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A Comparative Study on Physico-Chemical Characteristics and Phytoplankton Abundance between a Concrete and an Earthen Fish Pond in A.B.U., Zaria, Nigeria

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ABSTRACT

Fish culture is a cheap source of animal protein for many households in Nigeria and water quality is a crucial factor in fisheries. The abundance of phytoplankton and physico-chemical parameters of two fishponds in the Department of Biological Sciences, Ahmadu Bello University, Zaria, Nigeria was studied fortnightly from the month of May to July 2011. The range value (means± S.E) for physico-chemical characteristics observed are; Water temperature in pond A ranged from 25^{0}C to 30.8^{0}C (28.06 ± 1.96^{O}C), pond B ranged from 25^{O}C to 32.2^{O}C (28.78 ± 1.71^{O}C). Electrical conductivity in pond A ranged from 0-22 us/cm (118.50 ± 97.72) and pond B 0 to 169 us cm $^{-1}$(80.20 ± 73.67). Total Dissolved solids, pond A ranged from 0 to 112 ppm (57.25 ± 49.25) and pond B 0 to 87 ppm (40.83 ± 36.86). pH in pond A ranged from 5.86 to 9.11 (7.86 ± 0.88) while pond B ranged from 4.10 to 8.46 (7.32 ± 1.30). Hardness of water in pond A ranged from 48 to 88 mg/L (67.58 ± 13.64) while pond B ranged from 40 to 80 mg/L (55.00 ± 11.33). Alkalinity ranged from 10 to 22mg/L (13.42 ± 3.78 in pond A and 3 to 22 mg/L (7.00 ± 5.64) in pond B. Dissolved Oxygen (DO) ranged from 6. 50 60 10. 90 mg/L (8.39 ± 1.44) in pond A and 7. 50 to 8.80 mg/L (8. 25 ± 0.39) in pond B. Biochemical oxygen (BOD) ranged from 1.00 to 8.00 mg/L (3.85 ± 2.36) in pond A and 0.05 to 3.70mg/L (1.56 ± 1.09) in pond B. Phosphate-Phosphorus (PO_4-P) ranged from 1.60 to 2.50 mg/L (2.16 ± 0.34) in pond A and 1.52 to 2.50mg/L (1.97 ± 0.35) in pond B. Nitrate-Nitrogen (NO_3 – N) ranged from 1 to 33 mg/l (10.50 ± 9.58) in pond A and 1 to 7 mg/l (3.33 ± 2.10) in pond B. Physico-chemical parameters showed significant difference across the sampling period (p <0.05) while few others did not show significant difference (P > 0.05). The order of Magnitude in the number of individuals per litre of phytoplankton in the two ponds (A & B) are chlorophyta > cyanophyta > Bacillaciophyta. The three algal divisions observed did not vary statistically significantly between the two ponds (P>0.05). The observed statistically significant relationship between phytoplankton and physico-chemical parameters indicates that the abundance of phytoplankton is dependent on the physico-chemical parameters of the water bodies and vice versa. The results of this study show that the water in pond B is cleaner than pond A.

INTRODUCTION

Ponds are small, shallow but often thermally stratified waters with abundant growth of rooted and floating aquatic macrophytes (Gannon and Stemberger, 1978; Kuczriska-Kippen and Nagengast, 2008).

The monitoring of physico-chemical characteristics of a water body is vital for both long and short- term analysis because the quality, distribution and productivity level of organisms in a water body are largely governed by its physico-chemical and biological factors (Ashton and Schoeman, 1983; Adakole et al., 2003).

Phytoplankton are microscopic plants containing chlorophyll A, that float or swim on the upper sufaces of water or are suspended in the water column, where they are dependant on sunlight for photosynthesis (Verlencar and Desai, 2004). In addition to light and oxygen they require basic inorganic nutrients such as phosphates, nitrates and silicates in the case of diatoms (Rabalais, 2002). They require carbon in the form of carbondioxide and are primary producers in the aquatic environment serving as food for zooplankton and fish (Herring, 2008).

Phytoplankton is important in fisheries because they are primary producers (Bwala et al., 2009; Yisa, 2006). All life forms depend on them in the aquatic environment because they are at the base of the food chain serving as food to zooplanktons and other herbivorous aquatic organisms (Verlencar and Desai, 2004). Phytoplankton occurs naturally in water bodies but more may be introduced from cultures to serve as food supplement in aquaculture from cultures or by stimulating the growth of existing algae through fertilization (Huda et al., 2002). Phytoplankton has also been reported to cause fish poisoning in so many parts of the world because of the ability of some species to form toxins during blooms (Cook et al., 2004). Phytoplankton play important role as bioindicators of water quality (Tiseer et al., 2008; Haruna et al., 2006).

This study was carried out to evaluate water quality dynamics during fish culture in a concrete and an earthen fish pond.

MATERIALS AND METHODS

Study Area

The two fish ponds studied are located in the Department of Biological Sciences of the Ahmadu Bello University (ABU), Zaria. The ponds were constructed for fish production and hold water in all year round, except for occasional changing of the water. Pond A is a concrete pond while B is an earthen pond.

Sampling

Phytoplankton and water samples were collected fortnightly in the months of May, June and July 2011. Samples for physicochemical analysis were collected in one (1) Litre plastic jars at two (2) points in each pond. Dissolved Oxygen and Biochemical Oxygen Demand were determined using the Azide Modification of the Winkler Method, Alkalinity, Hardness, Nitrate-Nitrogen and Phosphate-Phosphorus were determined using methods described by APHA (1998). Electrical Conductivity, pH and Total Dissolved Solids were determined in situ using a portable Hanna Instrument.

Phytoplankton Collection

Phytoplankton was sampled with plankton net of 20cm diameter and a 50ml collection vial attached at its base. The samples were preserved in Lugol's Iodine solution. Cells count by drop count method as described by Verlencar and Dessai (2004) was used for enumeration and identification of phytoplankton. Texts such as Prescott (1977) and Perry (2003) were consulted as identification guides.

Statistical Analysis

Analysis of Variance was used to compare the phytoplankton abundance between ponds, Simpsons index was used to determine evenness, Shannon-Weiner diversity index was used to compare species diversity between the two ponds.

RESULTS

Surface water temperature in Pond A ranged from 24^0C to 30.8^0C with highest in the month of July and lowest in May. In Pond B it ranged from 25^0C to 32.2^0C with both highest and lowest values in the month of May. The two ponds had mean ± standard deviation of 28.06 ± 1.96^0C (Pond A) and 28.78 ± 1.71^0C (Pond B) (Table 1). The differences however, are not statistically significant between ponds and months (P>0.05) (Table 1).

The E.C ranged from 0 us/cm to 224 us/cm in pond A with the highest value in month of May lowest in June and July respectively. In pond B it ranged from 0 us/cm to 169 us/cm with the highest value in May and lowest in June and July respectively. The two ponds had mean ± S.E of 118.50 ± 97.72 (Pond A) and 80.20 ± 73.67 (Pond B). The observed differences were statistically significant between months ($P < 0.01$) (Table 1).

TDS in Pond A ranged from 0 to 112 ppm with the highest value in the month of May and lowest in June and July. Likewise pond B had its range value from 0 to 87 ppm. Pond A had mean ± S.E of 57.25 ± 49.25 and pond B had 40.83 ± 36.86. This observed variation in

TDS was statistically significant only between months (P < .0.01) and not between Ponds (P>0.05) (Table 1).

Values for pH ranged from 5.86 to 9.11 in Pond A with the highest value in the month of May and the lowest in July. Pond A had mean ± S.E of 7.86 ± 0.88 while Pond B had 7.32 ± 1.30 from descriptive statistics. Variations of pH however are not statistically significant between Ponds and months (P > 0.05) (Table 1).

Hardness of water had its peak value in the month of July (88mg/L) and lowest in May (48mg/L) and lowest value in May (40 mg/l). The mean ± S.E of Pond A was 67.58 ± 13.64 and Pond B was 55.00 ± 11.33. The variation of Hardness was statistically significant between Ponds (P < 0.05) but not between months (Table 1).

Alkalinity value was peak at 22mg/L in May and lowest at 10mg/L in June and July in Pond A. while in Pond B the highest value was 22mg/l in May and lowest 3mg/l in June and July. The mean ± S.E in Pond A is 13.42 ± 3.78 and Pond B, 7.00 ± 5.64. This variation in Alkalinity was statistically significant between Ponds and months (P < 0.01) (Table 1).

Table 1: Physico-chemical Characteristics of Pond A (Concrete pond) and Pond B (earthen pond) in the Department of Biological Sciences, A.B.U., Zaria

Month	Week	Pond	Station	Temp. (^{O}C)	E.C (µs)	TDS (ppm)	pH	Hardness (mg/l) $CaCO_3$	Alkalinity (mg/l) Ca CO_3	DO (mg/l)	BOD (mg/l)	PO_4-P (mg/l)	NO_3-N (mg/l)
MAY	WK 1	A	1	28.6	214	108	8.86	80	16	10.9	8	2.4	25
			2	29.8	222	109	9.11	72	22	10.8	7.8	2.5	33
		B	1	32.2	169	83	8.46	40	22	8.5	3.7	2.1	7
			2	31.5	166	87	8.28	48	10	8.8	2.5	2.5	6
	WK 3	A	1	24	224	112	7.56	48	16	8.6	4.6	2.1	7
			2	25	200	100	7.56	48	16	10	5.4	2.3	1
		B	1	29	154	77	7.62	52	11	8.7	1.8	1.52	2
			2	28	156	78	7.63	52	10	7.9	1.7	1.78	3
JUNE	WK1	A	1	28.1	191	94	7.9	80	11	7.5	2.5	1.9	8
			2	27.8	186	92	7.98	80	10	7.3	2.6	2.5	17
		B	1	28.2	125	62	8.02	72	3	8	2	1.7	3
			2	28.1	120	61	7.79	80	3	8.2	1.5	1.9	4
	WK3	A	1	30	0	0	7.63	75	14	7.9	2.5	2.5	5
			2	29	0	0	7.52	56	15	7.1	1.6	1.7	7
		B	1	29.6	0	0	7.62	48	6	8.5	2.5	1.52	4
			2	29.7	0	0	7.52	52	6	8.5	1.9	1.67	6
JULY	WK 1	A	1	28.5	100	32	8.86	60	11	6.5	1	2.5	4
			2	27.4	85	40	8.33	60	9	7.5	1.4	1.6	8
		B	1	27.7	40	17	8.06	60	4	7.9	0.6	2.1	1
			2	27.5	32	25	7.52	60	3	7.5	0.4	2	1
	WK3	A	1	30.8	0	0	7.14	56	10	8.3	3.8	1.97	6
			2	27.7	0	0	5.86	88	11	8.35	5.05	1.9	5
		B	1	27.3	0	0	5.22	48	3	8.05	0.05	2.3	1
Mean ± SE		A		28.06^{a} ±1.96	118.5^{a} ±97.72	57.25^{a} ±49.25	7.86^{a} ±0.88	67.58^{a} ±13.62	13.42^{a} ±3.78	8.39^{a} ±1.44	3.85^{a} ±2.36	2.16^{a} ±0.34	10.5^{a} ±9.58
		B		28.78^{a} ±1.71	80.20^{b} ±73.67	40.83^{b} ±36.86	7.86^{a} ±0.88	55.00^{b} ±11.35	7.00^{b} ±5.64	8.25^{a} ±0.39	1.56^{b} ±1.09	1.97^{a} ±0.35	3.35^{b} ±2.1

TDS= Total Dissolved solids, DO= Dissolved Oxygen, BOD= Biochemical Oxygen Demand PO_4-P= Phosphate-Phosphorus, NO_3-N= Nitrate-Nitrogen, E.C= Electrical conductivity, Temp.= Temperature. Means in the same column with the same superscript are not statistically different, means with different superscripts in the same column are statistically different, a>b

In Pond A, Dissolved Oxygen (DO) values had its peak in May (10.90mg/L) and lowest in the month of July (6.50mg/L). Pond B had values ranging from the highest (8.80mg/L) in May to the lowest (7.50 mg/L) in July, (Table 1). Mean ± S.E, pond A was 8.39 ± 1.44 and pond B 8.25 ± 0.39. The observed variation of DO was statistically significant only between the months ($P < 0.01$) but not between Ponds ($P>0.05$) (Table 1).

Pond A had the highest BOD value in May (8.00mg/L) and lowest in July (1.00mg/L). Pond B had the highest value in May (3.70mg/l) and lowest in July (0.05mg/L). Mean ± S.E of pond A was 3.85 ± 2.36 and Pond B was 1.56 ± 1.09. The variation of BOD was statistically significant between months ($P < 0.01$) and not between Ponds ($P>0.05$) (Table 1).

Phosphate-Phosphorus in Pond A had the highest value (2.50mg/l) in May, June and July and lowest (1.60mg/l) in July. Pond B had the highest value in May and July (2.50mg/L) and lowest in June (1.52mg/L). Pond A had mean ± S.E of 2.16 ± 0.34 and Pond B 1.97 ± 0.35. Variations however were not statistically significant between ponds or months ($P > 0.05$) (Table 1).

NO_3 – N concentrations was highest in May (33mg/L) and lowest in July (1mg/L) in Pond A while Pond B had the highest value in May (7mg/L) and lowest in July (1mg/L). The Mean ± S.E of pond A was 10.50 ± 9.58 and Pond B 3.33 ± 2.10. The observed variation was significant between ponds ($p < 0.05$) (Table 1).

A total of 27 phytoplankton species were observed from 3 divisions: Bacillariophyta, Chlorophyta and Cyanophyta. Bacillariophyta was represented by 6 species with a relative abundance of 6.5%. *Nitzschia sp* was the most abundant member of the Bacillariophyta (3.63%). The Chlorophyta had the highest relative abundance of 60.6% with *scenedesmus* sp being the most abundant member of the division (34.4%). The Cyanophyta had the highest number of species observed (12), with relative abundance of 32.9% (Table 2).

A higher number of Taxa of three (3) was observed for the Bacillariophyta in the months of May and June for pond A in comparison to the one (1) and Two (2) in pond B in the respective months. The number of individuals observed was higher in Pond A than B during the study period (Table 3).

In the chlorophyta Shannon-Weiner diversity index was higher in Pond A than in Pond B throughout the study period. Pond A also had a higher number of individuals than Pond B (Table 3).

The cyanophyta were more abundant and more evenly distributed in Pond B than Pond A in the months of June and July while Dominance showed a reversed trend in the months under consideration (Table 3).

Canonical corresponding analysis for the four most abundant phytoplankton species indicated that the species of *Niztchia, Chrococcus* and *Scenedesmus* were associated with TDS, EC and BOD. *Pediastrum* sp. was observed to be associated with DO (Fig. 1).

Cluster analysis based on Brays-Curtis index showed a similarity of 0.30 for Bacillariophyta (Fig. 2), 0.72 for chlorophyta (Fig. 3) and 0.83 for cyanobacteria (Fig 4).

Table 2: Phytoplankton Abundance in Pond A (Concrete pond) and Pond B (earthen pond) in the Department of Biological Sciences, A.B.U., Zaria

Phytoplankton Taxon	MAY		JUNE		JULY		**Total**	**% abundance**
	Pond A	Pond B	Pond A	Pond B	Pond A	Pond B		
BACILLARIOPHYTA								
Aphanoscapsa sp.	0	0	34	0	0	0	34	0.6
Chaetophora sp.	117	0	0	0	0	0	117	2.03
Fragillariopsis sp.	0	0	0	7	0	6	13	0.23
Navicula sp.	3	0	0	0	0	0	3	0.05
Nitzschia sp.	13	7	21	24	85	59	209	3.63
Pleurosigma sp.	0	0	3	0	0	0	3	0.05
CHLOROPHYTA								
Ankistrodesmus sp	3	0	0	0	0	0	3	0.05
Chara sp.	0	3	0	0	0	0	3	0.05
Closteriopsis sp.	14	0	0	0	0	0	14	0.24
Crucigenia sp.	3	0	0	0	0	0	3	0.05
Golenkinia sp.	100	13	0	0	72	0	185	3.22
Pediastrum sp.	138	200	225	361	207	13	1144	19.9
Scenedesmus sp.	189	402	148	601	223	413	1976	34.4
Selenastrum sp.	3	0	0	0	0	0	3	0.05

Ulothrix sp.	45	0	48	34	3	24	154	2.7
CYANOPHYTA								
Chroococcus sp.	79	124	71	156	192	75	697	12.12
Cyanarcus sp.	28	0	0	0	0	0	28	0.5
Cystodinium sp.	21	0	0	0	0	0	21	0.4
Dactylococcopsis sp.	0	10	48	62	28	17	165	2.9
Haematococcus sp	24	0	0	0	0	3	27	0.5
Lyngbya sp.	13	7	24	41	20	0	105	1.83
Merismopedia sp.	68	55	103	52	291	7	576	10.01
Nostoc sp.	38	0	17	10	3	0	68	1.2
Oscillatora sp.	3	33	17	14	35	45	147	2.55
Sphaeroplea sp	0	0	7	0	0	0	7	0.12
Spirulina sp.	24	0	0	0	0	0	24	0.42
Synochroccus sp.	0	0	0	24	0	0	24	0.42
Total	**926**	**854**	**766**	**1386**	**1159**	**662**	**1,921**	**32.90%**

Table 3: Phytoplankton diversity Indices of Pond A (Concrete pond) and Pond B (earthen pond) in the Department of Biological Sciences, A.B.U., Zaria

		MAY		**JUNE**		**JULY**	
		Pond A	Pond B	Pond A	Pond B	Pond A	Pond B
Bacillariophyta	Taxa_S	3	1	3	2	1	2
	Individuals	133	7	58	31	85	65
	Dominance_D	0.78	1.00	0.48	0.65	1.00	0.83
	Shannon_H	0.43	0.00	0.83	0.53	0.00	0.31
	Simpson_1-D	0.22	0.00	0.52	0.35	0.00	0.17
Chlorophyta	Taxa_S	8.00	4.00	3.00	3.00	4.00	3.00
	Individuals	495.00	618.00	421.00	996.00	505.00	450.00
	Dominance D	0.27	0.53	0.42	0.50	0.38	0.85
	Shannon_H	1.46	0.75	0.95	0.79	1.04	0.34
	Simpson_1-D	0.73	0.47	0.58	0.50	0.62	0.15
Cyanophyta	Taxa_S	9.00	5.00	7.00	7.00	6.00	5.00
	Individuals	298.00	229.00	287.00	359.00	569.00	147.00
	Dominance_D	0.17	0.37	0.23	0.26	0.38	0.37
	Shannon_H	1.95	1.20	1.65	1.60	1.18	1.18
	Simpson_1-D	0.83	0.63	0.77	0.74	0.62	0.63

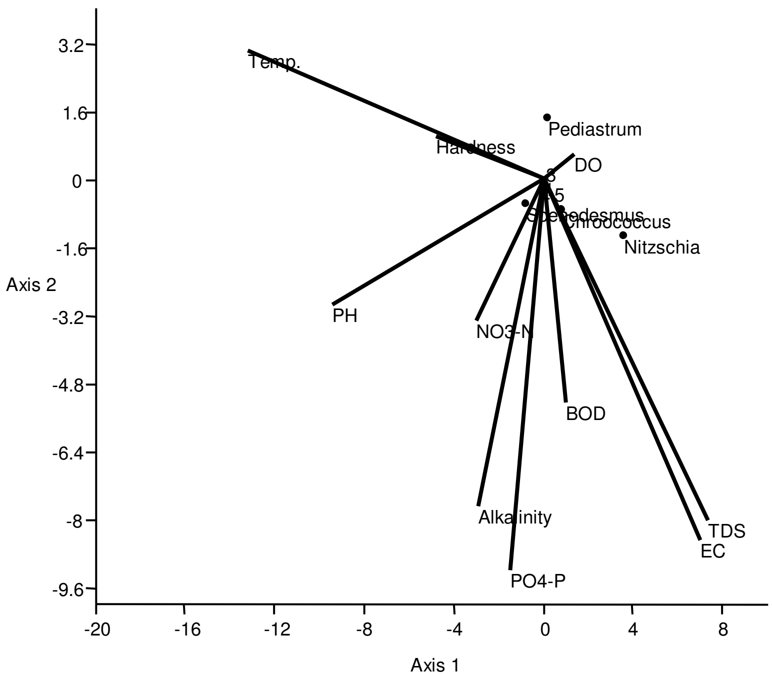

Fig. 1: Canonical correspondence analysis of Phytoplankton and physic-chemical characteristics of two fish pon

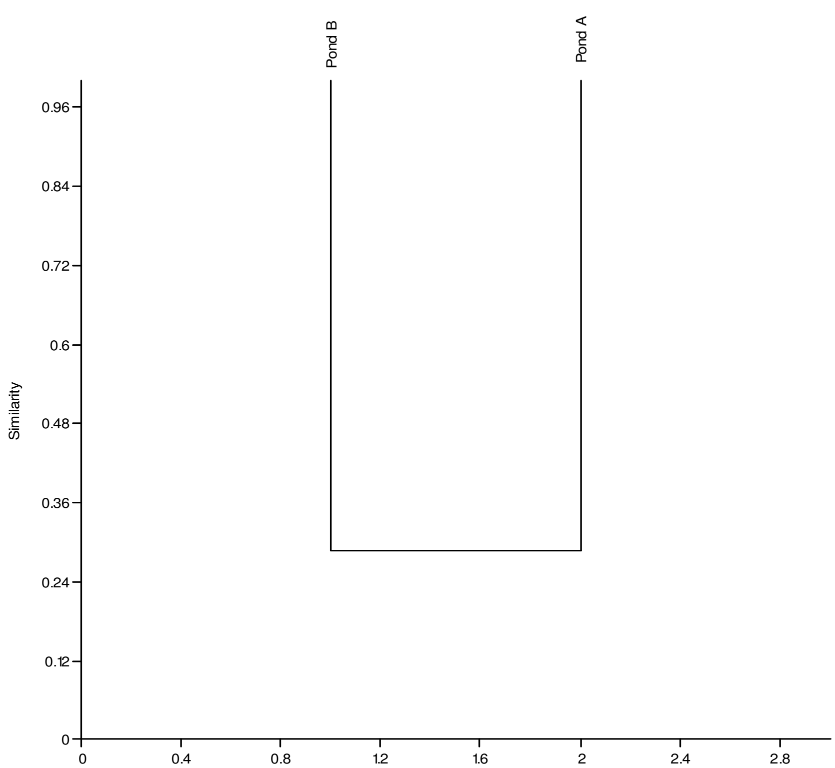

Fig. 2: Bray-Curtis similarity index for Bacillariophyta in Ponds A and B

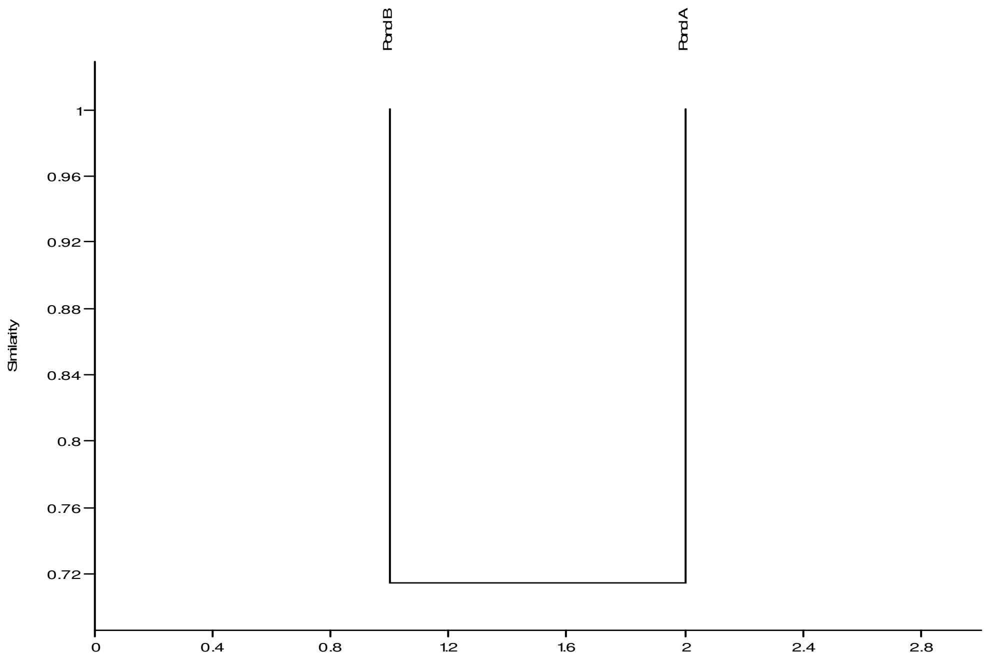

Fig. 3: Bray-Curtis similarity index for Chlorophyta in Ponds A and B

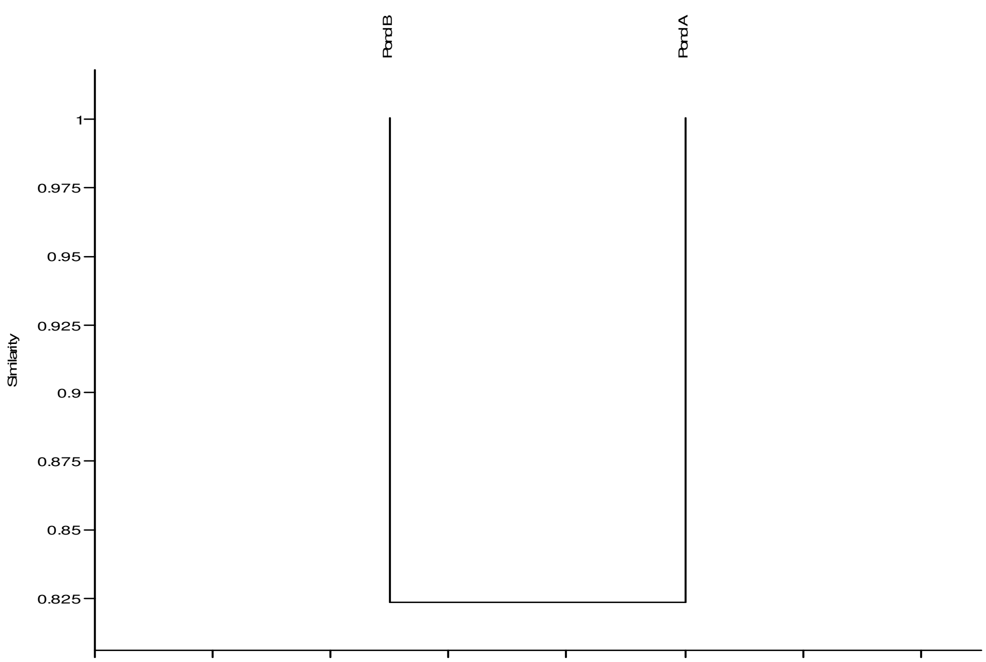

Fig. 4: Bray-Curtis similarity index for Cyanophyta in Ponds A and B

DISCUSSION

The statistically significantly lower concentration of Electrical Conducting ions, TDS, NO_3-N and BOD in Pond B is an indication that Pond B (earthen pond) has a better water quality than Pond A (concrete pond). These observed differences may be attributed to the fact that these substances in the earthen pond can leach into the soil in the Earthen Pond much easier than into the concrete base of Pond A, the concrete pond (UNESCO/WHO/UNEP, 1996).

Venkateswarlu and Reddy (2000) associated high cholorophyta diversity with a clean to oligotrophic trophic water status, while the cyanophyta as indicators of organic pollution, the higher number of taxa and individuals suggests that the two ponds are oligotrophic to mesotrophic.

Wilm and Dorris (1966) have suggested a relationship between species diversity (Shannon-Weiner diversity index) and pollution status of aquatic system and classified as follows; > 3 = Clean water, 1-3 = moderately-polluted < 1 = Heavily- polluted. Based on this classification, the two ponds may be classified as moderately polluted during the study period. Simpson index gives the evenness of species distribution, the Cyanophyta show a more even distribution than the Bacillariophyta and Chlorophyta in the two ponds. This is an indication that the water quality is more suitable to support members of the cyanophyta and is a bad sign as they indicate poor water quality status, and they are not the preferred food by fish.

The association between *Nizchia* sp. with BOD, TDS and EC is an indication that its growth is affected by these parameters. BOD, TDS and EC are measures of dissolved substances in water and most of which are nutrients.

The more similarity of the cyanophyta in the two ponds in comparison to the bacillariophyta and chlorophyta shown by the cluster analysis also suggests that the water quality is more suitable for the members of the division.

CONCLUSION

Based on the findings of this work, the use of an earthen pond may be more adventitious for fish culture in comparison to a concrete pond, in terms of maintenance of a good water quality.

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