80ds/m followed by 111.30ds/m in Issa Gbari and 58.80ds/m in Ugo River. The concentration of conductivity in the rivers is only within the acceptable limit set by WHO and above the acceptable limit of FAO.

The concentration of TDS shows that River Kufana has the highest concentration with 72.103mg/l, followed by River Issa Gbari 55.803mg/l and then Ugo River 29.303mg/l. The measured parameter in the three rivers is within the acceptable limits of WHO and FAO. This implies that the water in the rivers is fit for irrigation.

The temperature in the rivers is 28.80^{o}C > 25 acceptable limit of WHO, and 28.80^{o}C < 30 acceptable limit by FAO. The result shows that the temperature in the river is fit based on the acceptable limit of WHO and not fit based on the FAO limit.

Table 5. Sample Site, Date, Crop Cultivated and the Characteristics of the Rivers

Sample Site	Date	Crops cultivated	Water Colour	Water odour	Water Taste
River Ugo	24/3/2021	Maize, Cocoyam, Spinach, Pepper, onion, garden egg, watermelon, sugar cane	Brown	Grassy	Acidic
River Kufana	24/3/2021	Spinach, Pepper, onion, garden egg, watermelon, sugar cane	Yellowish-brown	Musty	Neutral
River Issa Gbari	24/3/2021	Cocoyam, Spinach, Pepper, onion, garden egg, watermelon, sugar cane	Yellowish-brown	Fishy	Acidic

Table 5 shows that the crops cultivated in Rivers Ugo are Maize, Cocoyam, Spinach, Pepper, onion, garden egg, watermelon, and sugar cane, while the sample water taken from the site is brownish in colour with a grassy odour and tasted acidic. This shows that the water is polluted with effluent from chemicals from fertilizer application; decayed crushed grass and herbicide applied in the farms.

River Kufana has similar crops cultivated with that of Ugo River. These crops are Spinach, Pepper, onion, garden egg, watermelon, and sugar cane. The water appeared yellowish-brown in colour with a musty odour and a taste of acidity. The effluent generated by decomposed straw results in the water colour.

Issa Gbari River also has similar crops cultivated with that of Ugo and Kufana Rivers. The water in the river is yellowish-brown in colour, resulting from remains of dead fish in the river. The level of acidity in the river also affects the taste of the river.

Conclusively, the effluent in the rivers significantly affects crop yield in the sample sites.

Testing of hypotheses

A one-way Analysis of Variance (ANOVA) was employed to test whether there is a statistically significant difference in the measured physicochemical parameters of the three rivers. The parameters (Calcium, Magnesium, Chlorine, Carbonate, Bicarbonate, Sulphate, pH, Conductivity, TDS, and Temperature) were treated as observations for each river.

The test was conducted at a **0.05 level of significance**.

Table 6. One-Way ANOVA of Physicochemical Parameters of Rivers Ugo, Kufana, and Issa Gbari

Source of Variation	Sum of Squares	df	Mean Square	F-value	p-value
Between Rivers	710.553	2	355.276	0.296	0.746
Within Rivers	32,380.216	27	1,199.267		
Total	33,090.769	29			

Since the p-value (0.746) is greater than 0.05, the null hypothesis is accepted**.** The ANOVA result indicates that there is no statistically significant difference in the physicochemical parameters of water from Rivers Ugo, Kufana, and Issa Gbari. This implies that the rivers are not polluted beyond acceptable WHO and FAO limits, and their water quality does not pose a significant threat to crop production in the study area. The conformity of most measured parameters with WHO and FAO standards suggests that the river waters are suitable for irrigation purposes. Hence, any observed variation in crop yield within the study area is likely attributable to factors other than river water quality, such as soil fertility, farming practices, or climatic conditions.

The major findings of the study were discussed in the following:

Characteristics of the Waters

Three rivers (i.e., River Ogu, Kufana and Issa Gbari) were the major focus of the study. The rivers were in the same cluster, thus having similar characteristics. Results from the study show that the ten parameters tested were concentrated in both rivers. For example, temperature in the rivers was measured at 28.80 °C in both rivers (see Table 2), while carbonate was void. Similarly, findings of the study equally revealed that the water has colour, taste, and odour (Table 5).

Concentration Levels of the Physical and Chemical Parameters of the Rivers' Water

Findings from the study revealed the concentrations of physical and chemical parameters in the three rivers (Ugo, Kufana and Issa Gbari). The study has revealed that the laboratory results show the concentration of calcium in rivers Ugo, Kufana and Issa Gbari as 0.70me/l, 2.20mg/l and 1.30mg/l respectively. Magnesium is 0.30mg/l in River Ugo and 1.50mg/l in River Issa Gbari, and Chlorine concentration in the three rivers is 23mg/l, 18.99mg/l and 16.99mg/l. Bicarbonate is also concentrated in the rivers, 24mg/l in River Ugo, 12mg/l in River Kufana, and 14mg/l in River Issa Gbari. 18mg/l of sulphate is concentrated in River Ugo 24mg/l in River Kufana, and 14me/l in River Issa Gbari. pH is low in the three rivers, 6.58mg/l is concentrated in River Ugo, 6.80mg/l in River Kufana, and 6.25mg/l in River Issa Gbari. Conductivity is highly concentrated in River Ugo with 58.80Ds/m, 144.80Ds/m in River Kufana, and 111.30Ds/m in River Issa Gbari. 29.30mg/l TDS is concentrated in River Ugo, 72.10mg/l in River Kufana, and 55.80mg/l in River Issa Gbari. The three rivers (Ugo, Kufana, and Issa Gbari) have a temperature concentration range of 28.80^{0}C. The result of this study is in line with the findings of Adegbola et al, (2019), whose result shows that most of the samples analyzed are within the acceptable range.

Level of Pollution of the Rivers

Analysis on the physical and chemical concentration level of the 10 measured parameters in relation to WHO water quality index (WQI) revealed that the concentration of calcium is ≤ 20 me/l which is within the acceptable standard; magnesium is far above the acceptable standard and therefore is unacceptable for irrigation. This study agrees with the findings of Dutter et'al (2018), whose findings revealed a water quality index of high contamination in the water tested. Chlorine concentration is within the WHO acceptable standard. Carbonate is void, while bicarbonate and sulphate concentrations are not within the acceptable range. pH, electrical conductivity, and TDS are all within the acceptable range of the WHO water quality standard, while the temperature concentration is unacceptable. This result shows that calcium, chlorine, pH, electrical conductivity, and TDS are within the acceptable standard of WHO and fit for irrigation. In a note shell the waters in the three rivers is 40 percent chances of been polluted and 50 percent of been pure for irrigation, this because four of the tested parameters that is Magnesium (0.30mg/l, 1.50g/l), Bicarbonate (24mg/l, 12mg/l and 14mg/l), Sulphate (18mg/l, 24mg/l and 14mg/l) and Temperature (28.80^{0}C) were not within the acceptable range of WHO and FAO water quality standard for Irrigation. This chemical intoxicates the rivers, which in turn makes the water unfit for irrigation.

4. CONCLUSION

This study assessed the physicochemical quality of river water from Rivers Ugo, Kufana, and Issa Gbari and examined its implications for crop production in the Kufana area of Kaduna State. Ten (10) key water quality parameters were analyzed and compared with World Health Organization (WHO) and Food and Agriculture Organization (FAO) standards for irrigation water. The findings revealed that the majority of the assessed parameters—namely calcium, chloride, pH, electrical conductivity, total dissolved solids (TDS), and, in most cases, sulphate—were within acceptable limits prescribed by WHO and FAO for irrigation purposes. Carbonate was completely absent in all sampled rivers, indicating minimal contamination from carbonate-related sources. These results suggest that, generally, the rivers possess acceptable water quality suitable for dry-season irrigation.

However, certain parameters such as magnesium, bicarbonate, sulphate (particularly in River Kufana), and temperature exceeded recommended limits in some locations. Although these elevated values indicate localized quality concerns, statistical analysis using Analysis of Variance (ANOVA) showed no significant difference in water quality among the three rivers at the 0.05 level of significance. Consequently, the null hypothesis—which states that the river waters are not significantly polluted and do not have a statistically significant effect on crop production—was accepted. In conclusion, the study therefore establishes that Rivers Ugo, Kufana, and Issa Gbari are presently suitable for irrigation and crop production. Sustainable land-use practices and proper management of agrochemical inputs are essential to prevent future deterioration of water quality and to safeguard agricultural productivity in the study area.

Based on the findings and conclusions of this study, the following recommendations are made:

i. Efforts should be made to ensure that the effluent quality meets standards, since the rivers Ugo, Kufana and Issa Gbari are used for irrigating farms during the dry season, to avoid bioaccumulation of toxic pollutants in the agricultural products.
ii. Farmers should be encouraged to use biofertilizers and biopesticides to avoid soil, surface water and groundwater contamination.
iii. An action plan should be formulated for the short-term and long-term management for the efficient use of surface water resources and other natural resources after taking into account the population of the people, agricultural activities, availability of water resources, etc.

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5. COMPETING INTEREST

None to declare

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