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Plankton Diversity and Water Quality in Azhagankulam Pond of Tirunelveli, Tamilnadu, India

R.Santha Kumari [a*]

[a] *St. Xavier's College (Autonomous), Palayamkottai, Tirunelveli, India.*

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

The present study investigates the diversity and abundance of plankton, alongside the physicochemical parameters of Azhagankulam Pond in Kurichikulam near Sankar Nagar, Tirunelveli district, India. Zooplankton feed on phytoplankton, helping to regulate algal populations and preventing uncontrolled growth. They respond quickly to environmental changes, making them valuable bioindicators of water quality, including factors like pH, dissolved oxygen, and nutrient levels. Their abundance and composition vary with organic pollution and geographical location. Water sample was collected by net made of nylon bolt mesh. The collected sample was filtered separately using filtering stand with different mesh sizes of 100 micron and 160 micron. Live zooplanktons including Rotifers were kept in clean glass slides and covered with cover slip for photography. Photographs were taken in the microscope. Statistical analyses were carried out by using multivariate statistical tools. A total of 24 species of zooplankton were identified, including Rotifers, Copepods, Cladocerans, Ostracods, Blue-Green Algae, Green Algae, Diatoms, and Protozoans. Among these, *Brachionus caudatus* (Rotifers), *Calanus* species (Copepods), *Daphnia*

**Corresponding author: Email: rsanthakumari73@gmail.com;*

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(Cladocerans), and *Spirulina* (Phytoplankton) were found to be dominant across the study period. The highest plankton abundance was recorded in March (21.99 standard deviation), with species numbers increasing progressively from December. Plankton populations are influenced by physicochemical factors such as temperature, salinity, and pollution. The study recorded eutrophic conditions, particularly in February and March, with *Brachionus caudatus* and Spirulina dominance, indicating high nutrient levels. The seasonal variations in plankton composition and diversity indices demonstrate the direct impact of environmental factors and nutrient dynamics on freshwater biodiversity. Long-term monitoring and sustainable management practices are essential to maintaining the ecological stability of Azhagankulam Pond.

Keywords: Environmental factors; nutrient dynamics; Zooplankton; phytoplankton.

1. INTRODUCTION

Zooplankton are microscopic aquatic organisms that play a crucial role in the food web, serving as intermediaries between primary producers (phytoplankton) and higher trophic levels, including fish(Dhamotharan *et al., 2010)*. Major zooplankton groups include Protozoans, Rotifers, Cladocerans, and Copepods. Their diversity is a key indicator of water quality and ecosystem health.

Zooplankton feed on phytoplankton, helping to regulate algal populations and preventing uncontrolled growth (Bhandharrkar and Paliwal, 2017). They respond quickly to environmental changes, making them valuable bioindicators of water quality, including factors like pH, dissolved oxygen, and nutrient levels (Arcifa *et al:.,*1986). Their abundance and composition vary with organic pollution and geographical location.

The distribution and diversity of zooplankton are influenced by climate change, physicochemical properties, and biotic interactions (Ahamad, et al., 2011, Alexander, 2012, Cottenie, et al., 2001). Temperature fluctuations impact their growth and survival (Hall & Burns, 2001), while salinity changes affect migration patterns and food availability (Perumal, et al., 2009). Water pH also plays a role, with low pH reducing biodiversity (Dehui, 1995, Ivanova & Kazantseva, 2006) and alkaline conditions favoring growth Phytoplankton, the primary producers in aquatic ecosystems, are highly responsive to environmental changes, particularly nutrient availability (Chellapa, et al., 2008). Their diversity is an important metric for assessing water pollution. In India, major freshwater pollution sources include agricultural runoff, industrial effluents, and domestic waste (Dwivedi, et al; 2018).

The present study investigates the diversity and abundance of plankton, alongside the physicochemical parameters of Azhagankulam Pond in Kurichikulam near Sankar Nagar, Tirunelveli district. This pond, used for agriculture and freshwater fish cultivation, serves as a case study for assessing water quality through plankton composition.

2. MATERIALS AND METHODS

The sample site is located at Naranammalpuram (Latitude is 8.85491◦and longitude is 77.7154◦) which is located at a distance of around 5 kms from Tirunelveli on the shores of Tamirabarani.

Water sample was collected by net made of nylon bolt mesh. The collected sample was filtered separately using filtering stand with different mesh sizes of 100 micron and 160 micron.

The filtered and isolated sample was made up to 10 ml. From the 10 ml subsample 1 ml was taken for observation. Rotifers were identified using the keys and classification of W. T. Edmondson (1959) and other species of plankton and protozoans were identified by using (Bee *et al.,*2015 and Nandigam, et al., 2016)

Live planktons and Rotifers were kept in clean glass slides and at the time of drying, photographs were taken in the microscope with SONY CORP DSC-W320(14 pixels) in different magnification (4X,10X).

Shannon – Weiner index(Shanon,1949):
Shannon – Weiner index (H) which depends on both the number of species present and the abundance of each species.

$$H = \sum P_i \ InP_i$$

Where, H = Shannon – Weiner index.

$P_i = \frac{ni}{N}$
∑ = Sum

In = Natural logarithm
ni = Number of individuals of each species in the sample.
N = Total number of individuals of all species in the sample.

Simpson's diversity indices:

Simpson's diversity index, is a measure of diversity.

(a) Simpson's index of dominance (Simpson, 1949):

$$\lambda = \sum \frac{ni(ni-1)}{N(N-1)}$$

ni = Number of individuals of each species in the sample.

N = Total number of individuals of all species in the sample.

(b) Simpson's index of diversity

1 – D

D = Simpson's index of dominance

Margalef Index (Margalef,1958):

The Number of species per sample is a measure of richness. Ma = $\frac{S-1}{In\ N}$

S = Number of species

N = Number of individuals in the sample.

Correlation: The Pearson correlation coefficient, often referred to as the Pearson 'r' test, is a statistical formula that measures the strength between variables and relationships (Kirch, 2008).

$$r = \frac{N\sum xy-(\sum x)(\sum y)}{\sqrt{\left[N\sum x^2-(\sum x)^2\right]\left[N\sum y^2-(\sum y)^2\right]}}$$

N = Number of pairs of scores

$\sum xy$ = Sum of the products of paired scores
$\sum x$ = Sum of x scores
$\sum y$ = Sum of y scores
$\sum x^2$ = Sum of squared x scores
$\sum y^2$ = Sum of squared y scores.

Standard deviation: Standard deviation is the measure of dispersion of a set of data from its mean. It measures the absolute variability of a distribution.

$$\sigma = \sqrt{\frac{\sum(x-\bar{x}^2)^2}{n}}$$

σ = Standard deviation
$\bar{x}$ = Mean / Average.

Water Quality Estimation: The water quality parameters like temperature, dissolved oxygen, salinity were noted for all water samples (APHA, 1989).

Temperature: Temperature is noted by mercury thermometer at the sampling site.

Dissolved Oxygen: Modified Winkler's method was adopted for the estimation of dissolved oxygen (Elli's et al.,1948). The sample for dissolved oxygen determination were conducted in 300ml bottles and fixed at the collection spot by adding Manganous sulphate (1ml) and Alkaline iodide(1ml).

$$\text{DO mg/l} = \frac{(V1)(N)(8)(1000)}{\frac{V4(V2-V3)}{V2}}$$

$$\text{Plankton(units 1)} = \frac{N(C)}{V}$$

Where,

N=Number of Brachionus counted in 1ml
C=total number of concentration
V=total volume of sample.

3. RESULTS AND DISCUSSION

3.1 Results

Zooplankton, including Protozoans, Rotifers, Cladocerans, and Copepods, are essential components of aquatic ecosystems, serving as primary and secondary consumers. They mediate energy transfer from primary producers (phytoplankton) to higher trophic levels, such as fish, and play a crucial role in maintaining ecological balance. Their diversity is a key indicator of water quality, as they respond rapidly to changes in physicochemical parameters such as pH, temperature, and nutrient levels.

Table 1. List of species obtained during the study period

Family	Species	December	January	February	March	Total
Rotifers	*Brachionus angularis*	8	15	24	20	67
	Brachionus caudatus	10	33	38	41	122
	Brachionus caudatus aspiens	0	0	6	8	14
	Brachionus forficula	3	9	0	4	16
	Brachionus diversicornis	26	22	10	18	76
	Euchlanis brahmae	0	12	15	19	46
	Hexarthra intermedia	4	9	6	2	21
	Calanus	41	35	54	58	188
Copepods, Ostracods and Cladocerans	*Calanus species*	33	38	26	28	125
	Daphnia	55	64	46	41	206
	Moina micrura	12	16	18	19	65
	Nauplius	0	15	28	37	80
	Ostracod species	3	6	7	15	31
	Calanus alchetron	5	4	6	0	15
	Copepod species	11	16	14	19	60
Blue Green Algae	*Coelosphaerium*	0	0	25	42	67
	Spirulina	0	15	73	95	183
Green algae	*Coelostrum*	5	12	19	15	51
	Chlorella	14	43	56	32	145
	Botryoccoccus	0	7	9	0	16
Diatoms	*Cyclotella*	10	8	18	29	65
Protozoa	*Lindia intermedia*	0	0	4	3	7
	Fomtonia	2	14	23	11	50
	Surirella	3	2	4	0	9

Table 2. Physicochemical Parameters

Parameters	Results
Total dissolved solids mg/L	**324**
pH	**7.02**
Total alkalinity as CaCo3 mg/L	**88**
Calcium as Ca mg/L	**42**
Magnesium as mg/L	**23**
Sodium as Na mg/L	**17**
Potassium as K mg/L	**2**
Free ammonia as NH3 mg/L	**0.00**
Nitrate as No3 mg/L	**110**
Phosphate as PO4 mg/L	**0.16**

Table 3. Shows the Diversity Indices

Name of the diversity index	December	January	February	March
Species Dominance	0.1215	0.07812	0.07122	0.07765
Simpson Index	0.8785	0.9219	0.9288	0.9224
Shanon Index	2.393	2.767	2.845	2.761
Pielou's evenness	0.644	0.7578	0.7476	0.753
Menhinck index	1.086	1.057	1	0.8906
Margalef index	2.908	3.345	3.508	3.164
Berger-Parker index	0.2245	0.162	0.138	0.1709
Standard deviation	14.4342	15.72586	18.9633	21.99143

Physicochemical Characteristics of Azhagankulam Pond:

The study of Azhagankulam Pond near Kurichikulam, Tirunelveli, revealed important water quality parameters:

- Water Temperature: 25°C, influencing biological and chemical processes.
- pH: 7.02, indicating a neutral aquatic environment.
- Electrical Conductivity: 476 µmho/cm, reflecting dissolved ionic substances.
- Total Dissolved Solids (TDS): 324 mg/L, with high levels of nitrates (110 mg/L) and phosphates (0.16 mg/L), suggesting nutrient enrichment.

Zooplankton and Phytoplankton Diversity:

A total of 24 plankton species were identified:

- Rotifers (7 species): Brachionus caudatus was numerically dominant.
- Copepods, Ostracods, and Cladocerans (8 species): Calanus and Daphnia species were most abundant.
- Phytoplankton (6 species): Spirulina exhibited dominance.
- Protozoans (3 species).

Seasonal Diversity Trends:

- Species dominance peaked in January (0.07812) and was lowest in December (0.1215).
- Shannon diversity index (H'): Highest in February (2.845), lowest in December (2.393).
- Simpson's diversity index: Maximum in February (0.9298), minimum in December (0.8785).
- Margalef species richness (R1): Highest in February (3.508), lowest in December (2.908).
- Menhinick index (R2): Fluctuated, peaking in December (1.086) and dipping in March (0.8906).

3.2 Discussion

Plankton populations are indeed influenced by physicochemical factors such as temperature, salinity, and pollution. These factors can affect plankton distribution, community composition, and overall productivity. This study recorded eutrophic conditions, particularly in February and March, with *Brachionus caudatus* and *Spirulina* dominance, indicating high nutrient levels. These findings align with studies highlighting the role of rotifers as bioindicators of eutrophication (Ejsmont-Karabin, 2012).

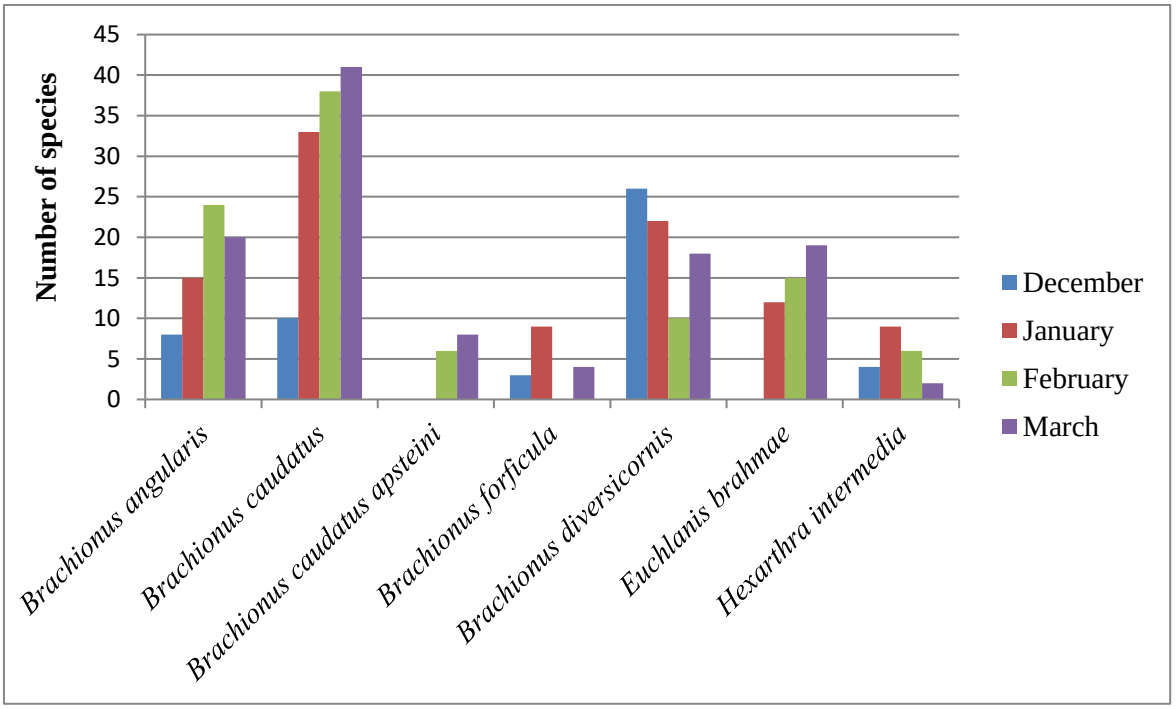

Fig. 1. Total abundance of Rotifers during the study period at Azhagankulam pond, Sankar nagar

Excessive agricultural runoff and pesticide use are likely contributors to nutrient enrichment in Azhagankulam Pond. High nitrate and phosphate levels indicate potential risks of algal blooms, which may disrupt the ecosystem. Studies have shown that fluctuations in dissolved oxygen, pH, and salinity significantly affect zooplankton abundance and diversity (Jane *et al*;2002).

Zooplankton and Phytoplankton Diversity Trends: A total of 24 species of plankton were identified, including Rotifers, Copepods, Cladocerans, Ostracods, Blue-Green Algae, Green Algae, Diatoms, and Protozoans. Among these, *Brachionus caudatus* (Rotifers), *Calanus* species (Copepods), *Daphnia* (Cladocerans), and *Spirulina* (Phytoplankton) were found to be dominant across the study period. The highest plankton abundance was recorded in March (21.99 standard deviation), with species numbers increasing progressively from December.

This study found that *Brachionus caudatus* and *Spirulina* were particularly dominant during February and March, indicating a eutrophic condition. This observation aligns with and Sladeček (1986), who identified rotifers as effective bioindicators of eutrophic water bodies. The dominance of *Daphnia* and *Calanus* species further supports the presence of high primary productivity, which sustains a diverse zooplankton community (Bulut and Saler,2019).

Impact of Physicochemical Parameters on Plankton Diversity: The water quality analysis showed that the pond had a neutral pH (7.02), moderate dissolved solids (324 mg/L), and high nitrate levels (110 mg/L). High nitrate and phosphate concentrations suggest nutrient enrichment, likely resulting from agricultural runoff, as Fu & He(2015) noted similar findings in highly fertilized aquatic systems.

- **Temperature (25°C):** Influences biological activity and metabolic processes of aquatic organisms (Gupta, 1989).
- **pH (7.02):** Regulates plankton metabolism, with optimal conditions supporting high species richness (Kahsay *et al.,*2022).
- **Electrical Conductivity (476 µmho/cm):** Suggests the presence of dissolved ions from agricultural and anthropogenic sources.
- **Nutrient Levels (Nitrates:** 110 mg/L, Phosphates: 0.16 mg/L): Indicate potential eutrophication, favoring algal blooms and shifts in plankton community structure (Kumari, 2014).

Seasonal Influence on Diversity Indices: The diversity indices showed seasonal fluctuations, with the highest species diversity occurring in February (Shannon Index: 2.845, Simpson Index: 0.9298) and the lowest in December (Shannon Index: 2.393, Simpson Index: 0.8785). The Margalef index, which measures species richness, was also highest in February (3.508), correlating with optimal water quality conditions.

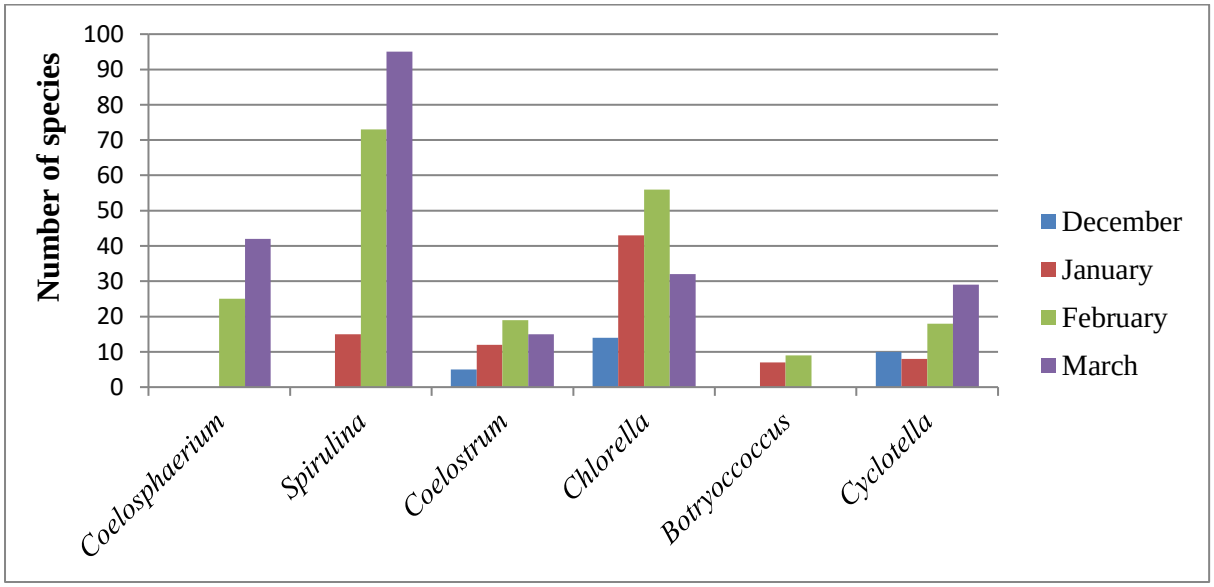

Fig. 2. Total abundance of Phytoplanktons during the study period at Azhagankulam pond, Sankar nagar

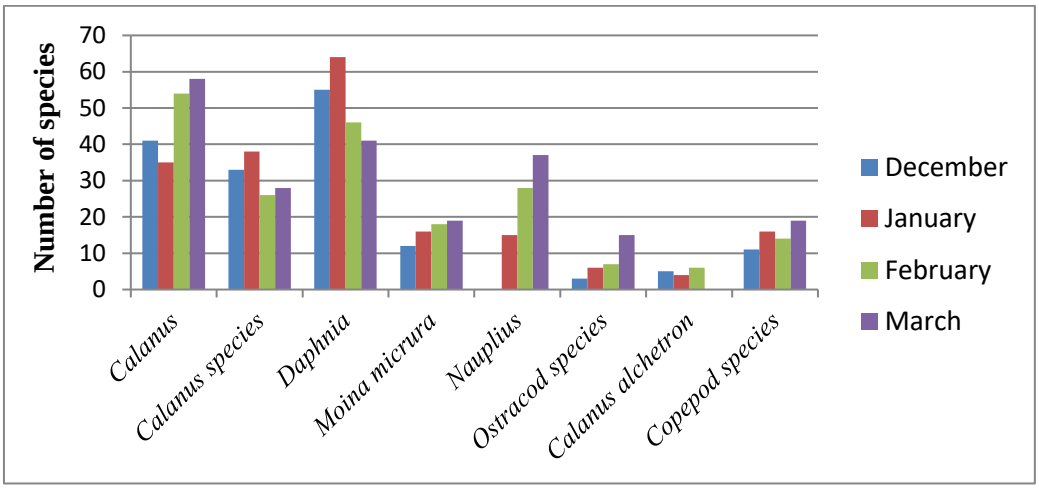

Fig. 3. Total abundance of Zooplanktons during the study period at Azhagankulam pond, Sankar nagar

These trends indicate that plankton diversity increases with nutrient availability and stable environmental conditions but decreases when excessive eutrophication leads to dominance by a few tolerant species (Ansari & Khan,2005 and Kumari, 2014). The study aligns with previous research suggesting that seasonal changes in temperature, nutrient levels, and biological interactions significantly impact aquatic biodiversity (Cottenie, et al., 2001, Hall & Burns, 2001 and Tasevska,2010).

Ecological Implications and Management Strategies: The presence of high nitrates and dominant eutrophic species suggests that Azhagankulam Pond is undergoing nutrient enrichment, which may lead to potential issues such as oxygen depletion, reduced biodiversity, and algal blooms(Forsberg,1982). To ensure sustainable water quality and ecological balance, the following measures are recommended:

1. Regulation of Agricultural Runoff – Implementing buffer zones and controlled fertilizer use can help reduce nutrient inflow into the pond.
2. Monitoring Zooplankton as Bioindicators – Since rotifers like Brachionus caudatus indicate eutrophication, regular monitoring can provide early warnings of environmental degradation.
3. Water Quality Management – Periodic assessment of physicochemical parameters such as dissolved oxygen, pH, and nutrient levels can guide conservation efforts.
4. Eutrophication Control – Reducing phosphate-rich effluents from agriculture and domestic sources can help prevent excessive algal growth.

4. CONCLUSION

This study highlights the critical role of plankton diversity in assessing aquatic ecosystem health. The seasonal variations in plankton composition and diversity indices demonstrate the direct impact of environmental factors and nutrient dynamics on freshwater biodiversity. Long-term monitoring and sustainable management practices are essential to maintaining the ecological stability of Azhagankulam Pond.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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