Avens Publishing Group J Environ Stud January 2019 Vol.:5, Issue:1 All right reserved Ugochukwu et al.

Eutrophication Potential of Nutrients in Oji River of Enugu, Nigeria

Keywords: Nutrients; River; Eutrophication; Diatoms; Phytoplankton

Abstract

In this study, the potential of nutrients input into Oji river (arising from anthropogenic activities) to cause eutrophication was investigated. Hence, the concentrations of nitrogen, silicon and phosphorus in the water column of Oji river were determined in addition to determining the pH, electrical conductivity, total dissolved solids, total organic carbon, dissolved oxygen, biochemical oxygen demand and chemical oxygen demand following standard procedure as prescribed by APHA (1998). Obtained results indicate that the increase in concentration of nutrients such as phosphorus and nitrogen in the rainy season is associated with a corresponding increase in concentration of silicon to the extent that growth and development of diatoms is likely to be favored in preference to that of non-diatom phytoplankton species such as dinoflagellates. Consequently, there is no significant risk of eutrophication at the present level of nutrients and silicon in Oji river. The anthropogenic activities around the study area such as Abattoir and Power Station appear not to affect the nutrient input into Oji River significantly.

Introduction

Response to pollution by biological communities in fresh water is highly recognized for a very long time now [1,2]. Most research efforts have been on the input of inorganic and organic pollutants from point and non-point sources into water systems that impair the water quality of such systems. In the recent times, the role played by point and diffuse sources in nutrient enrichment of aquatic ecosystems is highly recognized. The input of nutrients into aquatic ecosystems is known to be responsible for an environmental phenomenon and process known as eutrophication. Eutrophication has been defined as the enrichment of water by nutrients, especially compounds of nitrogen and phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned (OSPAR: https://www.ospar.org/work-areas/ hasec/eutrophication) [3]. In the very past, eutrophication studies concentrated on lentic and transitional waters such as lakes and estuaries respectively. However, since about fifty years ago, research efforts are also directed to nutrient enrichment of lotic systems [4]. The effect of nutrient enrichment of lotic systems such as rivers is more complicated than that of lentic systems due to their dynamic nature. Overall, same symptoms of excessive phytoplankton growth and changes in the structure of macrophytes remain typical effects of eutrophication with adverse impact on water supply, fisheries and conservation of the original ecosystem. Most eutrophication effects that are significant arise from enrichment of lotic systems by Phosphorus or a combination of Nitrogen and Phosphorus. The enrichment of nitrogen appears to be derived from dissolved nutrients in the water column whereas phosphorus enrichment is

Open Access

Journal of Environmental Studies

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Research Article

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Submission: 27 December, 2018 Accepted: 29 January, 2019 Published: 31 January, 2019

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associated with both water column nutrients and nutrients bound to sediments. The implication of this for eutrophication effects that are nitrogen-enrichment driven is that it is practicable to reduce nitrogen enrichment within a relatively short period of time by simply controlling activities that lead to input into lotic ecosystems. This is very much unlike the case where eutrophication effects are due to phosphorus-enrichment as reduction of phosphorus enrichment would require longer period of time.

Remedial actions that rely on in-situ solutions cannot be as good as management options that concentrate on reducing or eliminating inputs to the river system. It is therefore expected that point source pollutants would be easier managed and controlled than non-point sources from agriculture, industry etc. By and large, it is extremely important to establish whether it is point source or non-point source or both sources that is/are responsible for nutrient input.

Several studies have reported the status-quo of many rivers in the world with respect to their nutrient chemistry especially from countries such as the USA, Spain, India, China etc. [5-8].



Figure 1: Korean targeted PV generation price by 2035 planned in the Fourth Basic Plan for New and Renewable Energy.

Citation: Ugochukwu UC, Onuorah AL, Onuora OH. Eutrophication Potential of Nutrients in Oji River of Enugu, Nigeria. J Environ Stud. 2019;5(1): 4.

ISSN: 2471-4879

D .	Values of Parameters (October, 2017)												
Section	EC (µs/cm)	TDS (mg/L)	рН	NH ₄ -N (mg/L)	NO ₃ -N (mg/L)	NO ₂ -N (mg/L)	PO₄-P (mg/L)	SiO ₂ -Si (mg/L)	TOC (%)	DO (mg/L)	BOD	COD	
											(mg/L)	(mg/L)	
А	7.4	4.1	7	0.18	0.4	0.005	0.17	3.7	0.002	4.7	0.9	2.2	
В	9	4.75	6	0.19	0.4	0.006	0.12	2.9	0.0015	4.6	1.1	2.3	
С	14.8	7.8	7	0.14	0.3	0.004	0.05	3.4	0.0025	4.9	0.8	2.1	
D	18.1	10.8	6	0.18	0.4	0.006	0.08	3.1	0.03	3.2	1.6	3.8	
Values of Parameters (January, 2018)													
A	13.5	7.2	6	0.1	0.25	0.0015	0.1	2.05	0.001	4.8	0.7	1.9	
В	15.3	7.8	6	0.14	0.35	0.0025	0.065	1.06	0.001	4.7	0.9	2.1	
С	12.8	7	6	0.08	0.2	0.001	0.02	2.05	0.001	4.9	0.5	1.5	
D	12.9	7	6	0.14	0.35	0.0025	0.025	1.5	0.0015	4.1	1.1	2.3	

Table 1: Values of measured parameters (October, 2017 and January, 2018).

However, most aquatic ecosystems in Nigeria like in most African countries are poorly characterized with respect to nutrient chemistry and the attendant implication on eutrophication. Oji river in Oji River Local Government Area is an important lotic system that receives discharges from several anthropogenic point-source pollution sources such as Abattoir and Oji River Power plant activities among others and also non-point sources such as agricultural run-off. Till date, the authors are not aware of any study that provides information on the nutrient chemistry of Oji river. This study is therefore aimed at revealing whether or not the nutrient input to Oji river is such that eutrophication is a concern.

Materials and Methods

Study area

Oji river is a surface water in the category of rivers and traverses mainly Oji from where the local government area (LGA) coins its name as Oji River LGA. The Oji River LGA covers a total land area of 400 $\rm Km^2$ with a population of 126,587 as at the 2006 population census and is located geographically between latitude 6º 14' N and 6º 20' N and between longitude 7º 17' E and 7º 21' E. The entire area is a tropical rain forest with temperature that ranges between 27 and 32 °C. The geology of the area comprises 330 m thick Ajali formation that is underlain by 400 m thick Mamu- and 200 m thick Nkporo formations. These Ajali, Mamu and Nkporo formations are characterized by sandstone, sandy shale and mudstone respectively [9]. Rainy season which occurs between April and October and dry season which occurs between November and March are the two seasons in the study area. Rainfall at its peak can be quite heavy with several incidents of flooding evidenced by gullies in the area [10]. Oji river receives waste discharges from several anthropogenic activities such as abattoir, power plants, agricultural run-off etc. The agricultural run-off is a non-point source of pollution but the Abattoir and Power Plant wastewaters are point sources.

The study area and sampling locations are as presented in (Figure 1)

Sampling

Samples were collected at locations A, B, C and D. Location A is about 250 m upstream location B where an Abattoir is located. Locations C and D are 250 m and 500 m downstream the Abattoir respectively. Sample location D is actually around the Thermal Power Station.

Water samples were collected at the river-water column into a 1 L HNO₃ pre-washed polyethylene containers. Samples were held in a box filled with ice cubes so as to maintain the temperature below 4 $^{\circ}$ C while being transported to the laboratory for analysis.

Laboratory analysis

Electrical conductivity (EC), pH, total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved nitrate (NO_3 -N), nitrite (NO_2 -N), ammonium NH4-N, phosphate (PO_4 -P) and silica (SiO_2 -Si) were analyzed following APHA 1998 standard procedure. The total organic carbon (TOC) was analyzed by means of a TOC analyzer [11].

Statistical analysis

All statistical analysis was carried out using Minitab Version 18. Analysis of Variance (ANOVA) was used in comparing means of the values of the parameters in different locations of the river from where samples were drawn.

Results and Discussion

Values of physico-chemical parameters

The values of the measured parameters are as presented in (Table 1)

During the month of October (rainy season), the electrical conductivity (EC) varied from 7.4 - 18.1 μ S/cm and increases as we move from the up-stream section of the river to the down-stream (Table 1) indicating that the point-source anthropogenic activities of the Abattoir and Power Station lead to the input of chemical substances into the river that dissociate to form ions capable of conducting electricity. This is confirmed by the increasing trend observed for the Total Dissolved Solids (TDS) which increases from 4.1-10.8 mg/L. The TDS and EC values for locations A and B are lower and significantly different from those in locations C and D during the rainy season (*P-values < 0.05*). However, during the dry season, the EC values varied from 12.8-15.3 $\mu\text{S/cm}$ with TDS values varying from 7 -7.8 mg/L without following any particular trend. The TDS and EC values for location A are not significantly different (*P-values* > 0.05) from those of locations B, C and D implying that the anthropogenic activities affect the EC and TDS of the water mainly during the rainy season. These values are lower when compared with the values reported for other sections of Oji river and some streams in Enugu State [12].

ISSN: 2471-4879

Values for the rainy season (October, 2017)									
River Section	N/P ratio	Si/N ratio							
A	9.2	3.6							
В	12.8	2.87							
С	22.6	4.75							
D	18.4	3.3							
Values for the dry season (January, 2018)									
А	8.7	3.5							
В	7.1	1.5							
С	40	4.25							
D	48	2.1							

Table 2: Oji river N/P and Si/N ratios for the river sections A, B, C and D.

The pH of the river varies from 6.1-6.8 in the rainy season but 5.9-6.4 in the dry season indicating slightly more acidic in the dry season than the rainy season (Table 1). The dilution effect of more discharge into the river during the rainy season may have accounted for why in the rainy season, the river is of lower acidity than in the dry season. Similar pH values have been reported for same Oji river in a study conducted in another section of the river a few years ago [12].

The nitrate ion is the predominant form of Nitrogen among the other forms in both dry and rainy seasons indicating the prevalence of agricultural run-off, atmospheric precipitation, waste discharge and in-stream transformation of ammonium ion by bacteria as most probable sources of nitrogen input into the river [8]. Domestic sewage and/or faecal matter does not contribute significantly to the nitrogen input into the Oji river as NH₄-N + NO₂-N/NO₃-N ratio is < 1.0. There is no significant difference in concentration values of nitrate along the studied locations (*P*-values > 0.05) in both seasons but values are generally higher in the rainy season than dry season. The nitrate values in a study conducted in Ozom stream of Enugu state and another part of Oji river by falls between 0.2 and 0.9 mg/L which are close to those reported in this study [12]. Generally, the physico-chemistry values reported in this study are quite lower than those reported for Nyaba and Ekulu river in 2016 [13,14].

There is a significant increase in the concentration of phosphate as we move from dry to rainy season most probably due to input of phosphate into the river from agricultural run-off and waste discharge. The concentration of phosphate at location A is higher and significantly different from that of locations C and D for both rainy and dry season (*P-values* < 0.05).

The concentration values of silica do not differ significantly along the studied locations (*P-values* > 0.05) in both seasons but values are generally higher in the rainy season than dry season The concentration values of silica in the studied sections of Oji river are lower than those of other studies on other rivers in Enugu State such as Ajali river, Iyoyo river, Ekulu river, Nyaba river and Adada river [13]. The concentration of silica (SiO₂-N) increased significantly as we move from dry season (1.06-2.05 mg/L) to rainy season (2.9-3.7 mg/L) due to increased weathering of rocks and transportation of the produced silica that take place during the rainy season. This increase is proportionate to the increase in nutrients input during

the rainy season and therefore silica may not limit the production of diatoms as nutrients input increases. It is therefore not expected that additional input of nutrients during the rainy season would lead to any significant growth of multi-cellular algae and higher plants.

TOC is significantly higher in location D than any other location in the rainy season probably due to coal residue in the premises and adjoining environment of the Thermal Plant

The DO is marginally lower in the rainy season with a corresponding marginally higher BOD and COD in the dry season.

Analysis of oji river nutrient ratios

Table 2 Oji river N/P and Si/N ratios for the river sections A, B, C and D

Values for the rainy season (October, 2017)

N/P ratio for locations A, B, C, and D: The occurrence ratio of nitrogen to phosphorus in aquatic ecosystem is important for understanding or predicting whether the growth and development of phytoplankton's can be sustained [15]. This ratio as given by is N/P =16:1 meaning that N/P ratio significantly different from 16:1 will indicate that one of the elements is in limited supply and therefore will be the element limiting the growth and development of the phytoplankton's [15]. During the rainy season, growth and development of the phytoplanktons in location A of the river is likely to be limited by nitrogen. The ratios at locations B, C and D are not significantly different from value of 16 [15]. During the dry season, locations A and B with N/P ratios 8.7 and 7.1 respectively which are significantly different from 16 will have nitrogen limiting the growth and development of the phytoplankton. At locations C and D with N/P ratio of 40 and 48, growth and development of the phytoplankton will be limited by phosphorus.

Si/N ratio for locations A, B, C, and D: Just as the occurrence ratio of nitrogen to phosphorus in aquatic ecosystem is useful in understanding or predicting the growth and development of phytoplankton generally, the occurrence molar ratio of Si/N is used in predicting the growth of diatoms *vis-a-vis* other problematic nondiatom phytoplankton species such as din flagellates. Turner et al. found that Si/N molar ratio of 1 and above will favor the growth and development of diatoms whereas Si/N molar ratio of less than one will favor non-diatoms such as din flagellates that can result to algal bloom [16]. The Si/N ratio for all the locations in this study is above one indicating that there is low chance of algal bloom due to eutrophication.

Conclusion

The input of nutrients into Oji river is most likely to be from agricultural run-off, atmospheric precipitation, waste discharge and in-stream transformation of ammonium ion by bacteria. Domestic sewage or faecal matter does not contribute significantly to the nitrogen input into the Oji river. The concentration of the nutrients is higher in the rainy season than the dry season confirming the significant contribution of agricultural run-off. The activities of the Abattoir and Power station do not affect the input of nutrients into the river significantly. There is no likelihood of the problem of eutrophication considering the current levels of nutrients in Oji river.

ISSN: 2471-4879

However, anthropogenic activities likely to elevate concentration of nitrogen above threshold levels should be discouraged.

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