Research Journal of Animal, Veterinary and Fishery Sciences ISSN 2320–6535
Vol. **12(1),** 1-11, May **(2024)** *Res. J. Animal, Veterinary and Fishery Sci.*

Research on the Limnology of Waterpark Pond, a Wetland in Nepalgunj, Banke, Nepal

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Available online at: www.isca.in, www.isca.me
Received 9th May 2023, revised 19th February 2024, accepted 28th April 2024

Abstract

Wetland ecology depends critically on the physico-chemical characteristics of water. In order to determine its impact on plankton population, and fish population, the various physico-chemical parameters of the Waterpark pond were examined between January 2022 and December 2022. Physico-chemical and biological parameters were analyzed form the sample water and the author noted that the temperature of the water ranged from 9.5 to 27.6°C, transparency from 28.6 to 38.7 cm, dissolved oxygen from 5.8 to 8.9 ppm, free carbon dioxide from 14.0 to 26.0 ppm, pH from 7.2 to 9.8, and total alkalinity between 136.0 and 294.0 ppm. The phosphate ranged from 1.02-1.08 ppm, and the nitrate ranged from 1.07 to 1.38 ppm. 26 Phytoplankton species and 22 zooplankton species were identified so, the pond is rich in plankton diversity. The dominant phytoplankton species observed are of Chlorophycae and the dominant zooplanktons are of Rotifera. Plankton showed a bimodal pattern of seasonal variation, with first spike in July and a second spike in January. It was concluded that the physico-chemical and biological parameters of the Waterpark pond are favorable for freshwater aquaculture. Statistically neither phytoplanktons nor zooplanktons are very strongly correlated with temperature, pH, DO and Nitrate of the pond water. Most of them showed weak and moderate correlation with above parameters. The members of Cyanophycae and Copepods showed strong correlation with Nitrate.

Keywords: Aquaculture, correlation, plankton diversity, physico-chemical parameter, Waterpark pond

Introduction

The wetland is an area of land that transitions from a terrestrial to an aquatic environment and is typically distinguished by water that is at or near the surface or by shallow water that covers the area. Wetlands are regions where water is crucial in regulating the ecosystem and the organisms that inhabit there[1]. Wetlands are incredibly productive ecosystems that support food chains, water quality restoration, nutrient cycling, and biological cycle management. The powerful ecological processes of phytoplankton life forms and guilds to changing environmental conditions suggest that with more study, wetland phytoplankton functional groups could be utilized in tropical wetland biological assessments and monitoring[2].

The environment and society benefit greatly from wetland resources, which are essential parts of watersheds. Due to industrialization, dumping of garbage, and urbanization, wetlands are now becoming more polluted and shrinking. Most wetlands are suffering from increased levels of biologically active nutrient collection due to urbanization and anthropogenic pressure[3].

The surface discharge of used pesticides, sewage, and fertilizers also potentially contaminate the water bodies. Wetland ecological characteristics can be evaluated using the physico-chemical parameters of the water.

A review of literature found that numerous researchers, such as Bhattarai, Shrestha[4-10] and so on conducted studies on the limnology and plankton variety of various water bodies in Nepal. However, there are currently insufficient baseline data available regarding the limnological parameters of many water bodies and wetlands in Nepal, including the Waterpark pond of Nepalgunj.

Therefore, the author decided to research the limnological traits in relation to aquaculture in the Waterpark pond of Nepalgunj sub-metropolitan city of Banke district.

Materials and Methods

Study Area: Waterpark pond under research is situated in north location of the Nepalgunj sub-metropolitan city of Lumbini province of Nepal. It is about 500m distance from Dhambojhi Secondary School and situated between the latitude 28°04'30.72"N to 81°37'45.21"E (Figure-1). The pond has the total area of 1.012 hectares. The pond's highest depth during the monsoon season (July to August) is 10 feet, while the minimum depth throughout the summer is 6 feet during May-June. The source of water in the pond is drain water from agricultural field and rainfall. The pond is used for fish culture and also for water safari and entertainment by local people.

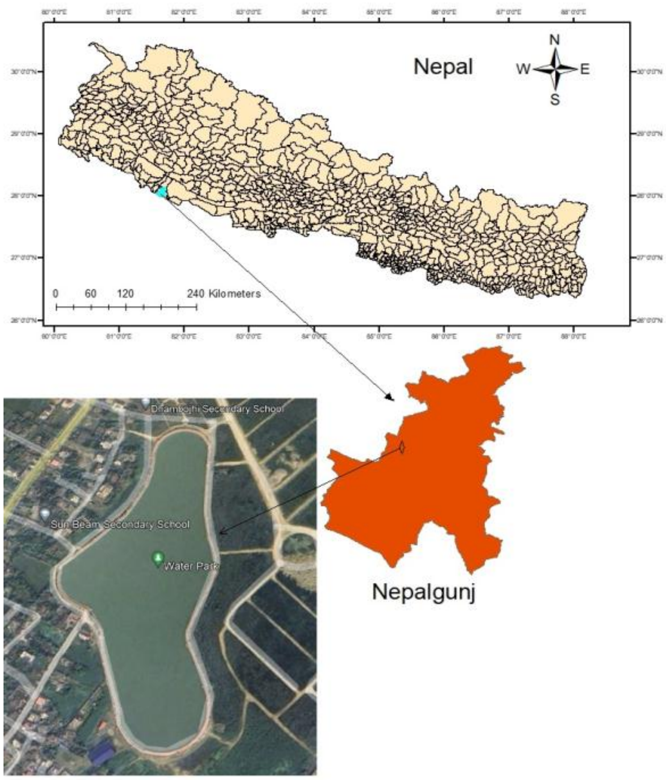

Figure-1: Map of Nepalgunj sub-metropolitan city and satellite view of the Waterpark pond.

Water was sampled in plastic stoppered bottles every two weeks from three different locations of the pond and the temperature, DO, FCO_2, and pH were recorded on the field using a water quality test kit. As per accepted methods[11], analyses of the total alkalinity, total hardness, nitrates, and phosphates were accomplished both in the lab and on the field. Using a Sedgewick Rafter plankton counting cell, the biological parameters of plankton productivity were measured in accordance with Welch[12]. Values are expressed as units per liter of pond water. The plankton species were identified with the help of standard references[13,14].

Statistical Analysis: Mean, Standard Deviation, and Pearson Correlation Coefficient (r) was calculated using the software IBM SPSS Statistics 25.

Results and Discussion

Physico-Chemical Properties of Waterpark Pond: Table-1 displays the findings about the physico-chemical properties of the pond water. The results are elaborated on and discussed below-

Water Temperature: The physiology of aquatic life are affected by temperature of the water. It has been observed that the temperature of air has an impact on water temperature. The highest temperature of water in the present study was recorded during summer season, followed by the rainy season, while the lowest temperature was reported during winter season. Since the pond is smaller in size and responds more quickly to changes in atmospheric temperature. Monthly variations in water temperature are because of differences in air temperature [15,16]. It was noted that the temperature of wate in the pond varied from 9.5 to 27.6ºC. The temperature of the water is excellent for the farming of major carps and exotic species of fish[17].

pH: One of the most essential aspects in water chemistry is pH, which is measured on a scale from 0 to 14 as the intensity of acidity or alkalinity and is the negative log of H^+ concentration. The pH of the aquatic system serves as an indicator of general environmental health. The alkaline water is favorable for aquatic life[18]. The water pH in the pond ranged from 7.2-9.8. The pH values of water were highest during summer and lowest during rainy season.

Transparency: Water transparency describe as the typical depth of vanishing the Sachhi disc and reappearing from an open water body. Turbidity has an inverse relationship with transparency[1]. At various trophic levels of the food chain, water transparency regulates the energy relationship[19]. The pond's water transparency varied from 28.6 to 38.7 cm. The highest transparency observed during the winter may also be related to the sedimentation of suspended particles[20]. Similarly winter was the season with the most transparency, while rainy seasons had a moderate amount and summer had the least. Low transparency seen during the summer may be caused by a significant planktonic population[19].

Dissolved Oxygen: Dissolved oxygen is crucial since it provides information about the physical, chemical, and biological activity in any given aqutic system. The DO of the pond fluctuates between 5.8 and 8.9 ppm. Winter months had the greatest DO levels, which may be due to a high amount of photosynthetic activity at that time and due to more solubility of Oxygen in water at low temperature. According to Hazelwood and Parker[21] the highest solubility of oxygen in winter may be due to low air temperature and minimum solubility of oxygen in summer may be due to increased metabolism of aquatic life. Slow rate of photosynthesis or respiration of heterotrophic organisms, decomposition of organic substances are all possible causes of oxygen depletion in water during the rainy season. According to Ansari and Prakash[22] the wetland is quite productive if the DO levels throughout the year exceeds 5.0 ppm.

Free Carbon dioxide (FCO_2): In a water body, source of free carbon dioxide is normally atmosphere, biotic respiration, and saprophytic degradation of organic waste. FCO_2 ranged in the current study from 14.0 to 26.0 ppm. Maximum and minimum FCO_2 concentrations were observed in the pond during the rainy season and winter seasons, respectively. High levels of free carbon dioxide that are observed in rainy season are probably linked to the active breakdown of organic materials.

Total Alkalinity: Alkalinity in most natural water body is caused by bicarbonates and carbonates. Alkalinity controls the H^+ concentratin and dissolved carbon dioxide of the quatic system, which has a direct impact on productivity of water bodies. The pond's water is nutrient-rich and highly productive, as indicated by the range of total alkalinity 136.0 to 294.0 ppm.

Total Hardness: Total hardness is the fertility measure of the aquatic ecosystem. The sum of carbonates of calcium and magnessium in water is used to calculate overall hardness. Moyle[23] proposed the hardness 40 ppm as a natural separating threshold between hard and soft waters. The range of total hardness 76-124 ppm shows that the pond water is suitable for fish culture[17]. Wintertime had the greatest hardness levels and wet months the lowest. The findings of Kumar, Chaudhary[1] provides support for the conclusion.

Nitrate: Nitrate is the most stable form of nitrogen. Surface runoff, decomposing vegetation, and animal waste are the principal sources of nitrates in aquatic bodies. Higher the concentration of nitrate produce algal bloom. The nitrate concentration of the water ranged from 1.07 to 1.38 ppm. Nitrate concentrations were maximum during the post-monsoon period. The findings of Khan, Kaiser[24] prove the conclusion.

Phosphate: Phosphate is the most important nutrient for the maintenance of productivity of the aquatic system. They restrict the primary production of the water body and are necessary for growth of organism. The phosphate concentration in the current investigation varied between 1.0-1.06 ppm. The lowest during the winter and the highest during the summer. Low phosphate levels during winter and high phosphate content during summer months may be linked to the slow breakdown of organic waste[25].

Biological Properties of the Waterpark Pond: Twenty five phytoplankton species and twenty two zooplankton species were identified in this investigation (Table-2). Of the 26 species of phytoplanktons 10 species belong to Class Chlorophycae (*Cosmarium* sp.,*Chlorella* sp., *Zygnema* sp., *Spirogyra* sp., *Volvox* sp., *Ulothrix* sp., *Crucigenia* sp., *Tetraspora* sp., *Chlomydomonas* sp. and *Oedogonium* sp.); 8 species belong to Bacilliriophycae (*Melosira* sp., *Synedera* sp., *Diatoma* sp., *Cymbella* sp., *Navicula* sp., *Cyclotella* sp., *Pinnularia* sp., and *Nitzschia* sp.); 6 species to Cyanophycae (*Anabaena* sp., *Nostoc* sp., *Spirulina* sp., *Oscillatoria* sp., *Cloecapsa* sp., and *Microcystis* sp.) and 2 species belong to family Euglenophycae (*Euglena* and *Phacus)*. Similarly, of the 22 species of zooplanktons 8 species belong to the family Rotifera (*Brachinous* sp., *Keratella* sp., *Notomate* sp., *Notholca* sp., *Rotaria* sp., *Asplanchna* sp., *Polyarthra* sp., and *Lecane* sp.); 7 to Cladocera (*Diaphnosoma* sp., *Ceriodaphnia* sp., *Daphnia* sp., *Simocephalus* sp., *Bosmina* sp., *Bosminopsis* sp., and *Macrothrix* sp.); 5 to Copepoda (*Cyclops* sp., *Mesocyclops* sp., *Diaptomus* sp., *Heleodiaptomus* sp.,and *Nauplius* larva) and 2 Ciliate species (*Paramecium* sp.,and *Vorticella* sp.). These species have been reported in different fresh water bodies of Uttar Pradesh, India[26-28] and also in Ghariyarwa pond of Birgunj, Nepal[10]. The above result of phytoplankton and zooplankton shows that the Waterpark pond is rich in plankton diversity.

Table-1: Monthly variation in physico-chemical parameters of water of Waterpark pond.

Months	Temp. (°C)	Trans. (cm)	pH	DO (ppm)	FCO_2 (ppm)	Total Alk. (ppm)	T.H. (ppm)	Nitrate (ppm)	Phosphate (ppm)
Jan	9.5	38.70	7.8	8.90	15.20	209	114	1.18	1.04
Feb	11.9	35.60	7.6	8.70	15.30	216	123	1.21	1.05
Mar	14.6	30.40	8.9	8.50	15.40	225	112	1.21	1.06
Apr	16.2	30.50	8.5	7.50	15.60	202	108	1.27	1.06
May	24.3	29.30	9.6	5.80	16.20	214	99	1.31	1.06
June	27.6	28.60	9.8	6.30	16.40	235	93	1.37	1.06
July	26.5	33.60	7.2	7.90	16.60	268	86	1.38	1.05
Aug	24.1	32.80	7.3	8.10	18.10	294	76	1.18	1.05
Sep	23.6	32.60	7.3	8.60	22.20	243	88	1.09	1.04
Oct	20.2	33.80	7.5	8.70	25.00	167	98	1.07	1.03
Nov	16.4	34.30	7.5	8.80	26.00	136	104	1.10	1.04
Dec	12.8	36.80	7.7	8.90	14.00	202	108	1.12	1.00
Ranges	9.5 - 27.6	28.6 - 38.7	7.2 - 9.8	5.8 - 8.9	14.0 - 26.0	136.0 - 294.0	76.0 - 124.0	1.07 - 1.38	1.00 - 1.06
Mean	18.98	33.08	8.06	8.06	18	217.54	100.75	1.20	1.045
S.D.	6.18	3.05	0.91	1.03	4.07	41.72	13.40	0.10	0.017

Table-2: Plankton diversity in the water park pond.

Phytoplanktons		Zoolplanktons	
Class	Name	Family	Name
Chlorophycae	*Cosmarium*sp., *Chlorella* sp.,	Rotifera	*Brachinous*sp., *Keratella*sp.,
	*Zygnema*sp., *Spirogyra* sp.,		*Notomate*sp., *Notholca*sp.,
	Volvox sp., *Ulothrix* sp.,		*Totaria*sp., *Asplanchna*sp.,
	*Crucigenia*sp., *Tetraspora*sp.,		*Polyarthra*sp., *Lecane*sp.
	Chlamydomonas sp., *Oedogonium* sp.		
Bacillariophycae	*Melosira*sp., *Synedera*sp.,	Cladocera	*Diaphnosoma*sp., *Ceriodaphnia*sp.,
	*Diatoma*sp., *Cymbella*sp.,		*Daphnia* sp., *Simocephalus*sp.,
	*Navicula*sp., *cyclotella*sp.,		*Bosmina* sp., *Bosminopsis*sp.,
	*Pinnularia*sp., *Nitzschia*sp.		*Macrothrix*sp.
Cyanophycae	*Anabaena* sp., *Nostoc* sp.,	Copepoda	*Cyclops* sp., *Mesocyclops*sp.,
	Spirulina sp., *Oscillatoria* sp.,		*Diaptomus*sp., *Heliodiaptomus*sp.,
	*Cloecapsa*sp., *Microcystis* sp.		*Nauplius* larva
Euglenophycae	*Euglena, Phacus*	Ciliata	*Paramecium* sp., *Vorticella* sp.

Table-3: Fluctuations in Plankton population (monthly) in Waterpark pond.

Months	Phytoplankton Group Diversity (units/litre)					Zooplankton Group Diversity (units/litre)				
	Chloro phycae	Cyano phycae	Bacilario phycae	Eugleno phycae	Total	Rotifera	Cladocera	Copepods	Ciliates	Total
Jan	687	828	657	92	2264	876	585	457	435	2353
Feb	404	302	203	25	934	836	567	421	111	1935
Mar	272	233	187	17	709	503	437	387	145	1472
Apr	152	621	192	27	992	433	356	201	98	1088
May	185	823	189	54	1251	343	452	217	132	1144
June	744	901	683	76	2404	321	378	756	232	1687
July	847	988	978	87	2900	882	654	659	643	2838
Aug	424	534	287	84	1329	476	543	127	99	1245
Sep	415	413	307	78	1213	321	431	113	87	952
Oct	423	346	298	88	1155	475	476	108	78	1137
Nov	130	237	178	78	623	365	352	98	98	913
Dec	137	398	167	89	791	231	531	95	96	953
Total	4820	6624	4326	795	16565	6062	5762	3639	2254	17717
Mean	401.66	552	360.5	66.25	-	505.16	480.16	303.25	187.83	-
Percentage (%)	29.09	39.98	26.11	4.79	-	34.21	32.52	20.53	12.72	-

Table-4: Correlation of coefficient of planktons with some parameters.

Phytoplankton			Zooplankton		
Class	Parameters	Correlation coefficient (r)	Family	Parameters	Correlation coefficient (r)
Chlorophycae	Temperature	0.372	Rotifera	Temperature	-0.271
Chlorophycaae	pH	-0.083	Rotifera	pH	-0.353
Chlorophycae	DO	-0.093	Rotifera	DO	0.281
Chlorophycae	Nitrate	0.465	Rotifera	Nitrate	0.261
Cyanophycae	Temperature	0.479	Cladocerans	Temperature	-0.105
Cyanophycae	pH	0.336	Cladocerans	pH	-0.497
Cyanophycae	DO	-0.636	Cladocerans	DO	0.301
Cyanophycae	Nitrate	0.778	Cladocerans	Nitrate	0.123
Bacillariophycae	Temperature	0.390	Copepods	Temperature	0.226
Bacillariophycae	pH	-0.058	Copepods	pH	0.369
Bacillariophycae	DO	-0.160	Copepods	DO	-0.351
Bacillariophycae	Nitrate	0.568	Copepods	Nitrate	0.781
Euglenophycae	Temperature	0.289	Ciliates	Temperature	0.159
Euglenophycae	pH	-0.410	Ciliates	pH	-0.123
Euglenophycae	DO	0.162	Ciliates	DO	-0.053
Euglenophycae	Nitrate	-0.233	Ciliates	Nitrate	0.560

Table-3 shows that the dominant species belong to class Cyanophycae about 40% of the total phytoplankton followed by Chlorophycae 29.09%, Bacillariophycae 26.11%, and Euglenophycae 4.8%. The yearly productivity of zooplankton indicates that the rotifers are dominant which constitute 34.21% of the total zooplankton, and followed by Cladocerans 32.52%, Copepods 20.53%, and Ciliates 12.72%. Similar findings have been made by Sinha, Prakash[27] and Verma and Prakash[28]. The result shows that the pond is fertile. A total of 58 individuals of zooplanktons and 85 individuals of phytoplanktons have been enumerated from the Ghodaghodi Lake of Sudurpaschim Province, Nepal with a conclusion that the Lake is favorable for fish diversity[29].

The study discovered a bimodal pattern of seasonal variability in plankton, with a primary peak in July and a secondary peak in January (Table-3). A similar pattern of plankton fluctuation was observed in the freshwater bodies of UP, India by Khan and Siddiqui[30], and Verma and Prakash[28].

Table-4 shows the correlation of phytoplankton and zooplankton with some physico-chemical parameters like temperature, pH, DO, and Nitrate. The phytoplanktons of class Chlorophycae show weak positive correlation with temperature and moderate correlation with nitrate (0.372 and 0.465 respectively), and weak negative correlation with pH and DO (-0.083 and 0.093 respectively). The phytoplankton of class Cyanophycae also shows moderate positive correlation with temperature and strong correlation with Nitrate i.e., 0.479 and 0.778 respectively, and shows weak positive correlation with pH and moderate correlation with DO e.i., 0.336 and -0.636 respectively. Similarly, the phytoplankton of class Bacillariophycae shows weak positive correlation with temperature and Nitrate (0.390 and 0.568 respectively), and weak negative correlation with pH and DO (-0.058 and -0.160 respectively). The members of class Euglenophycae show weak positive correlation with temperature and DO i.e., 0.289 and 0.162 respectively, and show moderate negative correlation with pH and weak negative correlation with Nitrate i.e., -0.410 and -0.233 respectively.

The zooplanktons of family Rotifera show weak positive correlation with DO and Nitrate i.e., 0.281 and 0.261 respectively but they show weak negative correlation with temperature and pH i.e., -0.271 and -0.353. The Cladocerans also show weak positive correlation with DO and Nitrate i.e., 0.301 and 0.123 respectively and show weak negative correlation with temperature and pH i.e., -0.105 and -0.497 respectively. The Copepods show weak positive correlation with temperature and pH, i.e., 0.226 and 0.369 respectively, and strong positive correlation with Nitrate i.e., 0.781 but the Copepods show weak negative correlation with DO (-0.351). Ciliates are the zooplanktons show weak positive correlation with temperature and moderate positive correlation with Nitrate i.e., 0.159 and 0.560 respectively and show negative correlation with pH and DO i.e., -0.123 and -0.053 respectively.

Conclusion

A study was conducted to investigate the limnology of the Waterpark pond of Nepalgunj city of Banke, Nepal since January 2022 to December 2022. Different physico-chemical parameters and plankton diversity was studied. The water temperature of a the Waterpark pond varied from 9.5 to 27.6ºC, which is ideal for the culture of Indian major carps and exotic carps. pH of water in the Waterpark pond ranged from 7.2-9.8, and was highest in the summer and lowest in the rainy season. The pond's water transparency varied from 28.6 to 38.7 cm., and winter was the season with the most transparency, while rainy seasons had a moderate amount and summer had the least. Dissolved oxygen levels fluctuate between 5.8 and 8.9 ppm and it was noted that winter months had the highest dissolved oxygen levels due to photosynthesis. Free carbon dioxide in a water body ranged from 14.0 to 26.0 ppm with maximum and minimum concentrations observed during the rainy and winter seasons. Pond is nutrient-rich and productive, with alkalinity ranging from 136.0-294.0 ppm and with a hardness ranging from 76-124 ppm is suitable for fish culture. Nitrate concentration ranged from 1.07 to 1.38 ppm which was highest during post-monsoon season. Phosphate concentration were between 1.00-1.06 ppm throughout the year.

26 phytoplanktons and 22 zooplnktons were identified form the Waterpark pond which proved that the pond is rich in plnkton diversity. The Chlorophycae and Rotifers were identified as dominant phytoplankton and zooplanktons of the pond. It was discovered that both phytoplanktons and zooplanktons are not highly associated with temperature, pH, DO, and Nitrate. The majority of them have a slight to moderate correlation with the parameters listed above. Members of Cyanophycae as well as Copepods have a strong correlation with Nitrates of the pond water.

Acknowledgement

The author appreciates the Department of Zoology, Mahendra Multiple Campus, Nepalgunj for providing lab support and water quality test kit during sample test and plankton study of the pond. The author also appreciates Mr. Ravi Mahatara's assistance for statistical analysis throughout the entire study period.

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