EFFECTS OF METEOROLOGICAL EVENTS ON THE LEVELS AND INTERACTIONS OF CHEMICAL INDICES OF A POLLUTED FRESHWATER SYSTEM

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ABSTRACT

The quality of fresh water sources as influenced by external and internal factors is a major consideration for water-use programs. Seasonal (rainy and dry) values and variations of pH, Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) and their interactions in Imo River quality were determined under standard analytical methods. Water samples were collected for two seasons - dry and rainy seasons-for two years, at seven major locations of human activities Ekenobizi, Udo, Owerrinta, Alulu, Owaza, Akwette and Obigbo along the River. There were significant variations in seasons (P<0.05) for pH at Ekenobizi, Udo, Owerrinta, Alulu, Owaza and Akwette, while, there were no significant seasonal variations in pH (P>0.05) at Obigbo. There were significant variations in seasons (P<0.05) for BOD at all the locations. There were significant variations in seasons (P<0.05) for COD at Ekenobizi, Udo, Owerrinta, and Alulu; while, there were no significant seasonal variations in COD (P>0.05) at Owaza, Obigbo, and Akwette. There were negative correlations of the pH with the BOD (r = -0.418) and COD (r = -0.347), while there was strong (positive) correlation of BOD with COD (r = 0.899) at R-square = 0.81. Meteorological event (seasonal changes) affected pH, BOD and COD. The negative correlation of the pH and the BOD and COD implied increased dissolved oxygen depletion, heavy metals speciation, bioavailability, and toxicity in Imo River. As the BOD increases, the COD increases and the lower the dissolved oxygen content of Imo River resulting to adverse aquatic health consequences.

Key words: Aquatic health, external and internal factors, interactions, physicochemistry, and pollution

INTRODUCTION

Lakes, rivers, and streams have important multi-usage components, such as sources of drinking water, irrigation, fishery, and energy production (Iscen et al., 2008). Water is a scarce and fading resource, and its management can have an impact on the flow and the biological quality of rivers and streams (Prat and Munne, 2000). In the recent past, expanding human population, industrialization, intensive agricultural practices, and discharges of massive amount of waste water into the stream have resulted in deterioration of the water quality (Nurcihan and Basaran, 2009). The impact of these anthropogenic activities has been so extensive that the water bodies have lost their significant capacity to a large extent (Sood et al., 2008).

The quality of water is typically determined by monitoring microbial presence, especially faecal coliform bacteria (FC) and physicochemical parameters like, pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), nutrients, heavy metals, oil and grease (USEPA, 1999). These parameters
could be affected by external and internal factors. There is an intricate relationship between the external and internal factors in aquatic environments. Meteorological events and pollution are a few of the external factors such as season (rainy and dry) and temperature, which affect physicochemical parameters (intrinsic factors) such as pH, and dissolved oxygen (DO) of the water (Nurcihan and Basaran, 2009). These parameters have major influences on biochemical reactions that occur within the water. Sudden changes of these parameters may be an indication of changing conditions in the water. Internal factors, on the other hand, include events, which occur between and within bacterial and plankton populations in the water body (Bezuidenhout et al., 2002).

This research therefore was aimed at understanding the interactions of some external (seasonal) and internal (pH, BOD and COD) factors that will help to study the impact of pollution on the quality of Imo River.

**Description of Study Area:**

The study area is Imo River and is as shown in Figure 1. Imo River is one of the major rivers in the south-eastern Nigeria. It probably originates from Isiochi in Abia State and cuts across three states including Abia, Imo, and Rivers states. Imo River flows from the eastern-north to the eastern-south, emptying in the Atlantic Ocean. The river serves as a source of water for domestic uses, fishery, recreational activities, and agricultural irrigation programs for more than 5 million people settled close to the water body. Apart from the afore listed uses, the river serves as a source of sand for sand excavators, recipient of industrial effluent discharges, dumping site for domestic wastes including sewage and industrial solid waste, and other rivers like Aba River, emptying into Imo River. Some major portions of the river include; Ekenobizi, Udo, Owerrinta, Alulu, Owaza, Akwette, and Obigbo.

**MATERIALS AND METHODS**

**Sample collection:**

Surface water samples were collected from 7 major human impacted points of Imo River. Samples were collected in triplicates with the aid of 1 liter water sampling cans. Collected samples were immediately transported to the laboratory. The samples were collected at the peak of two seasons – dry and rainy seasons for two years. The dry season was between November and March while the rainy season was between May and September.

**Chemical analysis:**

The pH, Biochemical Oxygen Demand (BOD$_5$) (mg/L) and Chemical Oxygen Demand (COD) (mg/L) concentrations of the water samples were determined as described in the *Standard Methods for the Examination of Water and Wastewater* (APHA/AWWA/WPCF, 1985).

**RESULTS AND DISCUSSION**

**Results:**

There were significant variations in seasons (P<0.05), as shown in Table 1, for pH at Ekenobizi (6.35±0.00 - 6.16±0.00), Udo (6.36±1.01 - 6.02±0.01), Owerrinta (5.94±0.02 - 5.66±0.01), Alulu (5.80±0.10 - 5.18±0.01), Owaza (6.16±0.01 - 5.80±0.10) and Akwette (5.92±0.01 - 5.83±0.01), while, there were no significant variations in seasons (P>0.05) at Obigbo (5.65±0.07 - 5.49±0.28). There were significant variations in seasons (P<0.05) for
Figure 1. Location map of Imo River showing the sampling points
BOD₅ at all the locations; Ekenobizi (0.65±0.01 - 0.54±0.01), Udo (0.97±0.01 - 0.31±0.01), Owerrinta (4.02±0.01 - 0.35±0.01), Alulu (2.88±0.01 - 2.42±0.01), Owaza (1.83±0.01 - 0.02±0.01), Obigbo (4.81±0.01 - 2.47±0.01) and Akwette (2.01±0.01 - 1.13±0.01). There were significant variations in seasons (P<0.05) for COD at Ekenobizi (1.24±0.01 - 1.01±0.01), Udo (2.30±0.10 - 0.71±0.01), Owerrinta (6.12±0.01 - 1.28±0.01), and Alulu (4.71±0.01 - 3.05±0.01) while, there were no significant variations in seasons (P>0.05) at Owaza (3.00±1.00 - 2.11±0.01), Obigbo (5.02±0.01 - 3.41±0.01), and Akwette (3.21±1.72 - 2.62±0.01).

As presented in Table 2, the pH correlated negatively with the BOD (r = -0.418) and negatively with the COD (r = -0.347) while there was strong (positive) correlation of BOD and COD (r = 0.899). The relationship between BOD and COD is shown in Figure 2 and equation (1):

\[ \text{BOD mg/L} = -0.22 + 0.74 \times \text{COD} \]  
At R-square = 0.81

### Discussion:

The pH at some locations was acidic. This might have been influenced by the influx of carbonate-bicarbonate and carbon (IV) oxide equilibrium (Hacioglu and Dulger, 2009). Apart from pollution, climate change or meteorological events (seasonal changes) can affect pH of aquatic systems. This was supported by the report of Bezuidenhout et al. (2002); similar observations have been made by Odokuma and Okpokwasili (1993). Slightly alkaline pH is preferable in waters, as heavy metals are removed as carbonate or bicarbonate precipitates. Heavy metals are not as toxic to aquatic life at alkaline pH as they would be at acidic pH. At alkaline pH, they are present mostly in the unavailable form. This corroborates the reports of Hacioglu and Dugler (2009). Water pH affects metal toxicity in two ways, firstly the speciation and bioavailability of metals may change, and secondly, the uptake and toxicity of metals can be affected by changes in the sensitivity of the cell surfaces as well as heavy metals. This is in consonance with the works of Campbell and Stokes (1985). The study revealed that the pH range favoured increased heavy metals speciation, bioavailability, and toxicity in Imo River. This is supported by the works of Hacioglu and Dugler (2009).

### Table 1. Seasonal variations in pH, BOD, and COD

<table>
<thead>
<tr>
<th>Locations</th>
<th>Season</th>
<th>pH</th>
<th>BOD₅</th>
<th>COD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ekenobizi</td>
<td>Dry</td>
<td>6.35±0.00A</td>
<td>0.54±0.01A</td>
<td>1.24±0.01A</td>
</tr>
<tr>
<td></td>
<td>Rainy</td>
<td>6.16±0.01A</td>
<td>0.65±0.01A</td>
<td>1.01±0.01A</td>
</tr>
<tr>
<td>Udo</td>
<td>Dry</td>
<td>6.02±0.01A</td>
<td>0.31±0.01A</td>
<td>0.71±0.01A</td>
</tr>
<tr>
<td></td>
<td>Rainy</td>
<td>6.36±1.01A</td>
<td>0.97±0.01A</td>
<td>2.30±0.10A</td>
</tr>
<tr>
<td>Owerrinta</td>
<td>Dry</td>
<td>5.66±0.01A</td>
<td>0.35±0.01A</td>
<td>1.28±0.01A</td>
</tr>
<tr>
<td></td>
<td>Rainy</td>
<td>5.94±0.02A</td>
<td>4.02±0.01A</td>
<td>6.12±0.01A</td>
</tr>
<tr>
<td>Alulu</td>
<td>Dry</td>
<td>5.18±0.01A</td>
<td>2.42±0.01A</td>
<td>3.05±0.01A</td>
</tr>
<tr>
<td></td>
<td>Rainy</td>
<td>5.80±0.10A</td>
<td>2.88±0.01A</td>
<td>4.71±0.01A</td>
</tr>
<tr>
<td>Owaza</td>
<td>Dry</td>
<td>6.16±0.01A</td>
<td>1.83±0.01A</td>
<td>2.11±0.01B</td>
</tr>
<tr>
<td></td>
<td>Rainy</td>
<td>5.80±0.10A</td>
<td>0.02±0.01A</td>
<td>3.00±1.00B</td>
</tr>
<tr>
<td>Obigbo</td>
<td>Dry</td>
<td>5.49±0.28B</td>
<td>2.47±0.01A</td>
<td>3.41±0.01B</td>
</tr>
<tr>
<td></td>
<td>Rainy</td>
<td>5.65±0.07B</td>
<td>4.81±0.01A</td>
<td>5.02±0.01B</td>
</tr>
<tr>
<td>Akwette</td>
<td>Dry</td>
<td>5.83±0.01A</td>
<td>1.13±0.01A</td>
<td>2.62±0.01B</td>
</tr>
<tr>
<td></td>
<td>Rainy</td>
<td>5.92±0.01A</td>
<td>2.01±0.01A</td>
<td>3.21±1.72B</td>
</tr>
</tbody>
</table>

- At P < 0.05, values with A - letter are significantly different from each other
- At P > 0.05, values with B - letter are not significantly different from each other
Table 2. Correlation between pH, BOD, and COD

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>BOD₅</th>
<th>COD</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>1</td>
<td>-0.418**</td>
<td>-0.347*</td>
</tr>
<tr>
<td>BOD₅</td>
<td>-0.418**</td>
<td>1</td>
<td>0.899**</td>
</tr>
<tr>
<td>COD</td>
<td>-0.347*</td>
<td>0.899**</td>
<td>1</td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level
**Correlation is significant at the 0.01 level

BOD - Biochemical Oxygen Demand
COD - Chemical Oxygen Demand

There was significant variation in BOD values at different locations and seasons. BOD values were higher in the rainy season (0.65 - 4.81mg/l) than in the dry season (0.31-2.4mg/l). The result corroborated the reports of Nurcihan and Basaran (2009), and Odokuma and Ijeomah (2002). This result may be due to the increase in nutrient load of the river during the rainy season. BOD₅ is the most important parameter used to monitor the quality of water regarding organic matter present in both suspended and dissolved form. High BOD levels in aquatic systems have been known to support high heterotrophic microbial populations (Odokuma and Okpokwasili, 1993). The BOD was below FEPA limit (50mg/l), (FEPA, 1991). This implied that the river was not heavily polluted by organic waste.

Chemical Oxygen Demand (COD) varied significantly at different locations and seasons. This result is similar to the report of Odokuma and Okpokwasili (1993). In dry season COD ranged from 0.71- 3.41mg/l and from 1.01 – 6.12mg/l in the rainy season. This difference may be attributed to the additional organic matter introduced into the river as a consequence of surface run-off and soil erosion caused by increased rainy season. Apart from these causes, oil spillage and effluent discharges can increase the COD load of fresh water systems (Sial et al., 2006). High COD level is responsible for depletion of oxygen levels in rivers.

The negative correlation of the pH and the BOD implied that at the low observed pH (acidity) at some locations, there were increased oxidation of organic waste introduced into the river from run-offs from agricultural lands, effluent discharges, and waste dump sites and possible resultant depletion of the dissolved oxygen level of the river. This corroborates the works of Ohimain et al. (2008). The same trend in the relationship between pH and the BOD levels of the river might also be observed with the COD levels of the river. At lower pH values the amount of oxygen needed to oxidize chemical components might have increased due to possible dissolution, dissociation, and ionization of chemical compounds at the observed range of pH values. This is supported by the works of Hacioglu and Dugler (2009). This increased COD values at lowered pH might have reduced the dissolved oxygen level of Imo River. Chemical oxygen demand (COD) does
not differentiate between biologically available and inert organic matter, and it is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values are always greater than BOD values (NGRDC, 1999). This relationship is as expressed with the equation. Therefore as the BOD levels of Imo River increased, the COD values increased.

CONCLUSION

This research confirmed the impact of seasonal variations on the pH, BOD and COD values of Imo River. The values of the BOD and COD increased more in the rainy season than in the dry season due to increased run-offs of contaminants from agricultural lands and discharges from domestic and industrial activities. The increase in BOD levels influenced the increase in the COD levels and these affected the Imo River quality its consideration for suitability for water-use programs.

REFERENCES


