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Submissions must adhere to the following conditions:

1. The language of communication of the journal is English.
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3. The title and institutional affiliation of the Author(s) and an abstract of not more than 250 words and six key words should be included.
4. Manuscript submitted for publication must be original articles which have not been published in any other journal.
5. Empirical reports must be written under the following distinctive headings:
   i. Introduction – with background of study: statement of problem, Significance of the study and appropriate literature built in.
   ii. Objectives/purposes, Research Questions, Hypothesis.
   iii. Methodology – this should contain the following distinctive sub-headings:

(a) Population (b) Sample, (c) instrument, (d) Data collection and analysis techniques.

   iv. Results, findings and discussions.
   v. Conclusion and recommendation.
6. Non empirical reports must have:
   i. Introduction – that shows clearly the focus of the article.
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   iii. Conclusion with appropriate recommendations where necessary.
7. References Literature must be relevant, rich and current. Reference should be according to the American Psychological Association (APA) format.

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ASSESSMENT OF IRRIGATION WATER QUALITY OF KAKURI INDUSTRIAL AREA KADUNA, KADUNA STATE

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ABSTRACT

The study assesses the level of irrigation water quality of Kakuri industrial area within Kaduna metropolis in Kaduna State. River Kaduna is used for many purposes including irrigation, fishing and water supply. Sampling of irrigation water was conducted in December, 2016 and February, 2017. Waste-water samples at the point of discharge into the river were collected and analyzed. The range of temperature, conductivity, pH, Dissolved Oxygen (DO), Cd, Fe, Zn, Cr, and Pb levels in December along River Kaduna at different sampling points were 26ºC, 120.1-480.6 µS/cm, (6.4-6.9, 2.92-8.64, 0.0020-0.0266, 0.11-6.28, 1.54-1.60, 0.33-0.34 and 0.0316-0.1225) mg/l respectively. Similarly, the range of temperature, conductivity, pH, DO, Cd, Fe, Zn, Cr and Pb in February along the river at different sampling points were 26-27ºC, 100.8-322.0 µS/cm, (8.74-9.61, 6.0-7.64, 0.0011-0.0289, 0.12-3.28, 1.47-1.48, 0.31-0.35 and 0.0489-0.1606) mg/l respectively. It was observed that the level of heavy metals Zn, Cr and Pb in the Kaduna River have exceeded the maximum permissible limit (MPL) given by the National Environmental Standard and Regulatory Enforcement Agency (NESREA) and World Health Organisaton (WHO) for irrigation and drinking purposes. However, the level of Cd and Fe are within the MPL given by NESREA and WHO. Also, there is no significant variation in the discharge level of these pollutants between December 2016 and February 2017. As the treatment given to the raw water is the conventional water treatment, there is tendency of these pollutants to persist in water and its uptake may cause long term health implications. Therefore, it is recommended that further research should identify the sources of these pollutants with a view to mitigating them.

Keywords: Industrial effluent; Heavy metals; River Kaduna; Wastewater, Irrigation water

INTRODUCTION

Industries contribute to the sources of nation's income; thus, of great importance to the nation's economy. But industrial activities and processes have major environmental effects that have negative impact on the general wellbeing of human and aquatic lives living in or near the river due to the waste/effluent that are generated and discharged by the industries (Ajayi & Osibanji, 1981). The effluents often contain considerable amounts of pollutants and heavy metals that are toxic and hazardous. Heavy metals are priority toxic pollutants that severely limit the beneficial use of water for domestic and industrial application. They are non-biodegradable, toxic to living beings and tend to bio-accumulate in plants and animals, causing chronic adverse effects on humans (Petrus & Warchol, 2005).

Frequent use of heavy metals contaminated water in agricultural fields leads to soil pollution and gradually enriches the soil with heavy metals. Different studies have revealed that the presence of toxic heavy metals like Fe, Pb and Hg reduces soil fertility and agricultural output (Lokhande, 1999). Zenglu (1992) observed that while metals like Cu, Fe, Mn, Ni and Zn are essential as micro nutrients for plants, other

metals such as Cd, Cr and Pb are detrimental when present beyond a certain limit. With sufficient surface water infiltration, soil contaminants such as heavy metals can leach to underlying groundwater. The effects of heavy metals on groundwater are different for different types of soils. Occurrence of heavy metals in groundwater is also related to soil characteristics of the area where the water sources are located.

In irrigation, poor water quality with excess salts affects plants in many ways, but the most common problems are caused by salts which influence the osmotic relationship between roots and soil moisture. Irrigation water must have appropriate salt concentrations and be free of chemical and biological pollutants. High salts in irrigation water reduce plant growth and affect the structure, aeration, permeability and texture of soil.

MATERIALS AND METHODS

Study area

Kaduna state is located on the southern end of the high plains of Northern Nigeria, bounded by latitudes 9°03/, N and 11°32/ N and extends from the upper River Mariga on longitude 6°05/ E to 8°48/ E on the foot slopes of the scarp of Jos Plateau (Udo, 1970). Figure 1 shows the map of Kaduna River indicating the sampling points. Kaduna River is a tributary of the River Niger which flows for 550 km through Nigeria. The river is navigable only part of the year and is subjected to great seasonal fluctuations (Encyclopedia Britannica, 2005).

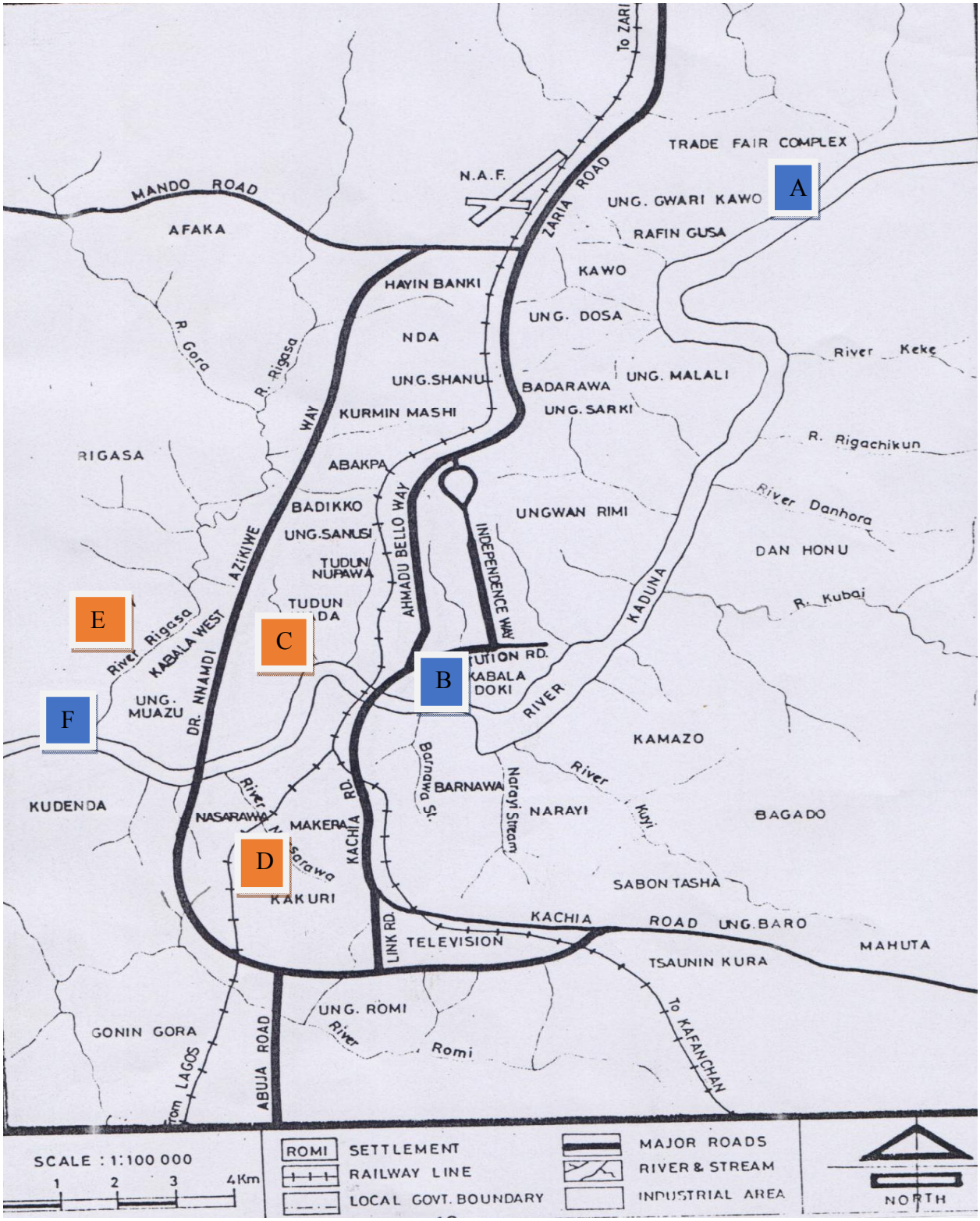

Figure 1: Kaduna metropolis showing different sampling points

Sampling technique

The study was carried out on River Kaduna. Station A is a point upstream where River Kaduna enters Kaduna Metropolis. Station A and B are points upstream, before effluent from Kakuri Industrial Estate starts polluting

the river and station F downstream, is a point where the River leaves the industrial area. Between the two reaches, wastewaters from Kakuri and Ungwan Muazu industries join the river. All points where wastewaters are discharged into the river were noted and sampling stations designated as station C to station E were established. Sample C is a wastewater discharge from (Peugeot, Tower Galvanized Product) in Kakuri. Sample D is a wastewater sample from Nigerian Breweries in Kakuri, Mutunci Plc and United Nigeria Textile Plc; it was collected some distance from the industries. Sample E is also a wastewater sample from Ungwan Muazu. Samples of industrial effluents at points of discharge into the river (i.e. samples C, D and E) and samples of the river at different points (i.e. A, B and F) along the river were taken. Tests were performed in the months of December 2016 and February 2017.

RESULT AND DISCUSSION

Figures 2 to 10 show the results of the river water quality as well that of the wastewater being discharged into the river.

Temperature

It was observed that the temperature does not change significantly along the river. The temperature was measured at the sampling points. The observed temperatures at the different sample locations were within the range of $\leq 40^0$C.

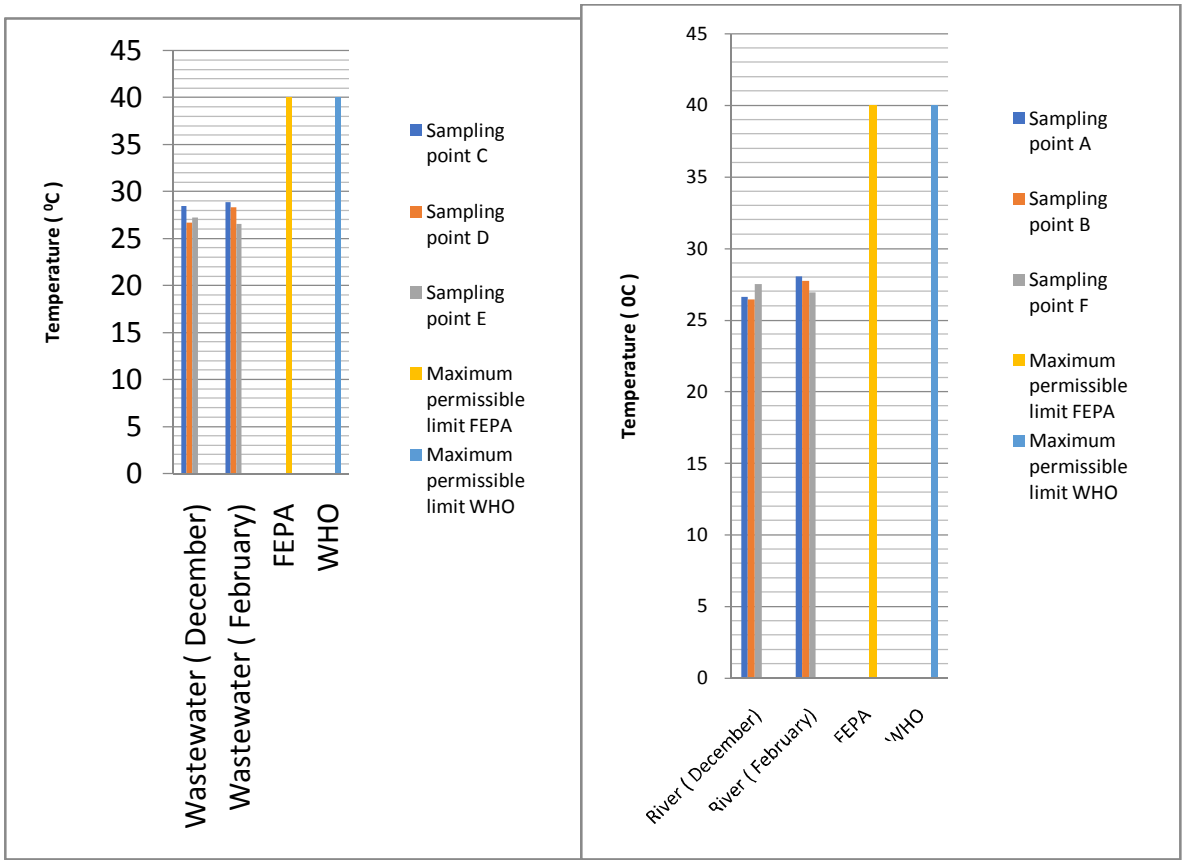

Figure 2: Temperatures of samples at different sampling points

Conductivity

The conductivity increases along the river from 173.033µS/cm at sampling point A to 440.933µS/cm at sampling point F in December 2016 due to increase industrial pollutions. The highest conductivity

796.4µS/cm was observed at sampling point C in December, the lowest 173.033 was observed at point A in February. The conductivity of all the samples fall within the range set by FEPA and WHO. For surface water, the conductivity was typically within the range 50–1000 µS/cm (Dojlido & Gerald, 1993). Some industrial waste water may have a conductivity value of several thousand µS/cm (Dojlido & Gerald, 1993).

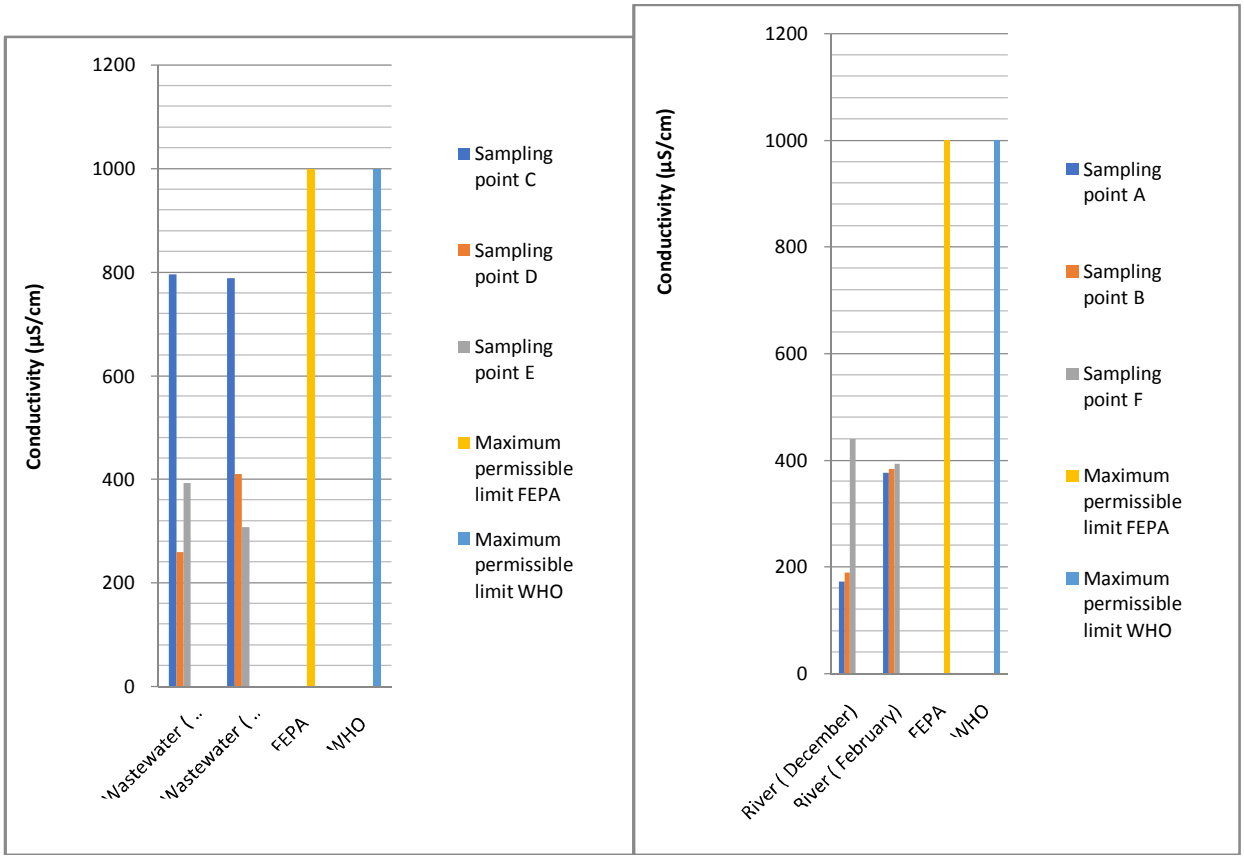

Figure 3: Conductivities of samples at different sampling points

pH

The pH levels at all the sampling point are within the range set by FEPA and WHO, except sampling point F 9.36 in February and sampling point C 4.64 in December. The normal range for pH in surface water systems is 6.5 to 8.5 (APEC, 2007).

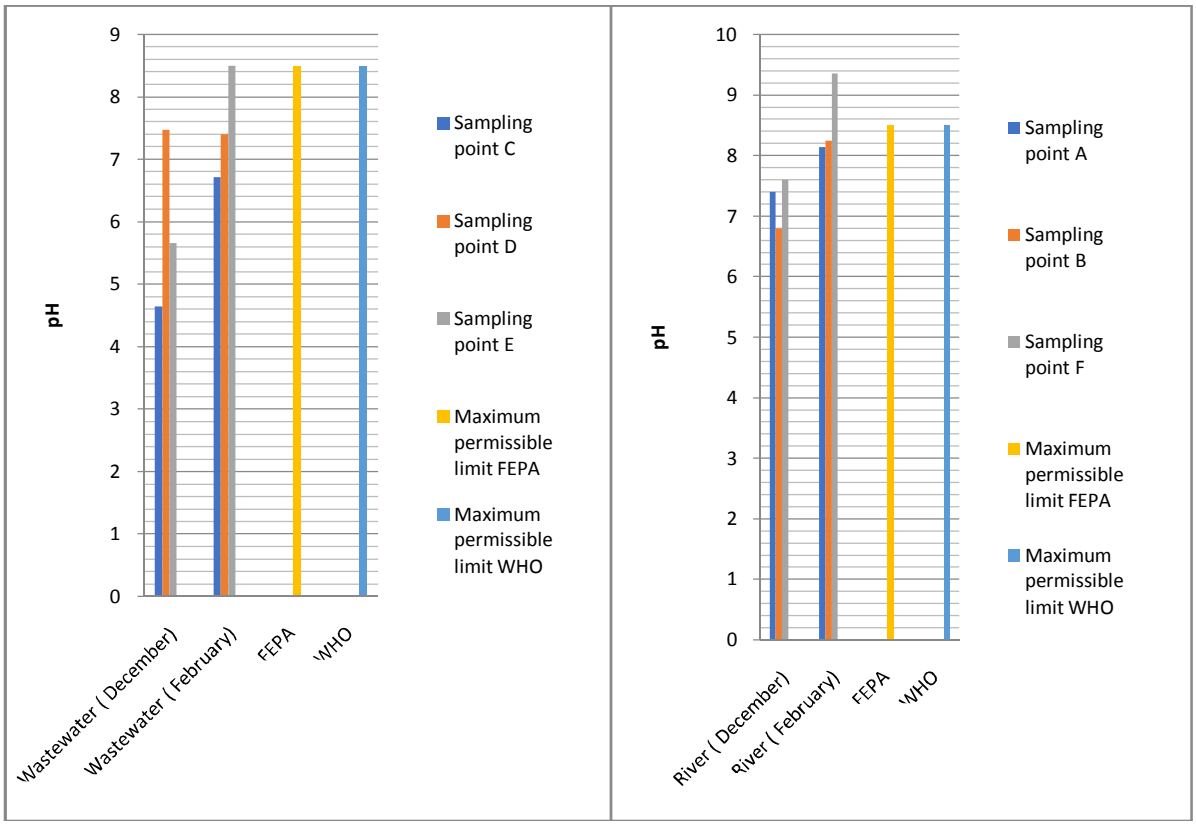

Figure 4: pH of samples at different sampling point

Dissolved Oxygen (DO)

The DO decreases along the river from 8.15mg/l at point A to 6.15 mg/l at point B to 3.79 mg/l at point F in December due to increase in pollution by the industries and this will cause the death of some aquatic animals. Similar trend was observed in February with DO decreases from 7.947 mg/l at point A to 6.633 mg/l at point F.

The highest was observed at point A in December 2016 and the lowest was observed at point F in December 2016. Except at sampling point A in December which falls within the range, the DO of some of the samples is below the minimum limit set by FEPA and WHO. The river and effluent can be used for irrigation purposes. In water bodies DO usually varies due to depth and time of day. The solubility of oxygen also decreases at higher temperatures and salinities.

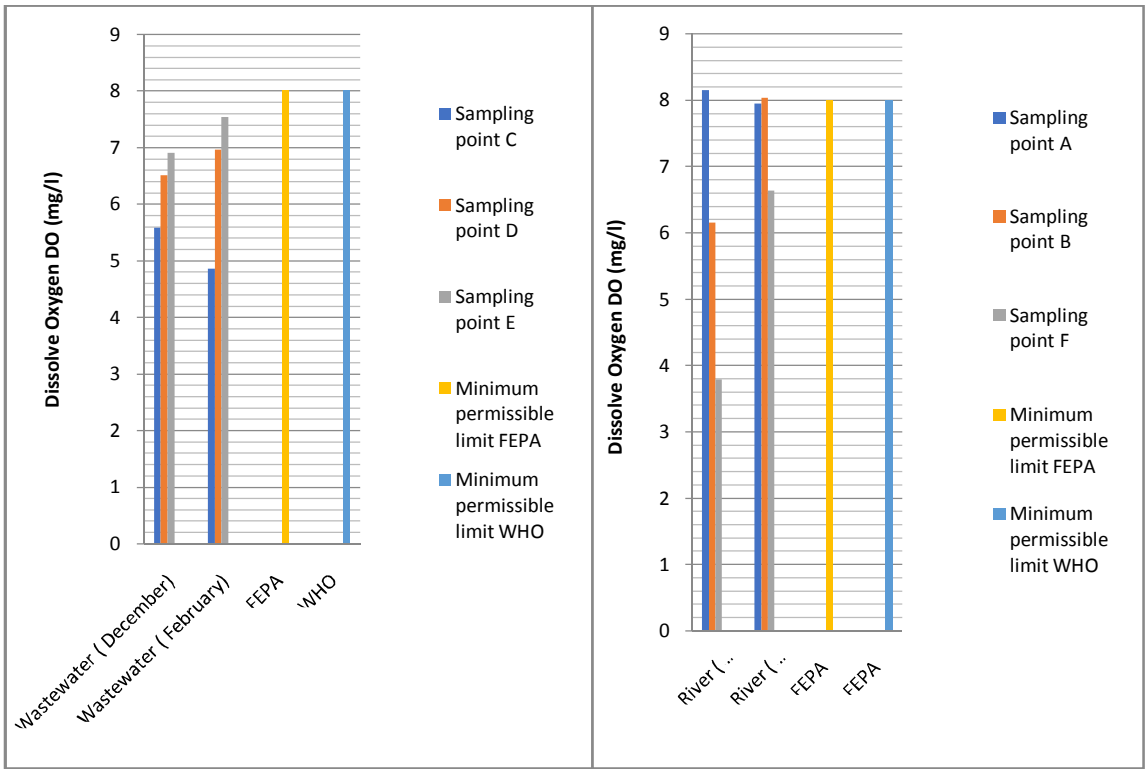

Figure 5; Dissolved oxygen in samples at different sampling points

Cadmium

The level of Cadmium in all the industrial effluents (C, D and E) exceeds the limit set by FEPA and WHO for drinking and irrigation purposes.

The level of cadmium in the river increases along the river from 0.002 mg/l at point A and B to 0.0266 mg/l at point F in December. Similar trend was observed in February 2017, with cadmium levels in the river increasing from 0.0011 mg/l at point A to 0.0289 mg/l at point F. The highest level of cadmium was observed at sampling point F in February 2017, due to increased pollution by the industries. The river water at point A and B in February and December are within the limit set by FEPA and WHO for drinking and irrigation purposes, the river at point A and B can be used for irrigation and drinking purposes. But the concentration at point F exceed FEPA and WHO limits, thus should not be used for irrigation because of high level of cadmium in it.

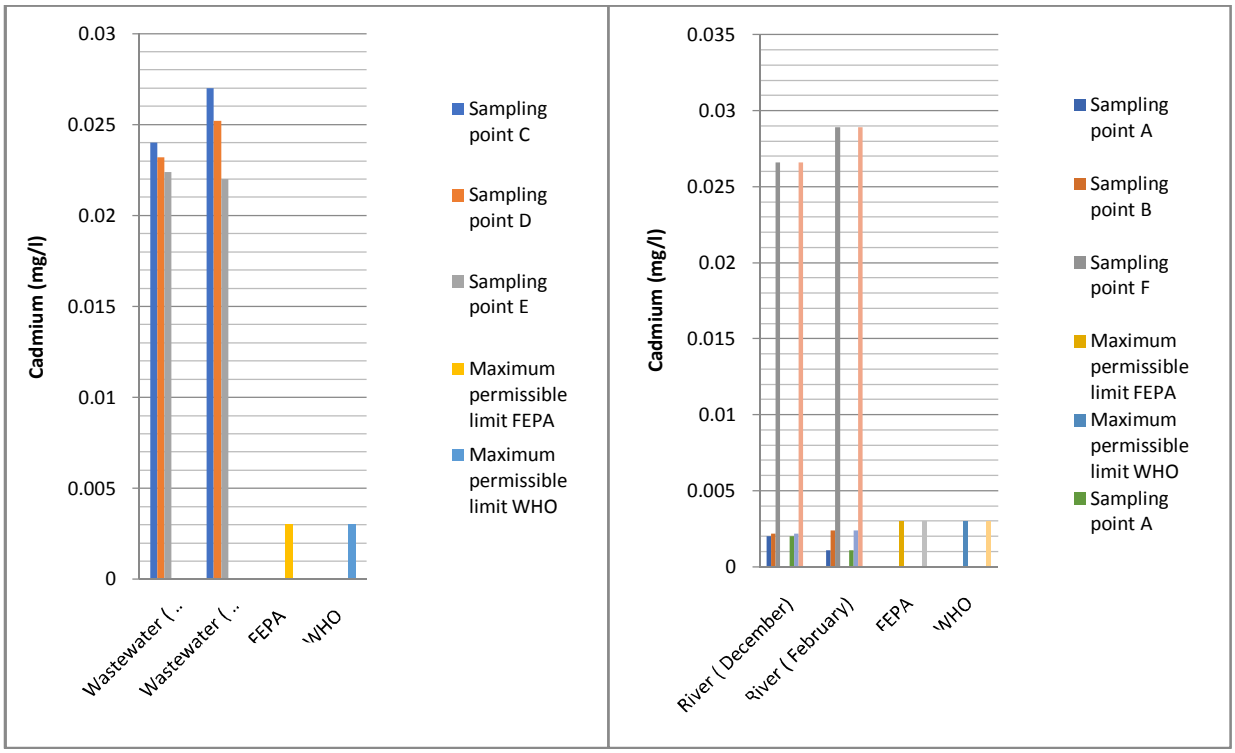

Figure 6; Concentration of cadmium in sample at different sampling points

Iron

The level of iron in industrial effluents (C and E) exceeds level set by FEPA and WHO for drinking purposes. The level of iron in effluents at sampling point D are within the limit set by FEPA and WHO for drinking and irrigation purposes. However the levels of iron in industrial influents do not exceed the limit set by FEPA and WHO for discharge in surface water.

The level of iron in the river increases along the river from 0.11 mg/l at point A and B to 6.28 mg/l at point F in December. Similar trend was observed in February 2017 with iron level in the river increasing from 0.78 mg/l at point A to 3.28 mg/l at point F. The river at point A in February, point B in February and point B in December are within the limit set by FEPA and WHO for drinking and irrigation purposes. The concentration at point F, point A February exceed level set by FEPA and WHO for drinking purposes because of high level of Iron in it.

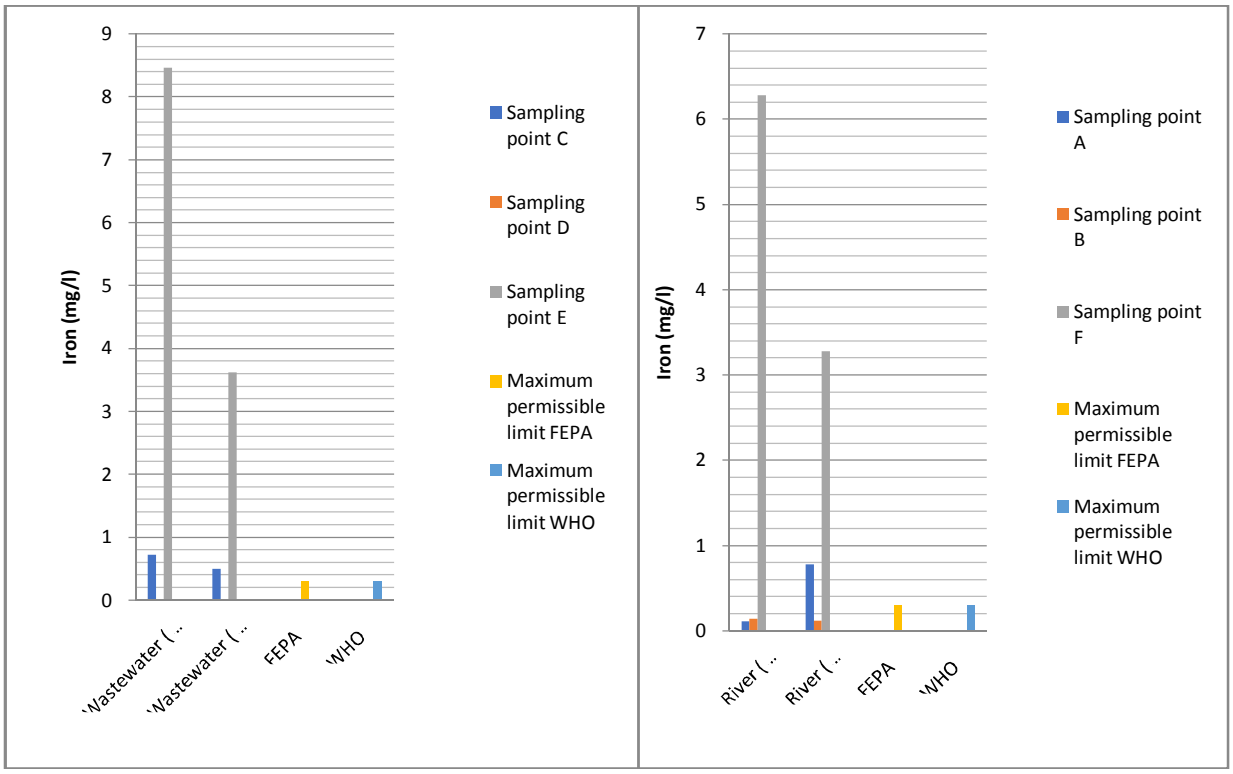

Figure 7; Concentration of iron in samples at different sampling points

Zinc

With exception of sampling point E in February 2017, all other sampling points exceed the limit set by FEPA and WHO irrigation purposes. The levels of zinc in industrial effluents exceed the limit set by FEPA and WHO for discharge in surface water.

The level of zinc in the river does not increase significantly along the river in December. Similar trend was observed in February.

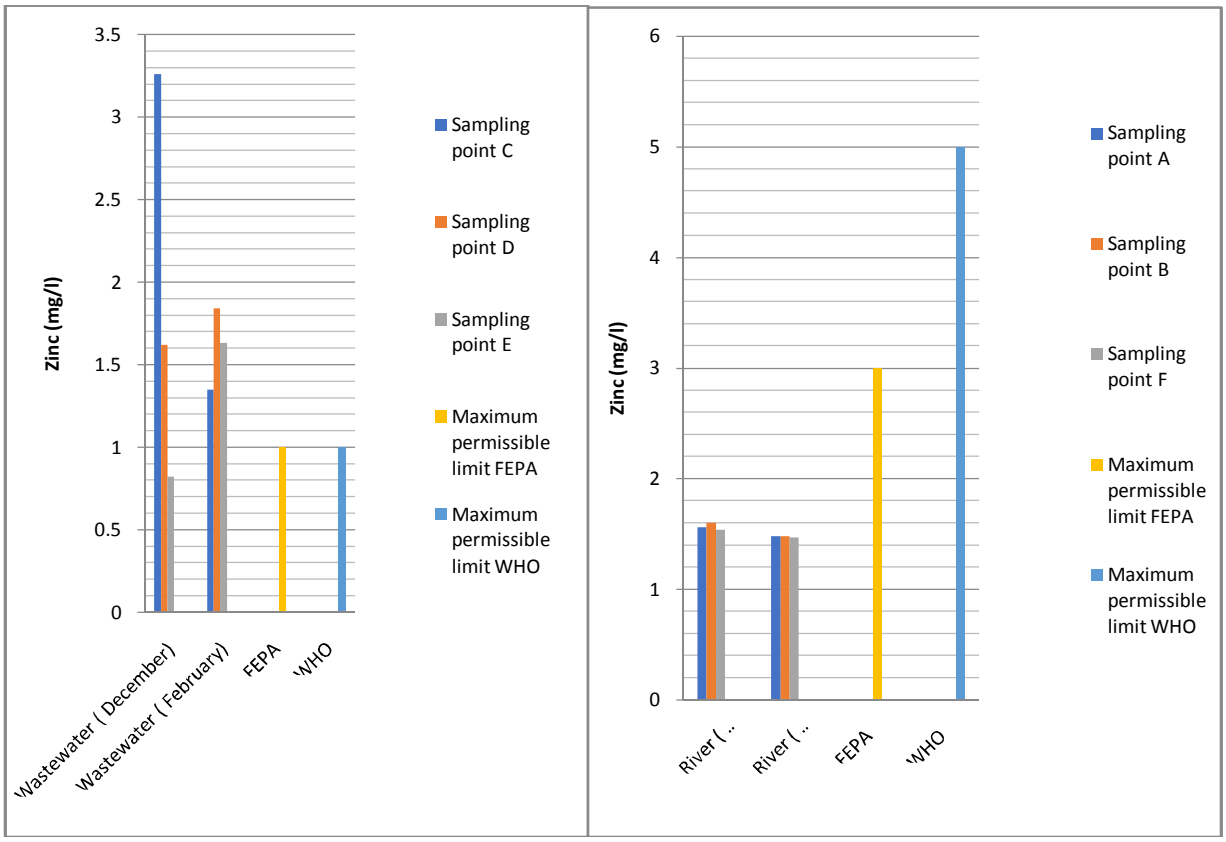

Figure 8; Concentration of zinc in samples at different sampling points

Chromium

The levels of chromium in industrial influents exceed the limit set by FEPA and WHO for discharge in surface water. It was found that the level of Cr at all the sampling points exceeds the limit set by FEPA and WHO for drinking and irrigation purposes, therefore the river, cannot be used for irrigation.

The level of chromium in the river decreases along the river from 0.34 mg/l at point A and B to 0.33 mg/l at point F in December, Similar trend was observed in February 2017 with chromium level in water decreasing from 0.35 mg/l at point A to 0.31 mg/l at point F. The highest level of chromium was observed at point E in February 2017.The lowest was observed at point F in February 2017.

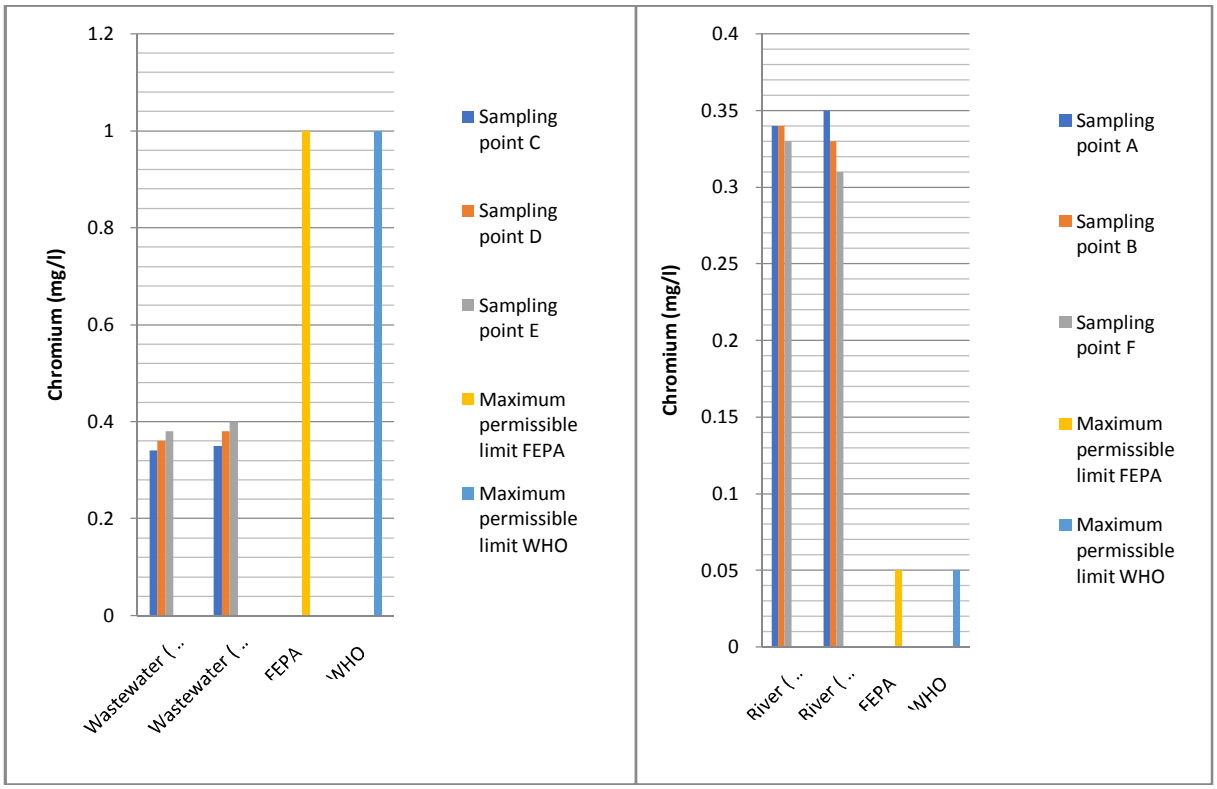

Figure 9; Concentration of chromium in samples at different sampling points

Lead

The level of lead in all the sampling point exceed the maximum limit set by FEPA and WHO for irrigation purposes but they are within the range set for discharge in surface water. The river as well as the industrial effluents cannot be used for irrigation.

The level of lead in the river increases along the river from 0.0322 mg/l at point A and B to 0.1225 mg/l at point F in December. It was observed in February 2017 with lead level in water increasing from 0.0972 mg/l at point A to 0.1606mg/l at point B and reduces to 0.0489 mg/l at point F. The highest level of lead was observed at point E in December 2016. The lowest was observed at point B in December 2016.

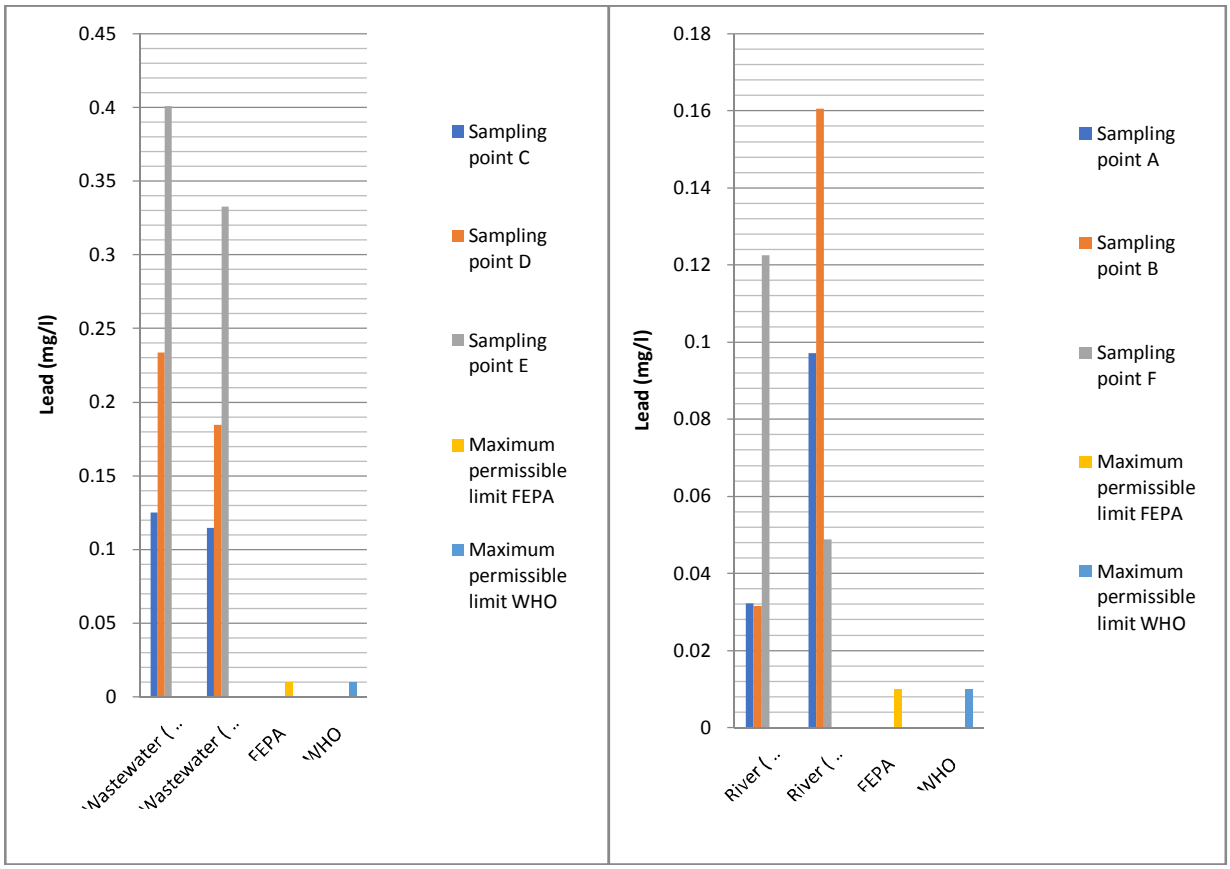

Figure 10; Concentration of lead in samples at different sampling points

CONCLUSION AND RECOMMENDATIONS

From the result of this work, the following conclusions can be drawn:

1. The levels of heavy metals discharge from industrial effluent are within the limit given by FEPA and WHO for discharge into surface water.
2. The level of heavy metals (Cr, Pb and Fe at point F) in the Kaduna River exceeded recommended limit set by NESREA and WHO for irrigation and drinking purposes. However, level of Cd is within the set limit.
3. The industrial effluents as well as the river are not suitable for irrigation purposes.
4. There is no significant variation in the discharge of these pollutants between December 2016 and February 2017.

It is recommended that further research should identify the sources of these pollutants with a view to mitigating them.

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