International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(3): 370-376
Received: 07-01-2024
Accepted: 10-02-2024

Adinath T Markad
Assistant Professor, College of Fishery Science, Udgir, Latur, Maharashtra, India

Ajay S Kulkarni
Assistant Professor, College of Fishery Science, Udgir, Latur, Maharashtra, India

Vijay B Sutar
Assistant Professor, College of Fishery Science, Udgir, Latur, Maharashtra, India

Supriya D Meshre
Assistant Professor (CHB), College of Fishery Science, Udgir, Latur, Maharashtra, India

Vikrant V Bansode
Assistant Professor (CHB), College of Fishery Science, Udgir, Latur, Maharashtra, India

Corresponding Author:
Adinath T Markad
Assistant Professor, College of Fishery Science, Udgir, Latur, Maharashtra, India

Impact of phosphate fertilizers on the aquatic ecosystem: A case study

Adinath T Markad, Ajay S Kulkarni, Vijay B Sutar, Supriya D Meshre and Vikrant V Bansode

DOI: https://doi.org/10.33545/2618060X.2024.v7.i3Se.501

Abstract
Most of the reservoirs and fresh water bodies in the developing countries are suffering from water contamination issues. Therefore it is becoming difficult to maintain good water quality which is safe for animal and human consumption. The water supply is under extreme stress due to rising demand and careless use habits. The present study aims to correlate the Total phosphorus with other water quality parameters have been collected monthly from five sampling sites of Tiru reservoir, Udgir, Dist: Latur, Maharashtra from February 2018 to January 2019. Seasonal patterns in physicochemical parameters determined from the surface water of the Tiru reservoir have been studied. The correlation coefficients of 18 water quality metrics were calculated to determine which water parameters are really contributing to pollution. In situ water quality assessments showed that TP concentrations highest in the summer, when reservoir levels were lowest. Total phosphorus associated strongly with Chl-a (0.925). Eutrophication, caused by phosphorus in water, raises chlorophyll-a levels (algal blooms).

Keywords: Limnology, physico-chemical parameters, correlation, eutrophication, Tiru reservoir

1. Introduction

Crucial to the survival of all forms of life on Earth is water. Life is precarious in the absence of water. Ecosystems, public health, food security, and economic growth are all directly impacted by water scarcity. Maintaining potable water is critical to human survival because of the close relationship between the two. Ponds, pools, marshes, rivers, streams, springs, reservoirs, and lakes only make up 5% of Earth's surface, whereas the seas cover 70%. The majority of the world's water comes from salt, comprising 96.42% of the total, while only 2.8% is fresh water. Rainfall is a major source of water for us. Humans are the ones responsible for water pollution due to their lack of care.

Water pollution can be caused by various natural sources, including gases, dirt, minerals, humus, animal waste, and dead organisms floating in the water (Lokhande and Kelkar, 1999) [15]. Rainwater carries surface debris, silt, and humus downstream to rivers, aquifers, and other water bodies. Copper tube corrosion and wastewater discharge from electroplating smelting and metal engraving industries are two examples of anthropogenic input from mining, domestic, and industrial activities. Due to their absorption into the sediment following their adsorption onto the deposits, heavy metal concentrations in the bottom sediment are elevated (Cheevaporn *et al*. 1995; Jeon *et al*. 2003; Schmitt *et al*. 2003) [6, 12, 23]. Sodium, potassium, calcium, and magnesium are inorganic minerals; heavy metals including iron, manganese, lead, mercury, chromium, cadmium, nickel, cobalt, beryllium copper, and so on can be harmful when present in excess of the permissible limit (Begum *et al*., 2009) [2].

As agriculture has progressed and integrated with other agricultural systems, the misuse and overuse of fertilizers and pesticides have also increased, leading to the well-known degradation of the aquatic environment. Pesticides, fertilizers, and industrial effluents are only a few of the inputs that harm the aquatic ecosystem. To ensure maximum harvest yields, farmers use fertilizers that are high in phosphorus (P), a chemical that crops cannot grow without. Unfortunately, the degradation of surface-water quality is accelerated by phosphorus loss from non-point agricultural sources.

Excessive phosphorus inputs can cause eutrophication, harmful algal blooms, and the creation of hypoxic zones (Haque, 2021; Le No¨e *et al*., 2021; Correll, 1998; Carpenter *et al*., 1998, Welch, 1978) [10, 13, 7, 4, 28]. Pesticide use in farming has led to a 75% increase in the net P storage of both terrestrial and aquatic ecosystems when compared to pre-industrial levels (Bennett *et al*., 2001; Zhou *et al*., 2017) [3, 29]. Some estimates put the non-point agricultural sources of surface-water P inputs at 70% (Havlin *et al*., 2005) [11].

Some parts of the world's soil are becoming more acidic due to human activities such as phosphorus (P) extraction and its subsequent transportation in fertilizers, animal feeds, agricultural crops, and other goods. Studies have shown that when soil phosphorus levels rise, there is a greater chance that phosphorus will be washed into aquatic ecosystems (Fluck *et al*. 1992, NRC 1993, USEPA 1996) [9, 17, 27].

Freshwater ecosystems could be impacted by phosphorus buildup in soils found in upland areas. P input determines production in the majority of lakes (Schindler 1977) [22]. When lakes are over enriched with nutrients, it leads to eutrophication, a problem that affects water quality. As a result of erosion, phosphorus-laden soil particles end up in waterways such rivers, streams, and lakes (Daniel *et al*. 1994; Sharpley *et al*. 1994) [8, 24]. Substantial amounts of this runoff are generated by severe storms that cause erosion (Pionke *et al*. 1997) [18]. Thus, land use in the watershed and the concentration of phosphorus in the soil have a significant impact on the likelihood of phosphorus pollution of aquatic ecosystems: Downhill aquatic environments are more likely to experience phosphorus discharge if soil erosion or soil P levels are increased (Daniel *et al*. 1994, Sharpley *et al*. 1994) [8, 24].

Beyond the current level of eutrophication, phosphorus accumulation in highland soils may pose a threat to water quality. The detrimental impacts of P build up in soil on freshwater ecosystems may not be noticeable for a long time (Reed-Andersen *et al*. 2000) [20]. The productivity of aquatic ecosystems may undergo unexpected and dramatic shifts as a result of soil P accumulation. Also, it can make it take longer for management to control eutrophication and see effects (Stigliani *et al*. 1991) [26].

The present study aims to investigate the relationship between total phosphorus with different physico-chemical parameters and to provide data on the main factors influencing the rate of water quality degradation in the Tiru reservoir in Udgir, District: Latur. By drawing attention to the need to address the agents responsible for contamination, the results of this study will help maintain excellent water quality in the Tiru reservoir.

2. Materials and Methods

2.1 Study Location

Tiru reservoir is located in the draught-prone area of Marathwada region of Maharashtra state. (Fig. 01). Reservoir water is mainly used for agriculture irrigation purpose. The reservoir area is surrounded by soyabean fields.

2.2 Sample Collection

Monthly water samples were taken for analysis between February 2018 and January 2019. The entire reservoir region was covered by utilizing five sample locations. The reservoir underwent DO fixing, and further analysis was conducted in the laboratory. Water temperature, pH, and Secchi Disk Depth (SDD) were measured at the designated sample locations. The collection of water samples was conducted using sterile polythene containers, which were subsequently transferred to the laboratory under controlled cold conditions. The laboratory analysis was conducted following the standard protocols and methods outlined by the American Public Health Association (2005) [1].

2.3 Statistical Analysis

The Pearson correlation coefficient was used to assess the magnitude of the linear association of P with other water quality measures over three distinct seasons. The IBM SPSS 23 program was used to analyse twenty significant physico-chemical parameter data obtained from five sampling sites. The relationship between seventeen physico-chemical parameters and five study locations was examined using Pearson's correlation coefficient (r) in a season-wise manner. The seasons included Monsoon, Winter and Summer during the year 2018-19. The statistical significance was assessed at $p<0.05$ and $p<0.01$. The statistical analysis was conducted using the Microsoft Excel and IBM SPSS 23 software packages.

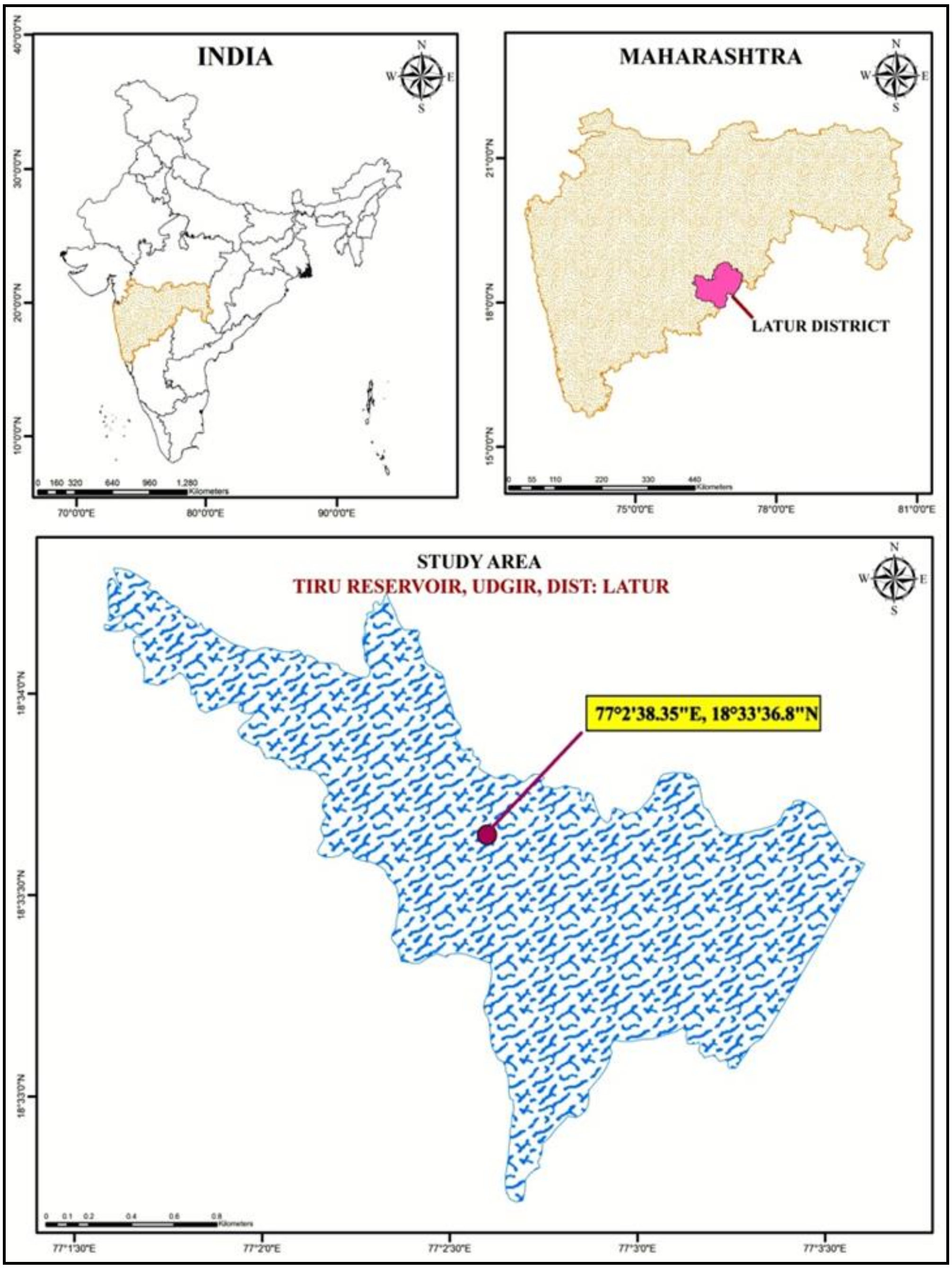

Fig 1: Study Area

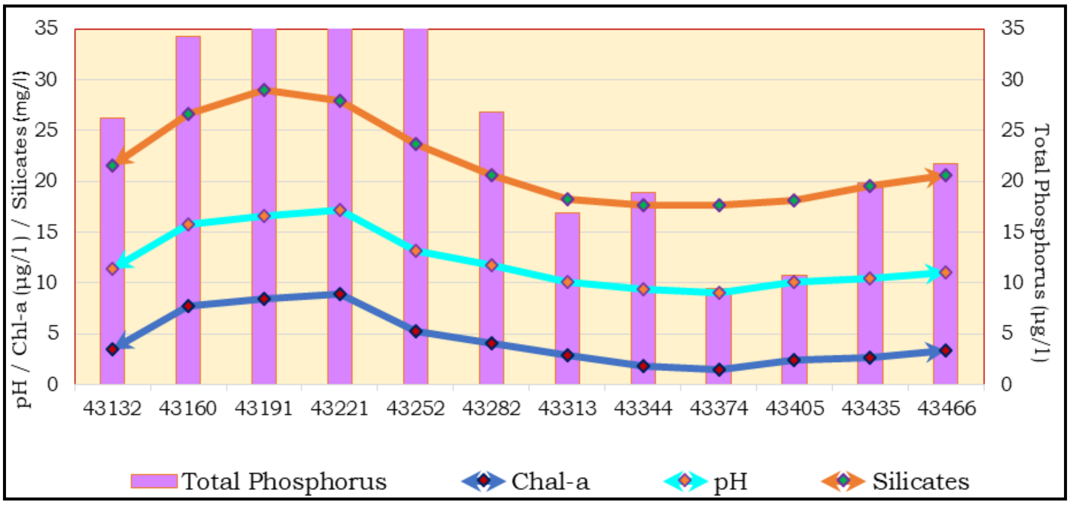

Fig 2: Correlation between Phosphorus and other water parameters

Table 1: Season-wise physico-chemical parameters part A

Season	Month	T (°C)	pH	DO (mg/l)	Conductivity (µSie)	SDD (m)	Turbidity (NTU)	TDS (mg/l)	Salinity (PPT)	PA (mg/l)	MA (mg/l)	TA (mg/l)
	Feb. 18	29.1	7.9	6.7	378.8	0.64	7.2	208.2	0.25	5.8	138.6	144.4
Summer	Mar. 18	27.4	8.0	7.3	383.0	0.59	9.8	212.6	0.26	4.2	121.8	126.0
2018	Apr. 18	31.6	8.2	8.3	386.2	0.58	13.8	216.8	0.26	4.0	115.6	119.6
	May. 18	29.4	8.2	7.9	398.0	0.54	15.4	221.2	0.27	7.4	147.4	154.8
		29.4	8.1	7.5	386.5	0.59	11.6	214.7	0.26	5.4	130.9	136.2
	Jun. 18	28.6	7.9	8.0	365.2	0.48	19.4	154.6	0.16	0.8	80.2	81.0
Monsoon	Jul. 18	24.4	7.7	7.7	277.2	0.51	22.4	121.6	0.11	0.0	75.8	75.8
2018	Aug. 18	26.7	7.2	7.1	291.4	0.55	23.2	119.4	0.07	1.2	76.4	77.6
	Sep. 18	27.5	7.5	6.4	340.8	0.60	20.0	128.4	0.14	2.6	93.6	96.2
		26.8	7.6	7.3	318.7	0.54	21.3	131.0	0.12	1.2	81.5	82.7
	Oct. 18	27.7	7.6	7.1	323.6	0.72	12.4	216.2	0.22	1.6	89.0	90.6
Winter	Nov. 18	26.7	7.7	7.5	341.8	0.65	9.8	229.4	0.22	3.2	109.8	113.0
2018	Dec. 18	25.0	7.8	8.0	358.2	0.64	7.6	221.8	0.23	2.6	117.2	119.8
	Jan. 19	26.7	7.8	7.3	371.6	0.62	6.4	227.4	0.24	4.2	119.6	123.8
		26.5	7.7	7.5	348.8	0.66	9.1	223.7	0.23	2.9	108.9	111.8

Table 2: Season-wise physico-chemical parameters part B

Season	Month	Hardness (mg/l)	Chl a (µg/l)	Chlorides (mg/l)	Silicates (mg/l)	PP (µg/l)	TP (µg/l)	NO3-N (mg/l)	NO2-N (mg/l)	NH3-N (mg/l)
	Feb. 18	131.6	3.47	42.66	10.25	0.15	26.25	0.52	0.01	0.15
Summer	Mar. 18	138.5	7.69	46.01	10.87	0.16	34.18	0.49	0.01	0.12
2018	Apr. 18	148.6	8.48	44.94	12.36	0.16	41.44	0.52	0.01	0.09
	May. 18	157.1	8.91	46.91	10.81	0.17	44.33	0.49	0.03	0.08
		144.0	7.14	45.13	11.07	0.16	36.55	0.51	0.01	0.11
	Jun. 18	128.0	5.30	43.55	10.41	0.21	36.43	0.72	0.07	0.08
Monsoon	Jul. 18	108.4	4.07	36.20	8.83	0.14	26.82	0.80	0.07	0.04
2018	Aug. 18	85.1	2.91	31.18	8.15	0.17	16.93	0.73	0.06	0.02
	Sep. 18	86.8	1.88	33.18	8.26	0.17	18.94	0.73	0.03	0.02
		102.1	3.54	36.03	8.91	0.17	24.78	0.75	0.05	0.04
	Oct. 18	91.4	1.51	35.10	8.58	0.12	9.41	0.74	0.02	0.03
Winter	Nov. 18	98.3	2.42	38.05	7.98	0.11	10.76	0.72	0.01	0.07
2018	Dec. 18	116.8	2.67	37.32	9.08	0.15	19.79	0.63	0.01	0.06
	Jan. 19	123.3	3.35	41.64	9.51	0.16	21.70	0.54	0.03	0.08
		107.5	2.49	38.03	8.79	0.14	15.41	0.66	0.02	0.06

Table 3: Pearson's correlation matrix of water quality parameters for the study period (Feb. 2018 - Jan. 2019.)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1		TP	T	pH	DO	EC	SDD	Turbidity	TDS	Salinity	TA	Hardness	Chl-*a*	Chlorides	Silicates	NO_3-N	NO_2-N	NH_3-N
2	TP	1																
3	T	.554**	1															
4	pH	.793**	.506**	1														
5	DO	.464**	.170	.445**	1													
6	EC	.583**	.629**	.749**	.210	1												
7	SDD	-.553**	-.055	-.248	-.281*	.093	1											
8	Turbidity	.116	-.075	-.343**	-.011	-.597**	-.591**	1										
9	TDS	.072	.282*	.516**	.224	.678**	.525**	-.874**	1									
10	Salinity	.320*	.421**	.704**	.176	.813**	.350**	-.783**	.896**	1								
11	TA	.392**	.388**	.630**	.057	.798**	.237	-.670**	.726**	.821**	1							
12	Hardness	.868**	.543**	.900**	.492**	.789**	-.247	-.343**	.496**	.670**	.680**	1						
13	Chl-*a*	.925**	.572**	.806**	.499**	.580**	-.468**	.028	.225	.413**	.447**	.858**	1					
14	Chlorides	.769**	.543**	.868**	.417**	.807**	-.204	-.397**	.540**	.694**	.648**	.918**	.796**	1				
15	Silicates	.850**	.686**	.808**	.404**	.694**	-.312*	-.191	.335**	.542**	.481**	.874**	.849**	.805**	1			
16	NO_3-N	-.588**	-.541**	-.698**	-.116	-.848**	-.068	.593**	-.639**	-.762**	-.858**	-.804**	-.657**	-.757**	-.723**	1		
17	NO_2-N	.111	-.262*	-.246	.125	-.542**	-.618**	.734**	-.702**	-.692**	-.621**	-.216	-.033	-.252	-.187	.529**	1	
18	NH_3-N	.522**	.434**	.678**	.106	.722**	-.013	-.597**	.518**	.667**	.668**	.744**	.509**	.785**	.668**	-.761**	-.387**	1

**. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed).

Table 4: Pearson's correlation matrix of water quality parameters for Monsoon 2018 (June 2018 - September 2018.)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1		TP	T	pH	DO	EC	SDD	Turbidity	TDS	Salinity	TA	Hardness	Chl-*a*	Chlorides	Silicates	NO_3-N	NO_2-N	NH_3-N
2	TP	1																
3	T	.257	1															
4	pH	.885**	.146	1														
5	DO	.805**	-.030	.626**	1													
6	EC	.484*	.867**	.464*	.047	1												
7	SDD	-.765**	-.018	-.511*	-.819**	-.044	1											
8	Turbidity	-.439	-.523*	-.598**	-.034	-.795**	-.102	1										
9	TDS	.561*	.512*	.591**	.378	.644**	-.124	-.749**	1									
10	Salinity	.508*	.352	.629**	.141	.674**	.076	-.831**	.729**	1								
11	TA	-.284	.397	-.012	-.639**	.512*	.725**	-.596**	.309	.559*	1							
12	Hardness	.962**	.202	.861**	.822**	.415	-.743**	-.417	.609**	.514*	-.317	1						
13	Chl-*a*	.902**	.116	.688**	.925**	.195	-.897**	-.086	.361	.160	-.617**	.889**	1					
14	Chlorides	.916**	.363	.807**	.709**	.563**	-.632**	-.459*	.593**	.495*	-.189	.881**	.814**	1				
15	Silicates	.910**	.446*	.753**	.717**	.560*	-.737**	-.409	.495*	.390	-.276	.899**	.844**	.814**	1			
16	NO_3-N	.076	-.815**	.189	.244	-.652**	-.238	.369	-.331	-.141	-.370	.112	.147	-.037	-.110	1		
17	NO_2-N	.576**	-.327	.416	.859**	-.323	-.728**	.255	.177	-.109	-.803**	.628**	.779**	.454*	.459*	.431	1	
18	NH_3-N	.973**	.380	.850**	.794**	.567**	-.701**	-.520*	.652**	.547*	-.235	.955**	.872**	.911**	.926**	-.091	.547*	1

**. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed).

Table 5: Pearson's correlation matrix of water quality parameters for winter 2018 (Oct. 2018 - Jan. 2019.)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1		TP	T	pH	DO	EC	SDD	Turbidity	TDS	Salinity	TA	Hardness	Chl-*a*	Chlorides	Silicates	NO_3-N	NO_2-N	NH_3-N
2	TP	1																
3	T	-.622**	1															
4	pH	.731**	-.731**	1														
5	DO	.304	-.737**	.565**	1													
6	EC	.893**	-.549*	.706**	.342	1												
7	SDD	-.504*	.350	-.798**	-.244	-.527*	1											
8	Turbidity	-.822**	.567**	-.778**	-.501*	-.899**	.611**	1										
9	TDS	.281	-.214	.164	-.030	.491*	-.308	-.329	1									
10	Salinity	.707**	-.376	.368	-.030	.699**	-.203	-.441	.542*	1								
11	TA	.775**	-.623**	.662**	.464*	.834**	-.542*	-.792**	.557*	.690**	1							
12	Hardness	.932**	-.619**	.727**	.418	.929**	-.482*	-.879**	.355	.724**	.798**	1						
13	Chl-*a*	.825**	-.458*	.794**	.244	.869**	-.805**	-.855**	.530*	.633**	.836**	.836**	1					
14	Chlorides	.591**	-.197	.476*	.173	.725**	-.505*	-.666**	.563**	.684**	.680**	.761**	.798**	1				
15	Silicates	.787**	-.310	.537*	.056	.631**	-.391	-.630**	-.062	.426	.355	.758**	.588**	.467*	1			
16	NO_3-N	-.946**	.399	-.654**	-.069	-.868**	.575**	.801**	-.358	-.695**	-.713**	-.885**	-.880**	-.681**	-.836**	1		
17	NO_2-N	.145	.260	.052	-.213	.087	-.147	-.076	.009	-.024	-.008	.057	.223	.129	.282	-.284	1	
18	NH_3-N	.691**	-.373	.614**	.195	.820**	-.680**	-.806**	.706**	.590**	.861**	.708**	.917**	.741**	.326	-.747**	.088	1

**. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed).

Table 6: Pearson's correlation matrix of water quality parameters for summer 2018 (Feb. 2018 - May. 2018.)

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1		TP	T	pH	DO	EC	SDD	Turbidity	TDS	Salinity	TA	Hardness	Chl-*a*	Chlorides	Silicates	NO_3-N	NO_2-N	NH_3-N
2	TP	1																
3	T	.397	1															
4	pH	.734**	.258	1														
5	DO	.781**	.659**	.409	1													
6	EC	.629**	.192	.546*	.435	1												
7	SDD	-.524*	-.072	-.661**	-.305	-.089	1											
8	Turbidity	.921**	.436	.677**	.744**	.502*	-.713**	1										
9	TDS	.467*	.086	.398	.308	.601**	.078	.214	1									
10	Salinity	.242	-.006	.522*	.069	.188	-.739**	.408	.121	1								
11	TA	.004	-.225	.021	-.214	.403	-.068	.083	.148	.165	1							
12	Hardness	.910**	.387	.707**	.696**	.757**	-.460*	.808**	.559*	.259	.164	1						
13	Chl-*a*	.918**	.211	.732**	.751**	.520*	-.607**	.838**	.383	.315	-.185	.800**	1					
14	Chlorides	.709**	-.127	.686**	.434	.635**	-.534*	.619**	.436	.379	.107	.681**	.825**	1				
15	Silicates	.532*	.545*	.384	.529*	.003	-.377	.555*	.027	.236	-.480*	.333	.550*	.203	1			
16	NO_3-N	-.277	.348	-.392	-.153	-.582**	.246	-.222	-.089	-.187	-.247	-.323	-.433	-.690**	.290	1		
17	NO_2-N	.684**	.064	.574**	.350	.603**	-.565**	.715**	.362	.288	.619**	.767**	.529*	.592**	-.058	-.381	1	
18	NH_3-N	-.969**	-.452*	-.689**	-.791**	-.605**	.576**	-.936**	-.464*	-.286	-.065	-.905**	-.875**	-.674**	-.518*	.221	-.732**	1

**. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed).

4. Conclusions

In the current research, twenty water quality measures were collected monthly from five sample locations between February 2018 and January 2019. We examined trends in evaluated physicochemical parameters collected from the reservoir depending on location and season. The correlation coefficients of 18 water quality metrics were calculated to determine which water parameters are really contributing to pollution. The analysis of water quality parameters in situ revealed that the highest concentration of TP occurred during the summer, when reservoir levels were at their lowest. Total phosphorus had a very significant positive connection with Chl-a throughout the study period. An increase in chlorophyll-a (algal blooms) indicates eutrophication, which is produced by an excess of phosphorus in water. The lowest TP and Chl-a concentrations were seen throughout the winter. There is less food available in the winter, the photosynthetic rate decreases due to lower temperatures, and light levels are low. A positive link between temperature and DO is feasible because higher midsummer water temperatures promote photosynthetic activity. Nutrient enrichment causes dissolved oxygen (DO) levels to increase because plankton flourish in these circumstances and their photosynthetic activities consume CO_2 while creating oxygen. Turbidity is mostly caused by an increase in suspended particles during the monsoon season. While the negative correlation between SDD and turbidity is primarily due to high levels of productivity in the summer, it is also due to high levels of suspended organic load discharged into the reservoir via surface runoff from nearby agricultural fields during the monsoon season. The overall findings revealed that the Tiru reservoir was eutrophic to hyper-eutrophic for almost the entire research period, owing mostly to a rise in pollution induced by human activity like as sewage dumping and excessive phosphate fertilizer usage in the soyabean farming.

5. References

1. APHA. Standard methods for the examination of water and waste-water, 21st ed. American Public Health Association, Washington DC; c2005.
2. Begum AM, Ramaiah H, Khan I, Veena K. Heavy metal pollution and chemical profile of Cauvery River water. E-Journal of Chemistry. 2009;6(1):47-52.
3. Bennett EM, Carpenter SR, Caraco NF. Human impact on erodible phosphorus and eutrophication: a global perspective. Bioscience. 2001;51:227-234.
4. Carpenter SR, Caraco NF, Correll DL, Howarth RW, Sharpley AN, Smith VH. Nonpoint pollution of surface waters with phosphorus and nitrogen. Ecol. Appl. 1998;8:559-568.
5. Chaubey S, Patil MK. Correlation Study and Regression Analysis of Water Quality Assessment of Nagpur City, India. International Journal of Scientific and Research Publications. 2015;5(11):753-757.
6. Cheevaporn V, Jacinto GS, McGlone SD. Heavy metal fluxes in Bang Pakong River Estuary, Thailand: sedimentary versus diffusive fluxes. Marine Pollution Bulletin. 1995;31:290-294.
7. Correll D. The role of phosphorus in the eutrophication of receiving waters: a review. J. Environ. Qual. 1998;27:261-266.
8. Daniel TC, Sharpley AN, Edwards DR, Wedepohl R, Lemunyon JL. Minimizing surface water eutrophication from agriculture by phosphorus management. Journal of Soil and Water Conservation. 1994;49:30-38.
9. Fluck RC, Fonyo C, Flaig E. Land-use-based phosphorus balances for Lake Okeechobee, Florida, drainage basins. Applied Engineering in Agriculture. 1992;8:813-820.
10. Haque SE. How effective are existing phosphorus management strategies in mitigating surface water quality problems in the U.S? Sustain. Times. 2021;13:6565.
11. Havlin JL, Beaton JD, Tisdale SL, Nelson WL. Soil Fertility and Fertilizers: an Introduction to Nutrient Management. Pearson Education, Upper Saddle River, New Jersey; c2005.
12. Jeon BH, Dempsey BA, Burgos WD, Royer RA. Sorption kinetics of Fe(II), Zn(II), Co(II), Ni(II), Cd(II), and Fe(II)/Me(II) onto hermatite. Water Research. 2003;37:4135-4142.
13. Le No¨e J, Garnier J, Billen G. Phosphorus management in the cropping systems of the Paris Basin: from farm to regional scale. J. Environ. Manag. 2021;205:18-28.
14. Lianthuamluaia, Landge AT, Purushothaman CS, Deshmukhe G, Ramteke K. Assessment of seasonal variations of water quality parameters of Savitri Reservoir, Poladpur, Raigad district, Maharashtra. The Bioscan. 2013;8(4):1337-1342.
15. Lokhande RS, Kelkar N. Indian Journal of Environmental Protection. 1999;19:664-668.
16. Mohseni-Bandpei A, Motesaddi S, Eslamizadeh M, Rafiee M, Nasseri M, Montazeri Namin M, Hashempour Y, Mehrabi Y, Riahi SM. Water quality assessment of the most important dam (Latyan dam) in Tehran, Iran. Environmental Science and Pollution Research. 2018;25(29):29227-29239.
17. National Research Council. [NRC] Restoration of aquatic ecosystems: Science, technology, and public policy. Washington (DC): National Academy Press; 1992.
18. Pionke HB, Gburek WJ, Sharpley AN, Zollweg JA. Hydrologic and chemical controls on phosphorus loss from catchments. In Tunney H, Carton OT, Brookes PC, Johnston AE, eds. Phosphorus loss from soil to water. New York: CAB International; 1997.
19. Qureshimatva UM, Maurya RR, Gamit SB, Solanki HA. Studies on the Physico-Chemical Parameters and Correlation Coefficient of Sarkhej Roza Lake, District Ahmedabad, Gujarat, India. Journal of Environmental and Analytical Toxicology. 2015;5(4):284.
20. Reed-Andersen T, Carpenter SR, Lathrop RC. Phosphorus flow in a watershed-lake ecosystem. Ecosystems. 2000;3:561-573.
21. Saluja R, Garg JK. Trophic state assessment of Bhindawas Lake Haryana. Environmental Monitoring and Assessment. 2017;189:32.
22. Schindler DW. Evolution of phosphorus limitation in lakes. Science. 1977;195:260-262.
23. Schmitt D, Saravia F, Frimmel FH, Schuessler W. Facilitated transport of metal ions in aquifers: importance of complex-dissociation kinetics and colloid formation. Water Research. 2003;37:3541-3550.
24. Sharpley AN, Chapra SC, Wedepohl R, Sims JT, Daniel TC, Reddy KR. Managing agricultural phosphorus for protection of surface waters: Issues and options. Journal of Environmental Quality. 1994;23:437-451.
25. Sheela AM, Letha J, Joseph S. Environmental status of a tropical lake system. Environmental Monitoring and Assessment. 2011;180:427-449.
26. Stigliani WM, Doelman P, Salomons W, Schulin R, Smidt GRB, Van der Zee SEATM. Chemical time bombs. Environment. 1991;33:4-30.

27. US Environmental Protection Agency. [USEPA] Environmental indicators of water quality in the United States. Washington (DC): USEPA; c1996.
28. Welch JL. The impacts of inorganic phosphates in the environment. Rep. EPA 560/1-78 003. Office of Toxic Substances, Washington, DC; c1978.
29. Zhou Q, Duryanto S, Zhiming X, Zhimin L, Minghu L, Xue C. Soil phosphorus budget in global grasslands and implications for management. J Arid Environ. 2017;144:224-235.