Assessment of the Quality of Effluent Generated by Aluminium Company in Port Harcourt, Nigeria

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***Abstract*– An investigation on the physico-chemical and biological parameters from a wastewater stream in a typical aluminium company was carried out to determine its compliance with the regulatory standards in Nigeria. Effluent from the aluminium company was monitored for a period of 12 weeks. Values of biological oxygen demand, pH, total dissolved solids, oil and grease were above the guideline limits of National Environmental Standards Regulation Enforcement Agency (NESREA). The study emphasizes the need for pollution prevention plan to ensure that Ognigba creek which is the receiving water body does not experience further pollution from the aluminium company.**

***Keywords*– Aluminium Company, Water Quality, Effluent, Physicochemical and Biological Parameters**

I. INTRODUCTION

Rapid population growth and urbanisation are among the challenges faced by Nigeria as a nation. In fact, the rate of urbanisation has been indexed at a yearly average of 5.5% and has been described as the highest rate in the world [1]. The high rate of urbanisation in the country also meant more building projects. Large quantity of materials such as aluminium sheets are used in the building of houses each year due to its strength and durability. Apart from oil spills, another potential source of large scale, but mostly undocumented environmental pollution in Nigeria arises from indiscriminate effluent discharges from industries and surface runoff from lands which are eventually washed into associated creeks, rivers and streams such as Oginigba creek. This practice is environmental disaster which has been re-echoed by various authors [1]-[5]. There is an increased global concern on environmental pollution. This arose due to the increasing trend in emission of organic and inorganic pollutants into the environment by the producing industries such as plating, metal processing, leather tanning, iron and steel industries.

Anthropogenic activities have resulted in increased concentration of pollutants in many aquatic environments. The concentrations of these pollutants are of great interest due to their detrimental effects to the ecosystem [3], [4]. The sinks of most of the pollutants in the aquatic environment are aquatic organisms and sediments. Many of these pollutants are known to be toxic and non-biodegradable, they have also been known to bio-accumulate in food chain, posing a threat to public health and wildlife. Various chemicals are employed as intermediate treatment chemicals in manufacturing companies. The produced water which is mostly released to the environment is contaminated by these chemicals and could impair the properties of the receiving water body. In order to reduce the contaminant load to an acceptable level, various regulatory bodies were set up in Nigeria. For example, Department of Petroleum Resources (DPR) of the Nigerian National Petroleum Cooperation and National Environmental Standards Regulation Enforcement Agency (NESREA) formally Federal Environmental Protection Agency (FEPA) have guidelines and standards for effluent and water quality. The DPR guidelines apply strictly to the Petroleum industry while that of NESREA apply to all categories of industries including aluminium industry.

Parameters including but not limited to pH, total suspended solids (TSS), biological oxygen demand (BOD_5), total dissolved solids (TDS) and free chlorine are important in assessing variations of water quality in a river [2]-[6]. The pH measures either the acidity or alkalinity of water and is very important in controlling biological life. Most bacteria flourish better under a pH range of 6 – 8, outside which only a selected few can survive [3], [4], [7]. Bacteria play an extensive and fundamental role in the decomposition and stabilization of organic matter both in nature and in treatment plants [8].

The Oginigba creek receives a significant quantity of wastewater from different companies, of which the aluminium company under investigation is one of such companies. The need to monitor the quality of effluent discharged into this creek is of high environmental importance since the communities along its stretch utilize this water for both bathing and drinking.

II. MATERIALS AND METHOD

The Oginigba creek is located at Trans-Amadi Industrial layout, Port Harcourt Rivers State. Rivers State is the economic hub of the Niger Delta region of the South-South zone of Nigeria. Wastewater generated from the aluminium company comes basically from two sources – the production/paint line and the auto workshop. The only pre-treatment unit consists of oil and water separator with mesh wire around it. The wastewater passes through this pre-treatment unit before being discharged into the drain. Along the auto line is a drum where skimmed oil are deposited and later burnt. Wastewater samples were collected from the two

main discharge points labelled point A and B (Fig. 1). These two discharge points empty into public drain through pipe network distribution. Grab samples of 2 litres each from both collection points were collected into sterile glass (2 litres) bottle and sealed. Sampling was done once every week for 12 weeks (June to August 2008) and collected at different times of the day. The sampling days were spread through the working days from Monday through Saturday and done on hourly basis between 10 am to 4 pm as shown in Table 1. The aim is to capture the peak flow essential for design purposes. The labelled samples were transported in a cool box and processed within 24 hours of collection in the laboratory. The sampled wastewater were analysed at Fugro Nigeria Limited (FNL), a technical consultancy offering services in environmental and laboratory testing services. The physico-chemical and biological parameters analysed as well as the methods are shown in Table 2.

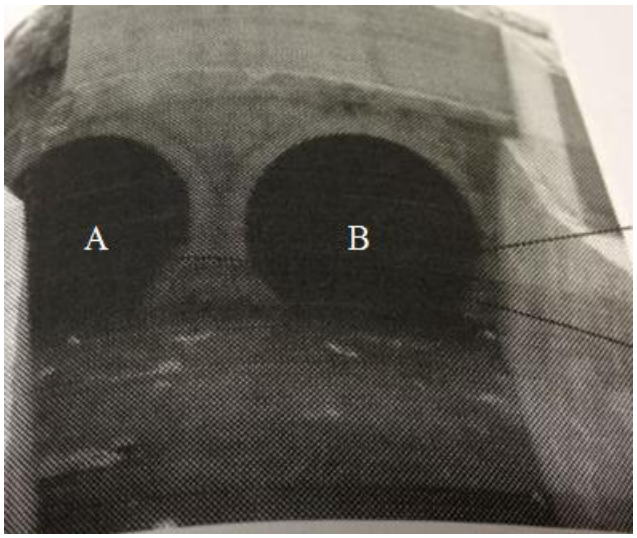

Fig. 1: The two discharge points

Table 1: Sampling schedule

Weeks	Time (GMT)	Days
1	10 am	Monday
2	11 am	Tuesday
3	12 noon	Wednesday
4	1 pm	Thursday
5	2 pm	Friday
6	3 pm	Saturday
7	4 pm	Monday
8	10am	Tuesday
9	11am	Wednesday
10	12 noon	Thursday
11	1 pm	Friday
12	2 pm	Saturday

Table 2: Parameters and methods of analyses

Parameters	Methods
pH at 25.4°C	APHA 4500H^+B
BOD_5 (mg/l)	APHA 5210B
TSS (mg/l)	APHA 2540D
Free chlorine (mg/l)	ASTM D1261
Oil and grease (mg/l)	ASTM D3921
Phenol (mg/l)	APHA 5530D
TDS (mg/l)	APHA2510A

III. RESULTS AND DISCUSSIONS

The results for the physico-chemical parameters obtained from the two sampling points during the 12 weeks are shown in Figures 2 to 8. Results show that all the measured parameters with the exception of total dissolved solids were generally higher than the accepted limit set by the Federal Environmental Protection Agency. The chemical characteristics of any wastewater define its strength and to a larger extent the type of treatment required. Thus, the following results are highlighted.

A. pH

Fig. 2 shows the fluctuating weekly pH values. The peak for sampling point A (12.1) and B (11.9) recorded at the 4th and 7th week respectively. pH affects biological treatment because microorganisms are very sensitive to pH range. Wide fluctuations in pH are detrimental in treatment plants of conventional design [8]. Since the wastewater from the aluminium company is emptied into Oginigba creek, it is necessary to adjust the pH of the effluent before discharge into the creek. Alkaline wastewater can be normalised with sulphuric acid or hydrochloric acid while acidic wastewater can be neutralised with sodium hydroxide [9]. Wastewater with very high pH might affect the concentration of hydrogen ions in the receiving water. The recommended pH for drinking water is 7-8 [10]. Given the Oginigba creek also serves as drinking water supply to the local residents, there is need for a treatment design which includes an equalisation basin for capturing the wastewater as a means to stabilise the pH before discharge. Equalisation basin can as well be used to minimise the chemical requirements necessary for neutralisation. It is advisable that pH electrodes be regularly calibrated with standard pH buffer solutions which could be pH 7 and either pH 4 or 9. However, pH 9 is recommended for wastewater that tend to be alkaline [9].

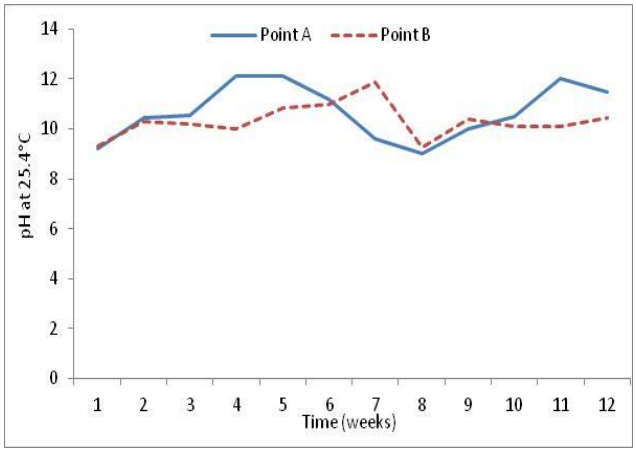

Fig. 2: Weekly pH over 12 weeks

B. Biological Oxygen Demand

Fig. 3 represents the weekly BOD_5 for the study period. For sampling point A, a peak of 520 mg/l was observed at the 7th week and 800 mg/l for sampling point B in the 5th week. These values are very high compared to 20 mg/l the limit set by FEPA and should be considered for design purposes as well. BOD_5 determines the approximate amount of oxygen required to biologically stabilise the organic matter present in wastewater. Thus, BOD_5 has been used to describe the degree of organic pollution of water [3], [7], [11]. Large amounts of biodegradable materials in water body can be related to the availability of dissolved oxygen because oxygen is needed for the breakdown of these materials. The demand for dissolved oxygen which increases as the process develops should not be allowed to decrease below 3-5 mg/l, which is the concentration required for aquatic organisms. Low dissolved oxygen concentration might lead to reduced levels of activities or even death of aquatic life. In general, the concentration of dissolved oxygen is used as indicator of water quality. It shows the river's capacity to assimilate pollution materials and support aquatic life.

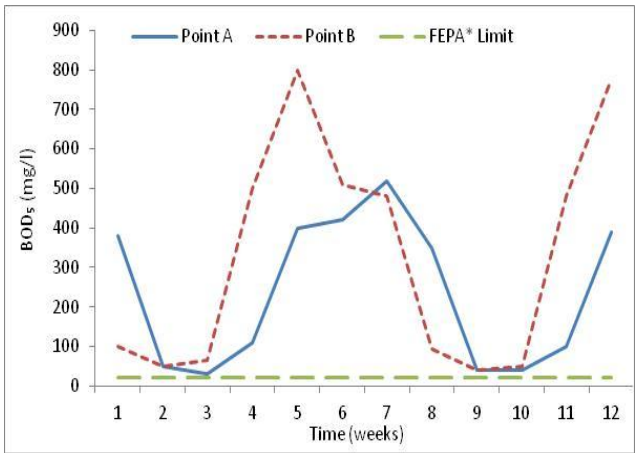

Fig. 3: Weekly biological oxygen demand (mg/l) over 12 weeks

C. Total Suspended Solids

It was observed that the two sampling points (A and B) had values of TSS above the FEPA limit as shown in Fig. 4. Sampling point A had a peak of 2030 mg/l in the 5th week while sampling point B has a peak of 780 mg/l in the 7th week. The presence of suspended matter in water makes it turbid. Turbidity can influence light-transmitting properties of water and in the long run affect its photophilic processes. Obstruction to penetration of light can adversely affect the activities of fishes and other aquatic organisms [2]. This could lead to declining fish production and possibly impacts on the livelihood of fish farmers given Oginigba creek is used for other activities downstream. Total suspended solids along with BOD_5 are widely used as parameters for effluent standards by which the performance of treatment plants is judged.

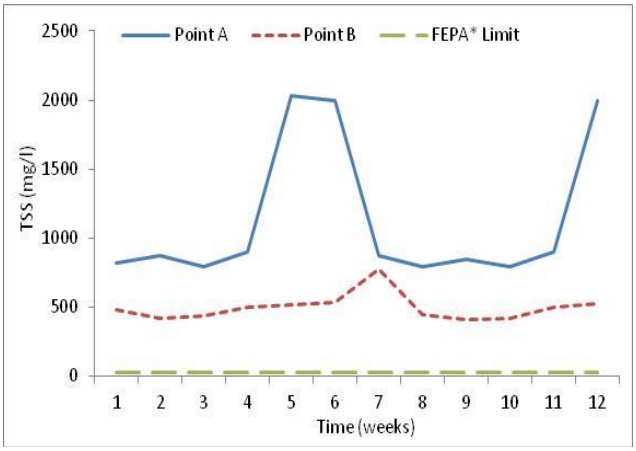

Fig. 4: Weekly total suspended solids (mg/l) over 12 weeks

D. Free Chlorine

The results from free chlorine as represented in Fig. 5 shows it to be higher than the accepted limit of 1.0 mg/l set by FEPA. In week 5, peak values of 28.4 and 7.1 mg/l were recorded for sampling point A and B respectively. However by from weeks 8 to 10 the values were lower than the set limit. Free chlorine is beneficial for disinfection of drinking water. The presence of free chlorine in sufficient amount inactivates bacteria capable of causing water borne diseases. Free chlorine can also combine with contaminants in the water to form chloramines and becomes unavailable for disinfection. However, excess of free chlorine imposes acidic conditions (low pH) to the water. Exposition to water with low pH can cause redness and irritation to the eyes.

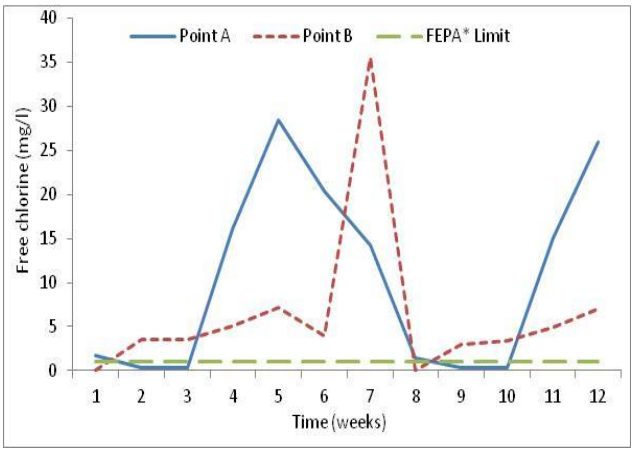

Fig. 5: Weekly free chlorine (mg/l) over 12 weeks

E. Oil and Grease

The weekly concentrations of oil and grease had much fluctuation as shown in Figure 6. The peaks were registered as 110 and 43.3 mg/l for sampling point A and B respectively. According to FEPA, the accepted limit is 50 mg/l and this makes it objectionable to discharge such effluent from the aluminium company into water body without any treatment. Oil and grease refer to variety of organic substances including hydrocarbons, fats, oils, waxes and high molecular fatty acids present in wastewater [8]. Oil could be dissolved or form film or emulsion in water. If grease is not removed from wastewater, it can interfere with biological life in water body by inhibiting the transfer of oxygen from the atmosphere into the water. Grease can also float on top of sedimentation tanks and can even clog filters thereby disrupting the treatment plant. The permissible concentration of mineral oil and petroleum products in water depends on intended use of water.

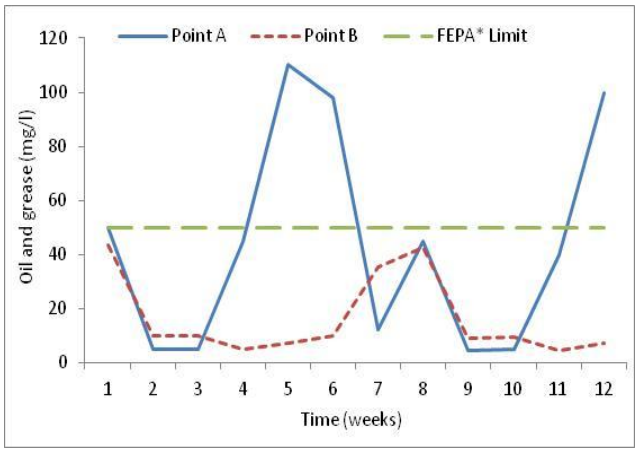

Fig. 6: Weekly oil and grease (mg/l) over 12 weeks

F. Phenol

Fig. 7 represents the weekly phenol from the wastewater for the period of study. The concentration of phenol was above the set limit of 0.2 mg/l by FEPA. Sampling points B and A recorded peak values in weeks 3 and 7 respectively. There could be a relationship between the concentration of phenol and pH of the wastewater since the peak pH was recorded in weeks 4 and 7 as previously shown in Fig. 2. This may be attributed to the reaction of free chlorine with phenolic compounds or other contaminants. The presence of phenol in drinking water is not desirable because it causes taste problems and odour.

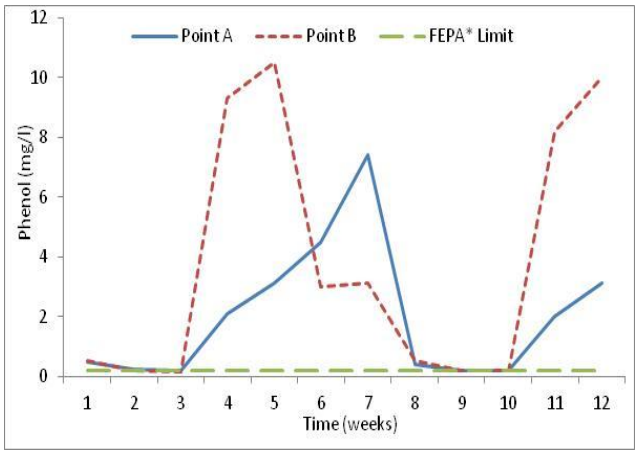

Fig. 7: Weekly phenol (mg/l) over 12 weeks

G. Total Dissolved Solids

The results from concentrations of the total dissolved solids showed the levels were below the 2000 mg/l accepted limit set by FEPA. The peak values were 268 and 200 mg/l at sampling point A and B respectively. The presence of total dissolved solids in water can impact on the level of dissolved oxygen. A high TDS suggests an increase in biological oxygen demand which depletes the dissolved oxygen and vice versa. However, in the present study the low TDS could be as a result of the fact that the total solids from the aluminium company is expected to be lower given the major product line is aluminium sheet.

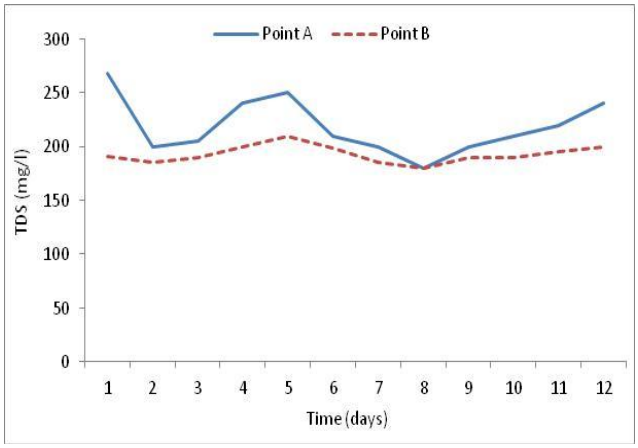

Fig. 8: Weekly total dissolved solids (mg/l) over 12 weeks

IV. CONCLUSION

The quality of wastewater from the aluminium company was investigated and their values compared with limits set by Federal Environmental Protection Agency of Nigeria. The discharge of wastewater from the company is point source pollution to Oginigba. Perhaps, dilution could influence the fate of pollutant transport in any water body. However, the local residents fetching water close to the point of discharge are at a very high risk of using contaminated water for drinking and other domestic purposes. The need to meet up with stringent environmental regulations cannot be overemphasised since the discharge of wastewater to surface waters affects the water quality. Therefore, the aluminium company under investigation should make sure that the quality of the wastewater discharged into Oginigba creek meets the limit set by FEPA. The regulatory framework in Nigeria should also include the selection of discharge locations and outlet stations for industrial wastewater and not just the level of treatment required.

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