Journal of Basic Physical Research ISSN: 2141-8403 Prints, 2141-8411 Online
Vol.12, Issue 2, October, 2024, pp. 53 - 59. Available online at https://journals.unizik.edu.ng/jbpr/

COMPARATIVE ASSESSMENT OF SOME PHYSICOCHEMICAL PROPERTIES OF WATER IN AQUACULTURE PONDS AROUND ILLEGAL REFINERY AREAS IN RIVERS STATE, SOUTH-SOUTH NIGERIA

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Abstract
This study compares some pHysicochemical properties of water in aquaculture ponds of African Regional Aquaculture Center (ARAC) and Mariculture Research Center (MRC) in Rivers State, Nigeria. To determine temperature, pH, electrical conductivity (EC), turbidity, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solid (TDS), total suspended solid (TSD), nitrate ion (NO_3^-) and chloride ion (Cl^-) in the ponds using their standard methods, water samples were collected at two tidal and one non-tidal aquaculture ponds. The results show that temperature ranged from 22.14 to 22.94 ^oC, pH (5.66 – 6.39), EC (12.29 – 45.00 µS/cm), DO (3.34 – 3.70 mg/L), BOD (0.92 – 13.09 mg/L), COD (1.80 – 26.04), turbidity (0.00 – 40.00 NTU), TDS (13.00 – 8601.00 mg/L), TSS (12.13 – 37.02 mg/L), (NO_3^-) 0.04 – 0.08 mg/L) and Cl^- (5.90 – 1049.90). Hence, temperature, pH, COD, turbidity and NO_3^- values of the water in the three ponds were within the permissible limits recommended by WHO and NESREA for aquatic lives while DO was below the limits. EC, BOD, TDS and Cl^- in ARAC non tidal and tidal ponds were found to be within the limits recommended by WHO and NESREA while these parameters were above the limits in the MRC tidal pond. TSS concentration of ARAC and MRC tidal ponds were within the permissible limits of these regulatory organizations while ARAC non tidal pond was above the recommended limits. This study suggests that all the ponds can sustain aquatic lives, however, proper monitoring of waste disposal around the vicinity of the ponds is recommended.
Keywords*: Aquaculture, Pond, Water Quality, Pollutants, Rivers State*

Introduction

Rivers State, located in the Niger Delta region of Nigeria is a hub for aquatic life and aquaculture. The state has numerous rivers such as the New Calabar, Bonny, Eleme rivers which provide a rich source of water for fishing, farming and other economic activities. However, these rivers are facing unprecedented threats as a result of anthropogenic activities like oil spills, agricultural activities, domestic wastes, chemical wastes among others [1, 2]. The impact of these pollutants on earthen fish ponds, which are used for aquaculture, is a particular concern. Earthen fish ponds are vital component of aquaculture providing a source of income and food for many communities. During high tides, water from rivers flow into ponds used for aquaculture purposes in different communities and the impact of contaminated water can leave negative consequences on farms [3].

Aquaculture can be defined as culture of aquatic lives in fresh, brackish and marine environments. Aquaculture shows vast prospect presently and in future to feed increasing human population and also serve as feed ingredients of high commercial value [4]. Based on salinity, aquaculture farming system could be in freshwater, brackish or marine farming systems. Aquaculture freshwater farming is prominent in zero saline water and could be practiced with rivers, lakes and in wetlands. Freshwater system belongs to one of the most endangered habitats in the world with alarming rates of extinction despite its enormous benefits. According to Ezekiel *et al.* [5] and Nyananyo *et al.* [6], freshwater is closest to neutral though in the Niger Delta region, most parts are acidic. Brackish comprises a mixture of seawater and freshwater with a salinity less than 30 pounds per trillion. Brackish water is rich in oxygen and plankton. Mangrove water system, creeks, estuaries are brackish in nature. Mollusks, milkfish, prawns, mussels, crabs, shrimps, fishes etc. are grown in brackish water. Marine water farming also known as mariculture involves rearing commercially important fishes and shell fishes in open sea by installing cages [5].

Illegal refinery of petroleum products is prevalent in Rivers State and its impact is not limited only to economic loss to the government but also accelerates environmental pollution and degradation [7]. The pollutants which can find way to aquaculture ponds includes heavy metals, petroleum hydrocarbons, polycyclic aromatic hydrocarbons and more [8, 9]. When these pollutants contaminate aquaculture ponds, parameters such as temperature, pH, electrical conductivity, and turbidity of the aquaculture ponds are adversely affected. In addition, the concentrations of dissolved oxygen, biological oxygen demand, chemical oxygen demand, nitrate ion, chloride ion, total dissolved solids and total suspended solids of the ponds' water body are altered which disturbs aquatic life and aquaculture.

Studies in and around Nigeria have revealed that heavy metals, PAHs, TPHs, etc. are some of the serious contaminants of the ecosystem: fish pond [10, 11], water [12, 13], soil [14, 15], sediment [16, 17] and even beverages [18, 19]. Again, studies abound on the determination of the aforementioned contaminants in soil, water, and sediment in Rivers State [20 - 23]. Nonetheless, literature is scarce on the pollution of aquaculture tidal ponds in Rivers State, South-South Nigeria. There is therefore a keen need to monitor and control indiscriminate inputs of pollutants into rivers, ponds and other water bodies across Nigeria and especially the oil rich Rivers State by researching on the effects of contamination of different water bodies by these contaminants which are ubiquitous and nondegradable and consequently mutagenic, teratogenic, carcinogenic, genotoxic, neurotoxic, etc. [24, 25].

The aim of this study is to investigate the levels of some pHysicochemical properties (temperature, pH, electrical conductivity, turbidity, dissolved oxygen, biological oxygen demand, chemical oxygen demand, total dissolved solid, total suspended solid, nitrate ion and chloride ion) of tidal ponds in ARAC and MRC in Rivers State, South-South Nigeria and compare them with those of the non-tidal pond in ARAC. The findings of this study will provide valuable insights about these parameters in the ponds and possibly propose a policy document for Nigerian government on best way of forming strategies for mitigating their impacts on aquatic life and human health.

Materials and Methods

The Study Area

The study area consists of two fish farms located in Rivers State, Nigeria. The first fish farm situated in Aluu, Ikwerre Local Government Area (LGA) is a fresh water aquaculture facility. It is located in longitude 6º53´43.54´´E and latitude 4º 54´48.089´´N. The second fish farm, located in Buguma, Asari-Toru LGA is brackish water aquaculture facility situated at longitude 6 º 51´24.415´´E and latitude 4 º 44´36.29´´N. Both fish farms feature earthen and tidal ponds, with the non-tidal pond water source originating from natural sources like rain fall and artificial sources like tap water. The non-tidal pond is located in Ikwerre LGA at longitude 6º53´43.151´´E and latitude 4º 54´55.876´´N. figure 1 depicts the map of Ikwere and Asari Toru LGAs of River State showing the sampling points.

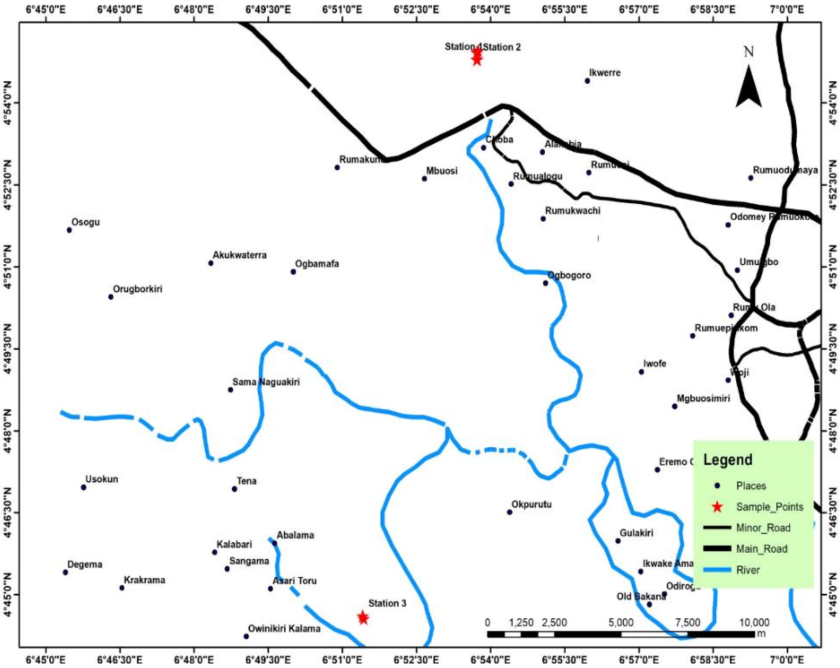

Figure 1. Map of Ikwerre and Asari-Toru LGA of Rivers State Showing Sampling Points

Sample collection and preparation

Water samples were collected from three sampling points namely freshwater tidal and non-tidal ponds both in ARAC, Aluu in Ikwerre LGA and brackish water tidal pond in MRC, Buguma in Asari-Toru LGA. The method of sample collection used by [26 - 28] with modifications was employed. Five water samples were collected at different points of each pond giving a total of 15 samples. At each sampling location, water was collected at a depth of approximately 10-20 cm and stored in clean glass sampling bottles that had been pre-washed with HNO_3 and thoroughly rinsed with deionized water. The 5 samples from each pond were then homogenized to get a composite sample of each pond. An alkaline potassium iodide solution was added after sampling to protect the water samples against pathogenic or fungal attacks. The bottles were sealed, appropriately labeled, and then transported to the laboratory, and stored in the refrigerator until analysis.

Results and Discussion

Physicochemical properties of the water from the ponds

Table 1 depicts the results of the pHysicochemical properties of the water from the three ponds. The temperature of the water in the three ponds are 22.14, 22.94 and 22.50 ^oC for ARAC non tidal, ARAC tidal and MRC tidal ponds respectively. Oribhabor *et al.* [29] shared similar observation of temperature range of 26 - 30 ^oC at Buguma creek. These results compare favourably well and are within the permissible limits of WHO and NESREA for fish farming.

ARAC non tidal, ARAC tidal and MRC tidal ponds recorded pH of 6.06, 5.66 and 6.39 respectively. The results are similar to pH values reported by some workers in Rivers State [27, 30 - 34]. The pH of the water in the ponds may be as a result of acidic rain or decomposition of organic matter washed into the ponds because acidic precipitation-induced floods (runoff) introduce a variety of organic and inorganic chemical pollutants into surface water, changing the system's water chemistry, particularly the pH [35]. Also, the location of the investigation was prone to illegal refinery hence there could be discharge of effluents, waste products which could result to the difference in hydrogen ion concentration of the surface water [36]. Nevertheless, the pH of all the sampling stations were below the recommendation limit of WHO and NESREA.

Table 1 Mean values of the Physicochemical Properties of the Ponds Water with WHO and NESREA recommended limits

Parameters	Non-tidal Pond	ARAC Tidal Pond	MRC Tidal Pond	WHO [37]	NESREA [38]
Temperature ℃	22.14	22.94	22.50	22-35℃	< 40℃
PH	6.06	5.66	6.39	6.5-8.5	6.5-8.5
E.C µS/cm	26.00	45.00	12.29	1000-10000	20-1500
DO, mg/L	3.34	3.70	3.56	5	NA
BOD, mg/L	0.92	1.86	13.09	10	10
COD, mg/L	1.80	3.90	26.40	40	40
Turbidity, NTU	0.00	30.90	40.00	NA	1-150
TDS, mg/L	13.00	23.00	8601.00	1000	2000
TSS, mg/L	37.02	12.13	22.03	30	30
Nitrate, mg/L	0.04	0.08	0.08	50	20
Chloride, mg/L	5.90	11.90	1049.90	250	600

The EC showed 26.00 µS/cm, 45.00 µS/cm and 12.29 µS/cm for ARAC non tidal, ARAC tidal and MRC tidal ponds respectively. ARAC non tidal and ARAC tidal ponds were within WHO permissible limit while MRC tidal pond was above the permissible limit and according to Verma *et al.* [39], polluted water environment can have up to 10,000 µS/cm which might have been caused by dissolved solids.

ARAC non tidal pond recorded a concentration of 3.34 mg/l of dissolved oxygen, ARAC tidal pond (3.70 mg/l) and MRC tidal pond (3.56 mg/l). They were all below the WHO permissible limit. For minimal stress and good growth, it is recommended that DO should be above 4.00 – 5.00 mg/L. Okabekwa *et al.* [28] reported a DO value of 6.09 and 6.23 mg/l in their assessment of pHysicochemical properties of Eleme River. Their values are higher than the values recorded in the current work. A DO concentration of 4.00 – 6.00 mg/l is recommended for fish and domesticated animals while 6.00 mg/L is for drinking [40 – 43]. Hence, the water in the ponds could sustain aquatic lives.

BOD concentration of 0.92 mg/L, 1.86 mg/l, 13.09 mg/l were recorded at ARAC non tidal pond, ARAC tidal pond and MRC tidal pond respectively. ARAC non tidal and ARAC tidal ponds were within NESREA permissible limit while MRC tidal pond was above the permissible limit. Similar results were obtained by both Abu and Egenonu [30] and Dienye and Woke [33]. High amount of BOD represents high amount of oxygen needed by aerobic organism for the breakdown of organic material in the pond, hence our result in MRC tidal pond may be attributed to waste discharge as a result of industrial activities, bunkering activities, and submerged plants [44 – 46]. COD concentrations in ARAC non tidal, ARAC tidal and MRC tidal ponds were 1.80, 3.90 and 26.45 mg/l respectively. They were all within the NESREA permissible limit.

The turbidity of ARAC non tidal pond was less than 0.00 NTU, ARAC tidal (30.90 NTU) and MRC tidal (40.00 NTU) and they were all within NESREA permissible limit. The results of our current study in the tidal ponds are in agreement with those of Serajuddin *et al.* [47] that recorded a range between 16.80 – 96.00 NTU in Dhaka Bangladesh. TDS of ARAC non tidal (13.00 mg/l) and ARAC tidal (23.00 mg/l) were within WHO and NESREA permissible limits while MRC tidal (8601.00 mg/l) was very much above the permissible limits. High levels of TDS can signal pollution due to the fact that it can affect the colour and smell of the water [48]. The high value obtained in MRC tidal pond may be as a result of high rainfall which decreased concentration of dissolved salts and other substance discharged into the pond as well as human inputs through bunkering [36]. TSS in ARAC non tidal, ARAC tidal and MRC tidal (37.02, 12.13 and 22.03 mg/l respectively) were within permissible limit of NESREA except in ARAC non tidal. High concentration of TSS can lead to decrease in pHotosynthetic activities, increase in surface temperature and hence reduce oxygen released by aquatic plants hence ponds with excessive TSS can have toxic effects on fish and fish eggs [49, 50].

ARAC non tidal had a nitrate ion concentration of 0.04 mg/l, ARAC tidal (0.08 mg/l) and MRC tidal (0.08 mg/l) were all within WHO and NESREA permissible limits. Ndayisenga and Dusabe [51] recorded a nitrate ion concentration of 0.10 mg/l in Kigembe and 0.30 mg/l in Nyamagana ponds which were higher than the results obtained in this study. Chloride ion in ARAC non tidal was 5.90 mg/l while 11.90 mg/l was recorded in ARAC tidal pond. MRC tidal pond recorded a chloride ion concentration as high as 1049.90 mg/l. ARAC non tidal and tidal ponds were within permissible limit of WHO and NESREA while MRC tidal pond was above the permissible limits. According to Bhatnagar and Devi [52] chloride concentration above 100 mg/l is of concern because it burns the edges of the gills with long term after effects. The increased value recorded in MRC tidal pond could be as a result of acidic rain, agricultural and animal wastes [36].

Conclusions

The temperature, pH, COD, turbidity and nitrate values of the water in the three ponds were within the permissible limits recommended by WHO and NESREA for aquatic lives while DO was below the limits. EC, BOD, TDS and chloride ion in ARAC non tidal and tidal ponds were found to be within the limits recommended by WHO and NESREA while these parameters were above the limits in the MRC tidal pond. TSS concentration of ARAC and MRC tidal ponds were within the permissible limits of these regulatory organizations while ARAC non tidal pond (control) was above the recommended limits.

Although there are illegal refining operations around these government facilities, aquatic lives are sustained probably due to treatment operations in and around the ponds. This study suggests that all the ponds can sustain aquatic lives and hence, there is a need for proper monitoring of waste disposal and sustainable remediation options.

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