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Water Quality Impact of Flow Station Effluent in a Receiving Creek.

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Abstract— *The physicochemical quality of a crude oil flow station effluent and water of an effluent receiving creek were investigated. Samples were characterized by laboratory analysis. High concentrations of some toxicants exceeding environmental standards were observed in the effluent and water samples, which include BOD_5 (544mg/L), COD (650mg/L), salinity (3162mg/L), copper (2.3mg/L), TDS (18900 mg/L), lead (0.51mg/L), and cadmium (0.04mg/L). The study underscored the need for proper treatment and monitoring of effluent to ensure compliance with statutory standard, before discharge into the environment to safeguard the ecosystem, as continued discharge of improperly treated effluent may compound the ecological problem of the receiving water environment*
Keywords—concentrations, degradation, impact, outfall, pollution, quality.

I. INTRODUCTION

Many activities of man have led to environmental pollution. Foremost among such is industrial activities. In addition to causing various devastating ecological and human disaster, industries contribute greatly to environmental degradation, and pollution problems of various magnitude, as a result of waste discharges (Nkwocha, and Okoye, 2007; Otaraku and Nkwocha, 2010; Nkwocha et al., 2013). Petroleum compounds are one of the major sources of water pollution. These are compounds discharged during the extraction, processing and refining of crude oil. In the petroleum industry, effluent waters (produced or process waters) are waste associated with oil and gas formation, and run-offs from production facilities/ Facilities such as flow stations, compressor stations, hold basins or discharge points are associated with handling oil-feed produced/formation water or process waters (SPDC, 2000). Effluent waters from crude oil and gas companies, refineries and petrochemical industries contain quantities of oil, organic components and heavy metals such as chromium, copper, iron, zinc, manganese lead, mercury, and cadmium at concentrations beyond tolerable limits, thus, requiring treatment. The discharge of untreated and fairly treated waste into ecosystem brings about structural, chemical and biological changes which affect the biota (Ogbeibu and Oribhubour, 2001).

Over the last three decades, a large number of developing countries have introduced industrial environmental standards. However, it is generally recognized that the implementation of those standards and instruments have typically been seriously lacking (Aluyor and Badmus, 2003). In Nigeria, there is a general concern for industrial pollution, especially in the oil and gas industry. The Federal Environmental Protection Agency (FEPA) has established effluent limitation guidelines for all categories of industries FEPA, 1991). The Directorate of Petroleum Resources (DPR) has also established similar standards for the oil and gas industry DPR, 1991), and regulates environmental standards in the oil and related industries.

However, despite the general concern about pollution in the oil and gas industry, there has not been much study on flow stations and related facilities, as to whether their effluent comply with legally accepted toxicants levels. Furthermore, the impact of these toxicants on the quality of the effluent receiving water body has not been investigated. This study is designed to evaluate the quality of a flow station effluent and its impact on the physicochemical quality of the watercourse receiving the effluent.

Study area

The flow station investigated (Nembe-1) is one of the many flow stations located in the Nembe district of Niger Delta region. It is owned and operated by one of the multinational oil companies based in Nigeria. It has a capacity of 60,000 bpd, and was established in 1977. In this flow station, drains from leaking vessels, liquid scrubbers, valves and other operational equipment are routed to a treatment facility. The basic treatment involves oil recovery, after which the resultant effluent is discharged into the surrounding creek.

II. MATERIALS AND METHODS

Effluent quality sampling

Samples were collected at the effluent discharge point with 2 litre plastic bottles that were pre-washed with nitric acid and thoroughly washed with distilled water. Samples for oil and grease were collected in dark air tight bottles. Collected samples were preserved in ice-chests and immediately transported to the laboratory for analysis. Sampling was done weekly for four weeks.

Water quality sampling

Samples for physicochemical quality analysis of the receiving water were collected 500m upstream and downstream respectively from the outfall using same procedure as for the effluent. Sampling was done fortnightly for 4 weeks.

Laboratory analysis of samples

The procedures of standard methods (APHA, 1995) were used for the laboratory analysis of samples. Temperature was determined at the point of sample collection using a mercury thermometer. An HACP pH meter was used for pH determination.

TDS was analyzed by weighing the deposits after evaporation of the filtrate of a known volume of sample, while the residue was used to estimate the TSS.

Oil and grease was analyzed by acidifying a known volume of sample with HCl, this was followed by extraction with trichlorofluoroethane and distillation. BOD was determined electro-analytically using an Oxyscan light oxygen meter, while COD was determined by oxidation with potassium dichromate.

A Perkin Elmer 3100 atomic absorption spectrophotometer (Boston, MA 02118-2512, USA) was used for the determination of heavy metals including cadmium (Cd), chromium (Cr), copper (Cu) zinc (Zn), iron (Fe) and lead (Pb).

III. RESULTS AND DISCUSSION

Effluent quality:

The weekly variations of the investigated effluent parameters compared with the limit set by DPR are presented in Figs 1-8. The effluent pH ranged between 7.2-7.6 with a mean value of 7.4 for the 4 weeks. These values were within the permissible limit of 6.5-8.5 set by DPR (1991) for effluents meant for discharge into inland waters. The effluent temperature ranged from 29.4 -30.9ºC with a mean value of 30ºC. DPR set a limit of 30 ºC. Other parameters that complied with the effluent limitation set by DPR include TDS, oil and grease. However, .BOD and COD with ranges of 20.8-544mg/Land 64.0-650mg/L respectively, exceeded DPR limit of 125 mg/L in the 1st week. High oxygen demanding effluents when discharged into natural water bodies have been linked with oxygen depletion of the water environment, and attendant health hazards on the aquatic organisms (Kiely, 2004; Abowei and Sikoki, 2005). The salinity of the effluent was higher than DPR recommended maximum level of 2000mg/L in the 1st and 2nd weeks. Pollution of the aquatic ecosystem poses a serious threat to aquatic organisms and ultimately the entire ecosystem (Otokonefor and Obiukwu, 2005).

Results of the heavy metal analysis of samples of the effluent are shown in Table 1. The concentration of these dissolved metals impacts ecological influence and affects the aquatic environment.. Hence, characterization of the metals in the crude oil effluent returning to the aquatic environment becomes a very important factor in the bid to combat ecological and structural degradation.

The levels of chromium and zinc were within the limits recommended by DPR.

Cadmium exceeded FEPA (1991) limit of 0.01mg/L throughout the period under investigation. Others that exceeded FEPA limits set for them include lead (2nd week), and copper (3rd and 4th weeks). Heavy metals are some of the most toxic, persistent, and widespread contaminants in aquatic systems (Carvalho et al., 1999) and their impact in various components of the ecosystem, particularly fishes, is a well-documented phenomenon (Ramaiingam et al., 2000; Jayakumar, 2000; Misra et al., 2002; Al-Saleh and Shenwari, 2002).

Water quality

The results of the analysis of the physicochemical properties of the impacted water body are presented in Tables 2 and 3. An upstream and downstream pH of 7.1 lies within the WHO acceptable standard for drinking water - pH 6.5-8.5 (WHO, 1993). The water did not fall within the values at which water is considered too acidic and unsafe for drinking and domestic purposes (Abara et al., 2005). Similarly, the temperature values (30.2 and 30.5 ºC) would not cause any threat to life since the values are almost within the acceptable limit (that is, 30 ºC). Elevated water temperatures cause a reduction in dissolved oxygen concentration of the water and attendant hazard to aquatic organisms (Bhatia, 2005; Obasi et al., 2004). Upstream and downstream TDS values of 17,662 mg/L and 18,950mg/L respectively, were by far higher than the acceptable limit of 250mg/L for potable water (WHO, 1993).

The high values also reflected in the salinity of the samples. The high values of the TDS and salinity of the upstream samples relative to the downstream implies that there may be other contributors/ apart from the effluent. Contamination by sea water and the impact of other oil exploration and production activities in the area are possible sources.

The other parameter that was elevated in the sample of the impacted water body is zinc. The concentration of zinc is worthy of note as it increased from 0.32mg/L upstream to 0.40mg/L downstream after impact, relative to WHO (1993) standard of 0.3mg/L. Toxicity identification studies have indicated that zinc may be the primary cause of toxicity in certain contaminated aquatic ecosystem (Bay et al., 2003). High concentration of zinc has been observed to be specifically toxic to an aquatic insect Ramotra elongate (1.658-2.853mg/L), and in the microtox test system (1.35mg/L) (Sukla and Omka, 1983).

IV. CONCLUSION

This study has shown that the quality of the flow station effluent discharged into Nembe-1 creek did not comply with statutory environmental standard. High levels of some toxicants exceeding the limit set by DPR and FEPA were observed in the effluent and impacted water body. Though, the contributions from other oil related activities around the study area may have added to the observed impact. The long term effect of effluent discharge into the creek is not known. A study by Reddy et al. (2002) has shown that hydrocarbon may remain buried in sediment for up to 30 years without major degradation. Continued discharge of improperly treated effluent may further compound the environmental problem of the area. An easy resolution of the problem entails proper treatment and monitoring of effluent to ensure compliance before release into the environment

Table.1: Weekly variations of effluent heavy metal concentration (mg/L) compared with DPR standard

Parameter	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Mean**	**DPR**
Cadmium	0.04	0.03	0.02	0.01	0.03	<0.01*
Chromium	<0.01	<0.01	<0.01	<0.01	0.01	0.5
Zinc	0.06	<0.08	0.53	0.5	0.65	5.0
Iron	0.48	0.26	0.65	1.0	0.66	20*
Lead	<0.001	0.51	<0.01	<0.01	0.01	0.05*
Copper	0.66	0.88	1.10	2.3	0.89	<1.0*

***FEPA limit (no limit set by DPR).**

Table.2: Water sample physicochemical quality analysis Unit in mg/L Values are means of determinations

Sampling Station	**pH**	**Temp. °C**	**Oil/Grease mg/L**	**TDS mg/L**	**BOD_5 mg/L**	**COD mg/L**	**Salinity mg/L**
Upstream	7.1	30.2	__	17662	37.6	84	11128
Down Stream	7.1	30.5	__	18950	29.8	73,4	11360

Table.3: Water sample heavy metal analysis Unit in mg/L Values are means of determinations

Sampling Station	**Cadmium**	**Chromium**	**Zinc**	**Lead**	**Copper**
Upstream	0.02	<0.01	0.32	0.03	<0.01
Downstream	0.02	<0.01	0.4	0.04	<0.01

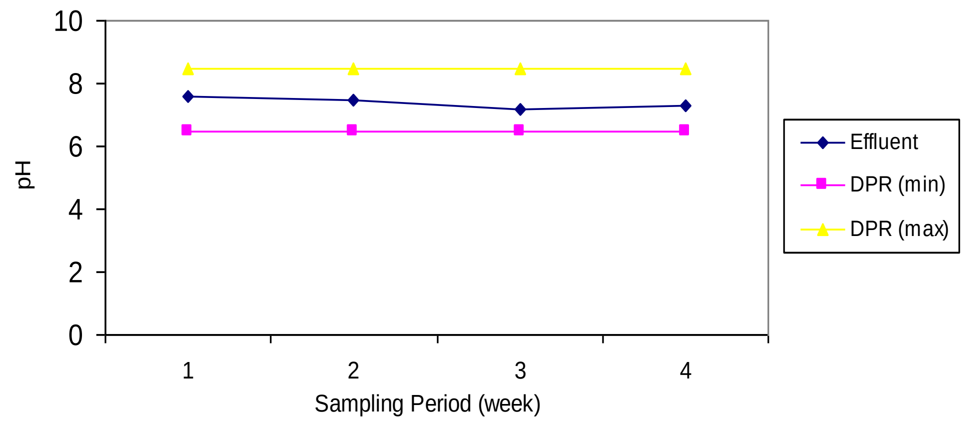
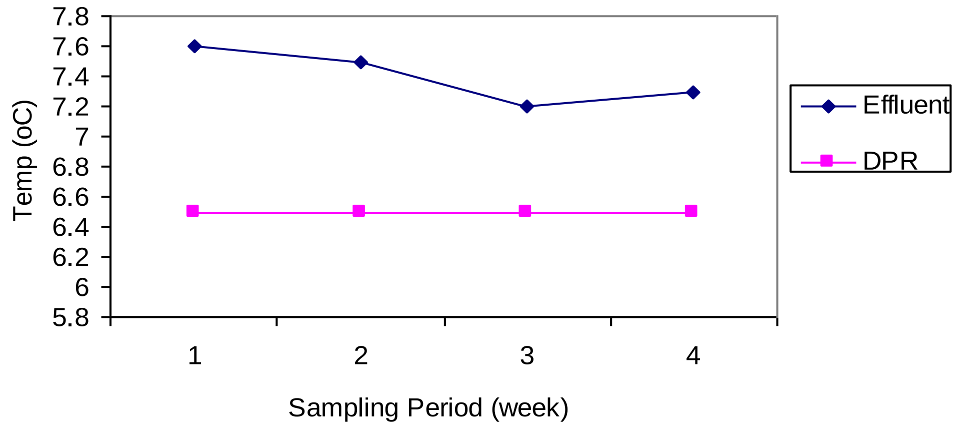


Fig. 1: Weekly variation of effluent pH compared with standard



Fig, 2: Weekly variation of effluent temperature compared with standard

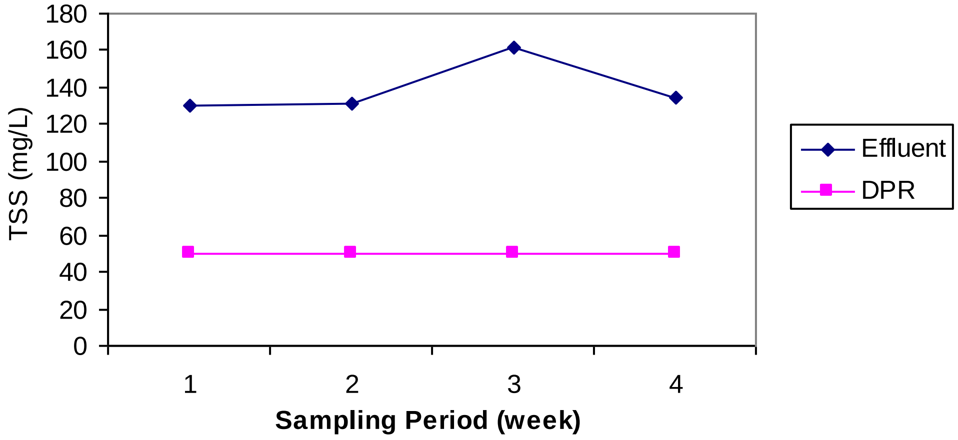


Fig. 3: Weekly variation of effluent TSS compared with standard

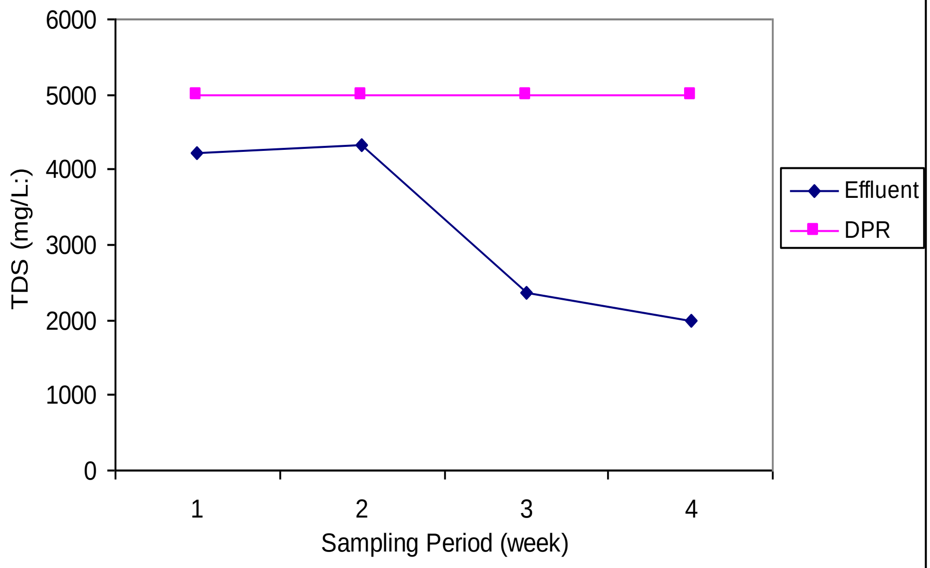


Fig. 4: Weekly variation of effuent TDS compared with standard

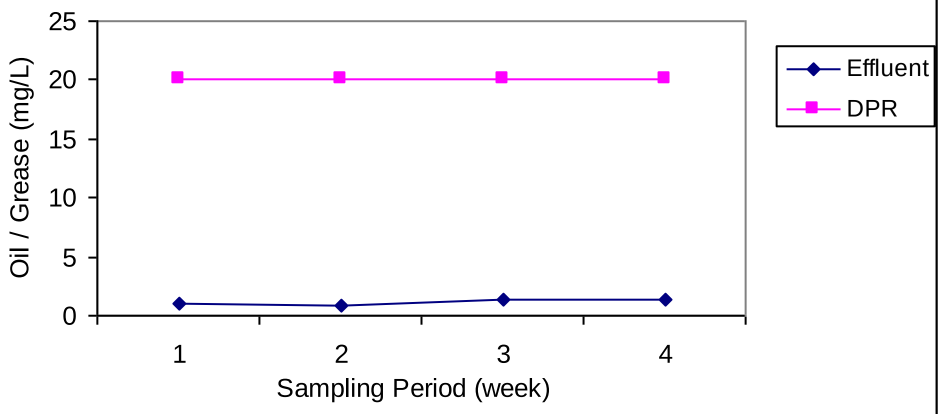


Fig. 5: Weekly variation of effluent oil and grease compared with standard

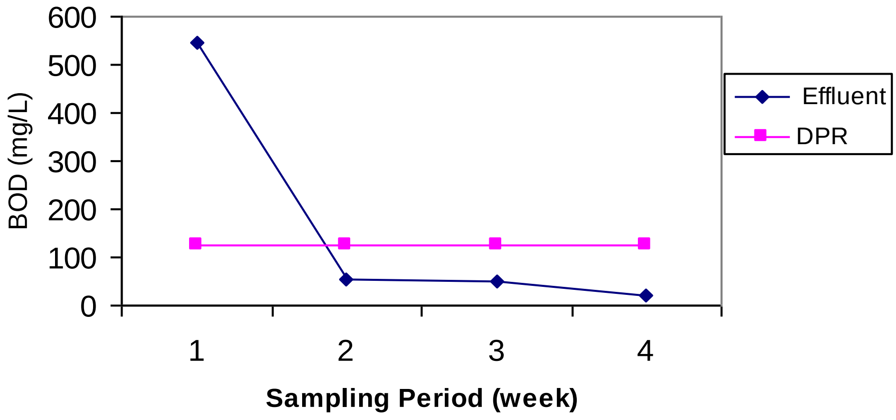


Fig. 6: Weekly variation of effluent BOD compared with standard

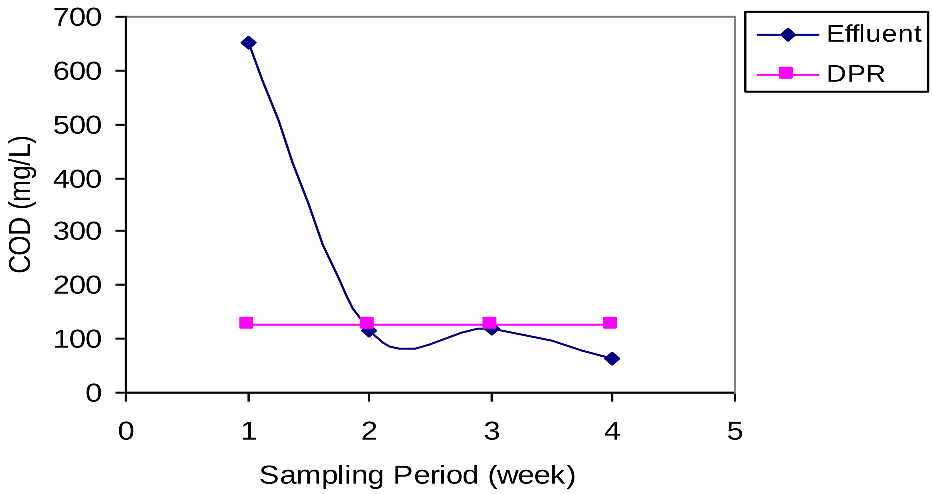


Fig. 7: Weekly variation of effluent COD compared wth standard

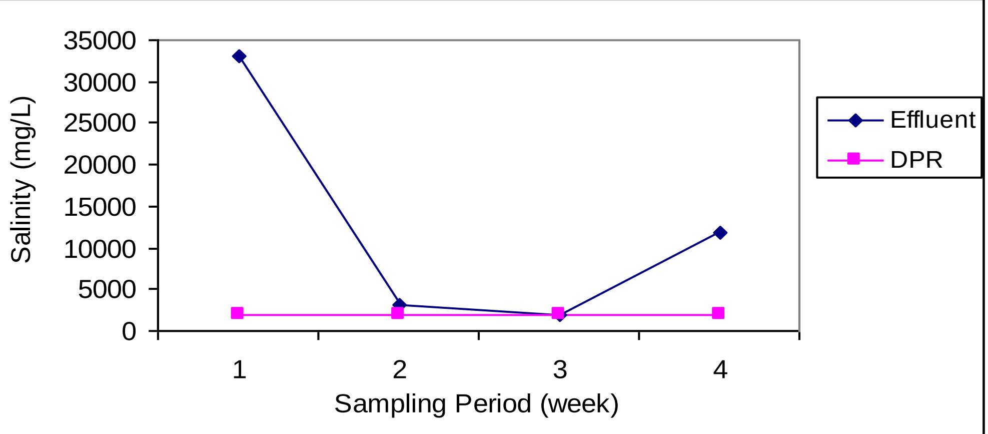


Fig. 8: Weekly variation of effluent salinity compared with standard

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