Effects of Effluents on the Quality of River Rido, Kaduna- State, Nigeria

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Abstract

This study examines the effect of discharged effluents on the quality of river Rido in Kaduna. Ten water samples were collected and tested for Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Nickel (Ni) and Zinc (Zn). The results revealed that in the dry season, six heavy metals, namely As, Cd, Cu, Mn, Ni and Zn, presented mean values that were higher after the point of effluent discharge; while Cr, Fe and Pb had lower values and Hg was not detected. In the wet season all the heavy metals tested, except Hg, increased in values after the point of effluent discharge. The values of As, Cd, Fe, Mn, Ni and Pb after the discharge point, in dry and wet seasons, were greater than the maximum tolerable limits set by the Standard Organisation of Nigeria (SON) and the World Health Organisation (WHO). The values recorded for Zn and Cu at both dry and wet seasons were below the limit set by the Standard Organisation of Nigeria (SON) and the World Health Organisation (WHO), but the value of Cr was lower than the maximum tolerable limit only in the dry season. The contamination of the river with heavy metals poses a grave danger to human health, as its water is used for diverse purposes. The wastewater treatment plant of KRPC should be rehabilitated and the wastewater can be pre-treated before it is discharged into the river.

Keywords: Downstream, heavy metals, industrial wastewater, upstream

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Ghana Journal of Geography Vol. 12(1), 2020 pages 159- 170

https://doi.org/10.4314/gjg.v12i1.9

Introduction

Water is important and a precious natural resource. It supports all forms of life and without water, life on Earth is impossible (Asthana & Asthana, 2001). Thus, for human existence, water is needed in the right quality and quantity. However, recognizing the importance of water quality came relatively slowly as early humans could only judge water quality through the physical senses of sight, taste and smell (Dara & Mishra, 2004).

Rapid population growth and increased human activities have adversely affected the quality and quantity of water in streams, rivers, lakes, lagoons and underground aquifers globally (Christopherson, 2006). Enger and Smith (2006) corroborate this when they observe that the increasing demand for water by humans for different uses (agriculture, domestic and industrial) has led to the contamination of most of the freshwater resources.

The effects of contaminated water on public health and the environment are usually of great magnitude (Reza, Jain & Singh, 2010). In Nigeria, the contamination of freshwater sources has resulted in the outbreak of diseases and negative consequences on the ecosystem (Yusuf & Shuaibu, 2009; John & Orish, 2009; Garba, Hamza & Galadima, 2010; Atubi, 2011; Onojake, Ukerun, & Iwuoha, 2011; Uzoekwe & Oghosanine, 2011; Salisu & Mustapha, 2013).

There is an increasing concern about the contamination of natural water bodies by industrial effluents in developing and densely populated countries like Nigeria. This is because rivers are a major means of waste disposal and especially effluents from industries nearby. Thus, major sources of drinking water in the country are often contaminated by the activities of the adjoining population and industrial establishments (Ishaya, 2016).

As demand for crude oil grew in Nigeria, the establishment of refineries in the country became necessary and commercially viable. The establishment of refineries at Warri, Kaduna and Port Harcourt sprang up as a result of this development. The Kaduna Refinery and Petrochemical Company (KRPC) Limited was established to refine 110, 000 barrels per day (BPD) into high quality petroleum products and to manufacture petrochemical and packaging products. KRPC is primarily engaged in the manufacturing of fuel, lubricants and petrochemical intermediates, using petroleum as a principal input material (Austin, 2010). The activities of KRPC generate effluents in all forms including liquid discharge, gaseous emissions and solid wastes in the form of sludge, a situation which has resulted in environmental pollution (Amin, 2006). The company is the major factory that drains its wastes into the Rido river, which is used by residents of Rido community. According to Oyewoye (1964) as cited in Buggu (2018), the provision for disposal of refinery liquid waste into river Rido was initially one of the reasons the refinery was located in Rido . The people of Rido are predominantly farmers who rely on the water of river Rido for agricultural and domestic uses; hence, the need to assess the effects that discharged effluents from KRPC have on the water quality.

Methodology

The study area is located some 16 kilometers south of Kaduna metropolis. It lies between Latitudes 10° 18' N to 10° 30' N and Longitudes 7° 15' E to 7° 52' E. The KRPC facility lies between Latitudes 10° 24' 05''N and 10° 25' 20''N and Longitudes 7° 28' 49''E and 7° 30' 01''E (Figure 1). The study area has tropical continental climate; thus, it is characterized by a wet season which lasts from May to September and a dry season which extends from October to April (Audu et al., 2018). It is drained by river Rido, one of the tributaries of river Rigasa, which drains into river Kaduna. All streams and rivers within the study area experience flash floods during the rainy season. Runoffs begin soon after the start of rainfall. In valley undersides, the water table is closer to the surface and water logging occurs (Buggu, 2018).

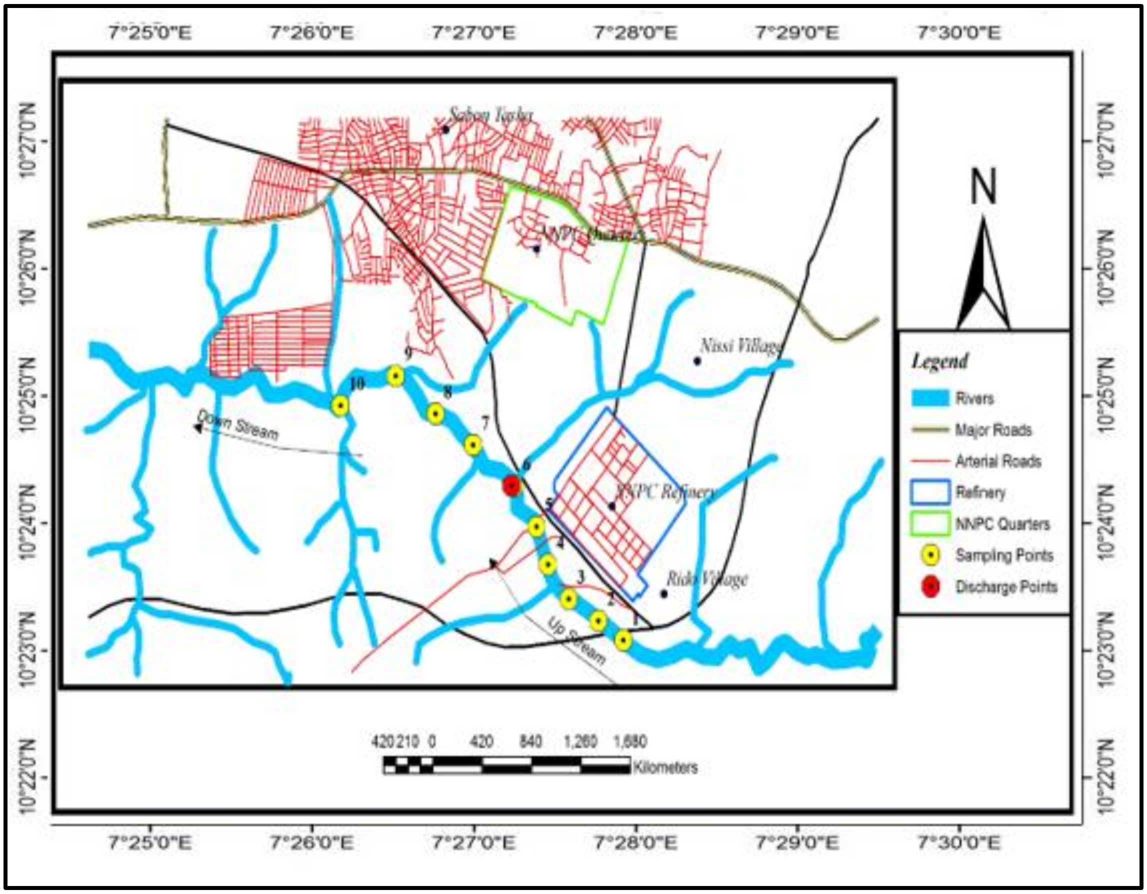

Figure 1: The Study Area

Source: Adapted from the Administrative Map of Kaduna State

Primary and secondary data were sourced for this study in 2018. Secondary data were obtained through the review of relevant documents. Data on Safety Standards for Potable Water from the World Health Organization (WHO, 2011) and the Standards Organization of Nigeria (SON, 2007) were also used to interpret water quality. The primary sources include field observations and results derived from the laboratory analysis of the quality of the water samples collected by transect methods from river Rido.

The process involved the collection of water samples along the river. The transect method was used to determine sampling points along the river to allow for flexibility in fixing the points in the river at which samples were taken. A total of ten samples were taken for the study, comprising of five control samples (points 1-5 on Figure 1) at intervals of 1km from each other before the point of discharge of effluents from KPRC and five samples (points 6-10 on Figure 1) from the point of discharge to 4km downstream.

A 100 metre synthetic tape was used to fix the distance for each sampling point. Water samples were collected along the river in the morning from 8-10 am using the Grab method which involves dipping a sampling container (plastic cup) from points in the stream along cross sections. Grab sampling techniques used in this study were consistent at each sampling point.

The water samples were all collected in clean 1.5 litre white polyethylene stopper containers which had been soaked overnight in dilute HNO_3 solution. The containers were first rinsed with distilled water and filled with distilled water to the sampling points. The containers were emptied at the sampling points and rinsed several times with the samples to be collected. The water samples were then collected into the containers and covered (airtight) with their lids immediately. Each bottle was labeled for clear identification and to avoid mixing up the samples. The samples were preserved by adding a little nitric acid (American Public Health Association, 2002). The samples were then placed in a plastic container with ice and transported to the Sheda Science and Technology laboratory, FCT- Nigeria, for analyses.

The water samples were taken at two different periods: the wet and dry seasons. These periods provided samples that were tagged high-flow samples and low-flow samples respectively. Each was tested for Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Nickel (Ni) and Zinc (Zn) using an atomic absorption spectrophotometer.

Results and Discussion

The mean values of the water samples tested in the laboratory and the tolerable limits of the heavy metals set by regulatory bodies are presented on Tables 1 and 2.

Table 1: Mean Values of Heavy Metal in River Rido

S/N	Metal (mg/L)	Mean Values of Control Samples		Mean Values at Points after Discharge (mg/L)		Differences in Mean Values	
		Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
1.	As	0.0061	0.0125	0.0387	0.0490	0.0326	0.0365
2.	Cd	0.0017	0.0017	0.0068	0.0071	0.0051	0.0054
3.	Cu	0.1030	0.4192	0.3359	0.8152	0.2329	0.3960
4.	Cr	0.0019	0.0265	0.0004	0.0946	-0.0015	0.0681
5.	Fe	1.0334	1.0052	0.9821	1.6252	-0.0513	0.6200
6.	Mn	1.1592	1.1931	1.4403	1.6551	0.2811	0.4620
7.	Ni	0.0019	0.0252	0.0220	0.0337	0.0201	0.0085
8.	Hg	-	-	-	-	-	-
9.	Pb	0.0481	0.0038	0.0439	0.0408	-0.0042	0.0370
10.	Zn	0.0978	0.4422	0.3529	0.5498	0.2551	0.1076

Source: Fieldwork, 2018

Table 2: Levels of Heavy Metals in River Rido and Maximum Tolerable Limits

S/N	Heavy Metal	Mean Values at Points after Discharge (mg/L		Maximum Tolerable Limits		Health Impact from SON
		Dry Season	Wet Season	SON (2007)	WHO (2011)	
1.	As	0.0387	0.0490	0.010	0.010	Cancer
2.	Cd	0.0068	0.0071	0.003	0.003	Toxic to the kidney
3.	Cu	0.3359	0.8152	1.000	2.000	Gastrointestinal disorder
4.	Cr	0.0004	0.0946	0.050	0.050	Cancer
5.	Fe	0.9821	1.6252	0.300	0.300	None
6.	Mn	1.4403	1.6551	0.200	0.050	Neurological disorder
7.	Ni	0.0220	0.0337	0.020	0.020	Cancer
8.	Hg	-	-	0.001	0.006	Affects the kidney and the central nervous system
9.	Pb	0.0439	0.0408	0.010	0.010	Cancer, interference with vitamin D metabolism, affects mental development in infants, is toxic to the central and peripheral nervous system
10.	Zn	0.3529	0.5498	3.000	5.000	None

Source: Fieldwork, 2018

Mean values of all the heavy metals tested in river Rido varied from upstream to downstream in the dry and wet season, with the exemption of mercury which was undetected (see Table 1).

The values obtained from the control samples upstream were indications that all heavy metals tested, except mercury, were present in the river at some point before the point of discharge of industrial wastewater. However, the values upstream for cadmium, copper, chromium and zinc at both dry and wet seasons were negligible and below the maximum tolerable limits prescribed by SON (2007) and WHO (2011).

At upstream, arsenic and nickel had values that were below the maximum tolerable limits in the dry season and values higher than the maximum tolerable limits in the wet season. Lead at upstream had negligible value in the wet season but recorded a much higher value than the tolerable limit in the dry season. Iron and manganese recorded values that were much higher than the tolerable limit upstream, as shown by the mean values of the control samples at both dry and wet seasons. Ishaya (2016), Zaky et al. (2016) and Abui et al. (2017) observed that areas before the point of effluent discharge of the Kaduna refinery were known to have heavy metals. Increased contamination of river Rido in the wet season could also be attributed to agricultural runoff in the area, as farmlands are situated on the riverbanks (Butu, 2018). It could also be due to runoff from roads and municipal sludge probably containing heavy metal pollutants, which flow into the surface water (KEPA, 2011, cited in Abui et al., 2017).

Downstream the values of six heavy metals exceeded the set limits by SON (2007) and WHO (2011) in the dry season (see Table 2). The highest exceedance was manganese at 620% and lead at 339%. The values for cadmium, iron and arsenic ranged from 127% to 287%, and the least of the exceedance was nickel at 10%. Three metals, chromium, copper and zinc, had values that were below the set limits, while mercury was not detected.

With the exception of mercury, the values of all the heavy metals tested increased downstream during the wet season (see Table 1), an indication that the discharge of industrial wastewater affected the concentrations of heavy metals in river Rido. Contaminants from the refinery battery limit, mostly solids, which did not go through the wastewater treatment plants all contributed to the elevation of the values of the heavy metals. Seven out of the ten heavy metals tested had values that were above the maximum tolerable limits set by SON (2007) and WHO (2011). The values showed that the most common exceedance was manganese at 728%, followed by iron at 442%, arsenic at 390%, and lead at 308% while nickel, chromium and cadmium had values that ranged from 69% to 137%. Two metals, namely copper and zinc, had values that were below the limits, and mercury was not detected.

Previous studies in the area by Amin (2006) and Ishaya (2016) had outcomes that corroborate the findings in this study and point to the presence of high levels of heavy metals like iron, lead and cadmium in the river. While some heavy metals such as zinc, copper and iron are necessary for the proper functioning of the human body when their levels are low, absorption of excessive quantities of these metals is harmful. Some other metals such as cadmium, mercury and lead are unnecessary for the human body and can cause serious threat to human health (Lander, 2003; Kosek-Hoehne et al., 2017). Human exposure to the high levels of arsenic, cadmium, chromium, iron, manganese, nickel and lead in the study area ─ the heavy metals which, at either dry or wet season or both, have values higher than the permissible limits ─ have serious health consequences such as cancers, neurological disorders and vital organ impairment. Also, Oguntoke (2002) had observed that there is a rising trend of cancer diseases in Nigeria, and identified one of the risk factors as contaminated water.

Conclusion and Recommendations

At both the dry and wet seasons, arsenic, cadmium, iron, manganese, nickel and lead had concentration levels that were above the permissible levels recommended by SON (2007) and WHO (2011). The exceptions were copper and zinc which had concentrations that fell within the permissible levels. Chromium was within the permissible levels only at dry season and mercury was not detected. The presence of these heavy metals in river Rido increases the likelihood of people in the study area and its environs developing cancer, neurological disorders and the impairment of vital organs, which could increase death rates and reduce productivity.

Based on the results of the study, and in order to meet the requirements of SON (2007) and WHO (2011) standards and regulatory guidelines, it is recommended that the wastewater treatment plant of KRPC should be rehabilitated and the clean water retention pond cleared, so that wastewater can be pre-treated before it is discharged into the river.

There should be a law, which should be enforced, to ensure that effluents are properly treated, tested and confirmed to be fit before being discharged into water bodies. The Kaduna Environmental Protection Authority (KEPA) should ensure that the Kaduna Refinery complies with Federal Environmental Protection Agency and National Standard Drinking Water Quality guidelines for industrial effluent discharge.

Efforts should be made by KRPC to ensure that the effluent quality meets standards, since it is used for irrigating farms during the dry season, in order to avoid bioaccumulation of toxic pollutants in the agricultural products.

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