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WATER QUALITY ASSESSMENT AND POLLUTION STUDIES OF RIVER ROMI KADUNA, NIGERIA

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Abstract

The World Health Organization emphasized that an assessment of the adequacy of the chemical quality of drinking-water relies on comparison of the results of water quality analysis with guideline values. During the early development of the standards, the importance of feacal contamination of water was recognized and the role of filtration and later, disinfection were emphasized as critical to the control of drinking water quality. This research aimed at assessing water quality and pollution studies of River Romi Kaduna, Nigeria. The research methodology is experimental in design, samples were collected five (5) times from each of the sampling points after a duration of 1month, namely; Rido village, Railway quarters, Downstream of Nigerian National Petroleum Corporation (NNPC), Upstream of NNPC and Kudenda collection points. The result shows that the mean values of temperature at different sample points; Rido (27^{0}C), Railway Quarters (27.5^{0}C), Upstream (28^{0}C), Downstream (27^{0}C) and Kudenda (30^{0}C) respectively. The temperature range at all the sampled points was within the acceptable limit of FEPA and WHO standard for irrigation and drinking water. The research concludes that the water in River Romi has been polluted by effluents discharged from the Refinery because of the variation in the concentration of the water in the upstream point of effluent discharge as well as downstream. It is recommended that Introduction of cost-effective Cleaner Production Technologies by all industries especially on-site to treat and reduce on the amount of effluents into the Rivers.

Key Words: *Water, Quality, Standard, Upstream, Pollution, Romi, River*

Introduction

Water quality assessment is necessary in the critical understanding and management of freshwater resources because of the reducing quality and quantity of available water resources (Ani *et al.,* 2016; Bauder *et al.,* 2013). However, proper management is also embedded in having information, gathering and monitoring physicochemical parameters (Ani *et al.,* 2016). Therefore, this research focused on determination of the presence of pollutants from Kaduna refinery and petro-chemicals discharged into river Romi, Kaduna – Nigeria.

Olawale (2016) found that the pH values in Asa River, Ilorin, Nigeria ranged from slightly acidic value of 6.23 for location 4 in the wet season to a neutral level of 7.27 for same location in the dry season. The overall pH range of 6.23-7.27 was almost within the range for inland waters (pH 6.5 - 8.5), as reported by Antoine and AI-Saadi (1982). Boyd and Lichtkoppler (1979) reported pH range of 6.09 - 8.45 as being ideal for supporting aquatic life including fish. Thus, the pH range obtained in the study was within the acceptable level of 6.0 to 8.5 for culturing tropical fish species (Huett, 1977) and, for the recommended levels for drinking water (WHO, 2016). Federal Environmental protection Agency (FEPA) recommended pH 6.5-8.0 for drinking and 6.0-9.0 for aquatic life.

According to WHO (2016), water should be free of tastes and odours that would be objectionable to most consumers. In assessing the quality of drinking-water, consumers rely principally upon their senses. Microbial, chemical and physical constituents of water may affect the appearance, odour or taste of the water and the consumer will evaluate the quality and acceptability of the water based on these criteria.

Olawale (2016) stated that of the many alkali metals specifically Sodium (Na) and Potassium (K) determined in Asa River, Ilorin-Nigeria, sodium showed the highest concentrations of 8.80-202.60mg/l with an overall mean value of 67.17mg/l compared to potassium having concentration range of 9.88-18.20mg/l with an overall mean of 13.06mg/l. The higher concentrations of these metals were obtained during the dry season's study than in the wet season. Na and K are abundant constituents of rocks and soils, hence their presence in surface water is dependent on the physio-chemical properties of geological formations, such as soils and rocks, with which it comes into contact while no guideline is ascribed to potassium, the concentrations recorded for sodium in his study was below the guideline value of 200mg/l for drinking water (WHO, 2008; EPA, 2001; Hassan, 2014).

WHO (2017) emphasized that an assessment of the adequacy of the chemical quality of drinking-water relies on comparison of the results of water quality analysis with guideline values. These Guidelines provide guideline values for many more chemical contaminants than will affect any water supply, so judicious choices for monitoring and surveillance should be made prior to initiating an analytical chemical assessment. For additives (that is; chemicals deriving primarily from materials and chemicals used in the production and distribution of drinking-water), emphasis is placed on the direct control of the quality of these commercial products. In controlling drinking-water additives, testing procedures typically assess whether the product meets the specifications.

Drinking Water Standards

The development of standards and regulations related to microbiological quality in the water and waste water focused on drinking water supplies (WHO, 2016). In Europe and North America in the nineteenth century this was primarily driven by the need to address epidemics of infectious diseases. During the early development of the standards, the importance of feacal contamination of water was recognized and the role of filtration and later, disinfection were emphasized as critical to the control of drinking water quality. A strong emphasis was placed on sanitary integrity of water sources and supplies and on the use of sanitary inspection in monitoring water supplies. This was associated with simple methods to test for their presence as a means for assessing the potential presence of pathogens (Helmer *et al*., 1999). Within the water sector, WHO has continued to advocate this approach with respect to control of drinking water quality (Adefemi, *et. al.,* 2007; WHO, 2017).

The sole use of numerical limit values for indicator bacteria also mitigates against the process of incremental improvements and innovation in water supply that are frequently required. There is little doubt that water supplies which consistently meet set standards for indicator bacteria represent reduced risks to public health. The detection and control of indicator bacteria has proven effective in reducing the frequency of epidemics of bacterial pathogens. Interpretation of the results of indicator bacteria analyses may not be straightforward. Typically, indicator bacteria are discrete in water and generally have non-random distribution in water (Helmer *et al*., 1999; Adefemi, *et. al.,* 2007). They are more likely to be found in clumps following treatment, rather than uniformly spread throughout the water (WHO, 2016). The volume of water analyzed by taking occasional 100ml samples from a large water supply is often less than one millionth of 1% of that produced. Therefore, the absence of indicator bacteria in these small samples may not reflect their true density in water (Helmer *et al*., 1999; Hassan, 2014).

Water quality assessment is necessary in the management of freshwater resources. When research is carried out, problems can be identified, and solution can be proffered. Problems of water quality related to the effluent discharge can be known and strategies can be recommended for efficient management of environmental resources (Adefemi, *et. al.,* 2007; Hassan, 2014). It is expected that at the end of this research, the result could be useful to the government for appropriate action. Hence, the study could serve as an effective implementation, monitoring and management tool for Kaduna Environmental Protection Agency (KEPA), and the Federal Environmental Protection Agency (FEPA) to ensure that the petro-chemical refinery company complies with the National Standards of Drinking Water Quality Guidelines of Industrial Pollution (effluent) discharge. The study will also help in designing appropriate designing appropriate preventive measures to ensure that the water quality in Romi River and elsewhere is improved.

Table 1: Physical Parameters

Parameter	Unit	Maximum Permitted Levels
Colour	TCU	15
Odour	-	Unobjectionable
Taste	-	Unobjectionable
Temperature	^{0} Celsius	Ambient
Turbidity	NTU	5

Source: SON, 2017

Table 2: Chemical Parameters

Parameter	Unit	Maximum Permitted Levels
Aluminum (Al)	mg/l	0.2
Cadmium (Cd)	mg/l	0.003
Iron (Fe+2)	mg/l	0.3
Chromium (Cr6+)	mg/l	0.05
Conductivity	µs/cm	1000
Copper (Cu+2)	mg/l	1
Chloride (Cl)	mg/l	250
Hardness (as CaCO3)	mg/l	150
Lead (Pb)	mg/l	0.01
Manganese (Mn+2)	mg/l	0.2
Ph	-	6.5- 8.5
Nickel (Ni)	mg/l	0.02
Total Dissolved Solids	mg/l	500
Zinc (Zn)	mg/l	3
Sodium (Na)	mg/l	200
Sulphate (SO4	mg/l	100
Magnesium (Mg+2)	mg/l	0.20

Source: SON (2017)

Materials and Methods

Description of the Study Area

River Romi is one of the tributaries of River Kaduna; it is in the southern part of Kaduna metropolis between latitude 10º to 11º North and longitudes 7º to 8º East. River Romi follows a course of about 16.4 km (Lekwot *et. al.*, 2012). It rises from the Rido, Kabusu, and Kujama Hill at elevation 882 meters, 685 and 847 meters above the mean sea level respectively. The river traverses Romi Village crosses the Abuja road and eventually discharges into Kaduna River at Garko. This flows throughout the year, but its volume is reduced during the dry season (Yunana, 2003).

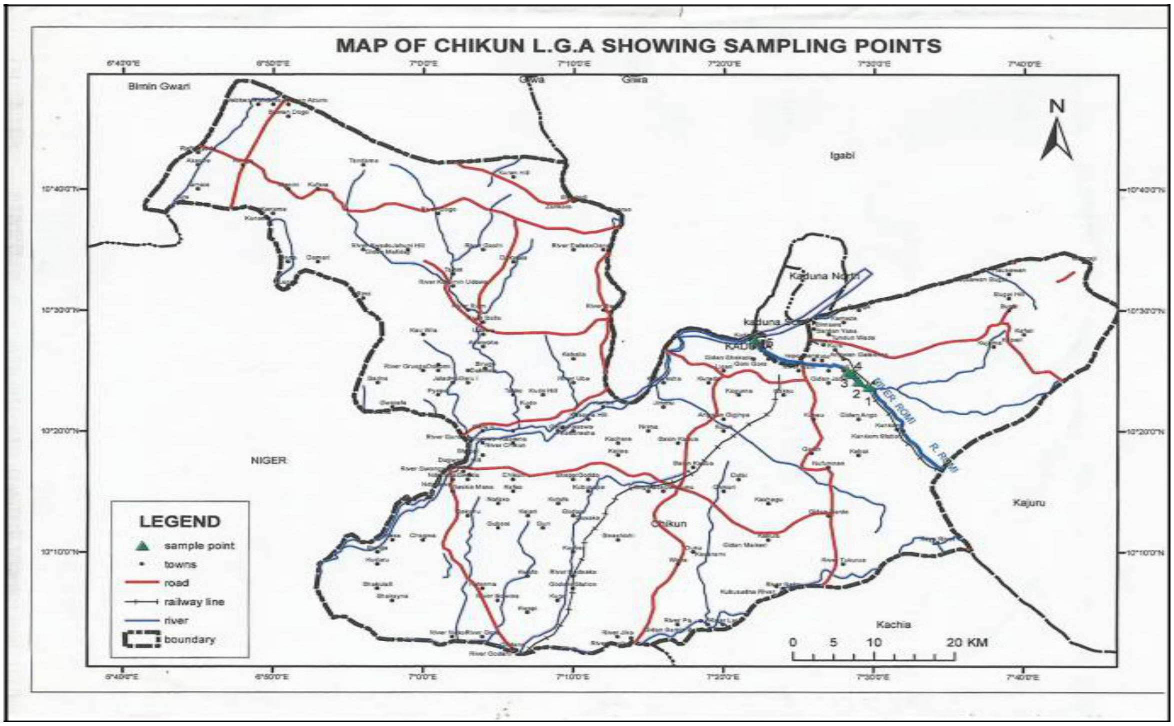

Fig. 1: Map of Chikun L.G.A showing the sampling points
Source: KADGIS, 2020

The river receives effluents from the Kaduna Refinery and Petrochemical Company at Rido. The settlement pattern in the study area is made up of scattered population of about 20,000 households distributed among the two villages Angwan Rido and Angwan Tanko along the Romi River Valley fertile land.

Sample Preparation and Laboratory Analysis

The Variables which are indicators of portable water quality such as pH and temperature were determined directly on site using portable meters. Pye Unicam model 292 metre (after standardization with buffer solution at pH4.0, 7.0 and 9.0) was used for pH and electrical conductivity determination.

Other parameters such as water hardness were determined in the laboratory using Palin test photometer. Use of Hardcol tablets NO1 and NO2, the tablets were crashed and dropped in 10mg/l test tube of water in order of 1 and 2 and the mixture left for 5mins, then readings were taken at 570nm wave length in the Palintest Photometer. Two test tubes were used, one acted as a control experiment (Hassan, 2014). Turbidity was analyzed using Turbidity tube where Water was poured in the tube while observing the **X** mark below the tube and if it disappeared that unit was recorded as the turbidity value for the water sample under analysis. It was measured in Naphthalene Turbidity Units (NTU).

Chemical elements that were analyzed for water quality include Iron and Nitrites following standard procedures for water analysis. All these parameters were determined photo electrically using the same method of Palin test (Photometer model 5000) the procedure for analysis for all parameters was the same at same wavelength of 520 nm for Iron and Nitrites, and different reagents used. For

Nitrites, the Nitricol tablets NO1 was used. The tab was crashed and dropped in 10 mg/l test tube of water, mixed and left for 10 minutes then the readings were taken at 520 nm wave length in the Photometer where by two test tubes were used, one acted as a control experiment. Also in the analysis of Iron, Iron testing tablets NO1 and NO2 were crashed and dropped in 10 mg/l test tube of water in order of 1 and 2 mixed and left for 2 minutes and the readings were taken at 520 nm wavelengths in the photometer. Two test tubes were used, one acted as a control experiment.

Statistical Analysis

Generalized Linear Model (GLM) procedure in Statistical Package for the Social Science (SPSS) was used in the analysis of data. GLM of two-way Analysis of Variance (ANOVA) was used to analyze the data. The mean, standard deviation at different periods for each point was determined. From the analysis of the result, inference was drawn if there was a significant change in water quality between before and after the discharge of effluent in the River and at different point along the river.

Result and Discussion

The result presents the analysis of data obtained from the laboratory water quality tests of River Romi in order to quantify the effect of effluent discharged from Kaduna Refinery into River Romi.

Physical Parameters

Temperature

Table 3 shows the mean values of temperature at different sample points; Rido (27^0C), Railway Quarters (27.5^0C), Upstream (28^0C), Downstream (27^0C) and Kudanda (30^0C) respectively. The temperature range at all the sampled points was within the acceptable limit of FEPA and WHO standard for irrigation and drinking water. Water temperature helps to regulate the metabolism of the aquatic organisms and high temperature stresses aquatic organisms by reducing the availability of oxygen in the water.

Table 3: Mean Values of Physical Parameters in River Romi at different locations

S/No.	Parameter	Rido	R. Qtr	U/stream	D/stream	Kudanda	FEPA	WHO
1	Temp °C	27	27.5	28	26	27	30	<35
2	Colour	Brownish	Brownish	Brownish	Brownish	Brownish	15NTU	-

Colour

The colour (table 3) in all locations was brown; it might be due to the presence of iron in water. The massive growth of vegetation was observed at the bank of the river (eutrophication), it might be the effect of nitrates in water from the upstream farms where fertilizers are applied.

Variability of the Physico-chemical Parameters at All Points of Sampling

Table 4 shows the results for the general means of parameters for all the periods of sample collection in River Romi.

Suspended Solid

The Suspended Solid ranged from 71.24±16.5 mg/l recorded at Rido to 90.9±14.8 mg/l at Kudenda. The values increased progressively from Rido to Kudenda in the direction of flow. The highest value recorded at Kudenda might be due to accumulation of solid over the entire reach of the River. However, at all points concentrations have exceeded the

FEPA limits of 30 mg/l for effluent discharge into surface water.

Dissolved Oxygen

Dissolved Oxygen concentrations at all points are less than the FEPA maximum permissible limit of 10 mg/l. Adequate dissolved oxygen is necessary for good water quality but above 14 mg/l can be harmful to aquatic life. The highest value of DO recorded is 8.276±0.9 mg/l upstream of NNPC which is within safe limit for aquatic life. The lowest value recorded at Rido might be due to high organic load which requires high amount of oxygen for oxidation and breaking down of chemicals especially organics.

Total Dissolved Solids

The Total Dissolved Solids observed at all points are lower than the highest permissible limits of all standard, based on the FAO standard, the water can be used for irrigation.

Biological Oxygen Demand

Biological Oxygen Demand (BOD) is one of the indexes used in water quality assessment; it represents the amount of oxygen required for the biological decomposition of organic matter under aerobic condition. It is perhaps an expression of the amount of oxygen required for microbes to oxidize a given quantity of organic matter. At all points, the BOD was higher than the highest permissible limits of all standards. The highest value of 136.4±14.7 mg/l was observed at Kudenda and this may result in depletion of dissolved oxygen with time which is detrimental to aquatic lives.

Turbidity

Turbidity recorded downstream of NNPC and Kudenda is above the highest permissible limit of FEPA and WHO standards of 5 NTU. The higher value of turbidity recorded is associated with higher concentration of suspended solid recorded in all locations, runoff effect, and domestic discharge from the quarters and effluents from the refinery.

Chemical Oxygen Demand (COD)

COD at all locations exceeded FEPA maximum permissible limit of 40 mg/l. These might be due to leachates from agricultural fields and runoff water from smaller tributaries. The mean values of EC, nitrate, chloride and Sulphate were below the maximum permissible limit of all standard as shown in Table 4. This implies that the water can be used for human consumption and irrigation based on the concentration of these elements.

pH

The pH ranges from 5.302±35.2-5.254±0.5 and this is below the lowest permissible limit for all standards. The findings in this study do mot tally with those of Dan'azumi and Bichi (2010) where the pH values were very high an indication of alkaline industrial waste discharged into the river and which exceeded the limit set by FEPA. The pH of irrigation water is not an accepted criterion of water quality because it tends to be buffered by soil and most crops can tolerate a wide range of pH.

Electrical Conductivity

The Electrical Conductivity of water ranges from 255.22±62.5-260.72±53.5 µS/cm. This implies that the water can be used for drinking, irrigation and poses no health risk as the values fall below the maximum permissible limit of FEPA, FAO and WHO standards. There will be no yield loss when used for irrigation as the water is of low salinity. The mean values of the physico-chemical parameters which are nutrients at low concentrations were very low in the study area but studies in other Nigerian Rivers have recorded higher values of some of these parameters.

Grease and Oil

Grease and oil composition as shown in Table 5 is below the highest permissible limit of FEPA but above the NSDQ standard. This implies that the water cannot be used for drinking, but the composition has no detrimental effect on the environment. Iron concentrations at all locations were above all standards except the FAO standard. Highest mean values of 3.036±3.4 mg/l were recorded in Rido and the lowest mean value of 2.238±16 mg/l was recorded in Kudenda and this concentration can stain laundry in domestic water supply. Iron composition of 0.1 mg/l of iron impact taste and brownish colour to water and this is below the lowest value recorded at different points. All other parameters are within acceptable limits for all standards as shown in Table 5. Lower values for some of these trace elements recorded during the periods of study compared to other periods as reported by other researchers might be due to maintenance work at refinery which resulted in reduced activities.

Table 4: Grand mean and SD of the Physico-chemical Parameters for all periods of Sampling at selected points of sampling

Location	Suspended mg/l	Dissolved Mg/l	TDS	BOD	Turbidity	COD	Hardness	pH	EC	Chloride	Nitrate	Sulphate	Bicarbonate
Rido	71.24±16.5	6.668±0.7	261.08±23	131.12±18.8	4.874±1.1	76.96±36.9	47.2±0.8	5.254±0.5	257.16±57.2	6.958±1	3.686±0.1	83.68±0.0	12±0
Railway Qtr	73.74±11.9	7.214±0.9	253.36±19.3	134.96±30.9	4.87±1	85.32±41.2	49.7±1	5.278±0.6	260.72±53.5	7.786±1.6	4.132±0.2	91.52±0	13.2±0
NNPC Upstream	78.2±15.1	8.276±0.9	244.44±17.1	131.2±29.9	4.968±1.2	87.08±36.1	57.4±1.1	5.272±0.2	259.96±60.9	7.974±1.9	4.29±0.2	103.88±0	15.32±0
NNPC Downstream	80.84±12.2	7.488±1.1	245.066±17.7	132.86±23.6	5.076±0.9	88.16±33.9	55.48±1.3	5.294±0.4	255.22±62.5	7.394±1.1	4.494±0	113.946±0	18.92±0
Kudandan	90.9±14.8	7.732±6.1	244.04±22	136.4±14.7	5.346±14.4	88.4±27.1	56.92±0.6	5.302±35.2	256.6±32.7	7.402±0.9	4.712±0.1	122.96±0	20.16±0
FEPA Standard	30	10	2000	10	5	40		6-9	600	600	20	250	
WHO Standard		10	1500	10	5		1000	6.5.8.5	1000	200	24	200	
FAO Standard			2000					6.5.8.4	3000	350	30	519	91
NSDQ			500		5		150	6.5.8.5	1000	250	50	100	

Table 5: Grand mean and SD of the Physico-Chemical Parameters for all period s of Sampling at selected points of sampling

Location	G&O	Iron	Zinc	Lead	Cadmium	Chromium	Arsenic	Copper	Calcium	Magnesium	Sodium	Nickel
Rido	1.542±0	3.036±3.4	0.1492±0	0.00548±0	0.00512±1.2	0.00204±1.1	0±0.9	0.0092±0.0	7.922±1.3	5.632±0.6	6.434±17.3	0.0396±8.5
Railway Qtr	1.832±0	2.76±17.3	0.148±0	0.00604±0	0.00192±	0.00244±1.1	0±1.1	0.00628±0	8.57±1	5.344±0.7	6.062±12.3	0.0032±9.2
NNPC Upstream	2.64±0	2.88±17.6	0.132±0	0.01408±0	0.0026±1.2	0.0032±0.7	0.002±0.8	0.00544±0	10.326±1.1	6.226±2	6.304±4.4	0.0072±9.1
NNPC Downstream	2.46±0	2.35±16.1	0.1144±0	0.0206±0	0.00676±2.1	0.0016±0.6	0±0.8	0.01368±0	9.854±1.3	6.458±0.8	7.656±51.1	0.0012±12.8
Kudandan	2.46±0	2.238±16	0.1252±0	0.00228±0	0.0056±1.1	0.00236±0.9	0.0004±1.5	0.0374±0	9.596±0.8	6.084±0.5	7.36±10.5	0.006±14.8
FEPA	10	0.3	1	0.05	0.01	0.05	1	1±	200	200		0.05
WHO Standard		0.3	1	0.05	0.003	0.05	0.01	0.5	200	150		
FAO Standard		5	2	5	0.01	0.1	0.1	0.2				0.2
NSDQ	0.03	0.3	3	0.01	0.003	0.05	0.01	1	75	0.2	200	0.02

Conclusion

The results obtained from the analyzes of some physicochemical properties of River Romi (upstream and downstream) reveals the values recorded for temperature, electrical conductivity, BOD, COD, total dissolve solid, sulphate, chloride, iron, cadmium, lead, zinc and copper are higher in the downstream of the river. The research concludes that the water in River Romi has been polluted by effluents discharged from the Refinery because of the variation in the concentration of the water in the upstream point of effluent discharge as well as downstream.

Recommendations

It is recommended that;

- Policymakers in developing countries need to design programs, set standards and act to mitigate further adverse health effects of water pollution.
- Introduction of cost-effective Cleaner Production Technologies by all industries especially on-site to treat and reduce on the amount of effluents into the Rivers.
- Water can be used for irrigation but management practices like liming, use of gypsum is necessary to neutralize it.

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