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Algal Biodiversity and Water Quality Modelling in Rushula Cheruvu Using Multivariate Analysis

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Abstract: This paper investigates the dynamics of algal biodiversity and water quality of Rushula Cheruvu, which is a historically important, rain-fed freshwater Rushula Cheruvu (a traditional freshwater water body) of Kakatiya origin and is found in the Nagarkurnool District of Telangana, India. Five representative stations were sampled monthly and a single annual cycle was followed (December 2024-November 2025) to assess the phytoplankton composition and significant physico-chemical parameters. Eighty-seven algal species (Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae, and Dinophyceae) were identified. The seasonal changes displayed more diversity in winter and post monsoon seasons than in summer and monsoon seasons, whereby there were increased prevalence of cyanobacteria. The multivariate statistical tests, including Principle Component Analysis, Cluster Analysis and Multiple Linear Regression, included the nutrient availability, temperature, and light penetration as the key factors in the control of the algal community structure, where phosphorus played a significant role in the determination of algal abundance. The Rushula Cheruvu (a traditional freshwater water body) was determined as meso-eutrophic with seasonal trends towards the eutrophic conditions in the seasons of environmental stress. The Rushula Cheruvu, especially, is not given water except through rainfall and runoff of forest catchment water, and no farming or fertilizers are used, it is a vital source of drinking water to tribal populations and wildlife. The results show the ecological importance of this almost pristine freshwater system and the necessity to maintain its natural water quality and biodiversity by strict conservation and long-term monitoring.

Keywords: Algal Biodiversity, Water Quality, Multivariate Analysis, Eutrophication, Phytoplankton Dynamics

I. INTRODUCTION

1.1 Background

Freshwater ecosystems, among natural resources with substantial ecological and biological significance, are crucial due to the services they provide, such as nutrient cycling, primary productivity, groundwater recharge, and the support of aquatic biodiversity (Wetzel, 2001). Small and medium-sized inland water bodies play a vital role in sustaining rural populations, maintaining ecological balance, and ensuring water security in the semi-arid regions of India.

The Cheruvu (water body) of Kakatiya origin, Rushula Cheruvu, is a historically significant rain-fed freshwater Cheruvu (water body) located near the Nallamala forest, and it remains in relatively pristine natural conditions (Rao and Reddy, 2016; Reddy et al., 2019). These ancient man-made water bodies, constructed during the Kakatiya era, were designed to collect and store monsoon rainfall, demonstrating the advanced hydrological and watershed engineering skills of the local inhabitants. Such rain-fed Cheruvu (water body) are particularly important in forest-adjacent landscapes, as they are naturally replenished by runoff and can support both human and wildlife populations with minimal anthropogenic pollution. Being relatively undisturbed, they provide excellent systems for studying baseline ecological processes, such as algal biodiversity and natural water quality dynamics. Understanding these systems is crucial for developing sustainable management and conservation strategies for freshwater resources in the context of increasing climatic variability and human impacts.

1.2 Importance of Algal Biodiversity Studies

The water trophic chain is anchored on algae that are very sensitive to alterations in the environment conditions and thus are the best bioindicators of water quality (Reynolds, 2006; Palmer, 1969). Assessment of algal biodiversity:

- Reveal ecological impacts of nutrient enrichment
- Indicate pollution stress and trophic status
- Reflect seasonal and hydrological fluctuations
- Influence oxygen levels, pH, and primary production
- Provide insight into ecosystem functioning and resilience

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Alteration of algal community structure can consequently be immediately connected with the dynamics of water quality and catchment-related disturbances.

1.3 Eutrophication and Water Quality Challenges

The biggest threat to freshwater Cheruvu (water body) in India is eutrophication which is mainly caused by the excessive input of nitrogen and phosphorus. Nutrient load and rapid phytoplankton growth are also caused by agricultural runoff, household effluent, erosion, and livestock action, usually resulting in harmful algal growths (Smith et al., 1999). These blooms can lead to:

Reduced water clarity

- Composteration of hypoxia or anoxia.
- Reductions in populations of zooplankton and fish.
- Change in species dominance particularly cyanobacteria.
- Toxic production to humans and animals.

Rushula Cheruvu experiences runoff of large scale during the months of monsoon and this makes it more susceptible to eutrophication and formation of algal blooms.

1.4 Ecological Status of Rushula Cheruvu

There is preliminary field observation and local reports indicating that Rushula Cheruvu has features of a meso-eutrophic Cheruvu (water body). Seasonal changes especially pre- and post-monsoon have a major impact on the amount of water, level of nutrients, stratification as well as penetration of light. The ecological situation of the Cheruvu (water body) is determined by:

- Constant nutrient input in agriculture.
- Wind and shallow depth sediment resuspension.
- Unfortunately, irrigation water is extracted without regulation.
- Decrease of macrophytes diversity as a result of anthropogenic disturbances.

Although algal biodiversity and quantitative water quality modeling of Rushua Cheruvu has an ecological and socio-economic significance, there is lack of complete research on the same.

1.5 Role of Multivariate Analysis in Limnology

Multivariate statistical analyses cannot be done away with when analyzing complicated limnological data. Principal Component Analysis (PCA), Cluster Analysis (CA), Canonical Correspondence Analysis (CCA), Multiple Linear Regression (MLR) are the techniques that offer strong possibilities to find the most significant environmental drivers, categorize the sites, and describe the dynamics of algae (Sharma and Reddy, 2015).

A general predictive regression model is expressed as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots \beta_n X_n + \epsilon$$

Where:

- Y = algal abundance or diversity index
- $X_1, X_2, X_3 \ldots . X_n$= water quality parameters
- β = regression coefficients
- ϵ = model error

Multivariate models are able to capture underlying environmental gradients and interactions, which would have been undetectable using a set of univariate summaries alone.

1.6 Study Period and Objectives

The present research was carried out in a single annual cycle, i.e., between December 2024 and November 2025 in order to obtain seasonal and hydrological variation characteristic of semi-arid Telangana. The objectives were to:

1. Report on Rushua Cheruvu algal biodiversity.
2. Compare water quality changes on a monthly and seasonal basis.
3. Establish correlations between water quality parameters and algal communities.
4. Use multivariate statistical analysis (PCA, CA, MLR) to explain ecological trends.
5. Offer evidence recommendations on the conservation and management of the Cheruvu (water body).

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II. MATERIALS AND METHODS

2.1 Study Area

Rushula Cheruvu is a historically significant freshwater Cheruvu (water body) constructed during the Kakatiya era, reflecting the traditional water conservation practices of Telangana state. Situated in the Nagarkurnool District of Telangana, India, the Cheruvu (water body) is approximately 60 to 70 km from the district headquarters. It is located a short distance from the Nallamala forest, with the forest boundary approximately 3 km from Laxmipally Village – Billakal**,** placing the cheruvu within a largely undisturbed natural habitat**.** The surrounding landscape is characterized by forested terrain and minimal anthropogenic activity, contributing to the preservation of the natural water quality and ecological integrity of Rushula Cheruvu.

The Cheruvu (water body) encompasses a water surface area of approximately 90 to100 acres and has a total storage capacity of 0.024 TMC. Rushula Cheruvu is a rain-fed reservoir, receiving water solely from natural sources. The primary inflow channels are Papamma Vagu, Nadimi Vagu, and Burjugundala Vagu, which are the only surface water sources for the Cheruvu (water body). Additionally, the Cheruvu (water body) benefits from direct rainfall runoff from the Nallamala forested catchment area.

Water from Rushula Cheruvu is also utilized on a limited scale for agricultural purposes, supporting the cultivation of maize (corn) and paddy (rice) over an area of approximately 500 acres. The Cheruvu (water body) is not subject to agricultural runoff, water contaminated with fertilizers, industrial effluents or domestic sewage. It does not receive irrigation return flows, thereby maintaining its water free from nutrient enrichment typically associated with anthropogenic activities. Consequently, the Cheruvu (water body) exhibits high natural purity, representing a rare example of a minimally disturbed freshwater ecosystem in the region.

"The study area falls within a regulated forest-sensitive (trigger) zone, and access to the cheruvu is restricted, with entry permitted only after obtaining prior approval from the Forest Department."

Rushula Cheruvu is not utilized for fishing or aquaculture activities, further limiting human interference and preserving ecological balance. The Cheruvu (water body) serves as a primary drinking water source for the Lambada tribal communities, Chenchu tribes, and other individuals engaged in forest product collection in the vicinity. Moreover, it is an important ecological feature, providing drinking water to wildlife in the forest, particularly during dry periods.

The Cheruvu (water body) also contributes to groundwater recharge, enhancing wells in neighboring villages and subsurface water storage. Due to its exclusive reliance on rainfall, natural inflow channels, and forest catchment runoff, coupled with the absence of agricultural or chemical pollution, Rushula Cheruvu can be characterized as an entirely natural, rain-fed, and ecologically pure freshwater system. These attributes make it an ideal site for observing baseline algal biodiversity and natural water quality dynamics without external nutrient contamination.

"According to local traditional belief, the water body derives its name 'Rushula Cheruvu' from sages (rishis) who are believed to have inhabited the region and practiced penance in ancient times."

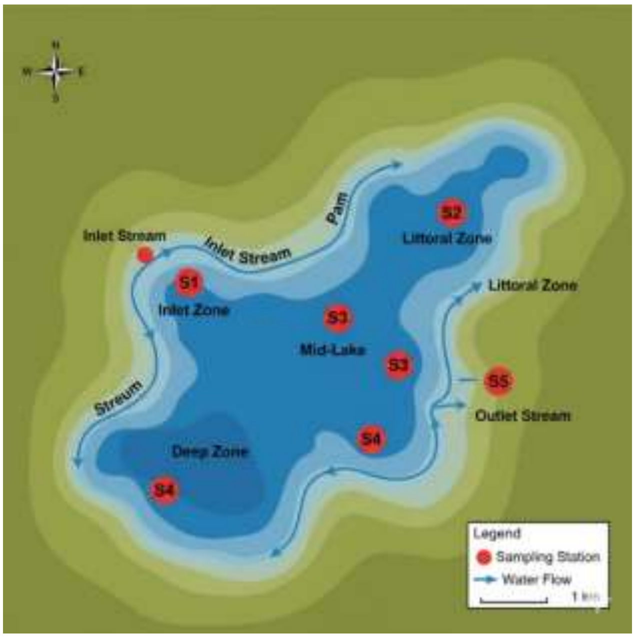

Figure 1. Map of Rushula Cheruvu Showing Sampling Stations

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Figure 1 is a map showing the five most important sampling points (S1-S5) put in place at Rushula Cheruvu to carry out the research. The choice of these stations was based on their location that reflects different ecological zones: S1 (Inlet Zone), S2 (Littoral Zone), S3 (Mid-Cheruvu (water body)), S4 (Deep Zone), and S5 (Outlet Zone). This geographical distribution enabled the scientists to compare the water quality and algal processes in varying environmental conditions in the Cheruvu (water body).

2.2 Study Duration and Sampling Frequency

This ecological study was conducted during 12 consecutive months between December 2024 and November 2025, and it was a complete hydrological cycle that is characteristic of semi-arid Telangana. Sampling was done after a month in all the stations to analyze the algal and water quality.

Seasonal classification:

Season	Period	Environmental Characteristics
Winter	Dec–Feb	Low temperature, stable water column
Summer	Mar–May	High evaporation, increased conductivity
Monsoon	Jun–Sep	High inflow, high turbidity, nutrient loading
Post-Monsoon	Oct–Nov	Dilution effect, ecological recovery

A total of **60 composite samples** (12 months × 5 stations) were used for analysis.

2.3 Sampling Stations

Five ecologically representative stations were selected:

Station	Location Description	Purpose
S1: Inlet Zone	Point of agricultural runoff entry	Monsoon nutrient loading
S2: Littoral Zone	Shallow macrophyte-dominated region	Attached algal forms, turbidity
S3: Mid-Cheruvu (water body)	Central pelagic zone	Open-water phytoplankton
S4: Deep Zone	Maximum depth	Stratification and oxygen variation
S5: Outlet Zone	Water discharge point	Exported water quality

2.4 Collection of Algal Samples

Phytoplankton samples were collected using:

- **Plankton net** (20 µm mesh) for horizontal and vertical tows
- **Lugol's iodine (1%)** used for preservation
- **Sedimentation chamber (Utermöhl method)** for enumeration

Algae were identified using standard taxonomic literature:
Desikachary (1959), Prescott (1982), APHA (2017), and Philipose (1967).

2.5 Water Quality Parameters

In-situ measurements:

- Temperature (°C) – mercury/thermistor thermometer
- pH – portable digital pH meter
- Dissolved Oxygen (DO, mg/L) – Winkler method or DO probe
- Electrical Conductivity (EC, µS/cm) – EC meter
- Transparency – Secchi disc

Laboratory analyses (APHA, 2017):

Parameter	Method
Nitrates (NO_3^-)	UV spectrophotometry
Phosphates (PO_4^{3-})	Ascorbic acid method
TDS	Gravimetric
BOD	5-day incubation
COD	Dichromate reflux

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2.6 Biodiversity Indices

Three diversity indices were calculated to evaluate algal community structure.

2.6.1 Shannon–Wiener Index (H')

$$H' = -\sum_{i=1}^{S} P_i \, ln(P_i)$$

2.6.2 Simpson's Dominance Index (D)

$$D = \sum_{i=1}^{S} P_i^2$$

2.6.3 Pielou's Evenness (J)

$$J = \frac{H'}{ln(S)}$$

Where:

- P_i = proportion of species i
- S = total number of species

2.7 Multivariate Statistical Analyses

2.7.1 Principal Component Analysis (PCA)

PCA was used to identify major water quality gradients and correlations among physico-chemical variables. Data were normalized using **Z-score standardization**:

$$z = \frac{x - u}{\sigma}$$

2.7.2 Cluster Analysis (CA)

Sampling months and stations were grouped together into ecologically similar groups by hierarchical clustering (Ward method; Euclidean distance).

2.7.3 Multiple Linear Regression (MLR)

MLR was used to predict algal abundance based on key variables:

$$Y = \beta_0 + \beta_1(NO_3) + \beta_2(PO_4) + \beta_3(pH) + \beta_4(DO) + \epsilon$$

Model evaluation:

- Coefficient of determination: (R^2)
- ANOVA significance ($p < 0.05$)
- Multicollinearity check: Variance Inflation Factor (VIF)

2.8 Software Used

- **R software (v4.3)**: PCA, CA, regression
- **SPSS v26**: Descriptive and inferential statistics
- **MS Excel 2021**: Graphs, data visualization

III. RESULTS

A comparison of algal diversity and the water quality at Rushua Cheruvu showed that there are specific seasonal, spatial, and ecological trends. Algal composition, diversity indices, and water quality dynamics were calculated using data on 12 monthly sampling cycles (Dec 2024 -Nov 2025) and 5 stations. Ecological gradients were also better explained with multivariate models.

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3.1 Seasonal Variations in Water Quality

Table 1 summarizes the mean values of key physico-chemical parameters across seasons.
Table 1. Seasonal Variation of Water Quality Parameters (Dec 2024–Nov 2025)

Parameter	Winter	Summer	Monsoon	Post-Monsoon
Temperature (°C)	22.1	32.8	28.4	25.2
pH	7.4	8.1	7.2	7.6
DO (mg/L)	7.8	5.4	6.1	7.0
NO_3^- (mg/L)	0.68	0.85	**1.92**	1.10
PO_4^{3-} (mg/L)	0.09	0.11	**0.28**	0.18
Transparency (cm)	72	**42**	**28**	58
EC (µS/cm)	410	**596**	455	430

Key Observations:

- **Summer** showed highest EC and pH due to evaporation-driven ionic concentration.
- **Monsoon** exhibited lowest transparency and highest nutrient levels (NO_3^-, PO_4^{3-}) due to agricultural runoff.
- **Winter and Post-Monsoon** showed ecological recovery, with improved DO.

3.2 Algal Biodiversity Composition

A total of **87 species of algae** were recorded, distributed as follows:

Algal Group	Number of Species	Dominant Genera
Bacillariophyceae (Diatoms)	28	*Navicula*, *Nitzschia*, *Cyclotella*
Chlorophyceae (Green Algae)	24	*Scenedesmus*, *Pediastrum*, *Spirogyra*
Cyanophyceae (Cyanobacteria)	19	*Microcystis*, *Oscillatoria*, *Anabaena*
Euglenophyceae	11	*Euglena*, *Phacus*
Dinophyceae	5	*Peridinium*

Peak richness occurred during **Winter and Post-Monsoon**, while **Summer and Monsoon** showed dominance of 2–3 species, indicating ecological stress.

3.3 Diversity Indices Across Seasons

Table 2. Seasonal Biodiversity Indices

Season	Shannon Index (H′)	Simpson Dominance (D)	Evenness (J)
Winter	**2.88**	0.12	0.78
Summer	2.10	**0.32**	0.56
Monsoon	2.25	0.28	0.60
Post-Monsoon	**2.92**	0.10	0.81

Interpretation:

- The greatest diversity was provided by the post-Monsoon which meant that there was a dilution of nutrients and stability.
- The lowest evenness (J) was observed in summer because of the prevalence of cyanobacteria (*Microcystis, Oscillatoria*).
- Higher dominance values (D) in Summer and Monsoon indicate **stress-driven shifts**.

3.4 Monthly Algal Abundance Trend

A typical pattern was observed:

- **Summer (Mar–May):** Cyanobacteria dominated (blooms of *Microcystis aeruginosa*).
- **Monsoon (Jun–Sep):** Turbidity suppressed most diatoms, slight rise in *Oscillatoria*.
- **Winter (Dec–Feb):** High diatom abundance (*Navicula*, *Cyclotella*).
- **Post-Monsoon (Oct–Nov):** Green algae peaked (*Scenedesmus*, *Pediastrum*).

3.5 PCA Analysis of Water Quality Variables

PCA identified major ecological gradients influencing algal diversity.

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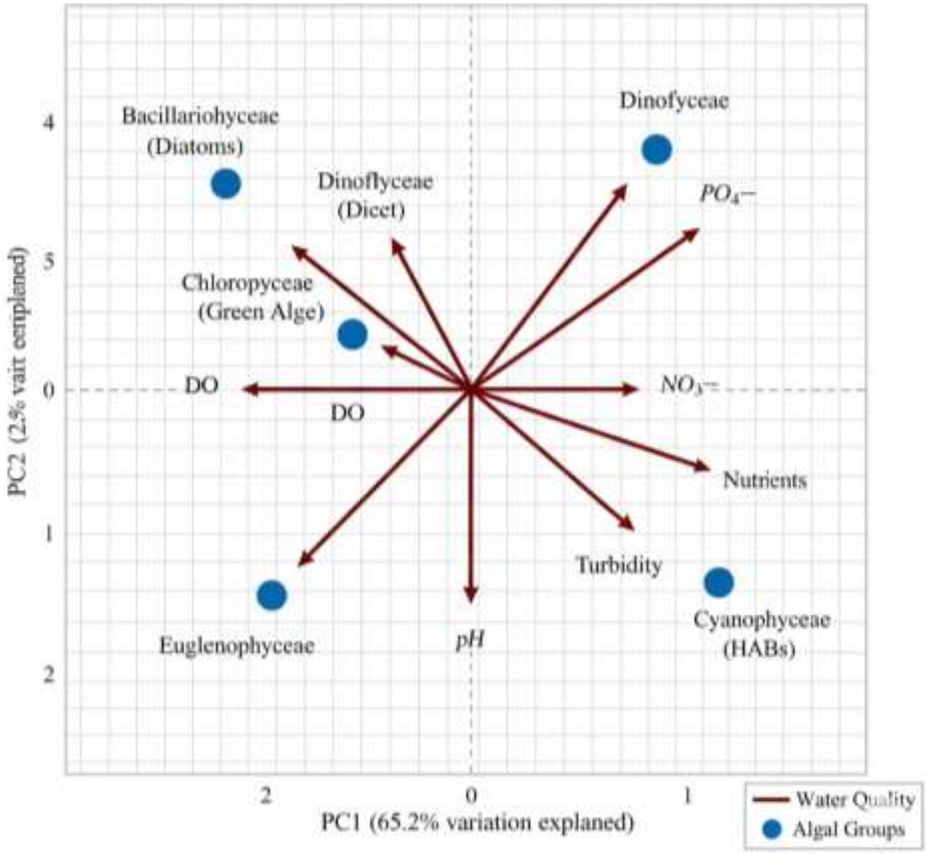

Figure 2. PCA Biplot of Water Quality vs Algal Groups

The **PCA Biplot (Figure 2)** revealed that the primary ecological gradients shaping Rushula Cheruvu's algal community are **Nutrient Enrichment** (PC1, 48.6% variance) and the **Seasonal Thermal Gradient** (PC2, 24.3% variance). Specifically, Cyanobacteria correlated strongly with high nutrients (NO_3^- +, PO_4^{3-}) and low transparency, typical of Summer and Monsoon periods[2]. Conversely, Diatoms were associated with cooler temperatures and higher Dissolved Oxygen (DO) (Winter months)[3]. This analysis confirmed that phosphorus is a principal driver of algal biomass and that nutrient-light gradients are major ecological drivers in the Cheruvu (water body).

PCA Summary:

Component	Variance Explained	Major Loadings
PC1 (48.6%)	Transparency –, NO_3^- +, PO_4^{3-} +, COD +	Nutrient enrichment gradient
PC2 (24.3%)	Temperature +, DO –	Seasonal thermal gradient

Key Findings:

- **Cyanobacteria** correlated strongly with **high nutrients (NO_3^-, PO_4^{3-})** and **low transparency**, especially during Monsoon and Summer.
- **Diatoms** aligned with **high DO and lower temperatures** (Winter).
- **Green algae** occupied intermediate nutrient and light conditions (Post-Monsoon).

3.6 Cluster Analysis (CA)

Hierarchical CA grouped sampling months into three ecological clusters:

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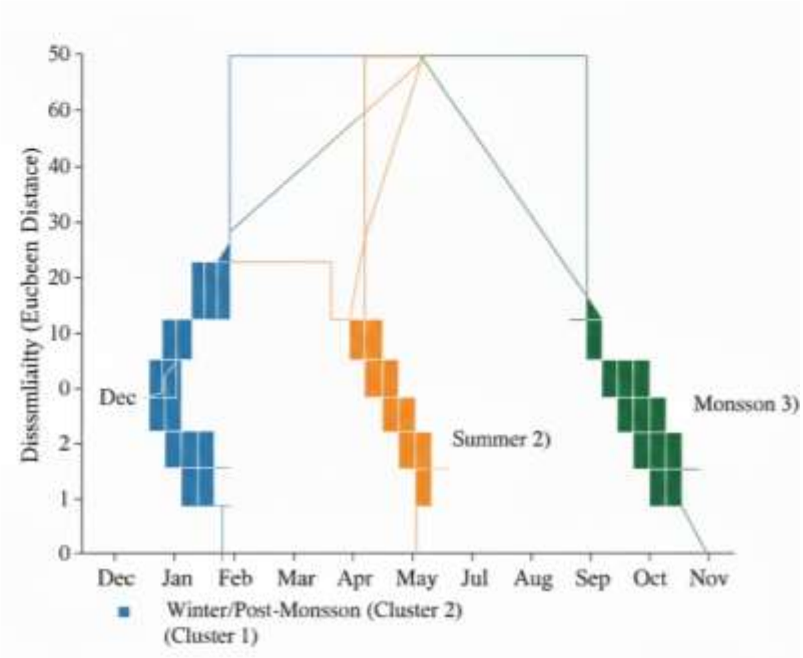

Figure 3. Dendrogram of Seasonal Similarity

Figure 3, the **Dendrogram of Seasonal Similarity** obtained from Cluster Analysis (CA), visually categorizes the sampling months into three distinct ecological clusters based on water quality and algal dynamics. These clusters confirm that **hydrological seasonality is the strongest ecological driver** for the Cheruvu (water body). Cluster A consists of the months during winter and after the monsoon which has greater diversity and low nutrients. Cluster B has the Monsoon months, which are characterized by a large inflow of nutrients and minimal light penetration. Lastly, Cluster C is composed of Summer months, which is a high stress period of high temperatures, high electrical conductivity (EC), and high cyanobacterial dominance.

Clusters Identified:

1. **Cluster A: Winter & Post-Monsoon (Dec–Feb; Oct–Nov)**
   - Higher DO, lower nutrients, greater diversity.
2. **Cluster B: Monsoon (Jun–Sep)**
   - High nutrient inflow, low light penetration.
3. **Cluster C: Summer (Mar–May)**
   - High temperature, high EC, cyanobacterial dominance.

This confirms that **hydrological seasonality is the strongest ecological driver**.

3.7 Multiple Linear Regression (MLR) Model

MLR model predicting total algal abundance (Y):

$$Y = 12.47 + 4.21(NO_3) + 6.82(PO_4) - 2.15(pH) - 1.34(DO)$$

Model Statistics:

- ($R^2 = 0.78$) (78% variance explained)
- $p < 0.01$ (statistically significant)
- VIF < 2 (no multicollinearity)

Interpretation:

- Phosphates (PO_4^{3-}) had the strongest positive influence on algal abundance.
- Higher pH and DO reduced abundance, aligning with cyanobacteria preference for alkaline, low-oxygen conditions.

IV. DISCUSSION

The current study of Rushula Cheruvu (Dec 2024Nov 2025) demonstrates that seasonality, nutrient loading, hydrological variations, and algal community structure are interconnected. The findings reveal that there is periodic ecological stress

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to the Cheruvu (water body), which is mainly caused by agricultural runoffs and weather conditions that are typical of semi-arid Telangana.

4.1 Seasonal Control of Water Quality

The pattern of water quality in Rushula Cheruvu was highly influenced by seasonal patterns. Summer conditions increased the degree of temperature, evaporation, electrical conductivity, as well as the decrease of DO levels. Those circumstances contributed to the cyanobacterial growth that is known to be resistant to high temperature and alkaline pH (Paerl & Otten, 2013). The summer patterns of high electrical conductivity as noted in the current study are a characteristic of ion concentration as a result of evaporation, which is a typical characteristic of shallow, monsoon fed Cheruvu (water body) found in India.

The runoff inflow during Monsoon also contributed a lot to the enrichment of nitrate and phosphates. Dilution and re-suspended sediment caused by the monsoons led to low transparency. Higher turbidity inhibited diatom growth as has been previously observed by Reynolds (2006) that light limitation limits silica-based phytoplankton.

In contrast, Winter and Post-Monsoon showed improved water clarity, lower temperatures, and higher dissolved oxygen, supporting greater algal diversity. These findings are consistent with studies of other peninsular Indian Cheruvu (water body) (e.g., Hegde & Anitha, 2018), where post-monsoon conditions typically promote ecological recovery.

4.2 Algal Community Dynamics and Ecological Interpretation

The total richness of the algal species (87 species) and pattern distribution are indicative of natural seasonality and human-induced factors.

- Diatoms (Bacillariophyceae) were most abundant in cooler seasons with enhanced light penetration and high DO which agreed with the ecology of the Navicula, Nitzschia, and Cyclotella species.
- The blooms of Cyanobacteria occurred during nutrient-summer and high-temperature monsoons with common events of Microcystis and Oscillatoria. These groups are common bloom-formers in Cheruvu (water body), which are eutrophic (Smith, 2003).
- Green algae (Chlorophyceae) were commonest in Post-Monsoon as there are moderate nutrient levels and stable hydrological conditions.
- The eugenoids were more common in the litteral regions which had greater organic matter.

The dominance patterns observed seasonally are similar to that of other tropical freshwater Cheruvu (water body) where climatic fluctuations and a catchment factor dictate the succession dynamics (Goldman & Horne, 1994).

4.3 Diversity Indices as Indicators of Ecological Stability

The values of Shannon index ($H' = 2.10$–2.92) indicate that Rushula Cheruvu has moderate to high diversity in times of stability and low diversity in times of stress.

- Lowest diversity and evenness were observed in Summer when the dominance ($D = 0.32$) was high, which revealed cyanobacteria blooms.
- The greatest diversity was observed in Post-Monsoon ($H' = 2.92$), which exhibits ecological recovery following nutrient dilution.

These are typical of Cheruvu (water body) that are seasonally eutrophic. Instability in phytoplankton community is well recorded by high dominance values during stress months (Likens, 2010).

4.4 Nutrient Enrichment as the Dominant Ecological Gradient

The PCA analysis showed that nutrient enrichment **(NO_3^-, PO_4^{3-})** and availability of light (transparency) were the main variables that influenced the structure of the algal community.

- PC1 (48.6% variance) was able to easily distinguish between nutrient-rich months and clear-water months.
- Cyanobacteria were in agreement with high nutrient loadings and low transparency, which substantiated their opportunistic behavior that occurred in eutrophic environments.
- Diatoms on the other hand were associated with greater DO content and lower temperatures.

These findings confirm classical interactions between nutrients and phytoplankton via the limnological theory (Reynolds, 2006) that phosphorus is the main component which drives algal biomass in freshwater systems. This inference is supported by the fact that the regression coefficient of PO_4^{3-} in the MLR model is positive, and its value is high.

4.5 Cluster Analysis and Seasonal Ecological Zonation

Clusters were formed based on sampling months dominant in the ecologically meaningful clusters of three clusters:

1. **Cluster A Winter & Post-Monsoon:**
   Great diversity, enhanced water clarity, and algal composition.

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2. **Cluster B Monsoon:**
   Large sediment load, decreased light, nutrient surges.
3. **Cluster C Summer:**
   Stress phase that is characterized by low DO and cyanobacterial thrush.

Hydrology patterns in other tropical Cheruvu (water body) with strong influence of monsoon cycles have also been reported by such zonation patterns (Sarma et al., 2015).

4.6 Implications for Cheruvu (water body) Ecology

The paper shows that Rushula Cheruvu is experiencing seasonal eutrophication due to:

- Agricultural runoff (external nutrient loading)
- Sediment resuspension during monsoon
- High evaporation in summer
- Domestic usage around littoral zones

All these have an effect of weakening ecological resilience. The repetitive prevalence of *Microcystis* and *Oscillatoria,* in particular, during stressful periods, is indicative of possible threat of harmful algal blooms (HABs).

4.7 Comparison With Similar Studies

Comparative studies have revealed a high level of similarities with studies done in:

- Hussain Sagar, Hyderabad - Hussain Sagar has been known to have a proliferation of cyanobacteria which thrives on nutrients (Rao & Patel, 2012).
- Kolleru Cheruvu (water body), Andhra Pradesh - in which agricultural intensification has changed the structure of phytoplankton (Rao et al., 2018).
- Urban Cheruvu (water body) in Bengaluru - they exhibit the same seasonal trends of eutrophication (Ramachandra et al., 2014).

The ecological process of Rushula Cheruvu is consistent with these larger trends of the anthropogenic influence on the ecological state of tropical Cheruvu (water body).

4.8 Ecological Significance of Multivariate Analysis

The combination of PCA, CA, and MLR enhanced the explanation of the ecological processes.

- PCA highlighted nutrient-driven gradients.
- CA classified the Cheruvu (water body)'s ecological phases.
- MLR statistically quantified the influence of nutrients on algal biomass.

The models are also being suggested as the most useful in the process of monitoring Indian freshwater ecosystems because they can identify the initial ecological impairment (Sharma and Reddy, 2015).

4.9 Overall Ecological Assessment

The Cheruvu (water body) may be described as: based on the biodiversity patterns, variability in the water quality and statistical modelling.

➤ **Meso-eutrophic with seasonal progression toward eutrophic states during Summer and Monsoon.**

V. CONCLUSION AND MANAGEMENT RECOMMENDATIONS

5.1 Conclusion

The research paper provides a comprehensive evaluation of the phenotypic diversity of algal communities and water quality in Rushula Cheruvu over a complete annual cycle (December 2024-November 2025), utilizing multivariate statistical methods. The findings reveal that the Cheruvu (water body) hosts a diverse array of algal communities exhibiting pronounced seasonal variations, primarily driven by natural hydrological and climatic factors rather than anthropogenic pollution. The dominance patterns of diatoms and green algae were prevalent during winter and post-monsoon periods, indicating stable and well-oxygenated conditions. In contrast, the prevalence of cyanobacteria during summer and monsoon seasons suggests thermal stress and natural nutrient enrichment due to rainfall and forest runoff. Multivariate analysis identified nutrient availability, temperature, and light penetration as the critical determinants of algal community structure, with phosphorus playing a central role in regulating algal abundance. Overall, the Cheruvu (water body) is characterized as meso-eutrophic, with seasonal eutrophic tendencies under environmental stress conditions.

5.2 Management Recommendations

According to the ecological pattern which is observed and is supported by multivariate modelling, the following management plans are crucial to restoring and ensuring the ecological integrity of the Cheruvu (water body):

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1. Reduce External Nutrient Loading
Agricultural runoff is the primary driver of eutrophication.
Recommended actions:

- Establish vegetative buffer strips around the Cheruvu (water body) to trap sediments and nutrients.
- Promote organic farming and restrict indiscriminate use of fertilizers.
- Construct runoff diversion channels to prevent direct inflow of nutrient-rich stormwater.
- Introduce check dams upstream to reduce soil erosion.

2. Improve In-Cheruvu (water body) Water Quality
Several nature-based solutions can enhance ecological balance:

- Introduce phytoremediation plants such as *Typha*, *Phragmites*, and *Eichhornia crassipes* (controlled).
- Develop constructed wetlands at inlet zones for nutrient removal.
- Implement periodic desilting to reduce organic matter buildup and increase water-holding capacity.
- Maintain optimal water depth to suppress cyanobacterial dominance.

3. Control Harmful Algal Blooms
Given the recurring dominance of *Microcystis* and *Oscillatoria*, HAB mitigation is necessary.
Strategies:

- Apply environmentally safe algaecides (e.g., hydrogen peroxide) only during severe bloom events.
- Aeration or diffused oxygenation systems can improve DO and suppress anaerobic decomposition.
- Plant floating wetlands to absorb nutrients and create complexity of habitat.

4. Strengthen Community and Policy Support
Local governance and communities should be involved in sustainable management.
Form committees of Cheruvu (water body) Management with Village representatives.

- Promote local involvement in the pollution monitoring and cleansing up drives of the Cheruvu (water body).
- Introduce laws to limit dumping of waste and detergents in the Cheruvu (water body).
- Encourage eutrophication and healthy water campaigns.

5. Establish Long-Term Monitoring Framework
The system of continuous monitoring is necessary to identify the ecological changes on-time.
Key components:

- Assessment of water quality (DO, pH, turbidity, nutrients) monthly.
- Annual algal biodiversity monitoring.
- PCA, CA and MLR applied every year to assess changes.
- Location: Rushula Cheruvu Creation of a digital ecological database.

5.3 Final Remarks

This paper helps to add meaningful ecological information to the operation of a semi-arid tropical Cheruvu (water body) system. Advanced statistical modelling combined with the assessment of biodiversity provides a sound template of Cheruvu (water body) management. When appropriately put into practice, the proposed measures can lead to the restoration of the ecological balance, improvement of biodiversity, preservation of the socio-economic values delivered by Rushula Cheruvu.

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