Effects of Warri Refinery Effluents on Water Quality from the Iffie River, Delta State, Nigeria

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Abstract
This study examines the effects of Warri refinery effluent on the Iffie river and its environs. It asserts the nature of effluent released into the water body and also the effect of effluent on water quality. The data that were used in this research where generated from direct field measurement of pH, Conductivity, Total Hardness, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Turbidity, and heavy metal profiles (Mg, Zn, Cr, Ni, Cl, Cu, H_2S, P) from the Iffie, Ubeji and Ughoton Rivers respectively. However, the Turbidity, Hydrogen Sulphide, Total Suspended Solids (TSS), Copper, Chromium records in Iffie and Ubeji Rivers were found to be higher than the WHO and FEPA standards, thereby making the water in these areas not suitable for consumption. Based on the findings, recommendations were proffered.

Keywords: Effluents, water quality, effects, Warri Refinery, Delta State, Nigeria

JEL Codes: 051, 053

INTRODUCTION

While the petroleum refinery and petrochemical industries are most desirable for national development and improved quality of life, the unwholesome and environmentally unacceptable pollution effects of the waste from these industries are cause for worry. This is because in the process of converting crude oil into petroleum products (liquefied petroleum gas, naphtha, kerosene, diesel oil and residual oil) and petrochemical products (polypropylene, polyethylene), wastes of different kinds are generated. The wastes can be broadly categorized into oily materials, spent chemicals, spent catalyst and other residuals. These wastes are released to the environment in the form of gases, particles, and liquid effluent (liquid consisting of surface runoff water, sanitary wastewater, solid waste and sludge) (World Bank, 1998).

The waste water released from the refineries are characterized by the presence of large quantity of crude oil products, polycyclic and aromatic hydrocarbon, phenols, metal derivatives, surface active substances, sulfides, naphthalene acids and other chemicals (Suleimanov, 1995). As a result of

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ineffectiveness of purification systems, waste water may become seriously dangerous, leading to the accumulation of toxic products in the receiving waster bodies with potentially serious consequences on the ecosystem (Beg et al, 2003; Aghalino and Eyinla, 2009).

The uncontrolled disposal of waste into water renders water unsafe for economic use, recreational use and poses a threat to human life and it is also against the principle of sustainable development. Water borne diseases and water caused health problems are mostly due to incompetent management of water resources. Safe water for all can only be assured when access, sustainability and equality can be guaranteed. Urban areas generally have a higher coverage of safe water than rural areas. Even within the urban area, there are variations in the quality of water as much of the water get contaminated in many different ways, through industrial effluent and untreated municipal sewage (Oluwande et al, 1993; Atubi, 2009a).

Kuehn et al (1995) observed that refinery effluent contaminated with aromatic hydrocarbons produces poor health and lethal toxicity in fishes and two species of tilapia. Onwumere and Oladimeji (1990) earlier demonstrated accumulation of heavy metals with accompanying histopathology in *oreochromnis niloticus* exposed to treated petroleum refinery effluent from the Kaduna refining and petrochemical company. These and other studies agree petroleum refinery effluents pose a serious problem to both aquatic and human life form.

Drinking contaminated water can cause various diseases such as typhoid fever, dysentery, cholera and other intestinal disease (Udoh, 1987; Adeyemi, 2004). According to Gore (1993), human beings are made up of water, in roughly the same percentage as water in the surface of the earth. Our tissues and membranes, brains, and hearts, our sweat and tears, all reflect the same recipe for life. Water is essential for the development and maintenance of the dynamics of every ramification of the society (United Nations Development Program, 2006). Water is indeed life and thus is the most important natural resource, without which life would be non-existent. Availability of safe and reliable source of water is an essential prerequisite for sustained development (Asonye et al, 2007).

Nigeria is regarded as the greatest gas flaring country in the world and in the process of flaring carbon dioxide, sulfur dioxide and nitrous oxides are released into the atmosphere which mix with rain to produce toxic acid rain causing damage to vegetation and aquatic life (Egborge, 1991; Atubi, 2009b). Oil prospecting in Nigeria has brought with it untold hardship to the environment. Dwellers of oil producing areas generally suffer from scarcity of farmlands as their lands has been made unproductive due to constant oil spillages and waste dump (FEPA, 1991).

One of the most visible consequences of numerous oil spills had been the loss of mangrove trees. The mangrove was a source of both fuel for the indigenous people and a habitat for the area's biodiversity, but is now unable to be sourced due to the oil toxicity of its habitat. Oil spills pose serious health risks to people when they consume contaminated seafood (Bogardy, 2004; Onuoha, 2007).

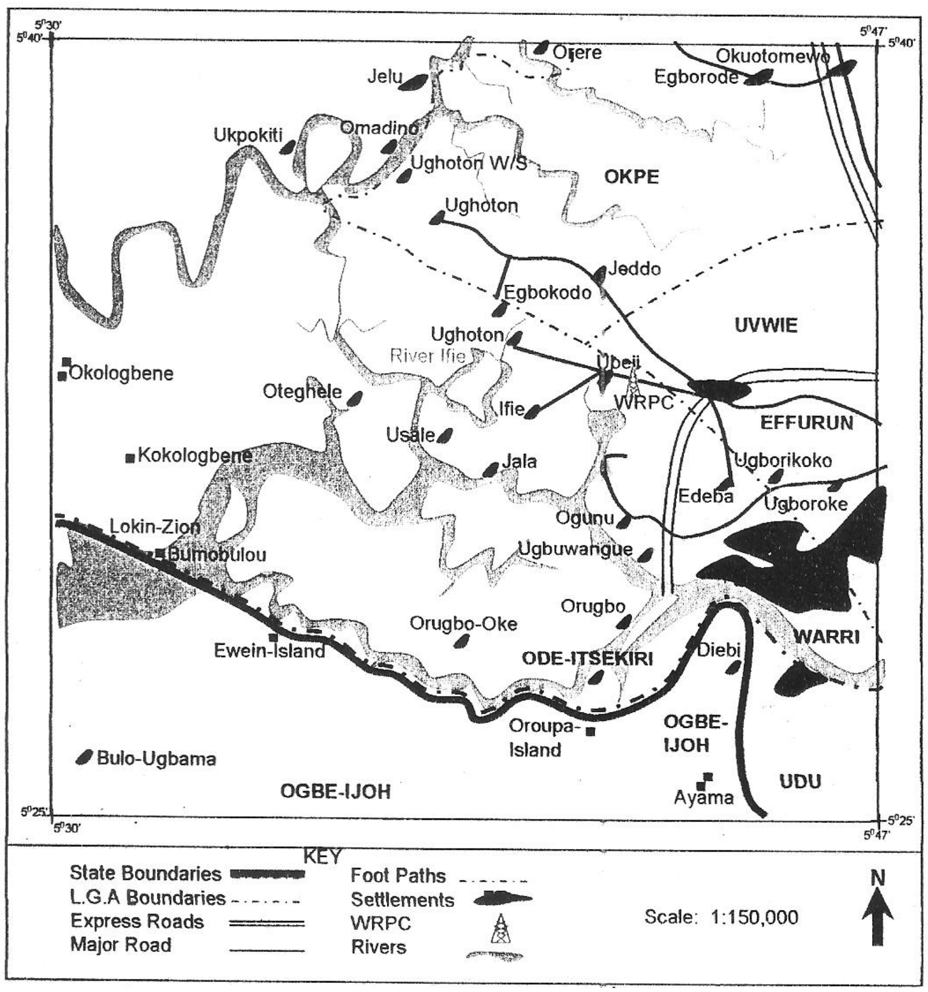
Nigeria has experienced increased pipeline vandalism, kidnapping, and militant take-over of oil facilities in the Niger Delta. As of April 2007, an estimated 587,000bbl/d of crude production was shut-in. Since December 2005, Nigeria has lost an estimated 16 billion dollars in export revenues due to shut-in oil production. Shell has incurred the majority of shut-in oil production (477,000bbl/d), followed by Chevron (70,000bbl/d), and Agip (40,000bbl/d) (Energy Information Administration, 2007).

Oil in the aquatic environment may be damaging in a variety of ways. These may involve changes in the composition of aquatic communities that affect their ability to survive, permanent damage and, in some cases, massive mortalities. Odor, taste and color are present in oil polluted water. Oil pollution of water also constitute a potential health risk to humans who use water for domestic and drinking purposes and consume fish found therein (Nwilo and Badejo, 2001; Helmer, 2006; Atubi, 2009b).

THE STUDY AREA

Warri refining and petrochemical company Ekpan, located in Delta State, is a subsidiary of the Nigerian National Petroleum Cooperation (NNPC), an oil company involved in refining crude into fuel, kerosene and other by-products. The refinery is bounded by three communities Ekpan, Jeddo and Ubeji. Iffie is next to Ubeji (Fig. 1). The study area is located around latitude 5^{0}31'N and 6^{0}11'N and between longitude 5^{0}44'E and 5^{0}47'E. The area is approximately 100 square kilometers and it is bounded by other communities. Human activities are mainly primary occupations such as fishing, crop farming, vegetable farming and a little of petty trading. The economy is agriculturally based.

FIG 1: MAP OF WARRI SOUTH SHOWING STUDY AREA



Source: Atubi ,A. O. 2010

RESEARCH METHODOLOGY

This research work is experimental with a survey of river water samples in Iffie, Ubeji and Ughoton. It involves laboratory analysis of the water samples collected from the rivers in these areas. Water samples were collected at three (3) locations equi-distance from the discharge point. Samples were collected from Ughoton River as a control point. Under the primary source of data collected, an empirical study on the effect of refinery effluent was carried out. Water samples were collected from study site to test for various parameters of water quality that is the physical and chemical composition. Thirty water samples were collected from three locations (equi-distance from the polluted point) with containers. From these containers, samples were collected using sterilized glassware, fitter and with information tags for identification. All samples were allowed to settle down before any laboratory analysis. This is to eliminate any form of turbidity influences on the tests. One dependent control source at Ughoton was established. The control sample served as standard characteristics of the nature of river water in the neighborhood and from which variations was identified.

DATA ANALYSIS

Data collected was by direct field collection of water samples from Iffie, Ubeji and Ughoton Rivers. These stations were established to cover possible affected area along the river course based on an earlier field reconnaissance survey. The locations of the various sampling points are; Iffie River, Ubeji River and Ughoton River. Iffie River and Ubeji River were divided into ten sites and Ughoton River into three sites. Running water from the three (3) rivers was carefully collected with plastic containers that had earlier been sterilized. These were assessed immediately for physical characteristics such as pH, conductivity and turbidity.

INSTRUMENTATION

The instrument used in this study includes Bulk Scientific Atomic Absorption Spectrophotometer (AAS) Computerized Model 210VGP with Epson Printer LX300+ and replaceable lamp holder. This was used to measure the heavy metals. Level of pH was measured with H tester 1 Tm, Model Cole Planner (R), conductivity was measured with the suntex conductivity meter, Total Dissolved Solids (TDS) was measured with the Hatch TDS meter, model CO20, Total Suspended Solids (TSS) was determined using weight loss technique and turbidity was measured with hatch spectrophometer, model DR2010.

DISCUSSION OF RESULTS/FINDINGS

From the water analysis (see Tables 1, 2, 3 and 4 in the Appendix), chemicals such as chloride, phosphate, oil and grease, chromium, hydrogen sulphide, magnesium, copper, zinc, nickel are released into the river and the major ones are heavy metals, such as chromium, phosphate, chloride, copper, zinc and nickel. The effect of these effluents released in the river makes the water unsafe for domestic consumption purposes, recreational purposes, and agricultural purposes.

In Table 1, the pH values recorded in Iffie River are generally within the WHO acceptable limits of 6.5 – 92 thresholds. This is evident from 6.53 mean pH value that is within the 6.5 – 92 WHO threshold. However, the lowest pH value of 6.21 and 6.29 was recorded in Iffie 5 and Iffie 6 respectively which fall outside the WHO acceptable limit. The low pH values recorded in Iffie 5 and 6 could be attributed to the effluents that enter the river from the Warri petrochemical company. This low pH values increase concentrations of some dissolved metals in the water and increase the toxicity of these metals.

The total hardness values of water samples analyzed were within the maximum limits of WHO standards of 100mg/L. This is seen from the mean of 36.49 total hardness recorded in Iffie river with Iffie 9 (48) and Iffie 7 (42) being the highest and lowest total hardness being recorded in Iffie 1, Iffie 2, Iffie 3, Iffie 4, Iffie 6, Iffie 8 and Iffie 10. The magnesium hardness values of the water samples collected from Iffie River were within the WHO acceptable limit of WHO standards 250 mg/L. This is seen from the mean value of 15.72 magnesium hardness recorded in Iffie 1, Iffie 2, Iffie 3, Iffie 4, Iffie 6, Iffie 7, Iffie 8 and Iffie 10.

The turbidity values of the water samples collected from Iffie River are generally higher than maximum limits of WHO acceptable standard of 25NTV. This is evident from the mean turbidity value 144.2NTU recorded in Iffie River with the highest being recorded in Iffie 5(282) and Iffie 9 and the lowest turbidity was recorded in Iffie 1 (109), Iffie 2 (124), Iffie 3 (118), Iffie 4 (76), Iffie 6 (129), Iffie 7 (116), Iffie 8 (78) and Iffie 10 (130).

Total Dissolved Solids (TDS) concentration in Iffie River had a mean of 60.09 which is within maximum limits of 1000 mg/L acceptable by WHO. However, the highest concentration of total dissolved solids value of 98 was recorded in Iffie 1. Iffie 6 (87.8) had the second highest concentration of total dissolved solids.

Water samples analyzed in Ubeji River showed the conductivity level in the ten points were below the 500 µs/cm limits of WHO standards. This is evident from the mean of 63 µs/cm recorded in Ubeji. The highest conductivity of 85.8 µs/cm was recorded in Ubeji 1 and 62 µs/cm in Ubeji 10, and the lowest conductivity values in Ubeji 2 (57.4 µs/cm), Ubeji 3 (60.8 µs/cm), Ubeji 8 (59.8 µs/cm), Ubeji 9 (59.3 µs/cm) and Ubeji 6 (61.6 µs/cm).

Total hardness concentrations in Ubeji River were generally within the maximum 100mg limits of WHO standards. This is seen from the mean of 31.1 mg recorded in Ubeji River. The highest total hardness concentration of 34.1 mg and 32.9 was recorded in Ubeji 6 and Ubeji 8 respectively and the lowest total hardness concentration of 31.7mg was recorded in Ubeji 1, Ubeji 2 (25 mg), Ubeji 3 (31 mg) and Ubeji 10 (30.3mg).

Turbidity recorded in Ubeji river ranges between 29NTU-115NTU with a mean of 85.9NTU with the highest turbidity duty of 115NTU and 110 being recorded in Ubeji 1 and Ubeji 10 respectively while the lowest turbidity were recorded in Ubeji 2, Ubeji 3, Ubeji 4, Ubeji 5, Ubeji 6, Ubeji 7, Ubeji 8 and Ubeji 9. Turbidity recorded in Ubeji River was generally higher than the 25 NTU maximum limits of WHO and Federal Environmental Protection Agency (FEPA) standards.

Total suspended solids concentration in Ubeji river was higher than the maximum limits of <30 mg/L and FEPA standards. This is seen from the mean of 60.64 mg/L total suspended solids recorded in Ubeji River. The highest total suspended solids of 93 mg/L was recorded in Ubeji 1 and the lowest total suspended solids of 20 mg/L was recorded in Ubeji 3.

In Table 3, pH concentration in Ughoton River was generally below 6.5 – 9.2 maximum limits of WHO and FEPA standards. This is evident from the mean of 5.74 observed in Ughoton River during the period of observation. The highest pH concentration of 5.98 was observed in Ughoton 3 and Ughoton 2 (9.95) respectively and the lowest pH concentration of 5.31 in Ughoton 1.

Turbidity values in Ughoton River were generally higher than the maximum 25 NTU limits of WHO and FEPA standards. This is evident from a mean of 66.33 NTU recorded in Ughoton River. The highest turbidity value was recorded in Ughoton 2 and the lowest in Ughoton 1 (61).

Total suspended solids concentration in Ughoton river was generally higher than maximum limits of <30 mg/L WHO standards. This is evident from the mean of 53.33 mg/L observed in Ughoton River. The highest total suspended solids concentration of 58 was recorded in Ughoton 2 and the lowest total suspended solids concentration of 48 mg/L was recorded in Ughoton 1.

In Table 4, the calculated F-value of 153.463 at 0.05 significant level is greater that the critical F-value of 2.21. It can be concluded that the quality of water from river Iffie is significantly dependent on effluent from the Warri petrochemical company. The effluent (waste water) from the refinery has a significant effect on the water, lives, and economic activities of the people of Iffie and its environs.

POLICY IMPLICATIONS/RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proffered:

1 Warri petrochemical refinery should adhere to remediation policies.

2 Warri petrochemical refinery company should ensure effluent is properly treated before discharge into the river. Federal government agencies responsible for proper discharge of this effluent must monitor them properly without compromise. The government of Delta State must provide pipe born water in these communities and revive the state of water board.

3 There is also the need for rural dwellers to be educated on the danger of using contaminated water, which clearly affects their lives, their health, and their economic (primary) activities.

CONCLUSION

This study has shown that the higher values of metals obtained at the effluent zones implicate the industry adjacent to the area as one of the sources of heavy metals in the river Iffie and Ubeji.

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APPENDIX

Table 1: Physiochemical Characteristics and Some Metals in River Iffie

Parameters	Iffie 1	Iffie 2	Iffie 3	Iffie 4	Iffie 5	Iffie 6	Iffie 7	Iffie 8	Iffie 9	Iffie 10	Mean	Range	
												+	-
pH	6.7	5.59	6.53	6.55	6.21	6.71	6.52	6.5	6.29	6.7	6.53	6.7	6.2
Conductivity	196	85.5	84.5	112	91	177.8	84.1	110	96	178	121.49	196	84
Total Hardness	40.8	41	41.2	40.9	0	32	40	42	48	39	36.49	48	0
Magnesium Hardness	15.8	16.2	16.3	15.9	0	22	17	17	28	9	15.72	16.3	9
Chloride (mg/L)	23.1	23	23.4	23.09	16.89	19.55	22.4	23.01	17	19.12	21.06	23.4	17
Turbidity	109	124	118	76	282	129	116	78	280	130	144.2	28.2	76
Phosphate	3.46	4.43	4.05	2.43	6.48	5.61	5.01	4.98	4.56	5.12	5.61	16.5	2.4
Hydrogen Sulphide (H_2S)	2.89	2.62	2.07	0.19	9.46	0.13	2.11	2.2	1.99	2.5	2.01	3.5	0.13
Total Dissolved Solid (TDS)	98	41.9	41.1	54.6	44.8	87.8	78	50	55.2	49.5	60.09	98	41.1
Total Suspended Solid (TSS)	91	96	98	52	72.8	106	98.4	76	97	94	88.12	106	52
Zinc (mg/L)	0.054	0.041	0.018	0.04	0.023	0.06	0.84	0.03	0.054	0.034	0.043	0.08	0.018
Nickel (mg/L)	0.055	0.014	0.008	0	0.02	0.019	0.021	0.024	0.023	0.026	0.021	0.06	0
Copper (mg/L)	0.29	0.017	0	0	0.001	0	0.014	0.016	0.018	0.017	0.037	0.04	0
Chromium	0.074	0.061	0.078	0.045	0.057	0.045	0.046	0.048	0.058	0.049	0.056	0.08	0.05

Source: Field Survey, 2009.

Table 2: Physiochemical Characteristics and Some Metals in River Ubeji

Parameters	Ubeji 1	Ubeji 2	Ubeji 3	Ubeji 4	Ubeji 5	Ubeji 6	Ubeji 7	Ubeji 8	Ubeji 9	Ubeji 10	Mean	Range	
												+	-
pH	6.5	5.93	5.93	5.96	5.8	6.3	6.9	6.82	5.94	6.87	6.19	6.9	5.8
Conductivity	85.8	57.4	60.8	61.4	60.7	61.6	60.8	59.8	59.3	62.1	62.97	85.8	57.4
Total Hardness	31.7	25	31	31.9	31.1	34.1	3.19	32.9	30.1	30.3	31.1	32.9	25
Magnesium Hardness	22.7	9.8	21	22	20	23	21.1	20.3	19.9	20.6	20.04	23	9.8
Chloride (mg/L)	19.5	10.67	19.5	19.4	16.9	18.2	17.9	19.2	18.6	19.6	17.94	19.6	10.7
Turbidity	115	50	29	87	79	89	99	95	106	110	85.9	115	29
Phosphate	5.62	1.56	2.04	2.92	2.56	2.45	2.67	1.98	2.01	2.1	2.59	5.6	1.6
Hydrogen Sulphide (H_2S)	0.16	0.11	0.18	2.42	0.68	0.59	0.55	0.43	0.4	0.2	0.57	0.68	0.2
Total Dissolved Solid (TDS)	41.6	69.3	28.2	29.5	40.2	39.8	45.7	45.6	45.9	50.3	43.57	50.3	6.9
Total Suspended Solid (TSS)	93	54	20	61	69	70	57	58.4	61	63	60.64	93	20
Zinc (mg/L)	0.017	0.013	0.017	0.025	0.024	0.021	0.029	0.019	0.02	0.023	0.02	0.029	0.02
Nickel (mg/L)	0.029	0.0029	0.019	0.041	0.034	0.028	0.035	0.036	0.032	0.031	0.031	0.036	0.019
Copper (mg/L)	0	0	0	0	0.013	0.017	0.012	0.01	0.011	0.014	0.007	0.017	0
Chromium	0.05	0.043	0.039	0.04	0.053	0.049	0.049	0.051	0.038	0.042	0.045	0.053	0.04

Source: Field Survey, 2009.

Table 3: Physiochemical Characteristics and Some Metals in Ughoton River

PARAMETERS	CONTROL 1	CONTROL 2	CONTROL 3	MEANS	WHO LIMIT
pH	5.31	5.95	5.98	5.74	6.5-9.2
Conductivity	60.1	61.2	62	61.1	500
Total Hardness	41	40	39	40	100
Magnesium Hardness	25	23	21	23	250
Chloride (mg/L)	19.49	19.3	19.48	19.42	250
Turbidity	51	70	68	66.33	5.82
Phosphate	2.52	2.49	2.46	2.49	5.82
Hydrogen Sulphide (H_2S)	1.88	1.98	1.89	1.91	0.1
Total Dissolved Solid (TDS)	30	36.6	40.1	35.56	100
Total Suspended Solid (TSS)	48	58	54	53.33	30.
Zinc (mg/L)	0.041	0.044	0.023	0.036	0.05
Nickel (Mg/L)	0.054	0.045	0.05	0.049	0.61
Copper (Mg/L)	0	0.015	0.041	0.009	0.02
Chromium	0.048	0.043	0.041	0.044	0.05

Source: Field Survey, 2009.

Table 4: Summary of ANOVA Explaining the Quality of Water from the River

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	7693.813	2	3846.906	2.21	0.05
Residual	275.741	11	25.067		
Total	7969.553	13			

a. Predictors (constant) Ubeji, Iffie
b. Dependent variable, Ughoton.