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# Physicochemical Characterization of Industrial Effluents on Receiving Water Bodies in Trans-Amadi, Port Harcourt, Rivers State

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**ABSTRACT:** The analysis of industrial effluent receiving water bodies in Trans-Amadi Area in Port Harcourt, Rivers State was assessed in this study. Seven (7) streams polluted by industrial wastes from beverage, oil drilling fluids and drink manufacturing industries as well as abattoir in different locations in the study area was selected for the investigation. The study shows that effluents from the industries have high impact on water quality of the receiving streams. This is depicted by the increase in concentration of most of the parameters analysed, which are above the maximum permissible limits set by WHO and NIS for quality water. The high values of most physicochemical parameters in the stream are as a result of the presence of suspended, organic and inorganic matters, or microscopic organisms in the effluents. It is therefore recommended that careless disposal of wastes should be discouraged and there is need for each industry to install waste treatment plant that will treat wastes before being discharged into the streams. Furthermore, Federal and State environmental regulators should enact and enforce laws that will regulate, manage and protect receiving streams from contamination.

KEYWORDS: Physicochemical Parameters, Receiving Stream, Effluents, Analysis

### 1. INTRODUCTION

Industrialization is considered as the foundation of development strategies considering its significant contribution to the economic growth of a nation and human benefits. Industries on the other hand manufactures products that generates hazardous waste products in the form of solid, liquid or gas that are deposited in water bodies. Most of these solid wastes and wastewaters discharged into soil and water bodies in due course, pose serious threat to human and proper performance of the ecological system.

Universally, water bodies are the principal dump sites for disposal of waste, mainly the effluents from industries that are near them. These effluents from industries have great toxic influence on the pollution of water body, as they can alter the physical, chemical and biological nature of the receiving water body (Sangodoyin, 1991; Adekunle and Eniola, 2008). Initially, the physical quality of waste polluted water is degraded, but later on, biological degradation becomes evident in terms of number, variety and organization of the living organisms in the water (Gray, 1989). Often the water bodies readily assimilate waste materials they receive without significant deterioration of some quality criteria (Adekunle and Eniola, 2008).

The availability and quality of water always have played an important role in determining the quality of life. Water quality is closely linked to water use and to the state of economic development (Chennakrishnan *et al.* 2008). Ground and surface waters can be contaminated by several sources. In urban areas, the careless disposal of industrial effluents and other wastes may contribute greatly to the poor quality of water (Mathuthu *et* 

al., 1997). Most of the water bodies in the areas of the developing world are the end points of effluents discharged from industries.

Considering the water streams in Trans-Woji which connects the residents of Rumuobiakani, Mini-Ewa, Oginigba, Woji and Okujagu communities as it hosts the activities of the majority of companies around the Trans-Amadi Industrial area and also provides water for fishing and water transportation, the water quality of these streams has been tremendously affected as a result of the industrial activities that send untreated effluents from industries in this area. Trans-Amadi is one of the areas known for industrial development in and around Port Harcourt, Rivers state. The industrial activities in this area among others include factories for fish filleting, foods and beverages, plastics, breweries, corrugated iron sheets and paints, refrigerating, petrochemicals, oil serving, abattoirs, etc. Effluents from the above industries are disposed into the streams almost exclusively without adequate treatment, which is likely to affect the water quality of the receiving streams and human activities. Ayotamuno *et al.* (2007) reported the negative impact the effluents from the industrial activities, including oil exploration had on the rivers and creeks around Trans-Amadi area. Also, it has been recorded that the discharge of municipal and industrial wastewater containing organic impurities poses serious environmental problem (Mdamo, 2001). Thus, the rivers and streams in the Niger delta are now becoming increasingly vulnerable to human due to industrial activities (Onojake et al., 2017).

Industrial effluents discharged into water bodies without adequate treatment results in nutrient enrichment, accumulation of toxic compounds in biomass and sediments (Dunbabin, 1992), loss of dissolved oxygen in water and other nuisances. The water in Trans- Amadi is highly coloured, turbid and the vegetation along the stream appears scorched despite the fact that water from these streams is a major resource in the area. It is used for cleaning, construction, irrigation, drinking for animals and birds, and recreation for children. Wetlands are known to act as natural filters for nutrients and contaminants that originate from the catchment area, thereby protecting the water quality (Kansiime and Nalubega, 2000). Regrettably, Trans- Amadi wetland that is expected to filter contaminants carried by streams in the areas has been degraded and reduced in size due to increased human and industrial activities, causing a reduction in its cleaning potential. This creates an urgent need to assess the impact of wastewater from Trans- Amadi industrial effluents on the quality of receiving streams. This study therefore, is designed to assess the impact of industrial effluents on the quality of receiving waters in Trans-Amadi, Port Harcourt.

### 2. MATERIALS AND METHODS

### 2.1 Study Area

Trans-Amadi industrial Layout, Obio/Akpor Local Government Area, Port Harcourt, Rivers State, is the study area and it is located at (latitude 4.8128<sup>°</sup> N and Longitude 7.0633<sup>°</sup> E). Trans-Woji stream is the main stream linking with Mini-Ewa, Rumuobiakani, Woji, Oginigba, Okujagu and Okrika streams and then, emptied down to Bonny River. The layout of the study area and the sample collection sites are shown in Figure 1. The study was carried out in Trans-Woji stream of Trans-Amadi industrial area and in effluent channel from seven industries (Table 1).



Figure 1: Map of the study area showing the location of sampling sites

Figure 2: Area view of the sampling sites

	Effluent Channel of Industries	Activity	Coordinates
Site 1	Breweries Limited	Manufacture of Alcoholic drinks	4°27'8''N 7°2'14''E
Site 2	Beverages Companies	Manufacture of soft drinks beverages	4°14'49''N 7°19'43''E
Site 3	Drilling Fluids	Manufacture Oil drilling Fluids	4°15'53"N 7°21'38"E
Site 4	Drilling Fluids	Manufacture of oil drilling fluids and servicing	4°48'51"N 7°1'17"E
Site 5	Slaughter (Abbattoire)	Slaughtering House	4°47'53"N 7°2'32"E
Site 6	Beverages Companies	Manufacture of beverages and biscuits	4°28'6''N 7°1'15''E
Site 7	Drilling Fluids	Tank farm / drilling fluids	4°27'9"N 7°2'19"E

#### Table 1: Industries assessed and their respective production activities

The discharged effluents from the seven selected companies, all have designed discharged points to the receiving streams that drain the untreated effluents into the stream.

### 2.2 Method of Sampling

Samples were collected with sampling tubes and bottles inserted to the effluent channels leading to the stream as designated to each operating companies, spaced at 15m apart along the Trans-Woji bridge abutment. Control samples of unpolluted water were taken before effluent discharged servings as reference point.

All polluted water samples collected for laboratory analysis were placed in one litre plastic bottle that was thoroughly washed with distilled water and rinsed with dilute nitric acid before use and tightly fastened, placed in a cooler and protected from sunlight before taken to the laboratory for analysis.

### 2.3 Sample Test Analysis

Samples were analyzed and determined for Physiochemical Properties from the Civil Engineering Department, Rivers State Polytechnic, Water and Environmental Engineering Laboratory. All parameters were analysed according to APHA (1998), Nigerian Standard for Water Quality (NSDWQ) (NIS, 2007) and World Health Organization (WHO, 1997 and 2008).

## 2.3.1 рН

The pH of the streams investigated was measured using pH meter.

## 2.3.2 Electrical conductivity (EC)

Electrical conductivity (EC) is a measure of the ability or the numerical expression of water's ability to conduct electric current. This was measured in-situ both in the effluent channel and in the stream using a Mettler Toledo MC 226 conductivity meter.

## 2.3.3 Turbidity

Turbidity of samples was analyzed using the HACH 2100A turbidity meter and HACH Ratio Turbid meter APHA-214A.

### 2.3.4 Chemical Oxygen Demand

Chemical oxygen demand (COD) is the amount of oxygen required to completely oxidize the organic matter in waste water by use of a strong oxidant and to convert it to carbon meter (Mettler Toledo 320 model) according to APHA (1998). Potassium dichromate was used in this test because of its superior oxidizing ability. A known quantity of water sample was mixed with a known quantity of standard solution of potassium dichromate  $(K_2Cr_2O_7)$  and the mixture heated. The organic matter was oxidized by the potassium chromate in the presence of sulphuric acid  $(H_2SO_4)$  and the oxygen used in oxidizing the water was determined.

## 2.3.5 Biochemical Oxygen Demand (BOD)

The (BOD) was determined by measuring the DO of the samples contained in a BOD bottle before and after five days of incubation of 20°C temperature. According to APHA-51210B, BOD was calculated as:

$$BOD = (S_1 - S_2) - (B_1 - B_2) \times \% \text{ dilution}$$
<sup>(1)</sup>

where:  $S_1 = DO$  for the sample,  $S_2 = DO$  after incubation of sample,  $B_1 = DO$  for the first day for blank and  $B_2 = DO$  after incubation for blank.

### 2.3.6 Heavy metals

Copper, iron and aluminium were determined using Atomic Absorption Spectrometer (model AA6800-SHIMADZU) according to APHA (1998).

### 2.4 Data analysis

Data were statistically analyzed in MS Excel tool. Mean, variance and standard error were used to vary and assess the spread of the data. The mean of parameters ( $\pm$ SE) and one-way analysis of variance (ANOVA) were calculated to make comparison of the mean values of observations based on the seven sites. Differences in mean values obtained were considered significant if calculated P-values were < 0.05. Correlation analysis test was performed to determine the association between various parameters along sampling sites.

### 3. RESULTS AND DISCUSSION

The physiochemical parameters determined in samples collected from streams receiving effluents from seven industries in Trans-Amadi Industrial Layout of Port Harcourt, River State are presented in Table 2.

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	WHO	NIS
pН	6.86	7.24	6.6	8.07	6.34	8.24	6.67	6.0-8.5	6.0-8.5
Temp. (°C)	27	26	22.4	26.7	27.3	24.2	26.7	24.28	NA
EC (µs/cm)	10788	9986	10648	10552	10688	9868	10676	1000	1000
Turbidity (NTU)	26.3	27.4	29.3	31.6	36.4	30.8	27.8	5	5
BOD	1.8	1.4	5.2	4.3	2.6	3.1	1.6	4	NA

 Table 2: Physicochemical Analysis of Waste from Receiving Water

4919

(mg/l)									
COD (mg/l)	76.7	71.3	78.3	64.8	79.3	66.3	68.3	NA	NA
DO (mg/l)	4.9	5.3	6.3	6.2	5.7	5.5	4.6	3-7	3-7
TSS (mg/l)	40.6	42.6	39.6	36.7	31.8	35.3	41.6	NA	NA
Salinity (mg/l)	1.6	2.1	1.3	0.9	1	1.3	1.4	NA	NA
Copper (mg/l)	3.47	3.09	2.56	2.44	3.36	3.41	3.10	1.0	NA
Iron (mg/l)	5.98	6.22	5.84	5.51	6.03	5.60	5.94	0.3	NA
Aluminium (mg/l)	0.82	0.64	0.55	0.73	0.59	0.52	0.67	0.2	NA

## 3.1 Sample pH

Though, the range of pH obtained across the sites were within the specified limits by international and local regulatory agencies (WHO, 1997 and 2008; NIS, 2007), but there are variations in pH in the respective sites, with least values recorded in site 5 (pollution from Abattoir) and the highest value in site 6 (pollution from beverages and biscuits manufacturing industry). The mean value of pH across the sites is  $7.15\pm0.74$ . The low pH recorded in some of the sites was could be attributed to several sources of water such as rain water runoff that made their ways into the streams thereby, increasing the acidity of the streams. The trend in pH is shown in Figure 3.



Figure 3: pH trend along the sampling sites

## 3.2 Temperature

Temperature across the sites are equally within the specified limits by WHO (24-28°C) except for site 3 (pollution from oil drilling fluids manufacturing industry). This implies that oil drilling fluids contain substances that increase the average temperature of the stream. The mean temperature across the sites is  $25.76\pm1.80$ . The temperature trend in across the sites is shown in Figure 4.





## **3.3** Electrical Conductivity

Electrical conductivity indicates the level of salt present in water. Thus, the higher the quantity of ions in water, the more its conductivity (Mosley et al., 2004). Figure 5 shows the level of electrical conductivity (EC) in the various sites. EC ranged from 9868 in site 6 (pollution from beverage and biscuit manufacturing industry) to 10788 $\mu$ S/cm in site 5 (pollution from Abattoir) with mean value of 10458.00±370.84 $\mu$ S/cm. The EC values across the sites are higher than the threshold limit by WHO and NIS of 1000  $\mu$ s/cm. The high EC recorded in beverage and biscuit manufacturing industry implied that there are more dissolved solids than other sites, which increased the stream ions and salts. The EC trend in across the sites is shown in Figure 5.



Figure 5: Electrical conductivity trend along the sampling sites

### 3.4 Turbidity

Figure 6 shows the level of turbidity in the sites. Thus, turbidity values across the sites are higher than the threshold limit by WHO and NIS. Site 5 recorded the highest turbidity (pollution from Abattoir) with mean value of  $29.94\pm3.41$ NTU. Turbidity was above WHO standards of 5NTU for the seven (7) sites. The high turbidity could be as a result of the presence of suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton, or other microscopic organisms in the effluents (Lamb, 1985). The result is also in agreement with similar investigation by Muwanga and Barifaijo (2006) in Uganda. This high turbidity will affect fish and aquatic life by interfering with sunlight penetration. If suspended particles block light, photosynthesis and production of oxygen for fish and other aquatic animals as well as sea weeds will be reduced (Smith and Davies-Colley, 2001).



Figure 6: Turbidity and colour trends along the sampling sites

### 3.5 Biochemical Oxygen Demand (BOD)

Figure 7 shows the level of Biochemical Oxygen Demand (BOD) across the sampling sites. The concentration of BOD in sites 3 and 4 are higher than the maximum permissible limit by WHO (4mg/l), indicating that oil drilling fluids and wastes from servicing materials discharged into water bodies contain high content of biodegradable organic matters, which are sure to raising the amount of BOD. Thus, the continued disposal of biodegradable organic waste into the streams will lead to increased consumption of dissolved oxygen, which may in turn affect aquatic life. In recent studies, high BOD in water was attributed to effect of temperature, salinity, and putrefaction of substances or deposition of organic pollutants from industrial wastewaters and agricultural wastes (Onojake *et al.*, 2017; Amic and Tadic, 2018).



Figure 7: Trend of BOD along the sampling sites

### 3.6 Chemical Oxygen Demand (COD)

Similarly, the level of COD in the streams is shown in Figure 8. The COD values obtained ranged from 64.8mg/l to 79.3mg/l with mean values of  $72.14\pm5.96mg/l$ . Although, there was no limit set for COD, the values recorded across the streams are above those obtained by Abu and Egenonu (2008) for New Calabar River, while values reported by Wakawa *et al.* (2008) for Challawa River in Kano State and Osibanjo *et al.* (2011) for Ona and Alaro rivers are above values recorded in this work. The high COD in water is due to high suspended organic matter (Amic and Tadic, 2018). COD values in the effluent streams are higher than their BOD counterparts. This is due to the fact that BOD only accounted for substances that oxidized biologically, while COD measures chemical and biological oxidation of substances in waste waters (Gray, 1989).

4922



Figure 8: Trend of COD along the sampling sites

## 3.7 Dissolved Oxygen

Dissolved oxygen (DO) in the streams is generally within WHO and NIS standards (3-7mg/l). The DO values ranged from 4.6mg/l to 6.3mg/l with mean values of 5.50±0.63mg/l. Thus, sites 3 and 4 recorded the highest value of DO, while the least value was observed at site 7, indicating that oil fluids wastes contain substances with high potential to increasing DO in water if not properly managed. Figure 9 shows the level of DO recorded in effluents from the various sites.



Figure 9: Trend of DO along the sampling sites

## 3.8 Total Suspended Solids

Total suspended solids (TSS) are present in sanitary wastewater and many types of industrial wastewater. They create uncharacteristic taste in water making it less potable (Mohamed and Hussain, 2012). The range of TSS across the sites was 31.8mg/l (site polluted by abattoir) to 42.6mg/l (site polluted by soft drinks and beverages manufacturing industry) with mean values of 38.31±3.88mg/l. Again, TSS limit are not given by WHO and NIS, but can be guided by the discomfort it creates.



Figure 10: Trend of TSS along the sampling sites

## 3.9 Salinity

Salinity is a measure of the total salt concentration, comprised mostly of Na<sup>+</sup> and Cl<sup>-</sup> ions. Even though there are smaller quantities of other ions in seawater (e.g., K<sup>+</sup>, Mg<sup>2+,</sup> or SO<sub>4</sub><sup>2-</sup>), sodium and chloride ions represent about 91% of all seawater ions. Like other parameters, salinity varied in the sampling sites and ranged from 0.90 mg/l (oil drilling fluids manufacturing and servicing industry) to 2.10 mg/l (site polluted by soft drinks and beverages manufacturing industry) as demonstrated in Figure 11 with mean value of  $1.37\pm0.40$ mg/l across the sites.



Figure 11: Trend of salinity along the sampling sites

## 3.10 Heavy metals

The results shown in Table 2 revealed that the contents of copper, iron and aluminium were above acceptable limits set by WHO. The lowest values for copper and iron was recorded in oil drilling fluids manufacturing and servicing industry, while for aluminium, it was recorded in beverage and biscuit manufacturing industry. However, effluent from alcoholic drinks manufacturing industry produced higher contents of copper and aluminium, while the highest amount of iron was produced from oil drilling fluids effluent. These variations could be attributed to treatments techniques applied before disposal. Figures 12 to 14 show the level of copper, iron and aluminium contents recorded in effluents from the various sites.





Figure 12: Copper trend along the sampling sites

Figure 14: Aluminium trend along the sampling sites

## 4. CONCLUSION

Overall, the study shows that effluents from industries, especially when mot properly treated, have high impact on water quality of the receiving streams. This is depicted by the increase in concentration of the parameters analysed as opposed to the maximum permissible limits set by WHO and NIS for quality water. Although the values in some cases were lower than the maximum allowable limits by WHO (1997, 2008) and NIS (2007), the continued discharge of un-treated effluents in the stream may result in severe accumulation of contaminants. This is a situation that should alert the Nigerian Standard for Water Quality to continuously monitor industrial effluents and enforce the regulation. In practice, industrial waste and effluents are supposed to be treated before been dispose of, but it seemed this has been compromised as the level of contaminants observed at the discharge point were not satisfactory, and their direct or indirect utilization by humans could be a potential sources of diverse of health related issues.

It is therefore recommended that careless disposal of wastes should be discouraged and there is need for each industry to install waste treatment plant that will treat wastes before being discharged into the streams. Furthermore, Federal and State environmental regulators should enact and enforce laws that will regulate, manage and protect receiving streams from contamination.

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