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## Comparative Analysis of the Physicochemical Parameters of Selected Pond Water Samples in and around Vellore District, India

V. Seetha and M. Chandran\*

Department of Zoology, Thiruvalluvar University, Vellore, India

\*Corresponding author

### ABSTRACT

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Lentic systems are a diverse set of inland freshwater habitats (Lakes and ponds) exist across the globe and provide essential resources and habitats for both terrestrial and aquatic organisms. The current work was intended to evaluate the quality of the selected ponds (Pond 1, 2 and 3) in and around Vellore district, TamilNadu. The water samples were collected to determine the physical and chemical parameters during every month in the year 2019. Water parameters such as temperature, pH, dissolved oxygen, Alkalinity, electrical conductivity, Chloride, Sulphate, Nitrate, Ca, Cl was studied. The physicochemical analysis of the samples was compared with each other and the quality status of the water was analyzed. The foremost aim of the present study was to give impression knowledge about the effluence level of pond water in terms of physico-chemical characteristics

### Introduction

Water is considered to be one of the essential factors for existence of life on the planet for all living organisms. Each and every organism depends on water for their survival. About 1% of total water in earth is present in aquatic resources such as ponds, rivers, dams etc which is used by mankind for day to day practices. Lakes and ponds (also known as lentic systems) are a diverse set of inland freshwater habitats that exist across the globe and provide essential resources and habitats

for both terrestrial and aquatic organisms. Although widely distributed and vital for many species, including humans, these habitats account for just over 3% of the Earth's surface (Downing *et al.*, 2006).

Importantly, these rare systems are increasingly threatened by the human demand for freshwater as well as human activity. Recent evidence suggests that freshwater systems are more imperiled than marine and terrestrial ones (Dudgeon *et al.*, 2006). Effective conservation and management of

these systems relies on our ability to fulfill the growing human demand for freshwater while maintaining system integrity. Humans also create lentic habitats. Across the world, humans have constructed impoundments and reservoirs to provide water resources for humans and livestock, generate energy, or control flooding.

While large water bodies have historically received most of the attention, ponds are the numerically dominant lentic habitat (Downing *et al.*, 2006). Ponds are generally < 2 hectares in size, shallow (< 3 m), and dominated by aquatic plants. Ponds have a diversity of ecological and geological origins including man-made impoundments. Moreover, due to their small size, ponds often have characteristics that are distinct from larger water bodies.

Water being an important source as it is highly used in agriculture, industries etc. (Kumar, 1997). But worsening of water quality is becoming faster day by day, which leads to adverse impact on the regular practices of mankind (Mahananda *et al.*, 2005). Deterioration of water resources is mainly due to the discharge of chemical waste from industries such as textile, tannery, sewage discharge etc.

On the other hand, water contamination is mediated by biological sources such as algal bloom (eutrophication) formation on the surface of water which turn the quality of the water by depleting the presence of biological oxygen in the water thus converts natural fresh water into toxic fluid for aquatic plants and animals. Other contaminants such as acids, salts, pesticides, heavy metals, azo dyes, dead and decaying animals and other living organisms were also considered as contaminants in water bodies.

Discharge of contaminations such as effluents, municipal discharge and sewage

water in biological resources leads to the change in its physical and chemical properties and makes them unfit for animals and human beings.

Physical texture of the water such as color, taste, odour, hardness and turbidity changes drastically. Based on the contaminant in the water, it can be classified as physical contaminant, chemical contamination, biological contamination and radioactive contaminants. Ponds are considered to be a useful source since ancient time as an essential source of water for ancient people. In general, seasonal changes in the nature of the water results in the variation in the population of specific algae in the aquatic bodies (Sharma *et al.*, 2016).

Temperature plays an important environmental factor in the aquatic system and temperature has a major influence in the rate of decomposition of organic matters in the water bodies. It also has its direct effect on various metabolic process and activities of the organism. The chemical characteristics of the Hydrogen ion concentration have its control over the distribution and activity of the aquatic flora and fauna. The free CO<sub>2</sub> and carbonates relationship help to regulate the pH value in the pond water. Dissolved oxygen has its major role in the aquatic life.

The oxygen dissolved in the water is the most important factor for the survival of aquatic life. The metabolic process of the aquatic system depends upon the dissolved oxygen in the water. There are two forms of carbon dioxide present in the pond, they are bicarbonate and carbonate. These two forms of carbon dioxide are a purely chemical source needed to buffer the environment against rapid shifts in acidity-alkalinity status. The level of carbon dioxide in aquatic system helps to regulate the biological process in the aquatic communities. The alkalinity in the pond is considered to be as the capacity of

pond water to the neutralization of the acids which is keeps on shifting the pH value towards the alkaline side of the pond water. According to several scientists, the alkalinity in the neutral water is based on the presence of the bicarbonate, carbonate and hydroxide.

The present study is intended to evaluate the physic-chemical properties of water samples collected from 3 different ponds named as Pond 1, Pond 2 and Pond 3 located in and around Vellore, Tamilnadu.

## **Materials and Methods**

### **Study area and sample collection**

The water samples for physicochemical analysis were collected from three different ponds designated as pond 1, pond 2 and pond 3 in and around Vellore districts, Tamilnadu with latitude and longitude 12.9165° N and 79.1325° E. The samples were collected during every month from January to December in the year 2019. The samples were collected aseptically in a sterile collection tube and transported to laboratory. The samples were subjected to analysis for experimental accuracy.

### **Physicochemical analysis of water samples**

Samples collected from the ponds were subjected to physicochemical analysis using standard procedure with standard method. Temperature of the water sample was measured using Agaro DT-555 Digital Thermometer.

The temperature of the samples was observed and recorded. pH of the water sample was measured using HM digital pH-80 hydro tester. The pH of the water sample was determined in the ratio 1:5 water: distilled water suspension. The electro conductivity of the water sample was determined in 1:5 (sample: water) suspension with the help of a

Conductivity meter. Alkalinity of the water is due to the presence of minerals producing sodium carbonate upon weathering.

It was determined by titrating the water suspension with a strong acid using methyl orange as an indicator. The chloride is an essential ion for plant growth. The chloride present in the sample was determined in 1:5 water sample: water suspension by Argentometric method.

Exchangeable Calcium and Magnesium present in the water sample were determined in ammonium acetate leachate by titration method. The sulphate present in the water sample was determined in 1:5 water samples: water suspension by turbidimetric method and measured by spectrophotometer. Available phosphorus was determined by extracting it with sulphuric acid by stannous chloride method by spectrophotometer. Dissolved oxygen in the sample was measured using Winkler's method.

## **Results and Discussion**

The results obtained in the physicochemical analysis of the water samples collected from the three ponds throughout the year are listed below (Table 1–3).

### **Temperature**

The temperature of the water samples in all the ponds were between 27 °C to 30 °C in the initial two months. The temperature of the pond water tends to increase during the third month. The temperature increased gradually during the month of March to November (30 °C to 36 °C). The temperature was found to be maximum during April to June.

### **pH**

pH of the pond water samples was measured by pH meter. pH value of pond water varied

between 6.39 to 8.96 respectively indicating well permissible limits throughout the year in all the ponds. The pH of the samples varied during the summer and remained neutral during winter seasons.

### **Electrical conductivity**

Electrical conductivity indicates the capacity of electrical current that passed through the water, which in turn is related to concentration of ionized substances present in it. E.C. varied from 218.18 to 116.36 mhos./cm during the months of the year.

### **Dissolved oxygen (DO)**

The dissolved oxygen (DO) concentration of the pond water samples ranged between 2.72 to 5.23 throughout the year. Quality of water depends on D.O. Occurrence of low DO value has been attributed to the process of decomposition of organic matter involving the utilization of oxygen. The level of dissolved oxygen remains similar throughout the year.

### **Total alkalinity**

Alkalinity is the buffering capacity of water. It is constituted principally by carbonates and bicarbonates of calcium, Magnesium, Potassium and Sodium, which appear in the water in the form of natural salts. Hydroxide or caustic alkalinity seldom exists in the samples. The sample 1 and sample 3 showed lower alkalinity during the month of October. Sample 2 showed lower alkalinity during the month of November.

### **Chloride**

The chloride concentration of the water samples ranged from 9.82 mg/L to 39.27 mg/L throughout the year. Chloride concentration of all samples was below the permissible limit. The maximum Cl<sup>-</sup>

concentration was observed in pond -2 (39.27 mg/L). Excessive prevalence of chlorides in the raw water may be indicative of pollution from human and animal wastes.

### **Nitrate**

The nitrate concentration of the water samples ranged from 0.17 to 0.38 mg/L. The maximum nitrate content was found in the pond 1 during the month of June. Nitrate represents the final stage of mineralization of nitrogenous organic matter such as dead green plants and animals. As such higher value of nitrate in the water may be indicative of sewage pollution.

### **Sulphate**

The sulphate concentration of the water samples varied from 1.03 to 1.83 mg/L in pond 1, 1.06 to 2.15 mg/L in pond 2 and 1.19 to 1.83 in pond 3. The result showed that the Pond Water have permissible range of Sulphate ions.

Physicochemical water quality constraints are substantial to the firmness of marine and other water ecologies (Sargaonkar and Deshpande, 2003). A surplus amount of P or N in waters is accountable for eutrophication, and it encourages extreme development of phytoplankton (Mishra et al., 2008) recognized as algal blooms in waters.

Water hardness, a quantity of divalent ions such as calcium and magnesium in water. And it is an important impact affecting phytoplankton efficiency. The temperature of water is most vital constraint which directly influence some chemical reactions in aquatic ecosystem the significant correlation between ambient temperature. Wind turbulence and temperature interact to influence stratification and water circulation within lakes. In the spring, wind turbulence circulates the water

throughout a lake supplying oxygen to the entire water column.

However, as the temperature increases during the summer and wind subsides, thermal stratification occurs, producing distinct layers in the water column; the upper warm-water epilimnion is separated from the lower cold-water hypolimnion by the thermocline. Oxygen concentration in the hypolimnion tends to decline compared to the epilimnion due to the lack of water circulation.

Changes in the pH level in water ecosystem are chiefly due to numerous biological activities (Roleda *et al.*, 2015). Hence pH is been considered as an essential factor in determining the status of the ecosystem (Nassar *et al.*, 2015). In general, alkaline pH is often the main characteristic feature of eutrophic and mesotrophic water bodies (Yang *et al.*, 2008; Ansari *et al.*, 2015).

Another critical factor in lakes and ponds is light transmission, which is required for photosynthesis in primary producers. Generally, the water column is divided into the photic and aphotic zones. In the photic zone, light penetration is >1% and plants undergo photosynthesis. In contrast, light penetration is <1% in the aphotic zone and respiration exceeds photosynthesis.

Water depth as well as water clarity influence light transmission. However, a deep lake with low water clarity may have a large aphotic zone because light transmission is blocked by suspended particles in the water column. Importantly, lakes and ponds can alternate between clear and turbid states as populations of primary producers respond to changes in light levels and nutrient availability (Scheffer and van Nes 2007).

Nevertheless, in reservoirs and lakes, these parameters were found higher. Surplus amount of Ca or Mg in lakes and reservoirs may also be due to extreme leakage of calcium-rich mineral rocks (Badrakh *et al.*, 2008).

Frequently, the increased quantity of DO in water bodies is associated with high phytoplankton density (Malik and Bharti, 2012), but a high density of phytoplankton in waters may not always be correlated with the high amount of DO because of excessive accumulation of degradable matter towards the end of productive algal growth.

Chloride ions are generally associated with Na, K and Ca ions, which are common elements in inland waters. The high levels of K in eutrophic sites are generally the consequence of K-containing chemical manures discharged out from the farming fields nearby the aquatic bodies.

Similar to any ecosystem, nutrient inputs and cycling have exerted significant impact on the structure and function of pond ecosystems. Nutrients are transported into lentic systems via terrestrial run-off, ground water flow, atmospheric deposition (e.g., rain), rock weathering, and direct input from terrestrial systems (e.g., leaf litter).

The three most important nutrients are nitrogen, carbon, and phosphorus, which are essential elements to all organisms. While phosphorus has historically been considered the most limiting in lentic systems due to low input rates and the high propensity to form complexes with iron, leading to mineralization (Elser *et al.*, 2007).

**Table.1** Physio- chemical properties of pond water 1

Parameters	MONTHS											
	January	February	March	April	May	June	July	August	September	October	November	December
<b>Colour</b>	Green	Green	Dark green	Dark green	Dark green	Dark green	Dark green	Green	Green	Green	Green	Green
<b>Temperature (°C)</b>	27.66 ±1.17	29.63 ±1.25	31.34 ±1.96	34.31 ±1.45	34.79 ±1.47	34.31 ±1.45	33.60 ±1.42	33.27 ±1.40	32.23 ±1.36	30.72 ±1.29	29.02 ±1.23	27.72 ±1.17
<b>pH</b>	7.53 ±0.51	7.87 ±0.34	8.09 ±0.34	8.86 ±0.33	8.26 ±0.35	8.95 ±0.34	8.18 ±0.34	6.57 ±0.28	7.08 ±0.29	7.98 ±0.34	7.16 ±0.37	7.09 ±0.30
<b>Transparency (cm)</b>	27.08 ±1.10	30.54 ±1.29	32.72 ±1.38	35.18 ±1.58	35.74 ±1.90	33.08 ±1.65	32.72 ±1.37	20.34 ±1.18	18.95 ±1.27	19.63 ±0.83	22.67 ±1.62	27.27 ±1.15
<b>DO (mg/L)</b>	4.36 ±0.18	4.82 ±0.24	4.92 ±0.25	4.92 ±0.25	4.69 ±0.19	4.37 ±0.18	4.38 ±0.22	3.93 ±0.19	3.38 ±0.16	3.43 ±0.17	3.05 ±0.13	2.72 ±0.14
<b>Conductivity (mS/cm)</b>	120.82 ±6.04	129.81 ±6.49	218.18 ±10.91	201.82 ±10.09	193.09 ±9.65	185.47 ±9.27	180.01 ±9.01	171.10 ±8.55	116.36 ±5.82	120.64 ±6.03	164.90 ±6.29	119.01 ±5.95
<b>Calcium (mg/L)</b>	49.11 ±2.07	44.73 ±1.89	56.73 ±2.39	106.91 ±4.51	104.73 ±4.42	100.37 ±4.24	90.54 ±3.82	75.10 ±3.18	89.46 ±3.77	85.08 ±3.59	75.26 ±3.18	54.54 ±2.30
<b>Total alkalinity</b>	22.91 ±0.97	30.55 ±1.29	32.01 ±4.97	35.99 ±1.52	31.64 ±1.34	31.64 ±1.34	32.72 ±1.38	26.18 ±1.10	29.45 ±1.24	19.64 ±0.83	21.82 ±0.92	27.26 ±1.15
<b>Magnesium (mg/L)</b>	32.73 ±1.38	29.45 ±1.24	31.82 ±0.92	52.36 ±2.21	61.09 ±2.58	73.08 ±3.08	67.63 ±2.85	49.11 ±2.07	33.81 ±1.43	48.01 ±2.03	43.64 ±1.84	37.08 ±1.56
<b>Chloride (mg/L)</b>	20.72 ±0.87	19.64 ±0.83	26.26 ±1.03	27.26 ±1.15	28.36 ±1.30	29.45 ±1.24	23.12 ±1.05	16.36 ±0.69	14.18 ±0.61	9.82 ±0.42	12.01 ±0.51	18.54 ±0.78
<b>Phosphorus (mg/L)</b>	0.14 ±0.01	0.18 ±0.017	0.21 ±0.02	0.25 ±0.027	0.25 ±0.015	0.28 ±0.025	0.25 ±0.028	0.23 ±0.018	0.23 ±0.036	0.19 ±0.022	0.18 ±0.026	0.16 ±0.017
<b>Sulphate (mg/L)</b>	1.03 ±0.05	1.31 ±0.067	1.54 ±0.74	1.83 ±0.097	1.92 ±0.092	1.61 ±0.07	1.77 ±0.75	1.29 ±0.052	1.46 ±0.063	1.32 ±0.065	1.22 ±0.063	1.07 ±0.045
<b>Nitrate (mg/L)</b>	0.31 ±0.01	0.24 ±0.014	0.35 ±0.016	0.36 ±0.015	0.37 ±0.01	0.38 ±0.014	0.34 ±0.017	0.21 ±0.013	0.22 ±0.011	0.24 ±0.04	0.32 ±0.018	0.37 ±0.015



**Table.2** Physio-chemical properties of pond water 2

Parameters	MONTHS											
	January	February	March	April	May	June	July	August	September	October	November	December
<b>Colour</b>	Green	Green	Dark green	Dark green	Dark green	Dark green	Dark green	Green	Green	Green	Green	Green
<b>Temperature (°C)</b>	29.47 ±1.24	31.73 ±1.34	34.09 ±1.44	36.16 ±1.52	36.38 ±1.53	36.98 ±1.56	35.46 ±1.50	35.07 ±1.48	34.53 ±1.46	33.16 ±1.40	31.19 ±1.32	30.42 ±1.28
<b>pH</b>	7.74 ±0.33	7.03 ±0.36	8.86 ±0.33	8.17 ±0.34	8.39 ±0.35	8.17 ±0.34	8.28 ±0.35	7.41 ±0.31	6.98 ±0.29	6.39 ±0.15	6.51 ±0.36	6.76 ±0.28
<b>Transparency (cm)</b>	21.12 ±0.92	26.18 ±1.10	30.55 ±1.29	31.45 ±1.24	32.82 ±0.92	26.78 ±1.10	23.99 ±1.01	18.56 ±0.78	17.45 ±0.73	13.08 ±0.55	19.64 ±0.83	16.36 ±0.69
<b>DO (mg/L)</b>	4.48 ±0.19	4.14 ±0.17	5.12 ±0.22	5.23 ±0.22	5.13 ±0.20	5.23 ±0.22	4.92 ±0.21	4.48 ±0.19	3.81 ±0.16	3.38 ±0.14	3.71 ±0.16	4.48 ±0.19
<b>Conductivity (mS/cm)</b>	130.91 ±5.52	133.10 ±5.61	207.27 ±8.74	196.36 ±8.28	185.47 ±7.82	174.55 ±7.36	163.64 ±6.90	163.64 ±6.90	158.18 ±6.67	150.55 ±6.35	128.72 ±5.43	122.15 ±5.09
<b>Calcium (mg/L)</b>	45.82 ±1.94	35.99 ±1.52	92.74 ±3.91	88.37 ±3.73	87.27 ±3.68	81.82 ±3.45	78.55 ±3.31	76.36 ±3.22	52.36 ±2.21	30.56 ±1.29	49.11 ±2.07	38.17 ±1.61
<b>Total alkalinity</b>	31.64 ±1.34	32.73 ±1.38	38.17 ±1.61	34.91 ±1.47	33.81 ±1.43	30.55 ±1.29	29.45 ±1.24	27.27 ±1.15	21.82 ±0.92	16.36 ±0.69	13.08 ±0.55	19.63 ±0.83
<b>Magnesium (mg/L)</b>	43.64 ±1.84	49.11 ±2.07	97.09 ±4.10	92.74 ±3.91	70.91 ±2.99	67.64 ±2.85	65.45 ±2.76	60 ±2.53	45.82 ±1.94	38.17 ±1.61	43.64 ±1.84	29.46 ±1.24
<b>Chloride (mg/L)</b>	23.99 ±1.01	29.46 ±1.24	39.27 ±1.65	38.17 ±1.61	37.08 ±1.56	33.81 ±1.43	21.82 ±0.92	22.91 ±0.96	19.63 ±0.83	13.08 ±0.55	10.92 ±0.46	27.27 ±1.15
<b>Phosphorus (mg/L)</b>	0.16 ±0.017	0.18 ±0.01	0.19 ±0.08	0.18 ±0.017	0.27 ±0.013	0.22 ±0.011	0.17 ±0.017	0.13 ±0.016	0.18 ±0.018	0.12 ±0.015	0.15 ±0.017	0.11 ±0.015
<b>Sulphate (mg/L)</b>	1.19 ±0.05	1.06 ±0.04	1.25 ±0.05	2.15 ±0.091	2.02 ±0.87	1.94 ±0.082	1.83 ±0.079	1.42 ±0.061	1.65 ±0.071	1.56 ±0.066	1.36 ±0.056	1.27 ±0.52
<b>Nitrate (mg/L)</b>	0.27 ±0.013	0.24 ±0.012	0.33 ±0.016	0.32 ±0.018	0.24 ±0.011	0.26 ±0.014	0.28 ±0.01	0.18 ±0.018	0.17 ±0.01	0.19 ±0.011	0.23 ±0.018	0.22 ±0.014

**Table.3** Physio-chemical properties of pond water 3

Parameters	MONTHS											
	January	February	March	April	May	June	July	August	September	October	November	December
<b>Colour</b>	Green	Green	Dark green	Dark green	Dark green	Dark green	Dark green	Green	Green	Green	Green	Green
<b>Temperature (°C)</b>	28.92 ±1.22	30.81 ±1.30	33.38 ±1.41	35.46 ±1.50	36.16 ±1.52	35.17 ±1.49	33.92 ±1.43	34.16 ±1.40	33.11 ±1.39	31.81 ±1.34	30.01 ±1.27	28.80 ±1.21
<b>pH</b>	7.64 ±0.32	8.07 ±0.34	8.96 ±0.34	8.07 ±0.34	8.28 ±0.35	8.17 ±0.34	8.07 ±0.34	8.27 ±0.35	7.87 ±0.28	7.17 ±0.34	6.39 ±0.35	6.87 ±0.28
<b>Transparency (cm)</b>	28.36 ±1.22	30.54 ±1.30	32.72 ±1.38	33.87 ±1.44	26.18 ±1.10	25.08 ±1.07	25.08 ±1.07	19.64 ±0.82	16.38 ±0.68	17.44 ±0.73	20.72 ±0.87	24 ±1.02
<b>DO (mg/L)</b>	4.36 ±0.18	4.69 ±0.19	5.13 ±0.21	5.03 ±0.21	4.49 ±0.15	4.79 ±0.21	4.92 ±0.21	4.25 ±0.18	3.58 ±0.17	3.30 ±0.16	3.05 ±0.13	3.81 ±0.16
<b>Conductivity (mS/cm)</b>	126.54 ±5.34	171.28 ±7.22	210.36 ±10.51	196.36 ±8.28	180.01 ±7.51	190.91 ±8.05	177.82 ±7.50	148.37 ±6.26	142.73 ±7.14	152.55 ±6.85	130.18 ±6.51	148.37 ±6.26
<b>Calcium (mg/L)</b>	46.92 ±1.98	42.54 ±1.79	101.56 ±5.03	95.99 ±4.05	97.09 ±4.10	86.17 ±3.63	82.92 ±3.49	79.64 ±3.36	61.09 ±2.58	40.36 ±1.70	44.18 ±3.13	50.18 ±2.12
<b>Total alkalinity</b>	32.73 ±1.38	28.36 ±1.20	37.08 ±1.56	32.73 ±1.38	31.64 ±1.34	32.73 ±1.38	31.64 ±1.34	27.27 ±1.15	23.11 ±1.35	18.54 ±0.78	19.64 ±0.83	25.09 ±1.06
<b>Magnesium (mg/L)</b>	38.17 ±1.611	39.27 ±1.65	82.92 ±3.49	75.26 ±3.18	65.45 ±2.76	56.73 ±2.39	58.92 ±2.49	46.92 ±1.98	52.36 ±2.21	42.54 ±1.79	35.99 ±1.52	26.18 ±1.10
<b>Chloride (mg/L)</b>	22.91 ±0.96	27.27 ±1.15	32.73 ±1.38	33.81 ±1.43	31.64 ±1.34	31.64 ±1.34	23.99 ±0.96	19.64 ±0.83	17.45 ±0.74	11.94 ±0.51	10.92 ±0.46	20.73 ±0.87
<b>Phosphorus (mg/L)</b>	0.15 ±0.016	0.17 ±0.017	0.19 ±0.011	0.22 ±0.14	0.26 ±0.08	0.23 ±0.012	0.22 ±0.011	0.19 ±0.018	0.17 ±0.01	0.18 ±0.018	0.16 ±0.01	0.14 ±0.016
<b>Sulphate (mg/L)</b>	1.81 ±0.075	1.36 ±0.055	1.99 ±0.083	1.93 ±0.081	1.89 ±0.078	1.71 ±0.07	1.61 ±0.068	1.71 ±0.071	1.57 ±0.064	1.52 ±0.06	1.31 ±0.054	1.19 ±0.05
<b>Nitrate (mg/L)</b>	0.19 ±0.011	0.24 ±0.018	0.36 ±0.016	0.35 ±0.017	0.34 ±0.016	0.33 ±0.014	0.32 ±0.015	0.33 ±0.014	0.28 ±0.01	0.27 ±0.011	0.26 ±0.012	0.18 ±0.018



While natural systems can be eutrophic, human activity can increase the input of nitrogen and phosphorus into lentic systems leading to anthropogenic eutrophication. Industrial, agricultural, or municipal wastewater can augment nutrient inputs into lentic systems, which can shift the environmental equilibrium and lead to eutrophication. Anthropogenic eutrophication can dramatically alter the food web structure and reduce water quality. Once eutrophication occurs, it is difficult to reverse owing to internal feedbacks (e.g., hysteresis).

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