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

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* (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

**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. 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. 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.

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 (Bednarz et al., 2002; Mustapha, 2009).

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.

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 (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**

 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 logrithm

 $ni$ = 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**

 λ = $\sum\_{}^{}\frac{ni(ni-1)}{N(N-1)}$

 $ni$ = 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:**

 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.

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

 $N$ = 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.

 $σ$ = $\sqrt{\frac{\sum\_{}^{}(x-\overbar{x}^{2})^{2}}{n}}$

 $σ$ = Standard deviation

 $\overbar{x}$ = 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).

 DO mg/l=$\frac{\left(V1\right)\left(N\right)\left(8\right)(1000)}{\begin{array}{c}\frac{V4\left(V2-V3\right)}{V2}\\\end{array}}$

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.

**RESULTS AND DISCUSSION**

**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).

**DISCUSSIONS**

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,2012).

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 (Gupta, 1989; Sengupta & Dalwani, 2008).

**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.

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

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.

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

**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 Gupta (2004) and Sengupta & Dalwani (2008) 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 (Sculthrope, 1967).
* 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 (Santha Kumari, 2014).

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

**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.

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 (Santha 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).

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. 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.

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.

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**REFERENCES**

1. Bulut, Hilal, and Serap Saler. “Effect of Physicochemical Parameters on Zooplankton at a Freshwater Body of Euphrates Basin (ElazÄ±g-Turkey)”. *Cellular and Molecular Biology* 65, no. 1 (January 31, 2019): 8–13. Accessed July 4,2022. <https://www.cellmolbiol.org/index.php/CMB/article/view/2688>.
2. Dwivedi S., Mishra S., Tripathi R.D., Ganga water pollution: A potential health threat to inhabitants of Ganga basin. Int. 2018; 117:327–338.
3. Madin, L. P., Horgan, E. F. and Steinberg, D. K. (2001). Zooplankton at the Bermuda Atlantic Time-series Study (BATS) station: diel, seasonal and interannual variation in biomass, 1994-1998. Deep Sea Research, 48: 2063- 2082.

3, Damotharan, N., Vengadesh Perumal., Arumugam, M., Perumal, P., Vijayalakshmi, S., and Balasubramanian, T., 2010. Studies on zooplankton ecology from Kodiakkarai (Point Calimere) Coastal waters (South east coast of India). Res. J Biol. Sci.., 5(2): 187- 198.

1. Forsberg, C., 1982. Limnological Research can improve and reduce the cost of monitoring and control of water quality. Hydrobiologia., 86: 143-146.
2. Edmondson, W. T. (ed.), 1959. Ward and Whipple's Fresh-Water Biology, 2nd edn. Wiley. [Note: Tommy authored the Preface and Chapters 1 (Introduction), 18 (Rotifera), and 46 (Methods & Equipment).]
3. Simpson, E. Measurement of Diversity. *Nature* **163,**688 (1949). <https://doi.org/10.1038/163688a0>
4. Shannon, C. E. and W. Wiener, 1949. The mathematical theory of communication. Urbana, University of Illinois Press, 177 p.
5. Margalef, R., 1958. Temporal succession and spatial heterogeneity in phytoplankton. In: Perspectives in Marine biology, Buzzati-Traverso (ed.), Univ. Calif. Press, Berkeley, pp. 323-347.
6. Nandigam, J., Rahgaiah, S., Geddada, M.N.R. (2016) A study on seasonal changes in relation to the physico-chemical parameters of Satyavaram pond, Srikakulam Dist, India. Indian Journal of Geo marine Sciences, 45(12): 1660-1668.

10. Pearson’s Correlation Coefficient. (2008) In: Kirch W. (eds) Encyclopedia of Public Health. Springer, Dordrecht. <https://doi.org/10.1007/978-1-4020-5614-7_2569>

10. Ellis, M. M., Westfall, B. A. and Ellis, M. D. Determination of water quality," Research Report No. 9, 1948. Fish and Wild Life Service.

11. APHA, AWWA and WPCF, 1989. Standard methods for the examination of waste waters, 17th edition. American Publ. Hlth Assoc., Inc., New York, USA

12. Sudhir Bhandarkar and Gopal Paliwal, 2017. Trophic status in Freshwater Lentic Ecosystem of Dhukeshwari Temple Pond Deori With Reference To Zooplanktonic Assemblage. International Journal for Environment Rehabilitation and Conservation,Vol. VIII [1] /145 – 159.

13. Tasevska, O., 2010. Comparative taxonomy-ecological researches of rotifers from Lake Ohrid, Lake Prespa and Lake Dojran. PhD work. University Sts. Cyrilus and Methodius, Faculty of Biology, Skopje, pp 262 (In Macedonian)

14. Kather Bee, S. , Chitra, J. and Malini, E., 2015. Studies on Plankton diversity and Water quality of Ambattur lake, Tamil Nadu.International Journal of Pure and Applied Zoology ISSN (Print) : 2320-9577 Volume 3, Issue 1, pp: 31-36, ISSN (Online): 2320-9585 Rishan Publications http://www.ijpaz.com Research Article

1. Arcifa, M.S, Northcote, T.G. and Froehlich, O. 1986. Fish-zooplankton interactions and their effects on water quality of a tropical Brazilian reservoir. Hydrobiologia. 139:49-58.
2. Cottenie, K., Nuytten, N., Michels, E., De Meester.,L., 2001.Zooplankton community structure and environmental conditions in a set of interconnected ponds. Hydrobiologia 442 (1-3), 339-350.
3. [Abid Ali Ansar](https://www.researchgate.net/profile/Abid-Ansari-5)i and [Fareed A. Khan](https://www.researchgate.net/profile/Fareed-Khan-6), 2005. Eutrophication: An

Ecological Vision, [The Botanical Review](https://www.researchgate.net/journal/The-Botanical-Review-1874-9372) 71(4):449-482, DOI:[10.1663/0006-8101(2005)071[0449:EAEV]2.0.CO;2](http://dx.doi.org/10.1663/0006-8101%282005%29071%5B0449%3AEAEV%5D2.0.CO;2)

1. The American Water Works Association, Inc. 2005. Water quality treatment-A handbook of public water supplies. 3rdedition. McGraw-Hill.
2. Calbet, A., Alcaraz, M., Saiz, E., Estrada, M. & Trepat, I. Planktonic herbivorous food webs in the Catalan Sea (NW Mediterranean): temporal variability and comparison of indices of phyto-zooplankton coupling based on state variables and rate processes. *Journal of Plankton Research* **18** (1996).
3. Santha Kumari, R.2014. Identification, culture and production of freshwater Rotifers and its applications in fish larviculture technology Ph.D. Thesis Awarded, Manonmaniam Sundaranar University, Tirunelvei, South India.
4. Sladecek, V.1986. Diatoms as indicators of Organic pollution, [Acta hydrochimica et hydrobiologica](https://onlinelibrary.wiley.com/journal/1521401x), <https://doi.org/10.1002/aheh.19860140519>.

22.Ejsmont-Karabin J. 2012 – The usefulness of zooplankton as lake ecosystem indicators: rotifer trophic state index – Pol. J. Ecol. 60: 339–350