



Determination of the Pollution level from Industries within Kaduna Metropolis

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ABSTRACT

Samples were collected bi-monthly and averaged for the period of rainy and dry seasons, from six locations on the course of the Kaduna River; Kaduna North Water Works (KNWW), Kaduna South Water Works (KSWW), River Kaduna Bye-Pass Bridge (RKBB), Kudenda Village (KV), Ungwar Muazu (UM) and Kabala West (KW), also from four main industrial drainages; Makera Drain (MD), Kakuri Drain (KD), Romi Drain (RMD) and Rafin Dai Drain (RFD). In the assessments, physical and chemical parameters were analyzed during the rainy and dry seasons to meet, exceed or occur less than the NESREA or WHO guidelines. From the assessment during the rainy season, few chemical characteristics recorded their highest concentration; alkalinity and iron at the MD; while chloride and nitrate at the KD. However, the assessment during dry season; the following physical characteristics; turbidity and colour recorded their highest concentration at the KD and electrical conductivity recorded its highest concentration at the MD during the dry season. Also, temperature and total solids recorded their highest concentration during the dry season at the RKBB and UM respectively. In the assessment of the chemical characteristics during the dry season, the following recorded their highest concentration; pH, manganese, total hardness, cyanide and chlorine at the MD and DO recorded its highest concentration and lowest concentration at the KNWW and MD respectively. BOD, COD, ammonia and fluoride recorded their highest concentration at the KD. Zinc and aluminium recorded their highest concentration at the RMD. Cyanide also recorded its highest concentration at the RKBB. Phosphorus recorded their highest concentration at the KW and UM respectively. The upstream of the river is assumed to be relatively unpolluted, but as the flow progressed downstream, wastes were introduced or even dispersed due to dilution or self-purification, therefore indicating some temporarily changes in the river process

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INTRODUCTION

Environmental pollution by industrial revolution is a major problem facing the world today and there is an increasing awareness of the fact that the level of contaminant that finally enter into our water bodies need to be determined. Environmental pollution is an unfavorable alteration of our surroundings brought about particularly by the industrial activities which is majorly caused by

the kind of production they undertake. Industrial projects have a profound influence on society and the environment not only in terms of benefits but also in risks and hazards. Man has been paying the cost of destruction he has produced in his environment and in natural process throughout the centuries. It is exact to say that the industrial revolution of the 19th century is mainly responsible for environmental pollution. This environmental



pollution added by different industries is causing a great threat to human, animals as well as to plants and formed Industrial pollution (Kabir *et al.*, 2020). Environmental pollution by different types of industries occurs in different forms but can usually be thought of as gaseous and particulate pollutants that are discharged from different industries and become part of the earth's atmosphere. The gaseous pollutants of industrial polluted environment consist of sulfur dioxide (SO₂), different oxides of nitrogen (NO_x), ozone (O₃), carbon monoxide (CO), hydrogen sulfide (H₂S), hydrogen fluoride (HF) and diverse gaseous forms of metals (Kabir *et al.*, 2020). Such contaminants are released from large industrial estates such as fossil fuel fired power plants, smelters, industrial boilers, petroleum refineries and manufacturing facilities as well as from different industrial units. These toxic substances which cause damage to environmental balance, can cause injury to living organisms, producing respiratory diseases and reduce visibility (Kabir *et al.*, 2020). Different contaminants occur as toxic substances in the crust of earth or biosphere and anthropogenic activities such as mining, industry, agriculture and other such activities support their release into the environment, leading to toxicity (Fargasova, 1994). The Kaduna South houses the major industries mostly of the "wet" type. The four main drains are indicated below

Makera Drain

- Kaduna Textile Ltd
 - Chanchangi Oil Depot
- The United Nigerian Textile has cut down its production rate with about 52% while the Supertex Nigerian Plc with about 80%.
Nigerian Brewery Plc is in full operation.

Kakuri Drain

- Arewa Textile Ltd
 - Finetex Ltd
- In this drain, only the Federal Superphosphate Fertilizer Company is producing.

Rafin Dai Drain

The Kaduna Flower Mills has cut down its production with about 60% for now. The

Sunglass Company and International Breweries and Beverage Industry are in full operation

Romi Drain

All the industries in this drain are in operation except for Tower Aluminum which does not contribute any waste water flow and is shut down. Though the Kaduna Refinery and Petrochemical Company (KRPC) is in partial production, yet the volume of wastewater has not changed because of its constant turn around maintenance.

Also in the Kaduna South sector, are two major domestic drains which discharge wastewater into the Kaduna River. They are the Nassarawa Domestic Drain and the Rigasa Domestic Drain. So far the industrial and domestic drains act as point pollution sources which discharge wastes into the river. The Kaduna Polytechnic Farm is also of point pollution origin as it discharges Chemical Allied wastes into the river. Other sources of pollution into the river are of non - point origin (commercial, agricultural, domestic etc). They discharge wastes into the river via storm runoff. This research aims at determination of the Pollution level from Industries within Kaduna Metropolis.

MATERIALS AND METHODS

Study Area

Kaduna, a capital town of Kaduna State lies roughly on longitude 7°25' east of the Greenwich Meridian and latitude 10°30' north of the equator. The entire land structure of the state is mostly an undulating plain with parts like Zaria, Kagoro, Kwoi having protruding hard resistant granite rocks, (KEPA, 2 /2002).

Kaduna River takes its source from the Kujama Hills in the Jos Plateau. It has an elevation ranging from 1 200 m to 1 500 m and an annual rainfall of 1 500 mm. Its drainage basin underlain by the basement complex has a total catchment area of 82 300 km² with an annual mean runoff of 17.190 billion cubic meters of average runoff yield of 209 mm. From the Kujama hills, the river flows for about 210 km before reaching Kaduna town. Beyond Kaduna, it flows into the Shiroro dam for about 100 km, then for another 200 km after the Shiroro dam where it discharges into the River Niger on the northern shores of Pategi, (KEPA, 2 /2002).The study area is shown in Figure 1 – Map

of the Kaduna River Course from its Source to the River Niger

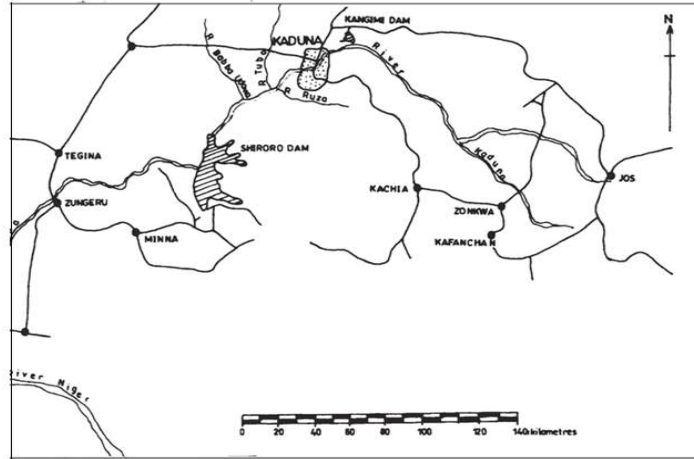


Figure 1: Kaduna River course from source to the River Niger Source: KEPA, 2006.

Sampling The water samples were collected at the main industrial drains. Figure 2 shows the Industrial Areas and Sampling Locations.

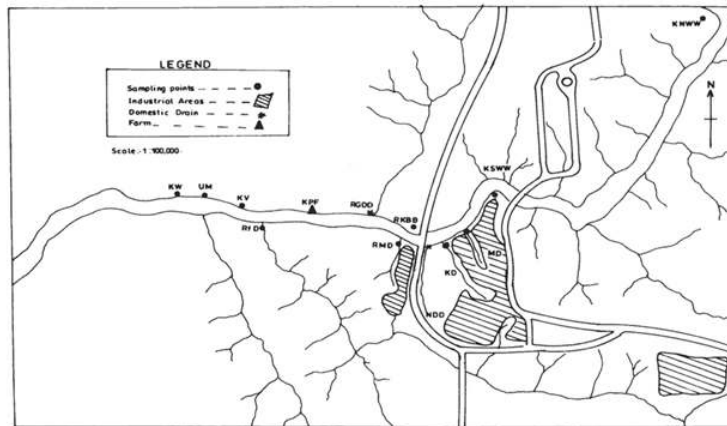


Figure 2: Industrial areas and sampling locations Source: Fieldwork, 2006.

The sampling locations are explained as follows:

- i. Downstream of the river at Kaduna South Water Works (KSWW) intake structure
- ii. Analysis was carried out at the point of industrial effluent discharge in the four major drains
- iii. Further analysis was conducted downstream of the Kaduna South Water Works (KSWW) at the point of industrial effluent discharge by the River Kaduna Bye-

Pass Bridge (RKBB). The Makera Drain and Kakuri Drain are located before the RKBB while the Romi Drain and Rafin-Dai Drain are after the RKBB.

- iv. Samples were also collected downstream of the bridge at community settlement by the River: Kudenda Village (KV), Ungwan Mu'azu (UM), Kabala West (KW).

Samples must represent the body of water from which it is taken. There must not be



any significant change in the samples between the time of collection and analysis. Based on this, the following requirements contained in the Quality of Domestic Water Supplies, Department of Water Affairs and Forestry, Pretoria-South Africa's Assessment Guide (1998), Sampling Guide (2000), and Analysis Guide (2001) were satisfied in the collection of water samples for analysis:

- i. Suitable plastic sampling bottles thoroughly washed and sterilized using an ultra violet (UV) light. The plastic bottles were used for the collection of the samples.
- ii. Every sample bottle was clearly labeled for easy identification.
- iii. Care was taken to avoid accidental contamination of the sample during collection and subsequent handling before the analysis.
- iv. The samples taken were not exposed to light and kept cool in an insulated container and taken to the laboratory instantly.
- v. The sample taken at mid-stream, where complete mixing is assumed to have taken place.

Analysis of Sample

In the analysis of water, there are various parameters in the water sample that may meet, exceed or occur less than the WHO guide for portable water and also NESREA interim guide for surface water, hence it is necessary to analyze water samples. The methods of water sampling analysis for the determination of parameters were based on the standard methods of operating the apparatus used for the examination of water and wastewater samples

Equipment

The apparatus for the analysis of each parameter are as follows:

- Digital Turbid meter
- Dissolved oxygen meter with electrodes
- Lovibond comparator with colour disc.
- Digital Thermometer
- Lovibond Conductivity meter SD 70
- Lovibond pH meter SD 50
- Multi-parameter bench photometer with indicators C 99 & C200 Series

- Hach Spectrophotometer
- Retort stand and clamp
- Bunsen burner
- Electronic Weigh Balance
- Autoclave
- Incubator
- Filter papers (11cm)
- Dessicator

Glass Wares (PYREX mode)

- Beakers (50ml, 250ml, 500ml)
- Burette (25ml, 50ml)
- Pipette (25ml)
- Conical flask (250ml, 500ml)
- Calibrated cylinders (50ml, 100ml, 250ml, 500ml)
- Funnel (50mm ϕ)
- Evaporation dish (100mm ϕ)
- Test tubes (25ml)
- BOD bottles (100ml)

Experimental Procedures

The procedures for each experiment are as specified by the instructional manuals of the equipment/apparatus.

RESULTS AND DISCUSSIONS

The results of the physical and chemical characteristic of the sample collected are presented in the Figure 1 – 23.

Physical characteristics

Turbidity

The turbidity of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 1. For the rainy seasons, highest concentration of turbidity was recorded in September with 170NTU at the RKBB and the lowest concentration of 52NTU was recorded in June at the KNWW. For the dry season, highest concentration of turbidity occurred in November with 93 5NTU at the KD and the lowest concentration occurred in March with 24.5NTU at the KNWW. This result indicates that higher turbidity was obtained at rainy seasons than the dry seasons. The WHO maximum permissible concentration of 25 NTU recommended is only achieved KNWW during the dry season.

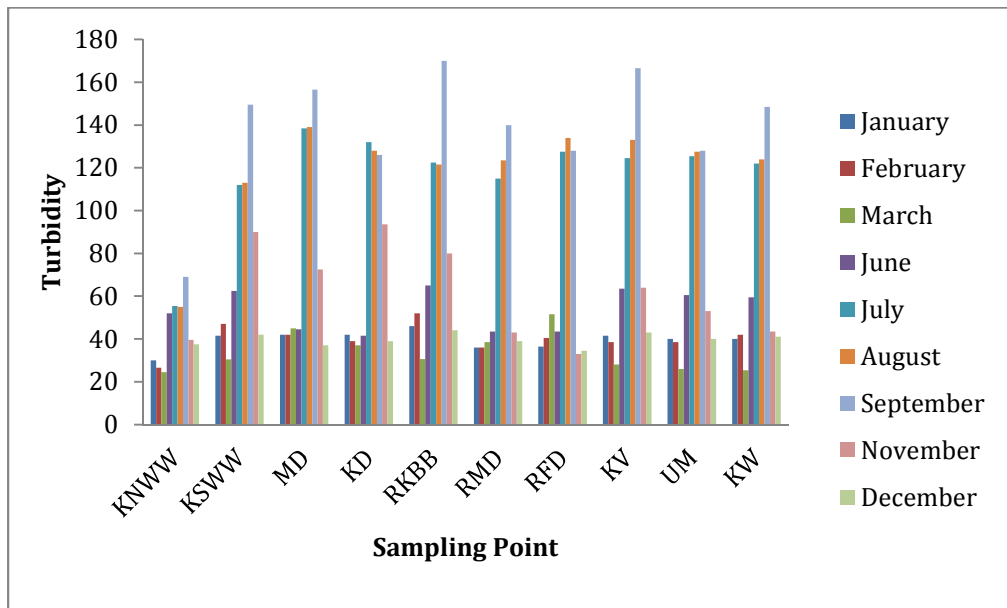


Figure 3: Variation of Turbidity across various sampling point for both wet and dry season

Temperature

The temperature of the entire sample collected within both rainy season and dry season for all the sample point is shown in Figure 2. For the rainy seasons, highest temperature of 36.5°C was recorded in June at the KD while the lowest temperature of 25.2°C was recorded in July at the KNWW. For the dry season, highest temperature of 42.6°C was recorded in March at

the KD while the lowest temperature of 24°C was recorded in November at the KNWW. This result indicates that higher temperature was obtained at dry seasons. All values obtained falls within the less than 40°C recommended by NESERA Interim effluent limitation guidelines for surface water except values obtained at MD and KD recorded at March.

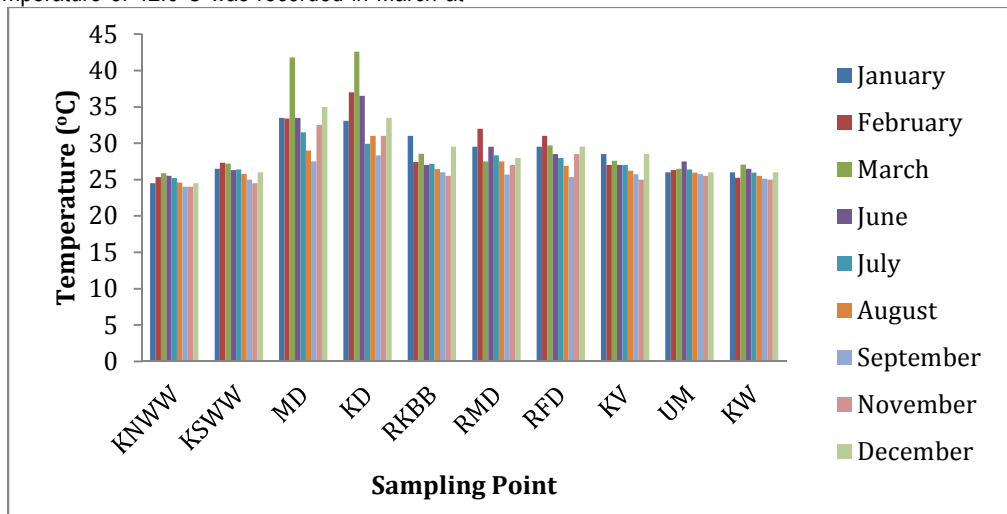


Figure 4: Variation of Temperature across various sampling point for both wet and dry season

Colour

The value of colour for sample collected within both rainy season and dry season for all the sample point is shown in Figure

3. The values obtained are all above 7 H⁰ recommended by NESERA Interim effluent limitation guidelines for surface water.

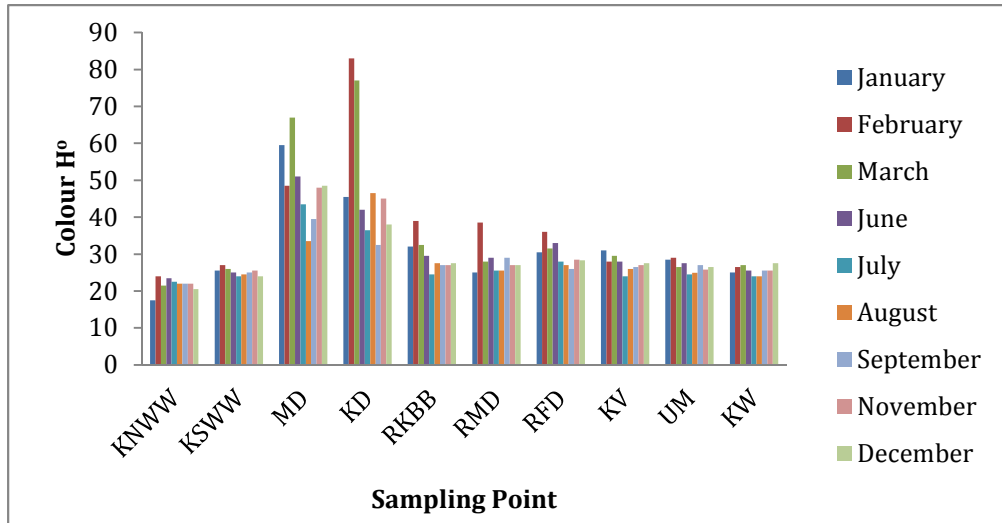


Figure 5: Variation of Colour across various sampling point for both wet and dry season

Electrical Conductivity

The value of Electrical conductivity for sample collected within both rainy season and dry season for all the sample point is shown in Figure 4. The highest concentration of electrical conductivity, 4525µm/cm occurred in June at the MD while the lowest electrical conductivity of 352.5µm/cm occurred at the KNWW. Only

samples from KNWW, KSWW and KW fell within the maximum value of 2000 µm/cm as recommended by NESERA Interim effluent limitation guidelines for surface water but all other samples are above the maximum permissible values and these are obtained in dry the season.

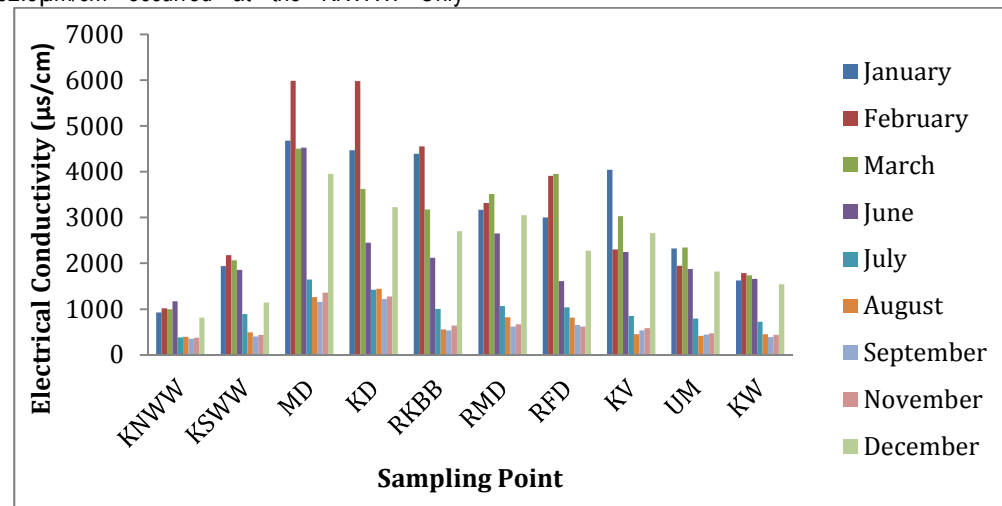


Figure 6: Variation of Electrical Conductivity across various sampling point for both wet and dry season



Total solid

The total solid of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 5. The total solids recorded 352.5mg/l of highest concentration which occurred in August at the KV

and the lowest concentration of 115mg/l occurred in July at the KNWW. The WHO maximum permissible concentration of 500 mg/l recommended was achieved for all samples tested.

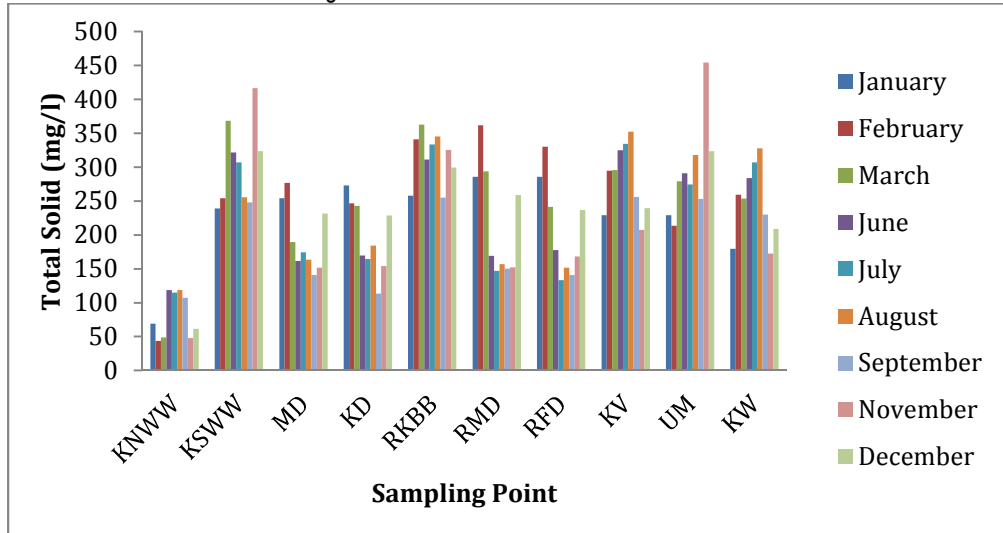


Figure 7: Variation of Total Solid across various sampling point for both wet and dry season

pH

The pH of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 6. The highest pH value of 10.9 was recorded in March at the MD while the lowest value of 6.6 was recorded in

November at the KD. The WHO maximum permissible concentration of between 6.6 and 9.2 recommended was achieved for all samples tested except for values obtained at MD in the month of February and March.

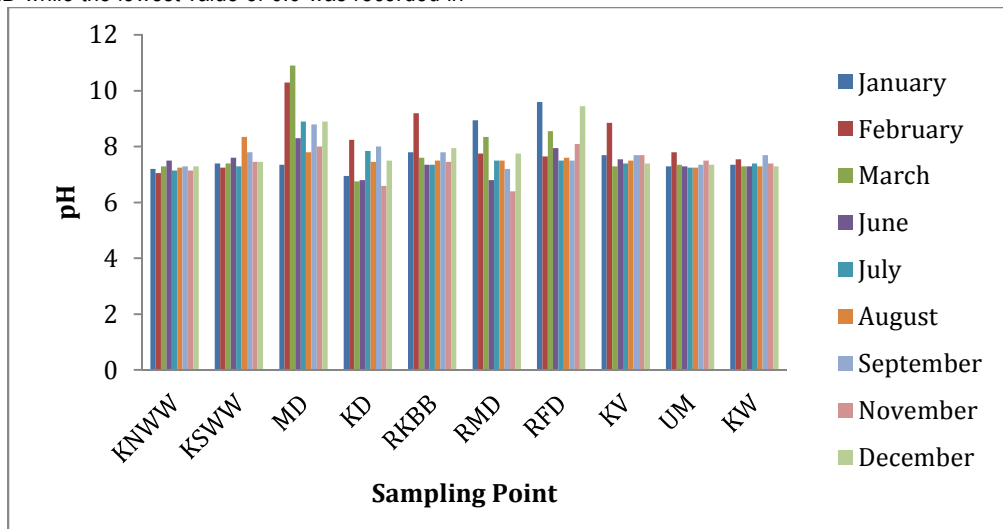


Figure 8: Variation of pH across various sampling point for both wet and dry season

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Alkalinity

The Alkalinity of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 7. For the rainy seasons, alkalinity recorded 680mg/l as highest concentration in July at the MD while the lowest concentration occurred in June and July with 49mg/l at the KNWW. For the dry season, alkalinity recorded the highest concentration of 599mg/l in November at the RFD and the lowest

concentration of 101.5mg/l also in November at the KNWW. This result indicates that higher alkalinity was obtained at rainy seasons than the dry seasons. The NESERA Interim effluent limitation guidelines for surface water maximum permissible concentration of 500 mg/l was exceeded in both rainy and dry season for samples gotten from MD and RFD.

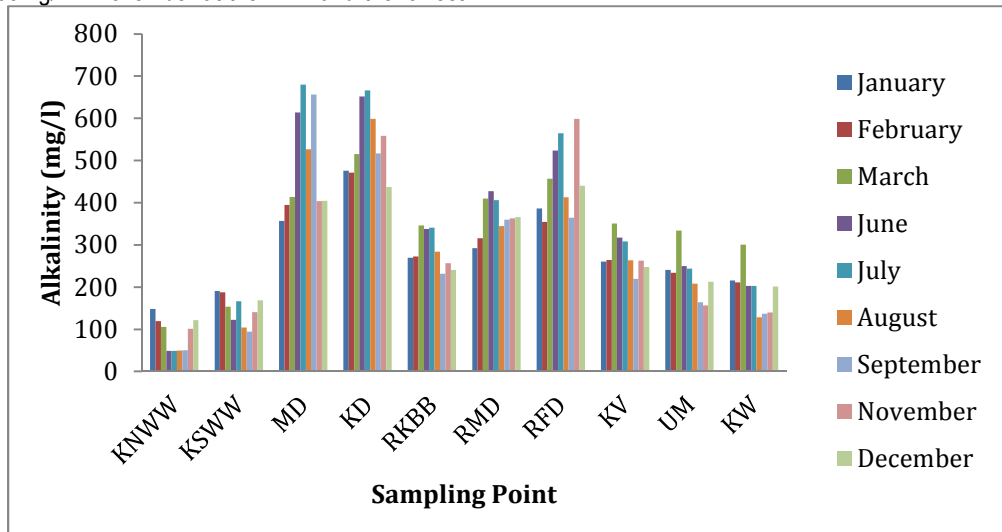


Figure 9: Variation of Alkalinity across various sampling point for both wet and dry season

DO

The DO of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 8. For the rainy seasons, DO record its highest concentration of 7.9mg/l in July and September at the KNWW and the lowest concentration of 2.3mg/l in June at the KD. For the dry season, DO record the highest concentration of 14.85mg/l in December at the

KNWW and the lowest concentration of 1.15mg/l in February at the MD. This result indicates that higher DO was obtained at dry seasons than the rainy seasons. The NESERA Interim effluent limitation guidelines for surface water specified that the value should not be less than 4.0 mg/l. Most of the samples tested met the NESERA requirement.

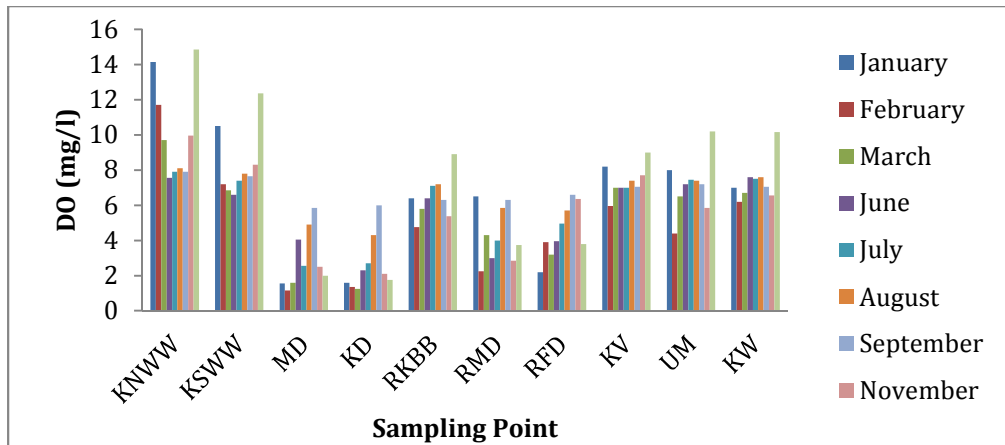


Figure 10: Variation of Dissolve Oxygen across various sampling point for both wet and dry season

Chloride

The Chloride of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 9. For the rainy seasons, highest concentration of chloride at 492.85mg/l was recorded in June at the KD while the lowest concentration of 88.9mg/l was recorded in September at the KNWW. For the dry season, Chloride recorded the highest

concentration of 421.85mg/l in November at the MD and the lowest concentration of 86.725mg/l also in November at the KNWW. The values obtained for all the samples are lower than the maximum permissible value of 600 mg/l specified by NESERA Interim effluent limitation guidelines for surface water.

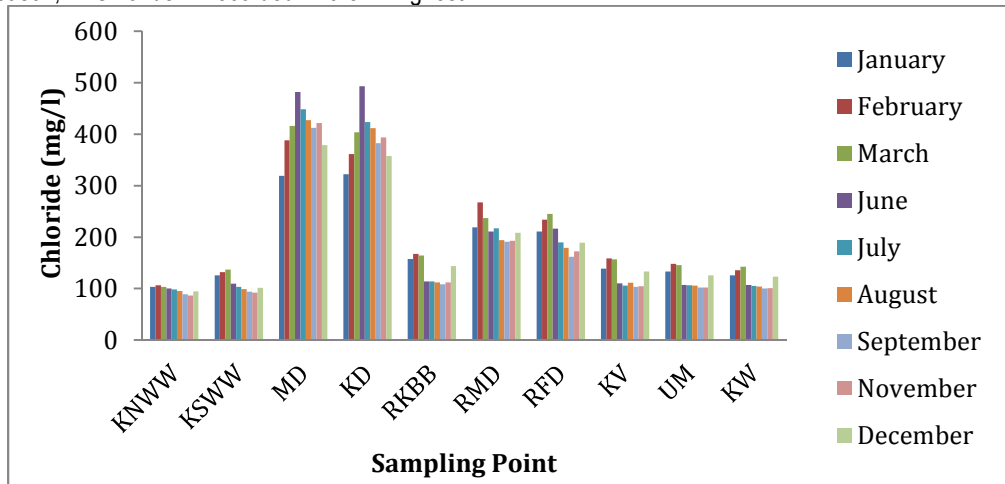


Figure 11: Variation of Chloride across various sampling point for both wet and dry season

Nitrate

The Nitrate of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 10. For the rainy seasons, Nitrate recorded the highest concentration of 68.65mg/l in June; it occurred at

the KD and recorded its lowest concentration of 9.05mg/l in September at the KNWW. For the dry season, highest concentration of nitrate occurred in November with 49.95mg/l at the MD and the lowest concentration in December with 7.75mg/l at the KNWW. The values obtained for all the

samples at MD, KD, RMD and RFD are higher than the maximum permissible value of 20 mg/l

specified by NESERA Interim effluent limitation guidelines for surface water

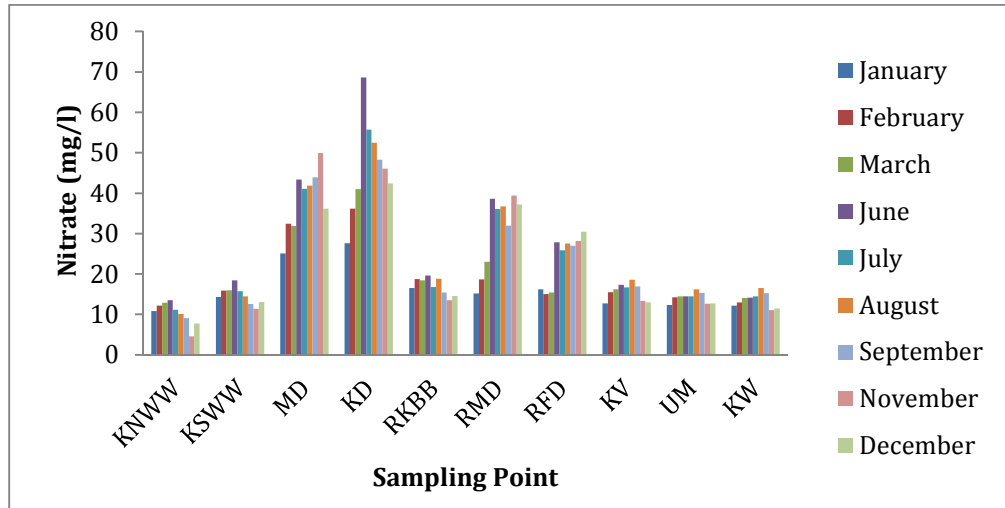


Figure 12: Variation of Nitrate across various sampling point for both wet and dry season

COD

The COD of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 11. For the rainy seasons, COD recorded the highest concentration of 98mg/l in June at the KD with the lowest concentration of 19.25mg/l in September which occurred at the KNWW. For

the dry season, highest concentration of COD occurred in March with 101mg/l at the KD and the lowest concentration of 15.25mg/l in November at the KNWW. The maximum values obtained for samples at MD and KD are higher than the maximum permissible value of 75 mg/l specified by NESERA Interim effluent limitation guidelines for surface water.

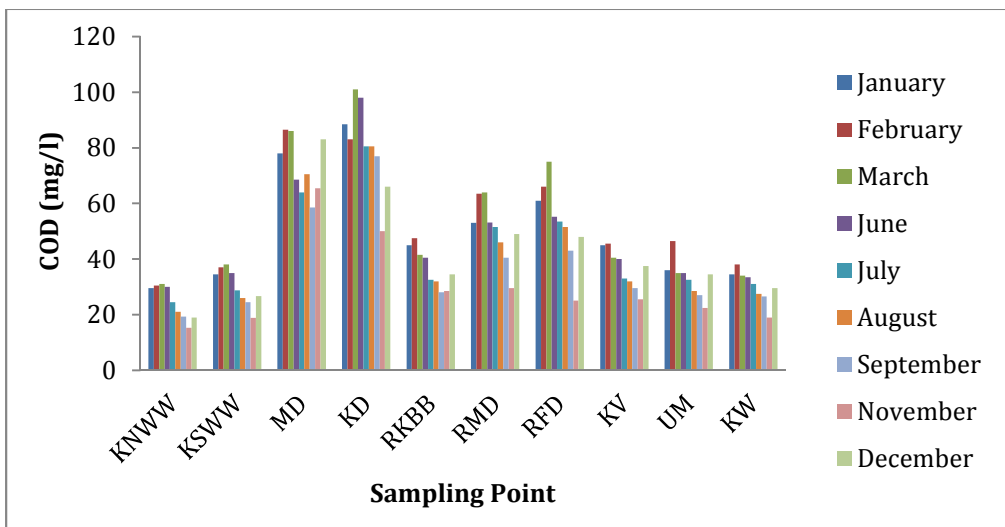


Figure 13: Variation of COD across various sampling point for both wet and dry season



BOD

The BOD of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 12. For the rainy seasons, BOD recorded the highest concentration of 75.25mg/l in June at the MD while the lowest concentration of 12.7mg/l was recorded in September at the KNWW. For the dry season, BOD recorded the highest concentration

of 91.4mg/l in March at the KD while the lowest concentration of 12.69mg/l occurred in November at the KNWW. The maximum values obtained for samples at MD, KD, RMD and RFD are higher than the maximum permissible value of 50 mg/l specified by NESERA Interim effluent limitation guidelines for surface water.

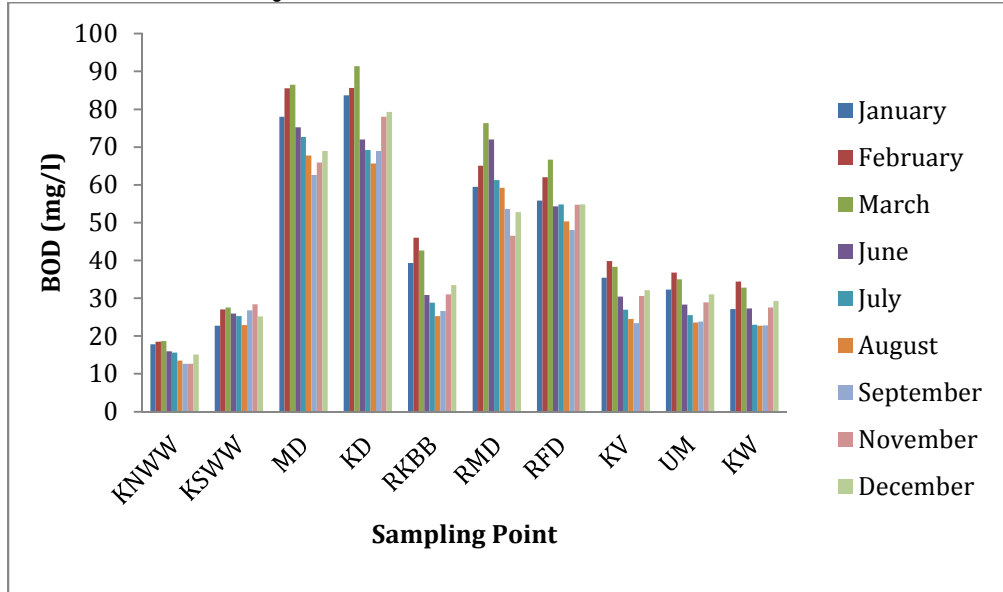


Figure 14: Variation of BOD across various sampling point for both wet and dry season

Iron

The Iron of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 13. For the rainy seasons, Iron recorded the highest concentration of 31.2mg/l in June at the MD and the lowest concentration of 0.615mg/l was recorded in September at the KNWW. For the dry season,

highest concentration of iron was recorded in December with 30.52mg/l at the MD and the lowest concentration of 0.425mg/l was recorded in November at the KNWW. The maximum values obtained for samples at MD and KD are higher than the maximum permissible value of 20 mg/l specified by NESERA Interim effluent limitation guidelines for surface water

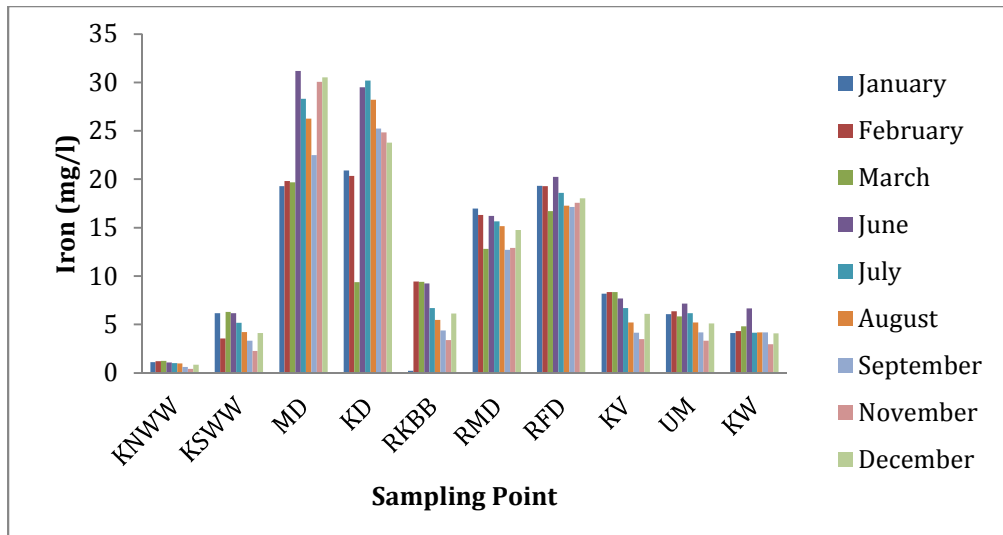


Figure 15: Variation of Iron across various sampling point for both wet and dry season

Manganese

The manganese of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 14. For the rainy seasons, Manganese recorded the highest concentration of 0.17mg/l in September at the KW, while five locations recorded zero concentration in June and July at all the locations except at the MD. August recorded zero concentration at all the sampling locations. However in September only KNWW, KSWW, RKBB, RFD, KV and UM recorded zero concentration. For the dry season, Manganese

recorded the highest concentration of 0.03mg/l in February at the MD and with zero concentration in January, February, March, November and November; in January, at the KNWW, RMD and RFD; in February, at the KNWW, RMD, UM and KW; in March, KNWW, RMD, RFD, UM and KW; in November, at all the sampling locations and in December at all the sampling locations, with the exception of MD and RMD. The maximum values obtained for all samples are lower than the maximum permissible value of 1.5 mg/l specified by WHO.

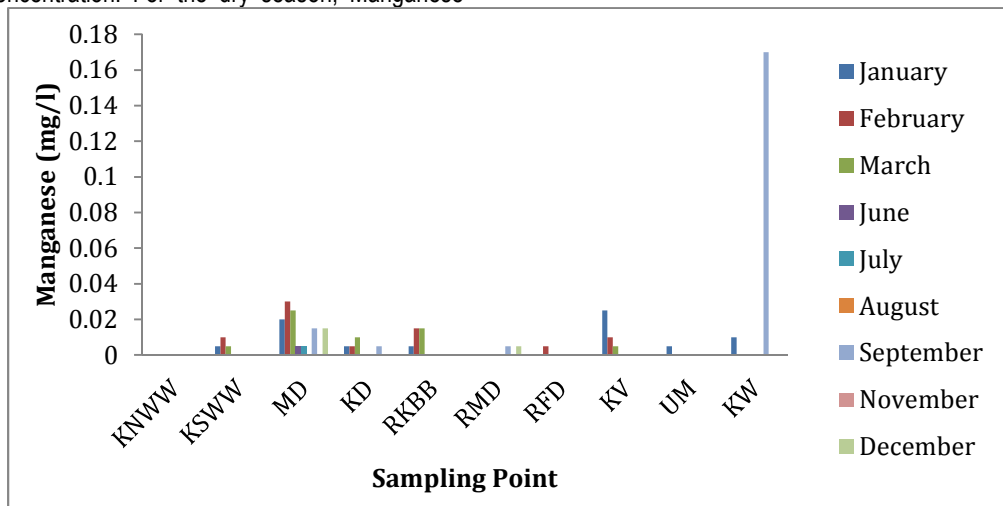


Figure 16: Variation of Manganese across various sampling point for both wet and dry season



Total Hardness

The total hardness of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 15. For the rainy seasons, highest concentration for total hardness occurred in June with 41.3mg/l at the MD, while the lowest concentration of 2.2mg/l occurred in August at the KNWW. For

the dry season, Total Hardness recorded the highest concentration of 55.6mg/l in March at the MD, while the lowest concentration of 5.195mg/l was recorded in November at the KNWW. The maximum values obtained for all samples are lower than the maximum permissible value of 100 mg/l specified by WHO.

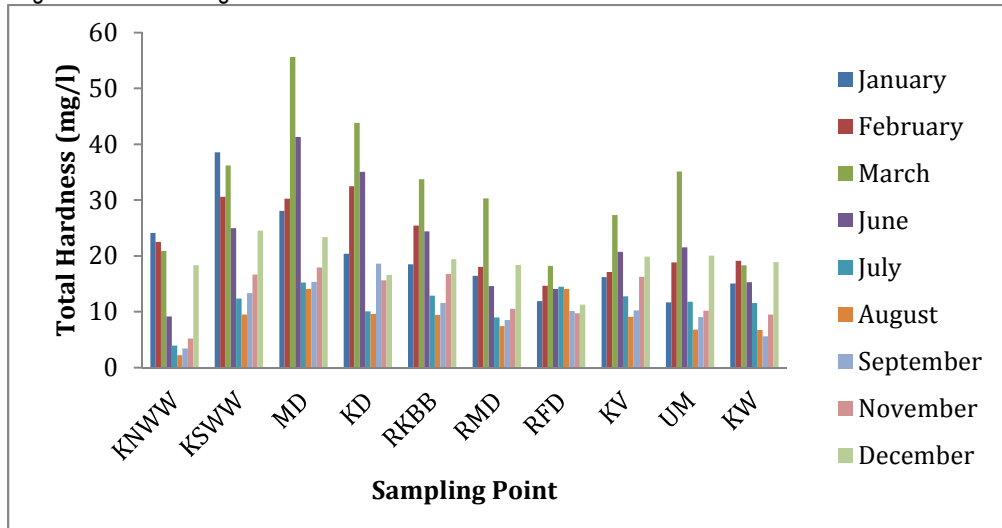


Figure 17: Variation of Total Hardness across various sampling point for both wet and dry season

Phosphorus

The phosphorus of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 16. For the rainy seasons, In June, phosphorous recorded the highest concentration of 3.7mg/l at the MD with its lowest concentration of 0.1mg/l in July at the RMD. The phosphorous highest concentration occurred in July with 5.0mg/l at the

KD, and a zero concentration in August at the KD. For the dry season, Phosphorus recorded the highest concentration of 9.455mg/l in January at the KW, and lowest concentration of 0.15mg/l also in January at the RFD. The highest concentration of phosphate of 9.2mg/l occurred in January at the UM while the lowest concentration of 0.72mg/l occurred in December at the RFD.

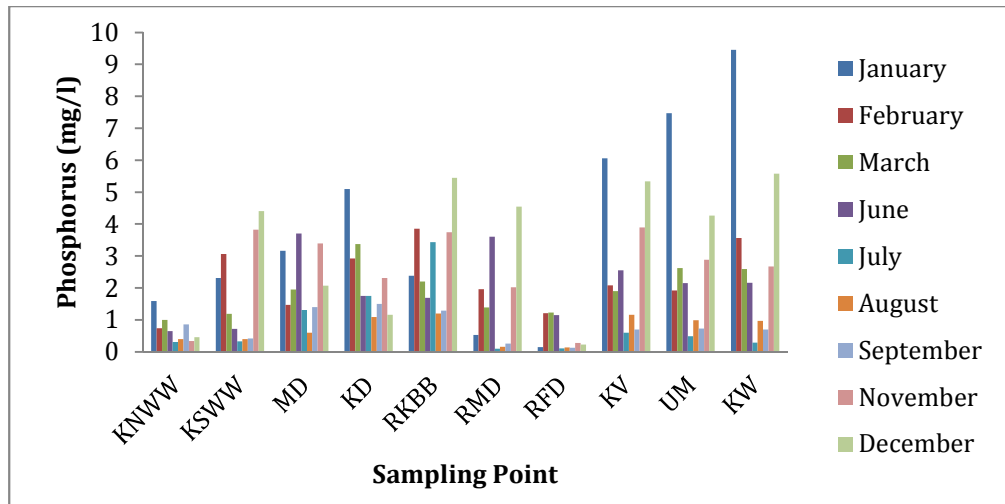


Figure 18: Variation of Phosphorus across various sampling point for both wet and dry season

Ammonia

The ammonia of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 17. For the rainy seasons, highest concentration of ammonia, 4.3mg/l occurred in June at the KD, while the lowest concentration of 0.0mg/l

occurred in September at the KNWW and KSWW. For the dry season, Ammonia recorded the highest concentration of 6.675mg/l in December at the KD and the lowest concentration of 0.43mg/l occurred also in December at the KNWW

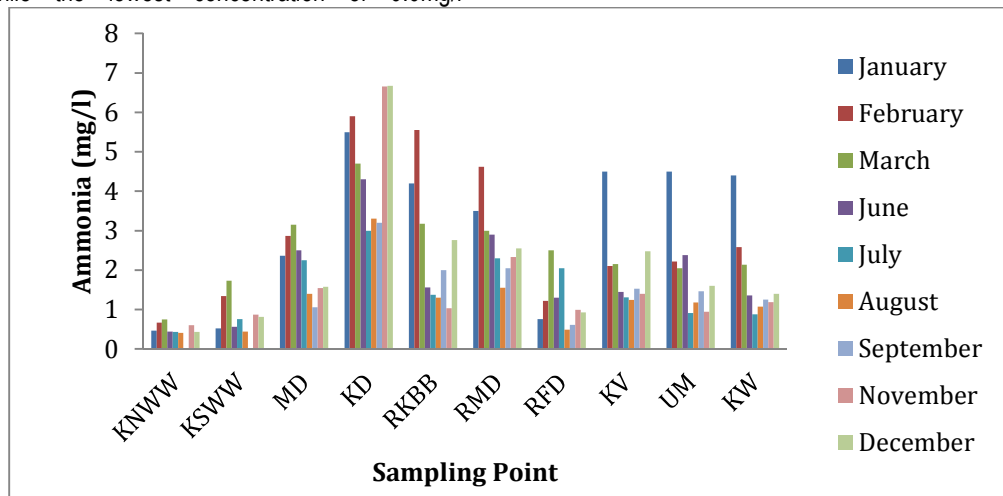


Figure 19: Variation of Ammonia across various sampling point for both wet and dry season

Zinc

The Zinc of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 18. For the rainy seasons, Zinc recorded zero concentration in all the sampling locations through the period of June

to September. For the dry season, Zinc recorded its highest concentration of 1.13mg/l in March at the RMD and zero concentration in November at all the sampling locations. The maximum values obtained for all samples are lower than the



maximum permissible value of 1.5 mg/l specified by WHO.

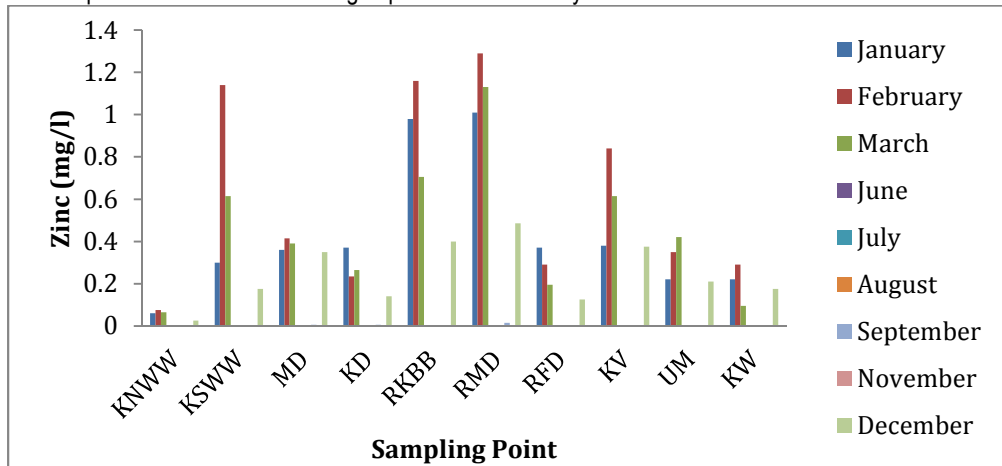


Figure 20: Variation of Zinc across various sampling point for both wet and dry season

Cyanide

The Cyanide of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 19. For the rainy seasons, Cyanide recorded zero concentration in all the sampling locations through the period of June to September. For the dry season, highest concentration of cyanide occurred in February and March with 0.001mg/l at the RKBB and MD, KW respectively, cyanide also recorded zero concentration in January, February, March, November and December at

some sampling locations; In January, at all the sampling locations with the exception of the MD; in February, at all the sampling locations with the exception of KSWW, MD and RKBB; in March, at all the sampling locations with the exception of MD, KD and KW; in November, at all the sampling locations; also in December, at all the sampling locations with the exception of RMD. The maximum values obtained for all samples are lower than the maximum permissible value of 0.05 mg/l specified by WHO

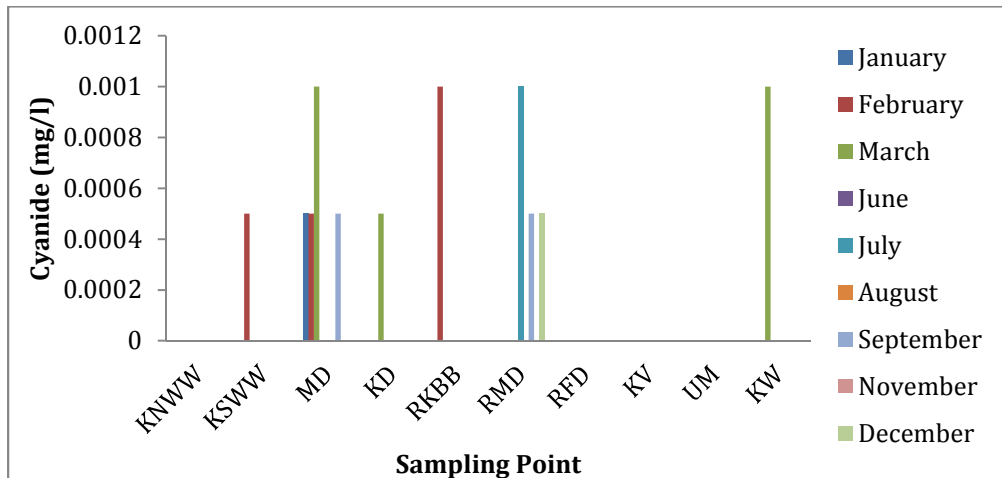


Figure 21: Variation of Cyanide across various sampling point for both wet and dry season

Chlorine

The Chloride of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 20. For the rainy seasons, chlorine recorded its highest concentration in June with 0.37mg/l at the MD and the lowest concentration of 0.02mg/l in June

and August at the KNWW. For the dry season, Chlorine recorded the highest concentration of 0.47mg/l in March at the MD while the lowest concentration of 0.015mg/l occurred in January at the KNWW.

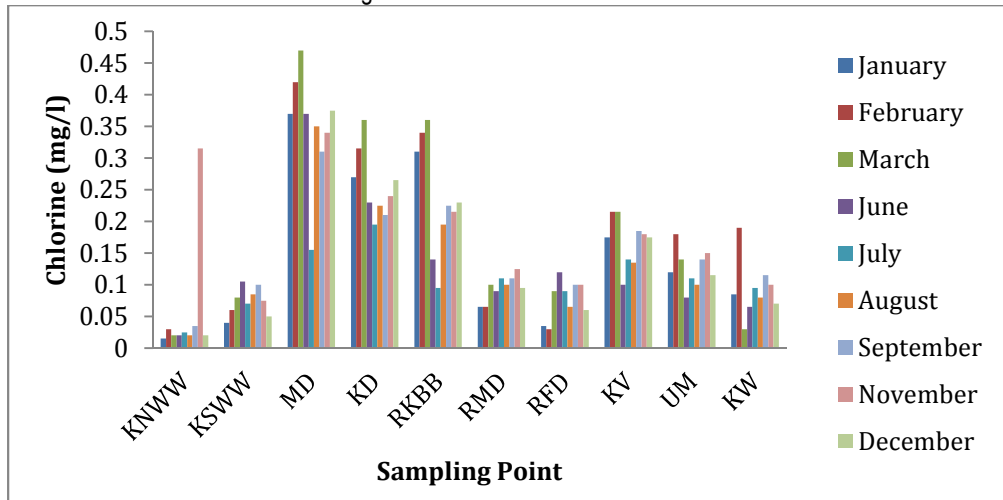


Figure 22: Variation of Chlorine across various sampling point for both wet and dry season

Aluminium

The Aluminium of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 21. For the rainy seasons, Aluminium recorded the highest concentration of 0.095mg/l in September at the RMD and with zero concentration at the KNWW, KSWW, KD, RFD, KV, UM and KW. Also zero concentration occurred in June, July and August. For the dry season, highest concentration of aluminium which is 0.15mg/l occurred in

February at the RMD and zero concentration in January, February, March, November and December at some sampling locations: in January, at all the sampling locations, except at the MD; in February at the KNWW, KD, KV, UM and KW; in March at all the sampling locations except at the KSWW; and in November and December at all the sampling locations except at the RMD.

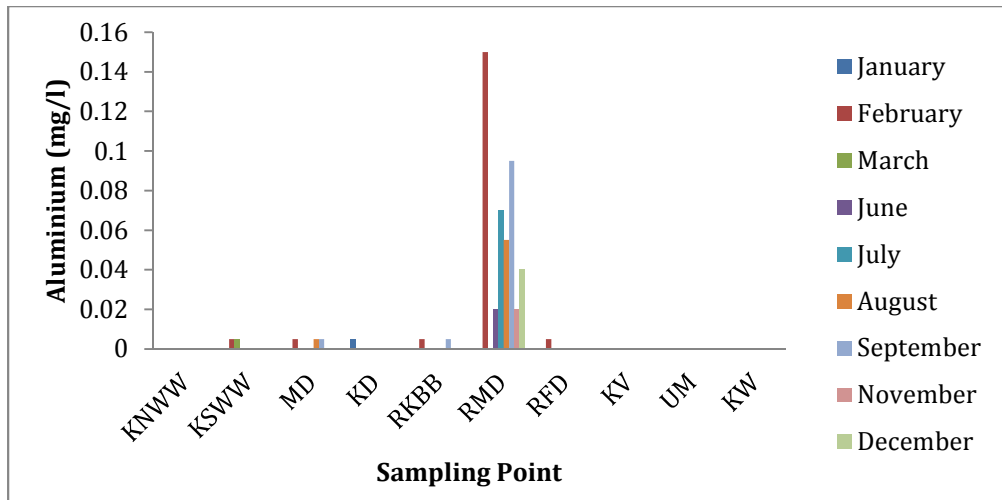


Figure 23: Variation of Aluminium across various sampling point for both wet and dry season

Fluoride

The Fluoride of all sample collected within both rainy season and dry season for all the sample point is shown in Figure 22. For the rainy seasons, Fluoride recorded the highest concentration of 0.015mg/l in July at the RMD, while zero concentration in June, July, August and September. In June at the RMD, in July at the KD, RMD and KV, in August at all the sampling locations except in the MD. For the dry season, fluoride recorded the highest

concentration of 0.2mg/l in February at the KD and zero concentration at some sampling locations; in January, February, March, November and December; in January, with the exception of the KD; in February with the exception of KD, RKBB and RFD; in March, with the exception of KD; and in November and December at all the sampling locations. The maximum values obtained for all samples are lower than the maximum permissible value of 0.8 mg/l specified by WHO.

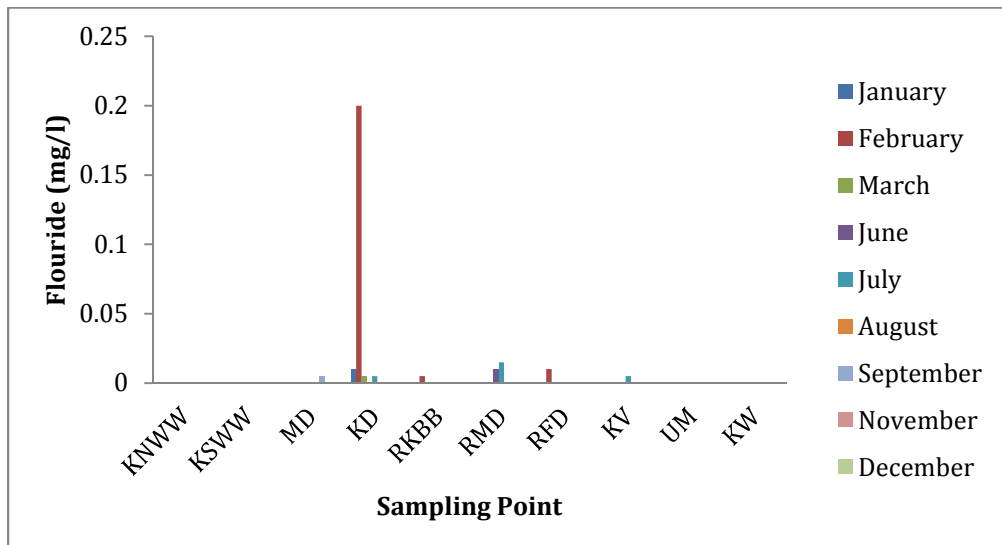


Figure 24: Variation of Fluoride across various sampling point for both wet and dry season



CONCLUSIONS

The water body in the upstream of the Kaduna River is assumed to be relatively unpolluted, as there are no industrial waste discharges. Generally, the water quality varies during the dry and wet seasons

1. The overall analysis show that the Physical and Chemical Parameters which are hazardous with very high or very low concentration occurred mainly in the industrial drains when compared with those of the points in the river course. Also, the assessment of physical and chemical parameters of the samples collected downstream of the Kaduna River, when compared with that of the upstream, KNWW sampling point show that, there is self-purification process as the flow advances downstream.
2. The results from the analysis clearly show variation in pattern in the river water quality due to seasonal influence. During the seasons of the wet (June – September) and dry (January - March, November - December), the analysis show that under these conditions, the parameters exhibited either a decrease or increase in their concentrations. Some of the parameters exhibited concentration of hazardous substances in the dry season, while others exhibited some rate of dispersion or dilution during the wet season. The distribution of pollutants along the river appears to outline or mark out the study area into two parts:
 - i. The Kaduna North Water Works area which is devoid of industrial waste discharges
 - ii. The Kaduna South area harbours both the industrial, domestic wastes and agricultural wastes due to activities taking place along the course of the river

RECOMMENDATIONS

From the analysis of the physical and chemical parameters of samples collected, the WHO guidelines for portable water should be adhered to, therefore, the following is recommended:

1. Construction of a centralized wastewater collection and treatment facility to treat wastes for recycling or disposal.

2. Research could be carried out to find ways of using environmentally friendly raw materials and inputs with less pollutant that are less harmful to the environment.

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