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Seasonal Variation of Physicochemical Parameters of Rivers Trans-Amadi, Port Harcourt, Rivers State

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Abstract

The variation in physicochemical properties of rivers located in industrial area of Trans-Amadi in Port Harcourt, Rivers State of Nigeria during the dry season and wet season was investigated. Seven (7) streams were used for the investigations and all returned similar results based on seasonal variation of parameters. Thus, the results showed there were variations in physicochemical parameters of rivers between the dry and wet seasons. Thus, the parameters are generally higher during dry season than in wet season. Although, both seasons results showed that the rivers are contaminated due to industrial effluent discharge, which calls on regulatory agencies to take proactive steps in guiding the water bodies in industrial areas.

Key words: Physicochemical Parameters, Receiving Stream, Effluents, Seasonal Variation

INTRODUCTION

Most solid wastes and wastewaters are discharged into the soil and water bodies and in due course pose a serious threat to human as well as hindering the proper performance of the ecological system. Universally, water bodies are the principal dump sites for wastes, mainly the effluents from industries that are near them. These effluents from industries have great toxic influence on the pollution of the water body, as they can alter the physical, chemical and biological nature of the receiving water body (Sangodoyin, 1991; Adekunle and Eniola, 2008). Often, the water bodies readily assimilate waste materials they receive without significant deterioration of some quality criteria; the extent of this is referred to as its assimilative capacity (Adekunle and Eniola, 2008).

Water is essential to all forms of life and makes up 50-97% of the weight of all plants and animals and about 70% of human body (Allan, 1995). Water is also a vital resource for agriculture, manufacturing, transportation and many other human activities. Despite its importance, water is the most poorly managed resource in the world (Chutter, 1998). 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).

Studies have shown that increased industrial activities have led to pollution of major rivers and streams in Nigeria (Sangodoyin, 1991; Ibekwe *et al.*, 2004; Fakayode, 2005). This affects both the water quality as well as the microbial and aquatic flora, with competing demands on limited water resources, and the awareness of issues involved in water pollution has led to considerable public debate about the environmental effects of industrial effluents discharged into aquatic environments (Ekhaise *et al.*, 2005). In a study by Fakayode (2005) on the impart assessment of industrial effluent on water quality of the receiving Alaro river in Ibadan, Nigeria, industrial effluents are characterized by abnormal turbidity, conductivity chemical oxygen demand (COD), total suspended solids biological oxygen demand (BOD) and total hardness. It has equally been reported that organic pollution into water bodies is more frequent which is worsen by land-based sources such as occasional discharge of raw sewage through storm water outlets and industrial effluents from refinery oil terminals, petrochemical plants, brewery and food and beverages manufacturing industries (Ajayi *et al.* 1981; Kanu *et al.*, 2006).

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 result of the industrial activities that send untreated effluents from industries in this area. Trans-Amadi is one of the areas zoned for industrial development in and around Port Harcourt, Rivers state. The industrial activities in this area among others include factories of fish filleting Foods and Beverages, plastics, breweries, Soft drinks, 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 that in recent times there has been a tremendous increase in human and industrial activities in these coastal areas, including oil exploration activities. These activities impact negatively on the rivers and creeks, thereby degrading their water quality.

The Trans-Woji River flows through many communities, serving as source of drinking and recreational water for most citizens. However, changes in nutrient concentrations of water due to industrial effluent discharge, may lead to consumers of this river water to be exposed to diverse of health challenges. Also, most heavy metals in streams of water are commonly associated with industrial discharges, which have cumulative toxic effects on aquatic lives. Thus, the physical-chemical parameters of an aquatic body not only reflect the type and diversity of aquatic biota but also the water quality and pollution (Birley and Lock, 1999).

It has been reported that the physicochemical properties of most rivers changes with respect to seasons (Onojake *et al.*, 2017; Xia et al., 2017). Thus, the assessment of the current status of water quality of receiving streams in Trans - Amadi area during the dry and wet seasons was investigated in this study.

MATERIALS AND METHODS

Trans-Amadi industrial Area is located in Obio/Akpor Local Government Area of Rivers State, Nigeria. It is situated at (latitude 4.8128^0 N and Longitude 7.0633^0 E). Trans-Woji stream is the main stream connecting to Mini-Ewa, Rumuobiakani through Woji, Oginigba, Okujagu and Okrika streams and empties 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 industries.

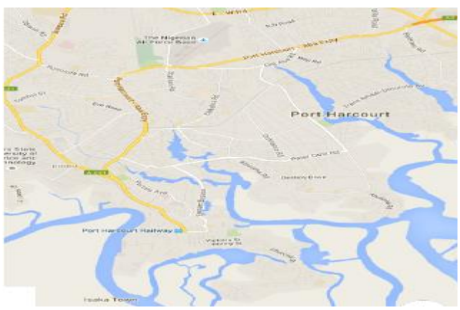

Figure 1: Map of the study area showing the location of sampling sites

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.

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.

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).

pH

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

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.

Turbidity

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

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.

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 20ºC temperature. According to APHA-51210B, BOD was calculated as:

$$BOD = (S_1 - S_2) - (B_1 - B_2) \times \% \text{ dilution} \quad (1)$$

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.

Heavy metals

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

RESULTS AND DISCUSSION

The physiochemical parameters analysis of water samples polluted by industrial effluents from beverage, oil drilling fluids, slaughterhouse and biscuit manufacturing companies are presented in Table 1 and also in Figures 1 to 11.

Table 1: Physicochemical Analysis of Waste from Receiving Water

Parameter	Season	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	WHO	NIS
pH	Dry	6.86	7.24	6.6	8.07	6.34	8.24	6.67	6.0-8.5	6.0-8.5
	Wet	6.35	7.03	6.23	7.74	6.01	7.77	6.24	-	-
Temp. (ºC)	Dry	27	26	22.4	26.7	27.3	24.2	26.7	24.28	NA
	Wet	28.4	25.8	22	26.2	26.8	22.8	26.1	-	-
EC (µs/cm)	Dry	10788	9986	10648	10552	10688	9868	10676	1000	1000
	Wet	8896	7867	7665	8667	7565	7654	7865	-	-
Turbidity (NTU)	Dry	26.3	27.4	29.3	31.6	36.4	30.8	27.8	5	5
	Wet	25.8	27	28.6	30.1	33.4	28.7	26.3	-	-
BOD (mg/l)	Dry	1.8	1.4	5.2	4.3	2.6	3.1	1.6	4	NA
	Wet	1.7	1.2	5	4.8	2.1	2.8	1.5	-	-
COD (mg/l)	Dry	76.7	71.3	78.3	64.8	79.3	66.3	68.3	NA	NA
	Wet	70.6	68.8	76.7	62.8	77.6	62.8	66.7	-	-
DO (mg/l)	Dry	4.9	5.3	6.3	6.2	5.7	5.5	4.6	3-7	3-7
	Wet	4.6	4.8	6	5.8	5.2	5.2	4.3	-	-
TSS (mg/l)	Dry	40.6	42.6	39.6	36.7	31.8	35.3	41.6	NA	NA
	Wet	36.5	38.7	34.8	37.7	38.7	33.6	38.6	-	-
Salinity (mg/l)	Dry	1.6	2.1	1.3	0.9	1	1.3	1.4	NA	NA
	Wet	1.2	1.7	1.1	0.7	0.8	1	1	-	-
Copper (mg/l)	Dry	3.47	3.09	2.56	2.44	3.36	3.41	3.10	1.0	NA
	Wet	3.21	2.97	2.49	2.21	3.15	3.12	2.16	-	-
Iron (mg/l)	Dry	5.98	6.22	5.84	5.51	6.03	5.60	5.94	0.3	NA
	Wet	5.45	6.02	6.27	4.99	5.88	5.11	6.24	-	-
Aluminium (mg/l)	Dry	0.82	0.64	0.55	0.73	0.59	0.52	0.67	0.2	NA
	Wet	0.53	0.54	0.52	0.57	0.58	0.53	0.54	-	-

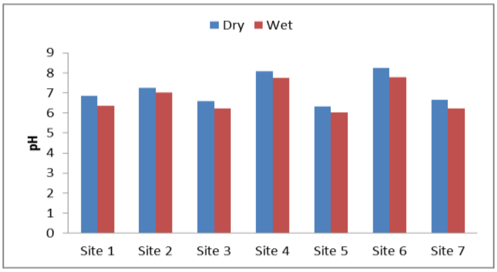

Figure 1: Measured pH of samples

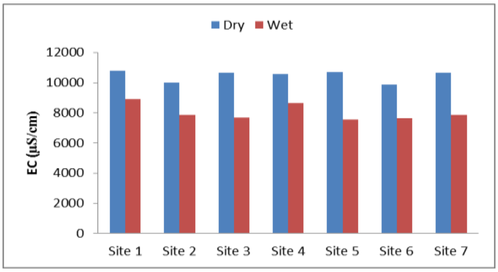

Figure 2: Measured Electrical conductivity of samples

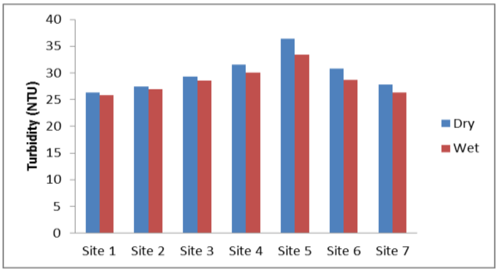

Figure 3: Measured turbidity of samples

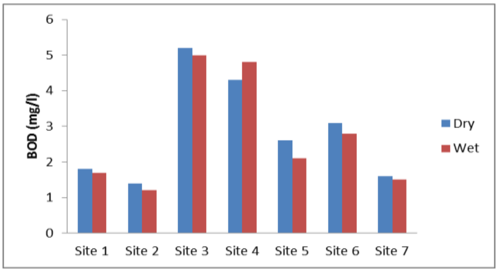

Figure 4: Measured BOD of samples

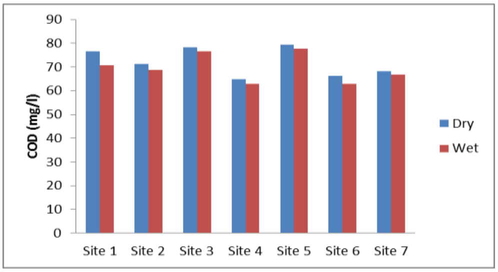

Figure 5: Measured COD of samples

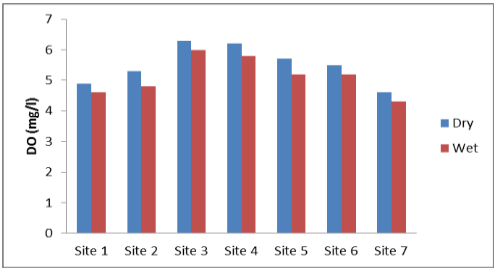

Figure 6: Measured DO of samples

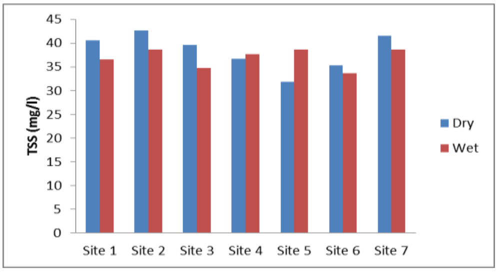

Figure 7: Measured TSS of samples

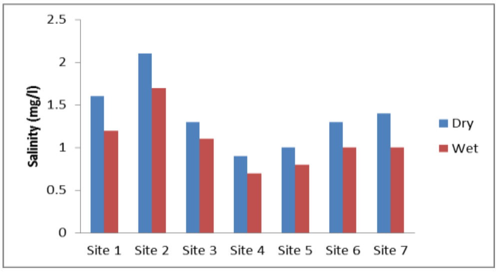

Figure 8: Measured salinity of samples

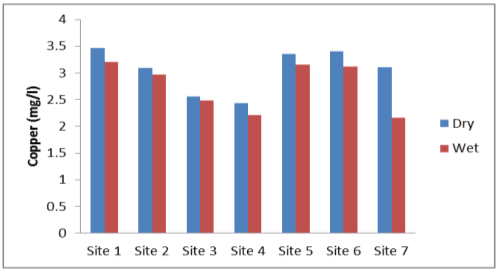

Figure 9: Measured copper ion of samples

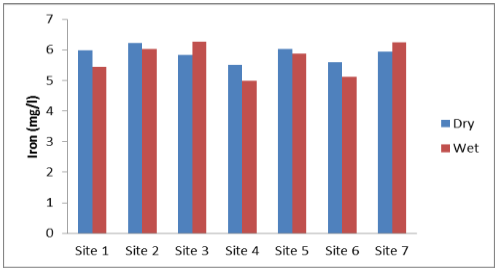

Figure 10: Measured iron ion of samples

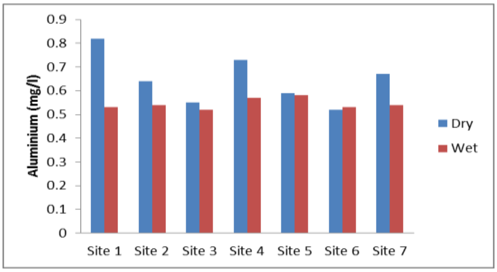

Figure 11: Measured aluminium ion of samples

The range of pH obtained between the dry and wet season varies across the sites. Thus, pH values of the respective effluent streams during the wet season were more acidic than in dry season. This scenario 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 1.

Electrical conductivity is a measure of the amount of salt present in water. High concentration of salts implies high conductivity (Mosley et al., 2004). Figure 2 shows the trends of electrical conductivity (EC) across the sites. The EC value was between 7565μscm^{-1} and 10788μscm^{-1} across all the sites, and exceeded the WHO guidelines of 1000 μscm^{-1} for drinking water. Again, EC of the respective effluent streams were lower during the wet season. The decrease in EC during wet season implied that dissolved solids which increased the stream ions and salts are less compared to dry season.

Turbidity in water is caused by the presence of suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms (Lamb, 1985). Turbidity was above WHO standards of 5 NTU across the seven (7) sampling site as shown in Figure 3. This is also in agreement with a similar investigation by Muwanga and Barifaijo (2006) in Uganda. Turbidity affects 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, but if light levels get too low, photosynthesis may stop altogether and algae will die (Smith and Davies-Colley, 2001). The high value of turbidity recorded may probably be as a result of the presence of organic particulate matter in the effluents.

BOD is a chemical procedure for determining the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period. Figure 4 shows the trend of Biochemical Oxygen Demand (BOD) of samples. The study revealed that site 1 has BOD levels below WHO standards while sites 3 and 4 have BOD levels above the maximum permissible limits. The continued disposal of biodegradable organic waste into the streams will lead to increased consumption of dissolved oxygen thereby affecting aquatic life. BOD recorded during the dry season was above those of wet season. This indicated that there was high release of biodegradable organic pollutants from the effluents in dry season into the river.

COD is a measure of oxygen equivalent during the decomposition of organic matters and the oxidation of inorganic chemicals such as ammonia and nitrite (Morrison et al., 2001). COD measurements are commonly made on samples of waste waters or of natural waters contaminated by domestic or industrial wastes (Gray, 1989). Figure 5 showed the variation of COD in the respective sites.

Again, COD analyses recorded during the dry season were above those of wet seasons across the sites. The COD values in the effluent streams are higher than their BOD counterparts. This was attributed 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). Also, the highest mean value of COD was recorded in site 5, and least in site 4.

Dissolved oxygen gets into the water by diffusion from the atmosphere, aeration of the water as it tumbles over falls and rapids, and as a waste product of photosynthesis. As shown in Figure 6, DO values are higher in dry seasons with site 3 having the highest mean value, and in site 7. Therefore, there was variation in DO along the sampling sites which ranged from 4.45±0.15 to 6.15±0.15 mg/l.

The Total suspended solids (TSS) of the water samples are shown in Figure 7. The TSS varied along the sampling sites and ranged from 34.45±0.85 to 40.65±1.95 mg/l. Thus, site 2 has the highest TSS, while site 6 recorded the least mean value of TSS. However, the dry season samples have more TSS than the wet season.

Salinity is the total of all non-carbonate salts dissolved in water. Salinity is a measure of the total salt concentration, comprised mostly of Na^+ and Cl^- ions. Like in other parameters, salinity varied along the sampling sites and ranged from 0.80±0.10 to 1.90±0.20 mg/l as shown in Figure 8. The highest salinity was recorded in site 2, while site 4 has the least values with dry season values taking the lead.

Similarly, the heavy metal analysis showed that dry season has more concentrations of metallic ions compared to the wet seasons. This is depicted in Figures 9 to 11 for copper, iron and aluminium ions. Therefore, it can be inferred generally, that effect of industrial effluents on streams and rivers in Trans-Amadi Industrial Layout are more significant during the dry season. This is because the flow rates of rivers are relatively lower in dry season as opposed to the wet season where the volume of water was high in the rivers.

CONCLUSION

Overall, the study has shown that effluents from industries have impact on the water quality of receiving streams in Trans-Amadi.

This is depicted by the general increase in concentration of most of the parameters analysed as opposed to the maximum permissible limits set by WHO and NSDWQ 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 the contaminants. This is a situation that should alert the Nigerian Standard for Water Quality to continuously monitor industrial effluents and enforce NSDWQ statue. Thus, while the regulatory bodies are charged to take proactive measures in tackling the ugly practice of industrial waste effluent disposal, this study has shown that streams in Trans-Amdi Industrial Layout are more polluted during the dry season.

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