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EFFECTS OF INDUSTRIAL EFFLUENT ON SURFACE WATER RESOURCES OF RIDO, KAPAM, NISSI VILLAGES OF KADUNA STATE NIGERIA.

MICHAELS, PETER SEGUN, ZINGCHANG ALFRED HABILA, UGBOAJA VINCENT CHIJOKE, WULET ABUBAKAR ASHE
National Water Resources Institute, Kaduna Nigeria
Correspondence email: smykelson@yahoo.com; Phone +234 8033763688

ABSTRACT
The environment is considered as man's important asset that must be protected for his life support. However, the situation is different where oil refinery, petrochemical plants (KRPC) and Industries (Northern Noodle) operate. Surface water resources in these areas poses serious threat to the ecosystem, often with undesirable effects. The effects of industrial effluent on surface water resources of Rido, Kapam, Nissi villages of Kaduna State Nigeria is being analysed. The study adopts simple descriptive statistics in data analysis and discovers the inhabitant of the area accuses the refinery of polluting the source of the water upon which they depend on for drinking and other domestic purposes. The farmers believe that the effluent discharge is responsible for the reduction and death of fishes in the river, and diseases in Rido, Kapam and Nissi Village. Harmful doses of various chemicals are seen in the effluent discharge and subsequently in the surface water bodies in the area. This research recommends that the waste water treatment plant of KRPC and Northern Noodles should be rehabilitated and the clean water retention pond cleared so that waste water should be pre-treated before discharging into the river.

KEYWORDS: *Industrial effluent, surface water, water pollution*

1.0 INTRODUCTION

Pollution maybe considered as analogous to contamination. It can be defined as the presence of high concentrations of a substance in the air, water and soil resulting in hazardous consequences (Burgis and Symeons, 1987). Thus, the management and utilization of natural resources need to be improved and the amount of waste and pollutants generated through anthropogenic activities need to be reduced on a large scale (Burgis and Symeons, 1987; Ugya and Umar, 2015).

Wastes may be classified into solids, effluent treatment solids and gaseous waste. Waste products from the Refinery generally consist of oils, organic and inorganic chemicals (particularly acids), alkalis, hydrocarbons, sulphides, phenols and other sulfur-bearing compounds with suspended Solids (Al-amin, 2013). He further stressed that inhabitants of the surrounding Kaduna refinery and its environment are at the risk of exposure to the toxic wastes emitted into both water and air.

Industries generate volumetric wastes which are discharged into nearby water bodies, potentially degrading their water quality (Omara et al 2020) The oil companies operating in Nigeria maintained that their activities are conducted to the highest environmental standards; but the Nigeria environmental laws, in most respects comparable to their international equivalents, are ineffectively enforced (Cynthia, 2006). Furthermore, due to rapid population growth, urbanization, industrialization and exploitation of natural resources, there has been a steady increase in the quantity, quality and diversity of discharge into the aquatic environment (FAO, 1991). These discharges contain huge amount of heavy metals and organic metals which adversely affect the physicochemical properties of the receiving water bodies and consequently its biota.

Accumulation of heavy metals with accompanying histopathology was observed in Oreochromis niloticus exposed to treated petroleum refinery effluent from the Nigerian National Petroleum Corporation, Kaduna (Onwumere and Oladimeji, 1990). Vivanet al. (2012a) carried out a study on River Romi and reported that Kaduna refinery did not adhere to the minimum permissible levels for effluents discharge into the receiving water body. Almost all the physicochemical parameters measured were above the World Health Organisation (WHO) acceptable limits. In addition, it has been demonstrated that phenol is one of the major pollutants found in the effluents from the refinery and was much higher than the 0.5mg/l minimum recommended for refinery effluent (Otokunefor and Obiukwu, 2004; Vivanet et al., 2012a).

One of the most critical problems of developing countries is improper management of vast amounts of wastes generated by various human activities. More challenging is the unsafe disposal of these wastes into the ambient environment. Unfortunately, water bodies especially freshwater reservoirs are the most affected. Such activities have rendered these natural resources unsuitable for both primary and or secondary usage (Fakayode, 2005).

Wastewaters released by Kaduna Petrochemical Company are characterized by the presence of large quantities of crude oil products, polycyclic and aromatic hydrocarbons, phenols, metal derivatives, surface-active substances, sulfides, naphthylenic acids, heavy metals and other chemicals (Suleimanov,1995;Vivanet al., 2012a). Due to the ineffectiveness of purification systems, wastewaters may become seriously dangerous, leading to the accumulation of toxic products in receiving water bodies with potentially serious consequences on the ecosystem (Beg et al., 2001; Beg et al., 2003).

While the studies cited above have been conducted to analyse the different aspects of water quality, none of these studies, to the best of the researcher's knowledge, has investigated how industrial discharge affects the water quality of Kapam, Rido and Nissi Communities and the economic activities of the area. The focus of this study therefore is to assess the effects of industrial effluents discharge on the water quality and the economic activities of these communities located in Chikun Local Government Area of Kaduna state.

2.0 Methodology

2.1 Study Area

The area is underlain by rock of basement complex consisting of biotite gneiss and older granites. These rocks have been subjected to weathering to produce fairly deep regolith which has been subjected to lateralization. There is also the occurrence of hardened laterite rocks of the basement complex of different locations within the metropolis and at the different section of the Kaduna River (Iguisi, 1996). Nissi, Kampam, Rido are Settlements surrounding Kaduna Refinery and Northern Noodles in Chikun Local Government Area of Kaduna State Kaduna Refinery and Northern Noodles discharges their water into the Romi river.

2.2 Reconnaisance Survey

A reconnaissance survey of the area was undertaken. This is to obtain relevant information on the study area and seek for co-operation of key stakeholders particularly residents of Rido, Nissi and Romi community through their leaders and to obtain a general overview of the study area in order to choose the appropriate methodology to be adopted.

2.3 Types of Data

Concentration level of pollutants at both Upstream and Downstream.
Physico-chemical and biological parameters.
Data on socio-economic activities like swimming, farming, fishing etc.
Field observation and photograph.

2.3..1 Primary Source of Data

The primary sources include results derived from the laboratory analysis of water quality of the water samples taken from upstream, the refinery effluents discharge point and down stream of Romi River. Other sources for this study include interview survey and field observations, the interview survey was employed in order to identify the socio-economic activities carried out on/along the Romi river such as fishing, swimming, irrigation, etc. The main target groups are the fishermen and close-by residence communities. The field observation concerns the physical characteristic of the river like color, odor etc.

2.3.2 Secondary Source of Data

This involved sourcing of information through the review of relevant literatures from document and materials such as journals, proceeding of seminars, textbooks and other research findings. Also documents containing Kaduna Refinery waste management plan and Environmental Audit have been used for this study.

2.4 Sampling Technique and Sample Size

The construction of the sample frame was done to ascertain a good representation of the sampled villages in the study area. This was made possible through the reconnaissance survey. Two communities were purposefully selected from three villages that are located along the River Romi namely; Nissi, Rido and Romi. This selection was based on purposive sampling technique and because of their proximity to the pollution affected area and the human activities. Majority of the sampled population were farmers who use the surface water for irrigation, fishing, animals watering, bathing or other related domestic use. The entire human population of the study area (communities) whose source of Surface water depends largely on the Romi River was about 1,800.

3.0 Result and Discussions

3.1 Age Distribution of Respondents

Table 3.1: Age Distribution of Respondents

Farmer Age (years)	Number of Respondents	Percentage (%)
15 – 25	65	19.87
26 – 45	71	21.71
46 – 65	191	58.41
Total	327	100%

Source: Fields Survey (2019)

The mean age of the respondents was 44.1 years in the age group 26 – 45 years (table 3.1).The respondents in the age bracket of 15 – 25 years constituted 19.87% and that of 26 – 45years constituted 21.71%, while the age group of 46 – 60 years made up of 58.41%. The respondents within the age of 26 – 45 years were energetic and very active for farming.

Those within the ages of 15 – 64 years as defined by FAO (1991) are economically productive. Consequently, the age of a farmer determine the type of farm operation he or she could undertake. The young farmers could embark on more demanding farm operation such as land tilling and tree felling than older farmers. While the aged engaged in less energy demanding tasks as planting, land clearing, thinning and harvesting.

3.2 Level of Education of Respondents

Table 3.2 Level of Education of Respondents

Level of Education	Number of Respondents	Percentage (%)
No Formal Education	57	17.43
Primary Education	73	22.32
Secondary Education	185	56.57
Tertiary Education	12	3.67
Total	**327**	**100%**

Source: Fields Survey (2019)

The highest level of education of respondents is given in table 3.2, it is seen that 56.57% of the respondents had secondary education, while 22.32% had only primary education. About17.43% of the respondents did not attend any formal educational institution while about 3%had post-secondary education. These results suggest that about 82.49% had one form of formal education or the other while 17.43% did not go to school at all. Therefore it is obvious that the educated respondents had really gone into farming and might have little knowledge on the effects of the effluent discharged by the refinery into their farmlands.

3.3 Location of Farmland of the Respondents

Table 3.3: Location of Farmland of the Respondents

Farm Location	Number of Respondents	Percentage (%)
River Bank	213	65.1
Upland	114	34.9
Total	327	100(%)

Source: Fields Survey (2019)

From the survey of farm locations along the River Romi (Table 3.3), 65.1% of the respondents have their farmlands located along the river bank and 34.9% of the respondents have their farmlands located at the uplands. And according to FAO (1991) the location of farmlands determines the types of the crops grown, also it helps in comparing the fertility of the riverbank farmlands and that of the upland farms. Therefore it is obvious why majority of the respondents have their farmlands located at the river bank.

3.4 Farming Experience of the Respondents

Table 3.4: Farming Experience of the Respondents

Farming Experience (years)	Number of Respondents	Percentage (%)
1 – 5	41	12.54
6 – 10	73	22.32
11 – 20	69	21.10
21 – 30	37	11.31
31 years and above	107	32.72
Total	327	100%

Source: Fields Survey (2019)

The results in table 3.4 show that 32.72% of the respondents have been farming their land for at least 30 years. This followed by 22.32% who have 6 – 10 years of farming experience of their land. The next is 21.10% of the respondent who have been farming their lands for 11 – 20 years. This result suggests that at least 30 years constitutes the majority of the farming experience in the area. Therefore it could be said that farmers in the study area are experienced in the farming process as they have been able to explain the situation of the Romi area before and after the establishment of the refinery.

3.5 Problems encountered for Farming, Fishing, Swimming, Cooking and Drinking

The results of the analysis of the effects of the effluent on human activities such as farming, fishing, swimming/bathing, cooking and drinking were presented in percentage in Figure 3.1

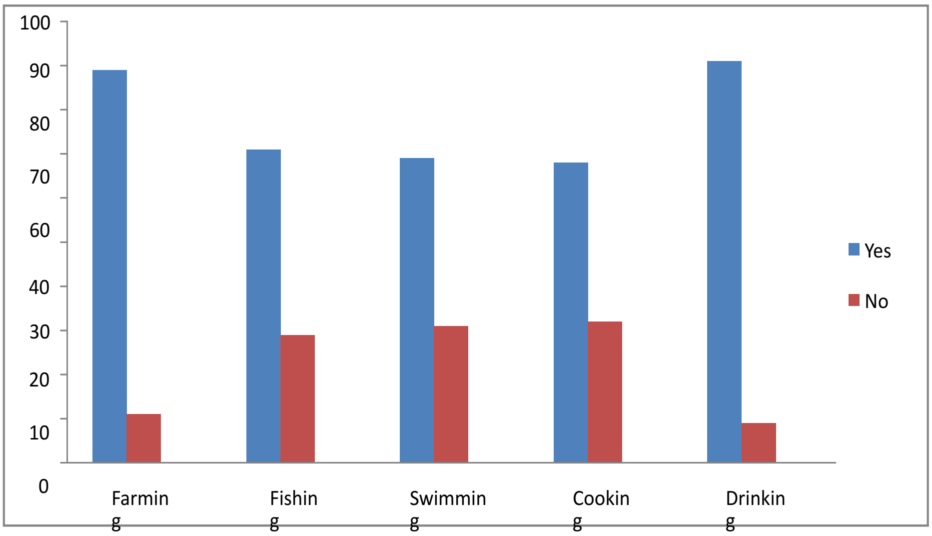

Figure 3.1: Problems encountered from Farming, Fishing, Swimming, Cooking andDrinking

Source: Author's analysis 2019

The results show that 89% of the respondent affirmed that the pollution of the river has negative effect on their farming activities while 11% said the pollution of the river do not. The respondents agree that the pollution of the river affected their fishing activities while 29% of the respondent said it does not because they do not engage in fishing activities. 69% of the respondent unanimously agrees that the pollution of the river has affected their swimming and bathing activities while 31% of the respondent said it doesn't because they do not swim or bath in river Romi. 68% of the respondent confirmed that the pollution of the river has affected their cooking activities and they no longer use water from the river to cook food while 32% of the respondent said no because they use water from hand dug well for cooking activities. Almost 91% of the respondent unanimously confirms that the pollution of River Romi has negatively affected their sources of water and they cannot depend on the river for drinking while 9% of the respondent said no they do not source water from river Romi. Therefore it can be said that effluent discharges in river Romi affect negatively the socio-economic activities of the nearby communities.

3.6 The Effect of Effluent on the Respondents Farmlands

During the interview with the host communities questions were raised by the researcher on the effect of effluent discharged on River Romi particularly whether it affects their farmlands and crop yield or not. The farmers revealed that they have been experiencing decline in crop yield over the years, and that the deteriorating crop output according to them was due to the pollution of the water from River Romi that usually over flood the farm during rainy season. According to the farmers, during the flood, deposit of oil, grease and other related organic chemicals cause immediate destruction of crops on the field. The farmers explained further that during these years, little or no harvest is made. The farmers also use the river for irrigation.

3.7 The Effect of Effluent on the Fishes in River Romi

During the interview with fishermen, the fishermen were of the opinion that the effluent discharged into River Romi by the refinery was responsible for declining and loss of the fish population. The fishermen strongly complained that fishes have died and some have migrated. Those that remained in the river were very tiny and are not palatable to taste.

3.8 The Effect of Effluent on the Domestic uses (swimming, bathing, cooking, drinking, and livestock watering)

The interview showed that the host communities accused the refinery of polluting the source of water which they depend upon for their livelihood- drinking, cooking, washing, bathing and livestock watering. The host communities complained further that they loose livestock as a result of the polluted water from the river Romi.

4.0 Observed Concentrations Compared with WHO/NESREA Standard

The Physico-chemical properties of the sampled water at 5km upstream and downstream of the effluent and at the discharge points are presented

Table 4.1: Mean Values of Physico-chemical Parameters Measured Across Sampling Point

Parameters	Point of collecting water sample			Maximum permissible limits	
	Upstream 5km	Point of Discharge	Downstream 5km	NESREA	WHO
pH	7.45	5.56	6.72	6.5-8.5	6.5-8.5
Temperature(oC)	34	37	34	30	30
Conductivity µm/cm	248	290	263	240	250
Total suspended solids (TSS)	68	420	96	30	30
Total dissolve solid (TDS)	300	495	324	200	250
Turbidity (NTU)	12	18	16	5	5
Colour	Light Brown	Light Brown	Light Brown	NA	NA
Biochemical Oxygen Demanding (mg/l)	3.45	8.5	4.37	10	10
Chemical Oxygen Demand(mg\l)	45	128	66	40	40
Oil and grease	2.7	17.2	4.7	10	
Dissolved Oxygen (mg/l)	6.7	4.6	6.4	10	10
Nitrate (NO3)	0.2	0.42	0.7	44	50
Iron (Fe)	0.93	1.2	0.2	20	20
Copper (CU)	0.25	0.98	0.36	1.0	2.0
Zinc (Zn)	0.27	0.42	0.36	1.0	1.0
Lead (Pb)	0.221	0.388	0.228	0.01	0.001
Cadmium (Cd)	0.022	0.031	0.024	0.003	0.005
Chromium (Cr)	0.22	0.38	0.21	0.1	0.05

Source: Author's Analysis (2019)

The parameters analysed in Table 4.1 are good indicators of pollutants that affect surface water quality to a large extent. Among the physical parameters measured was the pH which was found to be 7.45 upstream which is partially neutral in nature. The 5.56 value obtained at the effluent discharge points is acidic and 6.72 downstream which is also slightly acidic. Upstream and downstream pH values are within WHO standard while at effluent discharge point fell short of the standard. Mosley *et al* (2004) reported that water is hard with pH greater than 8.5. Similarly, Lekwot *et al* (2012c) in their study observed that pH deviates in Romi River from the acceptable limit of 6.5 downstream. The upstream shows high acidity with the highest pH value of 3.5 at effluent discharge point.

The temperature of the water sample was found to be 34°C upstream, 37°C at effluent discharge point and 34 downstream. This shows an increase in temperature downstream. The sharp increase in the temperature at the effluent discharge point may be as a result of heat from cooling since the water is being used to cool the machineries during the refining procedure. Thus, the temperature can be said to have exceeded the WHO 2006 standard limits of 30°C. This result varies slightly with the findings of Lekwot *et al* (2012c) who reported that temperature is 35°C upstream, 38°C at discharge point and 36°C downstream of Romi River.

The Electrical Conductivity (EC) of the water sample indicates that the value was 248µm/cm upstream and 263µm/cm downstream with a sharp increase of 290 µm/cm at effluent discharge point. This indicates that EC is high at effluent discharge point and has exceeded the WHO 2006 maximum limits of 250 µm/cm when compared to the values reported by Lekwot *et al* (2012c), with EC of 250 µm/cm upstream, 240 µm/cm downstream and 300 µm/cm at discharge point.

For the total suspended solid (TSS), the results obtained do not conform to the permissible limits of 30mg/l as stipulated by WHO 2006. There is a rise from 68mg/l upstream to 96mg/l downstream and a sharp increase to 420mg/l at effluent discharge point. The high TSS could be as a result of organic solids. Small suspended solid particles make water turbid (Dix 2001) while previous research by Lekwot *et al* (2012) showed that TSS remain high at all sample points in river Romi as against the permissible limits of 30mg/l, with upstream value of 40mg/l, discharge point 100mg/l and downstream 70mg/l value recorded.

The result for total dissolved solid(TDS) was observed to be high at 300mg/l at upstream, 324mg/l downstream and 495mg/l at effluent discharge point. The results show higher values compared to 200mg/l WHO 2006 standard of 250mg/l. In any case the concentration of TDS as compared to previous study by Lekwot *et al* (2012c) reported that TDS is relatively high with upstream value of 300mg/l, discharge point 400mg/l and downstream 250mg/l.

The result of turbidity the water sample upstream is has values of 12NTU, 16NTU downstream, and 18NTU effluent discharge point. The values are obviously higher than the permissible limit of 5NTU and could be attributed to high concentration of effluents. All values are above the WHO/NESREA standard. The colour of the water sampled was observed to be light brown. This indicates the floating of waste oil from the refinery and dissolved dust particles from farmlands around the river Romi. It was also observed that the water in River Romi has a sharp pungent smell especially downstream. At effluent discharge point, the water looks shiny brownish in colour. WHO/NESREA standard for color are not applicable.

The result for the biological oxygen demand (BOD) upstream is 3.45mg/l, downstream 4.37mg/l and 8.5mg/l at effluent discharge point. This is in conformity with the permissible standard of 10mg/l of the WHO 2006. Lekwot *et al* (2012c) measured 2500-3000mg/l in Romi River which is many times the strength of domestic water.

The chemical oxygen demand (COD) measured upstream is 45mg/l, downstream 66mg/l and128mg/l at the effluent discharge point. The COD values as measured at these points are all higher than the permissible standard of 40mg/l of WHO 2006. Especially at the effluent discharge point, the COD value is three times the permissible standard. This indicates a high presence of organic pollutant and is higher than what is obtained by Lekwot *et al* (2012) COD do not conform to the permissible limits for inland waters but less than what is obtained in this study.

The results obtained in the sample for oil and grease at both upstream and downstream are 2.7mg/l and 4.7mg/l respectively. These values are within the acceptable standard of 10mg/l of the WHO 2006. The value measured at the effluent discharge point is17.2mg/l. This value is higher than the acceptable standard. Lekwot *et al* (2012c) observed a similar result with oil and grease upstream 3.5mg/l, downstream 4.0mg/l and higher at discharge point 20.1mg/l.

For dissolved oxygen (DO), upstream value is 6.7mg/l, 6.4mg/l for downstream and 4.6mg/l at effluent discharge point. It was observed that the values for DO appear to be lower than stipulated 10mg/l of WHO 2006 permissible standard. On the other hand, Lekwot *et al* (2012) asserts that DO content of water samples indicates that it is almost normal upstream 9.8mg/l at discharge point it decreases significantly to 2.0mg/l and increases as it moves downstream with 9.0mg/l. The reason for the low values could be as a result of activation, since the water at the effluent discharge point is pumped with high pressure supplies by an air compressor. Metals such as nitrate (NO_3), copper (Cu), zinc (Zn), iron (Fe), lead (Pb), cadmium (Cd), arsenic(As) and chromium (Cr) create oxygen deficit and also determine water purity. They are pointers to water pollution in surface water (Abui, 2012). The results shows that nitrate concentration is (NO_3) 0.2mg/l upstream, 0.7mg/l downstream and 0.42mg/l at effluent discharge point, these values are low and decrease both at upstream and downstream of river Romi and after the effluent discharge point. Iron (Fe) concentration upstream 0.93mg/l, 0.27mg/l downstream and at discharge point is1.2mg/l the result shows it is lower than WHO 2006 standard. Abui (2012) observed that iron concentration in both dry and rainy season is high with 0.9mg/l and 0.40mg/l upstream, 0.92mg/l for both seasons at discharge point, 2.66mg/l downstream at both seasons due the difference in sampling period of the study. It is low at upstream and downstream but increases downstream above the permissible limit.

Copper (Cu) concentration measure upstream was 0.25mg/l, downstream 0.36mg/l and at effluent discharge point 0.96mg/l. The values are lower than permissible limit of 1.0mg/l and2.0mg/l stipulated by WHO 2006 respectively. This result shows a gradual decrease downstream from discharge point and gradual increase from the upstream to downstream. Butu (2002) in his study at Galma Dam observed a similar phenomenon where copper concentration increases from upper region to lower region of the Galma Dam. However this result do not conform with the study of Abui (2012) who reported that copper concentration decreases from upstream to downstream of river Romi.

Zinc (Zn) concentration of the water samples upstream is 0.27mg/l downstream 0.36mg/l upstream and at discharge point 0.42mg/l which is lower than 1.0 mg/l WHO 2006 permissible limit. The result of the study shows that zinc is far below permissible limit also when compared to the previous study by Abui (2012c). Both studies shows similarities in Zn concentration which increases upstream to downstream of the river Romi.

Lead content of the effluents discharge point is

0.38mg/l and 0.22mg/l for both upstream and downstream. These values are above the permissible limit of 0.001 stated by WHO 2006. Previous study done at river Romi by Lekwot *et al* (2012) observed that an average mean count on water samples of lead is 0.11mg/l while Butu (2002) also observed high concentration of lead in Galma dam. The reason could be as a result of some chemicals which contain lead such as petroleum products that have been discharged into the river. It could also be due to the excess dissolved solids and also due to mobilization of conducting ion during the decay process of organic materials in the stream and thermal mobilization of ions as water temperature increased (Bakyayita et al 2019)

Cadmium (Cd) levels upstream was found to be 0.022mg/l, downstream 0.074mg/l and at discharge point 0.078mg/l. This values decreases downstream of the sampling points which is higher than WHO 2006 standard. The value is higher than previous study by Lekwot *et al* (2012c) where it was found that cadmium was very low with upstream value 0.002mg/l, downstream 0.0004mg/l and at discharge point 0.024mg/l. The difference may be as a result of sampling period and lubricating oil discharged around the rivers may have contributed to the observed high Cadmium levels, since these metals can occur as impurities in fertilizers and in metal-based pesticides and compost manure.

Chromium (Cr) value upstream was 0.2mg/l, downstream 0.21mg/l and at discharge point0.38mg/l, the values are low and decrease both at upstream and downstream from the effluent discharge point. This is below the permissible standard of WHO 2006. The result is slightly different compared to Abui (2012) in which chromium was not detectable at upstream and downstream but small quantity was observed at discharge point. The reason could be that little quantity is released into the water and also this difference may be as a result of sampling period.

These parameters when compared with WHO some of the results are above the maximum permissible standard which may cause environmental degradation and reduce the effect of solar energy absorption while others are below the permissible standard which may not affect human and aquatic life.

5.0 Conclusion

The study analyzed water samples from River Romi and groundwater. It was observed that River Romi has been contaminated by the effluents discharged from the refinery. The results show that despite the 5km distance which would have enhanced rapid purification many of the parameters measured were high above the permissible limits set by NESREA and WHO. Also the effluent discharge point show high levels of pollutants for physico-chemical parameters and heavy metals emanating from the effluents discharged by the refinery in particular, pH, TSS,TDS, Turbidity, Oil/grease, BOD, COD, DO, Nitrate, Iron, Copper, Zinc, Lead, Cadmium and Chromium.

The results from the administered questionnaires reveal that the farmers have been experiencing decline crop outputs from their farmlands despite the application of fertilizer and the farmers attribute it to the polluted nature of water from river Romi. The inhabitant of the area accuses the refinery of polluting the source of the water upon which they depend on for drinking and other domestic purposes. The farmers believe that the effluent discharge is responsible for the reduction and death of fishes in the river, and diseases in the study area.

6.0 Recommendations

In order to meet the requirements of WHO regulatory guidelines and standards it is recommended that KRPC and Northern Noodles implements the following recommendations;

The wastewater treatment plant of KRPC and Northern Noodles should be rehabilitated and the clean water retention pond cleared so that waste water should be pre-treated before discharging into the river.

Kaduna Environmental Protection Authority (KEPA) should ensure that Kaduna Refinery and Northern Noodles complies with Federal Environmental Protection Agency and National Standard Drinking.

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