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Seasonal influences on levels and eutrophication potential of nutrients in Imo River, Nigeria

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Abstract

Water eutrophication is one of the most challenging environmental problems in fresh water systems. Effects of seasonal changes on levels of nutrients in Imo River and possible environmental consequences have been determined. Water samples were collected seasonally at major points and subjected to standard chemical analysis. The result showed significant variations in seasons ($P < 0.05$) for nitrate (mg/L) at all the locations; Ekenobizi, Udo, Owerrinta, Alulu, Owaza, Obigbo, and Akwette. There were significant variations in seasons ($P < 0.05$) for phosphate (mg/L) at Owerrinta, Owaza, Obigbo, and Akwette. While, there were no significant variations in seasons ($P > 0.05$) for phosphate at Ekenobizi, Udo, and Alulu. The nutrient levels increased higher in the rainy than dry season and might lead to eutrophication if not controlled.

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Introduction

According to Akoma (2008), the chemical composition, activity, and distribution of nutrients in freshwater systems represent the combining effects of contributory sources. This is consequent upon fluctuations associated with seasonal changes (John, 1986).Nutrient enrichment is a major threat to fresh water ecology, leading to severe pollution problems (Nhapi and Tinivarombo, 2004). The disposal of untreated wastewater into rivers is quite common in developing countries. This involved the discharge of nitrogen and phosphorus; the major nutrients that control biomass growth and these are available in abundance in municipal waste water. Eutrophication-related problems have been reported by Moyo (1997).

Nutrient enrichment through pollution of aquatic systems is one of the most challenging environmental problems in the world. The increasing severity of water eutrophication has been brought to the attention of both the governments and the public in recent years (Xia-e *et al*., 2008). The mechanism of water eutrophication are not fully understood, but excessive nutrients loading into surface water system is considered to be one of the major factors (Fang *et al*., 2004; Tong *et al*., 2003). The nutrient level of many lakes and rivers has increased dramatically over the past 50years in response to increased discharge of domestic wastes and non-point pollution from agricultural practices and urban development (Mainstone and Parr, 2002). For more than 30 years, nutrient enrichment, especially phosphorus (P) and nitrogen (N), has been considered as a major threat to the health of coastal marine water (Andersen *et al*., 2004). Once a water body is eutrophicated, it will lose its primary functions and subsequently influence sustainable development of economy and society (Xiao-e *et al*., 2008).

Therefore, this research was targeted at determining the nutrient levels at major points of human activities on Imo River and ascertaining seasonal fluctuations in levels and possible environmental consequences.

Materials and methods

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 source of water for domestic uses, fishery, recreational activities, and agricultural irrigation programs for more than 5 million people settling close to the water body. Apart from the afore listed uses, the river serves as 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 in Imo River. Some major human impacted points of the river include Ekenobizi, Udo, Owerrinta, Alulu, Owaza, Akwette, and Obigbo.

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 in 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

Determination of nitrate: The cadmium reduction method using the direct reading engineering HACH kit (HACH Water Analysis Handbook, 1981) with Nitra var 5 nitrate reagent was adopted for this test. For the blank, 25ml of nitrate free/distilled water sample put into a clean sample cell was used. Into another clean sample cell was dispensed 25ml of the test sample. One Nitra var 5 reagent pillow was added to each of these two sample cells of the spectrophotometer (DERL/5 HACH). The cells was stoppered and shaken vigorously for a minute. Another colour formation in the test sample cell before or when allowed to fully get developed within 5 minutes indicated the presence of nitrate.

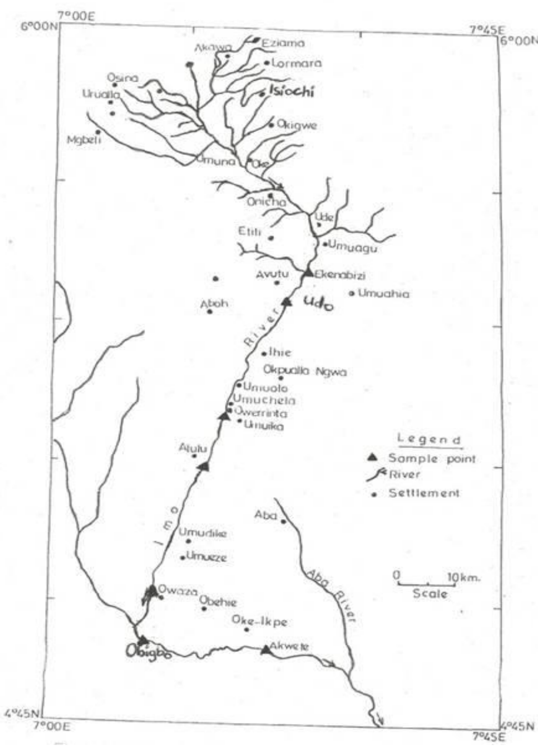

Fig. 1. Location map of Imo River showing the sampling points.

Using the spectrophotometer or the Nitra var 5 methods, the nitrogen-nitrate, nitrate meter scale was first inserted into the instruments meter and the wavelength adjusted to 500nm. The blank containing nitrate free water was used as reagent blank to zero the spectrophotometer. This was followed by inserting the test sample cell into the instrument and the concentration of nitrate – nitrogen (N) value obtained was multiplied by 4.4 to determine the concentration of nitrate expressed in mg/L.

Determination of phosphate: The spectrophotometric method using Phosphor var 5 phosphate reagent and HACH water analytic kit as described in HACH Water Analysis Handbook (1981) was adopted. A sample cell was filled to 25 ml with a distilled water sample without detectable phosphate content. One Phosphor var 5 phosphate reagent powder pillows was added to the blank and swirled to mix. This served as a reagent blank to zero the spectrophotometer. Another clean sample call was filled with 25ml of the test waste sample and one pillow of the Phosphor var 5 phosphate reagent powders was added and swirled thoroughly to mix. A white turbidity was formed indicating the presence of phosphate. The spectrophotometer (DREL/5 HACH) was then adjusted to zero reading using the blank. The reading of the spectrophotometer with the test sample gave the concentration of phosphate.

Results

Table 1 shows the result of analysis of nitrate (NO_3^-) (mg/L) variations at the different locations and seasons. There were significant variations in seasons ($P < 0.05$) at all the locations; Ekenobizi (3.30±0.10 - 2.00±0.00), Udo (3.40±0.10 - 1.70±0.10), Owerrinta (2.70±0.10 - 1.40±0.10), Alulu (4.20±0.10 - 1.80±0.10), Owaza (3.90±0.10 - 1.70±0.10), Obigbo (3.50±0.10 - 1.60±0.10), and Akwette (4.30±0.10 - 1.80±0.10). The value of nitrate increased more during the rainy season than during the dry season. It was highest during the rainy season at Akwette and lowest at Owerrinta, while during the dry season the value of nitrate was highest at Ekenobizi and lowest at Owerrinta.

Table 1. Result of analysis of NO_3^- variations at different locations and for different seasons.

Location	Season	Mean Deviation
Ekenobizi	Dry	2.00±0.00a
	Rainy	3.30±0.10a
Udo	Dry	1.70±0.10a
	Rainy	3.40±0.10a
Owerrinta	Dry	1.40±0.10a
	Rainy	2.70±0.10a
Alulu	Dry	1.80±0.10a
	Rainy	4.20±0.10a
Owaza	Dry	1.70±0.10a
	Rainy	3.90±0.10a
Obigbo	Dry	1.60±0.10a
	Rainy	3.50±0.10a
Akwette	Dry	1.80±0.10a
	Rainy	4.30±0.10a

At P < 0.05, *a - letter is significantly different from each other.

Table 2. Result of analysis of Phosphate (PO_4^{2-}) variations at different locations and for different seasons.

Location	Season	Mean Deviation
Ekenobizi	Dry	0.16±0.01b
	Rainy	0.13±0.06b
Udo	Dry	0.13±0.06b
	Rainy	0.09±0.01b
Owerrinta	Dry	0.05±0.01a
	Rainy	0.08±0.01a
Alulu	Dry	0.43±0.01b
	Rainy	0.60±0.44b
Owaza	Dry	0.27±0.01a
	Rainy	0.12±0.01a
Obigbo	Dry	0.04±0.01a
	Rainy	0.08±0.01a
Akwette	Dry	0.43±0.01a
	Rainy	0.11±0.01a

At P < 0.05, *a - letter is significantly different from each other.

At P > 0.05, *b - letter is not significantly different from each other.

Table 2 shows the result of analysis of Phosphate (PO_4^{2-}) variations at the different locations and seasons. There were significant variations in seasons ($P < 0.05$) at Owerrinta (0.08±0.01 - 0.05±0.01), Owaza (0.27±0.01 - 0.12±0.01), Obigbo (0.08±0.01 - 0.04±0.01), and Akwette (0.43±0.01 - 0.11±0.01). Phosphate values increased during the rainy season than during the dry season at those points. Highest value was recorded at Akwette while lowest value was at Owerrinta. There were no significant variations in seasons ($P > 0.05$) at Ekenobizi (0.16±0.01 - 0.13±0.06), Udo (0.13±0.06 - 0.09±0.01), and Alulu (0.60±0.44 - 0.43±0.01). This result showed that the values were approximately similar during the two seasons.

Discussion

The result of nitrate determination at different locations and seasons is as shown in table 1. Nitrate (N) values varied significantly during the seasons. It ranged from 1.40-2.00mg/l in dry season and 2.70-4.30mg/l in rainy season. The values in the rainy season were higher than those of the dry season. This conforms to the work of John (1986). Excessive nutrients come from both point-pollution such as waste water from industries and municipal sewage, and non-point pollution like irrigation water and surface runoff water containing fertilizer from farm land. This is in accordance with the reports of Khan and Ansari (2005), Moyo and Worster, (1997), Thornton and Nduku, (1981), and McKendrick (1982). Increased nutrient load to water body is now recognized as a major threat to the surface and functions of near shore coastal systems, and severe eutrophication problems associated with harmful algal bloom is a major manifestation (Xiao-e *et al.,* 2008).

The nitrate levels in Imo River are below FEPA specification (FEPA, 1990), and the river might not be prone to eutrophication. The result of the determination of phosphate (P) levels varied in different locations and seasons as shown in Table 2. Phosphate levels varied significantly at some locations and seasons. This result is in accordance with the report of Xiao –e *et al.* (2008). Phosphate ranged from 0.04-0.43mg/l during dry season and 0.08-0.60mg/l during the rainy season. This is similar to the report of Akoma (2008). Phosphate levels did not exceed FEPA limits (5mg/l) (FEPA, 1990). This implies that the Imo River is not heavily polluted with nutrients and might not be exposed to eutrophication process.

There are different opinions on the relationship of nutrient enrichment to Imo River eutrophication and algal bloom: (1) when phosphate concentration in Imo River is low, it may be the limiting factor for inducing water eutrophication and algal bloom; (2) when phosphate concentration in water increases rapidly, others may become a new limiting factor, such as pH, with depth, temperature, light, wave, wind or other biological factors; (3) the influence of nitrate and phosphate might still lasts for a longer time because of continuous industrial discharge. This is in accordance with the report of Zhao, (2004).

The ratio of N: P in water body (referred to as the Redfield ratio) is an important indicator of which nutrient is limiting eutrophication in Imo River. If the Redfield ratio is 16:1, P is most likely the limiting factor for eutrophication; lower ratio indicates that N is of great importance. This corroborates the works of Redfield *et al.* (1963), and Hodgkiss and Lu, (2004). Phosphorus has been shown to be the principal limiting nutrient for primary production of biomass in many fresh water environment (Philips, 2002), while N is commonly limiting in marine ecosystems (Cloem, 2001). However, there are many exceptions to this general pattern. In some fresh water environments, particularly in the tropics and subtropics, N has been found to be the primary limiting nutrient for biomass production, due in large part to excessive P load and long growing seasons (Xiao-e *et al.*, 2008).

Conclusion

This work confirmed nutrient discharges into Imo River and exposes the potential of the River to consequences of eutrophication. Presently the concentration of nutrients discharged into the water body might not be alarming but foretells the future condition of the River with increasing industrialization and dumping of refuse into the River if not seriously checked by relevant agencies.

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