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HYDROCHEMICAL DYNAMIC AND WATER QUALITY ANALYSIS OF THIRUVALLUVAR UNIVERSITY MUD POND

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ABSTRACT:

Any ponds located near residential and agricultural areas are very susceptible to contamination, which may provide substantial risks to both the surrounding ecosystem and human populations. The present research pond is located inside the Thiruvalluvar University and is near the village of Serkkadu Kootroad, Vellore District. Approximately 1000 households reside in this vicinity. They emit a substantial quantity of pollutants regularly and also use open toilets. During the times of rainfall, all of these substances have the potential to contaminate the Thiruvalluvar University pond via runoff. Thus, this study was carried out to examine the water quality of mud pond o Thiruvalluvar University highlighting the need to conduct a thorough evaluation and implementing appropriate mitigation strategies. The study results suggest that the water sourced from the pond at Thiruvalluvar University is not appropriate for consumption or other domestic use. Nevertheless, it might be advantageous for aquaculture purposes.

Keywords: Mud Pond; Water Qulaity; Water Pollution; Residential area; Hydrochemical dynamic

1. INTRODUCTION

Water is an essential resource for all living organisms, and its quality is crucial for the health and welfare of both people and the environment. Potable water is water that is safe to drink, use for cooking, maintain personal hygiene, and clean with, and may be provided to the user (Bos *et al.*, 2016).Throughout the state of Tamilnadu, the drinking water requirements of the population are met by various water bodies found in every village. These water bodies include ponds, kanmais, pits, kulams, kuttais, ooranis, lakes, rivers, and streams. Among these, kanmais and ooranis, as well as kulams and kuttais, in each village are particularly important for replenishing the underground water during the rainy season. They are also serve as a source of drinking water and fulfill other domestic needs for the nearby population. Today, all the water bodies have been polluted due to various anthropogenic activates pollution sources, including both point and non-point sources of pollution and agricultural runoff. This leads to a multitude of aliments among human beings. According to a study conducted by the United Nations Development Programme (UNDP 2015), more than 1.1 billion people, which are equivalent to one-sixth of the global population, do not have access to clean drinking water. Waterborne diseases such as choler a, diarrhoea, malaria, and dengue fever result in millions of deaths. Water-borne infections result in the daily mortality of more than 25,000 people worldwide, including over 5,000 children who die from water-related illnesses, mostly diarrhoea, each day (Davis, 2013). Each year, almost 1.8 million children succumb to diarrhoea and its related diseases, with the bulk of these cases concentrated in developing countries (Johnson *et al.*, 2011). An estimated 1.8 billion people are thought to drink water that is contaminated with Escherichia coli, indicating the presence of faecal contamination (Bain *et al.*, 2014). When the water is delivered to clients, it must meet certain quality standards for its chemical, biological, and physical characteristics (de Zuane, 1997). Approximately 1 billion people worldwide do not have access to safe drinking water. According to the 2002 study from the Third World Academy of Sciences (TWAS), the availability of safe and dependable (clean and uncontaminated) water is a fundamental right of humans (Samra and Fawzi, 2011). In 2017, the World Health Organisation (WHO) reported that around 89% of the world's population had access to safe drinking water. Therefore, in this research, the mud pond situated inside the Thiruvalluvar University campus was chosen to investigate the water quality. The aim was to evaluate its acceptability for both drinking and other household uses, as well as its potential for aquaculture practices.

2. MATERIALS AND METHOD

Nature of study site location

The study place, Thiruvalluvar University Pond, is located inside the campus, and next to the library and computer building in Serkkadu Village, Vellore district. The basement of the pond consists of a combination of rock and dirt. As a result, the water is continuously present throughout the year. Fresh water sources like rivers, ponds, lakes, kanmais, and kulums may get contaminated by a range of chemical compounds and heavy metals. This pollution is mostly caused by the activities of several small firms located in and around Vellore District, notably SIPCOT. The Vellore District and Ranipet District are well-known for their tanneries and leather enterprises. The toxins discharged by these enterprises provide a health hazard to all living beings.

Study Site Disrict Vellore Profile

The present investigation focuses on a particular area. Vellore is a district located in the state of Tamil Nadu in India. This district is among the 38 districts in the state. It is situated in the northern part of Tamil Nadu and is one of the eleven districts in that region. The district is located within the latitudes of 12° 15' to 13° 15' North and the longitudes of 78° 20' to 79° 50' East. It has boundaries with neighboring states like Andhra Pradesh, Karnataka, and Kerala. The Vellore district may be classified by two primary physical characteristics: rugged topography and flat regions. The Palar Plain is situated in the eastern region of the Eastern Ghats. The region's geography is mostly marked by rolling hills that gradually descend towards the east. According to the 2011 census, the population of Vellore district was 1,614,242, with a six ratio of 1,007 females per 1,000 males. The six ratio exceeds the national average of 929. Before the split of Ranipet District, it included a grand total of 841 villages. The industries in the Ranipet District have a substantial influence on the pollution levels in the nearby Vellore District due to their close vicinity.

Fresh water bodies in Vellore District

Freshwater bodies are located within the geographical boundaries of Vellore District. Throughout ancient times, the rulers of Tamilnadu state have diligently constructed several lakes, ponds, uranini, kulam, and kuttai to provide a sustainable water supply. Within these low-lying areas, both tiny and big depressions are used to collect and store rainwater during periods of severe precipitation, as well as surplus river water, for future purposes. There are a total of 842 villages in Vellore District. Every Village has a minimum of one lake or kanmai for irrigation, and many Oorani for livestock bathing and garment washing. The water bodies in every taluk in Vellore District were given in Fig 1-7.

Figure- 1-7. shows the water bodies in all seven taluke of Vellore District (before the separation of Ranipet District) (Source: NIC -Tamilnadu Government)

Fig-1

Fig-2

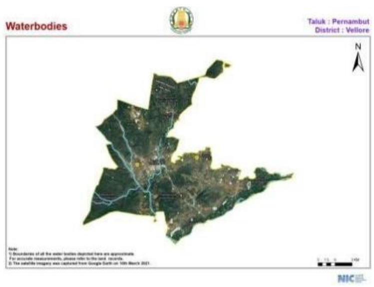


Fig-3

Fig-4

Fig-5

Fig-6

Fig-7

Study site Village profile

Serkadu is arural hamlet that is administered by a local self-governing body known as the Gramme Panchayat. It is located in the Katpadi taluka of the Vellore district in the southern state of Tamil Nadu, India. The town has a total land area of 828.87 hectares. The population of Serkadu consists of 3,455 inhabitants, including 1,682 males and 1,773 females. The literacy rate in Serkadu village is at 69.93%, with 76.75% of males and 63.45% of females being literate. Serkadu village has of 849 residences. The village of Serkadu is administered by a sarpanch, who is a representative elected via local elections. Based on the 2019 figures, Serkadu village is situated within the territorial limits of the Katpadi assembly constituency and the Arakkonam parliamentary constituency. Thiruvalam, situated around 5km from Serkadu, is the nearest town for all major commercial operations.

Climatic condition of study site village serkkadu

Serkādu has a tropical savanna climate. The climate has a steady warm temperature year-round, with distinct periods of rainfall and drought. The average annual temperature of Serkādu is 33 degrees Celsius, and the yearly rainfall is around 248 mm. The area has a dry climate for 282 days annually, with an average humidity level of 42% and a UV index of 7.

Study Pond related information

This inquiry focuses on the Thiruvalluvar University reservoir, situated near the university library and computer complex, just across from the main building. The shape of a pond is similar to that of the single-celled organism paramecium. The pond is located at the foot of somewhat large hills, which are heavily covered with tiny trees and plants and consist of stones. In the rainy season, the water that flows down from the hills is collected and stored in the pond. The pond's bottom consists of rock, resulting in the water in the pond being perpetual.

Sample site selection

A total of six water sample locations were selected for this investigation performed at the pond of Thiruvalluvar University. The coordinates of these sample sites were documented on a global map as TVUPS-1, TVUPS-II, TVUPS-III, TVUPS-IV, and TVUPS-VI. The abbreviation TVUPS refers to the Thiruvalluvar University Pond Site, with the Roman numerals used to denote the specific site number. The sample site was carefully chosen to include and accurately depict the overall state of the pond water. The two sampling locations were selected from the middle region of the pond to evaluate the water quality at its most profound section. Four additional sample sites were collected from the outside region of the pond, with one site chosen from each cardinal direction. Water samples were collected from each monitoring station during the year 2022, namely from January to December, using plastic bottles. The first month's sample collection took place on January 2nd, 2022, including all designated sampling sites. Consequently, sample collection for the present study occurred on the second day of each following month. The table below presents the names, elevations, and longitudes of the sample sites.

Table-1. Shows the name, latitude and longitude of the sample sites

S.No	Name of the sample sites	Latitude-N	Longitude-E
1	TVUPS-I	13°01’43.46”N	79°12”32.43”E
2	TVUPS-II	13°01’41.93”N	79°12”33.08”E
3	TVUPS-III	13°01’40.71”N	79°12”32.74”E
4	TVUPS-IV	13°01’40.47”N	79°12”31.62”E
5	TVUPS-V	13°01’53.46”N	79°12”31.75”E
6	TVUPS-VI	13°01’42.16”N	79°12”32.56”E

Figure-8. Shows the location of sample sites in the Thiruvalluvar University Pond

Labeling the samples bottle for identification

The precise details, such as the collection location, date, and time, were documented on the sample collecting vial using an indelible glass marker, ensuring that the ink cannot be wiped or deleted.

Preparation of samples bottle for water collection

Before obtaining the pond water sample, the plastic sample vial was cleaned with a phosphate-free detergent, followed by three rinses with cold tap water, a 10% hydrochloric acid solution, and deionized water.

Collection method

The bottle cap was removed just before sampling. Precautions were taken to avoid any touch with the inside of the bottle or its lid. The bottle was vertically oriented concerning the pond's surface. After the bottle was filled, it was securely closed with a cap.

Preservation and processing of water sample

Water samples, each with a volume of 500 ml, were gathered from all six sampling sites and placed in an insulated container. Subsequently, they were conveyed to the laboratory located at the Zoology Department. In the laboratory, every water sample underwent filtration using a Whatman No. 41 filter paper with a pore size of 0.45 µm. This filtration process aimed to ascertain the quantity of dissolved metal in each sample. Water samples, each measuring 500 ml, were collected and treated with 2 ml of nitric acid to prevent the development of metal precipitates. In addition, over the same time frame, spot analysis was performed to evaluate several physical attributes such as colour, temperature, and transparency. This examination followed appropriate standard protocols as recommended by APHA (2001) and CPC (2000)

Methods used for water a analysis

An array of analytical tests, including temperature, pH, EC, transparency, alkalinity, total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD) and chemical oxygen demand (COD) conductivity, were performed on mud pond water samples obtained from Thiruvalluvar University. These tests aimed to evaluate various parameters. Water samples were collected six times each month from each sample location in the pond to assess all the parameters of the current research. The aforementioned parameters were assessed following methods stated in the standard methodology of APHA (2001) and the reference handbook for wastewater analysis (CPC, 2000).

3. RESULTS AND DISCUSSION

In the current investigation, surface water samples were gathered from each of the six TVUP sites that are situated in Serkkadu Village, which is located in the Vellore District. In every sample day, the spot analysis technique was used to take measurements of the surface water temperature, EC, and transparency. These measurements were taken on the spot. The additional characteristics such as temperature, pH, EC, transparency, alkalinity, total dissolved solids (TDS), dissolved oxygen (DO), biological oxygen demand (BOD) and chemical oxygen demand (COD) were measured from collected water samples. At each sample site throughout the year, from January to December, on six randomly chosen days of each month, spot analysis and water sample collection for physico-chemical parameter analysis were carried out. To determine the results of the mean deviation, the data from each of the six days were subjected to statistical analysis.

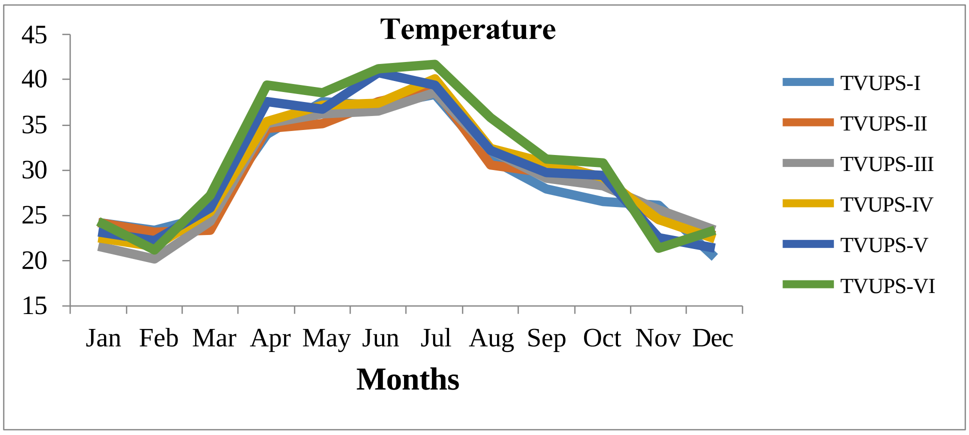
a. Temperatures

In the abiotic factors, temperature is considered to be a significant factor (Fry 1971; Brett 1979). In the process of determining the quality of water, temperature is an essential factor that makes a huge contribution. According to Nicolet *et al.*, (2004) and De Meester *et al.*, (2005), a temperature rise has a direct and consequential effect on the rate of photosynthesis in plants, the population of aquatic plants, the death rate of plants, the process of aerobic bacterial decomposition, and finally results in the depletion of oxygen. According to Dwivedi and Pandey (2002), Singh and Mathur (2005), Jalal and Sanalkumar (2012), and Tank and Chippa (2013), temperature is an essential factor that influences how the aquatic environment functions and has an effect on the growth and distribution of both plants and animals. Based on the findings of this investigation, all the six sites TVUP exhibited temperatures ranging from 21.4ºC to 40.7 ºC. Which has an affinity with the water temperature ranges 27 ºC to 30 ºC observed by Seetha and Chandran (2020). Whenever or whenever temperatures around 25 ºC are highly preferred for drinking purposes in all TVUPS. Temperatures that are higher than this optimal temperature (25 ºC) contribute to an increase in the development of the majority of opportunistic pathogens in drinking water (van der Wielen *et al.*, 2014), and thus are not recommended for drinking purposes.

Table 2. Shows the mean surface water temperature of the Thiruvalluvar University Pond from the month of January to December-2022.

Sites												
TVUPS-	24.2	23.4	25	34	37.6	37.2	38.4	31.2	28	26.6	26.2	20.4
I	1	±1.56	±5	±4.4	±3.5	±3.4	±3.8	±3.4	±3.1	±3.6	±3.9	±2.7
	±1.8											
TVUPS-	24.2	23.2	23.4	34.6	35.2	37.6	39 ±	30.6	29.8	28.8	24.6	22.8
II	±3.1	±3.4	±3.8	±4.2	±3.4	±3.3	3.1	±3.2	±2.8	±3.1	±3.2	±3.4
TVUPS-	21.6	20.2	24.4	35.2	36.2	36.6	38.6	32.2	29.1	28.3	25.6	23.4
III	±3.9	±3.4	±4.5	±4.1	±4.6	±3.8	±4.2	±3.4	±3.1	±2.9	±2.6	±3.5
TVUPS-	22.6	21.6	25.4	35.4	37.2	37.4	40.1	32.4	30.8	29.2	24.6	22 .4
IV	±3.4	±3.2	±4.2	±3.8	±3.5	±3.5	±3.1	±3.8	±2.8	± 3.2	±2.3	±4.1
TVUPS-	23.2	22.2	25.8	37.6	36.8	40.8	39.4	32.2	29.8	29.4	22.6	21.4
V	±3.1	±3.7	±4.3	±3.9	±4.2	±4.4	±3.1	±3.4	±2.8	±2.5	±3.0	±2.3
TVUPS-	24.4	21.2	27.2	39.4	38.6	41.2	41 .7	35.8	31.2	30.8	21.4	23.4
VI	±3.2	±3.7	±3.1	±2.4	±2.7	±3.2	±3.1	±2.8	±3.4	±3.5	±31	±3.6

Figure 9. Shows the mean surface water temperature of the Thiruvalluvar University Pond from the month of January to December-2022.



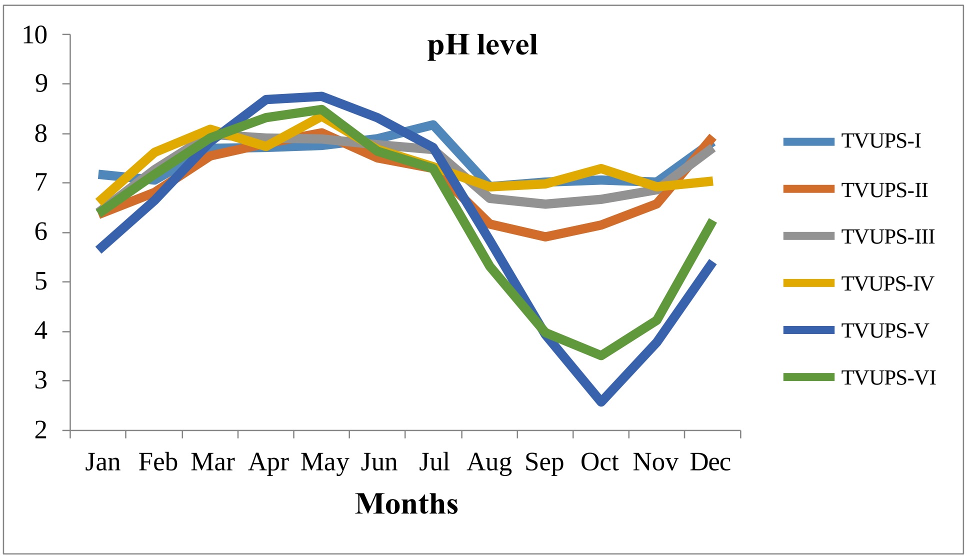
b. pH level

As established by Smith *et al.*, (2010), low pH levels may result are increased acidity in water, which can have detrimental consequences on aquatic creatures and the environments in which they find themselves. It was discovered that the pH levels of the TVUPS were much lower than neutral, with the pH values of 2.5 being the lowest. However, the pH levels that were the highest were far higher than the neutral range, with values reaching 8.7. Which has an agreement with the water pH ranges 6.39 to 8.96 observed by Seetha and Chandran (2020). To achieve optimum plankton growth, the pH range should be between 5 and 8.5. Additional proof that a pH range that is neutral to slightly alkaline is highly advantageous for fish ponds is provided by the research that was carried out by Banerjee in the year 1967. During present in some place examination, the pH readings were found to be lower and higher than the indicated optimum range of pH 6.5 to 8.5, which was defined by the Bangladesh Bureau of Standards (BBS). According to Rao (2006), the pH of a water system has a direct influence on all of the chemical and biological interactions that take place. According to Mitharwal *et al.*, (2009), the pH of water is an essential indication of its quality and plays a fundamental part in a wide variety of computations involving geochemical equilibrium or solubility.

Table 3. Shows the mean□ deviation value of surface water pH level of the Thiruvalluvar University Pond from January to December-2022.

Sites												
TVUPS -I	7.184 ±0.80	**7.07** ±0.43	7.704 ± 0.48	7.726 ±0.48	7.766 ±0.37	7.888 ±0.47	8.176 ± 0.56	6.93 ±0.74	7.026 ±0.80	7.052 ±0.79	7.012 ±0.87	7.84 ±0.64
TVUPS -II	6.362 ±0.68	6.804 ±0.82	7.536 ±0.88	7.792 ±0.69	8.014 ±0.62	7.506 ±0.64	7.302 ±0.63	6.172 ±0.78	5.908 ±0.69	6.156 ±0.88	6.568 ±0.91	7.936 ±0.64
TVUPS - III	6.406 ±0.88	7.272 ±0.78	7.986 ±0.78	7.92 ±0.63	7.896 ±0.78	7.782 ±0.85	7.676 ±0.95	6.694 ±0.73	6.584 ±0.49	6.668 ±0.41	6.874 ±0.52	7.718 ±0.64
TVUPS - IV	6.61 ±0.53	7.62 ±0.81	8.09 ±0.57	7.744 ±0.41	8.354 ±0.47	7.676 ±0.49	7.338 ±0.72	6.934 ±0.55	6.978 ±0.80	7.284 ±0.45	6.916 ±0.63	7.042 ±0.40
TVUPS -V	5.652 ±0.98	6.646 ±0.96	7.832 ±0.73	8.7 ±0.51	8.754 ±0.44	8.322 ±0.51	7.73 ±0.54	5.838 ±0.74	3.928 ±0.74	2.574 ±0.81	3.784 ±0.99	5.406 ±0.78
TVUPS - VI	6.39 ±0.70	7.182 ±0.72	7.91 ±0.60	8.324 ±0.60	8.488 ±0.78	7.64 ±0.75	7.296 ±0.75	5.314 ±0.88	3.966 ±0.72	3.512 ±0.73	4.218 ± 0.59	6.236 ±0.611

Figure 10. shows the mean surface water pH level of the Thiruvalluvar University Pond from the month of January to December-2022.



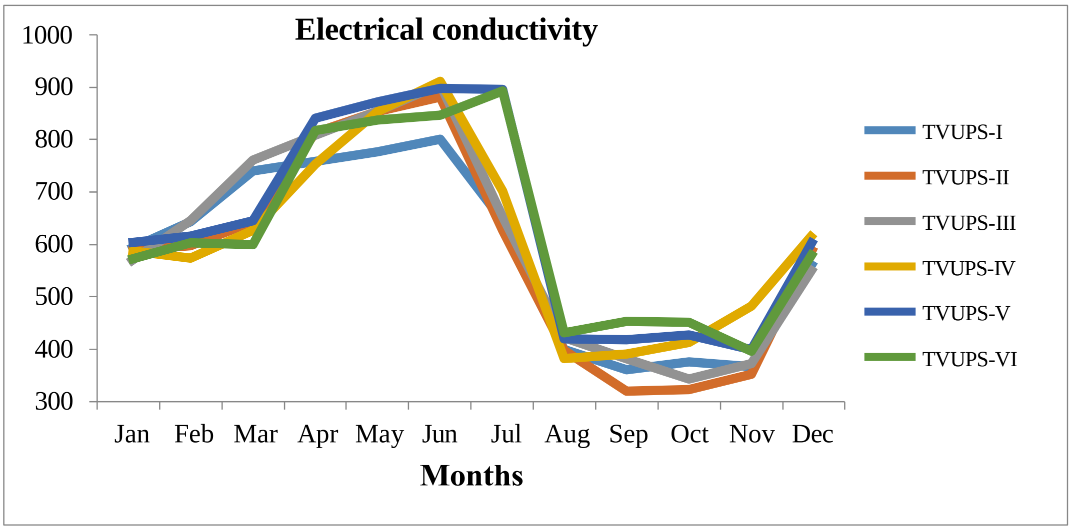
c. Electrical conductivity

According to Acharya *et al.,* (2008), the electrical conductivity of water is an important factor to consider when evaluating the cleanliness of water. According to the findings of Shrivastava and Kanungo (2013), the distribution of electrical conductivity (EC) in Surguja District in Chhattisgarh varied from 115.11 to 212.13 µmhos/cm. As explained by Marandi et al. (2013) and Kumar *et al.,* (2015), the electrical conductivity (EC) of a liquid is a quantitative measurement of the liquid's capacity to transport an electric charge. The source that is being referred to is the study that Sreenivasan did in 1964. All six TVUPS in this investigation had a maximum level of 911.4±70.3 µs/cm in terms of their electrical conductivity, while the lowest level was 320±73.7 µs/cm has a harmony with the water Electrical Conductivity ranges 218.18 to 116.36 mhos/cm observed by Seetha and Chandran (2020). Within the most ideal limit of 1500 µs/cm, all of the results that were obtained from this investigation were satisfactory. It is appropriate for drinking water supplies, irrigation, and all animals since the electrical conductivity of the water ranges from 0 to 800 µS/cm. In a similar vein, a range of 800-2,500 µS/cm represents an equally appropriate range for these particular objectives. It is recommended that the conductivity level of water used for irrigation, animal watering, and sometimes drinking water (with a preference for lower conductance ranges) does not exceed 2,500-10,000 µS/cm without exception. However, Olsen (1950) classified water bodies as eutrophic if they had conductivity values that exceeded 500.00 µS/cm.

Table 4. Shows the mean deviation EC values of all six sites in the surface water of Thiruvalluvar University mud ponds from January to December-2022.

Sites												
TVUPS-I	589.8	643.8	740.2	758	777	800.6	645	400.4	361.2	375.8	367.2	**569**
	±69.5	±66.05	±92.71	±83.8	±75.7	±82.87	±78.5	±63.42	±74.38	±77.22	±65.07	±61.65
TVUPS-II	587.6	597.8	643.4	813.8	853.6	881.2	627.6	398.6	320	323	351.6	595
	±58.4	±46.6	±82.23	±88.6	±70.06	±71.1	±75.5	±80.9	±73.71	±63.41	±68.84	±67.04
TVUPS-	564	646	761.2	808.4	854	904.8	652.2	421	381.2	342.8	371.8	557.6
III	±74.1	±71.3	±89.42	±83.07	±77.8	±73.5	±79.5	±77.9	±66.24	±62.63	±66.25	±74.27
TVUPS-	588	573.8	627	753.8	854.6	911.4	702.4	382	390.2	412.4	481.4	620.8
IV	±85.4	±90.6	±109.7	±94.42	±91.5	±74.9	±70.3	±54.8	±71.46	±64.82	±91.63	±79.6
TVUPS-V	602.4	616	645.4	840.8	872.6	897.8	896	420.8	418.2	428	399.4	610.8
	±60.04	±71.24	±84.7	±81.82	±81.36	±75.2	±69.8	±55.6	±53.35	±56.02	±41.31	±45.4
TVUPS-	570.8	602.8	599.8	817.8	836.6	846.8	892.8	431.8	453.6	450.4	396	586.8
VI	±69.08	±70.42	±81.0	±80.50	±76.5	±70.1	±65.8	±62.7	±60.01	±67.70	±50.27	±67.3

Figure 11. Shows the mean surface water EC values of the Thiruvalluvar University Pond from the month of January to December-2022.



d. Transparency

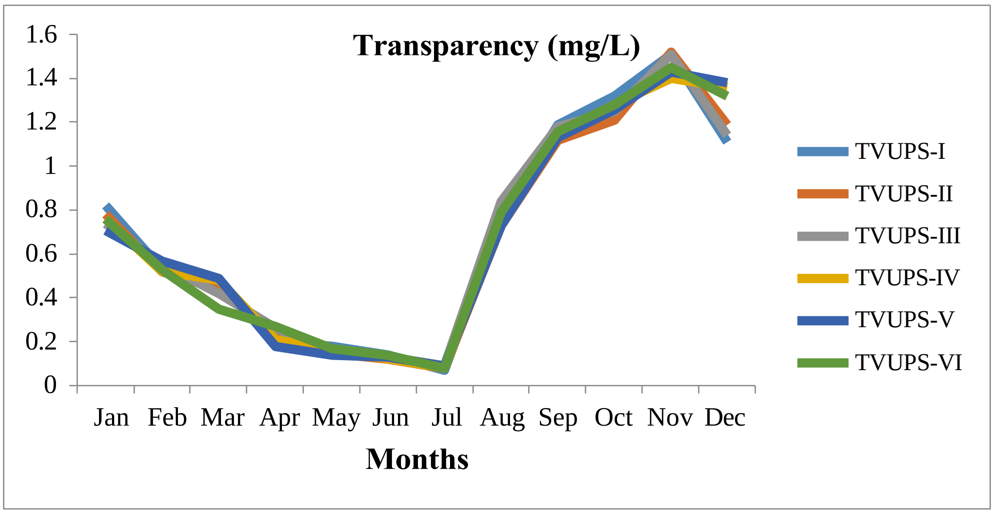
According to European legislation (Lindell *et al.*, 1999), water transparency is regarded as a crucial component in the process of evaluating the quality of water. Studies conducted by Havens (2003) and Bachmann *et al.*, (2002) have shown that the purity of the water is the primary factor that determines the depth at which submerged aquatic vegetation (SAV) may grow and the quantity of biomass that it can collect. Following the findings of Augusto Vundo *et al.*, (2019), water that has a transparency of 12m meters or higher is categorized as ultra-oligotrophic, water with a transparency of 6-12 m is categorized as oligotrophic, water with a transparency of 2-6 m is defined as mesotrophic, water with a transparency of 1.5-3 m is classified as eutrophic, and water with a transparency of 1.5 m or lower is classified as hypereutrophic. All six TVUP sites were found to have varying degrees of transparency during the present research. The highest level of transparency was recorded during the wet and winter months, measuring 2.8 ± 0.044 meters, while the lowest level was measured at 0.19 ± 0.006 meters during the warm month of July. It was only during the summer season that the lowest levels of transparency were seen, which suggests that higher temperatures directly encourage the development of phytoplankton and indirectly contribute to eutrophication via the blooming of algae.

Table 5. shows the water transparency (meter in Depth) in the Thiruvalluvar University pond, near Vellore, Tamilnadu from January to December-2022

Metals												
TVUPS -I	0.82 ± 0.019	0.53 ± 0.029	0.46 ± 0.017	0.20 ± 0.021	0.18 ± 0.012	0.14 ± 0.012	0.07 ± 0.002	0.77 ± 0.08	1.19 ± 0.11	1.32 ± 016	1.51 ± 0.15	1.11 ± 0.18
TVUPS -II	0.78 ± 0.051	0.52 ± 0.028	0.44 ± 0.019	0.24 ± 0.011	0.15 ± 0.013	0.12 ± 0.014	0.08 ± 0.001	0.73 ± 0.06	1.12 ± 0.12	1.21 ± 0.17	1.52 ± 0.16	1.19 ±0.04
TVUPS -III	0.74 ± 0.02	0.55 ± 0.02	0.42 ± 0.01	0.26 ± 0.01	0.14 ± 0.01	0.13 ± 0.01	0.09 ± 0.00	0.84 ± 0.09	1.18 ± 0.16	1.25 ± 0.19	1.51 ± 0.25	1.14 ± 0.17

	4	5	6	2	9	9	2					
TVUPS -IV	0.76 ± 0.028	0.52 ± 0.023	0.48 ± 0.011	0.21 ± 0.019	0.16 ± 0.015	0.12 ± 0.014	0.08 ± 0.007	0.76 ± 0.06	1.15 ± 0.15	1.28 ± 0.13	1.40 ± 0.29	1.36 ± 0.12
TVUPS -V	0.71 ± 0.029	0.57 ± 0.031	0.49 ± 0.014	0.18 ± 0.020	0.14 ± 0.011	0.13 ± 0.010	0.09 ± 0.003	0.73 ± 0.09	1.13 ± 0.19	1.26 ± 0.14	1.43 ± 0.22	1.38 ± 0.11
TVUPS -VI	0.76 ± 0.057	0.53 ± 0.037	0.35 ± 0.012	0.27 ± 0.015	0.17 ± 0.013	0.14 ± 0.010	0.08 ± 0.005	0.79 ± 0.06	1.16 ± 0.18	1.28 ± 0.15	1.45 ± 0.19	1.32 ± 0.18

Figure 12. Shows the mean surface water Transparency (mg/L) of the Thiruvalluvar University Pond from the month of January to December-2022.



e. Alkalinity

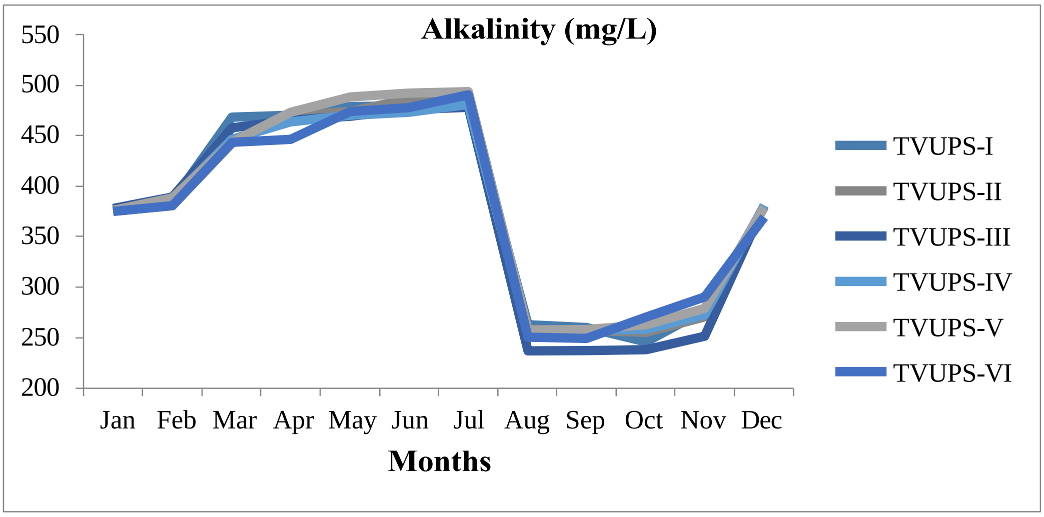
During July, the water samples that were obtained from all six sites of TVUP had the highest alkalinity levels, which ranged from 483±57.37 mg/L to 490.4 ± 50.96mg/L. On the other hand, the lowest alkalinity values were in the range of 246 ± 30.94mg/L to 257.8 ± 58.87mg/L. Which has an agreement with the lowest water alkalinity observed during the rainy season October and November (Seetha and Chandran, 2020). According to the findings of the current investigation, the alkalinity measurements did not exceed the acceptable threshold and upper limit that were set by the BIS in 2012, which were respectively 200 mg/L and 600 mg/L (CaCO3). According to the International Standards Institute (ISI), the recommended limit for alkalinity in drinking water is just 200 mg/l, while the maximum permissible amount is 600 mg/l.

Table 6. Shows the mean deviation alkalinity of all six sites in the surface water of Thiruvalluvar University mud ponds from January to December-2022.

Sites												
TVUP	377.	385.	468	469.	479	480	483	263.	260.	246	277.	380

S-I	4 ±44.55	8 ±58.15	±56.17	8 ±50.43	±39.95	±54.05	±57.37	4 ±50.78	6 ±33.21	±30.95	4± 40.69	±51.31
TVUPS-II	375.6 ±43.91	380.8 ±54.81	442.6 ±55.85	469.8± 45.47	473.8 ±46.47	485.8 ±52.60	489.8 ±50.57	258.4 ±57.73	257.6 ±55.35	255.4 ±52.38	270.6 ±54.83	380.8 ±50.51
TVUPS-III	378.2 ±44.03	389 ±60.38	457.6 ±5.77	465 ±8.09	469.6 ±5.54	476± 8.52	478 ±6.04	237.2 ±15.91	237.4 ±12.03	238.4 ±8.93	252 ±11.26	381.2 ±51.63
TVUPS-IV	375.4 ±47.15	387.8 ±62.08	446.2 ±53.93	463.6 ±29.58	470 ±22.68	473.4 ±50.67	480.8 ±66.99	256.6 ±58.43	257.2 ±51.86	258.8 ±39.51	272.2± 40.35	381.2 ±48.93
TVUPS-V	376 ±47.56	388.8 ±62.08	443.2 ±48.17	473.2 ±5.26	488 ±9.02	491.6 ±7.23	493.4 ±42.55	257.8 ±58.87	258.4 ±51.83	262.8 ±52.56	279.4 ±40.24	378.6 ±49.34
TVUPS-VI	375.2 ±46.93	380.4 ±53.63	443.8 ±49.90	446.8 ±44.33	474.2 ±41.13	477.6 ±47.52	490.4 ±50.96	250.4 ±31.71	249.6 ±30.41	271 ±32.51	290.2 ±33.01	369.4 ±40.53

Figure 13. Shows the mean surface water alkalinity of the Thiruvalluvar University Pond from the month of January to December-2022.



f. Total dissolved solids (TDS)

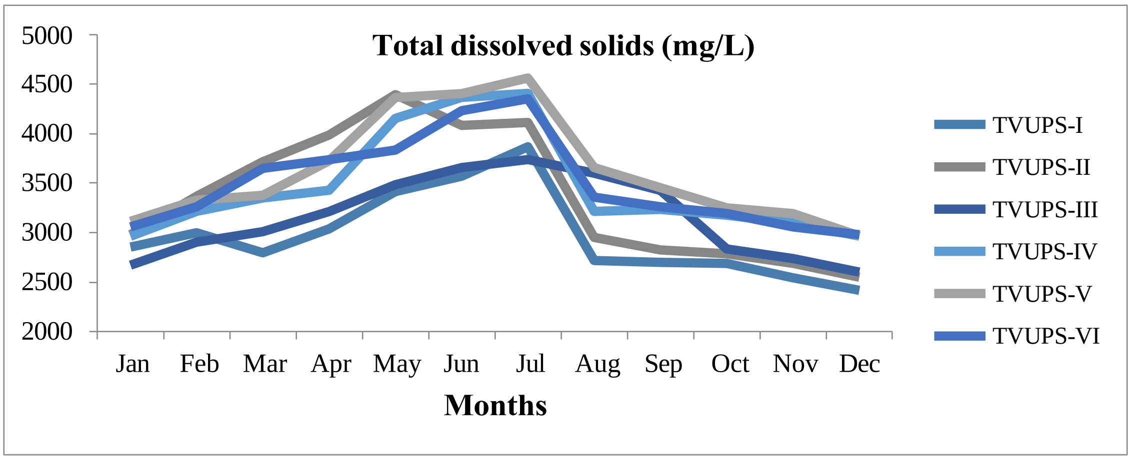
Indicators of the general features of water quality include total dissolved solids, often known as TDS (Olajire, 2001/). A considerable difference of several orders of magnitude was seen between the highest recorded total dissolved solids (TDS) level in July, which was 4.562±475mg/L, and the lowest TDS level measured in December, which was

2.417±532mg/L. This information was gathered from the present research. According to the Bureau of Indian Standards (BIS), the permitted level for Total Dissolved Solids (TDS) in water is 500 milligrams per liter (mg/L). Despite this, our total dissolved solids (TDS) levels were higher than the maximum acceptable range of 1000 mg/L, which was recommended by the World Health Organisation (WHO, 1996), and the highest concentration authorized by the World Health Organisation (WHO) is 600 mg/L (WHO,). According to Ajibade et al.'s research from 2020, elevated tissue dissolved solids (TDS) levels are indicative of the presence of toxic minerals, which may be a risk to aquatic life.

Table 7. Shows the total dissolved solids (mg/L) in the surface water of Thiruvalluvar University Ponds from januray to December-2022

Metals												
TVUPS -I	2851. 2	3003	2798 ±	3038. 8	3412 .	357 2	386 9	272 1	270 3	2685	2547 .	2417
	±	±	449	±	6	.6 ±	.4 ±	.6 ±	±	±	8 ±	±
	503	546		451	±427	425	430	450	413	495	482	475
TVUPS -II	2979. 6	3365. 2	3720. 2	3987. 8	4395	408 4	411 6	295 0	282 4	2787 .	2689 .	2549
	±	±	±	±	±500	±	.4 ±	.2 ±	.8 ±	2 ±	8±	±
	472	465	680	608		530	556	598	426	349	372	417
TVUPS -	2673. 2	2907	3010. 8	3209. 8	3482 .	365 5	373 9	360 3	342 6	2838 .	2734 .	2600
III	±	±	±	±	8 ±	±	.4 ±	.2 ±	.4 ±	8 ±	8 ±	±
	448	502	665	637	694.	702	574	657	576	438	441	478
TVUPS -	2963	3208. 4	3350. 2	3423. 2	4157 .	436 9	440 6	321 2	322 7	3170	3092 .	2961 .
IV	±	±	±	±	6 ±	.2 ±	.6 ±	.6 ±	.4 ±	±	2 ±	6 ±
	784	747	784	600	514	534	684	640	657	607	649	506
TVUPS -V	3116	3329. 4	3373. 2	3726. 4	4366 .	440 0	456 2	365 6	345 3	3253	3195 .	2967 .
	±	±	±	±	8 ±	±	±	±	.2 ±	±	8 ±	2 ±
	594	632	660	517	545	507	532	534	534	580	445	313
TVUPS -	3058	3264	3645. 6	3735. 2	3836 .	423 1	435 0	335 9	325 8	3193	3058 .	2979 .
VI	±	±	±	±	2 ±	±	.2 ±	.6 ±	±	±	2±	4 ±
	456	499	517	561	543	548	602	522	407	420	462	401

Figure 14. Shows the mean surface water total dissolved solids (mg/L) of the Thiruvalluvar University Pond from the month of January to December- 2022.



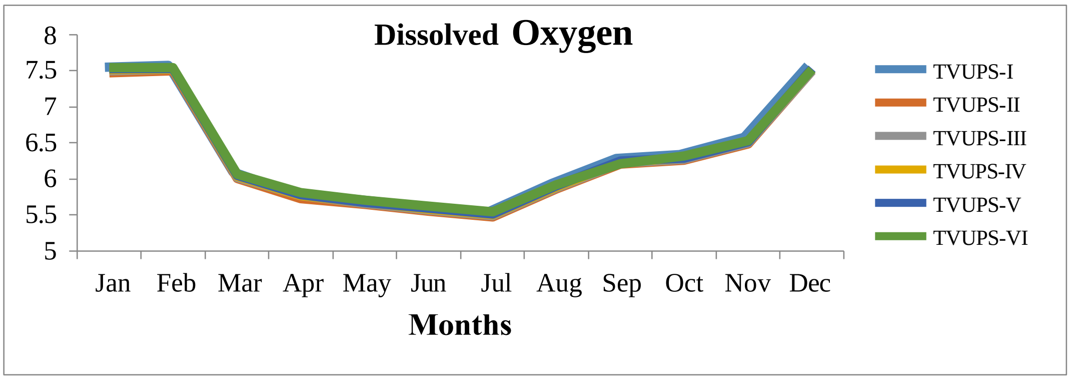
g. Dissolved Oxygen

Dissolved oxygen (DO) is an essential component in an aquatic environment that has a significant impact on water quality and the trophodynamics of an aquatic system (Antonopoulos and Gianniou, 2003). During the investigation, the greatest dissolved oxygen (DO) levels, ranging from 7.0 to 7.5mg/L were seen during the months of December and February. Conversely, the lowest DO levels, ranging from 5.0 to 5.5 mg/L, were recorded during the summer months of April to July. These findings suggest the existence of a significant organic load (Yayyntas *et al.,* 2007). The DO levels at all sites of TVUP were found to be within the allowed range suggested by the Indian standard, with the highest and lowest values falling within this range. The approved DO value is 5mg/L, which is also the maximum tolerance limit for fish. It is worth noting that DO levels below 2 mg/L may result in mortality, as stated by Chapman (1997). Therefore, the dissolved oxygen (DO) level in the pond is sufficient to support the survival of aquatic creatures.

Table 8. Shows the mean deviation Dissolved Oxygen values on surface water of all six sites of Thiruvalluvar University mud ponds from January to December-2022.

ampling months / Sites	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
TVUPS-I	7.462 ±0.44	7.484 ±0.07	6.004 ±0.49	5.708 ± 0.16	5.62 ±0.14	5.536 ±0.21	5.456 ±0.27	5.846 ±0.10	6.196 ±0.23	6.252 ±0.20	6.484 ±0.32	7.486 ± 0.37
TVUPS-II	7.482 ±0.39	7.504 ±025	6.016 ±0.64	5.73 ± 0.12	5.644 ±0.12	5.55 ± 0. 35	5.476 ±0.16	5.858 ±0.38	6.206 ±0.71	6.262 ±0.27	6.486 ±0.34	7.498 ± 0.39
TVUPS-III	7.506 ±0.40	7.526 ±0.46	6.028 ±0.42	5.766 ±0.09	5.66 ±0.70	5.57 ± 0.16	5.492 ±0.23	5.872 ±0. 19	6.222 ±0.91	6.272 ±0.31	6.504 ±0.77	7.51 ± 0.40
TVUPS-IV	7.516 ±0.42	7.522 ±0.38	6.04 ± 0.71	5.776 ±0.17	5.672 ±0.13	5.58 ± 0. 31	5.506 ±0. 31	5.888 ±0.25	6.232 ±0. 56	6.286 ±0. 52	6.514 ±0. 61	7.522 ±0.38
TVUPS-V	7.526 ±0.28	7.532 ± 0.45	6.05 ± 0.25	5.788 ±0.08	5.682 ±0.19	5.59 ± 0. 81	5.516 ±0.37	5.898 ±0. 22	6.244 ±0.23	6.296 ±0.29	6.522 ±0.35	7.532 ±0.22
TVUPS-VI	7.54 ± 0.19	7.544 ±0.71	6.068 ±0.11	5.806 ±0.14	5.698 ±0.51	5.62 ± 0. 65	5.542 ±0.26	5.914 ±0. 67	6.214 ±0.31	6.312 ±0.44	6.532 ±0.28	7.52 ± 0.64

Figure 15. Shows the mean surface water Dissolved Oxygen of the Thiruvalluvar University Pond from the month of January to December-2022



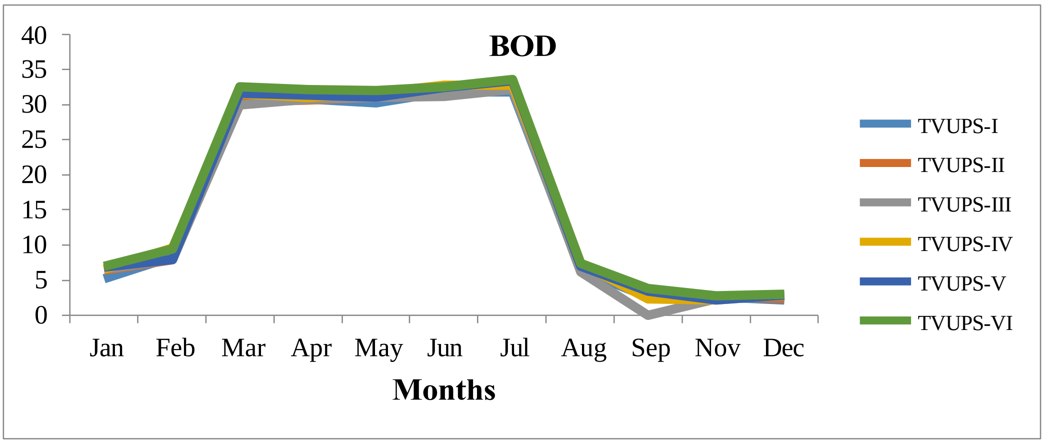
h. BOD

BOD, or biochemical oxygen demand, is a quantitative measurement of the level of organic matter pollution present in water. It is expressed in milligrams per liter (mg/L). The Biochemical Oxygen Demand (BOD) is often directly proportional to the quantity of organic matter in a given sample, providing an indicator of the waste's potency (Marske and Polkowski, 1972). The level of biochemical oxygen demand (BOD) is lower in unpolluted waters, but it is higher in contaminated waterways, as shown by Hussain *et al.*, (2004). The BOD levels at all six TVUP sites ranged from 31.8 ± 1.6 mg/L to 33.6 ± 1.8mg/L in July, which is considerably lower than the WHO recommended values of 50 mg/L for wastewater discharge into the stream. In September and November, the BOD levels were lower, ranging from 2.2 ± 0.3mg/L to 3.0 ± 0.5mg/L, still below the WHO limit of 50 mg/L. The presence of elevated COD and BOD levels in wastewater could potentially be attributed to the use of chemicals.

Table 9. Shows the mean deviation BOD (mg/L) in the surface water of all six sites of Thiruvalluvar University mud ponds from January to December-2022

Sampling months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Nov	Dec
Metals											
TVUPS-I	5.2 ±0.8	8.4 ±0.3	30.4 ±1.04	30.8 ±1.5	30.2 ±1.5	31.8 ±1.1	31.8 ±1.6	6.4 ±0.7	2.6 ±0.9	2.6 ±0.4	2.2 ±0.3
TVUPS-II	6.4 ±0.9	8 ±0.50	30.4 ±1.4	30.6 ±1.2	31 ±1.0	31.6 ±1.4	32.4 ±1.5	6.8 0.41	3.4 ±0 .6	2.8 ±0.5)	2.4 ±0.7
TVUPS-III	6.6 ±0.64	8 ±0.30	30 ±1.5	30.8 ±1.9	31 ±1.4	31.2 ±1.8	32.2 ±1.4	6.2 ±0.3	2 9 ±0.8	2.4 ± 0.3	2.8 ±0.8
TVUPS-IV	6.6 ±0.9	9.6 ±0.4	31.6 ±1.8	31 ±1.8	31.8 ±1.9	32.8 ±1.6	32.8 ±1.5	7.4 ± 0.8	2.4 ±0.8	2.2 ±00.6	2.9 ±0.5
TVUPS-V	6.8 ±0.3	8 ±0.6	31.6 ±1.7	31.4 ±1.6	31 ±1.4	32.4 ±1.3	33.4 ±1.6	7 ±0.4	3.4 ±0.8	2.2 ±0.4	2.9 ±0.7
TVUPS-VI	7 ±0.5	9.4 ±0.7	32.6 ±1.7	32.2 ±2.3	32 ±1.5	32.6 ±1.9	33.6 ±1.8	7.4 0.54	3.8 ±0.6	2.8 ±0.7	3.0 ±0.5

Figure 16. Shows the mean surface water BOD of the Thiruvalluvar University Pond from the month of January to December-2022.



i. COD

The COD value is the quantity of oxygen required for the oxidation of all organic compounds in water, measured in milligrams per liter or grams per cubic meter. The current study found that the chemical oxygen demand (COD) measured at all six locations of TVUP ranged from a maximum of 61.0 ± 4.3mg/L to 70.8 ± 4.7mg/L, and a minimum range of 3.9 ± 0.6mg/L to 3.7 ± 6.7mg/L. The research findings for both higher and lower ranges are well below the maximum allowable level for COD set by the World Health Organisation (WHO). The water is deemed acceptable for human consumption at concentrations of 200 mg/ L as per EPA standards, 1000 mg/L as per BIS standards, and 250 mg/L.

Table 10. Shows the mean deviation COD (mg/L)**in the surface water of all six sites of Thiruvalluvar University mud ponds from January to December-2022**

Sampling months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Metals												
TVUPS-I	32.4 ±3.4	38.2 ±2.9	43 ± 3.4	45± 2.9.	48.8 ± 2.6	53.4 ± 2.3	61.4 ± 4.3	9.2 ± 0.5	8.4 ± 0.6	5.0 ±0.8	3.9 ± 0.6	7.2 ± 0.5
TVUPS-II	39.8 ±2.9	40.6 ±2.6	43 ± 4.5	49.4 ± 3.1.	49.2 ± 3.1	57.8 ± 3.8	62.2 ± 3.4	8.6 ± 0.2	6.4 ± 0.4	5.2 ± 0.9	3.4 ±0. 6	7.1 ± 0.8
TVUPS-III	34 ± .9.	35.8 ±2.6	49.2 ± 3.4	43.6± 3.1	45.4 ± 3.7	55.6 ± .87	64 ± 3.5	9.2 ± 0.8	5.5 ± 0.9	5.1 ± 0.2	3.8 ± 0.9	6.0 ± 0.5
TVUPS-IV	34.6 ±2.6	36.4 ± 2.3	44.6 ± 3.2	46.2 ±3.0	47 ± 3.1	58 ± 4.3	67 ± 5.9	6.4 ± 0.8	6.8 ± 0.6	5.4 ± 0.6	3.6 ± 0.5	5.2 ± 0.9
TVUPS-V	38 ±2.9	39.2 ± 2.8	44.2 ± 2.7	46 ± 2.6	49.4 ± 2.6	59.4 ± 4.1	68.4 ± 2.8	8.1 ± 0.42	7.2 ± 0.7	5.7 ± 0.3	3.9 ± 0.4	7.7 ± 0.4
TVUPS-VI	37.2 ± 2.1	38.2 ± 2.6	47.8 ± 3.0	49.2 ± 2.9	51.4 ± 2.8	59.8 ± 2.0	70.8 ± 4.7	8.4 ± 0.5	6.8 ± 0.6	6.0 ± 0.9	3.7 ± 0.7	8.5 ± 0.7

Figure 17. Shows the mean surface water COD of the Thiruvalluvar University Pond from the month of January to December-2022.

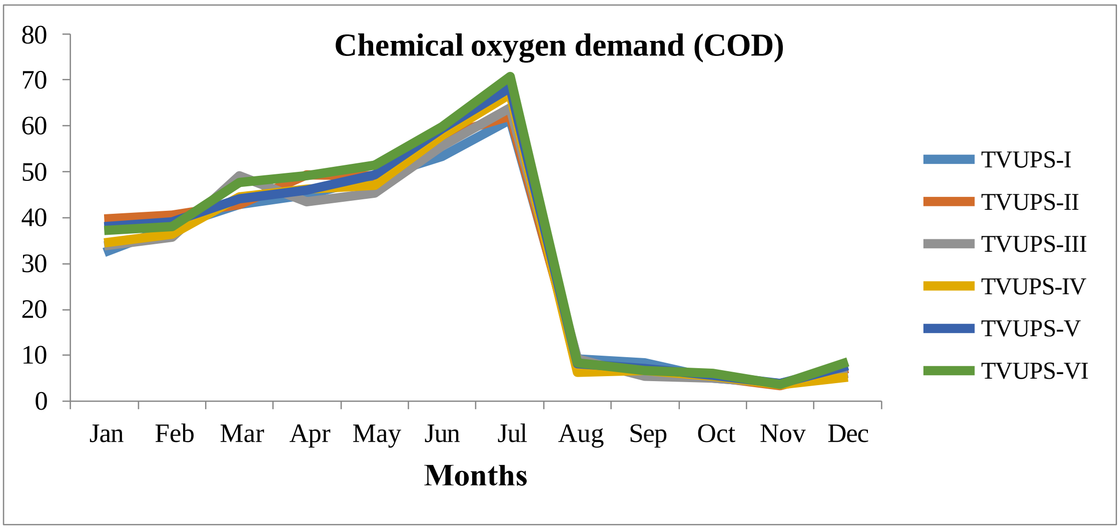


Table:11. Shows the minimum and maximum ranges of physic-chemical pharameters without the year with WHO, ICMR and EPA permissible limit.

Parameters	Minimum	Maximum	WHO (20110	ICMR/BIS	EPA
Temperature	20.4	41.7	30	35	-
pH	2.5	8.1	6.5-8.5	6.5-8.5	6.0–8.5
Ec	320	911.4	400	<300	500
Transparency	0.07	1.52	10cm(1973)	40cm*	-
Alkalinity	237.4	493.4	80-120	120	-
TDS	2417	4562	500	500	500
DO	5	7.5	10	5.0	4-6
BOD	6.4	33.6	10	<5	5
COD	3.4	70.8	10-20	15-30	4

*Santhosh and Singh, 2007

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