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Determination of Heavy Metals and Physicochemical Parameters of Kafin- Chiri Dam in Kano State, Nigeria

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Abstract **Original Research Article**

Physicochemical parameters of kafin-chiri were investigated for three seasons. Concentration of metals and physiochemical parameters were determined from water, soil and plant from four sampling locations. Water, soil and plant samples were collected from each reservoir in four sampling locations during Rainy, Dry and Cold season. The result of the parameters; such as Dissolved Solid, Biochemical Oxygen Demand, Total Dissolved Oxygen, Suspended Solid, Total Solid, Temperature, Turbidity, colour Total Hardness, pH of water, pH of Soil, Conductivity of Soil, Conductivity of Water, Nitrite, Nitrate, Chloride and Phosphate ; Mg/L 1.40-4.0, 2.0-3.3, 27.9-50.0, 30.0-44.5, 2.140-164, 48.0-190, 30-34, 125-142 NTU, 200-350 Hazen, 35.4-115, 7-8.8, 4.28-6.16, 522-772,60-90.6, 0.012-0.02, 8.4-24.5, 18.54-28.5 and 1.1-3.0. The result shows a spatial and temporal variation $p>0.05$in all the sampling location. The value of pH in Water is 7-8.8Mg/L for Soil 4.28-6.16 Mg/L and Conductivity of Water 60-90.6µscm^{-1}, for soil is 552-772µscm^{-1} it shows that soil has lower pH value and higher conductivity than water. The values obtained for all the parameters were found to be comparable to those reported by other researchers in similar environment. The result of metals analysis in water mg/L (Cr, Cu, Pb, Zn, Co, Cd, Fe, Mn and Ni) 0-0.73, 0-0, 0.058-0.07, 0.11-0.34, 0.045-0.197, 0.1-4.2, 0.02-0.06, 0.28-0.7 and 1.2-4.2 that of metal analyzed in Plant mg/kg, okra (Cr, Cu, Pb, Zn, Co, Cd, Fe, Mn and Ni) 0.78-0.94, 0.38-0.64, 3.1-4.24, 0.69-1.13, 0.65-1.1, 2.21-3.26, 2.12-2.67, 1.26-1.78 and 2.47-3.01; Spinach mg/kg, 0.52-0.68, 0.41-0.6, 0.48-0.69, 1.29-2.02, 0.63-0.91, 5.17-6.63, 4.98-6.01, 4.67-6.87 and 6.23-7.2; maize mg/kg, 0.04-0.1, 0.12-0.21, 0.23-0.48, 0.01-0.04, 0.06-0.418, 0.047-0.09, 0.01-0.23, 0.1-0.10 and 0.2-0.33 and level heavy metals in soil mg/kg (Cr, Cu, Pb, Zn, Co, Cd, Fe, Mn and Ni) 0.02-21, 0.2-0.35, 0.1-0.2, 0.019-0.02, 0.3-0.9, 0.4-1.2, 0.019-0.02, 0.57-1.0 and 8.4-14. Most of the elements analyzed were within the acceptable limit set by WHO. Some of the heavy metals in water, soil and plant are higher than the recommended values indicting the extent of pollution in the study location.

Keywords: Pollution Assessment, Reservoir, Water, Soil, Plant, Dams, Heavy metals.

INTRODUCTION

The quality of water in any ecosystem provides significant information about the available resources for supporting life in that ecosystem (Ibrahim, 2008). Good quality of water resources depends on a large number of physic- chemical parameters and biological characteristics to assess the monitoring of

these parameters is essential to identify magnitude and source of any pollution load (Adesalu*et al.*,2010). Due to increased population and use of fertilizers in agriculture and man-made activities, the natural aquatic environment is increasingly polluted leading to depletion of aquatic biota and water quality (Adakole *et al*., 2008 and Kawo *et al*., 2008). Impairment of water quality in reservoirs arises largely from anthropogenic contamination
and natural mineralization (APHA, 1995 and Adamu *et al.*, 2014).The physical and chemical
parameters serve as pollution indicators in water quality monitoring which is a fundamental
tool in the management of fresh water resources (Balarabe 2001). The monitoring of physicochemical characteristics of a water body is vital for both long term and short analysis
(Wood, 1995). Distribution and productivity levels of organisms in any waterbody are largely
determined by physicochemical factors (Adakole *et al.*, 2008). In developing countries, industrial effluents and domestic sewage are indiscriminately discharged into adjoining rivers
and water bodies without any pretreatment (Tiseer *et al*., 2008). In view of forgoing this research aimed at investigating physico-chemical parameters and ecological implications of
Watari Dam, Kano.
This study was conducted for the purpose of monitoring the quality of Kafin-chiri reservoir, Kano state Nigeria for drinking water purpose, using selected physico - chemical parameters. The result will help in predicting the pollution status of the reservoir and form a baseline data in identifying emerging water quality problems. Reservoirs in Kano state have subjected to contaminating materials capable of initiating the impairment of the aquatic environment. Untreated industrial effluents are discharged into water bodies (Bichi, 2013) because most industries in Kano do not have waste water treatment facilities. This poses a great threat to the aquatic environment (El-Buraire, 2010).

The assessment of the extent of pollution in the reservoirs, soil, plants may require the knowledge of the concentration of the various metal species in the soil at the tributaries, entry to the dam, and spillway were analyzed.

STATEMENT OF THE PROBLEM

- Improper planning in Kano environment often led to the discharge of industrial and average effluents into rivers and canals which were dump in to the reservoir. The rivers have a complex and fragile ecosystem, as they do not have self-cleaning ability and therefore readily accumulative pollutants which are dumped into the reservoirs with the corresponding sediment from the watershed (Indu *et al.*, 2010).
- Some contaminants in the sediment are taken up by animals, plants, and microbes that live on, in, or near the bottom substrate of aquatic environments, ranging from shallow coastal areas to the deep seafloor. When large animals feed on these contaminated organisms, the toxins are taken into their bodies, moving up the food chain in increasing concentrations, in a process known as bio-magnification.
- Kano state home of over 320 industries which release over 5 million liters of untreated wastes daily into rivers, streams and canals (Huange *et al.*, ,2010 and Karofi,2009).These rivers discharge their wastes into reservoir (dams) that are used in water supply to residential and industrial areas (Jimoh,2011) .

AIMS AND OBJECTIVE

The aim of this research is to determine the level of heavy metals and physicochemical parameter of Kafin- Chiri dam in kano state, Nigeria while the specific objective were as follows: -

- To assess the seasonal variation of heavy metals and physicochemical pollutants in the study areas
- To Determine the physical and chemical parameters of reservoir water, Soil and plants from the sampling sites and compares these values with the WHO and other regulatory agencies standard
- Find correlation levels of heavy metals pollution and physicochemical Parameters in

reservoir water, soil and plants in the study area.

- Calculate the water quality index (WQI) using the weighted arithmetic index from the values obtained from the physical and chemical parameters in the study areas.

STUDY AREA

Kafin-Chiri dam is located in kano state . Its center lies at latitude of 11.6^0N and longitude of 8.8^0E and it has an elevation of 478 meters above sea level (Ahmed, 2008). It receives water from rivers Dudduru (at Garin Ali town), Zabaro (at Mai manda town) and Marmara (at Dakatsalle town).

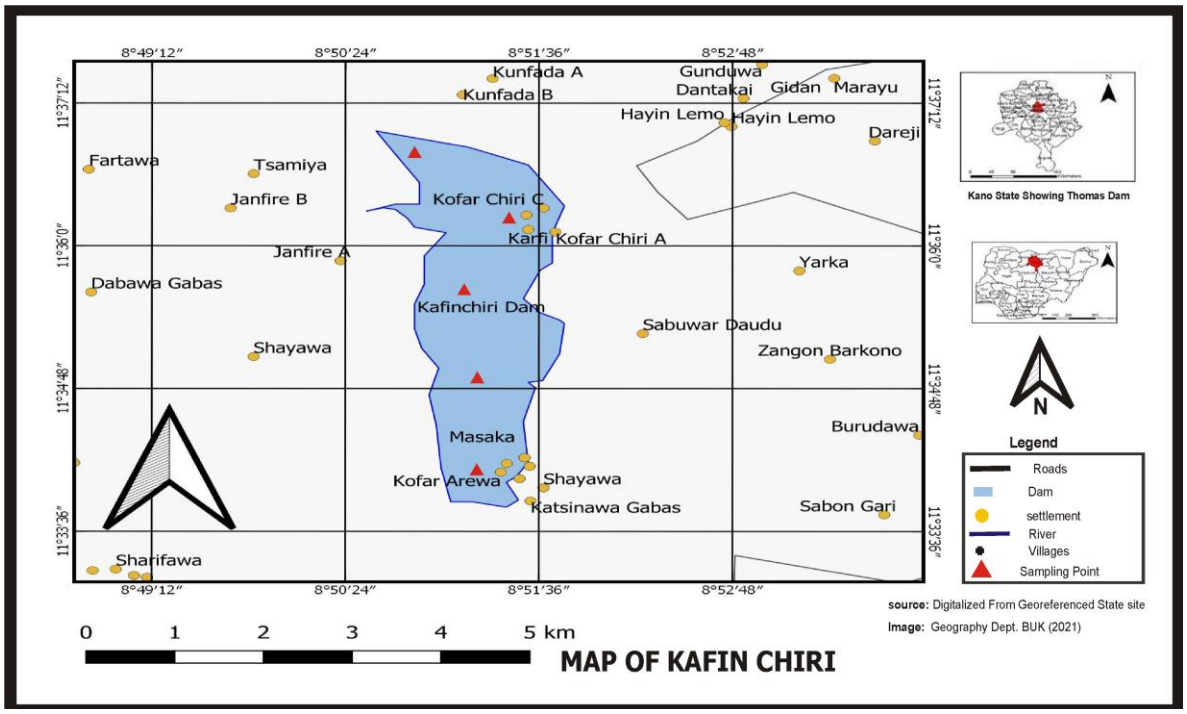

Fig. i: Map of Kafin chiri dam Showing the Sampling Sites (Source: Cartography Lab. Bayero University Kano, 2021).

MATERIALS AND METHOD

Sample Preservation and Storage

Samples were collected from Reservoir, Plant, and Soil in three season of the year using the method adopted by (Nollet, 2007).

Collection of Reservoir Water Samples

Water sample was collected within a depth of 20 cm into two separate pre clean plastic containers (Xiao Li *et al.*, 2006).

Collection of Soil Samples

A mild steel soil auger was used for soil sampling. Soil samples were collected at a depth of 15 cm from the top. All the soil Sample was subsequently air dried to constant to avoid microbial degradation.

Plant Analysis

The plant samples including maize (*Zea mays*), okra (*Abelmoschus esculentus*) and Spinach *(Spinacia oleracea)* samples were collected from different sample sites in an irrigated area. The samples were

collected both in dry and raining seasons of the years. (Garba *et al.,* 2014).

Physicochemical Parameters

Temperature, Total Dissolved Solids, Conductivity, Turbidity and Suspended Solids; pH, Total Hardness, DO, BOD, Cl^-, $N0_2^-$, $N0_3^-$, COD, and $P0_4^{3-}$ were analyzed using standard methods and procedures (Mustapha *et al.*, 2008), (NIS 2007). Some of the parameters were determined in the field using pre-calibrated hand held equipment. pH was measured using Jenway pH meter model 3505. DO was determined using water proof Jenway $D0_2$ meter model: 9200; conductivity, TDS and temperature were measured using HI ECi model No. 961. Turbidity was determined using Wagtech turbidity meter Wag WT 3020 model. The other parameters were brought to the laboratory for immediate analysis (Mustapha *et al.,* 2008). Chloride was measured in the laboratory by silver nitrate titration method. Suspended solid was measured gravimetrically after filtration. BOD was measured using HACH BOD Track meter model No. 205 by measuring initial and final BOD after incubation in the dark for five days. Nitrite was determined using sulphanilamide spectrophotometric method and Nitrate was determined by cadmium reduction method using HACH colorimeter model no. 890. COD was determined by dichromate oxidation method. Phosphate was measured using ascorbic acid molybdate spectrophotometric method (Mustapha *et al.,* 2008).

RESULT

The mean concentration of Physiochemical parameter was shown in table 1 parameter, seasonal variation was show in table 2

Table 1: Concentration of Physical Parameters

Season	DO	BOD	COD	T D S	S S	T S	TEMP	TBR	COLOR	TH	pHW	pHS	Con. S	Con. W
Rainy	4	2	50	44.3	164	190	34	140	200	50.6	8.8	6.16	522	60
Dry	1.7.0	2	30	44.5	2.45	50	34	142	320	35.4	8	5.98	772	90
Cold	1.4.0	3.3	27.9	30	2.14.0	48	30	125	350	115	7	4.28	561	90.6

Table 2: Seasonal Variation of Physical Parameters

Season	T D S	T S	COD	DO	S S	BOD	pH W	pH S	CON. S	CON. W	TEMP	TBR	COLOR	TH
Rainy	44.3	190	50	4	164	3.3	8.8	6.16	522	90.6	34	140	200	50.6
Dry	44.5	50	30	1.7	2.45	2	8	5.98	772	90	34	142	320	35.4
Cold	30	48	27.9	1.4	2.14	2	7	4.28	561	60	30	125	350	115

Key: TDS= Total Dissolved solid
TS= Total Solid
COD= chemical Dissolved oxygen
TEMP= Temperature
TBR= Turbidity
TH= Total Hardness

DO=Dissolved oxygen

S.S=Suspended solid

CON. S= Conductivity of Soil

BOD= Biological oxygen demand

pHW= pH of water

pHS= pH of Soil

CON. W= Conductivity of Water

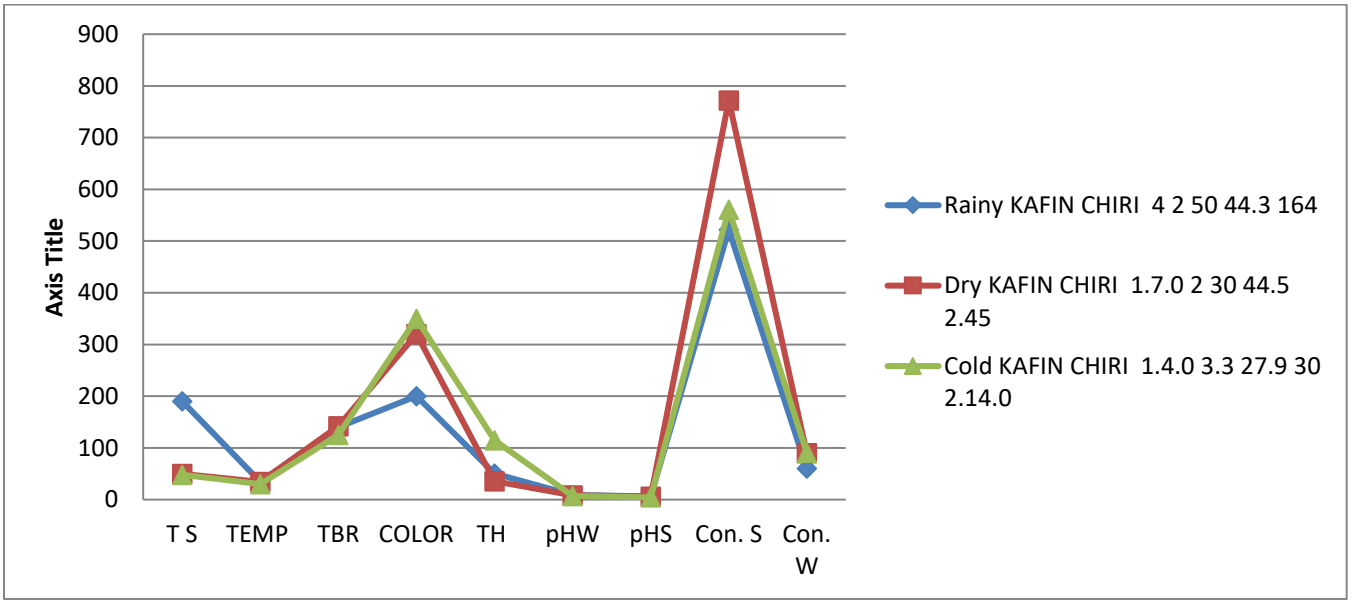

Fig ii: Mean concentration of Physical Parameters

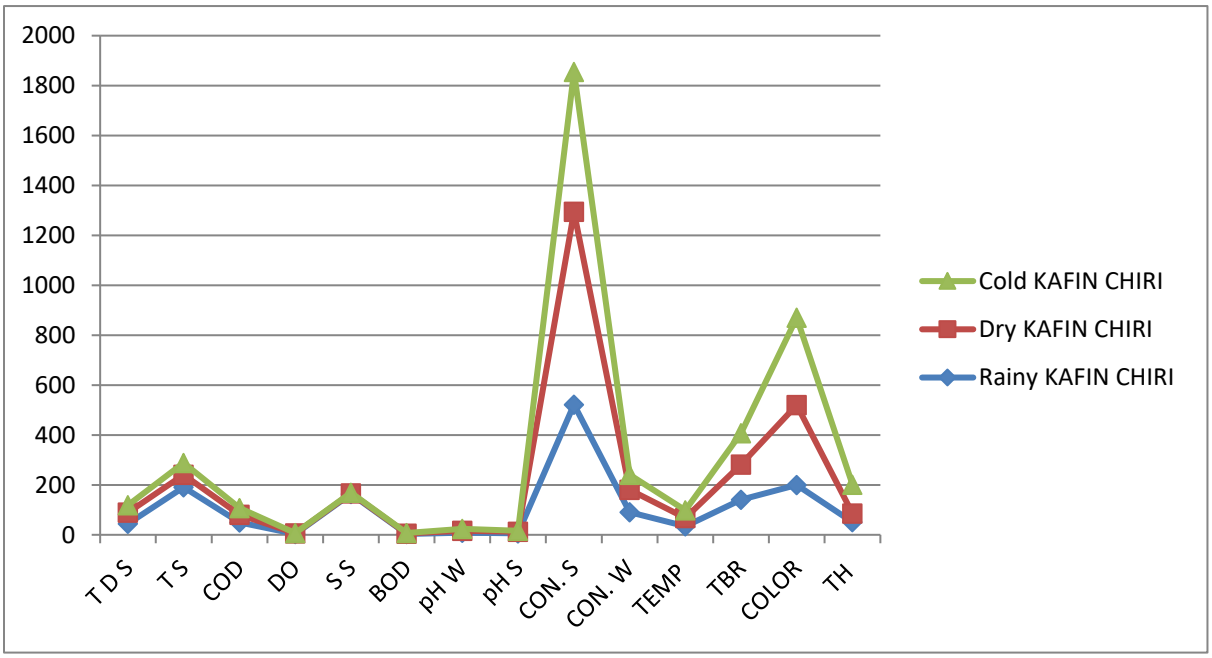

Fig iii: Mean Seasonal Variation of Physical Parameters

Chemical Parameters

Table 3 shows the mean concentration of Chemical parameters and table 4 shows the seasonal variation of chemical parameters

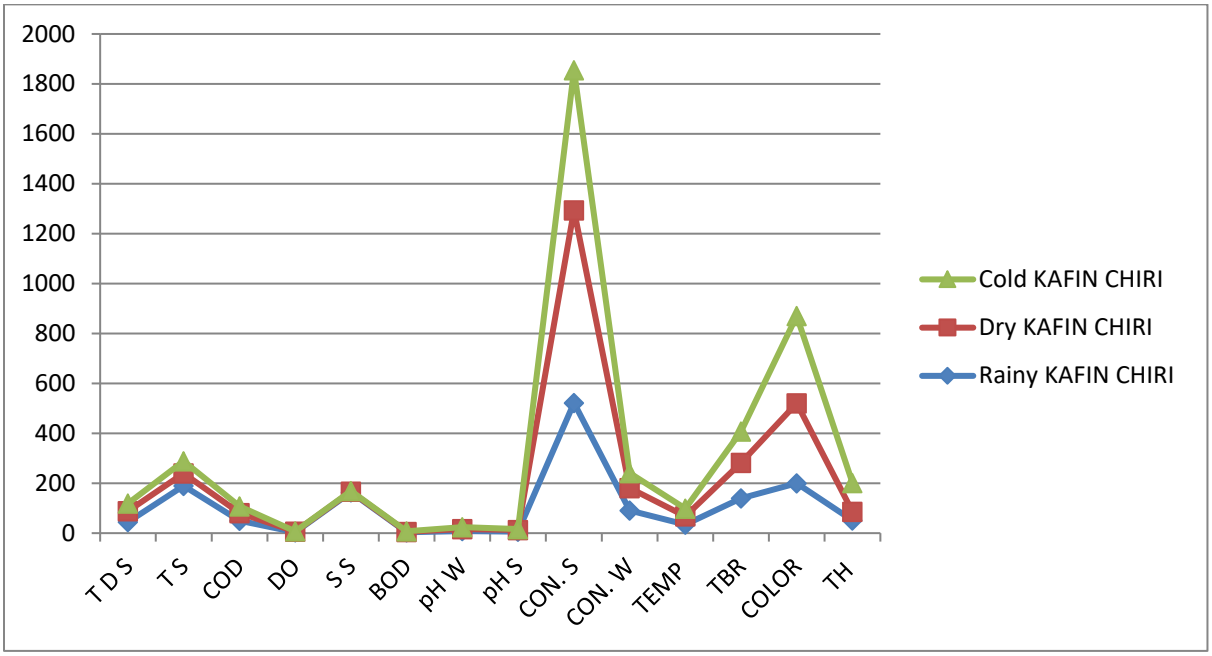

Table 3: Concentration of Chemical Parameters

SEASON	NITRITE	NITRATE	CHLORIDE	PHOSPHATE
Rainy	0.02	8.4	28.5	1.1
Dry	0.012	24.5	20.53	3
Cold	0.012	22.1	18.54	1.1

Table 4: Seasonal Variation of Chemical Parameters

Season	NITRITE	NITRATE	CHLORIDE	PHOSPHATE
Rainy	0.015	18.3	22.5	1.7
Dry	0.07	14	36.5	0.7
Cold	0.03	8.2	20.5	1.5

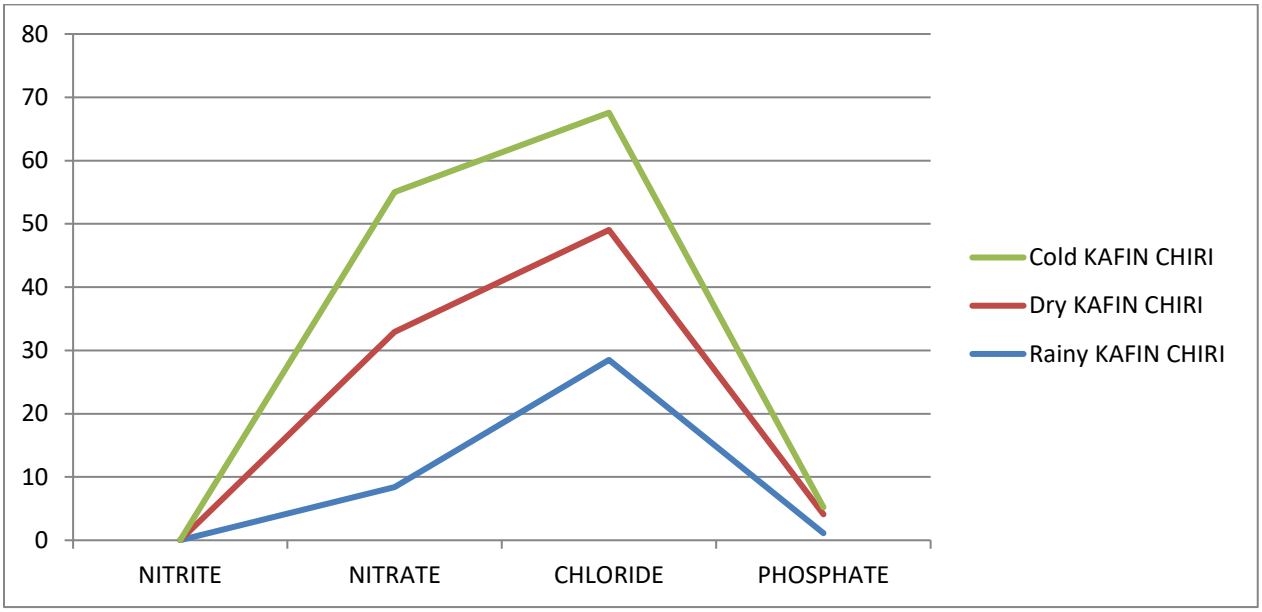

Fig iv: Mean Concentration of Chemical Parameters

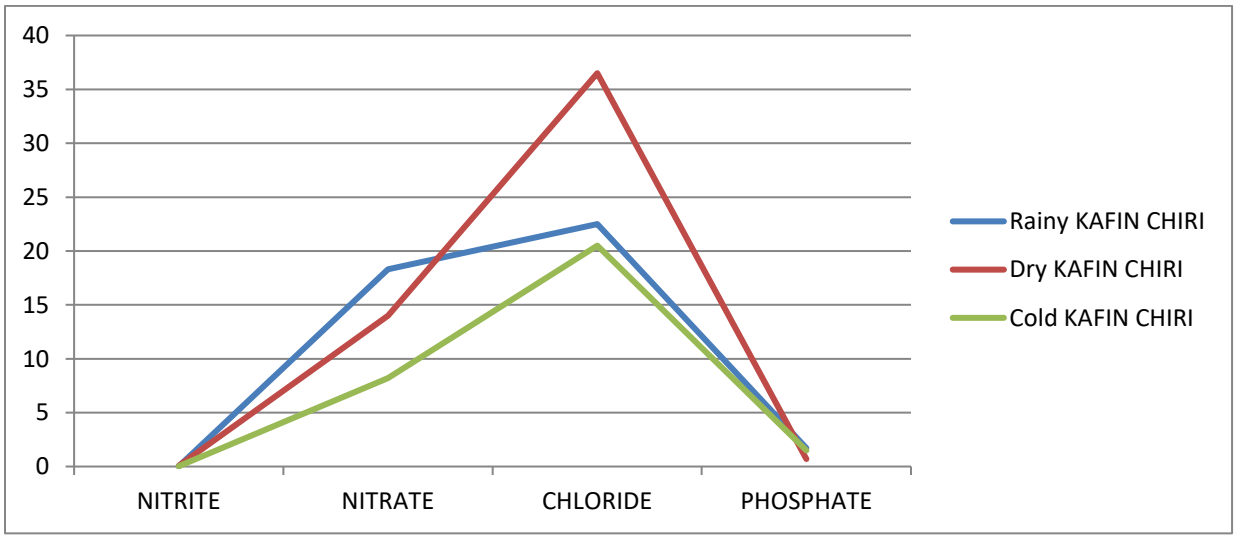

Fig v: Mean Seasonal Variation of Chemical Parameters

Heavy Metal in Plant

The mean concentration of heavy metal in plant (Maize, Okra and Spinach) Zn, Co, Cu, Cr, Ni, Pb, Cd, Mn, and Fe were shown in table 5 from three different seasons of the year

Table 5: Mean concentration of heavy metal in plant (Maize, Okra and Spinach) Mg/Kg

Plant	Season	Co	Cr	Cu	Ni	Pb	Zn	Cd	Mn	Fe
Spinach	Rainy	0.6	0.45	0.53	1.39	0.91	5.29	6.01	5.2	6.32
	Dry	0.68	0.6	0.69	2.02	0.67	6.63	5.01	6.87	7.2
	Cold	0.52	0.41	0.48	1.29	0.63	5.17	4.98	4.67	6.23
Okra	Rainy	0.94	0.64	4.24	1.13	1.1	3.26	2.56	1.78	3.01
	Dry	0.82	0.38	3.54	0.85	0.66	2.47	2.67	1.78	3.01
	Cold	0.78	0.4	3.1	0.69	0.65	2.21	2.12	1.26	2.47
Maize	Rainy	0.1	0.21	0.48	0.04	0.06	0.09	0.23	0.13	0.33
	Dry	0.06	0.12	0.23	0.02	0.418	0.056	0.12	0.1	0.21
	Cold	0.04	0.13	0.23	0.01	0.37	0.047	0.1	0.1	0.2

Table 6: Mean Seasonal Variation heavy metal in plant (Maize, Okra and Spinach) Mg/Kg

Plant	Season	Co	Cr	Cu	Ni	Pb	Zn	Cd	Mn	Fe
Spinach	Rainy	0.6	0.45	0.53	1.39	0.91	5.29	6.01	5.2	6.32
	Dry	0.68	0.6	0.69	2.02	0.67	6.63	5.01	6.87	7.2
	Cold	0.52	0.41	0.48	1.29	0.63	5.17	4.98	4.67	6.23
Okra	Rainy	0.94	0.64	4.24	1.13	1.1	3.26	2.56	1.78	3.01
	Dry	0.82	0.38	3.54	0.85	0.66	2.47	2.67	1.78	3.01
	Cold	0.78	0.4	3.1	0.69	0.65	2.21	2.12	1.26	2.47
Maize	Rainy	0.1	0.21	0.48	0.04	0.06	0.09	0.23	0.13	0.33
	Dry	0.06	0.12	0.23	0.02	0.418	0.056	0.12	0.1	0.21
	Cold	0.04	0.13	0.23	0.01	0.37	0.047	0.1	0.1	0.2

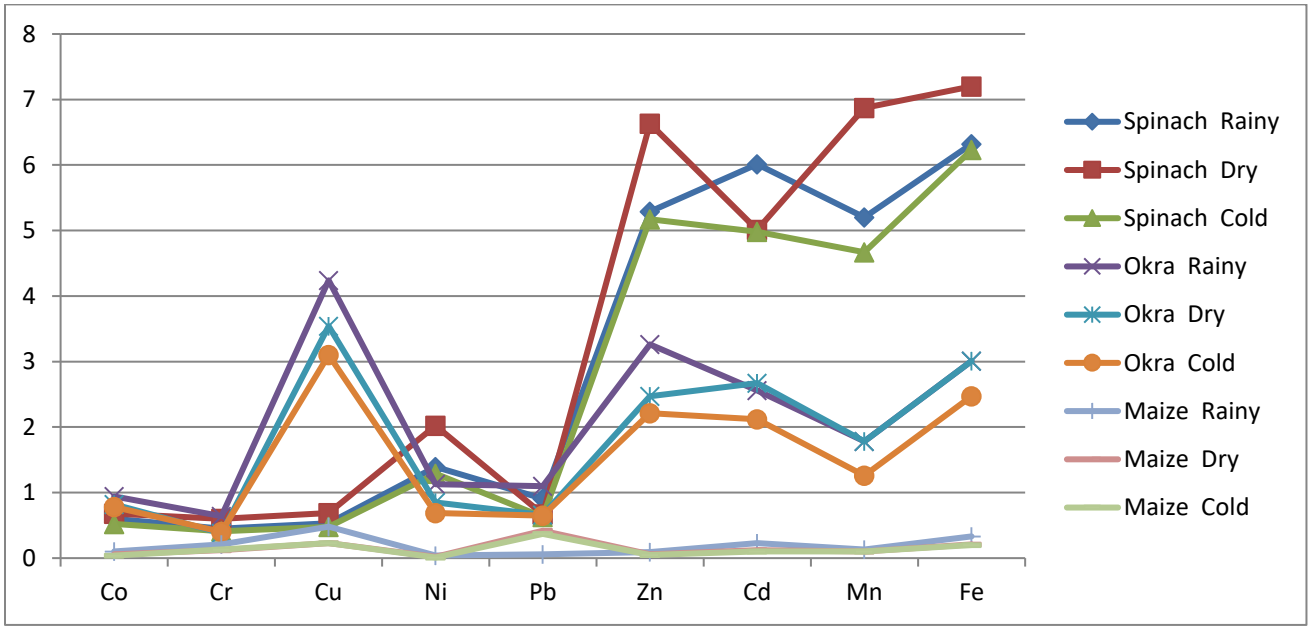

Fig vi: Mean Concentration of Heavy metal in Plants

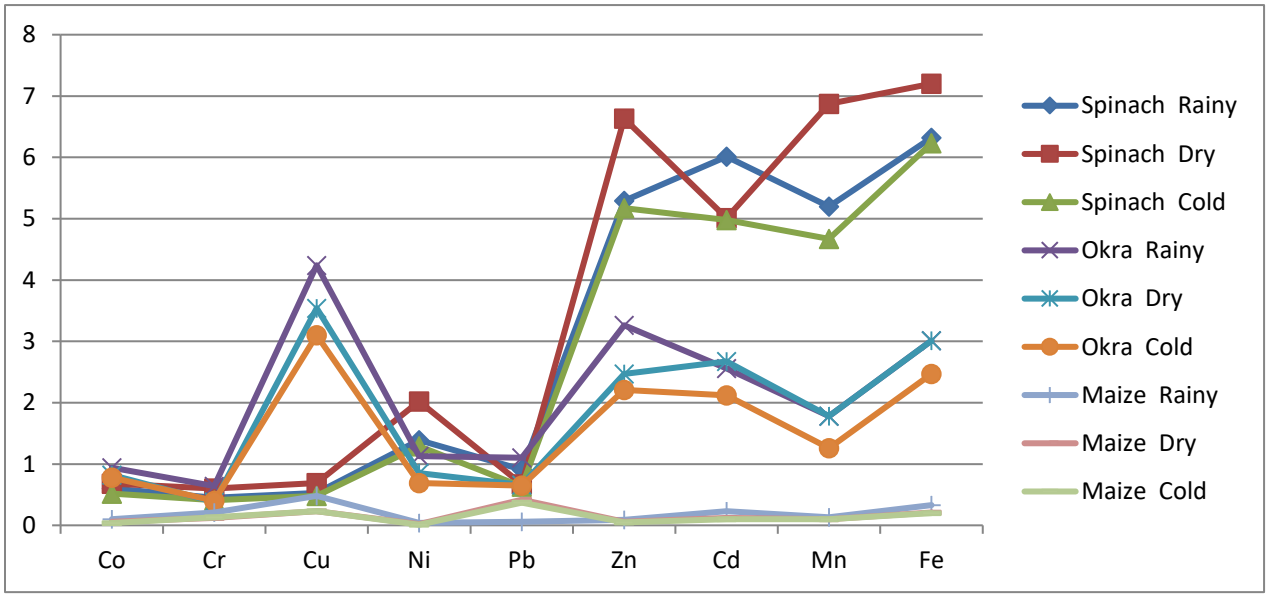

Fig vii: Mean Seasonal Variation of Heavy metal in Plants

Concentration of Heavy metal in Water

The results for the Heavy metal Concentration of water in Kafin-Chiri dam were presented in table 7 and 8

Table 7: Mean concentration of heavy metal in Water Mg/L

Season	Co	Cr	Cu	Ni	Pb	Zn	Cd	Mn	Fe
RAINY	0.73	0	0.07	0.12	0.045	4.2	0.06	0.7	3
DRY	0	0	0.061	0.34	0.197	0.1	0.03	0.28	4.2
COLD	0	0	0.058	0.11	0.12	2.5	0.02	0.51	1.2

Table 8: Mean Seasonal Variation of heavy metal in Water Mg/L

Seasons	Ni	Zn	Fe	Cu	Pb	Co	Cd	Mn	Cr
RAINY	0.12	0.1	3	0.07	0.045	0.73	0.06	0.28	0
DRY	0.34	4.2	4.2	0.061	0.197	0	0.03	0.7	0
COLD	0.11	2.5	1.2	0.058	0.12	0	0.02	0.51	0

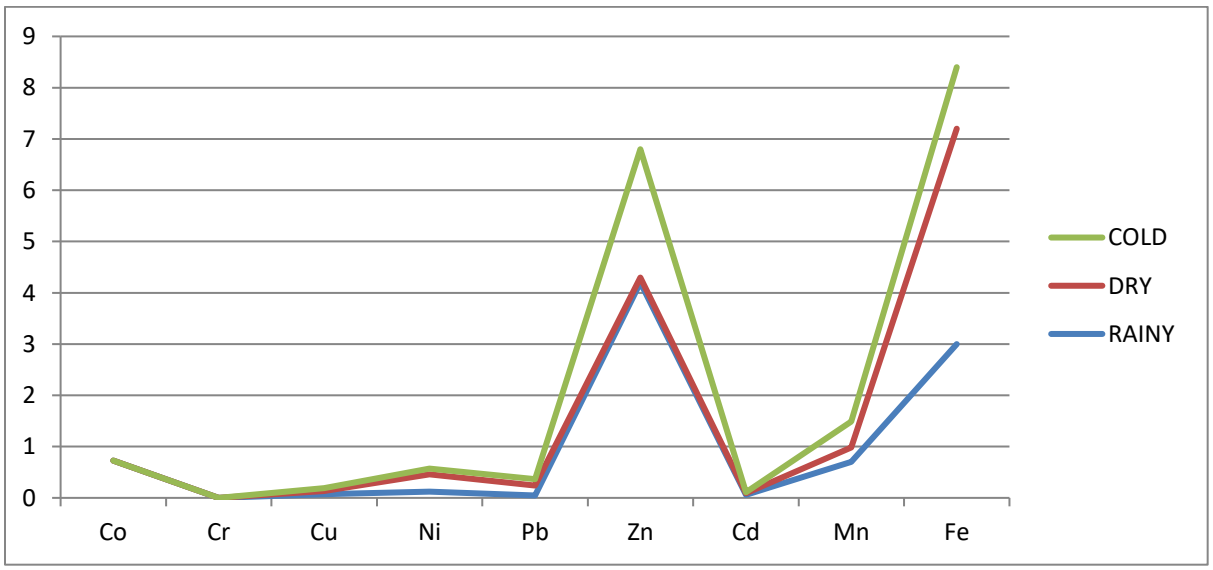

Fig viii: Mean Concentration of Heavy metal in Water

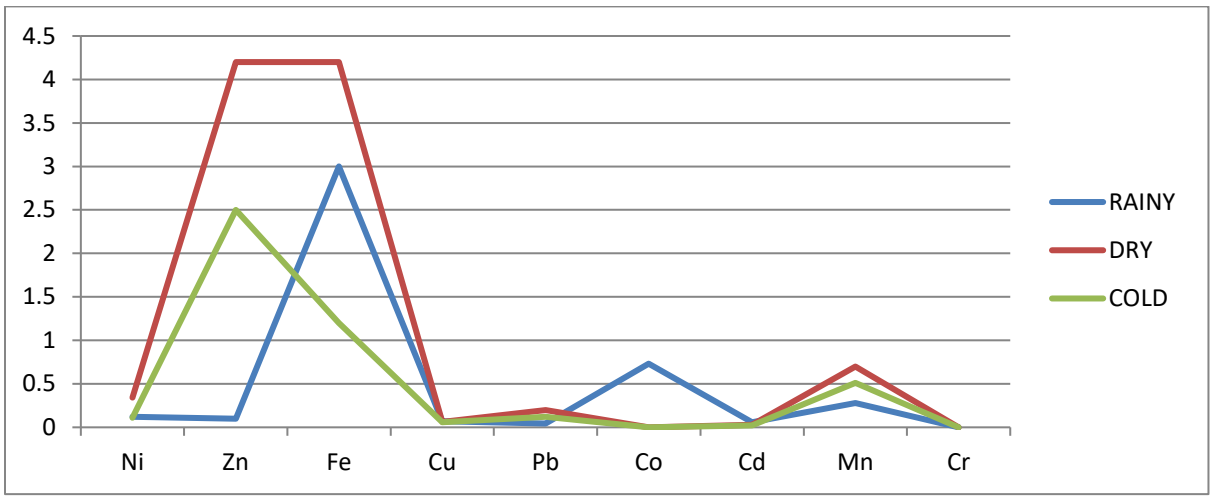

Fig ix: Mean Seasonal Variation of Heavy metal in Water

Heavy Metal in Soil

The concentration of heavy metals (Zn, Co, Cu, Cr, Ni, Pb, Cd, Mn, and Fe) in soil in Kafin-chiri dam for three seasons of the year were presented in Table 9-10

Table 9: Mean Concentration of Heavy metal in Soil

Seasons	Pb	Co	Mn	Fe	Ni	Cd	Zn	Cu	Cr
RAINY	0.35	0.02	0.65	8.9	0.02	0.021	0.46	0.1	0.2
DRY	0.9	0.02	1	14	0.02	0.02	1.2	0.2	0.35
COLD	0.3	0.21	0.57	8.4	0.019	0.02	0.4	0.1	0.22

Table 10: Mean Seasonal Variation of Heavy Metal in Soil

Seasons	Cd	Co	Cu	Fe	Ni	Pb	Zn	Mn	Cr
RAINY	0.02	0.02	0.1	8.9	0.02	0.35	0.46	0.65	0.2
DRY	0.02	0.02	0.2	14	0.02	0.9	1.2	1	0.35
COLD	0.02	0.21	0.1	8.4	0.019	0.3	0.4	0.57	0.22

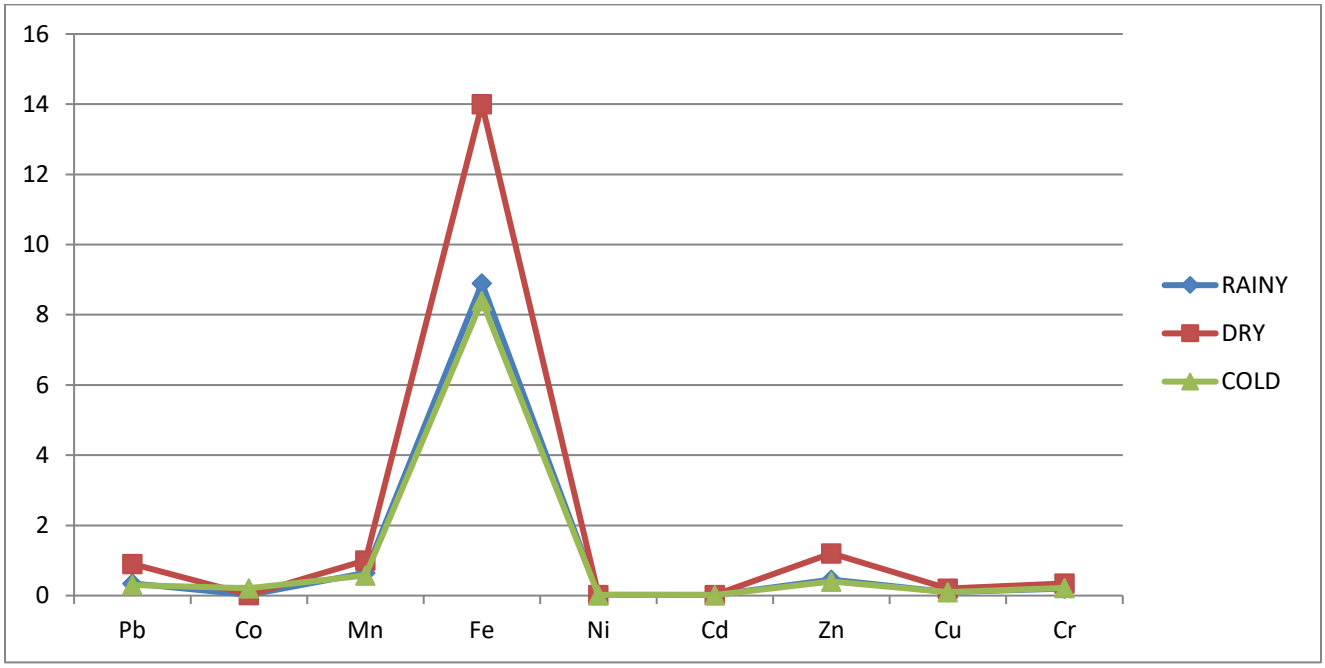

Fig x: Mean Concentration of Heavy metal in soil

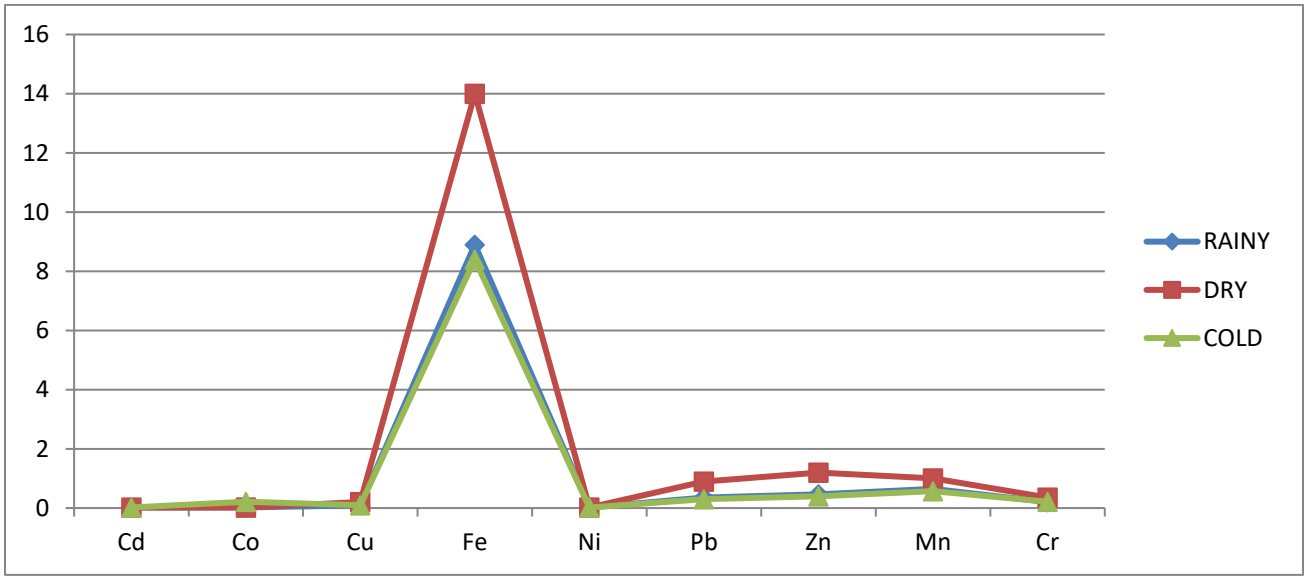

Fig xi: Mean Seasonal Variation of Heavy metal in soil

DISCUSSION

Physical parameters

The range of pH recorded during the study period was 6.5-8.5, the pH in the water body is slightly alkaline. The highest of 8.5 was obtained in august. The present findings are tandem with the findings of Akindele *et al.* (2013). Therefore, the recorded pH values are suitable for aquatic animals such as fish (Jahangir *et al.*, 2000). The pH recorded also Fall within the EU recommended range of 6 to 9 for fisheries and aquatic life (Akindele *et al.*, 2013) but above the WHO pH guideline for drinking water for

effective disinfections with chlorine (WHO, 2003). Similar values were also reported by (Nollet *et al.*, 2007) on assessing pollutant levels in Mario Jose tannery effluents from Kano metropolis, Nigeria.

Total dissolved solids and conductivity have mean range values of 44.3-60 (30-44.5) (mg/L) and (60-90.6) (IIScm^{-l}) respectively for the three seasons Fig II. The values obtained for both TDS and conductivity were found to be higher in dry and cold seasons due to low volume of the reservoir water (Figure II). The values recorded are much lower than WHO and EPA values for surface water 500mg/L and 100011Scm-l respectively. Conductivity indicates presence of dissolved ions in water. Water treatment process involves the use of flocculants to remove suspended and dissolved solids. Higher value for TDS is unpalatable and potentially unhealthy. The lower values for TDS and conductivity may be responsible for the soft nature of the water and excellent quality for drinking purpose. Similar values of conductivity were recorded by other researchers in similar environment. Mustapha (2008) recorded mean conductivity values of 80.41±0.8 to 178.8±2.0 µScm^{-1} in water quality assessment of Oyun Reservoir, Offa, Nigeria. Lower conductivity values were recorded by (Garba and Jamala, 2011) with a mean value of 54.28±12 nScm-1. Higher conductivity values were obtained by (Ishiaku *et al.*, 2011) with a range of 25 to 425 µScm^{-1} and a mean value of 141.30 µScm^{-1}.

Chemical Parameters

The result of chloride as shown in figure (iv) ranged from 18.54-28.5mg/L . The values obtained for chloride are within the range set by WHO (Stankovic, 2008) and NIS (Taiwo *et al.*, 2012).

Variation of Nitrate, Nitrite and phosphate in the reservoir reflect the effect of watershed and anthropogenic contamination around the reservoir. Mean values in the range of 0.02, 8.4, 28.5 and 1.1 Mg/L were obtained (Fig. IV). ANOVA ($P<0.05$) shows the values for Nitrate to be significantly higher in rainy season for all the three sampling sites. (Figure IV-V). Significant reduction in nitrate concentration is noticed at treated and potable water when compared with reservoir water. This work is in agreement with the work done by (Dan azumi *et al.*, 2010).

Color has a mean value that ranges from of 0.02 to 540.80 HAZEN. The large difference is as a result of values obtained at the treated and potable water which is very low compared to that obtained at the reservoir (Fig. IV). Similar results were obtained by (Xiao *et al.*, 2006). There is significant variation at $P<0.05$ between the three seasons (Figure IV).

Heavy Metal Concentration in Plant

The level of heavy metal analyzed in plant fall within the WHO limit and limnology, some of the heavy metals in plant are higher than the recommended values indicting the extent of pollution in the study location (Table 5-6). Eutrophication was noticed in the plant which is likely caused by excessive use of fertilizers and can cause serious pollution problem if unchecked. The problem of anthropogenic activities that probably come from rural and urban sewage, large- and small-scale industries, use of dumpsite as a sources of manure and indiscriminate waste disposal around the watershed should be checked before increasing to such critical level that threaten to health of humanity (Fig. VI-VII).

From the value obtain Fe have high percentage but when compared with FAO/WHO its below the permissible limit of 3.075 mgkg^{-1}. (FAO/WHO, 2001). This may be due to the evident in the case of the soil which could be attributed to the mobility of metals from dump sites to farmlands through leaching and runoffs. Fe is a common element in plants and humans. Thus, Fe has a relatively high WHO levels in food. Deleterious effects of daily intakes between 25-75 mg are unlikely in healthy persons (Ozkutlu *et al.*, 2011). The safety limit of Fe is high as coated by Nkansah *et al.*, 2010 (300 mg/kg). The recommended dietary allowance for Fe is in the range of 8-15 mg. High concentration of Fe can pose risk to the consumer.

Heavy Metal Concentration in Water

Some of the heavy metals in water are higher than the recommended values indicting the extent of

pollution in the study location (Fig. Viii-ix). The values obtained of heavy metals were higher in soil than in water. There is a marked variations of the metals analyzed with dry seasons having higher concentrations with significant variation p>0.05. The pollution comes from both natural and anthropogenic sources in all the reservoir water, soil and plant investigated. Effective water treatment process may however improve the quality of drinking water supply to urban and rural communities as observed in Kafin-chiri (Table 7-8).

Fe was consistently higher than the other metals there where statistically significance difference in the percent concentration between the sampling locations. Higher content of iron can be encountered due to the frequency of the elevated iron level in the earth strata related to the feeding aquifers. Leaching of iron salts (acid mine drainage) and iron product industrial waste may be a pollution source of iron (De Zuane, 1997).

Heavy Metal Concentration in soil

The values obtained of heavy metals were higher in soil than in water. There is a marked variations of the metals analyzed with dry seasons having higher concentrations with significant variation p>0.05. The results of heavy metals in soil seem to show no possibility of acute toxicity at the moment; nonetheless, continuous monitoring and implementation of pollution laws should be enforced. (Table 9-10)

The higher concentration of Fe may be due to influenced by other sources which include nature of area, industrial waste discharges, municipal domestic wastes, agricultural inputs, storm water run-off and atmospheric sources such as the hamattan dust (Sulaiman and Audu 2013). Leaching of iron salts (acid mine drainage) and iron product industrial waste may be a pollution source of iron (De Zuane, 1997). (Fig. X-XI)

CONCLUSION

Pollution comes from both natural and anthropogenic sources in all the reservoir water, soil and plant investigated. Effective water treatment process may however improve the quality of drinking water supply to urban and rural communities as observed in Kafin-chiri. Some of the heavy metals in water, soil and plant are higher than the recommended values indicting the extent of pollution in the study location. Eutrophication was noticed in the water, soil and plant which is likely caused by excessive use of fertilizers and can cause serious pollution problem if unchecked. The problem of anthropogenic activities that probably come from rural and urban sewage, large and small scale industries, use of dumpsite as a sources of manure and indiscriminate waste disposal around the watershed should be checked before increasing to such critical level that threaten to health of humanity. The results of heavy metals in water, soil and plant seem to show no possibility of acute toxicity at the moment; nonetheless, continuous monitoring and implementation of pollution laws should be enforced. Therefore, there is the need to continually monitor, control and take necessary policy decisions so as to limit and ultimately prevent these avoidable problems. However, in the meantime, farmers from the study areas are hereby encouraged to use well water for irrigation in their gardens instead of contaminated streams.

RECOMMENDATION

- It is therefore recommended that regulatory and statutory agencies such as NAFDAC, NASREA and SON should strengthen their legislation against indiscriminate and improper waste disposal along waterways,
- Dams inclusive. This will ease inflow and check contamination to a large extentPublic enlightenment should be carried out on the danger of indiscriminate disposal of waste in to water ways.
- Assessment should be carried out on local inhabitants of the reservoirs to ascertain the public health implications
- The study showed that there is a need for continuous pollution monitoring program of surface water and soils.
- Further research should be conducted on other irrigated crops around the reservoirs in

Kano state and sequential extraction be carried out to distinguish between the extent to which the different metals studied are hosted by all the non-residual fractions.

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