Environmental Assessment of Petrochemical Plant Effluent

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Abstract— **The objective of the study was to evaluate the physicochemical quality of effluent discharges from a petrochemical plant located in the Niger Delta, Nigeria, relative to stipulated environmental standard. Treated effluent samples were collected at the point of discharge from the plant, and analyzed monthly for eight months. The results obtained were compared with the standard stipulated by FEPA - the environmental regulatory agency in Nigeria. Effluent temperature ranged from 24.8 -39^{0}C, with 90 percent occurrence value of 35.3^{o}C, while the recommended level is 30^{o}C. Effluents pH range of 6.7 – 12.9, was outside the permissible range of 6.5 – 8.5. Lead concentration attained a maximum value of 0.167mg/L relative to the set limit of 0.05mg/L. Other parameters such as BOD, TDS, oil and grease. were consistently within specified limits. The discharge of poorly treated and unregulated effluents into the environment and pollution arising from industrial disposal and effluent discharges are becoming serious environmental issues in many developing countries. The study revealed the need for proper effluent treatment and monitoring to ensure consistent quality that meets recommended standard.**

Index Terms— **Statutory agency, set limit, concentration, elevated value, range, effluent, aquatic, parameter.**

I. INTRODUCTION

Petrochemicals are chemicals derived from oil and natural gas, and are among the most important materials used in industries. Waste waters released by crude oil-processing and petrochemical industries 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 and other chemicals (Suleimanov, 1995).

The major chemical composition of petrochemical wastewater comes mainly from cooling water commonly injected into cooling tower. These chemicals such as oil and grease, phenol and residual chlorides (mono, di, tri-chloramines) represent perhaps the most common chemicals threats to some aquatic lives such as fish and lower phyla. A second source of petrochemical wastewater composition namely; zinc, chromate, phosphate, and organics from recirculation of processing water that comes with high concentration of these metallic chemicals pose serious stress to aquatic life.

The ultimate recipient of all forms of pollution is the natural water body (Otaraku and Nkwocha, 2010 ; Nkwocha and Okoye, 2007). Due to the ineffectiveness of purification systems, wastewaters may become seriously dangerous, leading to the accumulation of toxic products in the receiving water bodies, with potentially serious consequences on the ecosystem (Beg *et al.,* 2001 ; Beg *et al*., 2003). Pollution from industrial disposal and effluent discharges is becoming a serious environmental issue in many developing countries of Africa.

Various studies have shown positive correlation between pollutions from industrial effluents and the health of aquatic organisms (Akpan and Offein, 1991; Chinda, 1998; Grant and Briggs, 2002). The study area is a petrochemical plant located in the Niger Delta area of Nigeria. The company generates effluents which are combined and discharged into the nearby creek after treatment. The Federal Environmental Protection Agency (FEPA) has established standards and guidelines for industrial effluents and regulates effluent discharges in Nigeria. The objective of this study was to assess the quality of the petrochemical effluent, to ascertain compliance with regulatory standards.

II. MATERIALS AND METHOD

Sample collection

Sample collection was done at the point of discharge from the plant, with plastic bottles, previously washed thoroughly with potable water and dried. Before use, they were rinsed twice with the sample. Sample collection was done monthly for eight months. Three samples were collected each time, at 1 hour intervals, and pooled together, preserved in ice chests and transported to the laboratory for analysis. Analyses were performed using standard methods [9] The following parameters were determined namely; temperature, pH, biochemical oxygen demand (BOD), total dissolved solids (TDS), total suspended solids (TSS), oil and grease, phenol, others include metallic pollutants such as lead, iron, and copper.

Temperature was determined at he point of sample collection using a mercury thermometer. BOD was analyzed electro-analytically using an oxyscan light-oxygen measuring meter. TDS was determined by weighing the deposit after evaporation of a known volume of the sample. Oil and grease was determined by acidifying a known volume of sample with hydrochloric acid, followed by extraction with trichlorofluorethane and distillation. Phenol was determined by chloroform extraction, while a Perkin Elmer 3100 atomic

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absorption spectrophotometer (Boston, MA 02118-2512, USA) was used for the determination of heavy metals.

Statistical Analysis of Data

Due to variations in effluent characteristics, it becomes necessary to subject the laboratory data to statistical analysis. The data were reported in terms of frequency of occurrence of a particular characteristic. This is the value of the characteristic that may be expected to be equaled or not exceeded 10, 50, 90 percent of the time. The frequency of occurrence was determined by Tchobanoglous and Schrolder (1985) and Echkenfelder (1989). for data with less than 20 points.

III. RESULTS

The physicochemical quality of the effluents discharged from the petrochemical plant was investigated, and the level of contaminants determined by laboratory analysis. The concentrations of the most significant pollutants in the effluents for the eight months experimental period are shown in Table 1. The laboratory data were subjected to statistical correlation and the 90 percent occurrence value of the physicochemical parameters are presented in Table 2. Plots of monthly variations in effluent parameters compared with FEPA set limits for the respective parameters are presented in Figs. 1-8.

DISCUSSION

The temperature of the effluent ranged from 24.8 – 39^{0}C (Table 1), with 90 percent occurrence value of 35.3^{0}C (Table 2). The highest values of 39 and 31^{0}C were observed in the 7th and 8th months respectively. However, these values are higher than 30^{0}C recommended for petrochemical effluents by FEPA (1991). Effluents at elevated temperatures when discharged into water bodies have been reported to cause a reduction in dissolved oxygen concentration of the receiving water environment, and attendant hazards to aquatic organisms (Bhatia, 2005; Obasi *et al.,* 2004).

Effluent pH ranged between 6.7-12.9 with 90 percent occurrence value of 12.5, while the permissible range is 6.5-8.5. The effluent exceeded the upper pH limit in the 6th - 8th month (Fig. 2), with values of 12.9, 12.1 and 9.8 respectively. Aquatic organisms are sensitive to pH changes. The high basicity of effluent could have a negative impact on the life of the watery species (Briton Bi *et al.,* 2006; Kuehn et al., 2002), in addition to, on the other hand, supporting the proliferation of the bacteria such as nitrosomomas and nitrobacters responsible for nitrification and nitratation that occur at pH ranging between 6.6 and 10 (Metcalf and Eddy, 2003; Weiner and Matthews, 2003).

The other parameter that was elevated in the effluent is lead. Effluent values of 0.132, 0.15 and 0.16 mg/L in the 3rd – 5th month, respectively (Fig. 8), do not meet the effluent limitations standard of 0.05 mg/L set by FEPA for petrochemical effluents in Nigeria. 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 (Ramalingam *et al.,* 2000; Jayakumar, 2001; Misra *et al*., 2002; Al-Saleh and Shinawari, 2002; Sikkema *et al.,* 1995). Low level exposure to lead such as through drinking water or eating contaminated fishes is also associated with many lead negative health effects. However, other parameters examined such as BOD, TDS, TSS pil and grease, phenol, iron, and copper, were consistently within the standard stipulated by the statutory agency.

This study has shown that the petrochemical effluent discharged into the Okrika area of the Bonny River estuary does not completely comply with statutory effluent standard. Gradual accumulation of toxicants in a water body can cause ecological imbalance, posing a serious threat to aquatic organisms and ultimately the entire ecosystem. It is recommended that the effluent be properly treated and monitored to ensure consistent quality that meets statutory standards.

Table 1: Physicochemical quality of petrochemical effluent

Parameter	Sampling Period							
	Aug	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Temp. ^{0}C	26.4	25.2	27.6	24.8	28.5	28	39	31
pH	7.3	7.0	6.7	6.8	7.5	12.9	12.1	9.8
BOD	1.0	1.2	1.3	1.9	0.7	1.3	2.6	2.4
TDS	153.6	428.7	134	128	198	176	176	142
TSS	20.1	4.7	5.0	7.3	4.6	4.5	6.9	5.0
Oil and grease	1.6	1.5	0.8	1.8	1.2	3.2	3.2	2.7
Phenol	<0.001	<0.001	<0.01	0.30	0.01	0.01	0.01	0.01
Lead (Pb)	<0.001	<0.001	0.132	0.15	0.167	<0.001	<0.001	0.005
Iron (Fe)	0.058	0.056	0.680	0.083	0.073	0.064	0.064	0.043
Copper (Cu)	0.004	0.004	0.002	0.006	<0.001	<0.001	<0.003	<0.00

Values are means of triplicate determinations and are in mg/L except temperature and pH Values with the less than (<) sign were below detection level.

Table 2: 90 percent occurrence values of effluent physiochemical parameters

Parameter	90% value
Temp ^{0}C	35.3
pH	12.5
BOD	2.5
TDS	32.3
TSS	14.2
Oil and Grease	3.2
Phenol	0.17
Iron (Fe)	0.41
Lead (Pb)	0.16
Copper (Cu)	0.005

Values are in mg/l except temperature and pH

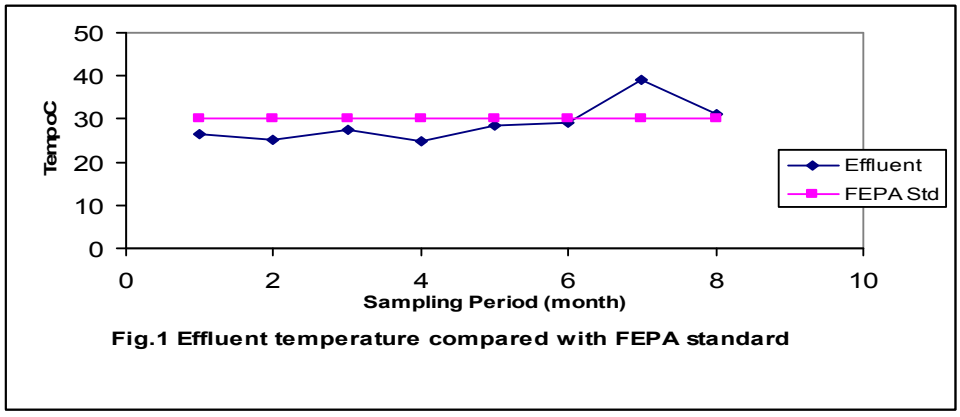

Fig.1 Effluent temperature compared with FEPA standard

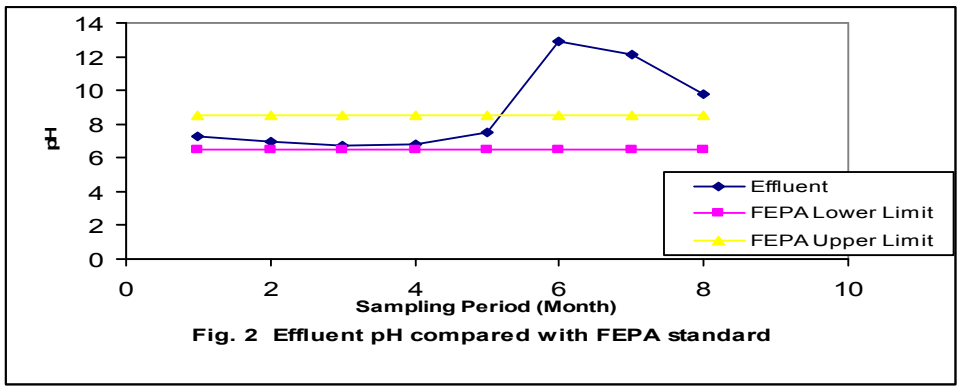

Fig. 2 Effluent pH compared with FEPA standard

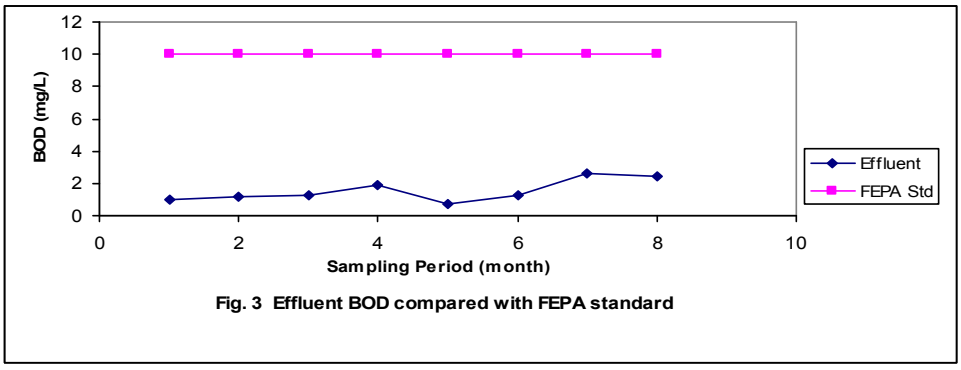

Fig. 3 Effluent BOD compared with FEPA standard

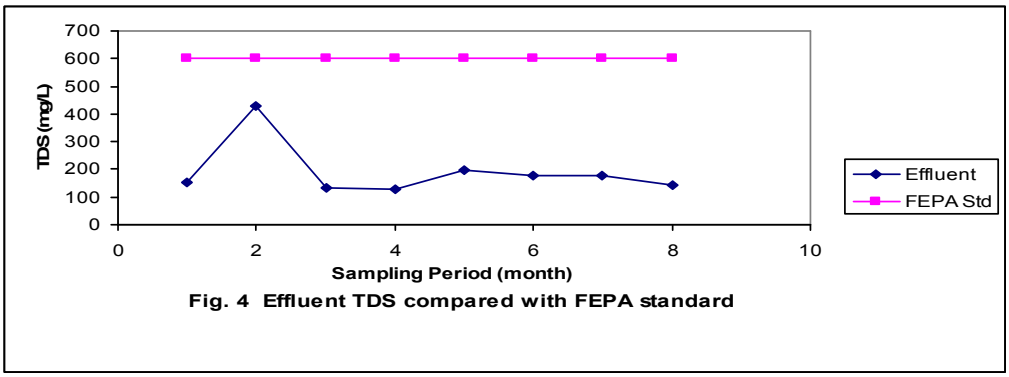

Fig. 4 Effluent TDS compared with FEPA standard

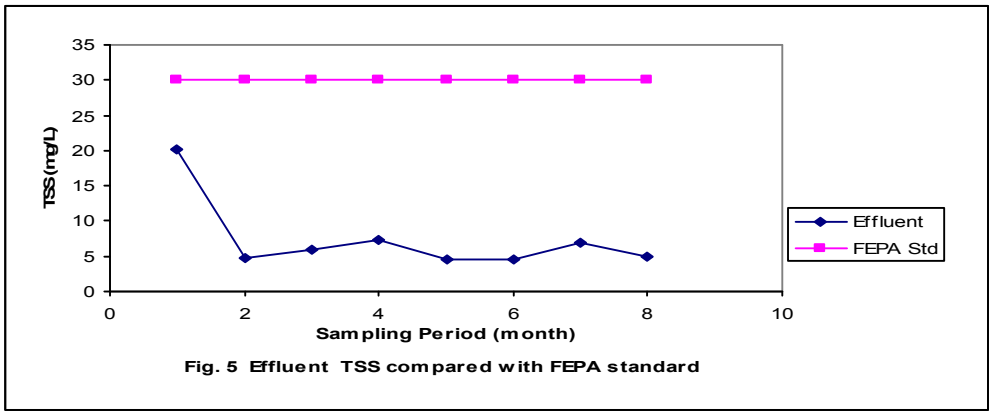

Fig. 5 Effluent TSS compared with FEPA standard

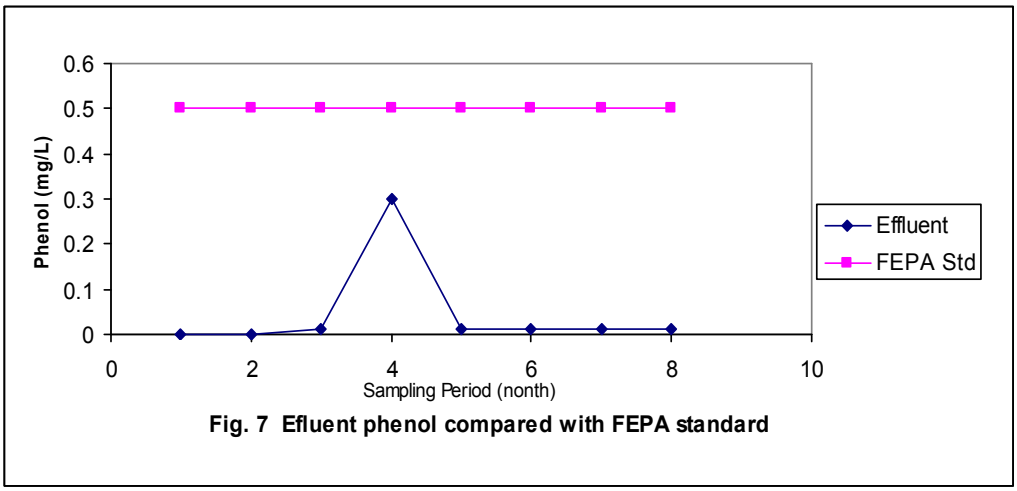

Fig. 7 Efluent phenol compared with FEPA standard

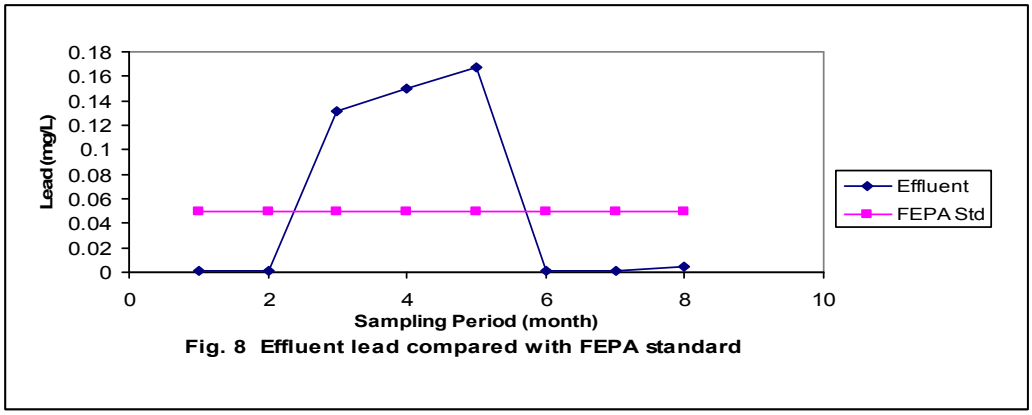

Fig. 8 Effluent lead compared with FEPA standard

REFERENCES

[1] Akpan, E.H. and Offeini J.O. (1991). Seasonal Variation in water quality of Cross River – Nigerian Review of Hydrobiology Tropica, 26(2): 93-103.

[2] Al-Saleh, I. and Shinwari, N. (2002)/ Preliminary Report on the Levels of Elements in Four fish Species from the Arabian Gulf of Saudi Arabia. – Chemosphere 48:749 – 755.

[3] APHA (1995): Standard Methods for the Examination of Water and Wastewater, 19th Edition, American Public Health Association, Washington D.C.

[4] Beg, M.U, Al-Muzaini, S., Saeed, T., Jacob, P.G., Beg, K. R., Al-Bahloul, M., Al-Matrouk, K., Al-Obaid, T., and Kurian, A. (2001). Chemical contamination and toxicity of Sediment from Coastal Area Receiving Industrial Effluents in Kuwait – Archives of Environmental Contamination and Toxicity, 4:289-297.

[5] Beg, M.U., Saeed, T., Al-Muzaini, S., Beg, K.R. and Al-Bahloul, M. (2003). Distribution of Petroleum Hydrocarbon in Sediment from Coastal Area Receiving Industrial Effluents in Kuwait: - Ecotoxicol Environ Saf. 54:47-55

[6] Bhatia, S.C. (2005). Environmental Pollution and Control in chemical Porcess Industries – Khana Publishers, Delhi,. pp 31- 67.

[7] . Briton Bi, G.H., Yao, K. and Ado, G. (2006). Evaluation of the Abidjan Lagoon Pollution. – J. Appl. Sci. Environ. Mgt. 10(3): 175-181.

[8] Carvalho, R.A., Brenfield, M.C. and Santschi, P.H. (1999). Comparative Bioaccumulation Studies of Colladally Complexed and Free-ionic Heavy Metals in Juvenile Brown Shrimp Penaius Astecus (Crustacea:Decapoda:Penaeidae) – Limnol. Oceanogr 44(2):403-413.

[9] Chinda, A.C. (1999). The Effect of Industrial Activities in the Periphyton Community of the Upper Reaches of New Calabari River, Niger Delta Nigeria – Water Researches, 32(4): 1137-1143.

[10] Eckenfelder, W.W. (1989). Industrial Pollution Control. – MeGraw Hill Book Co., Singapore.

[11] FEPA (1991). Federal Environmental Protection Agency, Nigerian National Environmental Protection (Effluent Limitations) Guidelines and Limitations.

[12] Grant, A. and Briggs, A.D. (2002): Toxicity of Sediments from around a North Sea Oil Platform: are metals or hydrocarbons responsible for ecological impacts. – Marine Environmental Research 54:21-48.

[13] Jayakumar, (2001). Levels of Heavy Metals in Commercial Fresh Water Fishes of Coimbatore. M. Phil. Dissertation Thesis Submitted to Bharathiar University,

[14] Kuehn, R.I., Berlin, K.D. Hawkins, W.E. and Ostrander, G.K. (2002). Relationships among Petroleum Refining, Water and Sediment contamination, and Fish Health.

[15] Journal of Toxicology and Environmental Health 46:101-116

[16] Metcalf and Eddy (2003). Wastewater Engineering Treatment and Reusw,4th edition, Tata McGraw Hill Publishing Co., Ltd., New Delhi, pp. 545 – 656.

[17] Misra, S.M., Borana, K., Pani, S., Bajpah A., and Bajpai A.K. (2002). Assessment of Heavy Metal Concentration in Grass Carp (ctenopharyn godon idella) – Poll. Res. 21(1):69-71.

[18] Nkwocha, A.C. and Okoye, J.I. (2007). Quality Evaluation of Industrial Liquid Effluent. – continental J. Applied Sciences, 2: 51-55.

[19] Obasi, R.A., Balogun, O. F. Ajayi, O. (2004). The Physicochemical Investigation of river Ireje in Ekiti State South West Nigeria. – Journal of Applied Science, 7 (2): 4124-4134.

[20] Otaraku, I.J. and Nkwocha, A.C. (2010). Assessment of Physicochemical quality of Petroleum Refinery Wastewater Effluents. – ICASTOR Journal of Engineering, 3(2):165-174.

[21] Ramalingam, V., Vimaladevi, V., Naramdarji, R. and Prabakaran, P. (2000). Effect of Lead on Haemotogical and Biochemical Changes in Fresh Water Fish (cirhinus mrigala. Poll. Res. . 19(1): 81-84

[22] Sikkema, J., de Bonti, J.A. and Poolman, B. (1995). Mechanisms of Membrane Toxicity of Hydrocarbons. – Microbiological Review 59:201-222.

[23] Suleimanov, R.A. (1995). Conditions of Waste Fluid accumulation of Petrochemical and Processing enterprises and Prevention of their Harm to Water Bodies. – Meditsina Truda i Promyshlennaia Ekologia, 12:31-36.

[24] Tchobanoglous, G. aand Schroeder, E.D. (1985). Water quality Management. – Addison Wesley Publishing Co., Inc., New York,

[25] Weiner, R.F. and Matthews, R. (2003). Environmental Engineering, 4th edition, Butterworth – Heinemann, Oxford, pp. 187 – 204.