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Study the *seasonal variations and* correlation analysis of various parameters of Tekanpur Lake

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Abstract
Present study has been carried out in Tekanpur Lake to Study the *Seasonal variations and* Correlation Analysis of various parametesr of Tekanpur la ke The study area was divided into 5 sampling sites to cover the whole lake area comprehensively. The parameters taken were pH, Conductivity (µmho/cm), Turbidity (NTU), Transparency (m), Total Hardness, TSS (mg/l), TDS (mg/l), Total Alkalinity, Free CO2(mg/l),DO (mg/l),BOD (mg/l), COD(mg/l), TN (mg/l), Nitrate-N (mg/l), Nitrite (mg/l), TKN (mg/l), TP(mg/l), Fluoride (mg/l),primary Productivity(mg C/m3(/d). The variations of each particular parameter across stations and that over seasons or years were calculated using the correlation and t-test(r -value)

Keywords: varitation, correlation, regression equations, t-test,,r –value

1. Introduction
Wetlands either natural or man-made account for in surfeit of 1.2 million km^2 (MEA, 2005), globally. The wetlands act as sink or sources or transformers of nutrients with rapid development of adjacent uplands the role of urban wetlands in flood protection and water quality maintenance becomes grave. Limnological studies, which are based upon wetlands like lakes provide a broad spectrum of assessment of status of a lake and their management implications water quality criteria, parts of limnological study, reveal the successional stage and point and non-point sources of pollution. As the natural and anthropogenic causes are identified, comprehensive conservation strategies could be chalked out to sustain the use of a lake ecosystem. Notable studies in *Seasonal variations and* Correlation analysis of various parameters were conducted by Medudhula *et al*., (2012) [12] at Manair reservoir,Andhra Pradesh, Bisht *et al*., (2013) studied in Himalayan Region of India, Sailaja and Reddy (2013) in Himayat Sagar Lake, Hyderabad and Ajayan and Naik (2014) [1] at Koppa lake in Karnataka. Tanwar and Tyor (2014) Lake Tilyar, Rohtak in Haryana. In Madhya Pradesh various studies were conducted in
Tekanpur tank (Verma, 1969), Ramua reservoir (Agrawal, 1980), Harsi reservoir (Kushwah, 1988) Chandanpura tank (Kaushik *et al.*, 1989), Tighra reservoir (Dixit, 1989), Chambal tank (Kaushik *et al.,* 1991), Motijheel (Kaushik and Saksena, 1992), Kailasagar tank (Dagaonkar and Saksena, 1992) and Harsi reservoir (Garg *et al.*, 2006) [7]

Material and Methods
The Tekanpur Lake is a man made reservoir constructed on a small rivulet Chhochund of Sindh, a tributary of the Chambal River. In order to alleviate the sufferings of the common man, the Scindhias harnessed the water of various seasonal nallahs and constructed a 1875 mtrs long and 17.7 meters high dam with a catchment area of 64.75 square km situated near Tekanpur village in Pichhor Tahsil of Gwalior District.
The study area was divided into 5 sampling sites to cover the whole lake area, comprehensively. It was also taken into consideration that the sites would give representative water quality of the lake. Water samples were collected following sampling protocol as prescribed by Central Pollution Control Board (CPCB), Delhi

Parameters
The physico chemical parameters were pH, Conductivity (µmho/cm), Turbidity (NTU), Secchi Depth or Transparency (m), Total Hardness (mg/l), Calcium (mg/l), Total Suspended solids (mg/l), Total dissolve solids (mg/l), Total Alkalinity as CaCO3 (mg/l), Bicarbonate (mg/l), Free CO2(mg/l), Dissolved Oxygen (mg/l), Biochemical oxygen Demand (mg/l), Chemical oxygen Demand (mg/l), Total Nitrogen (mg/l), Nitrate-N (mg/l), Nitrite (mg/l), TKN (mg/l), Total Phosphorus (mg/l), Fluoride (mg/l).

Presentation of Data and Statistical Analysis

Results of the descriptive measures (average and variance) for environment quality were calculated as per different study locations and months.

The sampling points in Lake are extensive and cover Shallow as well as deeper parts of lake. Mean value across the stations and seasons were used to express the whole lake values for specific parameters. The variations of each particular parameter across stations and that over seasons or years were calculated using the correlation and t-test

Result

The range of pH was 7.32 to 8.28. Total Suspended Solids (SS) was recorded in between 16.74 mg/L to 56.07 mg/L with average concentration of 38.61 mg/L. The mean Secchi depth was found to be 1.29 ± 0.49 cm with a range of 0.52 cm to 2.16 cm. Turbidity was found in the range of 2.00 NTU to 21.00 NTU with mean value of 8.45 ± 4.00 NTU. Electrical Conductivity (EC) was recorded in between 244.96 µmho/cm to 625.06 µmho/cm, with mean value of 443.47 ± 97.38 µmho/cm. In Tekanpur Lake the total solids (TS) were in the range of 203.97 mg/L to 493.31 mg/L, with a mean value of 357.91 ± 74.32 mg/L. Total Dissolved Solids (TDS) was found in the range of 176.37 mg/L to 450.04 mg/L with a mean concentration of 319.30 ± 70.11 mg/L. Total Hardness (TH) was recorded in the range of 93.48 mg/L to 238.52 mg/L with a mean concentration of 169.23 ± 37.16 mg/L. The range of alkalinity in the Tekanpur Lake was 77.59 mg/L to 197.97 mg/L and the mean value was 140.46 ± 30.84 mg/L. The Dissolved oxygen in Tekanpur Lake varied in the range of 5.23 mg/L to 9.53 mg/L with a mean value of 7.77 ± 0.68 mg/L. The mean Biochemical Oxygen Demand was 3.92 ± 0.59 mg/L, with a range of 2.83 mg/L to 5.36 mg/L. The mean Chemical Oxygen Demand (COD) was 31.27 ± 5.29 mg/L, and the values ranged from 20.25 mg/L to 43.02 mg/L. The mean Total Nitrogen (TN) was 9.20 ± 1.50 mg/L. The TN ranged from 6.82 mg/L to 14.00 mg/L. The mean Nitrate-Nitrogen (NO_3-N) 9.20 ± 1.50 mg/L. The NO_3-N ranged from 6.82 mg/L to 14.00 mg/L. The mean Nitrite (NO_2-N) was 0.36 ± 0.04 mg/L. The NO_2-N ranged from 0.28 mg/L to 0.45 mg/L The mean Ammoniacal Nitrogen (NH_3-N was 1.68 ± 0.19 mg/L. The NH_3-N ranged from 1.32 mg/L to 2.16 mg/L. The mean Total Kjeldahl Nitrogen (TKN) at Tekanpur Lake was 3.86 ± 0.57 mg/L, and the values ranged from 2.69 mg/L to 5.05 mg/L. The mean Total Phosphate (PO_4^{2-}) was 1.99 ± 0.47 mg/L, with a range of 1.05 mg/L to 2.96 mg/L. Tekanpur Lake the mean Bicarbonates (HCO_3^-) was 106.75 ± 23.44 mg/L, with a range of 58.97 mg/L to 150.46 mg/L. The mean Sodium (Na^+) was 19.63 ± 1.89 mg/L. The Na^+ ranged from 15.57 mg/L to 23.20 mg/L. The Potassium (K^+) was in the range of 1.28 mg/L to 2.15 mg/L, with a mean value of 1.65 ± 0.22 mg/L. Calcium (Ca^{++}) was found in between of 26.17 mg/L to 66.79 mg/L with a mean concentration of 47.38 ± 10.40 mg/L. The mean Magnesium (Mg^{++}) was 12.34 ± 2.71 mg/L. The Mg^{++} values ranged from 6.81 mg/L to 17.39 mg/L. Free CO_2 of Tekanpur lake water was found in between of 0.15 mg/L to 0.39 mg/L with a mean concentration of 0.27 ± 0.06 mg/L. The mean Chloride (Cl^-) was 68.27 ± 6.24 mg/L. The Cl^- concentration ranged from 56.34 mg/L to 82.32 mg/L. The mean Sulfate (SO_4^{2-}) was 4.16 ± 1.43 mg/L. The SO_4^{2-} concentration ranged from 1.24 mg/L to 5.68 mg/L. The mean Fluoride (F^-) at Tekanpur Lake was 0.23 ± 0.20 mg/L. The F^- concentration ranged from 0.01 mg/L to 0.50 mg/L.

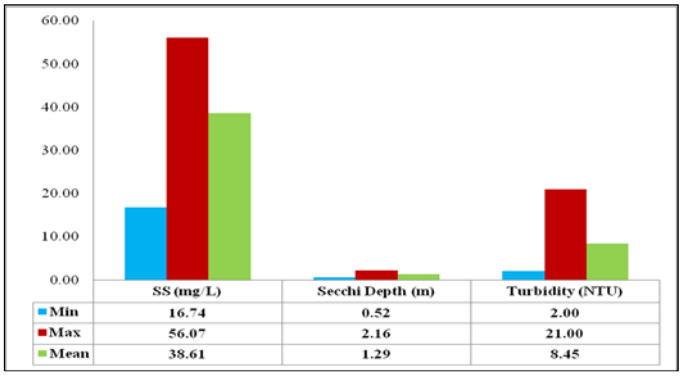

Fig 4.1: Mean concentrations of SS, Sechhi Depth and Turbidity observed at Tekanpur Lake during November 2011 to September 2014

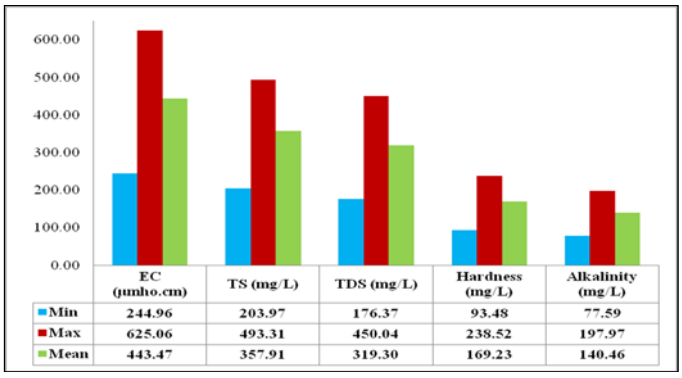

Fig 4.2: Mean concentrations of EC, TS, TDS, Hardness and Alkalinity observed at Tekanpur Lake during November 2011 to September 2014

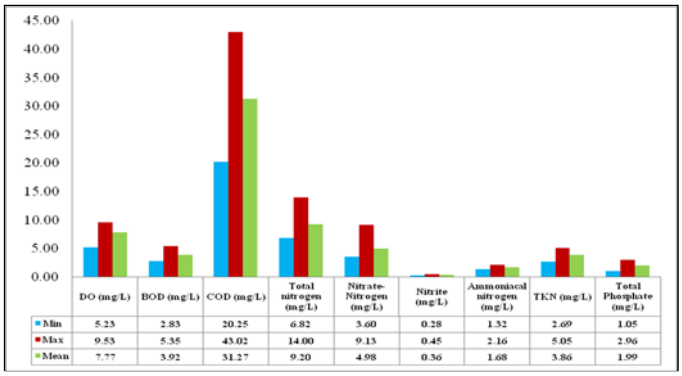

Fig 4.3: Mean concentrations of DO, BOD, COD, Total Nitrogen, Nitrate-Nitrogen, Nitrite, Ammoniacal Nitrogen, TKN and Total Phosphate observed at Tekanpur Lake during November 2011 to September 2014

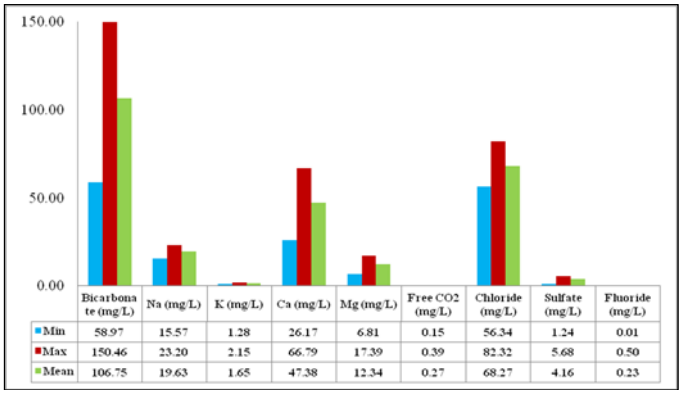

Fig 4.4: Mean concentrations of Bicarbonate, Na^+, K^+, Ca^{2+}, Mg^{2+}, Free CO_2, Cl^-, SO_4^{2-} and F^- observed at Tekanpur Lake during November 2011 to September 2014

Table 4.12: Correlation matrix of physico-chemical parameters estimated at Tekanpur Lake during 2011 to 2014.

Parameters	Turbidity	pH	DO	BOD	COD	EC	TS	SS	TDS	Hardness	Alkalinity	Bicarbonate	Na	K	Ca	Mg
Turbidity	1.000															
pH	0.188	1.000														
DO	-0.255	-0.179	1.000													
BOD	0.186	0.042	-0.646	1.000												
COD	0.461	0.260	-0.541	0.749	1.000											
EC	0.474	0.060	-0.088	0.487	0.707	1.000										
TS	0.472	0.042	-0.071	0.447	0.701	0.993	1.000									
SS	0.199	-0.116	0.093	-0.097	0.266	0.393	0.398	1.000								
TDS	0.374	0.660	0.088	0.487	0.707	0.840	0.993	0.393	1.000							
Hardness	0.473	0.347	-0.045	0.322	0.203	0.642	0.629	0.243	0.739	1.000						
Alkalinity	0.299	0.760	-0.062	0.284	0.062	0.502	0.607	0.303	0.503	0.646	1.000					
Bicarbonate	0.118	0.590	-0.059	0.043	0.075	0.411	0.676	0.204	0.582	0.539	0.924	1.000				
Na	0.409	0.219	-0.462	0.102	0.020	0.325	0.363	0.042	0.525	0.325	0.446	0.625	1.000			
K	0.333	0.427	-0.344	0.145	0.059	0.304	0.477	0.013	0.504	0.512	0.538	0.598	0.305	1.000		
Ca	0.329	0.040	-0.072	0.084	0.057	0.429	0.593	0.091	0.601	0.901	0.777	0.752	0.325	0.304	1.000	
Mg	0.121	0.060	-0.055	0.034	0.033	0.376	0.567	0.044	0.542	0.903	0.720	0.692	0.305	0.411	0.691	1.000
Total nitrogen	0.367	0.102	-0.192	0.642	0.280	0.372	0.341	-0.082	0.372	0.310	0.334	0.209	0.427	0.478	0.372	0.349
Nitrate-Nitrogen	0.158	-0.062	-0.067	0.527	0.089	0.188	0.149	-0.220	0.188	0.188	0.188	0.188	0.185	0.178	0.188	0.188
Nitrite	-0.395	0.205	-0.061	0.374	-0.065	-0.329	-0.358	-0.374	-0.229	-0.329	-0.311	-0.302	-0.304	-0.259	-0.301	-0.362
Ammoniacal nitrogen	0.466	0.325	-0.201	0.092	0.358	0.385	0.395	0.252	0.385	0.344	0.306	0.404	0.393	0.379	0.279	0.333
TKN	0.646	0.390	-0.754	0.207	0.545	0.089	0.593	0.290	0.589	0.188	0.367	0.482	0.741	0.884	0.088	0.056
Total Phosphate	0.479	0.243	-0.611	0.223	0.542	0.214	0.632	0.423	0.614	0.622	0.604	0.614	0.797	0.724	0.606	0.387
Free CO_2	0.225	0.174	-0.267	0.309	0.472	0.668	0.080	0.349	0.068	0.059	0.568	0.568	0.012	0.054	0.068	0.055
Chloride	0.320	0.507	-0.22	0.128	0.317	0.372	0.595	0.344	0.672	0.372	0.407	0.309	0.671	0.502	0.322	0.388

			1													
Sulfate	0.751	0.181	-0.169	0.166	0.461	0.548	0.603	0.676	0.540	0.571	0.521	0.044	0.688	0.367	0.059	0.028

t-Test

Important parameters which mainly govern the lake chemistry were considered for the t-test and it is found that values and concentrations of Turbidity, EC, TDS, Hardness, Alkalinity, Nitrate, TKN, Chlorophyll a, Primary Productivity and Fluoride were significantly different (p<0.05) from 2011 values to 2014 values. Although, BOD and COD were not significantly change over the study period.

Seasonal variations in physico-chemical parameters at Tekanpur Lake

As mean concentrations of each of the parameters were assessed, some seasonal trends were observed. Trends were similar irrespective of the sampling sites in the Tekanpur Lake.

The EC in Tekanpur Lake, irrespective of sampling locations showed increasing trend after March and was found highest during July. It decreased after July and continued to decrease till March when lowest EC was observed. Turbidity in the Lake was Lowest during November. It showed an increasing trend upto July when highest Turbidity was observed. TS followed a similar pattern as EC and were highest during July and lowest during May. However, the SS was lowest during May but highest during the month of September.

The DO concentrations in Tekanpur Lake irrespective of sampling locations were high at all seasons except from May. It was found highest during September and was lowest during May. BOD in the Lake was Lowest during January. It showed an increasing trend upto July when highest Turbidity was observed. COD followed a similar pattern as BOD and was highest during July and lowest during January

The TDS, Alkalinity, Hardness and Bicarbonates followed similar patterns as those were highest during July and were found lowest during March in Tekanpur Lake irrespective of sampling locations

The Na^+ in Tekanpur Lake irrespective of sampling locations showed increasing trend after November when it was lowest; and was found highest during May. Mean concentrations of K^+, Ca^{2+} and Mg^{2+} showed similar trends and were lowest during March and highest during July

In Tekanpur Lake the TN, NO_3^- and TKN showed a similar trend. They were lowest during November and highest during May. The mean concentration of NO_2^- was lowest during January and highest and same during May and July. The mean concentration of NH_3^- was lowest during January, however highest concentration was observed during September The mean concentrations of Total Phosphate and Free CO_2 showed similar trends. They were lowest during November and highest during May. The Cl^- showed an increasing trend from November, when it was lowest; till July when it was highest. The concentration of SO_4^- showed a more fluctuating trend from November till March and an increasing from then onwards till September. F was present in only three of the sampling sites and the mean concentration showed a fluctuating trend; however it was highest during July).

Correlation Analysis

The correlation analysis performed by Microsoft Excel provides an r- value as an output for each pair of water quality parameters. In the present statistical analysis, the correlation analysis was based on a 95% confidence level or a P-value of 0.05. In order to determine if a statistically significant correlation exists, a minimum r value has been determined from a correlation coefficient table. Table 4.12 provides the Excel output for the correlation analysis of the water quality data collected in this study. The highlighted green cells represent statistically significant (p <0.05) correlations between two parameters. Positive values represent directly proportional and negative values represent inversely proportional parameters Analysis of data

A correlation analysis was used to determine relationships between water quality parameters. The correlation is one of the most common and most useful statistics. A correlation is a single number that describes the degree of relationship between two variables. The main result of a correlation is called the correlation coefficient (or "r"). It ranges from -1.0 to +1.0. The closer r is to +1 or -1, the more closely the two variables are related. The Pearson correlation is +1 in the case of a perfect positive (increasing) linear relationship (correlation), −1 in the case of a perfect decreasing (negative) linear relationship (anti correlation), and some value between −1 and 1 in all other cases, indicating the degree of linear dependence between the variables. As it approaches zero there is less of a relationship (closer to uncorrelated). The closer the coefficient is to either −1 or 1, the stronger the correlation between the variables. As observed during the present study the turbidity was correlated with organic nitrogen and sulfate. Organic nitrogen (TKN) provided algal growth that contributed to turbidity. pH was highly correlated with TDS and alkalinity. DO was negatively correlated with BOD, COD, TKN and TP as increase in organic load would reduce the DO level due to bacterial activity. BOD was highly correlated with COD and TKN as it represented biodegradable organic matters. On the other hand, COD highly correlated with TDS and some organics like TKN and TP as it represented chemically oxidisable organic and inorganic matter in the water. TDS was highly correlated with EC, hardness, alkalinity, bicarbonate, chloride and sulfate and *vice versa*, as TDS represent the total amount of soluble solids present in the water. TN had a high correlation with nitrate, nitrite and TKN. However ammoniacal nitrogen was highly positively correlated with TKN, but negatively highly correlated with Sechhi depth. It also contributed positively with Chlorophyll production. Phosphate was highly correlated with Primary Productivity as it played a key role in nutrient input and enhanced growth of phytoplankton.

The *t*-Test assesses whether the means of two groups are statistically different from each other. The seasonal variations for Turbidity, EC, TDS, Hardness, Alkalinity, Nitrate, TKN, Chlorophyll a, Primary Productivity and Fluoride were significantly different. As the season passed the solids, nutrients and organic input varied due to altered rainfall and surface runoff patterns. So, those parameters changed significantly. Although BOD and COD were not significantly change over the study period as these two parameters were balanced by algal bloom and nitrogenous and carbonate-bicarbonate compounds present in the Lake water. Trophic level is the indicator of water quality for limnetic ecosystem. It shows the productivity of the system and biomass availability in that water body. The degree of nutrient enrichment is also classically indicated as trophic state of

water bodies. It could vary between oligotrophic to hyper-eutrophic states. TSI (TP) was found greater than TSI (CHL a) which indicates the increasing phosphorous surplus in the water and TSI (SD) was found lower than TSI (CHL a) is the sign of smaller particulate dominated turbidity along with phytoplankton turbidity. Present interpretation was based on the similar findings reported by Carlson (1977). After assessment of computed results, it can be observed that phosphorous concentration along with organics dominated turbidity in Tekanpur Lake are critical elements for eutrophication and water quality is concerned during summer months.

Conclusion

During present study it was found that the Lake is in good condition in terms of pollution. Although biologically very active, the Lake water has very few inorganic and toxic pollutants. The organic load also diluted during monsoonal rainfall. The highly productive lake has thriving population of planktons and fishes. The Lake water could be used for anything from irrigation to drinking purposes provided the water is biologically treated before use. As no industrialization has taken place in the surrounding areas, menace of effluent discharge and subsequent pollution is not evident in the Lake. However, the Lake could face problems of eutrophication as organic load is very high. It may be avoided by plantation in the banks and subsequent reduction in the surface runoff and siltation. Agricultural activities should also be avoided in the near vicinity of the Lake to avoid input of toxic substances like pesticides and heavy metals through chemical fertilizers.

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