

ORIGINAL RESEARCH

Impact of Nitrate on Water Quality Contamination at the Asaba River Niger Drainage System to the Atlantic Marine Ecosystem

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ABSTRACT

Nitrate is a product of nitrogen and oxygen reaction. Its presence identifies majorly organic contamination especially upon decay. It is a major component in water quality status of waterbodies. And, quality water is essential for healthy use. Nitrate intrusion to waterbodies contributes to its contamination otherwise deterioration of quality which statistically fuels above 90% of infectious disease transmission globally. Upon river drainage, the excess water flows through the river system made of the tributaries and main waters to a receiving destination of a larger system, finding its way to the marine ecosystem which is the largest of all ecosystems. The marine ecosystem being the end point receptacle of rivers is attributed with huge storage capacity, habitating numerous species including the largest, all interacting together and with their environment. Hence, studies with respect to waterbodies like river of major importance is vital, yielding information for possible strategies towards various efficiencies. Thus, the "impact of nitrate on water quality contamination at the Asaba River Niger drainage system to the Atlantic marine ecosystem" was carried out with the intent of ascertaining nitrate levels, water quality level, and impact due response of water quality at various nitrate concentrations. Results showed that nitrate levels in the early, mid-day, late, and average hours were totally and averagely 4.11mg/L with 0.34mg/L, 79.92mg/L with 6.66mg/L, 63.49mg/L with 5.29mg/L, and 49.17mg/L with 4.10mg/L, respectively. Hydro quality index were 78, 77, 78, and 78 respectively. The impact were 22%, 24%, 22%, and 23% respectively.

KEYWORDS

Nitrate

Contamination

River Drainage

River System

Marine Ecosystem

FULL TEXT

I. Introduction

Management and conservation of water remain non-overemphasized. Water is a top vital resource that deserves sustainability measures. And, identification of potential contamination is ideal for securing healthy water for diverse use.

Nitrate refers to polyatomic compound comprising of nitrogen and oxygen molecular ions. It is formulatively representable as NO_3^- . It may be found in water, air, soil, plants and animals contained. It exists in form of salts like the potassium nitrate, sodium nitrate, and others, or exist in form of ester like the cellulose nitrate, amyl nitrate, ethyl nitrate, and others. Nitrate two basic sources are of natural and anthropogenic. Natural sources include human and other animal waste, nitrogen fixation bacteria contained soils, and plant decays, while, anthropogenic include industrial and automobile airborne nitrogen emitted compounds (Ren, 2022). The natural sources complement the anthropogenic sources. From last century, global alterations of nitrogen cycle due to nitrogen load from natural sources record 30% less than the anthropogenic sources (Hu *et al.*, 2021). The growing presence of nitrate in waterbodies is influenced by inappropriate disposal mechanism, personal care waste materials, pharmaceuticals, pesticides, and others (Bajpai *et al.*, 2019). Nitrates usages extend to food preservation, and, explosives and munitions manufacturing (EPA, 2025), not excluding agricultural plants fertilizing uses. Nitrate has effects. Nitrate exposure causes endocrine disorders, developmental toxicity, reproductive endangerment, and various types of cancer (McGuigan, 2024). Ward *et al.*, (2018), added that nitrate contaminated water intake during pregnancy leads to fatal deaths, spontaneous abortion, neonatal deaths, birth weight reduction, prematurity, retarded intrauterine growth, and congenital malformations. Nitrate effects on aquatic ecosystems include water quality degradation, aquatic plants and animals deaths, and, water eutrophication (Hu *et al.*, 2021). Nitrate (NO_3^-) formation and movement in the nitrogen cycle is presented in figure 1 below;

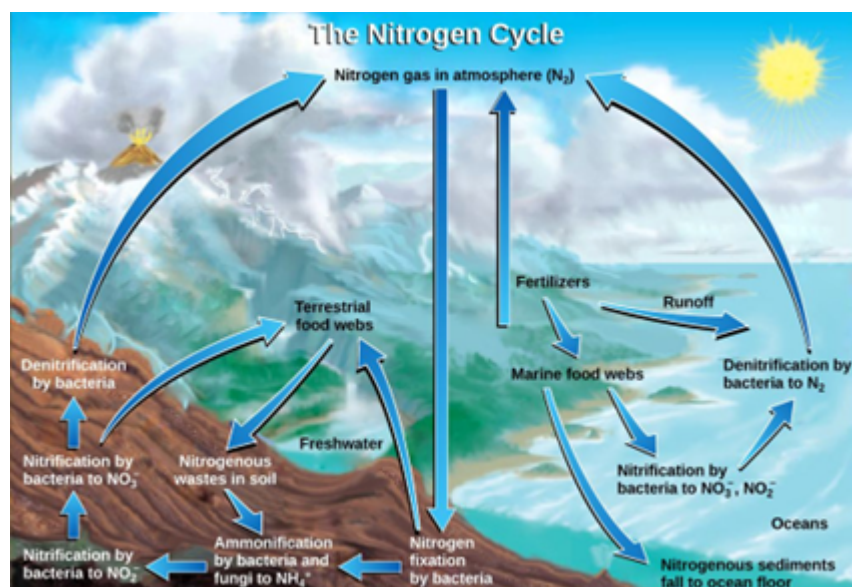


Figure 1: Nitrate (NO_3^-) in nitrogen cycle (TEA, 2025)

Contamination refers to deterioration of quality with respect to purity. Prior reports, domestic use and consumption of contaminated water accounts above 90% of infectious disease transmission (Moloantoa *et al.*, 2022). Water resources concentration of nitrate have increased due to sub - surface and surface water contamination arising from the drainings of about half of all nitrogen applications in agricultural lands (Ward *et al.*, 2018). Roughly 181.9 million of metric tons of agricultural fertilizer application to farms were estimatedly recorded globally in 2017 (Moloantoa *et al.*, 2022). Contamination from nitrogen (N), a top constituents of fertilizer, especially the NPK, produces nitrate which may also originate from other sources. Atleast about 1.7 billion persons globally in 2022 use drinking water from faeces contaminated sources (WHO, 2023). Faeces are waste products from human and other animal excretion containing decay able organics as well as nutrients that add to the deterioration of waters. These faeces containing nitrate and other constituent contaminants find their way to the waterbodies nearby, if not directly deposited. Statistically, about 115 million persons harness surface water prior abstraction from rivers, streams, lakes, and ponds, without treatment (WHO, 2023). Nitrate global distribution below the ground (soil) is presented in figure 2 below. It

described the rate of accumulation using four categorization of no information, none, few, and many. With respect to this work study area (Asaba, Nigeria), no information was used for, within, and around the region.

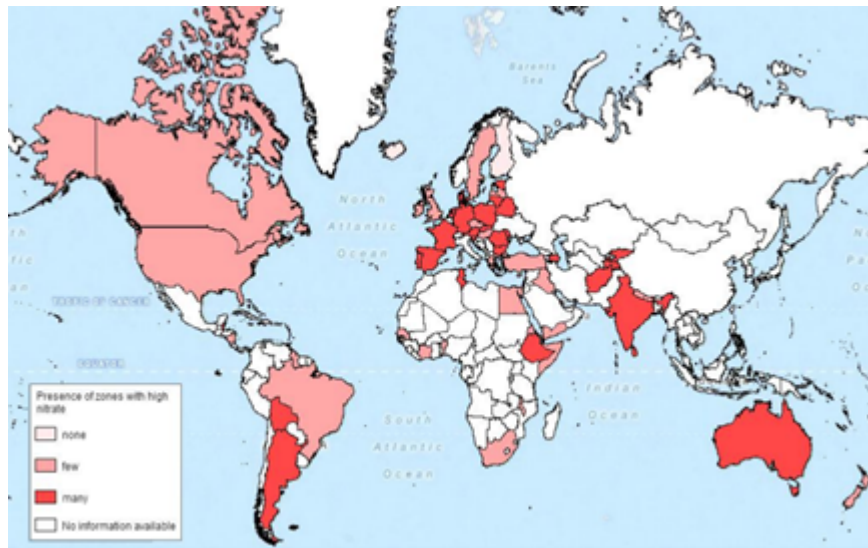


Figure 2: Nitrate global distribution (IGEM - BR, 2023).

River drainage refers to the removal of water (mostly through flows) to another receiving channel for possible transportation to the oceans or seas. The river drainage of the Niger River in Asaba where this work was conducted is internationally involving five countries and the Atlantic Ocean. It roots from Guinea highlands, flow across Mali, Benin, Niger, and some states of Nigeria before entering the Atlantic Ocean (Atlas, 2025). This principal West African drainage system has drainage area of approximately $2.1 \times 10^6 \text{ km}^2$ (Afolabi, 2025).

River system refers to component connections for enhanced delivery. It basically involves the main and tributaries waters. The units combine to improve flow to a bigger waterbody. The two (2) major types of contamination sources are the point and non point sources (Debnath *et al.*, 2021), in river systems. The point sources are the contamination generated at the contamination location. The non point sources are the contamination generated outside the contamination location. For instance, agriculture, wastes, atmospheric discharges along wind, *etc.* River system nitrate sources and movement to contaminable water is presented in figure 3 below;

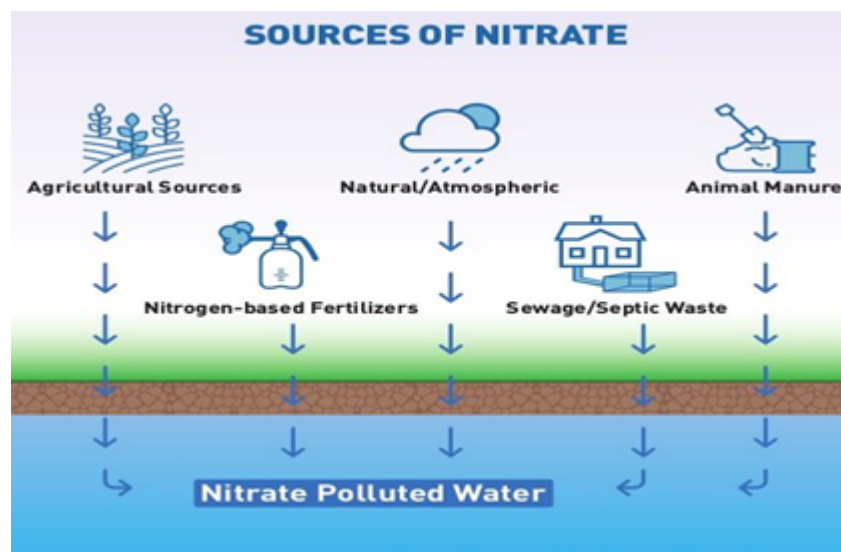


Figure 3: Nitrate contamination sources to river water (IGEM - BR, 2023).

Marine ecosystem refers to the ecosystems of the seas and ocean waters. They are the receptacles of smaller waterbodies especially river effluents. They are the largest ecosystems on earth due to their masses. It comprises of diverse aquatic biodiversity, as well as numerous species of various sizes including the largest creatures which interact with the smaller ones and the environment. Marine ecosystem is attributed to two components of biotic (living things of predatory, competitive, parasitic, and other similar species), and abiotic components (non-living things of salinity, density, turbulence, sunlight, concentrated nutrients, temperature, and other similar things) in its environment (Kumar, 2021). This ecosystem hosts habitats characterizable to low temperature, high pH, high pressure, high salinity, oligotrophic conditions, mineral contents of wide range, and high darkness (Fathima *et al.*, 2022). The marine ecosystem provides coastal protection, food through fisheries, and regulates the climate through the blue carbon (Chalkiadakis *et al.*, 2022), recreation, *etc.* Study of the sea environment informs scientific researchers, rural and urban development, coastal management, government and strategies (Okolotu *et al.*, 2024). The ecosystem is of importance to human existence, and the study of its influents adds to the understanding of the nature of contamination into its environment.

II. Materials

The River Niger system at the Otu - Ogwu Asaba in Nigeria was the study base for this work. It is situated in Delta State of Nigeria, West Africa. It is locatable in the global map presented in figure 4 below;



Figure 4: Location of the study area (Asaba, Delta State of Nigeria, West Africa)

Other used materials were the portable nitrogen water meter, mobile digital set, hydro indicator, *etc.*

III. Methods

The portable nitrogen water meter upon insertion into the water, were used in obtaining nitrate values. The nitrate values were further deployed into the hydro indicator in attaining the Index values. This was used in obtaining the quality classification, evaluated for possible impact due negative effect.

IV. Results

The obtained results are presented in tables 1 to 4, and figures 5 to 8 below;

S/N	Month	Nitrate (mg/L)	Level	Hydro Quality Index, HQI	River Classification	System	Quality	Impact Rate (%)	Impact Level
1	January	0.30		78	Good			22	Low
2	February	0.22		78	Good			22	Low
3	March	0.21		78	Good			22	Low
4	April	0.30		78	Good			22	Low
5	May	0.64		78	Good			22	Low
6	June	0.18		78	Good			22	Low
7	July	0.24		78	Good			22	Low
8	August	0.20		78	Good			22	Low
9	September	0.23		78	Good			22	Low
10	October	0.44		78	Good			22	Low
11	November	0.88		78	Good			22	Low
12	December	0.27		78	Good			22	Low
Total	-	4.11		936	-			264	-
Average	-	0.34		78	Good			22	Low

Table 1: The results from the early hours

S/N	Month	Nitrate (mg/L)	Level	Hydro Index, HQI	Quality	River System Classification	Quality	Impact Rate (%)	Impact Level
1	January	7.11		78		Good		22	Low
2	February	10.16		72		Good		28	Low
3	March	5.67		78		Good		22	Low
4	April	5.72		78		Good		22	Low
5	May	6.90		78		Good		22	Low
6	June	3.49		78		Good		22	Low
7	July	4.23		78		Good		22	Low
8	August	3.79		78		Good		22	Low
9	September	3.19		78		Good		22	Low
10	October	10.40		72		Good		28	Low
11	November	7.07		78		Good		22	Low
12	December	12.19		72		Good		28	Low
Total	-	79.92		918		-		282	-
Average	-	6.66		76.5		Good		23.5	Low

Table 2: The results from the mid-day hours

S/N	Month	Nitrate (mg/L)	Level	Hydro Index, HQI	Quality	River System Classification	Quality	Impact Rate (%)	Impact Level
1	January	5.07		78		Good		22	Low
2	February	5.70		78		Good		22	Low
3	March	5.49		78		Good		22	Low
4	April	5.74		78		Good		22	Low
5	May	6.38		78		Good		22	Low
6	June	5.30		78		Good		22	Low
7	July	4.29		78		Good		22	Low
8	August	6.27		78		Good		22	Low
9	September	4.68		78		Good		22	Low
10	October	3.56		78		Good		22	Low
11	November	5.13		78		Good		22	Low
12	December	5.88		78		Good		22	Low
Total	-	63.49		936		-		264	-
Average	-	5.29		78		Good		22	Low

Table 3: The results from the late hours

S/N	Month	Nitrate (mg/L)	Level	Hydro Index, HQI	Quality River System Classification	Quality	Impact Rate (%)	Impact Level
1	January	4.16		78	Good		22	Low
2	February	5.36		76	Good		24	Low
3	March	3.79		78	Good		22	Low
4	April	3.92		78	Good		22	Low
5	May	4.64		78	Good		22	Low
6	June	2.99		78	Good		22	Low
7	July	2.92		78	Good		22	Low
8	August	3.42		78	Good		22	Low
9	September	2.70		78	Good		22	Low
10	October	4.80		76	Good		24	Low
11	November	4.36		78	Good		22	Low
12	December	6.11		76	Good		24	Low
Total	-	49.17		930	-		270	-
Average	-	4.10		77.5	Good		22.5	Low

Table 4: The results from the average

The chart description of nitrate values, hydro quality index, as well as the impact during early hours is presented in figure 5 below;

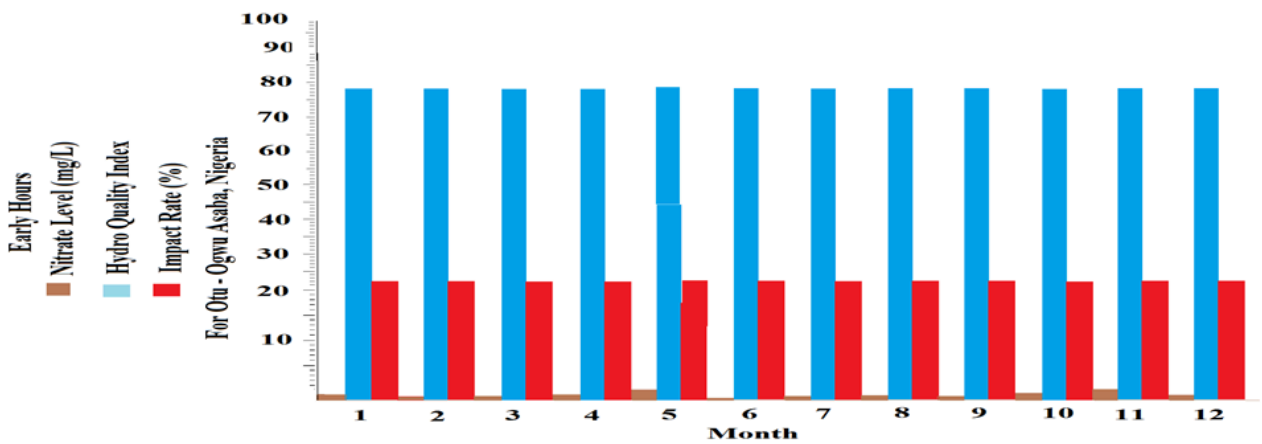


Figure 5: Chart of early hours nitrate values, hydro quality index, and impact

The chart description of nitrate values, hydro quality index, as well as the impact during mid - day hours is presented in figure 6 below;

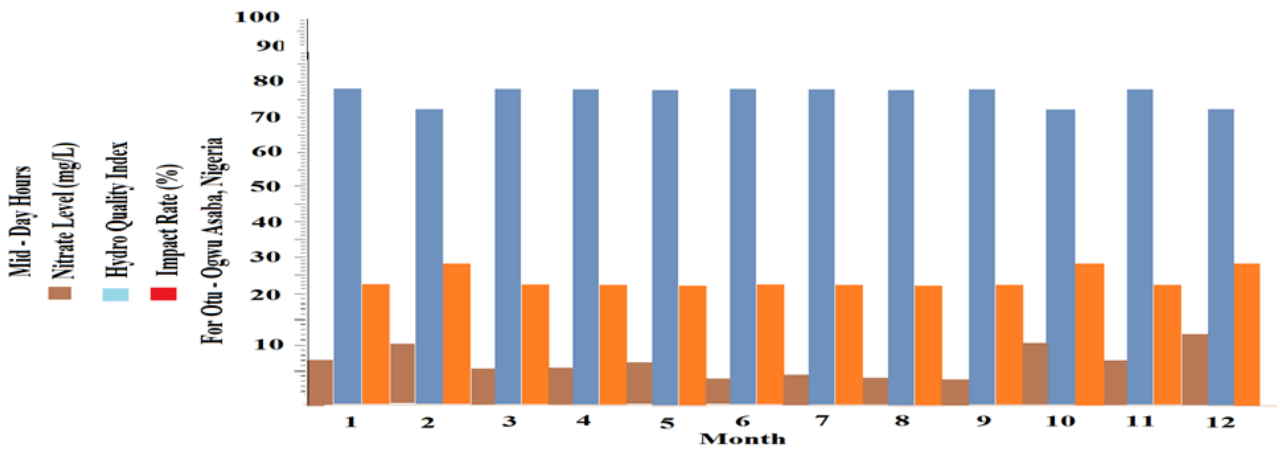


Figure 6: Chart of mid - day hours nitrate values, hydro quality index, and impact

The chart description of nitrate values, hydro quality index, as well as the impact during late hours is presented in figure 7 below;

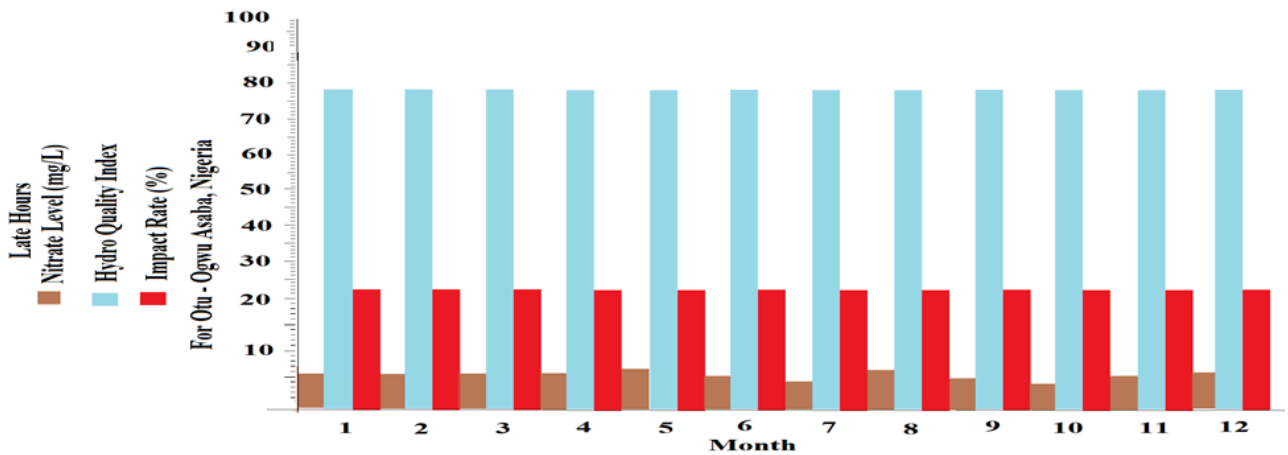


Figure 7: Chart of late hours nitrate values, hydro quality index, and impact

The chart description of nitrate values, hydro quality index, as well as the impact on average is presented in figure 8 below;

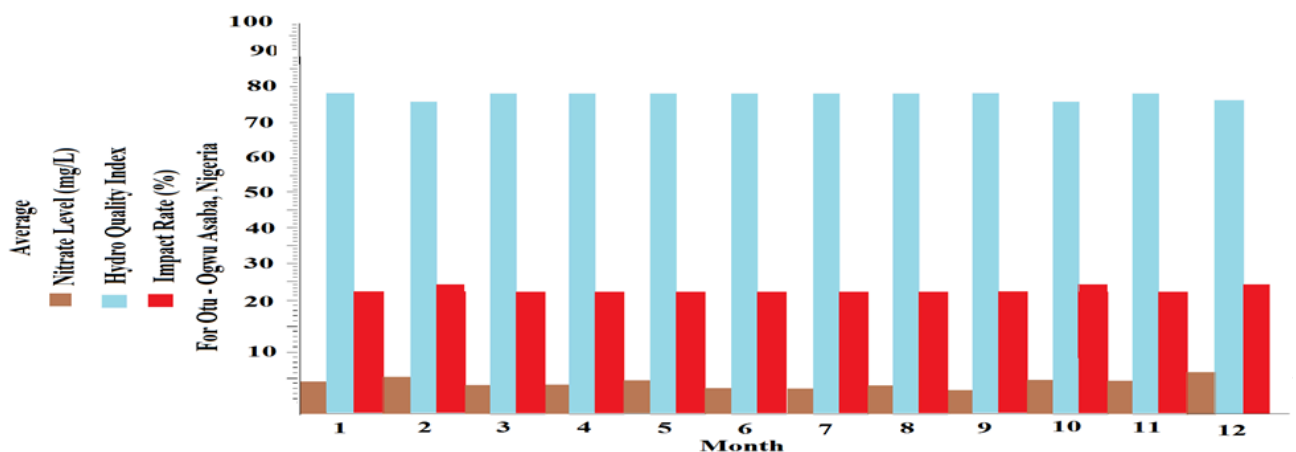


Figure 8: Chart of average nitrate values, hydro quality index, and impact

V. Discussion

From results obtained, nitrate levels were minimal during the early hours. This is graphically visible in figure 5 above. The low nitrate level implied that the river water system were of higher quality status in such early hours. This was in accordance with the general ideology of "the best river waters

abstraction are from dawn".

VI. Conclusion

From results of the early, mid-day, late, and average hours, it was concluded that the river system nitrate levels were 0.34mg/L, 6.66mg/L, 5.29mg/L, and 4.10mg/L, respectively. And that, hydro quality index were 78, 77, 78, and 78 respectively. While the impact were 22%, 24%, 22%, and 23% respectively.

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