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Research Article

Phosphate Impact on Eutrophication Hazards of Niger - River Ecosystem in Asaba for Biosystem Engineering and Other Functions Using Bioindex

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Abstract

Phosphate being one of the most essential elements required for numerous positive purposes, also plays negative function with respect to eutrophication. Eutrophication refers to deterioration of water health status due to addition of phosphate and other nutrious elements like nitrogen in waterbodies. In this study "Phosphate impact on eutrophication hazards of Niger - River ecosystem in Asaba for biosystem engineering and other functions using bioindex", the measured phosphate values, eutrophication values prior bioindex generative value classification for hazards were deployed in obtaining the potential negative effects, impacted from the phosphate presence in the river ecosystem water. Results showed that the early hours had 0.57 mg/L phosphate level with 1.14 EPI recording low hazard, mid - day hours had 5.92 mg/L phosphate level with 11.85 EPI recording medium hazard, while late hours had 4.83 mg/L phosphate with 9.66 EPI recording low hazard. It was concluded, that the river water system had low eutrophication potential hazards with overall and average values of 90.56 EPI and 7.55 EPI from 45.28 mg/L and 3.77 mg/L phosphate presence. This Indices a healthy condition of the river system, insighting more understanding for future decision of the aquatic bioenvironment, and, incorporate conservation and management idealogies for quality status improvement of waterbodies.

Keywords

Phosphorus, Phosphate, Phosphate Cycle, Contamination Hazards, Eutrophication

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1. Introduction

Conserving and management of waterbodies for quality and less hazards are of huge priority in sustainability of health. Partaining to biosystems, where one component is connected to another, a negative modification prior a component is bound to reflect on the functionality of others. For effective sustainability and management of available biosystems, especially attributive to eutrophication, adequate understanding and monitoring of the aquatic bioenvironment is vital. Eutrophication relative works of instance [1, 2], and others exist, but not despicable to the specific details incurable from this work for the respective river system in Asaba. In such essence, obtaining phosphate levels, eutrophication potential index, as well as eutrophication potential hazards as influenced by phosphate were the aims of this work.

1.1. Phosphorus

Phosphorus is a chemical element categorized with the symbol P. It is capable of existing in different forms and regarded as one of the most two vital nutrients. Among other inorganic elements, it ranks second in abundance to human body, as well as being a constituent of valuable compounds of DNA otherwise deoxyribonucleic acid, RNA otherwise ribonucleic acid, phosphate sugar, and others [3]. Its importance extends to all bioexistence. Till date, without phosphorus no identifiable organism can live [4]. Its essence extend to plants and animal life for instance in growth, provided as a component of proteins. However, excessiveness in waterbodies can tune up eutrophication especially in freshwater bodies [5]. Phosphorus travel to surface waterbodies through erosion relative to soil particles associated with the element mostly derived from fertilizers [6]. This element called phosphorus was discovered by Henning Brand in 1669, from philosopher's stone search in urine [4].

1.2. Phosphate

Phosphate refers to an occurrable salt relative to phosphorus. It forms upon reactions of chemical elements involving phosphorus and oxygen. Phosphate of phosphorus may exist for instance as phosphate ion represented with the symbol PO_4^{3-} [7]. It is a necessity to plants and animals in considerable amounts. Phosphate in human body makes up around 1% of the total weight, as well as serving as vital electrolyte [8]. Upon excretion, some are transferably deposited in soils. Humans, other animals, and plants decays contribute the element to the soil. Since it is a major nutrient in fertilizing agricultural plants, its presence in soil is always increasing. Statistically, the plants utilize about 10 to 15% water soluble applied phosphate fertilizers, leaving the remaining 85 to 90% in the soil prone to export from or with the soil [6]. Its transportation maybe facilitated by flood induced erosion from nearby connected lands and banks of water bodies [5]. Their generations are of human activities.

1.3. Phosphate Cycle

Phosphate cycle refers to the cycling movement undertaken by phosphorus in the form of phosphate in the environment. Phosphorus central function in organisms energy transfer, teeth, bones, membrane cell composition, and, genetic material structuring, portray its life sustainability importance as a major nutrient reflecting on the need for its cycling [9]. The cycling however involves transit movement processes for its sustainability. Phosphate transport to land from ocean are highly slow through soil, possessing phosphate ion averagely attributive to oceanic time of residence of 20,000 to 100,000 years [7]. The generation and transport from land is influenced by human as most generation comes from agriculture, pass through smaller waterbodies or find their way directly back to the ocean. The cycling of phosphorus is less complex since the element does not exist as gas. Phosphorus cycle illustrates its translocation as well as transformation inside soils, water, and organic materials [10]. A typical example of phosphorus cycle is presented in Figure below;

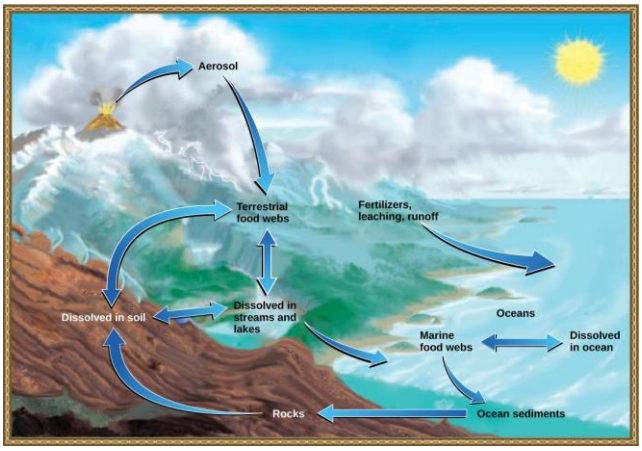


Figure 1. *Phosphorus (phosphate) cycle [11].*

1.4. Contamination Hazards

Contamination Hazards refer to the possible pollution and contamination encountable in the environment. They are incurable risks due contamination. With respect to this work eutrophication was the contamination source, associable to chemical type of contamination hazards. Chemical hazards sources can be water, pesticides, food substances, biocides, cleaning agents, agricultural contaminants, environmental contaminants, process contaminants, and others [12]. Other hazards other than chemical sources are microbiological (viruses, bacteria, moulds, and yeasts or fungi of single cells),

physical, allergens, *etc*. Hazards leads to environmental damage, deaths, injury, damage of property, economic and social disruption, loss of service and livelihood, and others [13].

1.5. Eutrophication

Eutrophication is defined as the response of ecosystem upon nutrient addition to aquatic system. It refers to the intrusion of nutrients of mostly nitrogen seconded by phosphorus, in waterbodies. This mostly raises the deterioration of water health status. Eutrophication is also of economic benefits as may be deploy for mass aquatic harnessment. Water quality and fish yield can be altered hypothesizely at required time while avoiding severe compromise [1]. The water quality may be intentionally lowered at a location (encouraging required contamination) for possible fish kills, and later restore after harvest. This is encouragible where appropriate skill and regulatory order are in place. [1], added that the fisheries bottom - up effects due eutrophication become overweighted upon higher water degradation, reducing yields due reproduction, growth, and survival. In all, on long run, eutrophication is of negative effects on river ecosystem. Source and processes of eutrophication are presented in Figure 2 below;

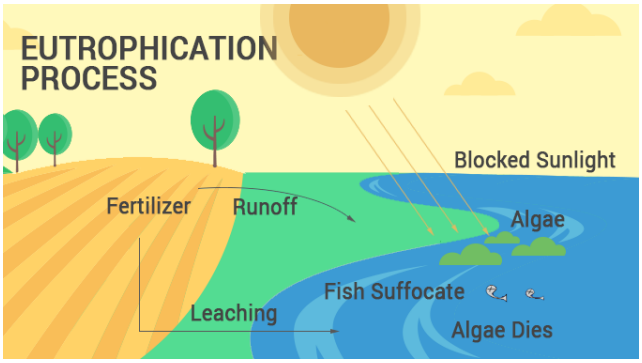


Figure 2. *Eutrophication Processes [2].*

2. Materials and Methods

The Niger River in Asaba, Nigeria of West Africa was the river system materially used for the conduct of this work. It is describable as a natural freshwater ecosystem. The location is of economic benefits through natural yieldings of the river, transportation involving speed boats and others, trade of which Asaba major marketplaces are sited along the bank, community livelihood upon which meat abattoirs and others access the water [14]. The Niger River section of Asaba in Delta State of Nigeria is part of the international river system. The Asaba section of Niger River being few distance to the Atlantic Ocean (where the Niger River transformingly ends), plays diverse key roles in the water system. The Niger River location is presented in Figure 3 below;



Figure 3. *Niger River location in Africa [15].*

Other materials were the portable hydro meter, eutrophication indicator, mobile digital set, *etc*.

Upon site survey of the river system, phosphate was measured using the portable hydro meter in the river. The values were deployed for potential hazards using eutrophication indicator, while the index values obtained were further utilized in determining the eutrophication potential hazard rates prior characterization.

3. Results

The obtained results are presented in Tables 1-4 and Figures 4 and 5 below;

Table 1. *The results from the early hours.*

SN	Month	Phosphate (mg/L)	EP Index, EPI	EP Hazard Rating
1	January	0.30	0.60	Low
2	February	1.60	3.20	Low

SN	Month	Phosphate (mg/L)	EP Index, EPI	EP Hazard Rating
3	March	0.60	1.20	Low
4	April	0.23	0.46	Low
5	May	0.61	1.22	Low
6	June	0.36	0.72	Low
7	July	0.31	0.62	Low
8	August	0.81	1.62	Low
9	September	0.59	1.18	Low
10	October	0.41	0.82	Low
11	November	0.63	1.26	Low
12	December	0.39	0.78	Low
Total	-	6.84	13.68	-
Average	-	0.57	1.14	Low

Table 2. *The results from the mid-day hours.*

SN	Month	Phosphate (mg/L)	EP Index, EPI	EP Hazard Rating
1	January	4.67	9.34	Low
2	February	7.83	15.66	Medium
3	March	5.33	10.66	Medium
4	April	4.16	8.32	Low
5	May	6.37	12.74	Medium
6	June	4.99	9.98	Low
7	July	4.07	8.14	Low
8	August	2.72	5.44	Low
9	September	3.26	6.52	Low
10	October	9.53	19.06	Medium
11	November	7.22	14.44	Medium
12	December	10.92	21.84	Medium
Total	-	71.07	142.14	-
Average	-	5.92	11.85	Medium

Table 3. *The results from the late hours.*

SN	Month	Phosphate (mg/L)	EP Index, EPI	EP Hazard Rating
1	January	3.85	7.70	Low
2	February	6.80	13.60	Medium
3	March	4.51	9.02	Low
4	April	3.44	6.88	Low

SN	Month	Phosphate (mg/L)	EP Index, EPI	EP Hazard Rating
5	May	4.99	9.98	Low
6	June	5.84	11.68	Medium
7	July	4.29	8.58	Low
8	August	4.30	8.60	Low
9	September	4.07	8.14	Low
10	October	5.09	10.18	Medium
11	November	4.69	9.38	Low
12	December	6.06	12.12	Medium
Total	-	57.93	115.86	-
Average	-	4.83	9.66	Low

Table 4. *The results from the average.*

SN	Month	Phosphate (mg/L)	EP Index, EPI	EP Hazard Rating
1	January	2.94	5.88	Low
2	February	5.41	10.82	Medium
3	March	3.48	6.96	Low
4	April	2.61	5.22	Low
5	May	3.99	7.98	Low
6	June	3.73	7.46	Low
7	July	2.89	5.78	Low
8	August	2.61	5.22	Low
9	September	2.64	5.28	Low
10	October	5.01	10.02	Medium
11	November	4.18	8.36	Low
12	December	5.79	11.58	Medium
Total	-	45.28	90.56	-
Average	-	3.77	7.55	Low

The chart of early, mid-day, and late hours eutrophication potential Index is presented in Figure 4 below;

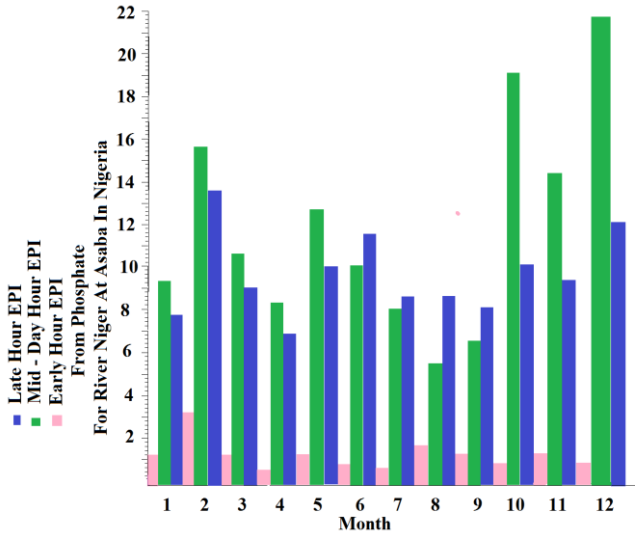


Figure 4. *Eutrophication potential index (EPI) for early, mid-day, and late hours.*

The chart of the average eutrophication potential index (EPI) for the area is presented in Figure 5 below;

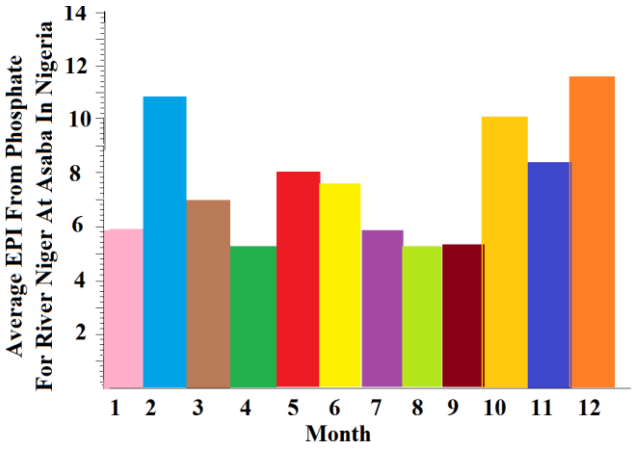


Figure 5. *Average eutrophication potential index (EPI) for the area.*

4. Discussion

From results obtained, early hours had 0.57 mg/L phosphate level with 1.14 EPI recording low hazard, mid - day hours had 5.9225 mg/L phosphate level with 11.85 EPI recording medium hazard, while late hours had 4.83 mg/L phosphate with 9.66 EPI recording low hazard. On average, December, February, and October months were the peak months of eutrophication potential index in the river. Their respective values were 11.58 EPI, 10.82 EPI, and 10.02 EPI, attributed to medium eutrophication potential hazard, EPH. These were in response to the 5.79 mg/L, 5.41 mg/L, and 5.01 mg/L respective phosphate impacts. April and August were the least with 5.2 EPI from 2.61 mg/L phosphate. This was followed by September with 5.28 EPI and 2.64 mg/L phosphate. These months of minimal EPI (April, August, and September) all exhibited low eutrophication potential hazard classification. In all, 90.56 EPI from 45.28 mg/L phosphate, and average of 7.55 EPI from 3.77 mg/L phosphate were attributed to the river water. In this work mg/L was used for phosphorus as the representative unit. This was in accordance with mg P/L used by [16], where P signified phosphorus. Also, EPI was also in associative to the TLI (trophic level index) used by [17].

5. Conclusions

It was in all concluded that the Niger River in Asaba Nigeria had low, medium, and low eutrophication potential hazards for the early, mid-day, and late hours respectively recording phosphate and eutrophication potential index of 0.57 mg/L with 1.14 EPI, 5.92 mg/L with 11.85 EPI, and 4.8275 mg/L

with 9.66 EPI. Also in all, the river system had overall and average values of 90.56 EPI and 7.55 EPI from 45.28 mg/L and 3.77 mg/L phosphate. These were the eutrophication potential values as impacted by phosphate in the river water system. Summarily, the river water system had low eutrophication potential hazards. This Indices a healthy condition of the river system. Finally, the intended aim of "obtaining phosphate levels, eutrophication potential index, as well as eutrophication potential hazards as influenced by phosphate" were attained.

Abbreviations

SN	Serial Number
EP	Eutrophication Potential
EPI	Eutrophication Potential Index
mg/L	Milligrams per Liter

Author Contributions

Godspower Ikechukwu Okolotu: Conceptualization, Methodology, Project administration, Validation, Writing – original draft

Romanus Nwadiolu: Visualization, Writing – original draft

Onoziogie Moses Akwenuke: Visualization, Writing – original draft

Chineze Glory Okeke: Visualization, Writing – original draft

Data Availability Statement

All recorded and computed data of relevance from the research site has been reported within this manuscript.

Conflicts of Interest

The author (s) hereby declare this research work to be of no existing conflict of any interest.

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Biography



Godspower Ikechukwu Okolotu (B. Eng., M. Eng., M. NSE, PhD, Re-COREN) is an academia of Southern Delta University, Ozoro Nigeria, West Africa, in the department of Agricultural Engineering 2023 to present. He attained the climax of his education in 2021 with a PhD in Soil and water engineering from department of Agricultural and Bioresource Engineering, at the Enugu State University of Science and Technology, Nigeria, upon M. Eng., and B. Eng., (2015 and 2011) in same. He also holds a certificate of practicing from Council for the regulation of Engineering In Nigeria from 2021 to present. Scholarly, he has authored multiple published papers.



Romanus Nwadiolu is an academia of Southern Delta University, Ozoro Nigeria (2021 till date). He holds his PhD, masters degree, and bachelors degree in the area of agricultural economics, faculty of agriculture. He has authored various research works, and has registered a substantial record in academics.



Onoziogie Moses Akwenuke (B. Eng., M. Eng., PhD, Re-COREN), graduated with a B. Eng in Civil Engineering from Bendel State University in 1986, M. Sc in Environmental Resources Management, Lagos State University, Ojo, Lagos, 2000, PhD in Water Resources/ Environmental Health Engineering, University of Benin, 2015, have published a number of international, national and local research articles in reputable journals, have practiced civil engineering over the years both in the private and public sectors that involves design, construction, management and lecturing.



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Research Field

Godspower Ikechukwu Okolotu: soil and water conservation and management, hydro status and health, aquatic environments, sphere water recharges, ecosystem, *etc.*

Romanus Nwadiolu: agriculture, agroresource, agroconservation, agro safe environment, water relative to agriculture, *etc.*

Onoziogie Moses Akwenuke: water resources management and conservation, environment, soil, groundwater, Waterways, *etc.*

Chineze Glory Okeke: bio processing, crop processing, agricultural processing, agroconservation, agroenvironments, *etc.*