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EVALUATION OF NUTRIENT LOAD AND TROPHIC STATUS OF LOTIC ENVIRONMENTS IN CHANDRAPUR, MAHARASHTRA

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ABSTRACT

Erai and Zarpat rivers, flows through the Chandrapur city and are lifelines of Chandrapur. Increasing anthropogenic activities within the catchment of these rivers influencing their water quality. Identifying the key nutrients responsible for eutrophication is important for proper management of watersheds. Total 70 water samples from 14 locations were collected for nutrient analysis to evaluate nutrient loading particularly due to nitrogen and phosphorus and dissolved silica to investigate DIN/DIP and DSi/DIN ratios.DIN/DIP ratio estimates the limiting factor and growth of phytoplankton was estimated by DSi/DIN ratio. DIN/DIP ratio of Erai river was 4:1 indicating phosphate limiting condition and DSi/DIN ratio was 5:1 indicating phytoplankton growth specially diatoms. For Zarpat River DIN/DIP ratio was 3:1 indicating phosphate limiting condition and DSi/DIN ratio 3:1 indicated phytoplankton growth especially due to diatoms. Authors come to the conclusion that phosphorus is the principal limiting nutrient controlling river eutrophication and DSi/DIN ratio showed the planktonic growth in both the rivers. Erai river showed enriched nutrient status for TSI (*Chl a*) and showed in the downstream region mesotrophic to hyper-eutrophic conditions and river Zarpat showed mesotrophic to eutrophic in upstream areas. TSI for TP of both the rivers showed hyper-eutrophic TSI confirming eutrophication conditions.

INTRODUCTION

At the global scale degradation of lotic environment is one of the most emerging environmental challenges and hence rating of trophic condition of these is mandatory for their management and sustainable use (Mamun et al., 2021). Considering the current status of the rivers there is a major concern regarding quality of these ecosystems since they are prone to eutrophication process (Klippel et al., 2019). Nutrient loading because of anthropogenic sources in these aquatic systemsis a worldwide concern (Varma et al., 2023). Nutrient addition is enhancing the trophic status of the river supporting eutrophic conditions (Pandey and Yadav, 2015).The sources of nutrients are of allochthonous and autochthonous origin (Jargal et al., 2021 and Sharma et al., 2017).

Nutrient input from agricultural and urban sources such as excessive use of fertilizer and fossil fuel, industrial waste and sewage is ceaselessly destructing quality of rivers (Bernot et al., 2010). About 3 - 20% of the phosphorus and 18% of the nitrogen is received from croplands to the surface waters(Varma and Jha, 2023). In lotic aquatic systems total nitrogen and total phosphorus are regulators of algal growth (Jones et al., 2003; Atique et al. 2013 and Paerl et al., 2016). In aquatic biota to estimate the nutrient limitation status of algae the total nitrogen and total phosphorous ratios are widely used as indicators. It has been broadly accepted that a higher total nitrogen and total phosphorous ratio denotes a substantial possibility of limitation of phosphorous (Redfield et al., 1958; Huo et al.2014). Phosphorous limiting conditions affecting the aquatic system by disturbing the framework and variety of aquatic biota thus disturbing a health of an ecosystem (Wade et al., 2004).

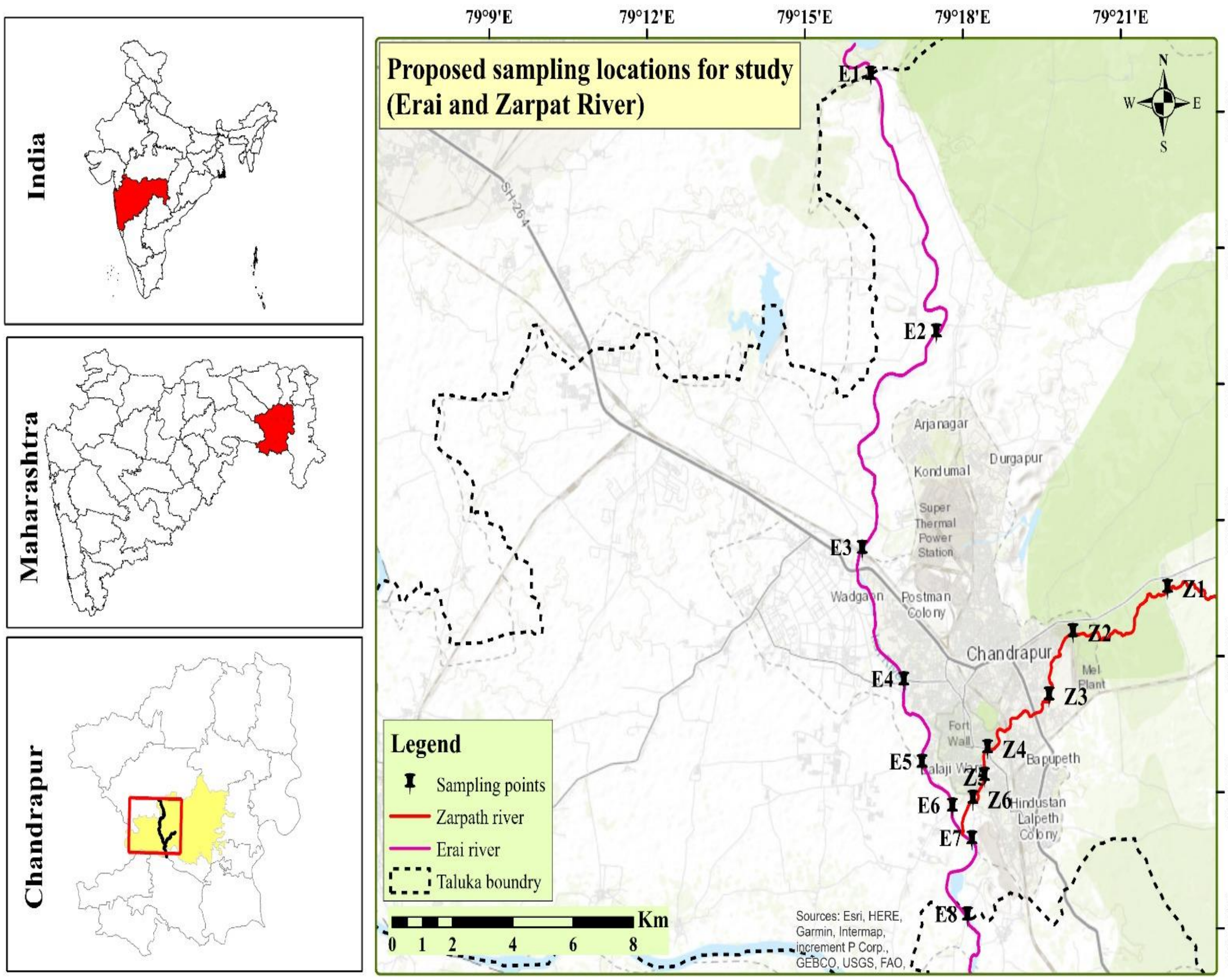
Trophic state represent is the biological feedback for nutrient additions to the water bodies (Chaurasia and Gupta, 2016).Trophic level of aquatic biota can be roughly assessed by using the limiting nutrient concentrations particularly sacchi depth phosphorus and chlorophyll *a*. Previously it was studied that eutrophication is mostly related to the stagnant or still water bodies like lakes, ponds and reservoirs. But due to anthropogenic activities rivers are also being subjected to this undesirable process. Early recognition of eutrophication and understanding the nutrient load-trophic response relationship in rivers and planning the most suitable combination of management measures required an in-depth knowledge of functioning of aquatic ecosystems.

In Chandrapur city there is no sewage treatment plant and also no underground sewerage carrying system. Hence sewage is partly treated in septic tanks and carried to the nalllas and discharged into Erai and Zarpat rivers. Also, the treated effluent from Chandrapur Super Thermal Power Station is partly discharged into the Erai River affecting its water quality.Domestic sewage from rural and urban population is continuously discharging into these rivers deteriorating their water quality. ThusZarpat and Erai rivers are becomesewerage carrying watercourses of Chandrapur city (Erai and Zarpat River Action Plan).

In this context there is an urgent need to check all those agencies which are responsible for nutrient pollution of these rivers. This study determines the pollution strength especially nutritional pollution and trophic pollution (eutrophic or hypereutrophic status) of these water resources. Through the rigorous literature survey it has been observed that researchers have done only physico-chemical analysis of lotic environments but not the studies about the trophic status and nutritional loads. This is the gap in the research which would be fulfilled with this research by assessing trophic status and nutritional loads to these lotic environment.

MATERIALS AND METHODS

Study Area:
Chandrapur taluka is the biggestone in the district Chandrapur and is situated about 761 feet above sea level and situated at 19° 57' north and 79° 22' east longitudes. It is located on the "Erai" and "Zarpat" confluence (Action Plan for Control of Air Pollution at Chandrapur). Erai and Zarpat rivers proceed along the western and eastern part of the Chandrapur city (Erai and Zarpat River Action Plan).



E1 = Downstream of Erai Dam, E2 = Kitali + Bhatadi WCL, E3 = Erai railway bridge, E4= After P.B.Homoeopathic Medical College, E5 = Ram Setu Bridge, Datala, E6 = BRS Furniture Industries, E7 = New Erai River Bridge, E8 = After Confluence Point (Erai+Zirpat)

Z1 = Lohara Village, Chandrapur, Z2 = SAIL Guest House Garden, Z3 = Government Medical College and hospital Chandrapur, Z4 = Zarpat nala, Z5 = Hanuman Tekdi, Z6 = Water treatment Plant

Fig No.1: Sampling locations of Erai and Zarpat rivers

Sampling Collection and Preservation

70 water samples were fetched from the selected sampling sites of Erai river and Zarpat rivers (figure: 1). Collected water samples were stored in pre-cleaned plastic containers having 1L capacityand brought immediately to laboratory for the investigation of various physico-chemical parameters.Samples collected were preserved and carried to the laboratory according to the standard methods given in APHA, 2017.

Analytical Methods

During this study samples were taken from both the riverspolyethylene bottles cleaned with acid during the pre-monsoon of the year 2024. The in-situ parameters like EC, TDS,pH and DO were analysed on-site by a Multiparameter with bluetooth (HI98494).

Parameters like NH_4-N by Semi-micro Kjeldal method, NO_3-Nby Chromotropic Acidmethod, PO_4-Pby Vanadomolybdo-phosphoric acidmethod andSiO_2-Si by Hetropoly Blue method were adopted using spectrophotometer. For BOD and COD analysis stoppered glass bottles were used for collecting samples and were analysed by method given in APHA, 2017. A 5 day BOD was determinedat 20 °C temperature and COD by open reflux method.All the samples were evaluated given in APHA (APHA 23th Edition, 2017 and 24th Edition, 2023), and the values were subsequently compared with their standard limits given by the BIS 2012.

Statistical Analysis

Statistical analysis is frequently carried to evaluate mathematical relationship of physical and chemical characters (Shah M.C., 2007, Bhandari and Nayal 2008, Tripathi et al., 2014). Pearson's correlation coefficient studied for estimating the correlation between various water quality parameters.The correlation between two variables was determined by Toolpak add-ins in MS-Excel 2013 (Professional plus).

Trophic State Index

TSI was determined by formula given byLamparelli (2004). AccordinglyTSI for TSI (TP) and (Chl *a*) for lotic systems was calculated. The formulae used for calculating TSI are as follows:

$$\text{TSI (Chl } a\text{)}=10\ (6-\ (\left(\frac{-0.7-0.6\times(\ln Chl\ a)}{\ln 2}\right)) \text{ ---------------------------}$$

1(Lamparelli, 2004)

$$\text{TSI (TP)}=10\ (6-\ (\left(\frac{0.42-0.6\times(\ln TP)}{\ln 2}\right)) \text{ -----------------------------}$$

2(Lamparelli, 2004)

where for lotic systems; Chl *a* refers to the chlorophyll-*a* concentration (μgL^{-1}) in the water, TSI (TP) represents the TSI related to the total phosphorus variable and TP represents the concentration of total phosphorus (μgL^{-1}).

DIN/DIP and DSi/DIP ratios

DIN/DIP ratio for both the rivers was investigated to calculate either phosphate or nitrate limiting conditions and eutrophication of river and DSi/DIP indicatesphytoplankton growth specially presumes of diatoms.

RESULTS AND DISCUSSION

In this investigation different physico-chemical parameters were performed to evaluate the trophic status, to estimate the impact of anthropogenic activities, nutrient load of Erai and Zarpat rivers in the catchment areaand isshown in tables 1 and 2 respectively. These parameters were compared with Indian drinking water specification, 2012.During this research pH, conductivity and turbidity of maximum sites of Erai and Zarpat werewithin permissible limit andTDS, chlorides, total hardness and total alkalinity were found to be above permissible limit of Indian Standards 2012.The water of Himalayan rivers are reported to be usually alkaline supporting our research (Sharma et al. 2017, Singh et al., 2005).

Table1:-Physico-chemical characteristics of Erai River

Sr. No.	Parameters	Sites								
		(E1)	(E2)	(E3)	(E4)	(E5)	(E6)	(E7)	(E8)	BIS 2012
1	Temp	30^0 C	30^0 C	33^0C	31^0C	30^0 C	31^0 C	31^0C	33^0 C	-----
2	pH	8.32	7.59	8.43	8.21	8.25	8.21	8.12	8.47	**6.5-8.5**
3	EC(mmhos/cm)	0.002	0.001	0.001	0.0008	0.0009	0.0009	0.0009	0.0008	-----
4	Turbidity(NTU)	02.8	04.4	03.1	03.4	05.8	09.2	04.2	03.7	**1**
5	Salinity (PSU)	0.17	0.26	0.46	0.63	0.53	0.54	0.38	0.57	-----
6	TDS (PPM)	184	290	473	640	539	554	585	590	**500**
7	Chloride (mg/l)	599.8	380.9	559.8	999.6	879.6	998.6	799.7	919.7	**250**
8	TH (mg/l)$Caco_3$	96	104	96	68	84	136	120	36	**200**
9	TA (mg/l)	592	700	564	484	592	636	700	772	**200**
10	DO (PPM)	7.70	6.42	7.57	5.63	5.37	4.73	3.00	5.13	-----
11	BOD (mg/L)	6.2	6.5	7.5	7.0	7.5	6.5	6.2	6.6	-----
12	COD (mg/l)	41.0	31.0	32.0	30.0	31.0	38.0	41.0	40.0	-----
13	PO_4-P(mg/L)	0.612	0.712	0.708	0.688	0.589	0.463	0.546	0.463	-----
14	NO_3-N (mg/L)	1.15	ND	ND	0.51	0.94	1.63	0.53	0.63	**45**
15	NO_2-N (mg/L)	0.002	0.011	0.014	0.141	0.031	0.046	0.084	0.099	-----
16	NH_4-N(mg/L)	1.4	0.37	0.75	3.64	0.19	0.19	0.84	0.56	**0.5**
17	TN (mg/L)	17.88	6.85	1.87	4.11	5.29	8.31	5.71	6.57	-----
18	SiO_2-Si (mg/L)	10.69	11.65	12.59	11.20	12.34	11.87	12.17	11.28	-----
19	Chl*a*(mg/m^3)	0.2	0.2	0.09	0.2	0.2	1.2	2.1	2.2	-----

Table 2: Physico-chemical characteristics of Zarpat Riv

Sr. No	Parameters	Sites						
		(Z1)	(Z2)	(Z3)	(Z4)	(Z5)	(Z6)	BIS 2012
1	Temp	28.63^{0}C	29.57^{0}C	32.40^{0}C	33.52^{0}C	31.75^{0}C	31.78^{0}C	-----
2	pH	7.31	7.20	8.30	8.24	8.14	8.20	**6.5-8.5**
3	EC(mmhos/cm)	0.0044	0.0058	0.0007	0.0007	0.0770	0.1430	-----
4	Turbidity(NTU)	6.7	6.6	5.5	7.5	6.8	2.7	**1**
5	Salinity (PSU)	0.11	0.08	0.67	0.70	0.002	0.00	-----
6	TDS (PPM)	113	86	701	709	709	114	**500**
7	Chloride (mg/l)	239.9	259.9	959.9	999.6	419.2	879.6	**250**
8	TH(mg/l)$Caco_3$	24	16	68	100	100	100	**200**
9	TA (mg/l)	860	804	504	460	560	460	**200**
10	DO (PPM)	7.03	7.06	4.42	4.87	4.37	7.13	-----
11	BOD (mg/L)	8.2	5.7	5.5	9.0	8.9	9.2	-----
12	COD (mg/l)	28	24	30	60	59	60	-----
13	PO_4-P(mg/L)	0.780	0.757	0.657	2.671	3.671	0.757	-----
14	NO_3-N (mg/L)	0.35	0.53	0.35	0.61	0.41	0.54	**45**
15	NO_2-N (mg/L)	0.012	0.010	0.011	0.031	0.030	0.052	-----
16	NH_4-N(mg/L)	4.48	0.37	0.84	12.13	3.64	0.56	**0.5**
17	TN (mg/L)	6.35	7.70	4.08	7.84	23.56	7.79	-----
18	SiO_2-Si (mg/L)	14.35	13.35	14.50	14.40	13.50	14.50	-----
19	Chl*a*(mg/m^3)	0.3	0.4	0.2	0.2	0.2	0.2	-----

	Temp	pH	EC	Salinity	TDS	DO	TA	TH	Cl	Turbidity	COD	BOD	PO4-P	NO2-N	NO3-N	NO4-N	TN	SiO2-Si	Chl a
Temp	1																		
pH	0.666	1																	
EC	-0.538	-0.211	1																
Salinity	0.582	0.395	-0.943	1															
TDS	0.525	0.337	-0.916	0.898	1														
DO	-0.045	0.09	0.502	-0.391	-0.698	1													
TA	0.167	-0.188	0.041	-0.168	-0.028	-0.409	1												
TH	-0.48	-0.398	0.213	-0.389	-0.211	-0.175	-0.075	1											
Cl	0.312	0.496	-0.645	0.788	0.796	-0.587	-0.136	-0.203	1										
Turbidity	-0.161	-0.139	-0.389	0.313	0.286	-0.432	0.115	0.543	0.437	1									
COD	0.13	0.331	0.376	-0.317	-0.108	-0.316	0.545	0.125	0.152	0.037	1								
BOD	0.291	0.298	-0.542	0.522	0.331	0.294	-0.511	-0.283	0.091	-0.036	-0.748	1							
PO4-P	-0.272	-0.389	0.239	-0.29	-0.381	0.601	-0.555	-0.002	-0.631	-0.544	-0.713	0.385	1						
NO2-N	0.396	0.212	-0.587	0.695	0.774	-0.569	-0.056	-0.449	0.721	-0.081	0.011	-0.04	-0.241	1					
NO3-N	-0.21	0.314	0.056	0.0917	0.055	-0.23	-0.049	0.277	0.586	0.651	0.474	-0.289	-0.698	-0.016	1				
NO4-N	0.018	0.113	-0.027	0.224	0.177	0.12	-0.651	-0.321	0.269	-0.457	-0.25	0.037	0.403	0.621	-0.134	1			
TN	-0.482	0.011	0.837	-0.674	-0.706	0.295	0.0844	0.144	-0.179	-0.05	0.584	-0.645	-0.213	-0.382	0.549	-0.03	1		
SiO2-Si	-0.191	-0.346	0.1411	-0.307	-0.422	0.558	-0.116	0.0322	-0.746	-0.251	-0.634	0.551	0.7	-0.65	-0.62	-0.323	-0.278	1	
Chl a	0.434	0.215	-0.274	0.232	0.48	-0.758	0.741	-0.09	0.428	0.175	0.714	-0.502	-0.795	0.462	0.189	-0.266	-0.059	-0.64	1

Correlation is significant at 0.05 levels (2-tailed)

Table 3: Corelation among the physicochemical parameters of the Erai River in before Mansoon

	Temp	pH	EC	Salinity	TDS	DO	TA	TH	Cl	Turbidity	COD	BOD	PO4-P	NO2-N	NO3-N	NO4-N	TN	SiO2-Si	Chl a
Temp	1																		
pH	0.922	1																	
EC	0.194	0.394	1																
Salinity	0.626	0.465	-0.572	1															
TDS	0.624	0.468	-0.572	0.999	1														
DO	-0.711	-0.692	0.202	-0.59	-0.595	1													
TA	-0.95	-0.967	-0.453	-0.443	-0.444	0.568	1												
TH	0.859	0.917	0.59	0.206	0.203	-0.558	-0.919	1											
Cl	0.883	0.857	0.184	0.694	0.694	-0.446	-0.901	0.703	1										
Turbidity	-0.119	-0.371	-0.864	0.414	0.406	-0.272	0.416	-0.382	-0.297	1									
COD	0.686	0.7078	0.668	-0.024	-0.034	-0.327	-0.749	0.928	0.493	-0.325	1								
BOD	0.248	0.329	0.59	-0.263	-0.278	0.016	-0.333	0.628	0.138	-0.205	0.83	1							
PO4-P	0.465	0.4	0.13	0.02	0.012	-0.647	-0.345	0.602	0.029	0.304	0.673	0.542	1						
NO2-N	0.486	0.573	0.885	-0.245	-0.252	0.066	-0.667	0.787	0.467	-0.668	0.882	0.771	0.2818	1					
NO3-N	0.399	0.126	0.227	0.092	0.078	0.186	-0.351	0.322	0.339	-0.003	0.494	0.321	0.177	0.52	1				
NO4-N	0.431	0.233	-0.309	0.516	0.499	-0.359	-0.234	0.347	0.289	0.61	0.444	0.511	0.563	0.121	0.41	1			
TN	0.115	0.184	0.383	-0.458	-0.459	-0.399	-0.112	0.417	-0.31	-0.002	0.511	0.437	0.836	0.271	-0.071	0.06	1		
SiO2-Si	0.343	0.464	0.065	0.506	0.505	-0.021	-0.431	0.3	0.686	-0.276	0.161	0.226	-0.352	0.273	-0.0585	0.24	-0.606	1	
Chl a	-0.792	0	-0.421	-0.368	-0.368	0.637	0.862	-0.9	-0.747	0.356	-0.731	-0.513	-0.433	-0.59	0.032	-0.308	-0.235	-0.565	1

Correlation is significant at 0.05 levels (2-tailed)

Table 4: Corelation among the physicochemical parameters of the Zarpat River in pre Mansoon season

For Zarpat river NH_4-N and PO_4-P concentration showed a positive correlation with the BOD value i.e. r= 0.511and 0.54 respectively indicating the effect of addition of sewage waste

Globally high values of trophic state index in rivers is a critical problem. The ultimate TSI is determined as the average of TSI (TP) and TSI (Chl *a*). On the basis of TSI numbers lotic systems can be classified as TSI ≤47 in the class ultra-oligotrophic, 47–52 as oligotrophic, 52–59 in the mesotrophic category, 59–63 ineutrophic class, 63-67-super eutrophic class and TSI >67 in hypereutrophicclass (Klippel et al. 2020). The TSI values of the Erai River in this investigation ranged between 56.167 and 76.923 and 59.677–56.167 for Zarpat River. It was observed that around 12% of the samples showed oligotrophic nature, 50% showed mesotrophic and 39% samples have hypereutrophic condition in the Erai River during summer (pre monsoon). For the Zarpat Riverthe most of the samples (66%) showed mesotrophic conditions followed by eutrophic (33%). The trophic situation of the Erai River is horrific, sincemore number of samples are denoting mesotrophic to hypereutrophic status. The trophic status of the Amazon river was reported to be ranged from super eutrophic to hypereutrophic (Affonso et al., 2011).

The trophic status of river Zarpat showed mesotrophic to eutrophic condition.The trophic situation of the Chaliyar River in the Western Ghats wasidentified that especially in the downstream areas, the water was enriched with nutrients indicating moderate to high nutrient conditions (Saha et al. 2022).

This might beowing to the contribution of nutrients in the catchment area from domestic and agricultural sources stimulating algal blooms and ultimately depleting the water

along with runoff from the agriculture area supporting our studies, r=0.51 (Ravi et al., 2021), Silica with Chl *a* has negative

correlation, r=-0.64 and TDS has high positive correlation, r=0.999 for Zarpat river (Table no.3 and 4).
quality.Similar studies were described by Varma and Jha, 2023 while studying the trophic status and nutrient load of Ganga and Yamuna rivers. The results of their investigation indicated that TSI values ranged in the dry season between 58.95 and 68.94 for the Ganga and reported that about 6% of the samples appeared mesotrophic nature in the premonsoon season, eutrophic indicated11%, 44% exhibit super eutrophic, and 39% revealed hypereutrophic condition during before monsoon in the Ganga river. The trophic status of the Yangtze River overviewed to be light eutrophic to hypereutrophic confirming eutrophication due to anthropogenic captivities' Li et al. (2019).

DIN/DIP and DSi/DINratios in the lotic organization are pivotal for survival aquatic lifeand are key indicators of the nutrient restriction of primary productivness (Nguyenetal, 2019).DIN/DIP ratio of Erai river was 4:1 indicating phosphate limiting condition and DSi/DIN ratio was 5:1 indicating phytoplankton growth specially diatoms. For Zarpat RiverDIN/DIP ratio was 3:1 indicating phosphate limiting condition and DSi/DIN ratio 3:1 indicated phytoplankton growth due to diatoms. Similar results were reported by Prajapati and co-investigators in 2020 exceeding the ratio 16:1in the Ganga, designatingthe phosphateconstraint for the growth of phytoplankton e.g., diatoms (Dasetal., 2022). This might be due to tendency of phosphate to bring about the uptake during biological activities (Correll, 1990). Dissolved silica, a micronutrient is regardedas that is essential for the growth of radiolarians,diatoms and sponges within the aquatic biota. Silica is originated from the chemical weathering of rocks is mainly of geogenic origin and soil present on the surface of the earth(Durr et al. 2011). The DSi/DIP ratio 3:1 showed Diatoms growth supporting eutrophication.

CONCLUSION

In this investigation high values of chlorides, turbidity,alkalinity,TDS and NH_4-Nexceeding BIS standards confirms the anthropogenic activities in the catchment areas of Erai and rivers. Positive correlation of BOD with NH_4-N and PO_4-P indicates impact of addition of sewage and agricultural runoff. The DIN/DIP ratio showed phosphate limiting condition and DSi/DIN ratio indicated planktonic growth particularly diatoms for both the rivers. Thus phosphorus is the foremost limiting nutrient controlling eutrophication of both rivers. Erai Rivershows mesotrophic to hypereutrophic conditions particularly in the downstream region and Zarpat river showed mesotrophic to eutrophic pattern in the upstream region. Both the river showed hypereutrophic trophic state index approving eutrophic conditions of these rivers.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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