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Correlation Analysis of Various Water Quality Parameters of the Tiru Reservoir, Maharashtra, India

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ABSTRACT

The present study was conducted in the department of Aquatic Environment Management, College of Fishery Science, Udgir, District Latur, Maharashtra, India during August, 2017 to January, 2019 to investigate trophic status of the Tiru reservoir. Twenty (20) water quality parameters had been collected monthly from five sampling sites of Tiru reservoir, Udgir, Latur district, Maharashtra, India. Seasonal trends were analysed and discussed in this chapter. Pearson's correlation coefficient (r) of eighteen physico-chemical parameters from five study locations were analyzed to know the pollution causing parameters. Water quality analysis showed that Total Phosphorus concentrations was highest in the summer, when reservoir water levels were lowest. Correlation between Total phosphorus and Chl-a was highest at 0.926. Eutrophication was mainly generated by phosphorus available in the water, which increases chlorophyll-a concentration (algal blooms). A positive correlation between temperature and DO might be possible because higher summertime water temperatures boost photosynthetic activity. SDD has shown a substantial negative connection with Chl-a throughout all seasons, since an increase in phytoplankton abundance yields a decrease in water transparency. The negative correlation between SDD and turbidity is primarily caused by the high levels of productivity in the summer, and high levels of suspended organic load due to surface runoff in the monsoon season. The majority of the time throughout the research period, Tiru reservoir was found in the eutrophic state, and in some cases even hyper-eutrophic.

KEYWORDS: Corelation, eutrophication, limnology, physico-chemical parameters, Tiru reservoir

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Water is crucial to the functioning of all ecosystems, maintaining public health, ensuring sufficient food supplies, and growing the economy. Human well-being is inextricably tied to water quality, hence protecting it is of paramount importance (Patil and Patil, 2010). Gases, dirt, minerals, humus, animal waste, and dead creatures floating about in the water are all natural causes of water pollution (Lokhande and Kelkar, 1999). When it rains, the dirt, muck, and humus from the surface wash into the river, tanks, and other water sources. Anthropogenic input from mining, household, and industrial activities, such as copper tube corrosion and wastewater discharge from electroplating, are also significant sources. They get absorbed into the sediment after being adsorbed onto the deposits (Cheevaporn et al., 1995; Jeon et al., 2003; Schmitt et al., 2003), leading to increased heavy metal concentrations in the bottom sediment. When present in excess of the safe limit, inorganic minerals such as sodium, potassium, calcium, magnesium, and heavy metals such as iron, manganese, lead, mercury, etc. may be detrimental (Begum et al., 2009; Akhtar et al., 2021).

According to Welch (1935), the physical and chemical properties of a body of fresh water determine the variety of its flora and fauna as well as its appropriateness, trophic status, and usefulness. High rates of organic production and eutrophication (Hutchinsan, 1957, Edmonson, 1966) are correlated with elevated levels of dissolved oxygen in a water body. Freshwater's high alkalinity and pH show that it has a high trophic level. Ruttner (1953) and Jackson (1961) shown that water's pH is correlated with its trophic status.

Sun et al. (2019) analysed the variation in the water quality in the Seagoing river water using pearson correlation analysis. Yilma et al. (2019) assessed the river water quality in Little Akaki River using multivariate statistical approach. Akongyuure and Alhassan (2021) investigated the correlation among water quality parameters from the Tono Reservoir in Northern Ghana. Gong et al. (2021) conducted studies for evaluating the water quality in Suzhou National Wetland Park in China. Horvat et al. (2021) analysed water quality of the Danube River by using correlation analysis.

Jothivnkatachalam et al. (2010) collected drinking water samples from Perur Block from Coimbatore district in Tamil Nadu for correlation analysis. Tyagi et al. (2013) checked surface water quality from Alaknanda, Mandakini, East Nayar, and Pinder rivers of Uttarakhand, India by using correlation analysis. Shroff et al. (2015) conducted correlation study by taking ground water samples from Valsad District in Gujarat. Chaubey and Patil (2015) analysed water parameters of Nagpur City water studied correlation among different water quality parameters. Kshirsagar et al. (2016) assessed correlation among physicochemical parameters from the Bhima River in Pandharpur, Maharashtra and reported that all the water quality parameters were interrelated with each other. Akhtar et al. (2019) reported multivariate analysis of heavy metals in Garautha Tehsil, Jhansi District, India. Kumari et al. (2019) assessed water quality of Lake Prashar, Himachal Pradesh by using multivariate correlation analysis. Kothari et al. (2020) studied correlation between different physico-chemical parameters of water samples collected from various districts of Uttarakhand and found that the Total Dissolved Solids showed highest correlation with conductivity, sulphate, and chlorides. Ashwin et al. (2022) observed correlation between water parameters collected from Mooli Kulam lake of Tiruppur District in Tamil Nadu. Gaur et al. (2022) recorded relationship among different water quality parameters from Tawang India. Shukla and Sharma (2023) reported correlation among different water quality parameters collected from Wainganga River.

The goal of the current research is to determine the rate of deterioration of water quality of the Tiru reservoir in Udgir, Dist: Latur by studying correlation among different physico-chemical parameters and to offer information on the main parameters influencing it.

2. MATERIALS AND METHODS

The study was undertaken in the department of Aquatic Environment Management, College of Fishery Science, Udgir, District Latur, Maharashtra, India during August, 2017 to January, 2019 to investigate trophic status of the Tiru reservoir.

2.1. Study Location

Tiru reservoir is located on the Tiru river which is a small tributary of Godavari river and located in the Latur District, Maharashtra. Water quality parameters of the Tiru reservoir, Udgir, Dist: Latur has been assessed from five sampling locations. Morphological features of the Tiru reservoir is given in the Table 1.

2.2. Sample collection

Water samples for analysis were collected on a monthly basis From August 2017 to January 2019. Five sampling sites were used to cover the whole reservoir region. DO fixation was performed at the reservoir, and additional examination was performed in the laboratory. At the sample locations, water temperature, pH, and Secchi Disk Depth (SDD) were measured. Water samples were collected in clean polythene containers and transported to the laboratory in a cold environment. The laboratory analysis (Table 2) was carried out in accordance with the Anonymous (2005) standard procedures and methods.

Table 1: Morphological features

Sl. No.	Item	Units	Value
i	Submergence area	Square kilometer	6.9
ii	Average water spread area	Square kilometer	4.8
iii	Watershed Area	Square kilometer	270
iv	Command area	Hectare	2654
v	Greatest Length	Kilometer	3.15
vi	Greatest Width	Meter	930
vii	Greatest Depth	Meter	7.31
viii	Mean Depth	Meter	3.98
ix	Volume	Cubic kilometer	311
x	Water-shed to lake surface area	Square kilometer	39.13

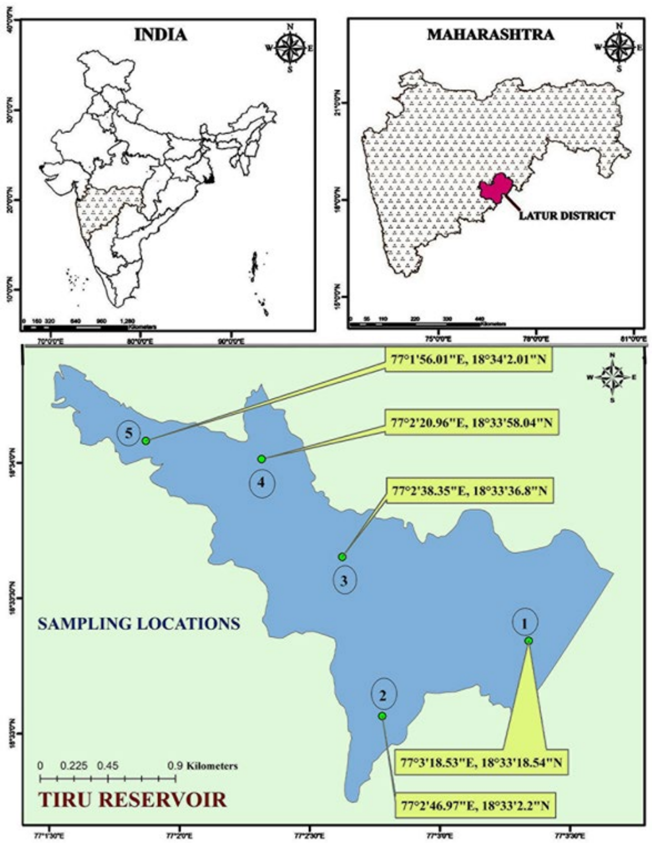
2.3. *Statistical analysis*

Data of different physico-chemical parameters were presented as Range, Mean, and SD during descriptive statistical analysis. Pearson's correlation was performed to identify the strength of the linear relationship between water quality parameters during three seasons. Seventeen important physico-chemical parameters collected from five sampling sites were analysed using IBM SPSS 23 software. Pearson's correlation coefficient (r) of these eighteen physico-chemical parameters and five study locations were analyzed season-wise [Monsoon-2017 (August 2017–Sep. 2017); Winter-2017 (Oct. 2017–Jan. 2018); Summer-2018 (Feb. 2018–May. 2018); Monsoon-2018 (Jun. 2018–Sep. 2018); Winter - 2018 (Oct. 2018–Jan. 2019) as well as for the whole investigation (August 2017–Jan. 2019). Significance was tested at $p<0.05$ and $p<0.01$. All mathematical and statistical analysis was accomplished in

Table 2: Water quality parameters estimation procedures

Sl. No.	Water Parameters	Abbreviations	Analytical method	Instruments/ Methods	Unit
1.	Water Temperature	Temperature	Instrumental	Mercury Thermometer	°C
2.	pH	pH	Instrumental	pH meter	pH Unit
3.	Dissolved Oxygen	DO	Titrimetry (APHA 2005)	Winkler idometric method	mg l^{-1}
4.	Electrical Conductivity	EC	Instrumental	Electrometric	µS cm^{-1}
5.	Secchi Disk Depth	SDD	Instrumental	Secchi Disk of 20 cm	m
6.	Turbidity	Turbidity	Nephelometric method	Nephelometer	NTU
7.	Total Dissolved Solids	TDS	Instrumental	TDS meter	mg l^{-1}
8.	Salinity	Salinity	Instrumental	Refractometer	ppt
9.	Phenolphthalein Alkalinity	PA	Titrimetry (APHA 2005)	Neutralizing with standard HCL	mg l^{-1}
10.	Methyl Orange Alkalinity	MA	Titrimetry (APHA 2005)	Neutralizing with standard HCL	mg l^{-1}
11.	Total Alkalinity	TA	Titrimetry (APHA 2005)	Neutralizing with standard HCL	mg l^{-1}
12.	Total Hardness	Hardness	Titrimetry (APHA 2005)	EDTA titrimetry	mg l^{-1}
13.	Chlorophyll a	Chl-a	Spectrophotometry	UV-Vis Spectrophotometer	µg l^{-1}
14.	Chlorides	Chlorides	Argentometric Titrimetric Method (APHA, 2005)	Argentometric determination	mg l^{-1}
15.	Silicates	Silicates	Molibdosilicate method	UV-Vis Spectrophotometer	mg l^{-1}
16.	Phosphate phosphorus	PP	Ascorbic acid Method (APHA, 2005)	UV-Vis Spectrophotometer	mg l^{-1}
17.	Total Phosphorus	TP	Persulfate Digestion (APHA, 2005)	UV-Vis Spectrophotometer	µg l^{-1}
18.	Nitrate Nitrogen	NO_3-N	Cadmium reduction method (APHA, 2005)	UV-Vis Spectrophotometer	mg l^{-1}
19.	Nitrite Nitrogen	NO_2-N	Phenate method	UV-Vis Spectrophotometer	mg l^{-1}
20.	Ammonical Nitrogen	NH_3-N	Spectrophotometry	UV-Vis Spectrophotometer	mg l^{-1}

the Microsoft Excel, IBM SPSS 23 statistica 10 software suites.



3. RESULTS AND DISCUSSION

Water samples collected from five sampling locations were evaluated in the laboratory by applying standard instruments and protocols. Monthly average values were grouped into seasons and season-wise water quality parameters are presented in the Table 3 and Table 4.

Range, mean, and standard deviation are calculated using statistical analysis. While mean provides average values and standard deviation indicates variability in the given sample, range is the gap between the greatest and smallest value in the collection. Table 5 gives the range, mean deviation, and standard deviation of the water samples taken from the Tiru reservoir at five different sampling points throughout the summer, monsoon, and winter seasons.

To evaluate the robustness of the linear relationship among water quality metrics, Pearson's correlation analysis was carried out. Table 6 (August 17–January 21), 7 (August 17–September 17), 8 (October 17–January 18), 9 (February 18–May 18), 10 (June 18–September 18), and 11 (October 18–January 19) display the correlation matrices of surface water quality parameters collected from the five sampling locations during the respective seasons.

4.1. Water temperature (°C)

Temperatures ranged from a low of 24.4 degrees Celsius in July 2018 to a high of 31.6 degrees Celsius in April 2018. Winter had the study period's lowest average temperature (26.3°C in 2017 and 26.5°C in 2018), followed by a significant rise towards monsoon season (26.8°C in 2018), and finally the highest average temperature (29.4°C in 2018) in the Summer. Water temperatures have been shown to be rather consistent throughout research undertaken in several Indian states. The water temperature ranged from 25 to 32 degrees Celsius in the nine Andhra Pradesh reservoirs as reported by Das (2000). The water temperature of Kodayar Lake in Tamil Nadu, as reported by Murugavel and Pandian (2000), is between 26 and 29.5 degrees Celsius.

During the monsoon and winter seasons, water temperature (T) was shown to have a substantial positive link with EC, Salinity, Alkalinity, Hardness, Chlorides, Silicates, and TP, and a significant negative correlation with DO. During the summer, there is a strong positive association between temperature and dissolved oxygen levels, which may be due to increased photosynthetic activity as temperatures rise. As the temperature rises, the reservoir's water level decreases, which increases nutrient enrichment. Both Khatoon et al. (2013) and Qureshimatva et al. (2015) reported results that were consistent with the present study.

4.2. pH

The pH levels in the Tiru reservoir ranged from 7.2 (in August 2018) to 8.2 (in May 2018), which is within the ideal range provided by the World Health Organization (2017) and coincides with the ideal range of water quality parameters favourable for fish culture given by Vass et al. (2009). Summer 2018's average pH was 8.1, with a sharp decline in monsoon 2018's pH of 7.6 owing to the arrival of flood water, containing free CO_2 and intermediate during winter's pH of 7.7. The excess of primary production over respiration, which consumes more CO_2 and therefore reduces the H+ ions, or a reduction in water level during the dry season, which causes a concentration of base cations, are both possible causes of the higher pH concentration in summer (Woldeab et al., 2018). Due to the diluting impact of entering rain water in the reservoir, the pH values were found to be lower at stations adjacent to streams (S4, S5), especially during monsoon. Several studies found pH values in a similar range: 7.4-8.4 for the Uppar reservoir in Coimbatore (reported by Murugesan and Manoharpian, 2000); 8.1 for the Hussainsagar reservoir in Hyderabad (documented by Piska and Chary, 2000); 7.8-8.0 for the Shahpura lake in Bhopal (reported by Saxena and Srivastava, 2001).

During the research period, a substantial positive correlation

Table 3: Season-wise physico-chemical parameters collected from five sampling sites

Season	Month	T (°C)	pH	DO (mg l^{-1})	Conductivity (µSie)	SDD (m)	Turbidity (NTU)	TDS (mg l^{-1})	Salinity (PPT)	PA (mg l^{-1})	MA (mg l^{-1})	TA (mg l^{-1})
Monsoon	Aug. 17	26.8	7.4	6.8	298.0	0.50	20.4	119.0	0.08	1.4	87.8	89.2
2017	Sep. 17	26.9	7.5	5.9	320.4	0.59	18.6	127.2	0.11	0.8	83.4	84.2
	Average	26.9	7.4	6.3	309.2	0.54	19.5	123.1	0.09	1.1	85.6	86.7
	Oct. 17	26.0	7.6	7.0	303.4	0.75	11.8	207.6	0.20	0.0	75.8	75.8
Winter	Nov. 17	26.5	7.7	7.7	334.8	0.66	9.2	210.4	0.21	1.4	93.8	95.2
2017	Dec. 17	26.0	7.8	7.9	363.0	0.64	6.6	198.6	0.22	2.8	98.0	100.8
	Jan. 18	26.8	7.8	6.7	373.0	0.63	5.2	206.0	0.24	9.2	137.8	147.0
	Average	26.3	7.7	7.3	343.6	0.67	8.2	205.7	0.22	3.4	101.4	104.7
	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
	Average	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
	Average	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
	Average	26.5	7.7	7.5	348.8	0.66	9.1	223.7	0.23	2.9	108.9	111.8

Table 4: Season-wise physico-chemical parameters collected from five sampling sites

Season	Month	Hardness (mg l^{-1})	Chl a (µg l^{-1})	Chlorides (µg l^{-1})	Silicates (mg l^{-1})	PP (µg l^{-1})	TP (µg l^{-1})	NO_3-N (mgl^{-1})	NO_2-N (mg l^{-1})	NH_3-N (mg l^{-1})
Monsoon	Aug. 17	76.3	3.31	31.43	8.12	0.16	22.64	0.69	0.04	0.02
2017	Sep. 17	84.1	2.59	32.82	8.20	0.17	13.80	0.72	0.02	0.02
	Average	80.2	2.95	32.13	8.16	0.16	18.22	0.70	0.03	0.02
	Oct. 17	89.1	1.29	35.87	8.66	0.09	8.24	0.74	0.01	0.03
Winter	Nov. 17	97.6	2.54	38.26	8.05	0.13	13.89	0.71	0.01	0.07
2017	Dec. 17	116.2	2.78	36.90	8.83	0.16	20.49	0.62	0.01	0.07
	Jan. 18	122.2	4.53	43.32	9.36	0.16	26.99	0.54	0.01	0.08
	Average	106.3	2.78	38.59	8.72	0.14	17.40	0.66	0.01	0.06
	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

Season	Month	Hardness (mg l^{-1})	Chl a (µg l^{-1})	Chlorides (µg l^{-1})	Silicates (mg l^{-1})	PP (µg l^{-1})	TP (µg l^{-1})	NO_3-N (mgl^{-1})	NO_2-N (mg l^{-1})	NH_3-N (mg l^{-1})
	May. 18	157.1	8.91	46.91	10.81	0.17	44.33	0.49	0.03	0.08
	Average	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
	Average	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
	Average	107.5	2.49	38.03	8.79	0.14	15.41	0.66	0.02	0.06

Table 5: Descriptive statistics of water quality parameters in the Tiru reservoir

Parameters	SITE I			SITE II			SITE III		
	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
T	25-31	27.12	1.60	24-32	27.14	1.89	24.7-32	27.27	1.83
pH	7.2-8.3	7.73	0.29	7.29-8.23	7.73	0.25	7.30-8.16	7.71	0.25
DO	5.6-8.3	7.36	0.77	6.1-8.4	7.30	0.56	6.2-8.7	7.39	0.72
EC	285-411	344.28	38.42	268-386	341.39	38.68	279-409	349.17	34.86
SDD	52-76	63.67	6.76	46.0-76.2	61.80	8.79	49-78.74	63.19	7.87
Turbidity	5-22	12.11	6.10	6-23	13.94	6.10	5-22	12.56	6.21
TDS	125-235	191.00	40.74	112-234	183.44	46.32	125-233	190.39	40.23
Salinity	0.09-0.26	0.20	0.05	0.07-0.25	0.19	0.06	0.09-0.25	0.20	0.05
PA	0-10	3.44	2.85	0-9	3.22	2.63	0-8	2.78	2.32
MA	79-142	106.2	20.43	75-141	100.11	20.34	76-154	106.44	25.94
TA	79-149	109.6	23.12	75-149	103.33	22.72	78-161	109.22	27.91
Hardness	68.7-161.1	111.8	26.63	72.5-153.5	111.49	24.85	81.6-157.9	112.30	22.18
Chl-a	1.3-8.8	3.75	2.24	1.25-8.83	3.84	2.28	1.23-8.74	3.74	2.27
Cl-	30.1-46.4	38.62	5.00	28.8-47.16	38.93	5.25	29.5-47.2	38.42	5.46
Silicates	7.6-12.3	9.01	1.29	7.89-11.85	9.26	1.25	8.04-11.77	9.30	1.18
PP	0.09-0.20	0.15	0.03	0.09-0.21	0.15	0.03	0.09-0.21	0.16	0.02
TP	8.60-44.05	22.59	10.64	8.6-43.2	23.74	10.62	8.15-47.04	22.92	10.67
NO_3-N	0.472-0.822	0.652	0.103	0.50-0.80	0.654	0.102	0.495-0.79	0.646	0.103
NO_2-N	0.007-0.075	0.023	0.022	0.007-0.07	0.021	0.021	0.007-0.07	0.023	0.021
NH_3-N	0.017-0.150	0.064	0.037	0.016-0.14	0.062	0.037	0.016-0.15	0.063	0.036

Table 5: Continue...

Parameters	SITE IV			SITE V		
	Range	Mean	SD	Range	Mean	SD
T	23-32	27.23	1.84	25-31	27.28	1.47
pH	7.22-8.31	7.75	0.30	7.19-8.18	7.77	0.26
DO	5.8-8.3	7.14	0.75	5.7-8.2	7.27	0.64
EC	273-391	346.11	36.19	281-395	343.61	34.77
SDD	45.7-76.2	57.86	8.49	44.35-68.6	55.48	6.91
Turbidity	4-24	13.72	6.02	6-25	14.11	6.02
TDS	112-231	187.0	44.13	98-228	177.72	48.19
Salinity	0.05-0.29	0.20	0.07	0.03-0.28	0.18	0.09
PA	0-8	2.61	2.40	0-11	2.72	2.97
MA	71-149	103.22	23.79	70-151	101.17	27.95
TA	71-155	105.83	25.89	70-160	103.89	30.44
Hardness	79.8-154.8	110.20	23.85	78.9-158.2	109.58	23.34
Chl-a	1.28-9.24	3.96	2.38	1.34-8.9	4.07	2.35
Cl-	30.6-47.77	38.76	5.28	29.2-46.69	38.42	5.19
Silicates	7.65-12.13	9.10	1.33	8.25-13.73	9.53	1.31
PP	0.097-0.21	0.15	0.03	0.09-0.21	0.15	0.03
TP	7.85-43.82	23.11	10.62	7.25-43.59	22.38	11.00
NO_3-N	0.48-0.79	0.644	0.102	0.477-0.82	0.647	0.106
NO_2-N	0.007-0.07	0.023	0.020	0.007-0.09	0.026	0.026
NH_3-N	0.014-0.15	0.062	0.037	0.016-0.14	0.062	0.037

was seen between pH with EC (0.784), TDS (0.554), salinity (0.715), alkalinity (0.628), hardness (0.893), chlorides (0.846), silicates (0.785), and TP (0.736), whereas a negative connection was observed between pH with NO_3-N (-0.693). Similar patterns were also seen in the investigations conducted by Qureshimatva et al. (2015).

4.3. Dissolved oxygen (mg l^{-1})

The result showed that the DO in the trophogenic zone ranged from 5.9 mg l^{-1} (Sep. - 2018) to 8.2 mg l^{-1} (Apr. - 2018), which indicates a high rate of photosynthetic activity and is conducive for fish production according to research by Vass et al., 2009. The summer of 2018 had average readings of 7.5 mg l^{-1}, which was higher than the monsoon (6.3 mg l^{-1} in 2017 and 7.3 mg l^{-1} in 2018) or the winter (7.3 mg l^{-1} in 2017). DO values in similar outcomes were reported by Das (2000) for Andhra Pradesh›s Lower Manair Dam, Singur Reservoir, and Somasila Reservoir; by Sivakumar et al. (2000) for the Kamarajsagar Reservoir; by the residents of Ooty's Marlimund Lake, and by Dwivedi and Sonar (2004) for the Sagalee Reservoir in the state of Arunachal Pradesh.

Correlation study revealed a negative relationship between DO and temperature in almost all seasons with the exception of summer 2018. Barakat et al. (2016) also reported similar kind of results. In the southwest of Ethiopia, Meme et al. (2014) and Woldeab et al. (2018) found a similar trend of a positive association between DO and Temperature throughout the summer season. During the summer, DO and Temperature tend to go up together, which may be because of increased photosynthetic activity when temperatures rise. During the summer of 2018, a significant inverse relationship was found between DO and NH_3-N. There was a significant positive relationship between DO, Chl-a, and TP over the summer and monsoon of 2018. DO levels rise because nutrients encourage plankton development and photosynthetic activities of plankton use CO_2 by emitting oxygen (Patil et al., 2012).

4.4. Electrical conductivity (μS)

The average electrical conductivity (EC) in the catchment region ranged from 277.2 (July, 2018) to 398.0 (May, 2018) μS cm^{-1}, indicating that there are less dissolved solids and no substantial pollution sources. The seasonal average EC at Tiru reservoir reached 386.5 μS cm^{-1} during the summer owing to fertilizer content at the minimum water level. Due to dilution, monsoon water reduced EC values (309.2 μS cm^{-1} - 2017 and 318.7 μS cm^{-1} - 2018), and the recovery phase was observed during the winter season (343.6 μS

Table 6 Pearson's correlation matrix of water quality parameters for the study period (Aug. 2017–Jan. 2019.)

0	1	2	3	4	5	6	7	8	9
1		T	pH	DO	EC	SDD	Turbidity	TDS	Salinity
2	T	1							
3	pH	0.472**	1						
4	DO	0.141	0.461**	1					
5	EC	0.564**	0.784**	0.295**	1				
6	SDD	-0.158	-0.138	-0.114	0.032	1			
7	Turbidity	0.031	-0.380**	-0.157	-0.580**	-0.560**	1		
8	TDS	0.218*	0.554**	0.349**	0.641**	0.523**	-0.834**	1	
9	Salinity	0.332**	0.715**	0.330**	0.779**	0.401**	-0.776**	0.907**	1
10	TA	0.380**	0.628**	0.103	0.799**	0.073	-0.599**	0.626**	0.742**
11	Hardness	0.515**	0.893**	0.516**	0.827**	-0.151	-0.377**	0.538**	0.700**
12	Chl-a	0.604**	0.762**	0.406**	0.598**	-0.458**	0.040	0.197	0.375**
13	Chlorides	0.510**	0.846**	0.431**	0.809**	-0.077	-0.440**	0.600**	0.733**
14	Silicates	0.677**	0.785**	0.387**	0.687**	-0.247*	-0.159	0.350**	0.524**
15	TP	0.568**	0.736**	0.408**	0.604**	-0.526**	0.093	0.073	0.302**
16	NO_3-N	-0.511**	-0.693**	-0.156	-0.840**	0.026	0.546**	-0.562**	-0.691**
17	NO_2-N	-0.109	-0.181	0.120	-0.410**	-0.587**	0.712**	-0.607**	-0.578**
18	NH_3-N	0.426**	0.730**	0.294**	0.770**	0.001	-0.577**	0.579**	0.710**

Table 6: Continue...

0	1	10	11	12	13	14	15	16	17	18
1		TA	Hardness	Chl-a	Chlorides	Silicates	TP	NO_3-N	NO_2-N	NH_3-N
2	T									
3	pH									
4	DO									
5	EC									
6	SDD									
7	Turbidity									
8	TDS									
9	Salinity									
10	TA	1								
11	Hardness	0.708**	1							
12	Chl-a	0.517**	0.818**	1						
13	Chlorides	0.696**	0.908**	0.759**	1					
14	Silicates	0.508**	0.863**	0.835**	0.788**	1				
15	TP	0.494**	0.824**	0.926**	0.724**	0.822**	1			
16	NO_3-N	-0.863**	-0.792**	-0.678**	-0.747**	-0.709**	-0.636**	1		
17	NO_2-N	-0.433**	-0.106	0.087	-0.179	-0.052	0.224*	0.402**	1	
18	NH_3-N	0.698**	0.797**	0.545**	0.822**	0.675**	0.556**	-0.749**	-0.276**	1

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

cm^{-1} - 2017 and 348.8 µS cm^{-1} - 2018). Das (2000) found a comparable EC range in Andhra Pradesh's Lower Manair Dam (280-390 µS cm^{-1}), Mid Penna Dam (220-390 µS cm^{-1}), and Singur reservoir (280-390 µS cm^{-1}). Varunprasath and Daniel (2010) found EC values in the range of 180–320 µS cm^{-1} for the Bhavani River in Tamil Nadu.

During the research period, EC had a strong positive connection with TDS (0.641), Salinity (0.779), Alkalinity (0.799), Hardness (0.827), Chlorides (0.809), Silicates (0.687), and TP (0.604). Bikundia and Mohan (2014) and Gaury et al. (2018) found a favorable link between EC and TDS before the monsoon and a high correlation during the monsoon and after the monsoon. Woldeab et al. (2018) discovered a strong positive association between EC and TDS throughout the rainy and dry seasons.

4.5. Secchi disk depth (m)

Secchi disk depth was calculated in this research utilizing a 12-inch diameter Secchi disk. SDD measurements showed both temporal and geographical variability. SDD readings were reported at their lowest in June 2018 (0.48 m), and at their greatest in October 2017 (0.75 m). The monsoon season had the lowest SDD reading (0.54 m in 2017 and 2018), while the winter season had the highest (0.67 m in 2017 and 0.66 m in 2018). Sheela et al. (2011) and Saluja and Garg (2017) found similar results in Indian reservoirs. Surface runoff from agricultural fields carries non-algal turbidity, which is the primary source of the lowest SDD values during the monsoon season. Summer production would explain the strong significant negative connection of SDD with turbidity (-0.713) (Saluja and Garg, 2017).

Identical SDD readings were reported in the various reservoirs of India, like Musi reservoir (0.4 m to 0.9 m) and Nagarjunasagar reservoir (0.4 m to 0.9 m) of Andhra Pradesh studied by Das (2000); Gunderipallam Reservoir (0.48 m), Vembakottai Reservoir (0.51 m) and Vidur reservoir (0.56 m) of Tamil Nadu reported by Murugessan et al. (2003); Thirumullavaram Temple Pond (0.57-0.74 m) in Kerala recorded by Sulabha and Prakasam (2006).

SDD had a substantial negative connection with Chl-a throughout all seasons, since an increase in phytoplankton abundance yields a decrease in water transparency. During the monsoon, SDD had a considerably high negative association with turbidity. This is because of the high amount of suspended organic load entering the reservoir as a result of surface runoff. Summer production would explain the strong significant negative connection of SDD with turbidity (-0.713) (Saluja and Garg, 2017).

4.6. Turbidity (NTU)

The floating particles soak up heat from the sun, which warms the cloudy water and lowers the amount of dissolved oxygen in it. During the time of the study, the average

Table 7. Pearson's correlation matrix of water quality parameters for Monsoon 2017 (Aug. 2017–Sep. 2017.)

0	1	2	3	4	5	6	7	8	9
1		T	pH	DO	EC	SDD	Turbidity	TDS	Salinity
2	T	1							
3	pH	0.152	1						
4	DO	-0.178	-0.712*	1					
5	EC	0.071	0.434	-0.550	1				
6	SDD	-0.347	0.234	-0.689*	0.524	1			
7	Turbidity	-0.218	-0.347	0.701*	-0.621	-0.527	1		
8	TDS	0.143	0.139	-0.559	0.434	0.676*	-0.384	1	
9	Salinity	-0.221	-0.036	-0.314	0.371	0.728*	-0.243	0.683*	1
10	TA	-0.186	-0.385	0.196	-0.461	0.010	0.040	0.173	0.409
11	Hardness	0.112	0.467	-0.409	0.864**	0.409	-0.554	0.370	0.207
12	Chl-a	0.032	-0.468	0.813**	-0.760*	-0.875**	0.644*	-0.557	-0.551
13	Chlorides	0.067	0.174	-0.407	0.767**	0.523	-0.446	0.298	0.211
14	Silicates	0.318	-0.008	0.261	0.029	-0.436	0.088	-0.545	-0.687*
15	TP	-0.235	-0.576	0.859**	-0.746*	-0.675*	0.803**	-0.421	-0.298
16	NO_3-N	0.048	0.455	-0.678*	0.596	0.642*	-0.479	0.257	0.504
17	NO_2-N	-0.055	-0.592	0.800**	-0.645*	-0.684*	0.588	-0.272	-0.324
18	NH_3-N	0.019	0.196	-0.612	0.575	0.673*	-0.592	0.263	0.281

Table 7: Continue...

0	1	10	11	12	13	14	15	16	17	18
1		TA	Hardness	Chl-a	Chlorides	Silicates	TP	NO_3-N	NO_2-N	NH_3-N
2	T									
3	pH									
4	DO									
5	EC									
6	SDD									
7	Turbidity									
8	TDS									
9	Salinity									
10	TA	1								
11	Hardness	-0.492	1							
12	Chl-a	0.360	-0.624	1						
13	Chlorides	-0.719*	0.664*	-0.763*	1					
14	Silicates	-0.779**	0.196	0.108	0.416	1				
15	TP	0.393	-0.680*	0.907**	-0.665*	-0.037	1			
16	NO_3-N	-0.339	0.347	-0.852**	0.657*	-0.021	-0.752*	1		
17	NO_2-N	0.502	-0.482	0.916**	-0.734*	-0.106	0.874**	-0.940**	1	
18	NH_3-N	-0.495	0.380	-0.844**	0.857**	0.232	-0.764*	0.827**	-0.885**	1

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

turbidity was largest in August 2018 (23.2 NTU), and it was lowest in January 2018 (5.2 NTU). Turbidity was largest during the wet season (19.5 NTU in 2017 and 21.3 NTU in 2018) because of surface water from agricultural areas. Turbidity was lowest during winter (8.2 NTU in 2017 and 9.1 NTU in 2018). Throughout the year, the sediment was higher at sample stations II, IV, and V, which were close to streams, than at stations I and III, which were farther away.

During the study time, there was a very strong link between Turbidity and TDS (0.834), Salinity (-0.776), and Alkalinity (-0.599). During the winters of 2017 and 2018, a very strong negative association was found between turbidity and salinity, alkalinity, hardness, chlorophyll-a, and TP. During Monsoon 2018, there was also a high negative association between turbidity and the above factors. Sheela et al. (2011) found that the solids in the water have a big effect on how cloudy the water is. During the rainy season, more water flows into the pond from the nearby streams and rivers, which makes the water more cloudy and less salty (Dasharath et al., 2018). During the summer, Turbidity was linked to TDS, Salinity, Alkalinity, Hardness, Chl-a, and TP in a way that was not positive. During the time of the study, there was a negative relationship between turbidity and SDD. This showed that colloidal particles are the primary cause of lowering the water transparency (Sheela et al., 2011).

4.7. Total dissolved solids (mg l^{-1})

TDS is the total amount of anions, cations, minerals, salts and metals in the water (Sundaray et al., 2009; Gaury et al., 2018). TDS levels were highest in winter (223.7 mg l^{-1} in 2018), moderate in summer (214.7 mg l^{-1}), and lowest in the rainy season (131.0 mg l^{-1} in 2018). TDS levels are higher in sites with deep water and distant from streams (Station I and III). Similar TDS values was reported by Das (2000) in the Mid Penna Dam (143 mg l^{-1} to 253.5 mg l^{-1}) and Singur Reservoir (182 mg l^{-1}- 253.5 mg l^{-1}) of Andhra Pradesh; Sivakumar et al. (2000) in Kamarajsagar Reservoir (120 mg l^{-1}- 290 mg l^{-1}) located in Ooty; Sulabha and Prakasam (2006) in Thirumullavaram Temple Pond (173.3 mg l^{-1}- 240.5 mg l^{-1}), Kerala.

Significant positive correlation of TDS was reported with EC (0.641), Salinity (0.907), Alkalinity (0.626), Hardness (0.538) and Chlorides (0.600) during the study period.

4.8. Salinity (ppm)

In the Tiru reservoir, the average monthly salinity was highest in May 2018 (0.27 ppm) and lowest in August 2018 (0.07 ppm). The monsoon season had the lowest season average salinity (0.12 ppm in 2018), while winter (0.23 ppm) and summer (0.26 ppm) saw increases. Due to the diluting impact of water with rainwater influx, very low salinity was detected at stations II, IV, and V adjacent to rivers.

Table 8: Pearson's correlation matrix of water quality parameters for Monsoon 2017 (August, 2017–September, 2017)

0	1	2	3	4	5	6	7	8	9
1		T	pH	DO	EC	SDD	Turbidity	TDS	Salinity
2	T	1							
3	pH	0.068	1						
4	DO	-0.362	0.000	1					
5	EC	0.278	0.826**	0.031	1				
6	SDD	-0.268	-0.461*	-0.134	-0.627**	1			
7	Turbidity	-0.181	-0.528*	-0.057	-0.861**	-0.419	1		
8	TDS	0.485*	-0.278	-0.402	-0.183	0.052	0.187	1	
9	Salinity	0.390	0.504*	-0.351	0.680**	-0.216	-0.762**	0.072	1
10	TA	0.529*	0.514*	-0.371	0.803**	-0.488*	-0.823**	0.071	0.863**
11	Hardness	0.213	0.680**	-0.056	0.926**	-0.482*	-0.928**	-0.257	0.748**
12	Chl-a	0.500*	0.618**	-0.241	0.883**	-0.588**	-0.830**	-0.062	0.780**
13	Chlorides	0.602**	0.321	-0.399	0.602**	-0.351	-0.612**	0.082	0.693**
14	Silicates	0.129	0.336	-0.538*	0.490*	-0.089	-0.496*	-0.208	0.487*
15	TP	0.303	0.651**	-0.099	0.903**	-0.517*	-0.891**	-0.220	0.729**
16	NO3-N	-0.335	-0.651**	0.227	-0.895**	0.508*	0.875**	0.148	-0.783**
17	NO2-N	-0.094	-0.462*	-0.541*	-0.562**	0.532*	0.501*	0.202	-0.364
18	NH3-N	0.492*	0.624**	0.039	0.854**	-0.585**	-0.759**	0.023	0.666**

Table 8: Continue...

0	1	10	11	12	13	14	15	16	17	18
1		TA	Hardness	Chl-a	Chlorides	Silicates	TP	NO_3-N	NO_2-N	NH_3-N
2	T									
3	pH									
4	DO									
5	EC									
6	SDD									
7	Turbidity									
8	TDS									
9	Salinity									
10	TA	1								
11	Hardness	0.834**	1							
12	Chl-a	0.963**	0.863**	1						
13	Chlorides	0.880**	0.641**	0.877**	1					
14	Silicates	0.579**	0.654**	0.535*	0.474*	1				
15	TP	0.883**	0.928**	0.937**	0.765**	0.569**	1			
16	NO_3-N	-0.917**	-0.947**	-0.927**	-0.760**	-0.707**	-0.956**	1		
17	NO_2-N	-0.259	-0.454*	-0.372	-0.101	0.163	-0.431	0.340	1	
18	NH_3-N	0.790**	0.752**	0.870**	0.684**	0.202	0.802**	-0.722**	-0.581**	1

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

High significance positive correlations were found between salinity and pH (0.715), EC (0.779), alkalinity (0.626), and chlorides (0.733). Sheela et al. (2011) noted a similar pattern.

*4.9. Total alkalinity (*mg l^{-1}*)*

Throughout the research, the Tiru reservoir's total alkalinity ranged from 75.8 mg l^{-1} (Jul. 2018) to 154.8 mg l^{-1} (May 2018), suggesting its productivity. Total alkalinity followed pH trends: monsoon lowest (86.7 mg l^{-1}–2017; 82.7 mg l^{-1} –2018), winter high (104.7–2017; 111.8–2018), and summer peak (136.2–2018). Peak magnitudes varied. Summer total alkalinity was maximum because the reservoir remained steady with no water input or outflow. Values drop during monsoon floods. Das (2000) reported comparable TA values in the Lower Manair Dam (124–128 mg l^{-1}), Mid Penna Dam (64–112 mg l^{-1}), and Nagarjunasagar Reservoir (96–128 mg l^{-1}) in Andhra Pradesh State; Saha et al. (2001) in Subhas Sarobar Lake (103-158 mg l^{-1}), Kolkata; and Arun Kumar et al. (2013) in Barna Reservoir, Raisen Dist (85.5–140 mg l^{-1}), Madhya Pradesh.

TA had substantial positive correlations with pH (0.628), EC (0.799), Salinity (0.742), Hardness (0.708), and chlorides (0.696), but a strong negative association with NO_3-N (-0.863). TA correlated strongly with Hardness, Phosphate, and Nitrate, but negatively with Silicates. TA and temperature were negatively correlated in summer and winter 2018. Salinity and temperature affect TA because evaporation and precipitation concentrate or dilute ions in water. pH correlates positively with total alkalinity. Total alkalinity is the sum of all water ions that may neutralize H^+. Freshwater has a lower TA concentration because it contains few ions other than OH^- than seawater.

4.10. Hardness (mg l^{-1})

Hardness peaked in May 2018 (157.1 mg l^{-1}) and dropped in August 2017 (76.3 mg l^{-1}). In this research, summer had the highest values owing to increased water evaporation and no input (144.0 mg l^{-1}), winter (106.3 mg l^{-1}–2017; 107.5 mg l^{-1}–2018), and monsoon (80.2 mg l^{-1}–2017; 102.1 mg l^{-1}–2018).

Total Hardness correlated positively with chlorides (0.908) throughout the research. Umanageswari et al. (2019) found similar results. A warmer summer leads to higher evaporation, which lowers the reservoir's water level and, in turn, raises the concentration of nutrients in the water, which explains the strong positive association between hardness and temperature (0.515). Hardness correlated positively with EC (0.827) and TDS (0.538), similar to Chaubey and Patil (2015).

4.11. Chlorophyll-a (μg l^{-1})

May 2018 had the highest Chl-a value (8.91 μg l^{-1}) and October 2017 the lowest (1.29 μg l^{-1}). Chl-a concentrations were highest in summer (7.14 μg l^{-1}), moderate in monsoon 2018 (3.54), and lowest in winter (2.78 in 2017 and 2.49 in 2018). In summer, the reservoir's water level drops, allowing nutrients and plankton to accumulate and boost Chl-a concentration. Low primary production in winter owing to temperature decline, low nutrition level, and photosynthetically active sunlight may cause lowest Chl-a concentration. (Saluja and Garg, 2017).

During the research, Chl-a had a substantial positive connection with temperature (0.604) as water temperature and sunshine enhanced phytoplankton development (Saluja and Garg, 2017). SDD was negatively correlated with Chl-a (-0.458 over research period) in all seasons. Phytoplankton reduces water clarity.

4.12. Chlorides (mg l^{-1})

May 2018 had the highest chloride value (46.91 mg l^{-1}) and August 2018 had the lowest (31.18 mg l^{-1}). Summer 2018 had the highest average value (45.13 mg l^{-1}) and monsoon the lowest (32.13–2017; 36.03–2018). Winter had intermediate values (38.59–2017; 38.03–2018). Summer chloride levels are higher due to warmer temperatures, lower humidity, and more freshwater-sewage mixing. Piska and Chary (2000) reported a chloride value of 39.4 mg l^{-1} in the Osmansagar Reservoir, Hyderabad; Sivakumar et al. (2000) reported the chloride in the range of 33–35 mg l^{-1} in the Padumund Lake, Ooty; Thorat and Sultana (2000) recorded 38–42 mg l^{-1} in the Salim Ali Lake, Aurangabad; and Das (2000) reported 22.72-48.28 mg l^{-1} in the Yerrakalva.

Chlorides correlated positively with T (0.510), pH (0.846), EC (0.809), TDS (0.600), Salinity (0.733), TA (0.696), and Hardness (0.908). The hardness-chloride relationship matches with the findings of Umamageswari et al. (2019). Cl^- was positively correlated with EC, nitrate, phosphate, and magnesium by Khatoon et al. (2013). Sewage and industrial waste disposal contributes most chlorine to waters. Water hardness comes from calcium and magnesium chlorides and sulfates. Nutrients enter water from surface runoff during rainfall (Sheela et al., 2011; Saluja and Garg, 2017).

4.13. Silicates (mg l^{-1})

Silicates varied from 7.98 mg l^{-1} (Nov. 2018) to 12.36 mg l^{-1} (Apr. 2018). Summer 2018 had the highest mean silica content of 11.07 mg l^{-1}, while monsoon 2017 had the lowest, 8.16 mg l^{-1}.

SiO_2 correlated positively with EC (0.687), TDS (0.350), Hardness (0.863), Cl^- (0.788), and TP (0.822) and negatively with NO3-N (-0.709) throughout the research. Mohseni-Bandpei et al. (2018) found positive correlations of SiO_2 with EC, TDS, Cl^-, NO_2 and NO_3. Khan et

Table 9: 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
1		T	pH	DO	EC	SDD	Turbidity	TDS	Salinity
2	T	1							
3	pH	0.258	1						
4	DO	0.659**	0.409	1					
5	EC	0.192	0.546*	0.435	1				
6	SDD	-0.072	-0.661**	-0.305	-0.089	1			
7	Turbidity	0.436	0.677**	0.744**	0.502*	-0.713**	1		
8	TDS	0.086	0.398	0.308	0.601**	0.078	0.214	1	
9	Salinity	-0.006	0.522*	0.069	0.188	-0.739**	0.408	0.121	1
10	TA	-0.225	0.021	-0.214	0.403	-0.068	0.083	0.148	0.165
11	Hardness	0.387	0.707**	0.696**	0.757**	-0.460*	0.808**	0.559*	0.259
12	Chl-a	0.211	0.732**	0.751**	0.520*	-0.607**	0.838**	0.383	0.315
13	Chlorides	-0.127	0.686**	0.434	0.635**	-0.534*	0.619**	0.436	0.379
14	Silicates	0.545*	0.384	0.529*	0.003	-0.377	0.555*	0.027	0.236
15	TP	0.397	0.734**	0.781**	0.629**	-0.524*	0.921**	0.467*	0.242
16	NO3-N	0.348	-0.392	-0.153	-0.582**	0.246	-0.222	-0.089	-0.187
17	NO2-N	0.064	0.574**	0.350	0.603**	-0.565**	0.715**	0.362	0.288
18	NH3-N	-0.452*	-0.689**	-0.791**	-0.605**	0.576**	-0.936**	-0.464*	-0.286

Table 9: Continue...

0	1	10	11	12	13	14	15	16	17	18
1		TA	Hardness	Chl-a	Chlorides	Silicates	TP	NO_3-N	NO_2-N	NH_3-N
2	T									
3	pH									
4	DO									
5	EC									
6	SDD									
7	Turbidity									
8	TDS									
9	Salinity									
10	TA	1								
11	Hardness	0.164	1							
12	Chl-a	-0.185	0.800**	1						
13	Chlorides	0.107	0.681**	0.825**	1					
14	Silicates	-0.480*	0.333	0.550*	0.203	1				
15	TP	0.004	0.910**	0.918**	0.709**	0.532*	1			
16	NO_3-N	-0.247	-0.323	-0.433	-0.690**	0.290	-0.277	1		
17	NO_2-N	0.619**	0.767**	0.529*	0.592**	-0.058	0.684**	-0.381	1	
18	NH_3-N	-0.065	-0.905**	-0.875**	-0.674**	-0.518*	-0.969**	0.221	-0.732**	1

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

Table 10: Pearson's correlation matrix of water quality parameters for Monsoon 2018 (Jun. 2018–Sep. 2018.)

0	1	2	3	4	5	6	7	8	9
1		T	pH	DO	EC	SDD	Turbidity	TDS	Salinity
2	T	1							
3	pH	0.146	1						
4	DO	-0.030	0.626**	1					
5	EC	0.867**	0.464*	0.047	1				
6	SDD	-0.018	-0.511*	-0.819**	-0.044	1			
7	Turbidity	-0.523*	-0.598**	-0.034	-0.795**	-0.102	1		
8	TDS	0.512*	0.591**	0.378	0.644**	-0.124	-0.749**	1	
9	Salinity	0.352	0.629**	0.141	0.674**	0.076	-0.831**	0.729**	1
10	TA	0.397	-0.012	-0.639**	0.512*	0.725**	-0.596**	0.309	0.559*
11	Hardness	0.202	0.861**	0.822**	0.415	-0.743**	-0.417	0.609**	0.514*
12	Chl-a	0.116	0.688**	0.925**	0.195	-0.897**	-0.086	0.361	0.160
13	Chlorides	0.363	0.807**	0.709**	0.563**	-0.632**	-0.459*	0.593**	0.495*
14	Silicates	0.446*	0.753**	0.717**	0.560*	-0.737**	-0.409	0.495*	0.390
15	TP	0.257	0.885**	0.805**	0.484*	-0.765**	-0.439	0.561*	0.508*
16	NO_3-N	-0.815**	0.189	0.244	-0.652**	-0.238	0.369	-0.331	-0.141
17	NO_2-N	-0.327	0.416	0.859**	-0.323	-0.728**	0.255	0.177	-0.109
18	NH_3-N	0.380	0.850**	0.794**	0.567**	-0.701**	-0.520*	0.652**	0.547*

Table 10: Continue...

0	1	10	11	12	13	14	15	16	17	18
1		TA	Hardness	Chl-a	Chlorides	Silicates	TP	NO_3-N	NO_2-N	NH_3-N
2	T									
3	pH									
4	DO									
5	EC									
6	SDD									
7	Turbidity									
8	TDS									
9	Salinity									
10	TA	1								
11	Hardness	-0.317	1							
12	Chl-a	-0.617**	0.889**	1						
13	Chlorides	-0.189	0.881**	0.814**	1					
14	Silicates	-0.276	0.899**	0.844**	0.814**	1				
15	TP	-0.284	0.962**	0.902**	0.916**	0.910**	1			
16	NO_3-N	-0.370	0.112	0.147	-0.037	-0.110	0.076	1		
17	NO_2-N	-0.803**	0.628**	0.779**	0.454*	0.459*	0.576**	0.431	1	
18	NH_3-N	-0.235	0.955**	0.872**	0.911**	0.926**	0.973**	-0.091	0.547*	1

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

al. (2015) found the same positive connection of SiO_2 with Cl- and TDS owing to rock-water interaction and anthropogenic influences.

4.14. Total phosphorus (µg l^{-1})

Summer season (36.55 µg l^{-1}) at Tiru reservoir has record total phosphorus levels compared to winter (17.40 and 15.41 µg l^{-1}) and monsoon (18.22 and 24.78 µg l^{-1}). The highest monthly mean TP measurement was 44.33 µg l^{-1} in May 2018 and the lowest was 8.23 in October 2017. Summer TP values are higher owing to low water levels, which enhance nutrients, and strong microbial activity due to high temperatures, which releases phosphorous from sediments. (Saluja and Garg, 2017). Eutrophication is caused by algal overgrowth due to high phosphorus levels.

Total phosphorus correlated positively with T (0.568), pH (0.736), EC (0.604), Hardness (0.824), Cl- (0.724), and Silicates (0.822) and very strongly with Chl-a (0.926), but negatively with SDD (-0.526). James et al. (2009) found that TP's seasonal patterns matched Chl-a's pattern and that TP had a negative connection with SDD. Barakat et al. (2016) found TP positively correlated with Turbidity, TSS, and BOD. Such phosphorus is mostly from natural and human sources. TP correlated positively with pH and negatively with NO_3 according to Mohaseni-Bandpei et al. (2018). Winter and monsoon seasons showed a stronger negative connection between TP and NO3-N than summer.

4.15. Nitrate nitrogen (mg l^{-1})

NO_3-N levels ranged from 0.49 mg l^{-1} (May 2018) to 0.80 mg l^{-1} (Jul 2018). Monsoon had the greatest mean value (0.75 mg l^{-1} in 2018) and summer the lowest (0.51 mg l^{-1}).

NO_3-N had a substantial negative connection with T, pH, EC, TDS, salinity, TH, Cl^-, TP, and NH_3-N. Barakat et al. (2016) found negative correlations of NO_3-N with Temperature and EC and positive correlations with COD and DO, possibly owing to leaching from agricultural land.

During monsoon 2017, NO_3-N and DO had a strong negative association (-0.678), showing that aerobic bacteria need oxygen to nitrify (Sheela et al., 2011; Shaluja and Garg, 2017). Lianthuamluaia et al. (2013) found high positive correlations between nitrate and nitrite and strong negative correlations with alkalinity.

4.16. Nitrite nitrogen (mg l^{-1})

NO_2-N concentrations ranged from 0.007 mg l^{-1} (Dec. 2017) to 0.070 mg l^{-1} (Jul. 2018). Monsoon season had the greatest mean NO_2-N concentration (0.05 mg l^{-1} in 2018) and summer the lowest (0.01 mg l^{-1}).

NO_2-N correlated positively with Turbidity (0.712) and negatively with EC (-0.410), SDD (-0.587), and TDS (-0.607). Ling et al. (2017) found a substantial positive

Table 11: 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
1		T	pH	DO	EC	SDD	Turbidity	TDS	Salinity
2	T	1							
3	pH	-0.731**	1						
4	DO	-0.737**	0.565**	1					
5	EC	-0.549*	0.706**	0.342	1				
6	SDD	0.350	-0.798**	-0.244	-0.527*	1			
7	Turbidity	0.567**	-0.778**	-0.501*	-0.899**	-0.611**	1		
8	TDS	-0.214	0.164	-0.030	0.491*	-0.308	-0.329	1	
9	Salinity	-0.376	0.368	-0.030	0.699**	-0.203	-0.441	0.542*	1
10	TA	-0.623**	0.662**	0.464*	0.834**	-0.542*	-0.792**	0.557*	0.690**
11	Hardness	-0.619**	0.727**	0.418	0.929**	-0.482*	-0.879**	0.355	0.724**
12	Chl-a	-0.458*	0.794**	0.244	0.869**	-0.805**	-0.855**	0.530*	0.633**
13	Chlorides	-0.197	0.476*	0.173	0.725**	-0.505*	-0.666**	0.563**	0.684**
14	Silicates	-0.310	0.537*	0.056	0.631**	-0.391	-0.630**	-0.062	0.426
15	TP	-0.622**	0.731**	0.304	0.893**	-0.504*	-0.822**	0.281	0.707**
16	NO_3-N	0.399	-0.654**	-0.069	-0.868**	0.575**	0.801**	-0.358	-0.695**
17	NO_2-N	0.260	0.052	-0.213	0.087	-0.147	-0.076	0.009	-0.024
18	NH_3-N	-0.373	0.614**	0.195	0.820**	-0.680**	-0.806**	0.706**	0.590**

Table 11: Continue...

0	1	10	11	12	13	14	15	16	17	18
1		TA	Hardness	Chl-a	Chlorides	Silicates	TP	NO_3-N	NO_2-N	NH_3-N
2	T									
3	pH									
4	DO									
5	EC									
6	SDD									
7	Turbidity									
8	TDS									
9	Salinity									
10	TA	1								
11	Hardness	0.798**	1							
12	Chl-a	0.836**	0.836**	1						
13	Chlorides	0.680**	0.761**	0.798**	1					
14	Silicates	0.355	0.758**	.588**	0.467*	1				
15	TP	0.775**	0.932**	0.825**	0.591**	0.787**	1			
16	NO_3-N	-0.713**	-0.885**	-0.880**	-0.681**	-0.836**	-0.946**	1		
17	NO_2-N	-0.008	0.057	0.223	0.129	0.282	0.145	-0.284	1	
18	NH_3-N	0.861**	0.708**	0.917**	0.741**	0.326	0.691**	-0.747**	0.088	1

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

connection of NO_2-N with DO during monsoon 2017 (0.800) and 2018 (0.859). Summer 2018 showed a 0.684 positive connection between NO_2-N and TP, comparable to Sheela et al. (2011).

4.17. Ammoniacal nitrogen (mg l^{-1})

NH_3-N ranged from 0.02 to 0.15 mg l^{-1}. Summer 2018 had the greatest seasonal mean (0.11 mg l^{-1}) and monsoon 2017 the lowest (0.02 mg l^{-1}).

NH_3-N is positively correlated with pH, EC, TDS, Salinity, TA, Hardness, Chlorides, Silicates, and TP. During the investigation, turbidity (-0.577) and NO_2-N (-0.749) were negatively correlated. During summer 2018, NH_3-N had a substantial negative connection with T(-0.452), pH(-0.689), and DO(-0.791) and no significant positive association with other metrics. Lianthuamluaia et al. (2013) found similar results. Umamageswari et al. (2019) reported that NH_3-N correlated positively with EC, TDS, and Cl-.

5. CONCLUSION

Maximum concentration of Total phosphorus occurred in the summer, when reservoir levels were at their lowest and it showed very strong positive correlation with Chl-a (0.926). An increase in chlorophyll-a (algal blooms) is a symptom of eutrophication, which is caused by an excess of phosphorus in water. The overall results showed that the Tiru reservoir was in a eutrophic to hyper-eutrophic condition.

6. REFERENCES

Anonymous, 2005. Standard methods for the examination of water and waste-water, 21st ed. American Public Health Association, Washington DC.

Akhtar, N., Syakir Ishak, M.I., Rai, S.P., Saini, R., Pant, N., Anees, M.T., Qadir, A., Khan, U., 2019. Multivariate investigation of heavy metals in the groundwater for irrigation and drinking in Garautha Tehsil, Jhansi District, India. Analytical Letter 53, 774–794.

Akhtar, N., Syakir Ishak, M.I., Bhawani, S.A., Umar, K., 2021. Various natural and anthropogenic factors responsible for water quality degradation: a review. Water 13(19), 2660.

Akongyuure, D.N., Alhassan, E.H., 2021. Variation of water quality parameters and correlation among them and fish catch per unit effort of the Tono Reservoir in Northern Ghana. Journal of Freshwater Ecology 36(1), 253–269.

Ashwin, K.R.N., Arulmozhi, S., Gopalan, A., Mageshkumar, P., Rangaraj, A., Panneerselvam, M., Nirmala Devi, B., Aravindhan, C., Prasath, E., Nyagong, Santino, D.L., 2022. Correlation, regression analysis, and spatial distribution mapping of wqi for an urban lake in noyyal river basin in the textile capital of India. Advances in Materials Science and Engineering 2022, 3402951.

Barakat, A., Baghdadi, M.E., Rais, J., Aghezzaf, B., Slassi, M., 2016. Assessment of spatial and seasonal water quality variation of Oum Er Rbia River (Morocco) using multivariate statistical techniques. International Soil and Water Conservation Research 4, 284–292.

Barakat, A., Baghdadi, M.E., Rais, J., Aghezzaf, B., Slassi, M., 2016. Assessment of spatial and seasonal water quality variation of Oum Er Rbia River (Morocco) using multivariate statistical techniques. International Soil and Water Conservation Research 4, 284–292.

Begum, A.M., Ramaiah, H., Khan, I., Veena, K., 2009. Heavy metal pollution and chemical profile of Cauvery River water. E-Journal of Chemistry 6(1), 47–52.

Bikundia, D.S., Mohan, D., 2014. Major ion chemistry of the ground water at the Khoda Village, Ghaziabad, India. Sustainability of Water Quality and Ecology 2014(3–4), 133–150.

Chaubey, S., Patil, M.K., 2015. Correlation study and regression analysis of water quality assessment of Nagpur City, India. International Journal of Scientific and Research Publications *5*(11), 753–757.

Cheevaporn, V., Jacinto, G.S., McGlone, S.D., 1995. Heavy metal fluxes in Bang Pakong River Estuary, Thailand: sedimentary versus diffusive fluxes. Marine Pollution Bulletin 31, 290–294.

Cotruvo, J.A., 2017. WHO guidelines for drinking water quality: Frst addendum to the fourth edition. Journal-American Water Works Association, 109, 2–39.

Das, A.K., 2000. Limno-chemistry of some Andhra Pradesh reservoirs. Journal of Inland Fisheries Society of India 32(2), 37–44.

Dasharath, D., Reddy, E.N., 2018. Relation between turbidity and total dissolved solids based on flow rate of the Godavari water. Journal of Ultra Chemistry *2*(2), 45–48.

Dwivedi, P., Sonar, S., 2004. Evaluation of physico-chemical and biological characteristics of water samples of reservoirs around Rono Hills, Doimukh (Dist. Papum Pare), Arunachal Pradesh. Pollution Research 23(1), 101–104.

Edmonson, W.T., 1966. Change in the oxygen deficit of lake Washington Verh Internet Varein. Journal of Limnology 16, 153–158.

Gaur, N., Sarkar, A., Dutta, D., Gogoi, B.J., Dubey, R., Dwivedi, S.K., 2022. Evaluation of water quality index and geochemical characteristics of surface water from Tawang India. Scientific Reports 12(1), 1–26.

Gaury, P.K., Meena, N.K., Mahajan, A.K., 2018. Hydrochemistry and water quality of Rewalsar Lake of Lesser Himalaya, Himachal Pradesh, India. Environmental Monitoring and Assessment 190, 84.

Gong, Y., Ji, X., Hong, X., Cheng, S., 2021. Correlation analysis of landscape structure and water quality in suzhou national wetland park, China. Water 13(15), 2075.

Horvat, Z., Horvat, M., Pastor, K., Bursic, V., Puvaca, N., 2021. Multivariate analysis of water quality measurements on the Danube River. Water 13, 3634.

Hutchinsan, G.E., 1957. A treatise on limnology Vol-I. New York, John Wiley and Sons, Inc.

Jakson, D.F., 1961. Comparative studies on phytoplankton photosynthesis in relation to total alkalinity. Journal of Limnology 14, 125–133.

James, R.T., Havens, K., Zhu, G., Qin, B., 2009. Comparative analysis of nutrients, chlorophyll, and transparency in two large shallow lakes. Hydrobiologia 627, 211–231.

Jeon, B.H., Dempsey, B.A., Burgos, W.D., Royer, R.A., 2003. Sorption kinetics of Fe(II), Zn(II), Co(II), Ni(II), Cd(II), and Fe(II)/Me(II) onto hermatite. Water Research 37, 4135–4142.

Jothivnkatachalam, K., Nithya, A., Chandra Mohan, S., 2010. Correlation analysis of drinking water quality in and around Perur block of Coimbatore district, Tamil Nadu, India. 3. Rasayan Journal of Chemistry 3(4), 649–654.

Khan, A.A., Shammi, Q.J., Dar, S.H., Nabi, N.G., 2015. Seasonal variations in physico-chemical parameters in upper lake of Bhopal (M.P.). International Journal of Applied and Universal Research 2(2), 1–7.

Khatoon, N., Khan, A.H., Rehman, M., Pathak, V., 2013. Correlation study for the assessment of water quality and its parameters of Ganga river, Kanpur, Uttar Pradesh, India. Journal of Applied Chemistry 5(3), 80–90.

Kothari, V., Vij, S., Sharma, S., Gupta, N., 2020. Correlation of various water quality parameters and water quality index of Districts of Uttarakhand. Environmental and Sustainability Indicators 9. 100093.

Kshirsagar, S., Vijaykumar, Gurav, M., Rao, K., 2016. Correlation studies of physicochemical parameters during different seasons from Bhima River, Pandharpur, Maharashtra. International Journal of Current Biotechnology 4(5), 1–7.

Kumari, R., Sharma, R.C., 2019. Assessment of water quality index and multivariate analysis of high-altitude sacred Lake Prashar, Himachal Pradesh, India. International Journal of Environmental Science and Technology 16, 6125–6134.

Lokhande, R.S., Kelkar, N., 1999. Indian Journal of Environmental Protection 19, 664–668.

Meme, F.K., Arimoro, F.O., Nwadukwe, F.O., 2014. Analyses of physical and chemical parameters in surface waters nearby a cement factory in North Central, Nigeria. Journal of Environmental Protection 5(10), 826–834.

Mohseni-Bandpei, A., Motesaddi, S., Eslamizadeh, M., Rafiee, M., Nasseri, M., Montazeri Namin, M., Hashempour, Y., Mehrabi, Y., Riahi, S.M., 2018. Water quality assessment of the most important dam (Latyan dam) in Tehran, Iran. Environmental Science and Pollution Research 25(29), 29227–29239.

Murugavel, P., Pandian, T.J., 2000. Effect of altitude on hydrology, productivity and species richness in kodayar-a tropical peninsular Indian aquatic system. Hydrobiologia 430, 33–57.

Murugesan, V.K., Manoharan, 2000. Management of reservoir fisheries through private entrepreneurs case studies. Journal of Inland Fisheries Society of India 32(2), 68–75.

Patil, P., Sawant, D.V., Deshmukh, R.N., 2012. Physico-chemical parameters for testing of water - a review. International Journal of Environmental Sciences 3(3), 1194–1207.

Patil, V.T., Patil, P.R., 2010. Physicochemical analysis of selected groundwater samples of Amalner town in Jalgaon District, Maharashtra, India. Journal of Chemistry 7(1), 111–116.

Piska, R.S., Charry, K.D., 2000. Impact of tropical nature of reservoir on the reproductive capacity of catfish, Mystus bleekeri (Day). Ecology Environment and Conservation 6(4), 447–452.

Qureshimatva, U.M., Maurya, R.R., Gamit, S.B., Solanki, H.A., 2015. Studies on the physico-chemical parameters and correlation coefficient of Sarkhej Roza Lake, District Ahmedabad, Gujarat, India. Journal of Environmental and Analytical Toxicology 5(4), 284.

Ruttner, F., 1953. Fundamentals of limnology. Univ. Toronto Press, Toronto Canada.

Saha, T., Manna, N.K., Majumder, S., Bhattacharya, I.N., 2001. Primary productivity of the Subhas Sarobar lake in East Calcutta in relation to some selected Physico-chemical parameters. Pollution Research 20(1), 47–52.

Saluja, R., Garg, J.K., 2017. Trophic state assessment of Bhinda was Lake Haryana. Environmental Monitoring and Assessment, 189, 32.

Saxena, A., Srivastava, P., 2001. Primary production by phytoplankton in a Sewage fed Lake and energy transformation to fish yield. Pollution Research 20(4), 613–617.

Schmitt, D., Saravia, F., Frimmel, F.H., Schuessler, W., 2003. Facilitated transport of metal ions in aquifers: importance of complex-dissociation kinetics and colloid formation. Water Research 37, 3541–3550.

Sheela, A.M., Letha, J., Joseph, S., 2011. Environmental status of a tropical lake system. Environmental Monitoring and Assessment 180, 427–449.

Shroff, P., Vashi, R.T., Champaneri, V., Patel, K.K., 2015. Correlation study among water quality parameters of groundwater of Valsad district of south Gujarat (India). Journal of Fundamental and Applied Sciences 7(3), 340–349.

Shukla, S.K., Sharma, R.K., 2023. Correlation and regression analysis of physicochemical parameters of wainganga river water in central India. Journal of Indian Association for Environmental Management 43(1), 11–17.

Sivakumar, R., Mohanraj, R., Azeez, A.P., 2000. Physico-chemical analysis of water sources of Ooty, South India. Pollution Research 19(1), 143–146.

Sulabha, V., Prakasam, V.R., 2006. Limnological features of Thirumullavaram temple pond of Kollam municipality, Kerala. Journal of Environmental Biology 27(2), 449–451.

Sun, X., Zhang, H., Zhong, M., Wang, Z., Liang, X., Huang, T., Huang, H., 2019. Analyses on the temporal and spatial characteristics of water quality in a seagoing river using multivariate statistical techniques: a case study in the Duliujian river, China. International Journal of Environmental Research and Public Health 16(6), 1020.

Panda, P.K., Panda, R.B., Dash, P.K., 2018. The study of water quality and pearson's correlation coefficients among different physico-chemical parameters of River Salandi, Bhadrak, Odisha, India. American Journal of Water Resources 6(4), 146–155.

Sundaray, S.K., Nayak, B.B., Bhatta, D., 2009. Environmental studies on river water quality with reference to suitability for agricultural purposes: Mahanadi River estuarine system, India-a case study. Environmental Monitoring and Assessment 155(1–4), 227–243.

Tyagi, S., Dobhal, R., Kimothi, P.C., Adlakha L.K., Singh, P., Unial D.P., 2013. Studies of river water quality using river bank filtration in Uttarakhand, India. Water Quality, Exposure & Health 5, 139–148.

Umamageswari, T.S.R., Sarala Thambavani, D., Liviu, M., 2019. Hydrogeochemical processes in the groundwater environment of Batlagundu block, Dindigul district, Tamil Nadu: conventional graphical and multivariate statistical approach. Applied Water Science 9, 14.

Varunprasath, K., Daniel, N.A., 2010. Physico-chemical parameters of river bhavani in three stations, Tamilnadu, India. Iranica Journal of Energy and Environment (IJEE) 1(4), 321–325.

Vass, K.K., Shrivastava, N.P., Katiha P.K., Das. A.K., 2009. Enhancing fishery productivity in small reservoir in India. A Technical Manual. World Fish Center Technical Manual No. 1949. The World Fish Center, Penang, Malaysia. 19.

Welch, P.S., 1935. Limnological methods (1st Ed.) McGrow-Hill Book Co., New York, London.

Woldeab, B., Beyene, A., Ambelu, A., Buffam, I., Mereta, S.T., 2018. Seasonal and spatial variation of reservoir water quality in the southwest of Ethiopia. Environmental Monitoring and Assessment 190(3), 1–13.

Yilma, M., Kiflie, Z., Gessese, N., 2019. Assessment and interpretation of river water quality in Little Akaki River using multivariate statistical techniques. International Journal of Environmental Science and Technology 16, 3707–3720.