

Physicochemical parameters and plankton diversity in water from selected ponds within Makurdi Metropolis

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ABSTRACT: Physicochemical parameters and plankton diversity in water from five (5) selected ponds was investigated. In the investigation, some physicochemical parameters of water, the composition and abundance of plankton were determined. Some of the parameters include temperature, electrical conductivity, pH, dissolved oxygen, nitrates and phosphate. The samples were collected and transported to the laboratory of the Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University Makurdi for analysis. The preserved plankton samples were observed using a digital Celestron compound microscope and digital Celestron cosmos dissecting microscope. A combination of keys and guides provided were used for identification of the plankton species. A total of 13 different plankton species, with a total abundance of 308 were observed. The most abundant species was *Chlorella vulgaris* with an abundance of 85 and was observed in all three pond types. This was followed by *Scenedesmus acutus* (45) which was observed only in the concrete and liner ponds. *Paramecium* was next and was observed only in the earthen and concrete ponds. The rest of the plankton species were observed in only one pond type. The physicochemical parameters for the selected earthen, concrete and liner ponds were also selected. The pH and dissolved oxygen were observed to be higher in the concrete pond and lowering the liner pond. The electrical conductivity and total dissolved solid were however lower in the concrete pond and higher in the earthen pond, both the temperature and turbidity were higher in the liner pond and lower in the earthen pond. The phosphate concentration was also higher in the linear pond and lower in the earthen pond, while the concentration of Nitrite was equal in both earthen and concrete pond with no amount observed in the liner pond.

Keywords: Aquaculture, physicochemical parameters, plankton diversity, pond.

INTRODUCTION

Water is the most important compounds of the ecosystem and to all forms of life. The social, economic, and political development of the society are affected by water resources and water quality. It is the environment for fish and other aquatic organisms; it is the physical support where they carry out their life functions such as feeding, swimming, breeding among others (Arain *et al.*, 2015). According to Arain *et al.*, (2015), its reactions with the environment, natural processes and anthropogenic inputs and the natural chemistry have an important bearing on living things. All stages of healthy fish development require

good water quality however, requirement in water quality in aquaculture differ between species of fish and between fish development stages (Obasohan and Agbonlahor, 2010).

Physical and chemical factors like dissolved gases, temperature, and nutrients affect the quality of water both directly and indirectly, which directly affects survival and health of fish and other aquatic organism in aquatic bodies (Abd El-Hamed, 2014). It is essential to maintain good water quality for both survival and optimum growth of cultured fish, levels of metabolites in pond water that can

have an adverse effect on growth. These are generally an order of magnitude lower than those tolerated by fish for survival (Obasohan and Agbonlahor, 2010).

Aquatic ecosystem is the most diverse ecosystem in the world. The first life originated in the water. Water covers about 70% of the earth. Majority of water available on the earth is saline in nature; only small quantity is fresh water (Odo, 2019).

Aquatic habitats (Ponds, lakes and their associated biodiversity) provide food, water, shelter, and space essential for the survival of aquatic animals and plants, both microscopic and macroscopic. Aquatic biodiversity is generally rich, and harbors a variety of plants and animals i.e. from primary producers like algae to tertiary consumers like large carnivorous fishes, intermittently occupied by zooplankton, small herbivorous or planktivorous fishes, aquatic insects, etc. Many of these animal and plant species live in water, whereas others like insects and frogs may use waters only during the breeding season or as juveniles.

In aquatic habitats, the environmental factors include various physical properties of water such as solubility of gases and solids, the penetration of light, temperature, and density. The chemical factors such as salinity, pH, hardness, phosphates and nitrates are very important for growth and density of phytoplankton, on which, zooplankton and some higher consumer depend for their existence (Wetzel, 2001). Measurement with emphasis on water quality parameters in aquaculture ponds such temperature, pH, dissolved oxygen, electrical conductivity, phosphate, nitrites were pivotal. The relationship between the physicochemical parameters of water quality and plankton production in fish ponds is of great importance and essential for fish culture.

The plankton community is comprised of the primary producers or phytoplankton and the secondary producers or zooplankton. More than 75% of freshwater fish feed on plankton at one or the other stage of their life cycle. Phytoplanktons are the primary producers of water bodies; these are the main source of food directly or indirectly to the fish population (Sayeswara *et al.*, 2011). The zooplankton and other micro invertebrates also depend upon phytoplankton for their existence. Presence of phytoplankton, filamentous algae and vascular aquatic plants in an aquatic environment is essential to ensure proper aeration of water by releasing oxygen and absorbing carbon dioxide (Elegbe *et al.*, 2017).

Aquaculture in sub-Saharan Africa has immense potential as a means of increasing food security. According to Mjoun *et al.* (2010), fish such as tilapia have got very high nutritional value. It has been found out that, Americans are consumers of fish because of its high nutritional value and mild taste. Aquaculture also promotes other auxiliary industries such as net making, packaging material industries and boat building (Ojo *et al.*, 2004).

The need to understand the dynamics of aquaculture in relation to appropriate fish production is paramount. The

water quality directly and indirectly contributes to low aquaculture production as poor water quality causes stress to fish affecting their growth and at times fish mortality. The study provided information on suitability of water quality in aquaculture ponds in Makurdi.

METHODOLOGY

Study area

Makurdi, capital of Benue State, Nigeria lies between latitude 7.7322°N and longitude 8.5391°E (Figure 1) with an elevation of 104 meters with a population of about 500,797 according to 2006 census (NPC, 2006). The study area, Makurdi metropolis is a planned urban layout built to modern design standards. It is one of the high density and high income residential areas in Benue State. In Makurdi, fish ponds are common and found within residence. This work was limited to five selected fish ponds in Makurdi.

Plankton sample collection and identification

The study covered two months and samples were collected fortnightly early in the morning between 7.00am to 8.00am. Three water samples from each location were collected weekly. Samples of water for plankton analysis were collected 10 cm below the pond water surface. The samples for plankton analysis were collected by straining 100 liters of water from each pond through plankton net of 55 µm mesh size and each concentrated sample was preserved in 4% formalin solution in the field according to George *et al.* (2009). The samples were transported to the laboratory of the Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University Makurdi for analysis. The preserved plankton samples were observed using a digital Celestron® compound microscope Model #44345 and digital Celestron® cosmos dissecting microscope Model #44362. A combination of keys and guides provided were used for identification of the plankton species. The organisms in the concentrated samples were counted in a counting chamber. Pictures of the plankton were taken with a digital microscope and identified by referring to standard manuals and textbooks.

Determination of water quality parameter

At each pond visited, water samples were collected about 10 cm down from the surface water fortnightly for a month using one-liter plastic bottles. Collected Samples were analyzed on site and in the laboratory using standard methods (APHA, 2012).

Turbidity

Turbidity was measured by using Sper® Scientific Turbidity

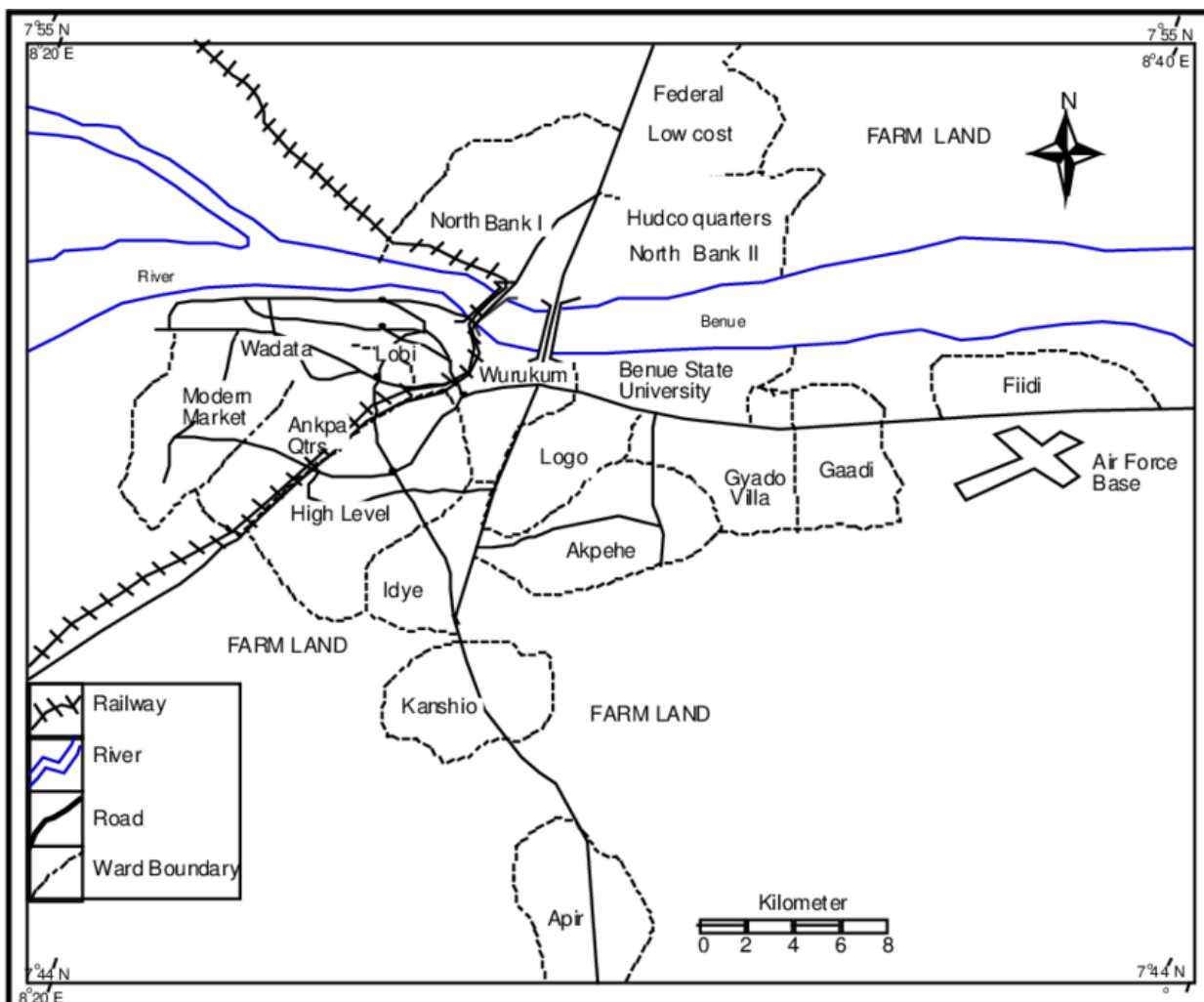


Figure 1. Map of Makurdi showing the sampling sites (Source: Wikipedia, 2015).

Meter Model L87652. This was determined in the laboratory by taking 10 ml of water sample into the glass vial using adjustable micropipette. The sample was inserted into the well of the equipment after been cleaned and the lid closed. The test button was press and results displayed on the Liquid Crystal Display (LCD).

Dissolved oxygen (DO)

Dissolved oxygen was determined using HANNA® dissolved oxygen (DO) meter Model HI 93246. This was done *in situ* by immersing the probe of the meter into the water and the reading on the LCD taken when it stabilized.

pH (Hydrogen ion concentration)

This was determined using HANNA® multiparameter water tester model HI 98129. This was done by inserting the

probe of the meter into the water sample and setting the mode to read pH using the MODE keypad.

Temperature

This was determined using HANNA® multiparameter water tester model HI 98129. This was done *in situ* by inserting the probe of the meter into the water sample and setting the mode to read temperature using the MODE keypad.

Electrical conductivity (EC)

Electrical conductivity was determined by using HANNA® multiparameter water tester model HI 98129. The probe was immersed in water sample and the mode to read EC using the MODE keypad. The reading was taken after it was left to stabilize for about five (5) minutes.

Table 1. The composition, abundance and diversity of plankton in selected fish ponds within Makurdi metropolis.

Plankton species	Pond type			Total
	Earthen pond	Concrete pond	Liner pond	
<i>Chlorella vulgaris</i>	20	30	35	85
<i>Scenedesmus acutus</i>	-	25	20	45
<i>Coelastrium</i>	-	-	15	15
<i>Rhizoclonium</i>	-	-	20	20
<i>Zygnema spp</i>	-	-	8	8
<i>Synedra spp</i>	5	-	-	5
<i>Euglena ehrenbergii</i>	8	-	-	8
<i>Eudorina</i>	10	-	-	10
<i>Chlamydomonas</i>	45	-	-	45
<i>Paramecium</i>	34	10	-	44
<i>Oocystis</i>	5	-	-	5
Mosquito larvae	10	-	-	10
Brown worm	8	-	-	8
Total (%)	145 (47.08)	65 (21.10)	98 (31.82)	308 (100)
Shannon weinner index (H)	1.897	1.012	1.508	
Evenness (E)	0.864	0.922	0.937	

$\chi^2 = 31.487$; $df = 2$; $P = 0.000$.

Total dissolved solids (TDS)

Total dissolved solids (TDS) was determined by using HANNA® multiparameter water tester model HI 98129. The probe was immersed in water sample and the mode to read TDS using the MODE keypad. The reading will be taken after left to stabilize for about five (5) minutes.

Nitrite

This was determined by using the Lovibond® Tintometer Model MD 600. This was measured in the laboratory by taking 10 ml of water sample into the glass vial of the meter using adjustable micropipette. Nitrite parameter was selected using the mode key. The sample was inserted into the well of the equipment after being cleaned and zeroed using the meter zero key. The sample was removed and NitriVer powder was added and shake for one minute. The sample containing the powder was inserted into the well of the equipment, the test key was pressed and the reading was displayed on the LCD.

Phosphate

This was determined by using Lovibond® Tintometer Model MD 600. This was determined in the laboratory by taking 10 ml of water sample into the glass vial of the meter using adjustable micropipette. Phosphate parameter was selected using the mode key. The sample was inserted into the well of the equipment after been cleaned and zero the meter using the zero key. The sample was removed and phosphate powder was added and shake for one minute. The sample containing the powder was inserted

into the well of the equipment, the test key was pressed and the reading was displayed on the LCD.

Data analysis

Data collected was analyzed for descriptive statistics (mean and standard error of means) using Minitab 17. The data was further subjected to analysis of variance (ANOVA). Results and observations are presented in tables and figures.

RESULTS

Table 1 shows the composition, abundance and diversity of plankton in selected fish ponds in Makurdi metropolis. A total of 13 different plankton species, with a total abundance of 308 were observed. The most abundant species was *Chlorella vulgaris* with an abundance of 85. It was observed in all three pond types. This was followed by *Scenedesmus acutus* (45) which was observed only in the concrete and liner ponds. *Paramecium* was next and was observed only in the earthen and concrete ponds. The rest of the plankton species were observed in only one pond type.

The results further showed that the earthen pond had more planktons than the concrete and liner ponds with an abundance of 145 representing 47.08% of total number observed. This was followed by the liner pond with an abundance of 98(31.82%). The abundance and distribution of plankton in Makurdi metropolis was observed to be dependent on the type of pond sampled. The Shannon-Weinner Index (H) of 1.897, 1.012 and 1.508 were observed for earthen, concrete and linear ponds respectively.

Table 2. Comparative plankton diversity and abundance in earthen, concrete and liner ponds in Makurdi.

S/N	Pond type	Species richness	Mean abundance
1	Earthen pond	9	16.11±14.24
2	Concrete pond	3	21.67±10.41
3	Liner ponds	5	19.60±9.91
	FLSD (0.05)	NS	NS

NS = No significant difference.

Table 3. Mean physicochemical parameters of earthen, concrete and liner ponds investigated in Makurdi metropolis.

Physio-chemical parameters	Earthen ponds	Concrete ponds	Liner ponds	FLSD (0.05)
pH	7.97 ± 0.43 ^a	9.07 ± 0.06 ^b	7.70 ± 0.10 ^a	<0.01
Electrical conductivity (µs/cm)	1683.17±1010.66 ^b	382.33±1.53 ^a	460.67±0.58 ^a	0.01
Total dissolved solids (mg/L)	839.50±507.27 ^b	191.33±1.15 ^a	230.67±0.58 ^a	<0.01
Dissolved oxygen (mg/L)	6.25±1.04	7.20±1.00	5.80±0.10	0.09 ^{NS}
Temperature (°C)	26.13±0.84	27.57±0.58	28.80±0.10	1.90 ^{NS}
Turbidity (NTU)	36.08±16.09 ^a	51.10±0.10 ^{ab}	65.07±0.58 ^b	0.02
Nitrite(mg/L)	0.007±0.008	0.337±0.574	0.000±0.000	0.90 ^{NS}
Phosphate(mg/L)	0.167±0.258 ^a	0.233±0.208 ^b	1.243±0.038 ^c	0.03

Mean values with similar alphabets in a row are not significant.

This shows higher plankton diversity in earthen pond.

The comparative plankton diversity and abundance in earthen, concrete and linear ponds in Makurdi is presented in Table 2. The mean plankton abundance was observed to be slightly higher in concrete pond, followed by the liner ponds. However, no significant difference was observed between them ($p>0.05$). In terms of specie richness, the earthen pond had higher number of species followed by the liner pond; however, the species richness was observed not to be dependent on pond type.

The physicochemical parameters for the selected earthen, concrete and liner ponds were also observed (Table 3). The pH and dissolved oxygen were observed to be higher in the concrete pond and lowering the liner pond (Figure 2). The electrical conductivity and total dissolved solid were however lower in the concrete pond and higher in the earthen pond (Figure 3). In Figure 4, both the temperature and turbidity were higher in the liner pond and lower in the earthen pond. The phosphate concentration was also higher in the liner pond and lower in the earthen pond, while the concentration of nitrite was equal in both earthen and concrete pond with no amount observed in the liner pond (Figure 5).

DISCOUSION

Physicochemical parameters

From the result, appreciable temperature was recorded, this high temperature in liner ponds than the earthen and

concrete ponds can be attributed to the fact that liner ponds were made of thick black polythene paper which absorbed more heat from the sun as compared to the other ponds. The fluctuations of pond water temperature could also be attributed to atmospheric variables such as air temperature, wind direction and pond bottom (Iqbal *et al.*, 2010). The low amount of dissolved oxygen in liner pond could be due to high temperature mean recorded in the liner pond and the high amount of dissolved oxygen in concrete pond could be attributed to the lower mean temperature recorded in the concrete pond. This is because dissolved oxygen in water decrease with increase in temperature of the water. On the other hand, low water temperature meant low respiration and low requirement of dissolved oxygen by the metabolic organisms (Ekubo and Abowei, 2011). Liner pond recorded the minimum amount of dissolved oxygen probably due to high temperatures because dissolved oxygen decline with increase in temperature. Conversely, higher dissolved oxygen levels in earthen and concrete ponds can be attributed to lower temperature levels recorded in these ponds.

The variation in conductivity levels observed in the three types of ponds in this study could be due to pond bottom material on which the ponds were built and to the effect of anthropogenic activity. The pH mean ranged from 7.7 to 9.0 in all ponds. The recorded pH in this study varied slightly over the period of study indicating well buffered conditions in the three types of ponds. The relatively recorded higher pH value in the concrete ponds than liner ponds and earthen pond could be attributed to increase in carbon dioxide production due to the photosynthetic

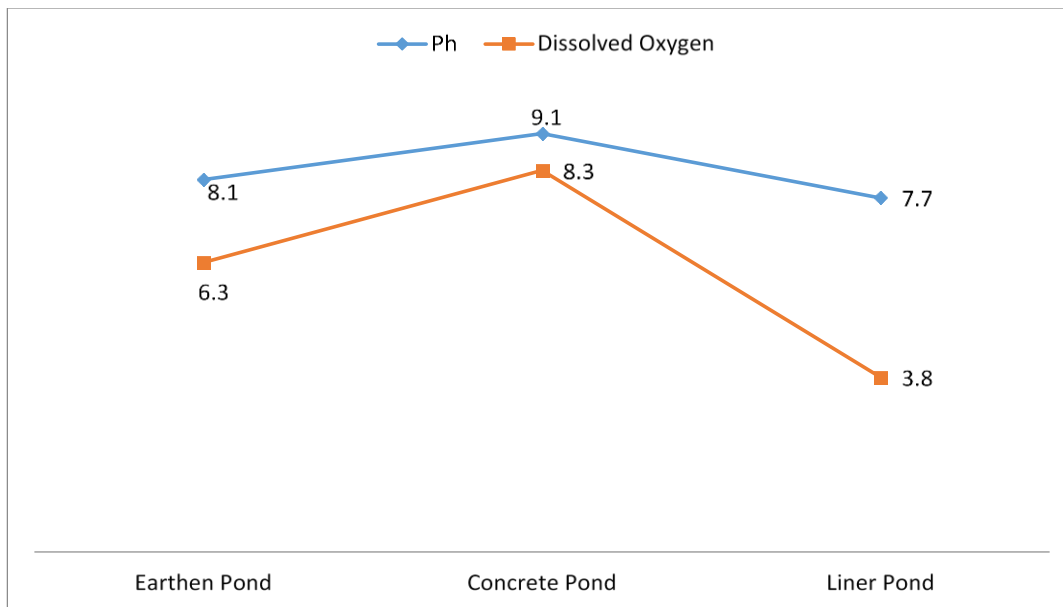


Figure 2. The pH and dissolved oxygen of the earthen, concrete and liner ponds investigated in Makurdi metropolis.

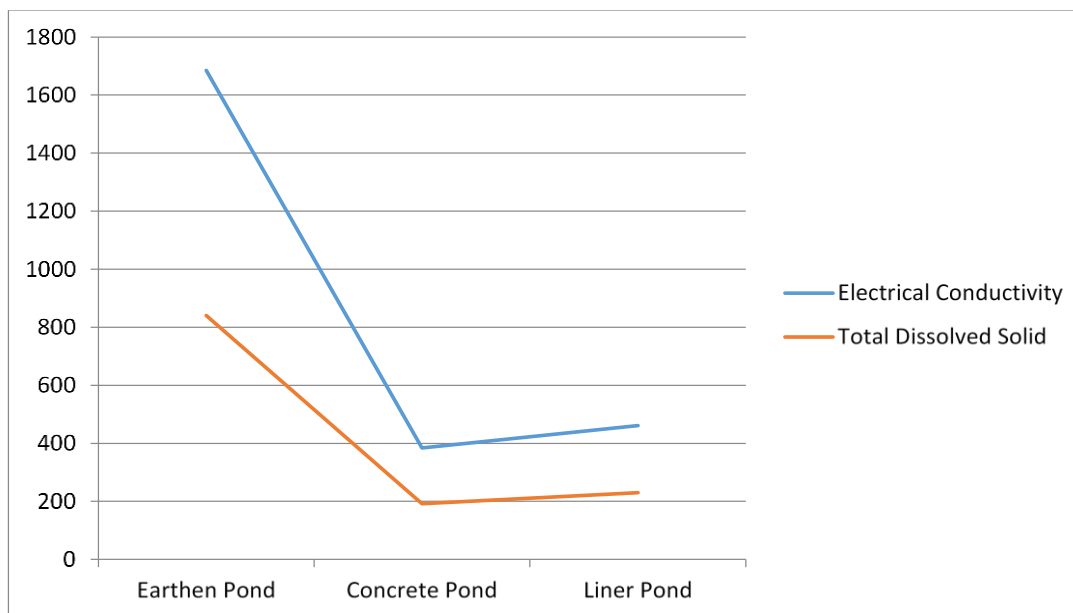


Figure 3. The electrical conductivity and total dissolved solid of the earthen, concrete and liner ponds investigated in Makurdi metropolis.

activities of phytoplankton. The present pH results are in agreement with Palanisamy *et al.* (2013).

In this study, the mean turbidity value of 65.07 NTU was recorded; this was higher than a range of between 32.5 NTU and 34.0 NTU recorded by Gabriel (2013) while researching on the general distribution and diversity of plankton in earthen freshwater fish ponds. The high

turbidity in concrete pond in this study can be attributed to enhanced wind mixing and gentle settling of clay particles. The amount of total dissolved solids (TDS) in this study recorded in concrete and liner ponds were in agreement with those reported by Danba *et al.* (2015). Moreover, lower values of total dissolved solids were recorded by Shakila *et al.* (2012) with a range of 140 to 230 mg/l while

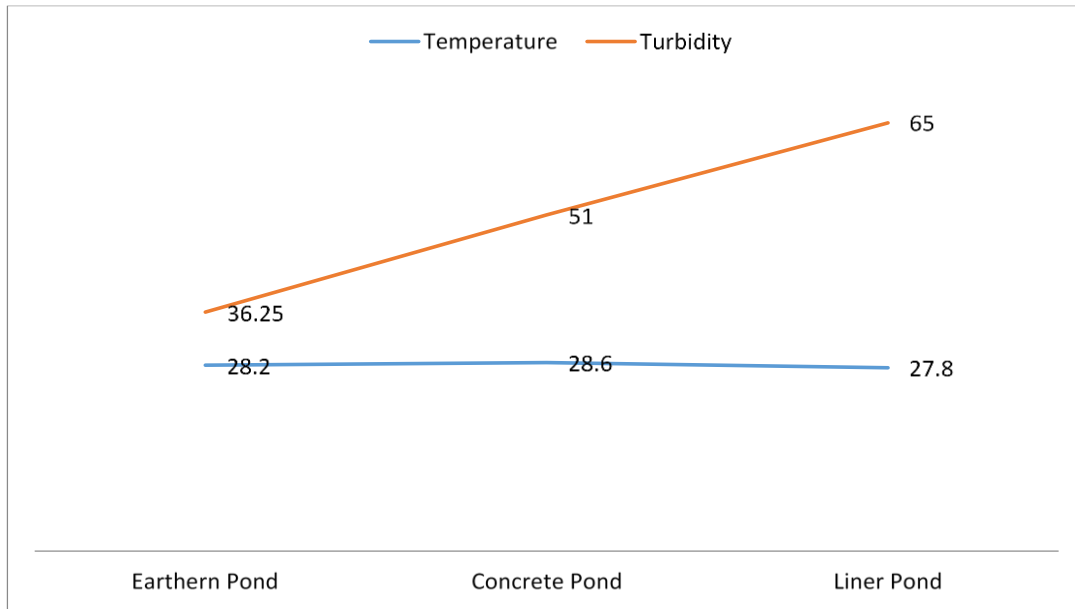


Figure 4 The temperature and turbidity of the earthen, concrete and liner ponds investigated in Makurdi metropolis.

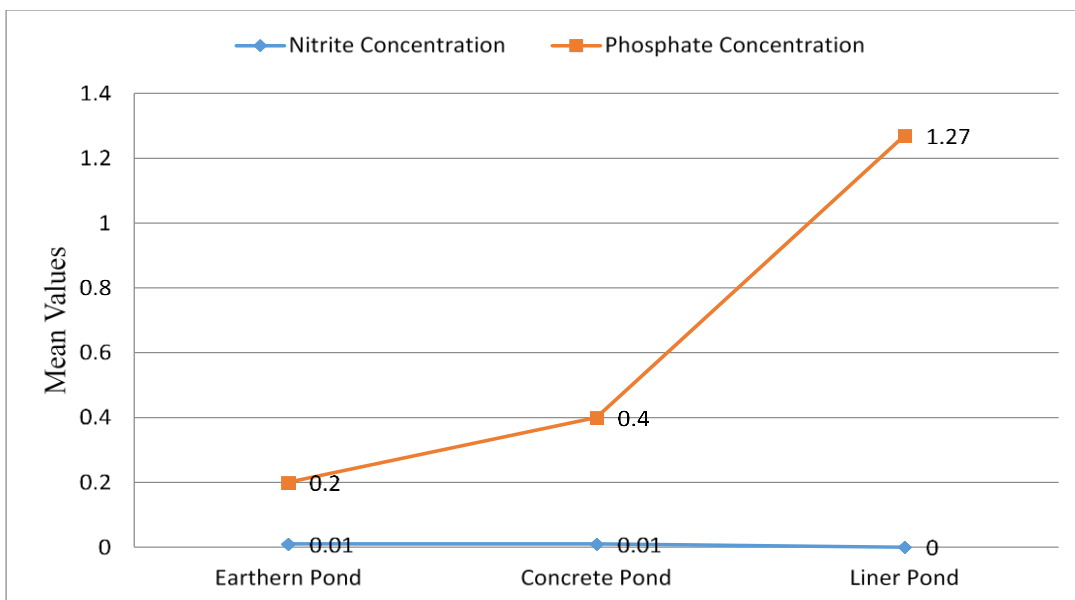


Figure 5. The nitrite and phosphate concentrations of the earthen, concrete and liner ponds investigated in makurdi metropolis.

studying phytoplankton diversity and its relationship to physicochemical parameters.

Nutrients and phosphate

In this study, total nitrite concentration ranged from 0.00 mg/l in earthen ponds to from 0.337 mg/l in concrete ponds

which was similar to that of Ssanyu and Schagerl (2010). Concrete pond recorded relatively high amount of total nitrites due to low number of nitrifying bacteria and the absence of soil medium in the bottom of the pond.

The mean total phosphate levels were 1.243 mg/l in liner ponds in this study. This was similar to the findings of Verma *et al.* (2012). Lower values of phosphates in this study can be attributed to its utilization by phytoplankton

for photosynthesis and low circulation in the pond (Verma *et al.*, 2012).

Plankton abundance and distribution

In the current studied ponds, *chlorella vulgaris* was the most abundant (85%), followed *scenedesmus acutus* (45%), the abundance of both of them was significantly represented by slightly higher percentage. This could be attributed to the impact of phosphorous and direct sunlight since the ponds were all sited in a fairly open place.

Plankton diversity indices

The Simpsons index is normally used to calculate the biodiversity of various habitats ranging from terrestrial to aquatic. It takes into consideration the abundance of those species present. The higher the diversity index values the higher the sample diversity. In the present study, Shannon Weiner Diversity Index ranged from 1.012 to 1.897. It is clear that the studied ponds show moderate pollution level. However, Chukwu *et al.* (2017) suggested that the normal ranges are between 0 and 4. The index shows that the water is clean; values of between 1 and 3 indicate moderate pollution while value less than 1 are regarded to be highly polluted.

Conclusions

The physicochemical parameters that were studied are, electrical conductivity, dissolved oxygen, pH, temperature, nitrites, phosphate, turbidity and total dissolved solids when tested showed significant difference in the three types of ponds. The three types of ponds studied were characterized by a total of 13 different plankton species with a total abundance of 308. In the current study, the abundance and composition of plankton was affected by the pond type and physicochemical condition of the pond. So, the abundance and diversity of plankton was found to be higher in earthen ponds as compared to liner and concrete fish ponds. A higher value of diversity and richness of species earthen ponds had more favorable conditions as compared with liner and concrete ponds. In general, earthen ponds showed a higher diversity of plankton. The use of earthen fish ponds in fish culture is recommended to realize increased production as they offer a favourable environment for plankton growth which can lead to increase primary production.

CONFLICT OF INTEREST

The authors declare that they have not conflict of interest.

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