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Multivariate Statistical Analysis for Water Quality Variation in Baraila Lake, Bihar, India

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Abstract

The Baraila Lake plays an important role in conservation of the plant and animal species in Vaishali, Bihar, India. Since, water quality of this Lake is utilized for different human purposes, complete periodic chemical and physical quality assessment of its water seems necessary. Water quality assessment was calculated using the following parameters:- Water Temperature, P^H, Turbidity, Dissolved Oxygen, Chloride, Alkalinity, Phosphate, Nitrate, Ammonia, Fluoride, Sulphate, Chemical Oxygen Demand , Biological Oxygen Demand, TDS, TC and FC. There is no such spatial variation in concentration of water quality observed during the study period. The correlation matrix shows that the micronutrient and macronutrient concentration is negatively correlated with alkaline nature of Baraila Lake. The lake manager needs to study the monitoring of water quality parameters of Baraila Lake on seasonal basis.

Keywords: Correlation matrix; Water quality; Baraila Lake

Introduction

The aquatic ecosystems (rivers, reservoirs, Lakes, lake and estuary) are directly or indirectly benefiting human being by maintaining ecological cycle. The Lakes are the one of important aquatic ecosystem that provide habitat to various aquatic and water dependent flora and fauna, also used for supplying drinking water and used for agriculture. The water is the main component of aquatic ecosystem to draw conclusion for determining the status. The physicochemical characteristics are helpful for assessing the quality of water. The water quality often gets degraded with the effect of pollutant from source of agricultural land, industrial discharge and many other men made as well as natural reasons. Polluted drinking and bathing water, both are source of many waters borne diseases. Thus; this needs immediate action and continuous monitoring of pollution level in order to prevent the pollution because of its importance in maintaining the human health, plants and agriculture and also biodiversity of the particular ecosystem. The current study aims to access the quality of water in Baraila Lake of Vaishali district in Bihar with respect to different environmental condition as well as seasonal variability. This study will be only representing the water quality during summer. However, in order to understand the seasonal variability study will be carried out during peak monsoon, and peak winter. Various concepts were used to develop better understanding of Complex datasets of water quality parameters by researchers, where the concept of Water Quality Index (WQI) is one of the most effective approaches to convey the information on water quality from common people to the stakeholders for better understanding and decision making (Shah and Joshi 2017). It generates a single value after integrating a large number of water parameters through mathematical operations, which decides the quality status of water [8] studied that the analysis of Zooplankton contents, counting and determination of the species was difficult because of the great number of phytoplankton in the chaurs of the studyarea. The Zooplankton analysis showed a good diversity of Zooplankton community; mainly consisting of Rotifera, cladocera and codopoda groups [7], studied that the surafce water of this “BAT” shaped Lake has decreased rapidly in last half decade which is alarming for the related ecology and biodiversity [2]. Studied that the high diversity of wild and naturalized angiospermic species within the eco-sensitive zone of Baraila lake Salim Ali , Jubbani Sahni bird Santury , Vaishali district, Bihar.

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Study Area

The Baraila lake Salim Ali Jubba Sahni Bird Sanctuary, Vaishali district, Bihar has aggregate area of 12.7 km^2 located in between 25°45'58" & 25°45'37" North latitude and between 85°31'48" & 85°34'50" East longitude. The sanctuary is of immense ecological and environmental importance by way of performing hydrological and Lake and aquatic ecosystem functions of riverine zone in Gangetic plains and habitat of various aquatic flora and fauna. The study area has immense ecological and environmental importance by way of performing hydrological and Lake and aquatic ecosystem. Keeping the conservation aspects in mind the Government of Bihar declared the Lake as sanctuary in in the year 1997. However, it was published in Gazette of India as Baraila lake Salim Ali Jubba Sahni Bird Sanctuary in 2016.

Material and Methods

Sampling Technique

The Lake area was divided into equal size of grids (500*500 meters) using GIS software. Grids for sampling were chosen based on random sampling method. Water samples were collected inside the randomly selected grids (marked in red dots) of the Lake as shown in the (Figure 1). The sample collection method was followed as the procedure recommended in [1] guidelines for ambient water quality. All the collected samples were immediately preserve in dark sterile bottles and was processed for individual parameters analysis.

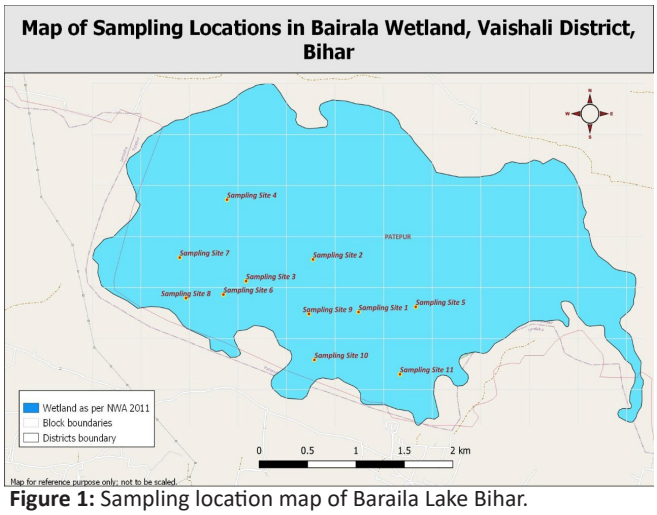

Figure 1: Sampling location map of Baraila Lake Bihar.

Sample Analysis

The water temperature, turbidity and P^H of the collected samples were measured by using the water quality checker by immersing directly in the water body for a time period, sufficient to permit constant reading. The color of the water samples was measured by visual comparison method. The transparency was measured by using sechidisk. The P^H of the samples were cross checked by P^H meter using standard buffer solutions of P^H. Nutrients (Nitrate, Ammonia, and O-Phosphate) were analyzed by auto analyzer scalar methodology mode. The DO and BOD were analysed by Winkler's method. The water quality monitoring was confined to surface euphotic zones of the Baraila Lake.

Results and Discussion

Spatial Variations of Physio-Chemical Water Quality Parameters

Water temperature, P^H: Water temperature plays an important role in influencing and the periodicity, occurrence and abundance of phytoplankton. In the present study water temperature varied from 27-29°C with avg. 28°C. The P^H represents hydrogen ion concentration. It is the factor, which controls the biogeochemical cycle process of the Lake. It varied between 6.89-8.89 with avg. 7.79. The avg. P^H of the Lake is alkaline during all of our observations, it concluded that the whole Lakeis slightly alkaline in nature.

Turbidity: In the present study, Turbidity varied from 3.3-77.4 with an Avg.13.045. NTU Turbidity values have been given in (Table 1). The Pearson correlation matrix shows that phosphate concentration is strongly correlated with Turbidity.

Dissolved Oxygen (DO): Dissolved oxygen is mostly required for living organism to sustain their life. A definite level of oxygen is required for living organism in any aquatic ecosystem, below which mass mortality of fish and other aquatic animal has been reported. Oxygenation process in anaquatic system depends on the rate of photosynthesis, decomposition of organic matter and physicochemical properties of water. The phytoplankton and macrophytes are the primary producers and are the source of dissolved oxygen. However when they decompose, the nutrients contained in that organic matter are converted into inorganic form by microorganisms consuming oxygen. The depleted oxygen levels in turn may lead to fish kills and a range of other effects reducing biodiversity. The DO concentration was varied in between 3.6 – 12.2 with avg. 8.31 mg/l (Table 1) The Pearson correlation matrix shows that dissolved oxygen level influence by the alkaline nature of the Lake (Table 2).

Chloride: Chloride is considered to be an essential nutrient for human health and the main source of chloride is from foods, with drinking water making up only a small portion of normal dietary intake. High levels of chloride can corrode and weaken metallic piping and fixtures, give a "salty" taste to the drinking water, damage household appliances, boilers, and, if the water is being used for irrigation, it may inhibit the growth of vegetation. Chloride values for all the 11 station are shown in the graph the value of chloride have been subjected to analysis of variance. In the present study, chloride varied from 11.0 - 21.0 with avg. 15.727 (mg/l).

Alkalinity: The alkalinity of water is its capacity to neutralize acids. Alkalinity of water is a measure of weak acid present in it and of the cations balanced against them [9]. Total alkalinity of water is due to presence of mineral salt present in it. It is primarily caused by the carbonate and bicarbonate ions [16]. In the present study, total alkalinity varied from 130.0 - 190.0 with avg. 177.45 (mg/l as $CaCO_3$).

Phosphate: Phosphorus (P) is a key biogeochemical element supporting phytoplankton growth and fish production in lake as well as estuarine and continental shelves. Phosphorus is exclusively present as Phosphate in natural Environment. The source of Phosphate from river runoff and human made activity modernise agricultural process and using phosphate base fertilizer and detergent. Phosphate is considered as the most important inorganic nutrient which can limit phytoplankton production and thereby the overall ecological processes in marine ecosystems. In aquatic ecosystem, 60% of the PO_4 input to water may occur from the sediment-water exchange. However, PO_4 dynamics in shallow waters are not well deciphered in view of its rapid biological and geochemical processes. Plants directly take up the phosphates as essential nutrients during photosyn-

thesis. Orthophosphates are typically preferred by autotrophic phytoplankton, although some assimilation of organic phosphorus may occur, especially during periods of P deficiencies When plants die or are eaten, the organic phosphorus is rapidly converted to orthophosphates. In the present study, Phosphate varied from 0.02 - 0.018 with avg. 0.026 (mg\l).

Ammonia: Ammonia values for all the 11 station are shown in the graph the value of Ammonia have been subjected to analysis of variance. In the present study, ammonia varied from 0.04 – 0.41 with avg. 0.187 (mg\l).

Fluoride: The levels are usually lower in estuarine areas due to dilution by fresh water, unless fluoride pollution is occurring upstream. Measuring fluoride in water is important as fluoride is toxic to humans and aquatic life. Fluoride values for all the 11 station are shown in the graph the value of Fluoride have been subjected to analysis of variance. In the present study, fluoride varied from 0.25 – 0.96 with avg. 0.483 (mg\l).

Sulphate: Sulphur is an essential plant nutrient. Aquatic organisms utilize sulphur and reduced concentrations have a detrimental effect on algal growth. The most common form of sulphur in well-oxygenated waters is sulphate. When sulphate is less than 0.5 mg/L, algal growth will not occur. Sulphate values for all the 11 station are shown in the graph the value of sulphate have been subjected to analysis of variance. In the present study, Sulphate varied from 2.24 – 42.95 with avg. 16.3 (mg\l).

Nitrate (NO_3): It is also one of the form of Nitrogen, generally it is in higher conc. than nitrite in a system. NO_3 is the oxidized form of nitrogen can cause eutrophication when present in excess. Hence it is a good indicator of water quality. In the present study, Nitrate varied from 0.06 - 0.18 with avg. 0.118 (mg\l).

Table 1: Spatial variation of physiochemical variables of water quality of Baraila Lake.

Sampling Location/Parameters	PH	Turbidity (NTU)	DO (mg/l)	Chloride (mg/l)	Alkalinity (mg/l)	Phosphate (mg/l)	Ammonia (mg/l)	Fluoride (mg/l)	Sulphate (mg/l)	Nitrate (mg/l)	COD (mg/l)	BOD (mg/l)	TDS (mg/l)	TC (MPN/100 ml)	FC (MPN/100 ml)
BW1	8.25	4.3	9.5	13	180	0	0.2	0.39	2.46	0.12	36	4.6	238	9200	3500
BW2	7.89	3.3	9.4	13	186	0	0.08	0.36	2.24	0.08	36	3.2	248	1300	790
BW3	7.39	4.7	4.7	15	190	0	0.04	0.27	2.57	0.06	60	1.1	246	1100	790
BW4	6.93	4.6	3.6	11	216	0	0.16	0.3	3.69	0.1	20	2.2	260	3500	240
BW5	7.63	5.3	9.6	16	190	0.02	0.01	0.25	2.24	0.12	24	2.2	240	2400	270
BW6	6.89	4.9	4.1	16	190	0	0.19	0.44	3.13	0.07	36	2.3	252	3500	4400
BW7	8.89	12.3	11.9	21	144	0.07	0.19	0.51	25.73	0.17	40	5.9	246	940	68
BW8	7.35	4.3	6.3	18	180	0.04	0.27	0.52	36.35	0.14	28	3.1	278	160000	92000
BW9	7.99	8.2	8.8	20	180	0.08	0.35	0.8	42.95	0.14	42	5.3	278	92000	17000
BW10	7.79	77.4	11.3	18	166	0.18	0.41	0.96	41.16	0.12	36	7.2	296	16000	5400
BW11	8.71	14.2	12.2	12	130	0.06	0.16	0.52	16.78	0.18	44	5	174	9200	5400
Minimum	6.89	3.3	3.6	11	130	0	0.01	0.25	2.24	0.06	20	1.1	174	940	68
Maximum	8.89	77.4	12.2	21	216	0.18	0.41	0.96	42.95	0.18	60	7.2	296	160000	92000
Average	7.79	13.05	8.31	15.73	177.45	0.04	0.19	0.48	16.30	0.12	36.55	3.83	250.55	27194.55	11805.27

Table 2: Pearson correlation matrix among physiochemical variables of the water quality of Baraila Lake.

	PH	Turbidity	DO	Chloride	Alkalinity	Phosphate	Ammonia	Fluoride	Sulphate	Nitrate	COD	BOD	TDS	TC	FC
PH	1														
Turbidity	0.123	1													
DO	.892**	0.416	1												
Chloride	0.222	0.266	0.258	1											
Alkalinity	-.850**	-0.301	-.803**	-0.289	1										
Phosphate	0.349	.890**	0.578	0.543	-0.511	1									
Ammonia	0.097	.625*	0.209	0.486	-0.233	.757**	1								
Fluoride	0.259	.759**	0.434	0.558	-0.416	.909**	.922**	1							
Sulphate	0.269	0.536	0.367	.715*	-0.412	.822**	.847**	.882**	1						
Nitrate	.744**	0.147	.709*	0.318	-.758**	0.48	0.359	0.399	0.564	1					
COD	0.322	0.032	0.112	0.152	-0.389	0.073	-0.066	0.11	0.045	-0.113	1				
BOD	.681*	.677*	.781**	0.438	-.677*	.836**	.741**	.830**	.703*	.665*	0.061	1			
TDS	-0.46	0.387	-0.29	0.525	0.479	0.364	0.557	0.454	0.487	-0.297	-0.243	0.132	1		
TC	-0.136	-0.089	-0.13	0.426	0.02	0.178	0.491	0.354	.658*	0.293	-0.158	0.076	0.424	1	
FC	-0.199	-0.106	-0.184	0.295	0.008	0.069	0.34	0.177	0.497	0.233	-0.224	-0.048	0.328	.932**	1
****p <0.01**	*** <0.05**														

Chemical oxygen demand (COD): COD is a measure of the oxygen equivalent of the organic matter in a water sample that is susceptible to oxidation by a strong chemical oxidant. COD is widely used as a measure of the susceptibility to oxidation of the organic and inorganic materials present in water bodies and in the municipal and industrial wastes. Chemical oxygen demand (COD) values for all the 11 station are shown in the graph the value of COD have been subjected to analysis of variance. In the present study COD varied from 20.0 - 44.0 with avg. 35.63 (mg/l).

Biochemical oxygen demand (BOD): It is the environmental parameter, which is very much important to monitor to check the health of the ecosystem in terms of the pollution status of the lake indicating the total organic matter load to the system. It controls the biodiversity of the ecosystem with a greater extent. In the present study BOD varied from 1.1 – 7.2 with avg. 3.827 (mg/l).

Total dissolved solid (TDS): The total dissolved solids test is used as an indicator test to determine the general quality of the water. TDS values for all the 11 station are shown in the graph the value of TDS have been subjected to analysis of variance. In the present study TDS varied from 174.0 - 296.0 with avg. 250.54 (mg/l).

Total coliform (TC) and faecal coliform (FC): TC and FC test is done for assessing quality of water, which is intended to use for different purpose like bathing, drinking. It shows the level of microbial contamination which is unfit for use. It show pathogen contamination in drinking water which causes many diseases if consumed on regular basis. In the present study, TC varied from 940.0 to 160000.0 with avg. 27,194.54 (MPN/100 ml) and FC varied from 68.0 to 92000.0 with avg. 11,605.27 (MPN/100 ml).

Conclusion

In this study; all water quality parameters varied significantly across the Lake stretches during the study period. The water quality parameters like: D.O., Chloride, Fluoride i.e., which varied many fold than the standard values and have significant contribution in compromising the overall water quality of this Lake. This Lake is the only surface water resource in this area, which fulfils the water demand of rapidly increasing population for the purpose of irrigation, livestock maintenances and long term use. Health of aquatic life as well as the life of dependent population is crucial. Thus; its important for wetland manager to implement the conservation action in a sustainable manner.

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