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An Assessment of Water Quality Status of Challawa River in Kano State, Nigeria

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Abstract
This study assessed the physico-chemical characteristics of surface water samples along river Challawa in Kano state, Nigeria. Five sampling points were identified along the river. Water samples were collected at a consecutive distance of about 200m apart in the downstream direction, starting from a point of suspected effluent influx. The samples were then analysed for physico-chemical parameters that include temperature, pH, dissolved oxygen (DO), total dissolved solids (TDS), nickel ion (Ni^{2+}), lead ion (Pb^{2+}), cadmium ion (Cd^{2+}), chromium ion (Cr^{2+}), zinc ion (Zn^{2+}) in accordance with standard methods. The results revealed acidic pH values for all the samples. DO concentrations increased from 2.31mg/l in the first sampling point to 7.73mg/l in the last sampling point while the concentrations of TDS for all the samples were within the acceptable WHO guideline threshold. Among the five examined heavy metal ions, the concentrations of Cr^{2+} were highest in all samples. Eighty percent of the samples show heavy metal concentrations in order: $Cr^{2+} > Pb^{2+} > Zn^{2+} > Ni^{2+} > Cd^{2+}$. The high concentrations of Cr^{2+} observed could be attributed to the influx of chromium containing effluents from tanneries located in the nearby Challawa industrial estate. It is, therefore, recommended that effluents from the nearby industrial estates should be properly decontaminated before release into the environment.

Keywords: Water quality, physico-chemical, pollution, river Challawa, Kano state

INTRODUCTION
Water, which is one of the most important components of all living organisms, can be rendered useless on account of pollution (Olorunfemi *et al*., 2011). Surface and ground availability and the possibility of consumptive uses are influenced, largely, by the quality status of their sources. According to the Texas Commission on Environmental Quality (TCEQ, 2018), part of the general criteria for surface water quality is to be free from taste and odor producing substances, floating debris and substances liable to alter the chemical composition of the water. Also, a number of physical and chemical parameters such as turbidity, salinity, conductivity, pH, DO, volatile organic chemicals, inorganic chemicals and heavy metals concentration are examined when determining the quality of a water body(CWT, 2010; Philadelphia Water, 2015).

Water quality degradation results from a variety of substances arising from different sources. Such contaminants include particulate matter that sediment from the air, fertilizers and pesticides from agro-allied practices, spillage from septic tanks, toxic chemical wastes

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from industrial processes, sewage and other urban wastes among others (Katsanou and Karapanagioti, 2017).The impact of water quality degradation on health of humans and aquatic lives is researched and documented by many authors. WHO/UNICEF (2019) reported that 485,000human lives are lost annually due to contaminated drinking water. According to Adeosun *et al*. (2015), aquatic organisms, especially fish, can suffer severe adverse effects due to exposure to heavy metals. In a research carried out by Afshan *et al*. (2014), the effects of chromium were reported to be damaging to the gills of fish, blood cells and generally reducing the resilience of fish species. They also stated that effects such as hypoxia, dormancy, imbalance and death have been associated with fish exposure to zinc.

The assessment of water quality is a necessary step for the determination of pollution, monitoring, regulation and management of water resources. Accordingly, many studies have been conducted on water quality assessment in Nigeria and other parts of the world. For instance, Anyanwu and Ukaegbu (2019), assessed the physicochemical characteristics of the Ossah river in southeastern Nigeria and found that as the amounts of DO and pH values did not meet the required standards in all the samples examined. Uzairu *et al*. (2014) identified the risk of exposure to metals found in river Challawa due to their bioavailability and mobility. Although several studies have been conducted in river Challawa, continuous monitoring of the waterbody will provide relevant updated information that will aid pollution prevention and control efforts as well as decision making. It is in that regard thatthis study was undertaken in order to evaluate the physico-chemical characteristics of river Challawa.

MATERIALS AND METHODS

Study Area

This research was carried out in river Challawa (shown in Figure 1) that originates from the Challawa Gorge dam in Challawa village within Kumbutso local government area in the southern part of Kano state, northwestern Nigeria. Kano state occupies a central position in the northern Nigeria (Akan *et al*., 2007). Industrially, it is one of the most developed cities in the region. It has three major industrial estates namely Bompai, Challawa and Sharada industrial estates. Each of them accommodates many wet industries. Tanneries and textile processing are some of the dominant industries. Kano state covers an area extending between latitudes 10^{o}30′ to 12^{o} 40′ and longitudes 7^{o} 40′ to 9^{o} 40′ and 418 m above sea level (Uzairu *et al*., 2014).

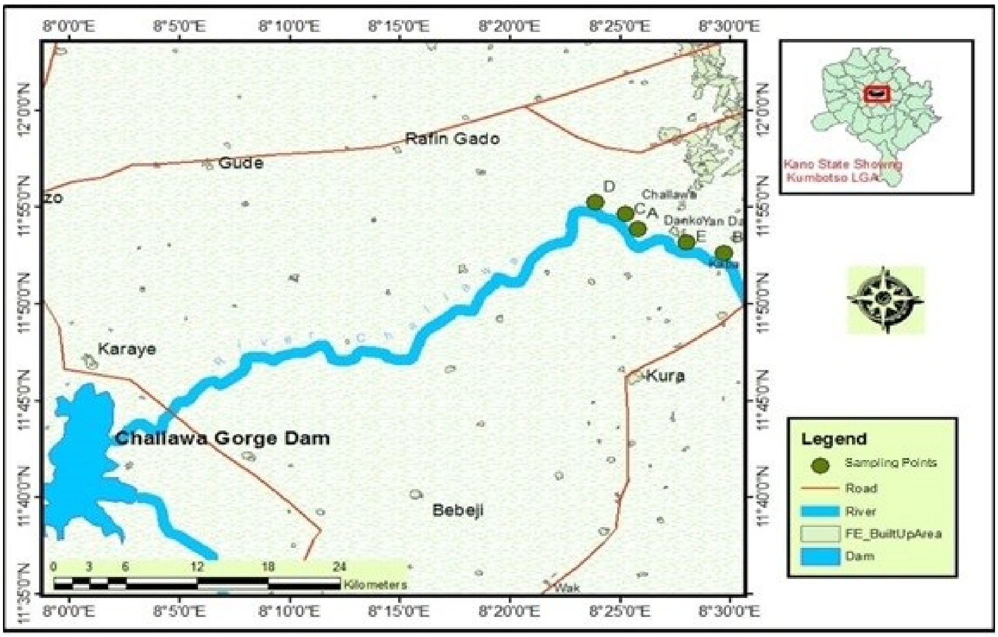

Figure 1: Map of the study area showing River Challawa
Source: BUK GIS 2018.

River Challawa is the second largest river system in Kano state after river Kano. It is about 50 km in length flowing northeast to finally join river Hadejia (Hussain and Ibrahim, 2017; Abdulhamid, 2014). It has a confluence with river Kano at Tamburawa that is located around 20km south of Kano metropolis. The river represents a major source of water for agricultural, industrial and domestic activities in Kano metropolis and its environs (Kawo and Daneji, 2011). This is obvious in the fact that the main waterworks of Kano state that supply drinking water is located by the river and source freshwater therein. A major industrial layout, Challawa industrial estate is situated around the river and largely depends on the water works for its water needs. Effluents from the industrial estate, often, ends up drained into the river. Geologically, river Challawa is underlain with pre-cambrian basement complex rocks, which comprises of gneisses, amphibolites, marbles and the older granites (Mustapha *et al.*, 2019). Derived Savanna is the dominant vegetation in Kano state with about 75% of the land cultivated (Badamasi, 2014).

Samples Collection and Analysis
Five sampling points were identified along river Challawa. Water samples were collected at a consecutive distance of about 200m apart, starting from the point of suspected effluent inflow and to the downstream direction of the river. Figure 1 shows the study area showing the sampling points along the river. In each sampling point, water samples were collected using a pre-cleaned 2L bucket and emptied into pre-cleaned0.75L plastic bottle containers and labelled accordingly. The samples were then stored in cooler boxes at 5^oC and transported to the laboratory for physico-chemical analysis in accordance with the standard analytical methods for water quality examinations as prescribed in APHA, (1985).The parameters analysed include temperature, pH, DO, TDS, Ni^{2+}, Pb^{2+}, Cd^{2+}, $Cr^{2+}$and Zn^{2+}. The results obtained were then processed using Microsoft Excel and discussed.

RESULTS
Table 1 presents a summary of the findings of this research. It shows the physico-chemical compositions of the water samples analysed and the relevant WHO guideline values for drinking water quality prescribed in WHO (2017). The trends are analysed and visualised in figures and contextualised in the discussion section.

Table 1: Summarized physico-chemical characteristics of the water samples

Parameter	Station 1	Station 2	Station 3	Station 4	Station 5	WHO Guidelines
Temperature (°C)	28.5	28.5	30	29.5	28.5	
pH	6.0	6.2	6.6	6.7	6.7	6.5 - 8.5
DO (mg/l)	2.31	3.76	5.81	4.32	7.73	6.0
TDS (mg/l)	280	230	273	220	220	600
Nickel (mg/l)	0.052	0.023	0.018	0.037	0.031	0.07
Lead(mg/l)	0.167	0.111	0.237	0.122	0.011	0.01
Cadmium(mg/l)	0.019	0.003	0.012	0.007	0.001	0.003
Chromium (mg/l)	0.823	0.590	0.339	0.281	0.118	0.05
Zinc (mg/l)	0.158	0.095	0.164	0.080	0.015	0.01

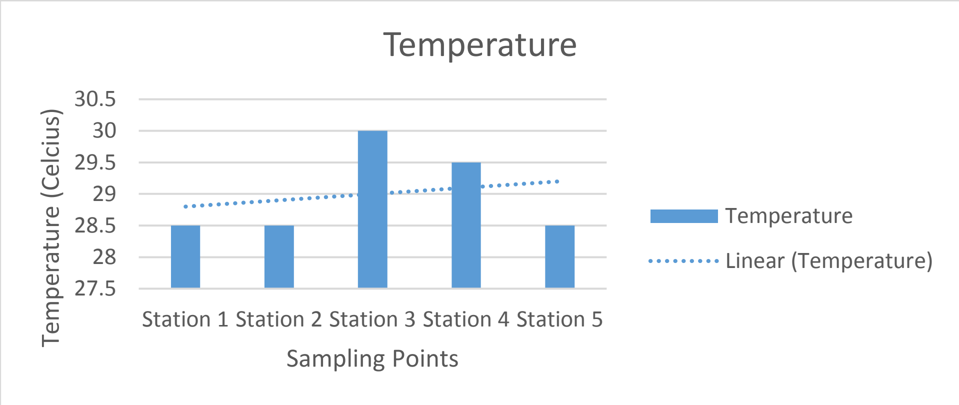

Figure 2:Temperature of all the water samples

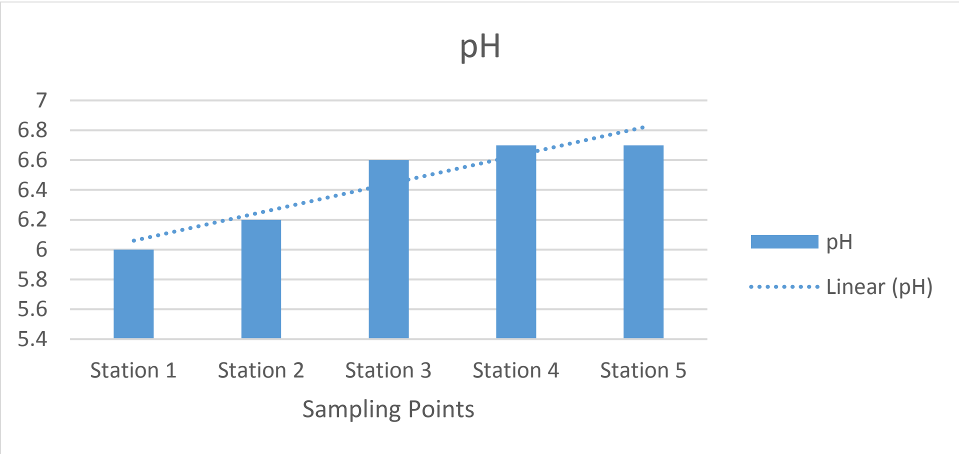

Figure 3: pH values of all the water samples

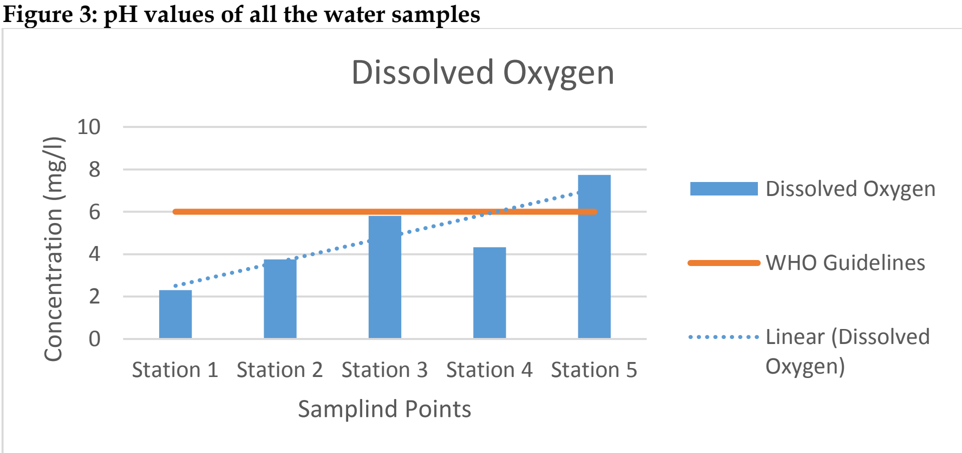

Figure 4: Dissolved Oxygen concentrations of all the water samples

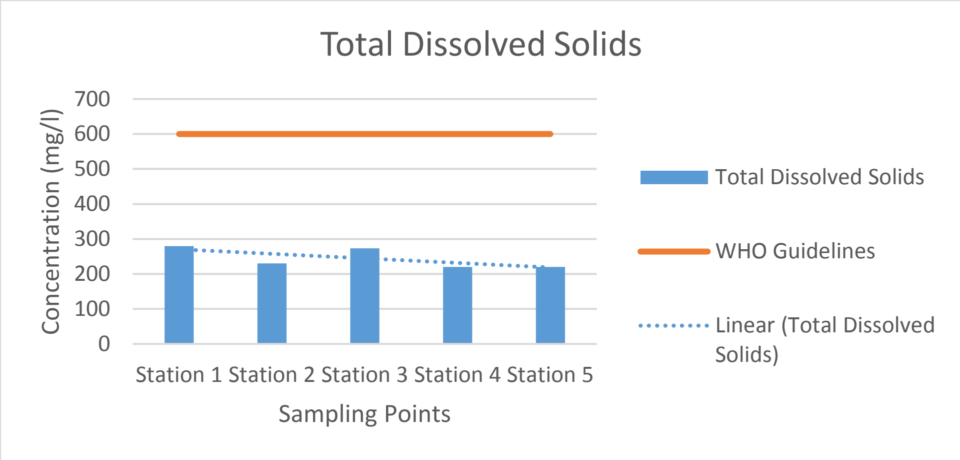

Figure 5: Total Dissolved Solids concentrations of all the water samples

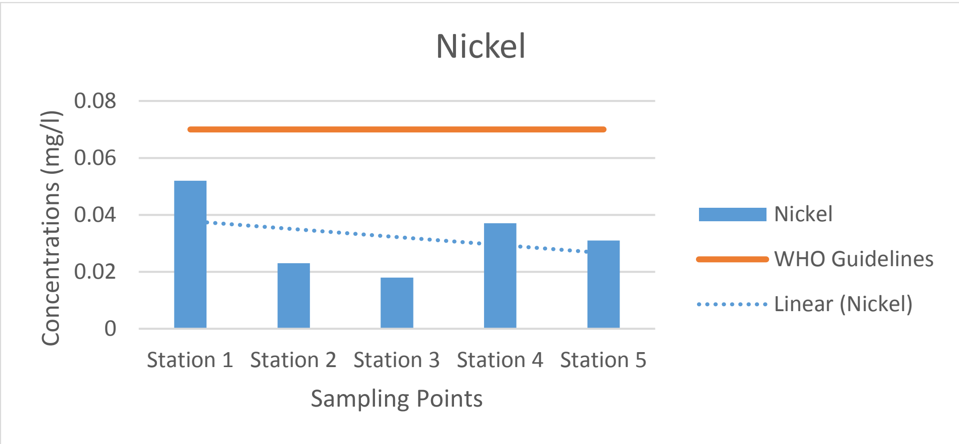

Figure 6: Nickel (II) ion concentrations of all the water samples

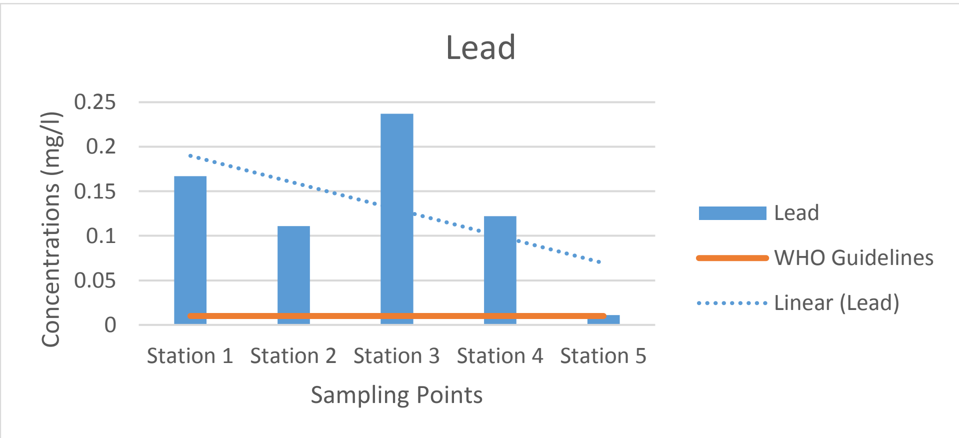

Figure 7: Lead (II) ion concentrations of all the water samples

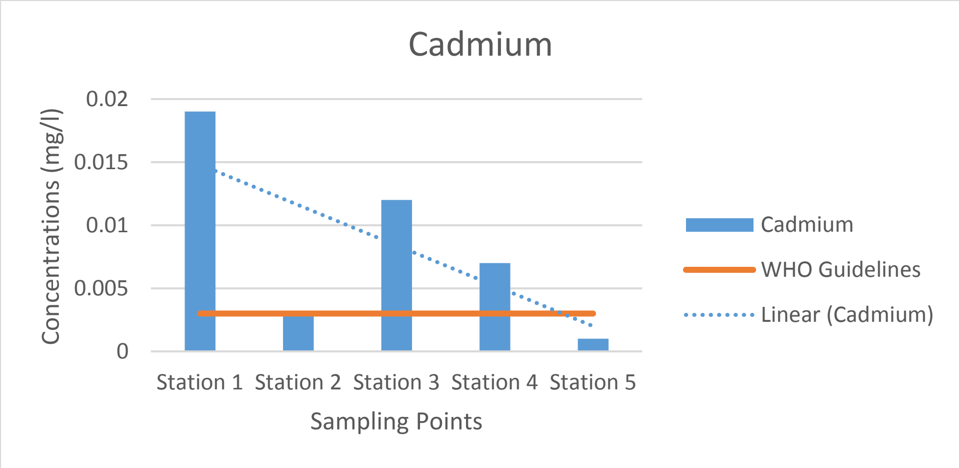

Figure 8: Cadmium (II) ion concentrations of all the water samples

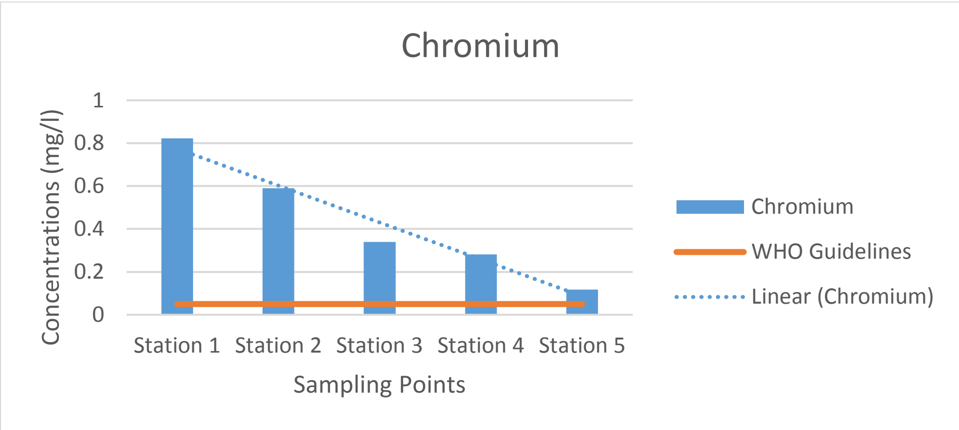

Figure 9: Chromium (II) ion concentrations of all the water samples

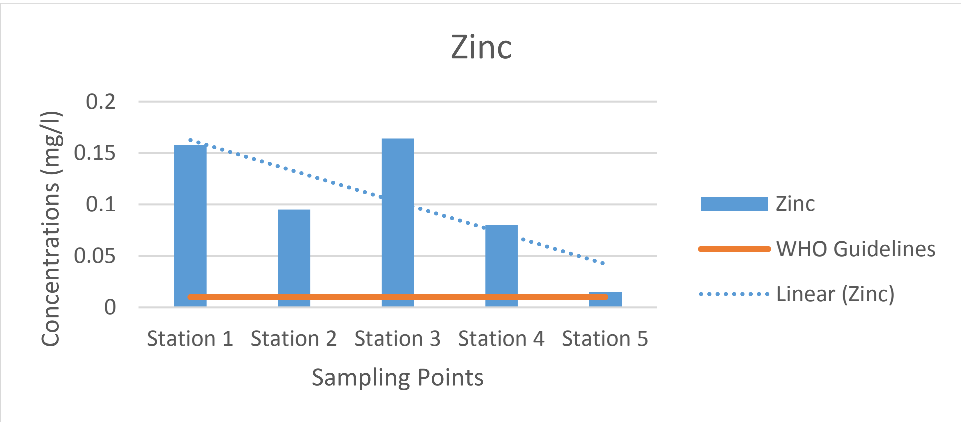

Figure 10: Zinc (II) ion concentrations of all the water samples

DISCUSSION

The findings revealed significant fluctuations in concentrations of the parameters examined across all the samples. When compared to the WHO guidelines for acceptability in drinking water as prescribed in WHO, (2017), many of the samples exhibit unacceptable physico-chemical characteristics. Figure 2 presents the temperature readings observed for all the samples. The values ranged from 28.5^{o}Cto 30^{o}C for all samples. This range agrees with what several authors, such as Abowei (2010), have reported in other assessments of surface water quality in Nigeria. The pH values of all the samples are presented in Figure 3. On its own however, pH is not a contaminant, rather is an indication of the presence of some chemical constituents present in water bodies. As such, pH is often regarded as an important water quality parameter that have an indirect effect on public health and aquatic lives (WHO, 2017). In this study, pH values ranged from 6.0 to 6.7 for all the samples. These values are slightly acidic, but 60% of the samples are within the WHO guideline range of acceptable values (6.5-8.5).The lower pH values noted in stations 1 and 2 might be attributed to the inflow of effluents into the river occurring near the first sampling station. It should be noted that effluents discharged from Challawa industrial estate comprises of different chemicals and toxic wastes that could potentially drain to the river and increase its acidity.

The concentrations of DO for all the samples were below the WHO guideline value of 6.0 mg/l except at station 5, which has a value of 7.73 mg/l, as shown in Figure 4. There is a trend of increasing DO values from sampling station 1 through to the last station, except in station 4 that has lower value than station 3. This could point to a decreasing pollution load from the first sampling station that is located close to the point of effluent inflow, through to the last station that is about 1km downstream. Concentration of DO is a critical determinant of species diversity found in a water body. A vast majority of aquatic organisms are aerobes that depend on the amount of dissolved oxygen in the water. Thus, the consequence of low amounts DO on the affected species may mean death or forced migration to other areas with better oxygen supply. Numerous anthropogenic sources of pollutants can contaminate water environment, including inputs from waste waters flowing from mines and waste storage, runoff of pesticides from agricultural land or atmospheric deposition (Song *et al*., 2010).

TDS concentration represents the amount of inorganic salts and small amounts of organic matter that are dissolved in water. Typically, TDS in water originates from natural sources, sewage, urban runoff and industrial wastewater (WHO, 2017). In this study, concentration of TDS for all the samples ranged from 220mg/l to 280mg/l as presented in Figure 5. They were all below 600mg/l, which is the WHO guideline threshold for acceptability. There appears to bea decreasing trend in the TDS values. This could be an indication of decreasing contaminant load from the first sampling station through to the last.

The five selected heavy metal ions assessed in this study are Ni^{2+}, Pb^{2+}, Cd^{2+}, Cr^{2+} and Zn^{2+}. Nickel ion concentrations in all the samples were found to be lower than the acceptable WHO guideline value of 0.07mg/l. However, there seems to be a decreasing trend from station 1 through to station 5, as can be seen in Figure 6. The concentrations of lead ion in all the samples are shown in Figure 7 and ranged from 0.011mg/l in station 5 to 0.237mg/l in station 3. These values are all above the acceptable WHO guideline value of 0.01mg/l. Lead is one of the commonest heavy metals found on Earth's crust. It is used commonly in the production of lead acid batteries, solder and alloys among many others(WHO, 2017).Thus, aside from the possible natural sources, lead ions in the river could have been sourced from the municipal waste dumpsites that drains to the river especially during the wet season. It should be noted that all waste streams including electronic wastes that could contain lead and other heavy metals are, often, co-disposed in open dumpsites in Kano metropolis.

Cadmium ion concentrations ranged from 0.001 mg/l in station 5 through to 0.019mg/l in sampling station 1. While 80% of the samples were below the acceptable WHO guideline value of 0.003mg/l, there is a trend of decreasing concentrations from station 1 through to station 5, as shown in Figure 8. Apart from the natural sources of cadmium, the WHO (2011) suggested that fertilizers produced from phosphate ores constitute a major source of diffuse cadmium pollution, and its solubility in water is influenced to a large degree by its acidity. It should be noted that the river also drains a heavily cultivated area that uses fertilizers, which could be a possible source of cadmium ions in the water.

The amounts of Cr^{2+}werehighestin all the sampling points and were all above the WHO guideline threshold for acceptability, as presented in Figure 9. The trend observed in all the samples followed the order; Cr^{2+}> Pb^{2+}>Zn^{2+}> Ni^{2+}>Cd^{2+}except in the last sampling station, in which the metal concentrations followed the order, Cr^{2+}> Ni^{2+}>Zn^{2+}> Pb^{2+}>Cd^{2+}. The noticeably high chromium ion concentration among all samples may be attributed to the likely contaminant inputs from tanneries located in Challawa industrial estate that discharge chromium containing effluents. However, there appears to be a decreasing concentration of chromium from sampling station 1 through to station 5. This could imply increasing rate of attenuation of contaminants as the river flows.

Zinc ion concentrations in all the samples ranged from 0.015mg/l in station 5 to 0.164mg/l in station 3, as presented in Figure 10. While there is decreasing trend from sampling station 1 through to station 5, the concentration at station 3appears to be significantly higher than all stations. According to the guidelines of the WHO (2017), zinc is not normally found in surface water at concentrations above 0.01 mg/l. Accordingly, the entire samples contain concentrations of zinc ions greater than there commended guideline value. This implies that the level of contamination in the river is highly likely to have originated from anthropogenic sources. It is worth noting that the catchment area of river Challawa drains a large part of Kano state that include industrial, commercial and residential areas. Given the poor environmental management practice in the area, considerable amounts of anthropogenic contaminants may be drained into the river and result in significant contamination.

CONCLUSION

The study concludes that river Challawa is contaminated, most likely, from anthropogenic sources. A key suspect is the discharge of effluents from industrial estates located within the catchment area and, often, drains into the river to cause pollution. The polluted status of the river could pose deleterious effect on aquatic organisms and public health. It is, therefore, recommended that all direct and indirect discharges of untreated effluents into the river should be ceased. Also, all effluents should be properly decontaminated in accordance with the recommended guidelines before being discharged into the environment. These measures will, ultimately, safeguard environmental quality and public health.

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