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RESEARCH ARTICLE

A STUDY ON PHYSICO-CHEMICAL PARAMETERS AND CORRELATION ANALYSIS OF SURFACE WATER OF NAWABGANJ LAKE

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ABSTRACT

A study of the physico-chemical parameters on surface water of Nawabganj Lake was conducted from summer and winter. Surface water was collected from twenty different stations along the Lake. Water samples were collected and analysed for physico-chemical variables. The average value of surface water on winter-summer the pH was 7-7.042105; EC (Electrical Conductivity) 524.8-492.5µs/cm, Tub. (Turbidity) 4.9-5.5NTU, DO (Dissolve Oxygen) 6.65-6.61Mg/L, BOD (Biological Oxygen Demand) 3.55-3.3Mg/L, TDS (Total Dissolve Solids) 322.95-300.7Mg/L, TS (Total Solids) 459.95-422.3Mg/L, Cl (Chloride) 50.9-43.15Mg/L, SO_4 (Sulphate) 25.5-26.25Mg/L, N (Nitrate) 5.95-5.35Mg/L, Na (Sodium) 30.25-29.85Mg/L, K (Potassium) 3.835-3.76Mg/L, Mg (Magnesium Hardness) 73.7-72.25Mg/L, PO_4 (Total Phosphorus) 0.134-0.124Mg/L, COD (Chemical Oxygen Demand) 12.3-13.1Mg/L, T.C.(Total Coliform) 376-347.5MPN/100ml, F.C.(Feacal Coliform) 191.5-142.95MPN/100ml, F (Fluoride) 0.595-0.645Mg/L, Fe (Iron) 0.3545-0.3345Mg/L, Zn (Zinc) 0.0975-0.07Mg/L. The databases obtained were subjected to Pearson correlation matrix. Correlation coefficients revealed positive and significant correlations between the pairs of parameters and metals in surface water. The major variations are related to anthropogenic activities (irrigation agricultural, construction activities, clearing of land, and domestic waste disposal). The present study, however, makes several is believed to serve as a baseline data for further studies. Future research should therefore noteworthy contributions to the existing knowledge on the spatial variations of surface water quality and concentrate on the investigation of temporal variations of water quality in the lake. The lake is gradually tending towards eutrophication.

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INTRODUCTION

The knowledge of the physico-chemical regime of a water body is of great value in the determination of its productivity, usefulness and other characteristics which influence the vertical and horizontal migration of organisms, their distribution, diversity, composition and feeding pattern (Adebisi *et al.,* 1981). The physical and chemical characteristics of water are important parameters as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals. Variations in water quality parameters due to pollution affect the quality of life resident species and changes are reflected in the biotic community structure with the most vulnerable dying off leaving behind tolerant species. Some species are eliminated, some are re-enforced for survival, some are proliferated, and some decrease in number. Water quality monitoring is of immense importance in the conservation of water resources for fisheries, water supply and other activities; it involves the assessment of physico-chemical parameters of water bodies. Impacted changes in the quality of water are reflected in the biotic community structure, with the vulnerable dying, while the most sensitive species act as indicators of water quality (Barbour *et al*., 1999). Several studies on aquatic ecosystem impairment have been reported in Nawabganj lake water bodies. These include the works of (Ogbogu *et al*., 1996, 2001).

Correlation analysis measures the closeness of the relationship between two variables at a time. The values of correlation coefficient nearer to +1 or –1, shows the probability of linear relationship between the variables x and y. This analysis attempts to establish the nature of the linear relationship between the variables and thereby provides a mechanism for prediction (Mulla *et al*., 2007; Kumar *et al*., 2005; P. Lilly Florence *et al*., 2012). Therefore, in recent years an easier and

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simpler approach based on statistical correlation, has been developed using mathematical relationship for comparison of physico-chemical parameters. Extensive research has been carried out on statistical analysis to assess the surface water quality (Joshi *et al*., 2009) have assessed the water quality characteristics of river Ganga in Haridwar, India using Person's Correlation. Statistical analysis of physico-chemical parameters of water has been reported from the different parts of India (Bhandari *et al*., 2008, Sharma *et al*., 2009).In this present study, an attempt has been made to evaluate and improve the quality of surface water in the study area and thereby to analysis correlation study of various physico-chemical parameters. This study is necessary to update the information and determine the effects of anthropogenic activities on water quality characteristics and nutrient level in relation to zooplankton abundance of the lake.

METERIALS AND METHODS

In order to identify the quality of lake water sampling was carried out at 20 different locations during winter and summer seasons as described below in the Table 1. Water samples were collected during each sampling season for physico-chemical parameters. The sampling sites in the Nawabganj Lake were located near national highway, bridge site, ring road, near Ravanhar, near Nawabganj to Bichiya road, deer park, Island, and watch tower etc. in winter and summer season. The samples collected in a pre-cleaned plastic bottles and fix it by adding preservatives. The analysis of physico-chemical parameters include pH, Electrical Conductivity, Turbidity, DO, Total Dissolve Solids, Total Solids, Chlorides, Sulphate, Nitrate, Sodium, Potassium, Magnesium, Total Phosphorus, BOD, COD, Total Coliform, Fecal coliform, Fluoride, Ion, Zinc and Arsenic.

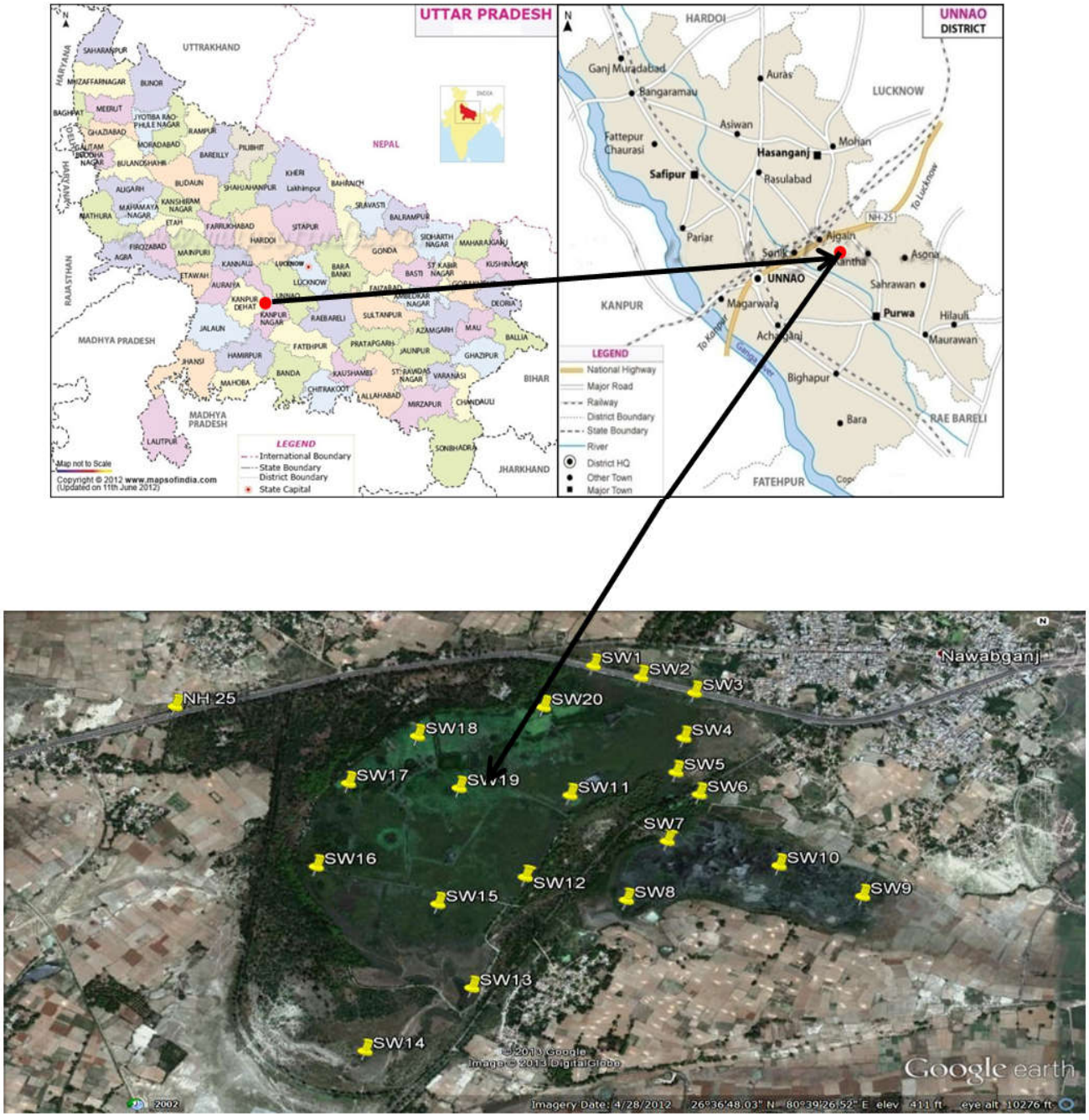

Fig. 1. Map showing sampling sites on the Nawabganj Lake Unnao.

The samples were taken in the replicates at each site of the lake and analysed as per standard procedure as mentioned in APHA laboratory manual 1989. Location of the sampling sites are given in the Table 1.

The correlation co-efficient 'r' was calculated using the equation (Zaidi and Pal, 2015).

$$r = \frac{N\sum (XiYi)-(\sum Xi).(\sum Yi)}{\sqrt{[N\sum Xi^2-(\sum Xi)][N\sum Yi-(\sum Yi)^2]}}$$

Where, Xi and Yi represents two different parameters.
N= Number of total observations

Table 1. Location of the sampling sites (Nawabganj Lake)

S.No.	Sampling Code	GPS Reading		
		Elevation(ft.)	Latitude-North (deg., min, sec)	Longitude-East (deg., min, sec)
1.	SW1	408	26°37'13.19"N	80°39'30.12"E
2.	SW2	410	26°37'11.35"N	80°39'36.34"E
3.	SW3	409	26°37'9.70"N	80°39'40.85"E
4.	SW4	407	26°37'4.47"N	80°39'42.95"E
5.	SW5	412	26°36'57.64"N	80°39'42.10"E
6.	SW6	417	26°36'55.59"N	80°39'42.12"E
7.	SW7	412	26°36'50.54"N	80°39'40.06"E
8.	SW8	407	26°36'41.27"N	80°39'36.13"E
9.	SW9	402	26°36'43.39"N	80°40'5.58"E
10.	SW10	407	26°36'46.93"N	80°39'51.56"E
11.	SW11	405	26°36'54.07"N	80°39'29.19"E
12.	SW12	411	26°36'45.52"N	80°39'24.63"E
13.	SW13	408	26°36'30.25"N	80°39'17.49"E
14.	SW14	413	26°36'21.69"N	80°39'5.42"E
15.	SW15	402	26°36'41.16"N	80°39'13.21"E
16.	SW16	411	26°36'46.73"N	80°38'59.32"E
17.	SW17	410	26°37'0.43"N	80°39'4.51"E
18.	SW18	415	26°37'6.76"N	80°39'12.85"E
19.	SW19	404	26°36'53.26"N	80°39'14.21"E
20.	SW20	416	26°37'5.77"N	80°39'29.27"E

RESULTS

Physico-Chemical Parameters

The physico-chemical nature of surface water depends upon number of factors like the hydrological and geological nature of the watershed, soil and the type of vegetation it supports and a variety of biological processes both within and outside lake. The average recorded value of physico-chemical properties of Nawabganj lakes have been presented in Table 3 and 4 respectively and are as follows:

pH

The pH is the measurement of free acidity or alkalinity of water solution; hence it is an important factor for water analysis. The pH is one of the most important factors that influence the aquatic production. The variation in the pH is an important parameter in water body since most of the aquatic organisms are adapted to an average pH and do not withstand abrupt changes (Mini *et al*., 2003) Slightly alkaline where pH varied from winter season 6.34 to 7.72, whereas in summer season 6.25 to 7.78 (refer Table 3-4).

Electrical Conductivity (EC.)

Conductivity is a measure of the ability of water to conduct an electric current. It is sensitive to variations in dissolved solids, mostly mineral salts. Decrease in Conductivity may be due to dilution by rain water and high conductivity values have been reported to be indicative of an increase in the amount of polluting particles. Higher levels of conductivity reflect on the pollution status as well as trophic levels of aquatic body. Electrical conductivity (EC) which is a measure of the ability of water to conduct an electric current and ranged from 468 to 628 µS/cm during winter, 384 to 594 µS/cm in summer (refer Table 3-4).

Dissolved Oxygen (DO)

Dissolved Oxygen (DO) play an important role in water quality determination. The introduction of Oxygen demanding materials, either organic or inorganic into water causes depletion of the DO in the water. This poses a threat to fish and other higher forms of aquatic life. The concentration of DO regulates the distribution of flora and fauna. It is also essential to all forms of aquatic life especially for those organisms responsible for self purification process in natural waters. The Dissolved oxygen (DO) in winter season followed5.0 to 7.7 mg/L, 5.1 to7.4mg/L in summer (refer Table 3-4).

Biological Oxygen Demand (BOD)

Biological Oxygen Demand (BOD) is the quantity of Oxygen required for the metabolic activities of microorganism for the biological degradation of organic matter present in water. The mean BOD was similar in winter 2 to 8mg/L and in summer 2 to 7mg/L (refer Table 3-4). In most of the cases, the BOD was more during summer and winter season which might be due to reduced rate of water flow and the accumulation of waste from anthropogenic activities.

Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) is a method to determine the organic load of water body i.e, susceptible to oxidation. The mean COD was similar in Nawabganj lake 6 to 25mg/L in winter and 7 to 24mg/L in summer, (refer Table 3-4). Enhanced level of COD observed during present investigation may be due to high temperature and increased evaporation of water.

Turbidity

Turbidity is an expression of light scattering and light absorbing property of water and is caused by the presence of suspended particles such as clay, silt; colloidal organic particles, plankton, soil particles, discharged effluents, decomposed organic matter and total dissolved solids as well as the microscopic organisms. Higher turbidity affects the life indirectly by cutting the light to be utilized by the phytoplankton growth. The turbidity was similar in winter 2 to 9 NTU and in Summer 3 to 8 NTU, (refer Table 3-4).

Table 3. Physico-Chemical Characteristics of Water at Different Sampling Sites in the Study Area: Winter (Jan-March, 2013)

Sampling Site	pH	EC	Tub.	DO	TDS	TS	Cl	SO_4	NO_3	Na	K	Mg	PO_4	BOD	COD	T.C	F.C	F	Fe	Zn	As
SW1	7.54	410	2	7.4	248	362	32	16	5	20	3.4	56	0.13	2	7	180	60	0.4	0.34	0.08	<0.01
SW2	7.48	456	4	7	284	394	40	18	4	22	4.4	70	0.17	3	6	230	90	0.6	0.24	0.06	<0.01
SW3	7.25	502	4	6.2	308	432	45	22	6	32	3.9	68	0.16	4	14	240	100	0.8	0.44	0.07	<0.01
SW4	6.34	493	8	7.7	301	429	44	19	6	25	3.6	70	0.14	2	8	280	130	0.6	0.31	0.07	<0.01
SW5	6.98	528	4	6.8	325	458	53	24	10	26	4.3	76	0.09	3	15	240	140	0.7	0.41	0.05	<0.01
SW6	7.72	468	3	7.3	286	400	45	19	2	25	2.6	62	0.11	3	11	300	160	0.3	0.27	0.1	<0.01
SW7	6.6	526	5	6.6	324	449	51	25	4	38	3.6	71	0.14	3	12	330	150	0.4	0.42	0.07	<0.01
SW8	7.2	560	5	6.8	344	483	58	27	6	36	4.2	83	0.18	2	7	410	190	0.7	0.3	0.14	<0.01
SW9	6.76	552	7	6.3	335	489	53	24	8	32	3.4	80	0.14	6	23	470	200	0.6	0.39	0.11	<0.01
SW10	7.19	493	5	6.2	306	442	50	20	7	26	4.1	68	0.11	3	14	290	170	0.6	0.26	0.08	<0.01
SW11	7.64	509	3	7.1	316	454	48	24	3	30	3.5	69	0.1	4	12	350	150	0.7	0.32	0.14	<0.01
SW12	6.34	570	4	6.9	354	497	60	31	5	37	3.6	76	0.17	3	11	440	230	0.5	0.36	0.07	<0.01
SW13	7.28	618	6	6.6	386	537	64	35	5	44	4.6	90	0.12	3	13	530	280	1	0.44	0.12	<0.01
SW14	6.4	525	7	6	320	540	52	32	10	35	3.7	74	0.15	5	16	520	260	0.9	0.36	0.12	<0.01
SW15	7.01	592	5	6.8	365	509	60	38	6	36	4.5	87	0.16	2	6	450	220	0.7	0.4	0.1	<0.01
SW16	6.88	422	3	7.4	262	373	35	21	2	26	2.9	62	0.1	3	9	400	250	0.5	0.25	0.08	<0.01
SW17	7.22	510	4	6.5	311	441	45	24	5	28	3.8	69	0.14	4	11	440	230	0.3	0.44	0.06	<0.01
SW18	6.44	584	6	5.5	354	490	58	31	10	40	4.7	79	0.12	4	13	510	290	0.8	0.38	0.14	<0.01
SW19	6.28	628	9	5	388	540	70	35	11	21	4.3	88	0.13	8	25	540	290	0.6	0.34	0.14	<0.01
SW20	7.45	550	4	6.9	342	480	55	25	4	26	3.6	76	0.12	4	11	370	240	0.2	0.42	0.15	<0.01

Note: EC (Electrical Conductivity µs/cm), Tub. (Turbidity NTU), DO (Dissolve Oxygen Mg/L), TDS (Total Dissolve Solids Mg/L),TS (Total Solids Mg/L), Cl (Chloride Mg/L), SO4 (Sulphate Mg/L), N (Nitrate Mg/L), Na (Sodium Mg/L), K (Potassium Mg/L), Mg (Magnesium Hardness Mg/L), PO4 (Total Phosphorus Mg/L), BOD (Biological Oxygen Demand Mg/L), COD (Chemical Oxygen Demand Mg/L),T.C. (Total Coliform MPN/100ml), F.C. (Feacal Coliform MPN/100ml), F (Fluoride Mg/L), Fe (Iron Mg/L), Zn (Zinc Mg/L), As (Arsenic Mg/L).

Table 4. Physico-Chemical Characteristics of Water at Different Sampling Sites in the Study Area: Summer (April-May, 2013)

Sampling Site	pH	EC	Tub.	DO	TDS	TS	Cl	SO_4	NO_3	Na	K	Mg	PO_4	BOD	COD	T.C	F.C	F	Fe	Zn	As
SW1	7.68	384	3	7.2	235	335	31	20	4	22	3.2	58	0.11	2	8	170	50	0.6	0.31	0.07	<0.01
SW2	7.62	412	6	7.1	254	264	39	16	3	27	4.5	64	0.16	2	9	210	70	0.8	0.25	0.07	<0.01
SW3	7.21	480	5	6.9	286	401	45	25	6	29	3.8	71	0.14	3	12	240	80	0.7	0.38	0.07	<0.01
SW4	6.45	467	5	7.4	282	396	42	23	4	24	3.6	70	0.13	2	9	250	82	0.5	0.28	0.07	<0.01
SW5	7.03	510	7	6.7	314	445	48	22	8	31	4.1	75	0.09	4	16	220	72	0.9	0.39	0.07	<0.01
SW6	7.78	430	5	7	265	375	41	17	2	26	2.9	66	0.09	2	10	260	90	0.4	0.26	0.07	<0.01
SW7	6.61	496	4	6.8	302	418	46	28	5	35	3.5	70	0.13	3	13	320	110	0.6	0.35	0.07	<0.01
SW8	7.15	422	7	6.7	256	373	39	33	4	32	4.1	78	0.15	3	14	390	140	0.8	0.28	0.07	<0.01
SW9	6.74	435	6	6.1	266	389	40	26	6	34	3.2	79	0.12	5	21	430	165	0.8	0.38	0.07	<0.01
SW10	7.19	485	5	6.5	292	418	44	28	5	27	4	68	0.1	3	14	280	140	0.5	0.29	0.07	<0.01
SW11	7.56	574	4	6.9	353	503	33	30	3	33	3.4	69	0.12	3	11	330	140	0.5	0.29	0.07	<0.01
SW12	6.36	538	8	6.7	330	462	28	27	6	38	3.9	77	0.15	3	14	400	170	0.7	0.37	0.07	<0.01
SW13	7.43	594	6	6.5	360	509	42	32	7	42	4.5	83	0.1	4	16	500	230	0.9	0.42	0.07	<0.01
SW14	6.25	518	5	5.9	314	453	46	30	9	32	3.6	73	0.12	6	19	480	190	0.9	0.32	0.07	<0.01
SW15	6,58	540	6	7	328	474	50	32	4	35	4.1	81	0.14	2	9	380	150	0.6	0.38	0.07	<0.01
SW16	7.06	408	3	7.1	251	358	40	19	3	22	2.8	59	0.12	2	7	360	180	0.4	0.26	0.07	<0.01
SW17	7.34	464	4	6.4	285	401	42	22	4	26	3.7	70	0.15	3	12	420	190	0.3	0.42	0.07	<0.01
SW18	6.58	562	7	5.4	345	480	54	29	9	38	4.6	78	0.1	5	16	470	220	0.9	0.36	0.07	<0.01
SW19	6.24	586	8	5.1	361	521	62	40	12	19	4.2	80	0.12	7	24	500	230	0.8	0.29	0.07	<0.01
SW20	7.52	545	6	6.8	335	471	51	26	3	25	3.5	76	0.14	2	8	340	160	0.3	0.41	0.07	<0.01

Note: EC (Electrical Conductivity µs/cm), Tub. (Turbidity NTU), DO (Dissolve Oxygen Mg/L), TDS (Total Dissolve Solids Mg/L),TS (Total Solids Mg/L), Cl (Chloride Mg/L), SO_4 (Sulphate Mg/L), N (Nitrate Mg/L), Na (Sodium Mg/L), K (Potassium Mg/L), Mg (Magnesium Hardness Mg/L), PO_4 (Total Phosphorus Mg/L), BOD (Biological Oxygen Demand Mg/L), COD (Chemical Oxygen Demand Mg/L),T.C. (Total Coliform MPN/100ml), F.C. (Feacal Coliform MPN/100ml), F (Fluoride Mg/L), Fe (Iron Mg/L), Zn (Zinc Mg/L), As (Arsenic Mg/L).

Table 5. Pearson Correlation matrix of physico-chemical parameters of surface water with reference to Nawabganj Lake in winter season

	pH	EC	Tub.	DO	TDS	TS	Cl	SO4	NO3	Na	K	Mg	PO4	BOD	COD	T.C	F.C	F	Fe	Zn
pH	1	-0.43	-0.72	0.44	-0.40	-0.49	-0.42	-0.46	-0.60	-0.28	-0.19	-0.38	-0.20	-0.35	-0.41	-0.50	-0.46	-0.25	-0.14	0.00
EC	-0.43	1	0.62	-0.62	1.00	0.93	0.98	0.88	0.52	0.59	0.61	0.94	0.19	0.41	0.45	0.74	0.67	0.40	0.52	0.52
Tub.	-0.72	0.62	1	-0.58	0.59	0.67	0.60	0.49	0.68	0.19	0.39	0.64	0.19	0.54	0.58	0.57	0.47	0.41	0.14	0.31
DO	0.44	-0.62	-0.58	1	-0.59	-0.64	-0.62	-0.56	-0.75	-0.24	-0.52	-0.52	-0.07	-0.75	-0.73	-0.57	-0.54	-0.36	-0.31	-0.38
TDS	-0.40	1.00	0.59	-0.59	1	0.92	0.98	0.88	0.48	0.58	0.61	0.95	0.18	0.39	0.43	0.73	0.67	0.40	0.50	0.51
TS	-0.49	0.93	0.67	-0.64	0.92	1	0.92	0.90	0.60	0.59	0.52	0.88	0.20	0.48	0.51	0.80	0.71	0.50	0.48	0.55
Cl	-0.42	0.98	0.60	-0.62	0.98	0.92	1	0.86	0.52	0.52	0.57	0.92	0.14	0.41	0.48	0.71	0.67	0.37	0.39	0.53
SO4	-0.46	0.88	0.49	-0.56	0.88	0.90	0.86	1	0.45	0.64	0.54	0.85	0.21	0.32	0.30	0.83	0.76	0.48	0.46	0.48
NO3	-0.60	0.52	0.68	-0.75	0.48	0.60	0.52	0.45	1	0.10	0.57	0.50	0.04	0.52	0.62	0.37	0.32	0.49	0.27	0.19
Na	-0.28	0.59	0.19	-0.24	0.58	0.59	0.52	0.64	0.10	1	0.35	0.54	0.26	-0.12	0.00	0.56	0.45	0.53	0.49	0.26
K	-0.19	0.61	0.39	-0.52	0.61	0.52	0.57	0.54	0.57	0.35	1	0.69	0.24	0.05	0.05	0.27	0.23	0.59	0.30	0.14
Mg	-0.38	0.94	0.64	-0.52	0.95	0.88	0.92	0.85	0.50	0.54	0.69	1	0.25	0.33	0.36	0.71	0.62	0.50	0.41	0.48
PO4	-0.20	0.19	0.19	-0.07	0.18	0.20	0.14	0.21	0.04	0.26	0.24	0.25	1	-0.10	-0.24	0.10	-0.10	0.11	0.07	-0.08
BOD	-0.35	0.41	0.54	-0.75	0.39	0.48	0.41	0.32	0.52	-0.12	0.05	0.33	-0.10	1	0.89	0.52	0.46	0.08	0.18	0.40
COD	-0.41	0.45	0.58	-0.73	0.43	0.51	0.48	0.30	0.62	0.00	0.05	0.36	-0.24	0.89	1	0.44	0.39	0.19	0.26	0.28
T.C	-0.50	0.74	0.57	-0.57	0.73	0.80	0.71	0.83	0.37	0.56	0.27	0.71	0.10	0.52	0.44	1	0.93	0.33	0.28	0.59
F.C	-0.46	0.67	0.47	-0.54	0.67	0.71	0.67	0.76	0.32	0.45	0.23	0.62	-0.10	0.46	0.39	0.93	1	0.20	0.23	0.55
F	-0.25	0.40	0.41	-0.36	0.40	0.50	0.37	0.48	0.49	0.53	0.59	0.50	0.11	0.08	0.19	0.33	0.20	1	0.12	0.20
Fe	-0.14	0.52	0.14	-0.31	0.50	0.48	0.39	0.46	0.27	0.49	0.30	0.41	0.07	0.18	0.26	0.28	0.23	0.12	1	0.04
Zn	0.00	0.52	0.31	-0.38	0.51	0.55	0.53	0.48	0.19	0.26	0.14	0.48	-0.08	0.40	0.28	0.59	0.55	0.20	0.04	1

Table 6. Pearson Correlation matrix of physico-chemical parameters of surface water with reference to Nawabganj Lake in summer season

	pH	EC	Tub.	DO	TDS	TS	Cl	SO4	NO3	Na	K	Mg	PO4	BOD	COD	T.C	F.C	F	Fe
pH	1	-0.37	-0.42	0.50	-0.35	-0.41	-0.38	-0.53	-0.65	-0.20	-0.21	-0.47	-0.10	-0.57	-0.55	-0.51	-0.40	-0.39	-0.10
EC	-0.37	1	0.47	-0.50	1.00	0.94	0.46	0.71	0.55	0.45	0.48	0.69	-0.16	0.48	0.42	0.57	0.60	0.25	0.45
Tub.	-0.42	0.47	1	-0.50	0.48	0.40	0.36	0.48	0.55	0.32	0.66	0.77	0.08	0.47	0.56	0.39	0.33	0.57	0.21
DO	0.50	-0.50	-0.50	1	-0.51	-0.53	-0.61	-0.62	-0.84	-0.14	-0.39	-0.54	0.23	-0.92	-0.86	-0.74	-0.73	-0.48	-0.19
TDS	-0.35	1.00	0.48	-0.51	1	0.94	0.45	0.69	0.54	0.44	0.47	0.68	-0.17	0.49	0.42	0.57	0.60	0.24	0.44
TS	-0.41	0.94	0.40	-0.53	0.94	1	0.44	0.76	0.55	0.39	0.29	0.70	-0.28	0.52	0.47	0.62	0.64	0.17	0.47
Cl	-0.38	0.46	0.36	-0.61	0.45	0.44	1	0.46	0.58	-0.15	0.37	0.45	-0.19	0.51	0.42	0.36	0.38	0.18	0.18
SO4	-0.53	0.71	0.48	-0.62	0.69	0.76	0.46	1	0.61	0.32	0.43	0.74	0.01	0.63	0.63	0.69	0.63	0.38	0.21
NO3	-0.65	0.55	0.55	-0.84	0.54	0.55	0.58	0.61	1	0.17	0.49	0.54	-0.29	0.92	0.86	0.55	0.50	0.70	0.24
Na	-0.20	0.45	0.32	-0.14	0.44	0.39	-0.15	0.32	0.17	1	0.41	0.59	-0.05	0.17	0.25	0.40	0.30	0.50	0.49
K	-0.21	0.48	0.66	-0.39	0.47	0.29	0.37	0.43	0.49	0.41	1	0.57	0.12	0.33	0.34	0.27	0.27	0.62	0.24
Mg	-0.47	0.69	0.77	-0.54	0.68	0.70	0.45	0.74	0.54	0.59	0.57	1	0.04	0.53	0.61	0.68	0.57	0.48	0.57
PO4	-0.10	-0.16	0.08	0.23	-0.17	-0.28	-0.19	0.01	-0.29	-0.05	0.12	0.04	1	-0.28	-0.25	0.02	-0.05	-0.17	0.05
BOD	-0.57	0.48	0.47	-0.92	0.49	0.52	0.51	0.63	0.92	0.17	0.33	0.53	-0.28	1	0.95	0.68	0.60	0.64	0.16
COD	-0.55	0.42	0.56	-0.86	0.42	0.47	0.42	0.63	0.86	0.25	0.34	0.61	-0.25	0.95	1	0.63	0.53	0.66	0.19
T.C	-0.51	0.57	0.39	-0.74	0.57	0.62	0.36	0.69	0.55	0.40	0.27	0.68	0.02	0.68	0.63	1	0.96	0.30	0.32
F.C	-0.40	0.60	0.33	-0.73	0.60	0.64	0.38	0.63	0.50	0.30	0.27	0.57	-0.05	0.60	0.53	0.96	1	0.17	0.30
F	-0.39	0.25	0.57	-0.48	0.24	0.17	0.18	0.38	0.70	0.50	0.62	0.48	-0.17	0.64	0.66	0.30	0.17	1	0.10
Fe	-0.10	0.45	0.21	-0.19	0.44	0.47	0.18	0.21	0.24	0.49	0.24	0.57	0.05	0.16	0.19	0.32	0.30	0.10	1

Total dissolved Solid (TDS)

In natural water dissolved solids are consists of inorganic salts, small amount of organic matter and dissolved materials. Dissolved solids are mainly due to carbonates, chlorides, sulphates, nitrates, phosphates, Ca, Mg, Na, K, Fe, Mn, etc. In the present study in winter 248 to 388mg/L and in summer 235 to 360 mg/L, (refer Table 3-4).

Total solid (TS)

Total solids are a measure of the suspended and dissolved solids in water. Total solids are those that can be retained on a water filter and are capable of settling out of the water column into the stream bottom when stream velocities are low. They include silt, clay, plankton, organic wastes, and inorganic precipitates such as those from acid mine drainage. Dissolved solids are those that pass through a water filter. They include some organic materials, as well as salts, inorganic nutrients, and toxins. During the present investigation maximum total solid was recorded at winter 362 to 540mg/L and in summer 264 to 521mg/L, (refer Table 3-4).

Fluoride

Fluoride is a trace element typically present in water at levels from 0.1 to 1.5 mg/L. It may be added excess to water as a measure to prevent tooth decay in humans (0.7 to 1.2 mg/L). Levels at or above 3 mg/l are reported to cause losses of some fish species, depending upon complex water conditions. During the present investigation maximum and minimum range of average Fluoride was recorded in winter 0.2 to 1mg/L and summer 0.3 to 0.9mg/L, (refer Table 3-4).

Nitrate

The concentration of nitrate contained in fresh water seems to be increased agricultural waste and sewage contamination. Such increase may be due to rapid decomposition of organic matter (Ali *et al*., 1999). It also emphasized that when the dead organic matter decomposes in water, it forms complex proteins which get converted into nitrogenous organic matter and finally to nitrate by bacterial activity. In the present investigation maximum and minimum range of nitrate was recorded in winter 2 to 11mg/L and summer 2 to 12mg/L, (refer Table 3-4).

Chloride

Chloride is one of the most important parameter in assessing the water quality. It is of the opinion that higher concentration of Chloride indicates higher degree of organic pollution.In the present investigation maximum and minimum range of chloride in winter 32 to 70mg/L and summer 28 to 62mg/L, (refer Table 3-4).

Sulphate

Sulphate is one of the major anions occurring in natural waters. It may enter natural water through weathering of sulphate bearing deposits. Sulphate can be produced by bacterial or oxidizing action as in the oxidation of organic-sulphur compounds. The source of Sulphate content may be industrial waste, soil, rocks containing gypsum, iron sulphide and other sulpher compounds. In the present study in winter 16 to 38mg/L and in summer 16 to 40mg/L, (refer Table 3-4).

Mg Hardness

Hardness often employed as indicator of water quality depends on the concentration of carbonates and bicarbonates salts of calcium and magnesium or sulphate chloride or other anions of minerals acids. In the present study in winter 58 to 90mg/L and in summer 56 to 83mg/L, (refer Table 3-4).

Iron

The concentration of Fe was found to be very high in water samples collected from different sampling sites, mainly due to the inflow of surface run off from hill torrents and agricultural wastes (agricultural and rocks). Exchangeable Fe usually relates to the adsorbed metals on the sediment surface can be easily remobilized into the Lake water. In the present study, maximum and minimum Iron was recorded 0.3 to 0.44 mg/L at winter and in summer 0.25 to 0.41mg/L, (refer Table 3-4).

Total Coliforms

Total Coliforms is attributed to the anthropogenic activities which are common in the watersheds, Coliforms were recorded from the during winter season maximum and minimum range 180 to 540 MPN/100ml and in summer 170 to 500MPN/100ml, (refer Table 3-4).Theaverage recorded value function graphs for the various parameters are shown in Figure 2.

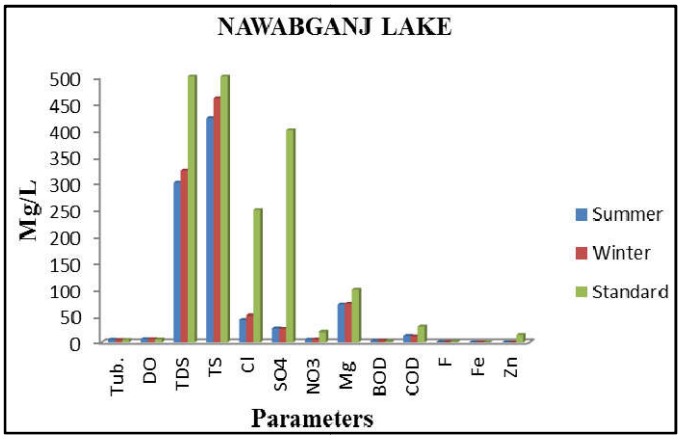

Fig. 2. The graphical representation of the various parameters of Nawabganj Lake

Statistical Analysis

Pearson's correlation analysis (r) is a measure of the extent to which two quantitative variables are linearly related. It summarizes the magnitude of a linear relationship between pairs of variables. The value of relationship takes values ranging from -1 to +1, where +1 represents an absolute perfect positive linear relationship, 0 represents no linear relationship, whereas -1 represents an absolute inverse relationship between

the bivariates. The sign in front of the correlation coefficient value determines the direction of the relationship. Pearson correlation coefficients were computed in order to understand the association and relationship of different physical and chemical parameters including heavy metals of the Nawabganj lake. Pearson correlation matrix was calculated by using SPSS software for different physicochemical parameters (pH, EC, DO, BOD, COD, TDS, TS, Mg Hardness, Cl, NO_3, PO_4, SO_4, Na, K, F, Fe, Zn, Total coliform, and Fecal coliform). Correlation Pearson correlation coefficients were computed in order to understand the association and relationship of different physical and chemical parameters including heavy metals of the Nawabganj lake. During the investigation find-out significant positive correlation and recorded negative correlation between BOD and DO that means where BOD increase then DO will be also decease. The correlation coefficients are presented in the form of matrix, for the Nawabganj lake (Table 5-6).

Conclusion

The results of present investigation conclude that the Nawabganj Lake is slightly polluted. The lakes are also productive and will support diverse number of organism from planktons, benthos to fishes and macrophytes going by the abundance of chemical ions needed for inter-conversion of energy and production of organic materials present in the lakes. Physico-chemical parameters influenced the water quality of this lake. The only threat to it productivity was the case of cultural eutrophication, which was observed in the lakes. The correlation analysis on water quality parameters revealed that all parameters are more or less correlated with each other Person's Correlation matrix. It is observed that some of the parameters do not have significant correlation between them indicating the different origin source of pollution. From correlation analysis, the negative relationship DO with other parameters reveals the high organic pollution with anthropogenic activities in the Nawabganj lake. The results of the physico-chemical examination of this could be helpful in the management of the lake for its water quality and fisheries. The data obtained in this lake could be used as a baseline and reference point when assessing further changes caused by nature or man in these lakes, since there has not been published information of data on these important lakes.

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