ASSESSMENT OF WATER QUALITY IN RIVER KADUNA, NIGERIA

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ABSTRACT

The study looked at the water quality of the River Kaduna using the Canadian Council of Ministers of the Environment (CCME) Water Quality Index. The study covered both raining and dry seasons in 10 sampling points. Water parameters analyzed were turbidity. Zn, Pb, Cd, Cr, Cu, Mn, Fe, dissolved oxygen, electrical conductivity, pH, TDS and Ni using standard laboratory techniques. The data obtained were used to develop Water Quality Index (WQI) across the 10 sampling points. The WQI reveals that the water quality at Barnawa, Kudenda, Tudun Wada, Makera and Anguwn Muazu were poor as their index values ranged between 31.8 – 42 while the other locations Kawo, Anguwun Dosa, Malali, Kigo and Anguwn Rimi were marginal as their index ranged between 45 – 61.3. It is recommended that pollution be controlled at the source.

Keywords: water quality, environment, pollution

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INTRODUCTION

Water is a universal solvent essential to man for various activities and two main problems man contends with are the quantity and quality of water (Oluyemi, Adekunle, Adenuga and Makinde, 2010). Water is indispensable to man and the entire ecosystem. The availability and quality of freshwater is the single most critical environmental and sustainability global issue. Freshwater is precious to all living things, human cannot live without it and human activities have profound impact on the quantity and quality of freshwater available (Udiba *et al.*, 2014). Aquatic environments are exposed to various types of pollutants such as heavy metals, pesticides, detergents, petroleum products, and other materials. In addition, industrial, agricultural and medical wastes may lead to negative impact on public health and biodiversity (Maitera *et al.*, 2010; Osibanjo, Daso and Gbadebo, 2011). Water pollution occurs in both rural and urban areas of most developing nations like Nigeria. Surface water pollution entails the introduction of foreign substances by man capable of causing harm to man, hazard to other living organism or interference with the legitimate use of the environment into the surface water bodies (Ojo *et al*., 2012).

It is apparent that water quality and water quantity are inextricably linked, however water quality deserves special attention because of its direct implication in public health and quality of life (Hassan *et al*., 2010). Water quality is changed and affected by both natural processes and human activities. Generally natural water quality varies from place to place, depending on seasonal changes, climatic changes and with the types of soils, rocks and surfaces through which it moves. A variety of human activities such as agricultural activities, urban and industrial development, mining and recreation;

potentially and significantly alter the quality of natural waters, and changes the water use potential. The strategic to sustainable water resources is to ensure that the quality of water resources are suitable for their intended uses, while at the same allowing them to be used and developed to a certain extent (Mohammed, 2014). Water quality is the overall quality of the aquatic environment (Chapman, 1996). The quality of freshwater at any point on a landscape reflects the combined effects of many processes along water pathways and both quantity and quality of water are affected by human activity on all spatial scales (Peters and Meybeck, 2000). An integral part in any environmental monitoring program is the reporting of results to both managers and the general public. However, most findings from water quality researchers were based on comparing the different analyzed parameters with their respective permissible limits set by regulating bodies (local or international). For instance, researchers such as Mohammed *et al*. (2015), Queen (2015) and Mahre *et al*. (2007) have reported the water quality of River Kaduna by describing the trends and compliance with official stated guidelines. These studies found that the quality of water in River Kaduna did not meet the expected standards. Water is considered an important indicator of environmental pollution (Ogoyi *et al*., 2011). However, the general public have always preferred information concerning the general public health than the status of water (Carlos and Alejandra, 2014). Hence, the Canadian Council of Ministers of Environment (2001) reported that one possible solution to this problem is by employing an index that will mathematically combine all water quality measures and provide a general and readily understood description of the water. There is limited information on the water quality of River Kaduna. In other words, developing Water Quality Index (WQI) for River Kaduna will summarize the various analyzed water ingredients (parameters) and rank the overall quality of the water. The ranking could be excellent, good, fair, marginal or poor. This paper therefore is an attempt to examine the spatial variation of the water quality in River Kaduna, which serves as a major source of water in Kaduna, Nigeria.

MATERIALS AND METHODS

Study Area: River Kaduna is a tributary of the River Niger originates from the Kajuma hills in Jos Plateau Nigeria and flows for about 200km before reaching Kaduna town and stretches down about 100km into Shiroro dam project areas where it finally empties into River Niger at the northern shores of Pategi (Emere and Dibal, 2013). The River Kaduna traverses Kaduna into north and south (Al-Amin, 2013). It covers a total distance of 540km from source to mouth where it empties its water into the River Niger (Figure 1).

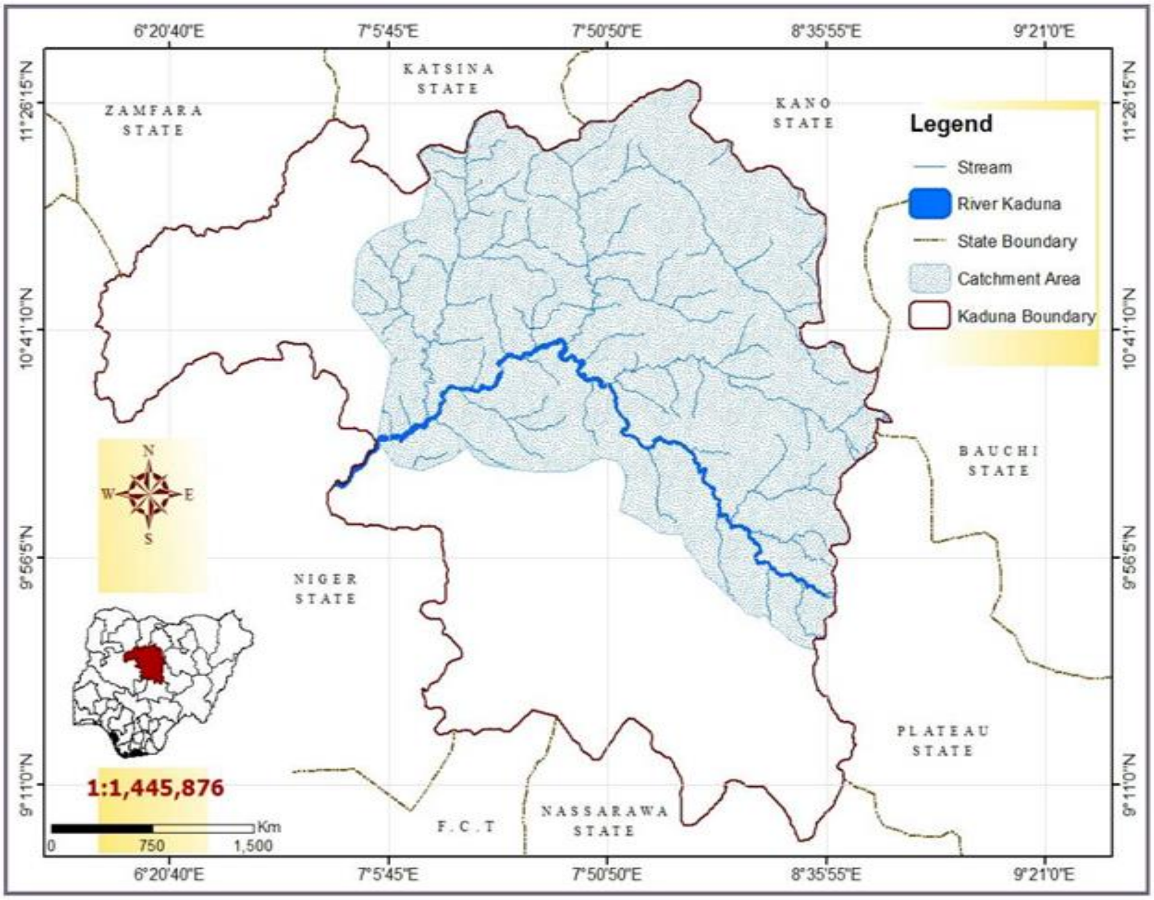

Figure 1.2: Drainage Basin of River Kaduna
Source: Kaduna Geographic Information Services (2018)

The River is a perennial river. Most of its courses pass through open savanna woodland but its lower section has cut several gorges above its entrance into the extensive Niger floodplains. The drainage system of the study area is very complex as the study area is made up of rock outcrops in the plateau and sand bed (Saminu *et al*., 2013). In addition to climatic factors, the flow regime of the river system depends upon topography, surficial geology, soil and vegetation cover of the drainage area. The drainage pattern is mostly dendritic. It's navigable in the dry season and sometimes carries as much waste as freshwater (Olugboye, 1975).

Types and Sources of Data

The data generated were the water samples collected on site (simple grab method) and taken to the laboratory for analysis. Surface water sample was collected from 10 selected points. These points were selected because they represent the best gaining access to the River and also suitable for easy sampling of the current pollution status to the river due to possible mixing of the contaminants. It is not possible to study the entire course of the river, therefore, about 24km of the study area was covered for this study from the upstream Kawo (Rafin Guza) to Kudenda which is the downstream point (Figure 2). This portion of the river dissects the entire Kaduna Metropolis. The sampling points were selected because they represented the best points for gaining access to the River and also suitable for easy sampling of the current pollution status of the River due to possible mixing of the contaminants.

A total of 60 water samples were collected with 30 in raining season and 30 in dry season. The sampling

time was between 7 – 8 am in 3 months within each season. The grab sampling method was employed at each sampling point. To collect the water samples, 250ml plastic bottles was used as recommended in the standard methods for water and wastewater analysis (APHA, 1998). The sample bottles were disinfected with methylated spirit and then thoroughly rinsed with the sample water three times before sample collection to ensure no foreign substance is introduced into the samples as recommended by APHA (1998). The samples were collected by dipping the plastic bottles 30 cm below the water surface at the selected sampling locations and ensuring that the mouth of the bottle faces the water current and allowing it to overflow before withdrawal (Plate 1). After collecting the samples, the bottles were labeled as to the source and date of collection before taken to the laboratory at the National Research Institute for Chemical Technology (NARICT), Zaria.

The pH, Electrical Conductivity (EC), Turbidity, Total Dissolved Solids (TDS) and Dissolved Oxygen (DO) were determined in situ using handheld instruments. This was because these parameters have the tendency of changing characteristics overtime once collected from the River. Fifty millimetre (ml) of water was measured into a 250ml beaker and 15ml hydrogen chloride (HCl) and nitric acid (HNO_3) was added. The beaker and the content were placed on a hot plate, heated at 100^0C to dry and digest until brown fumes of HNO_3 escaped. The heating continued until the content was reduced to 10ml. The contents were then washed into a 50ml volumetric flask, the digest obtained was preserved in a refrigerator till analysis.

Plate 1: Sample Collection at Barnawa, Kaduna

The analysis of the selected heavy metal concentration was carried out using Atomic Absorption Spectrophotometer (AAS) (AA-6800, Shedmazu, Japan) after digestion of samples at National Research Institute for Chemical Technology (NARICT), Zaria. This method is suitable for both dissolved and total metals in water. 100ml of the digest in each sample was run on the Atomic Absorption Spectrophotometer (AAS) which uses Air Acetylene Flame. By choosing the correct wavelength of the various elements and running a known standard curve of the various elements, the absorbance values of the chemical elements present in the samples were determined. Using the standard absorbance of the various elements, the absorbance from the various heavy metals contained in the samples was converted to parts per million (ppm) values as their levels of concentration. This was repeated three times for every element in every sample and the mean concentration was taken as the actual level of concentration of the elements in ppm

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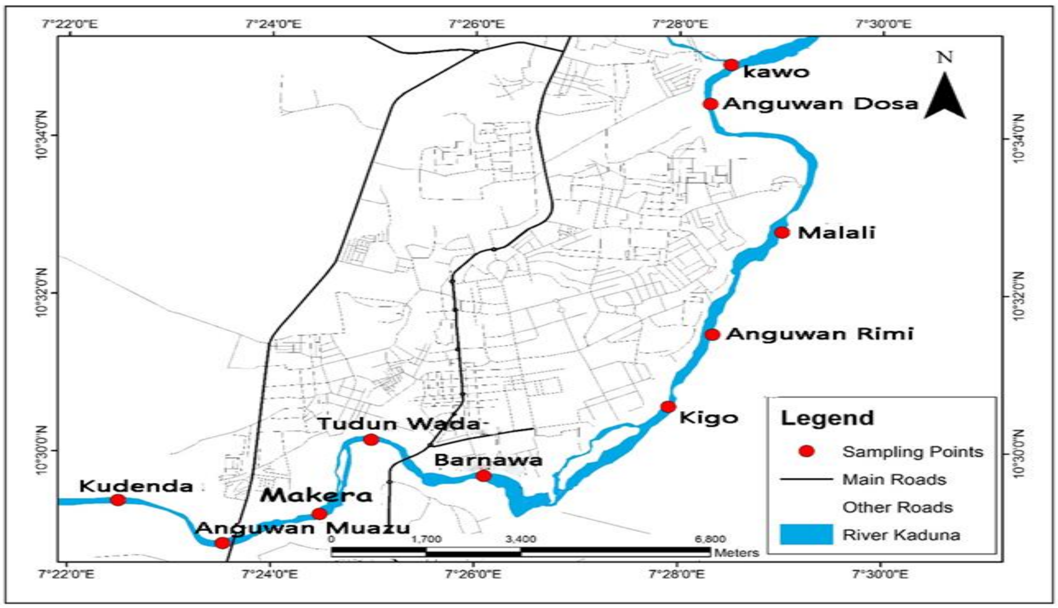

Figure 2: Location of Ten Sampling Points

The Water Quality Index (WQI) developed was based on the Canadian Council of Ministers of Environment (CCME), which has been adopted by the Global Environmental Monitoring Systems. The detailed formulation of WQI, as described in the Canadian WQI Technical Report (CCME, 2007), is as follows:

$$CWQI = 100 - \sqrt{\frac{F1^2 + F2^2 + F3^2}{1.732}} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Calculation of the index was based on scope (F1), frequency (F2) and amplitude (F3). Division of these 3 terms by 1.732 is based on the fact that each of the three factors contributing to the index can reach the value of 100. Explanation of each term of the index:

Scope; Factor 1 (F1): This factor expresses the percentage of parameters did not comply with the corresponding guideline during the study period.

$$F1 = NFV/TNV \times 100 \quad \ldots\ldots (2)$$

Where:
F1 = Factor 1
NFV = Number of failed variables
TNV = Total number of variables

Frequency; Factor 2 (F2): This factor represented the percentage of individual tests that do not meet the guidelines ('failed tests)

$$F2 = NFT/TNT \times 100 \quad \ldots\ldots (3)$$

Where:
F2 = Factor 2
NFT = Number of failed test
TNT = Total number of test

Amplitude; Factor 3 (F3): Represents the difference between the non-compliant analytical results with the guidelines to which they refer. The term F3 is an asymptotic function, representing the normalized sum of excursions (NSE) in relation to guidelines within the range of values from 0 to 100.

$$F3 = \frac{NSE}{0.01nse + 0.01} \quad \ldots\ldots (4)$$

To calculate the overall degree of non-compliance, we add the excursions of non-compliant analytical results and divide the sum by the total number of analytical results. This variable is called the normalized sum of excursions (NSE).

$$NSE = \sum \text{excursion} / \text{Number of tests}$$

There are two possible ways of determining the excursion:

$$\text{excursion} = \left(\frac{\text{failed test value}}{\text{objective}}\right) - 1$$

When the test value must not fall below the objective:

$$\text{excursion} = \left(\frac{\text{objective}}{\text{failed test value}}\right) - 1$$

These values are combined to produce a single value that lies between 0 and 100 which represents the overall water quality at a given location (Table 1).

Table 1: Ranking of Overall Water Quality

	Status	Scores	Water Quality
i	Excellent	95-100	Water quality is protected with virtual absence of threat or impairment; conditions very close natural or pristine levels.
ii	Good	80-94.9	Water quality is protected with only minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
iii	Fair	65-79.9	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
iv	Marginal	45-64	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
v	Poor	0-44	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

Source: Sataa *et al* (2017)

RESULTS

The result of the measured parameter collected from the ten sampling points are presented in Table 2. This shows the measurement of each of parameters at each sampling point. Cadmium measures between 0.0048 to 0.0158 while Lead lies between 0.0016 to 0.0111. Zinc have a value of 0.0057 to 0.0922 and Copper have the value of 0.0022 to 0.0133, also Nickel have a value of 0.0082 to 0.1732. The table also shows that DO have values of 3.5 to 8.9; The Ph values lies between 6.5 and 8.9; TDS measures between 83.3 and 463.3 while Iron varies from 0.0119 to 0.1981. This shows that there is changes in the values of the parameters observed at the sampling points.

The result of the descriptive statistic of the measured parameter collected from the ten chosen locations for the study are presented in Table 3. It shows the range, mean, sum and standard deviation for each point. The results show that Cadmium have a range of 0.0149 with mean of 0.00876 and SD of 0.0051 while Lead have a range of 0.0095 with mean of 0.0047 and SD of 0.0033. Zinc have a range of 0.1647 with SD of 0.0531 and Copper have the range of 0.0111 with mean of 0.0758 and SD of 0.0032. Also, Nickel have a range of 0.155 with SD of

0.0051. The Table also shows that Manganese have a range of 0.1498 and mean of 0.06756; DO have a range of 5.4 and SD of 1.8; EC have a range of 667.5 with SD of 1.8 while Turbidity have a mean of 49.57 and SD of 17.3506. The Ph have a range of with mean of 7.15 and SD of 0.6654; the value of the Iron has a range of 0.1862 with mean of 0.0568 and SD of 0.0717varies from 0.0119 to 0.1981. Table 3 has shown the statistic description for each parameter at each sampling point to enable good understanding of the variation in the observed values.

Table 2: Results of Parameter at Sampling Points

Parameter	Pi	Pii	Piii	Piv	Pv	Pvi	Pvii	Pviii	Pix	Px
Cadmium (mg/l)	0.0058	0.0006	0.0009	0.0009	0.0057	0.0084	0.0158	0.0141	0.0048	0.0148
Zinc (mg/l)	0.0124	0.0922	0.0104	0.1653	0.0138	0.0142	0.0122	0.0143	0.0123	0.0057
Chromium (mg/l)	0.0049	0.0082	0.0048	0.0042	0.0052	0.0082	0.0155	0.0127	0.0075	0.0077
Lead (mg/l)	0.0083	0.0016	0.0019	0.0024	0.0031	0.0019	0.0075	0.0111	0.0043	0.0057
Copper (mg/l)	0.0085	0.0116	0.0133	0.0076	0.0075	0.0082	0.0022	0.0045	0.0056	0.0068
Manganese (mg/l)	0.1532	0.1557	0.1038	0.0152	0.016	0.1414	0.0121	0.0116	0.0059	0.0607
Nickel (mg/l)	0.1632	0.0775	0.0114	0.0105	0.0082	0.0133	0.0144	0.0094	0.0315	0.0833
Iron (mg/l)	0.0472	0.0156	0.1981	0.017	0.0127	0.0119	0.0138	0.0123	0.0594	0.1797
Nitrates (mg/l)	1.1367	0.9467	0.9433	0.8933	1.0817	0.9033	0.8417	0.8883	0.9583	0.9967
Phosphate (mg/l)	1.535	1.1917	1.0433	1.1083	1.27	1.0933	1.11	1.2067	0.9583	13,283
Turbidity (NTU)	40.1	25.6	45.7	40.3	83.8	39.5	44.9	75	49.6	51.2
TDS	85	100	82.8	91	463.3	83.3	430	437.7	92	85
Ph	7.2	7.1	7.2	6.9	6.6	7.1	6.5	8.9	7.2	6.8
DO	8	5.9	7.3	5.5	8.9	6	4	3.5	5.4	4.1
EC (us/cm)	125.3	149.3	125.5	125.5	694.3	125	644	792.5	137	127.7

Source: Fieldwork (2019)

Table 3: Descriptive Statistic of Parameters

Element	Range	Minimum	Maximum	Sum	Mean	Std. Deviation
Cadmium	0.0149	0.0009	0.0158	0.0876	0.008760	0.0051
Zinc	0.1647	0.0006	0.1653	0.3388	0.033880	0.0531
Lead	0.0095	0.0016	0.0111	0.0478	0.004780	0.0033
Chromium	0.0146	0.0009	0.0155	0.0771	0.007710	0.0043
Copper	0.0111	0.0022	0.0133	0.0758	0.007580	0.0032
Nickel	0.1550	0.0082	0.1632	0.4216	0.042160	0.0510
Manganese	0.1498	0.0059	0.1557	0.6756	0.067560	0.0644
Iron	0.1862	0.0119	0.1981	0.5677	0.056770	0.0717
Nitrates	0.295	0.8417	1.1367	9.5853	0.9585	0.0915
Turbidity	58.2	25.6	83.8	495.7	49.570	17.3506
TDS	380.5	82.8	463.3	1950.1	195.010	171.8620
Ph	2.4	6.5	8.9	71.5	7.150	0.6654
phosphate	0.4917	1.0433	1.5350	11.9333	1.193330	0.1524629
DO	5.4	3.5	8.9	58.6	5.9	1.8
EC	667.5	125.0	792.5	3046.1	304.610	282.2852

Table 4 presents the summary of the Canadian WQI of the sampling points, which shows the level WQI ranging from marginal to poor for the sample point used in the study. The CWQI at Kawo is 61.3 while at Anguwn Dosa is 46.4; Malali have CWQI is 45. Anguwn Rimi have CWQI 51 and Kigo have CWQI of 46; Barnawa have CWQI of 39.9 while Makera have 41.1 and Anguwn Muazu have 42 and Kudenda 35.8. Table 4 also shows that the WQI ranges between marginal and poor. Kawo, Anguwn Dosa, Malali, Anguwn Rimi and Kigo are frequently threatened or impaired While Kudenda, Agauwn Muazu, Makera and Barnawa are always threatened.

Table 4: Summary of Canadian WQI of Sampling Points

Location	Sampling Points	WQI	Interpretation
Kawo	Pi	61.3	Marginal
Anguwn Dosa	Pii	46.4	Marginal
Malali	Piii	45	Marginal
Anguwn Rimi	Piv	51	Marginal
Kigo	Pv	46	Marginal
Barnawa	Pvi	39.9	Poor
Tudun Wada	Pvii	41.1	Poor
Makera	Pviii	31.8	Poor
Anguwn Muazu	Pix	42	Poor
Kudenda	Px	35.8	Poor

DISCUSSION

The water samples collected from the Kaduna River at the 10 selected points were analyzed. The result reveals that the mean concentration of Cd ranges from 0.006 to 0.0084 with Anguwn Dosa having the lowest concentration of Cd followed by Malali and Anguwn Rimi. While Tudun Wada have the highest level of Cadmium (0.0158) and closely followed by Kudenda (0.0148), Makera (0.01410 and Barnawa (0.0084) (Table 2). Sources of Cd can be attributed to usage of phosphate fertilizers, sewage sludge, and industrial effluents and from household wastes. Cd is very bio-persistent and is used for stabilizers for Polyvinyl chloride (PVC), in alloys and electronic compound. Cd is also present as an impurity in several products including detergents and refined petroleum products (Vivian *et al*., 2012). Cd is toxic and carcinogenic to humans (Garba *et al*., 2013).

The result reveals that the concentration of Zinc ranges from 0.1653 to 0.0104 in River Kaduna. It also shows that Anguwn Rimi have the highest level of Zn followed by Anguwn Dosa and Tudun Wada. The presence of Zn at each sample point can be attributed to routing of debris containing Zn into the River by runoff from the vast catchment area which covers several urban and semi-urban settlements. Zinc is also suspected to have entered the River from household wastes, agricultural wastes from the use of fertilizers, pesticides and herbicides. Zn is also embedded in geological formation and released gradually via chemical weathering and finally drained into the River (Butu, 2011). The result also shows that the mean value of Zn is 0.0339 while the Standard Deviation is 0.0051 (Table 3).

The result further shows that mean concentration of chromium ranges from 0.0155 to 0.0042, with Anguwn Rimi having the lowest level and Tudun Wada have the highest. Cr mean value along the River is 0.0077 with standard deviation of 0.0043. Cr is used in metal alloys and pigments for paints, cements and rubber and other materials (Butu, 2011). Cr can be drained into the River from soaps, detergents used for washing at homes and from dyes from textiles, from waste incineration, industrial effluents (Dan-Azumi and Bichi, 2010). Cr is one of those metals whose concentration steadily increases dues industrial growth, erosion of rocks and municipal wastes (Galadima and Garba, 2012). Chromium often accumulates in aquatic life, adding to the danger of eating fish that may have been exposed to high levels of Cr. Low level exposure of Cr can cause skin irritation and ulceration while long term exposure can cause damage to circulatory and nerve tissues (Butu, 2011).

The mean concentration of Pb ranges from 0.0111 to 0.0016 with Anguwn Dosa having the lowest (0.0016) followed by Malali and Barnawa (Table 2). Pb average mean value is 0.0077 mg/l. Makera have the highest level of Pb followed by Kawo and Kudenda. The direct use of water for drinking and irrigation from the River by downstream dwellers could be detrimental to their health, as it may result in possible neurological damage in fetus, abortion and other health complications in children under the age of three (Akinola *et al*., 2012).

The level of copper in the river ranges from 0.0022 (Tudun Wada) to 0.0133 in Malali and. Cu is an essential macro nutrient that helps in the production of blood haemoglobin but in high concentrations it can cause anaemia, liver and kidney damage, stomach and intestinal irritation (Garba *et al*., 2012). Result from the analysis shows that Mn is high at all the sampling points. It reveals that Anguwn Dosa have the highest level of Mn and followed by Kawo (0.1532) and Barnawa. It also reveals that Anguwn Muazu have the lowest closely followed by Anguwn

Rimi and Kigo. The reason for high values of Mn in River Kaduna can be attributed to the draining of effluents that contain Mn into the River by surface flow from nearby settlements and also from geological formation. Mn is a common compound that can be found everywhere on earth. It is necessary for humans but also toxic at high concentrations. Mn effects occur mainly in the respiratory tract and in the brain (Ogunmodede and Ajayi, 2014). Other sources of Mn include burning of fossil fuels and sewage sludge (Al-Amin, 2013).

The concentration of Ni ranges from 0.0082 to 0.1632 in Kigo and Kawo. Sources of Ni can be attributed to waste incinerators, household wastes, and farm runoff. Ni can be carcinogenic and toxic in high concentrations. The concentration of Fe ranges from 0.1981 to 0.0119, Malali have the highest level of Fe followed by Kudenda, Anguwn Muazu and Kawo. Fe is one of the most abundant metal and persists in the environment (Akan *et al*., 2010). The reason for the presence of Fe in the river may be due to weathering and routing of lateritic materials into the River. Intensive agricultural activities in the study area may have aided weathering and the release of Fe into the River. Excess Fe in the body can cause liver and kidney damage (Emmanuel *et al*., 2012).

Nitrate level ranges from 1.1367 to 0.8417 and phosphate ranges from 1.535 to 1.0433. The presence of nitrate in the river can be attributed to wastewater discharge from settlements. The presence of phosphate in this zone can be attributed to urban surface run-off from waste disposal. Anthropogenic activities are the main contributors of excessive phosphate into river channels; sewage discharge, runoff from agricultural sites, and the release of detergent during domestic washing. Turbidity is a measure of only one effect of suspended solids on the quality of water (Peters and Meybeck, 2000). Other sources of turbidity are microorganisms, algae, dead plant matter, silica or other mineral substance, clay, silt and fibers. Excessive turbidity affects the aquatic ecosystem in many ways (Vivian *et al*., 2012). High turbidity significantly reduces the aesthetic quality of water bodies and. It also tends to increase the cost of water treatment (Rahman e*t al*., 2012). It can affect fish and other aquatic organisms by reducing food supplies, degrading spawning beds and affecting gill function (Vivian *et al*., 2012). Turbidity can also be caused by growth of phytoplankton, human activities that disturb land such as agriculture, mining, construction which in turn can lead to high sediment levels entering the River due runoff (Obilonu *et al*., 2013).

The Turbidity concentration ranges from 83.8 to 25.6 with Kigo having the highest and Anguwn Dosa the lowest. TDS ranges from 463.3 to 82/8 across the River, with Kigo have highest followed by Makera, Tudun Wadao and Anguwn Doas. While Malali, Kawo and Kudenda have the lowest level. TDS across the sample points could be attributed to various socio-cultural factors such as indecent disposal of household water into water channels, excessive use of fertilizers from farming activities on floodplains and unchecked effluents discharged directly into water bodies. Total dissolved solids (TDS) in broad sense reflects pollutant burden on the aquatic system (Abubakar, 2015).

The pH value ranges from 8.9 to 6.5 across the sampling points. Makera have the highest followed by Kawo, Malali and Anguwn Muazu (7.2) while Tudun Wada have the lowest followed by Kigo and Anguwn Rimi. The pH of an aquatic ecosystem is important because it is closely linked to biological productivity (Sataa *et al*., 2017). pH can lead to death of aquatic organisms and affect the solubility and toxicity of chemical and heavy metals in water bodies. High levels of pH can affect egg production in fish. It can also cause skin and eye irritation to humans (Ojo *et al*., 2012). Lower pH levels can increase the risk of mobilized toxic metals that can be absorbed by animals and humans. The pH in rivers can be due to wastewater, municipal discharge, heavy rainfall and agricultural runoff (Chikogu *et al*., 2012).

The dissolved oxygen (DO) value also ranges from 8.9 to 3.5 (Table 2). DO is very essential for the survival and wellbeing of fish and other aquatic organisms. Significant amount of DO in water also helps in determining of freshness of a River (Abubakar, 2015) It could also be from indiscriminate discharge of municipal wastes containing high concentration of nutrients and organic wastes. DO is important for the healthy growth of aquatic organisms (Chikogu *et al*., 2012). Electrical conductivity across the sample points is closely tied to the secretion of acidic substances such as phosphate, and nitrate, contained in solid wastes entering into the river as well as effluent discharged from industries into the river. Conductivity level increases with the existence of inorganic suspended solids in runoff as well as the presence of nitrate from sewage systems which by extension reduces the purity of the surface water (Abubakar, 2015).

The calculated values of both chemical and physicochemical parameters on Table 2 were subjected into the Canadian water quality index models across all the sampling locations. Table 4 presents the summary of the Canadian Water Quality Index (WQI) of the sampling locations. The result reveals that the WQI in Barnawa, Tudun Wada, Makera, Angwan Mu'azu and Kudende are poor. This means that the water quality here is always threatened or impaired. This could be attributed to the kind of anthropogenic activities around these areas that drains contaminants into the River; they include industrial effluents, agricultural and heavy municipal wastes, weathering among others. The result also indicates that the water quality of the river upstream was marginal based on the Canadian WQI.

CONCLUSION AND RECOMMENDATIONS

Based on the results obtained in this research, it could be concluded that the WQI of River Kaduna on the Canadian scale is marginal upstream and poor downstream. The areas with high impairment level (poor) along the river are located within Makera, Tudun Wada and Kudenda communities. The use of environmentally friendly household products such as cleaning agents be encouraged and the use of pesticides and fertilizers be reduced, this will also prevent runoffs of these chemicals into the river. Hence, relevant environmental law enforcement agencies should identify the sources of pollution in areas and towns shown to have impairment level in the water quality assessment and then impose disciplinary measures against culprits. Also, there is the need for proper environmental education as well more studies on the implications on human health.

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