EFFECTS OF REFINERY AND PETROCHEMICAL EFFLUENTS ON THE VEGETATION OF ROMI RIVER AREA OF KADUNA STATE

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ABSTRACT: The negative effects of the oil operations in Kaduna have given great concern to the government and the inhabitants. Water samples of the river Romi were collected and vegetation inventory taken before and after the discharge point of the effluents. The analysis of the water involved the selection of parameters that covered the physical, chemical and biological properties. The laboratory results were compared with the permissive limits of the Federal Environmental Protection Agency. It was also observed that Romi area have been experiencing reduction, disappearance, and lost of vegetations. It was discovered that the vegetation covere was scanty at the downstream due to the effluents discharged on the environment over time. To ensure the protection of the environment, there is need for proper and adequate treatment of the refinery effluents to safety levels before discharge. FEPA standards on environmental pollution control should be strictly adhered to.

INTRODUCTION

In the last twenty five years, Nigeria has experienced increased activities in the areas of oil refining and products marketing operations. While these activities have generated immense financial benefits to the country, they have also created health and environmental problems. Oil industry operations have introduced pollutants as liquid discharges and oil spills into the environment (Dansereau and Piere 2006).

Petrochemical companies generate solid and sludges, some of which are hazardous because of the presence of toxic organics and heavy metals. Accidental discharges as a result of abnormal operations especially from polyethylene and ethylene oxide-glycol plants in petrochemical complex can be a major environmental hazard, releasing large quantities of waste product into the environment. According to Israel *et al.* (2008), ineffectiveness of purification system, wastewaters may become seriously dangerous, leading to the accumulation of toxic products in the receiving water bodies with potentially serious consequences on the ecosystem.

River Romi being the source of water supply for the inhabitants of Romi settlement serves as a sink for the Kaduna refinery and Petrochemical wastes. Downstream, the river has extensively been used for irrigation, laundry, swimming and livestock watering during the dry seasons. With all the waste discharged into the river, it is expected that the water would be polluted and waste would have detrimental effects on the vegetation, fish, crab, and snail population.

The study was aimed at determining the effects of the effluents on the vegetation of Romi area of Kaduna State. The study therefore determined the quality of the River Romi before and after the point of discharge of the effluent and examined the effects of the wastewater on the vegetation of the Romi area;

The soils of the study area fall within the tropical ferruginous soils. The topsoil is coarse sandy loamy to clay loamy (Adetola 1990). The area is located in the slightly thicker wooded

vegetation of the north guinea savannah zone of Nigeria. The activities such as overgrazing, bush burning, over cropping and tree felling for fire wood have generally modified the vegetation to wooded shrub-like vegetation (Ileoje 1985). Romi area is drained by the river Romi that rises from the Kujama Hill at elevation of 847m above the mean sea level (Lock and Partners 1987). The river is a tributary of river Kaduna located east of Kaduna town. The river transverses Romi village, crosses Kaduna-Abuja road and eventually discharges into the river Kaduna at Garko (Fig.2).

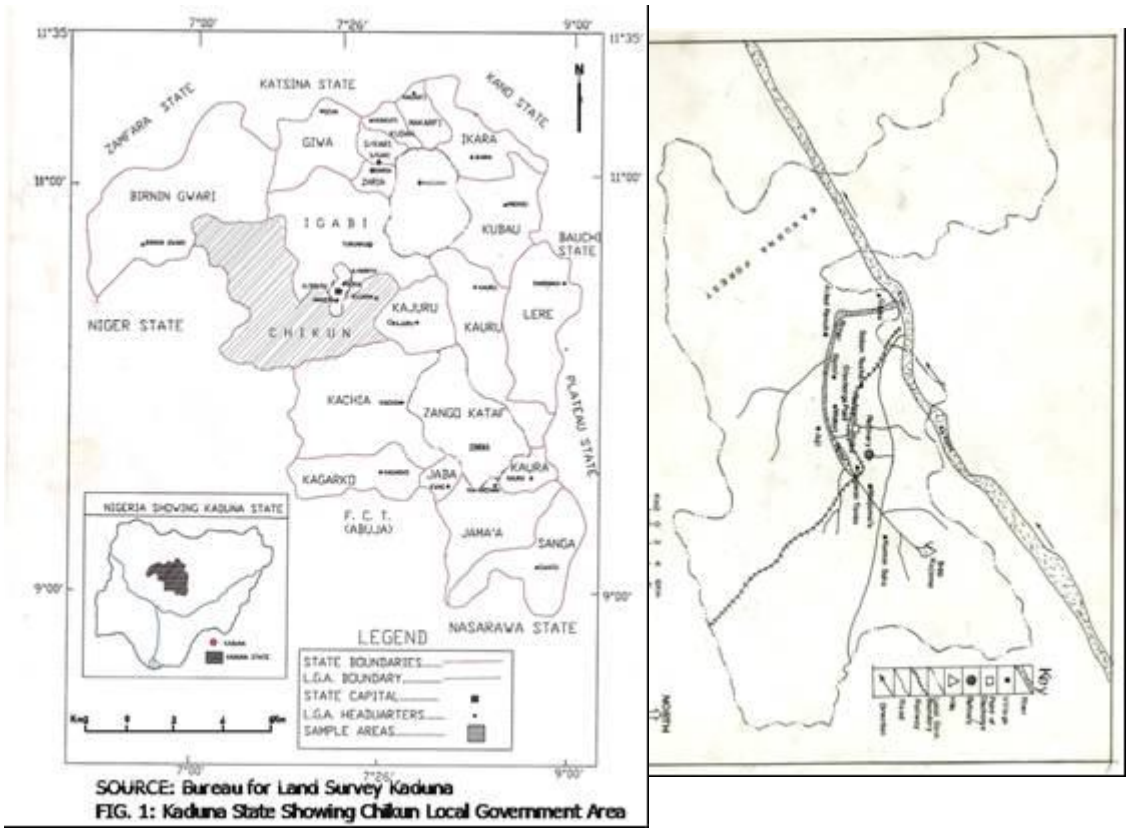

Figure 2: Location of River Romi and its environs

METHODOLOGY

The data for the study were obtained from laboratory analysis of the selected water parameters and vegetation species inventory. The water samples were collected using Grab method from the river Romi at five points. The first sample was taken at the upstream point before the point of discharge of the Refinery effluents, second at the discharge point and the remaining three downstream after the discharge point of the effluents at distances of 2, 2km between points. The samples were collected on 20th may, 2012 using 250mls plastic containers and each sample labelled and taken to the Kaduna Environmental Protection Agency (KEPA) laboratory within one hour for analysis.

The method used in the analysis of the water parameters was in accordance with the procedure and standard of FEPA, (2003). Two techniques were employed in data analysis: Gravimetric and Volumetric techniques. The gravimetric techniques was adopted for the analysis of Total Dissolved Solid and Suspended Solid of the water samples, while the volumetric techniques

was used for the analysis of BOD, COD, and Oil + Grease, Cyanide, Zinc, Iron, Chromium, Copper, Sulphate, Nitrate and Ammonia.

Temperature, pH and Conductivity measurements were carried out by the use of YSI DO/T Meter. Turbidity was determined using Partech Model DRT 100B Turbimeter. Cyanide was analysed using pyrazalane method, Zinc was determined using zicon method, Ferrover method for iron, Diphenylcarbohydziicle for chromium, Bicinchoninate method for copper, Ammonia and phenol were determined using spectrophotometer, Grease and oil were determined using Hexane extraction method. For the analysis of benzene, toluene, xylene and styrene the Atomic Absorption Spectrophotometer method was used as described by Osuji and Onoja (2004)

Results from analysis were compared with FEPA standards to establish the quality and status of the water. The data for the vegetation were obtained in the field through observations and measurements. This was undertaken to assess the frequency and the density of the vegetation using 3m x 3m quadrat (Wratten and Fry, 1980). Four transects (A, B, C and D) were laid out from the base of the river Romi running outward the banks of the river along each study transects. In each of the study transects, (10) 3m x 3m sample plots were established systematically in order to cover all habitat types and plant communities in the area. Species in the field were recorded according to life form groups in order of their appearance.

The quadrats were placed at regular intervals of 1m along the line. At the throw of each quadrat, the presence or absence of a species was recorded as 1 or 0. A total of 40 quadrats were thrown along the river Romi. For the density, individual number of the plant species in each of quadrat thrown was counted and the average calculated in relation to quadrats used from the total sample.

RESULTS AND DISCUSSION

Physicochemical Properties of Water Samples from River Romi

At the upstream the temperature was 20.5^0C and at downstream 28^0C, 29.5^0C and 30^0C respectively. This indicates a progressive increase of the temperature downstream. The analysis carried out on electrical conductivity of the water samples indicate that at the point of discharge of the refinery effluents, the EC value was 0.55mg/l and was thereby followed with a sharp decrease to 0.24mg/l at 6km downstream.

The results of the total suspended solids obtained from the analysis indicate that the values at both the upstream and downstream do not conform to the standard of 30mg/l as stipulated by FEPA. There is a sharp rise of 57mg/l, up to 6km downstream where the values rose to 177mg/l. It was observed that the TDS levels remained consistently low downstream with a range of 830mg/l to 258mg/l. The turbidity results of the water sample analysis indicate a progressive decrease downstream from the point of discharge of the effluents. At the upstream, it was as low as 18.91NTU. The dissolved Oxygen samples were high above the FEPA standard. That of the upstream sampling point has the average value of 3.9mg/l lower compared to the 40mg/l allowed FEPA standard. The values rose to 6.6mg/l, 6km downstream (Table 1).

Table 1: Physicochemical properties of River Romi water samples

S/N	Para-meters	Up-stream 2km	NNPC Effluent Dischare Point	Down-stream I 2km	Down-stream II 4km	Down-stream III 6km	FEPA Standard
1	pH	7.94	7.95	7.80	7.20	6.83	6.5-8.5
2	Temp.	20.5	30.0	28.0	29.5	30.0	30
3	EC	0.349	0.559	0.426	0.029	0.024	NS
4	TSS	32	6	57	185	177	30
5	TDS	1980	900	830	300	258	2000
6	Turbidity	18.91	22.1NTU	21.1NTU	12.1NTU	11.5NTU	NS
7	DO	3.9	8.3	7.9	7.0	6.6	4.0
8	Appearance	brownish	Shining brownish	Shining brownish	Shining brownish	Shining brownish	Clear colour
9	Odour	Odourless	Choking smell	Choking smell	Choking smel	Choking smell	Without smell

Elemental Properties of River Romi Water Samples

The elemental parameters (Table 2); cyanide, zinc, aluminum and copper with exception of iron, were low and in agreement with FEPA standard. However their concentrations decreased both upstream and downstream from the discharge point. The iron content of effluent at discharge point ranged from 0.92 to 2.66mg/l and was above the FEPA permissible standard. Chromium was not detected in water samples from the effluent discharge point. However, minute concentration of Cr was noticed in the discharged effluent. This indicates that little quantity of it was released with the wastewater.

Barium at upstream was 3mg/l and 8mg/l at the discharge point. Sulphate was above the FEPA standard both at upstream, discharge point and 2km downstream, but was not found along the 4-6km distance downstream. This could be as a result of the fertilizer discharge from the farms along the river.

Table 2: Elemental properties of River Romi water samples

S/N	Parameters	UP STREAM 2km	NNPC Waste water Dischare Point	Down Stream I 2km	Down Stream II 4km	Down Stream III 6km	FEPA Standard
1	Cyanide Mg/L	0.002	0.009	0.008	0.005	0.004	0.1
2	Zinc Mg/L	0.26	0.38	0.37	0.37	0.36	1.0
3	Iron Mg/L	0.93	0.92	0.85	2.95	2.66	20
4	Chromium	Nil	0.001	Nil	Nil	Nil	0.1
5	Barium Mg/L	3	8	7	6	5	0.1
6	Sulphate	73	104	92	Nil	Nil	0.2
7	Copper	0.06	0.03	0.01	Nil	Nil	1.0
8	Aluminium	0.15	0.34	0.27	0.10	0.8	NS
9	Nitrate	0.7	0.3	0.28	0.30	0.8	NS
10	Ammonia	0.99	1.3	0.45	0.26	0.11	40

Organics Status of River Romi Water Samples

The levels of COD and BOD presented in Table 3 revealed none conformity to the 40mg/l and 10mg/l respectively recommended by FEPA. For example the COD level recorded upstream was 120mg/l, while a much higher value of 221mg/l was obtained downstream, 6km from the effluent discharge point. The values for oil and grease were within the FEPA recommended standard of 10mg/l and phenol was not detected in all the samples.

Table 3: The concentration of organic contaminants of River Romi water smples

	Parameters	Upstream 2km	NNPC Wastewater Dischare Point	Down Stream I 2km	Down Stream II 4km	Down Stream III 6km	FEPA Standard
1	BOD	4	30	9	15	13	10
2	COD	120	437	421	232	221	40
3	Oil and grease	0.0386	0.1192	0.0862	0.052	0.012	10
4	Phenol	Nil	Nil	Nil	Nil	Nil	0.5

Aromatic Hydrocarbons in River Romi Water Samples

At upstream, aromatic hydrocarbons were not detected. However at the point of discharge, the concentrations of benzene (2.1mg/l), toluene (1.9mg/l), styrene (2.5mg/l) and xylene (2.02mg/l) in the the river water samples were and indicated none conformity to the maximum allowed standard for FEPA. At 6km downstream, the aromatic hydrocarbon parameters; benzene (0.8mg/l), toluene (0.4mg/l), styrene (0.9 mg/l) and xylene (0.84mg/l) were also high and beyond the FEPA recommended limit of 0.001mg/l.

Table 4: Aromatic hydrocarbons in River Romi water samples

S/N	PARA-METERS	UPST-REAM	NNPC DIS-CHARGE POINT	DWN STREAM I	DWN STREAM II	DWN STREAM III	FEPA STANDARD
1.	Benzene	Nil	2.1	0.8	1.2	0.8	0.001
2.	Toluene	Nil	1.9	1.6	1.52	0.4	0.001
3.	Styrene	Nil	2.5	1.9	1.6	0.9	0.001
4.	Xylene	Nil	2.02	1.73	1.7	0.84	0.001

Effect of Effluent on the Vegetation of River Romi Area

The effluent discharge affected the distribution, prevalence and diversity of plant species in the impacted area. The effect however varied with the location of sampling (Transect) and distance from the discharge point. At transect A (Table 5), the most prevalent species were Giantbluestem (90%), Goose grass (80%), Yellownutsedge (70%), Purple nutsedge (70%), and Ganbagrass (70%) Species. At Transect B (Table 6) the dominant species were Purple nutsedge (90%), Hedgehoggrass (80%) and Ganbagrass (70%).

Table 5: Distribution and prevalence of plant species at Transect A

		TRANSECT										
	SPECIES	1	2	3	4	5	6	7	8	9	10	FREQ
1	Yellownutsedge	1	0	1	1	1	0	0	1	1	1	70
2	Purple nutsedge	1	1	0	1	1	1	0	0	1	1	70
3	Brackenfern	1	0	0	0	1	1	0	1	0	1	50
4	Ganbagrass	1	1	0	1	1	0	1	1	1	0	70
5	Giant bluestem	1	1	0	1	1	1	1	1	1	1	90
6	Brachiara lata	0	1	1	1	1	0	1	1	0	1	60
7	Hedgehoggrass	0	1	0	0	1	1	0	1	0	1	60
8	Bahama grass	0	0	1	1	0	0	1	0	1	0	30
9	Brachiaria deflexa	0	0	1	0	1	0	0	0	1	1	50
10	Digitgrass,crabgrass	0	0	0	1	0	0	1	0	1	1	40
11	Junglerice	1	0	0	1	0	0	1	0	1	1	40
12	Goose grass, bullgrass	1	1	1	1	1	1	0	1	1	0	80
	TOTAL	6	6	5	9	9	4	7	7	7	10	

Table 6: Distribution and prevalence of plant species at Transect B

S/N	SPECIES	TRANSECT 1	2	3	4	5	6	7	8	9	10	FREQ
1	Yellownutsedge	1	0	0	0	1	1	0	1	0	1	50
2	Purple nutsedge	1	1	1	1	1	1	1	1	0	1	90
3	Brackenfern	1	0	1	1	0	0	0	0	0	1	40
4	Ganbagrass	1	1	1	1	0	1	0	1	0	1	70
5	Giant bluestem	1	1	1	1	1	0	0	0	0	0	50
6	Brachiara lata	1	1	1	1	1	0	0	0	0	0	50
7	Hedgehoggrass	0	1	1	1	1	1	0	1	1	1	80
8	Bahama grass	0	1	0	0	0	0	1	0	0	1	30
9	Brachiaria deflexa	0	1	0	0	1	1	0	1	0	1	50
10	Digitgrass,crabgrass	0	1	1	1	0	0	0	1	1	1	60
11	Junglerice	0	0	1	1	0	1	1	1	0	1	60
12	Goose grass, bullgrass	0	1	0	0	0	0	0	0	0	0	10
13	Lovegrass	0	1	1	1	0	0	0	0	0	0	30
	TOTAL	6	10	9	9	6	6	3	7	2	9	

For Transect C (Table 7) located downstream, 6km from effluent discharge point, the prevalent plant species were the Purple nutsedge (60%) followed by Brackenfern, Ganbagrass and *Brachiara lata* species with 50% prevalence rate. On the other hand, Transect D (Table 8) had Brackenfern, Hedgehoggrass and *Brachiaria* sp as the most dominant species with 50% prevalence rates.

Table 7: Distribution and prevalence of plant species at Transect C

S/N	SPECIES	TRANSECT 1	2	3	4	5	6	7	8	9	10	FREQ
1	Yellownutsedge	0	1	1	0	0	1	0	1	0	0	40
2	Purple nutsedge	0	1	0	1	1	0	1	0	1	1	60
3	Brackenfern	0	0	1	0	1	1	0	0	1	1	50
4	Ganbagrass	0	0	0	1	1	0	1	1	1	0	50
5	Giant bluestem	0	0	1	0	1	1	0	1	0	0	40
6	Brachiara lata	0	0	0	0	1	1	1	0	1	1	50
7	Hedgehoggrass	0	0	0	0	0	1	1	0	0	1	30
8	Bahama grass	0	0	0	0	0	0	1	0	1	0	20
9	Brachiaria deflexa	0	0	0	0	0	0	0	0	1	0	10
10	Digitgrass,	0	0	0	0	0	0	0	0	1	1	20
	TOTAL	0	2	3	2	5	5	5	3	7	5	

It was also observed at transects (C and D) that quadrats closer to the river at downstream had no plants species occurrence, while those further away the river bank were more in number. For instance, the first three quadrats closer to the river recorded 0-3 species, while those further away had 6-7 species per quadrat. This implies that plant occurrence increased with distance from the discharge point.

Table 8: Distribution and prevalence of plant species at Transect D

S/N	SPECIES	TRANSECT 1	2	3	4	5	6	7	8	9	10	FREQ
1	Yellownutsedge	0	0	1	0	0	1	1	0	1	0	40
2	Purple nutsedge	0	0	0	1	0	0	1	0	1	0	30
3	Brackenfern	0	0	0	1	1	0	1	1	0	1	50
4	Ganbagrass	0	0	1	0	0	1	0	1	0	1	40
5	Giant bluestem	0	0	0	1	0	0	1	0	0	1	30
6	Brachiara lata	0	0	0	0	0	0	1	1	1	1	40
7	Hedgehoggrass	0	0	0	0	1	1	0	1	1	1	50
8	Bahama grass	0	0	0	0	0	0	1	0	0	1	20
9	Brachiaria deflexa	0	0	0	0	1	0	1	1	1	1	50
10	Digitgrass,	0	0	0	0	0	1	0	1	1	0	30
TOTAL		0	0	2	3	3	4	7	6	6	7	

Effect of Effluent on Density of Plant Species in River Romi Area

The density of plant species in the riparian forest area was also influenced by effluent discharge. At Transect A (Table 9), Yellow nutsedge had the highest density of 60, followed by purple nutsedge and goose grass with 43 individuals each. In Transect B (Table 10), the most established plant species were Giant bluestem 30, Ganbagrass 28, *Brachiara lata* 26 and Digitgrass Crabgrass 25. For Transect C (Table 11), the most established plants were Bahama grass 20, Brackenfern 17 and *Brachiara lata* 15 while Hedgehoggrass 20 and *Brachiaria deflexa* 19 were well established in Transect D (Table 12).

Table 9: Variation in density of plant species at Transect A

	SPECIES	TRANSECT 1	2	3	4	5	6	7	8	9	10	DENSITY
1	Yellownutsedge	5	0	12	8	6	5	4	9	3	8	60
2	Purple nutsedge	8	4	0	6	9	4	0	0	9	3	43
3	Brackenfern	7	0	0	0	6	8	0	8	0	5	34
4	Ganbagrass	6	6	0	3	3	0	7	4	9	0	38
5	Giant bluestem	10	8	0	2	1	4	5	2	9	8	47
6	Brachiara lata	0	4	4	5	9	0	1	1	0	6	30
7	Hedgehoggrass	0	4	0	0	7	7	0	6	0	4	28
8	Bahama grass	0	0	6	8	0	0	4	0	7	0	25
9	Brachiaria deflexa	0	0	3	0	1	0	0	0	9	7	20
10	Digitgrass,crabgrass	0	0	0	5	0	0	9	0	3	5	22
11	Junglerice	1	0	0	3	0	0	9	0	7	4	24
12	Goose grass,bullgrass	7	5	6	6	7	4	0	2	6	0	43
TOTAL		44	31	31	46	49	32	39	32	62	52	415

Table 10: Variation in density of plant species at Transect B

		TRANSECT										
S/N	SPECIES	1	2	3	4	5	6	7	8	9	10	DENSITY
1	Yellownutsedge	2	0	0	0	5	4	0	6	0	5	22
2	Purple nutsedge	7	7	5	8	4	6	3	5	0	6	51
3	Brackenfern	4	0	6	6	0	0	0	0	0	4	20
4	Ganbagrass	7	7	6	5	0	3	0	3	0	3	28
5	Giant bluestem	9	7	6	6	2	0	0	0	0	0	30
6	Brachiara lata	6	7	5	5	3	0	0	0	0	0	26
7	Hedgehoggrass	0	5	6	5	3	2	0	3	6	6	36
8	Bahama grass	0	2	0	0	0	0	2	0	0	3	7
9	Brachiaria deflexa	0	2	0	0	3	2	0	2	0	1	10
10	Digitgrass,crabgrass	0	3	4	3	0	0	0	3	5	7	25
11	Junglerice	0	0	2	3	0	3	6	3	0	3	20
12	Goose grass,	0	2	0	0	0	0	0	0	0	0	2
13	Lovegrass	0	3	4	3	0	0	0	0	0	0	10
	TOTAL	35	44	40	38	20	20	11	25	11	38	267

Table 11: Variation in density of plant species at Transect C

		TRANSECT										
S/N	SPECIES	1	2	3	4	5	6	7	8	9	10	DENSITY
1	Yellownutsedge	0	2	2	0	0	3	0	5	0	0	12
2	Purple nutsedge	0	2	0	3	3	0	2	0	2	2	14
3	Brackenfern	0	0	3	0	2	4	0	0	3	5	17
4	Ganbagrass	0	0	0	3	2	0	2	2	4	0	13
5	Giant bluestem	0	0	3	0	2	2	0	3	0	0	12
6	Brachiara lata	0	0	0	0	1	4	3	0	2	5	15
7	Hedgehoggrass	0	0	0	0	0	2	4	0	0	5	11
8	Bahama grass	0	0	0	0	0	0	1	0	1	0	20
9	Brachiaria deflexa	0	0	0	0	0	0	0	0	2	0	2
10	Digitgrass,	0	0	0	0	0	0	0	0	2	1	3
	TOTAL	0	4	8	6	1	1	12	10	10	17	97

Table 12: Variation in density of plant species at Transect D

		TRANSECT										
S/N	SPECIES	1	2	3	4	5	6	7	8	9	10	TOTAL
1	Yellownutsedge	0	0	2	0	0	3	3	0	3	0	11
2	Purple nutsedge	0	0	0	4	0	0	2	0	3	0	11
3	Brackenfern	0	0	0	2	3	0	3	2	0	5	15
4	Ganbagrass	0	0	1	0	0	2	0	2	0	3	8
5	Giant bluestem	0	0	0	2	0	0	2	0	0	3	7
6	Brachiara lata	0	0	0	0	0	0	3	6	2	4	17
7	Hedgehoggrass	0	0	0	0	1	5	0	4	6	6	20
8	Bahama grass	0	0	0	0	0	0	2	0	0	2	4
9	Brachiaria deflexa	0	0	0	0	2	0	3	3	6	5	19
10	Digit grass,	1	0	0	0	0	3	0	3	3	0	10
TOTAL		0	0	2	3	3	4	7	6	6	7	122

Analysis of the water samples have shown that River Romi is seriously impacted by effluent or wastewater discharged by the Kaduna Refinery and Petrochemical Company. The sharp upsurge in the concentration of the contaminants was due to the content of the effluent discharges from the refinery operations. The results have shown that the impact is extensive and apparent even at 6km downstream away from the refinery.

Among the parameters found to be beyond the FEPA permissible limits was TSS. This parameter showed a very high value in the river Romi. The high content originated from the organic solids in discharged effluents. Dix (2001) observed that small-suspended solid particles make water turbid. It has also been reported to reduce the effects of solar energy absorption resulting in lowering the rate of photosynthesis, reduction in plant growth and slows down natural water purification processes. The long term effect is environmental degradation.

It was also observed that the BOD and COD levels in River Romi were high and exceeded the FEPA recommended limits and may results to the loss of aquatic lives. The high COD is an evidence of high concentration of biologically resistant substances as well as organic impurities such as oil and grease. The later creates a film on the water surface, thus preventing aeration and causing environmental destruction of the aquatic lives. The high level of the oil in the water prevents direct contact of the water body with the atmospheric oxygen for exchanges. This causes reduction in the oxygen level of the water body. The high value of Biochemical Oxygen Demand suggests that the river exhibits a relatively high proportion of biodegradation substances. Oxygen saturation in water is a vital factor which affects life in aquatic ecosystem.

Barium and sulphate were noticed to be highly concentrated. This is very dangerous to soils, vegetation and human health. The pollutants are in particulate form and when rain falls or the wastewater over flow the farmlands, they sink into the soil to be taken up through the plant xylem tissue. The plant may grow stunted with broad and green leaves, but finally with low yield. These do not have much direct effect on the plants but on human beings and animals that feed on the plants. Fish are also known to harbor these toxic pollutants in their organs. Human consumption of the affected fish posses some danger for human life.

The concentrations of aromatic hydrocarbons such as benzene, xylene, styrene and toluene in the water samples were found to be high and above the allowed FEPA standard. Consequently, some plants do not survive, others are reduced in number and some food chain nets are affected. It was obvious that the impacted River Romi negatively affected the vegetation of the riparian forest area. The distribution, prevalence and density of plant species were adversely affected. The impact was more severe in areas close to effluent discharge point.

CONCLUSION AND RECOMMENDATION

The present study focused on determining the effects of refinery and petrochemical effluents or wastewaters on River Romi water quality and the vegetation of the riparian forest area. The results have shown that Kaduna Refinery and Petrochemical Company effluents discharge is responsible for the pollution of River Romi and this adversely affects the aquatic lives and the vegetation attributes of the riparian forest area. There is need to put in place a mechanisms that would ensure the protection of the environment. To maintain a balanced ecological system, one may consider the following;

- Proper and adequate treatment of the refinery effluents to safety levels before discharge.
- Standards of FEPA on environmental pollution should be adhered to.
- A comprehensive assessment of the water quality of the Nigerian water resources should be developed.

- The refinery should report the quality of their effluents and results of the chemical analysis of aqueous effluents discharge into the Romi area in daily papers.
- Effluents should be sampled weekly or bi-weekly and analysis done in accordance with laid procedures.
- An enforcement mechanism to ensure compliance to effluents discharge should be put in place.

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