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EXPLORING ALGAL DIVERSITY WITH SPECIFIC REFERENCE TO PHYSICO-CHEMICAL PARAMETERS IN LINGTI STREAM OF KANGRA DISTRICT, HIMACHAL PRADESH, INDIA

PRATIBHA	DEPARTMENT OF BIOSCIENCES, HIMACHAL PRADESH UNIVERSITY, SUMMER HILL, SHIMLA, HIMACHAL PRADESH, 171005, INDIA.
NITESH KUMAR*	DEPARTMENT OF BIOSCIENCES, HIMACHAL PRADESH UNIVERSITY, SUMMER HILL, SHIMLA, HIMACHAL PRADESH, 171005, INDIA.
VISHAL RANA	DEPARTMENT OF CHEMISTRY, THAKUR P.G. COLLEGE OF EDUCATION DHALIARA, KANGRA, HIMACHAL PRADESH, 177103, INDIA.
SAURABH SHARMA	DEPARTMENT OF CHEMISTRY, THAKUR P.G. COLLEGE OF EDUCATION DHALIARA, KANGRA, HIMACHAL PRADESH, 177103, INDIA.
MANJU SHARMA	DEPARTMENT OF BOTANY, GAUTAM COLLEGE HAMIRPUR, HIMACHAL PRADESH, 177001, INDIA.

ABSTRACT:

Algal diversity is a crucial bioindicator of aquatic ecosystem health, reflecting the impact of environmental factors on community composition. The present study explores the algal diversity in the Lingti Stream of Kangra District, Himachal Pradesh, India, with a specific focus on the relationship between algal distribution and physico-chemical parameters. This study investigates algal diversity and its relationship with physico-chemical parameters in the Lingti Stream, Kangra District, Himachal Pradesh, India. Algal samples were collected and identified, revealing the presence of five major taxonomic groups: Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae, and Zygnematophyceae. Cyanophyceae and Chlorophyceae exhibited high species dominance, indicating nutrient-rich conditions. The study highlights the ecological significance of algal diversity. The findings provide valuable baseline data for future biomonitoring and conservation efforts in the region. Given the increasing anthropogenic pressures on freshwater resources, continuous monitoring, and sustainable management practices are recommended to preserve the ecological integrity of the Lingti Stream and similar freshwater habitats.

KEYWORDS:

ALGAL DIVERSITY, FRESHWATER ECOSYSTEM, PHYSICO-CHEMICAL PARAMETERS, WATER QUALITY.

INTRODUCTION:

Freshwater ecosystems are dynamic environments that support a vast diversity of aquatic organisms, including algae, which play a fundamental role in sustaining ecological balance (McAllister et al., 1997). Algae serve as primary producers, contributing to nutrient cycling, oxygen production, and food web dynamics in aquatic habitats (Matveev & Robson, 2014). The composition and distribution of algal communities are influenced by various physico-chemical parameters, making them valuable indicators of water quality and environmental health (McGlathery et al., 2004). The Lingti Stream, located in the Kangra District of Himachal Pradesh, India, is a significant freshwater body that supports diverse aquatic flora and fauna. It flows through a region characterized by a unique topographical and climatic setting, making it an important site for ecological studies (Bales et al., 2006). However, freshwater ecosystems in the Himalayan region are increasingly threatened by anthropogenic activities such as deforestation, agricultural runoff, and urbanization, which alter water chemistry and impact biodiversity (Mukherjee et al., 2023). Assessing algal diversity and its ‘ relationship with environmental variables can provide critical insights into the health of such aquatic ecosystems. (Kumar & Thomas, 2019). Fluctuations in these factors can lead to shifts in algal communities, influencing overall water quality (Coffey et al., 2019). For instance, nutrient enrichment from agricultural runoff can cause excessive algal blooms, leading to eutrophication and degradation of aquatic habitats (Wurtsbaugh et al., 2019). Conversely, high dissolved oxygen levels and stable pH conditions are often associated with a balanced algal community indicative of a healthy ecosystem (Coffey et al., 2019). Despite the ecological significance of algae in freshwater ecosystems, limited studies have been conducted on algal diversity in streams of Himachal Pradesh, particularly in the Lingti Stream. Understanding the interactions between algal communities and physico-chemical parameters is essential for effective water quality management and conservation efforts. Therefore, the present study aims to assess the algal diversity in the Lingti Stream by identifying the dominant algal group and analysing key physico-chemical parameters influencing algal composition. The findings of this study will provide baseline data for future ecological monitoring, contributing to the sustainable conservation of freshwater resources in the region (Diwyanjalee & Premarathne, 2025).

Study Area: Himachal Pradesh, situated in the northernmost part of India, is characterized by its mountainous terrain. Its geographical coordinates are approximately 32° 5' 3.1416'' North latitude and 77° 34' 16.2012'' East longitude. Kangra district, situated within Himachal Pradesh, occupies a region between 31˚ 21′ to 32˚ 59′ N latitude and 75˚ 47′ 55″ to 77˚ 45′ E longitude. This district is positioned along the southern slope of the Himalayas and experiences varying elevations due to the presence of the Shivalik Mountains, Dhauladhar Range, and the Himalayas themselves, stretching from the northwest to the southeast.

Lingti Stream: It is situated between latitude 32.16118° North and longitude 76.406934° East. Lingti Stream is the Right Bank tributary of Neugal Khad.

MATERIAL AND METHOD

ALGAL AND WATER SAMPLE COLLECTION

Algae samples were taken from the Lingti stream in the Kangra district using forceps and needles. To avoid contamination, all samples were preserved in polycarbonate bottles containing a 4% formalin solution, as per Kaushik (1987). The risk of contamination was minimized since fresh samples were used. After reaching the laboratory, the fresh algae samples were transferred into petri plates. A glass slide was prepared by adding one or two drops of glycerol. A small portion of the sample was then carefully placed onto the glycerol using forceps and a needle. Finally, a cover slip was placed over the glycerol. The samples were examined under a microscope and identified using standard references. Physico-chemical analyses of the water samples were performed following standard protocols (Association, 1926; Kaushik, 1987; Kumar & Thomas, 2019). Water samples from the Lingti stream were collected for assessment. On-site measurements of temperature, pH, total dissolved solids (TDS), and electrical conductivity were conducted using a water testing meter (Mishra et al., 2023). Titration methods were used to determine total hardness, as well as calcium (Ca^{2+}) and magnesium (Mg^{2+}) hardness, following the guidelines established by the (Association, 1926). Water sample titration was conducted according to the Indian Standard method of water testing.

RESULT AND DISCUSSION:

ALGAL DIVERSITY:

The present study analyzed the algal species diversity in the Lingti Stream, categorizing them into different taxonomic groups: Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae, and Zygnematophyceae. The results, presented in Table 1, indicate a varied distribution of algal species, with some species being highly prevalent while others were recorded in lower abundance. Bacillariophyceae, commonly known as diatoms, were represented by three species in the Lingti Stream. *Fragilaria intermedia* was recorded in moderate abundance (+), while *Hantzschia amphioxys var. vivax* was found in high abundance (++). Diatoms are known to thrive in nutrient-rich waters, and their presence is indicative of the ecological conditions of the stream (Datta et al., 2019). The green algae, classified under Chlorophyceae, exhibited a significant presence in the Lingti Stream. Among the six species recorded, four (*Chlamydomonas mucicola, Hydrodictyon indicum, Scenedesmus dimorphus,* and *Stigeoclonium tenue*) were found in high abundance (++), while *Cladophora glomerata* and *Oedogonium pyriforme* were observed in moderate abundance (+). The dominance of *Chlamydomonas mucicola* and *Hydrodictyon indicum* suggests that Lingti Stream provides suitable conditions such as light availability and moderate nutrient concentrations, which are essential for their growth. The presence of *Cladophora glomerata* in lower abundance indicates that filamentous algae may not be as competitive under prevailing environmental conditions (Michalak & Messyasz, 2021). Cyanophyceae, or blue-green algae, were also well-represented in the Lingti Stream. Out of the four species identified, three (*Anabaena utermohlii, Calothrix javanica,* and *Oscillatoria agardhii*) were highly abundant (++), while *Anabaena fertilissima* was found in moderate abundance (+). The dominance of *Oscillatoria agardhii* and *Anabaena utermohlii* suggests that the stream might have higher organic matter and moderate eutrophication, as these species are known to thrive in such conditions. The presence of nitrogen-fixing cyanobacteria like *Anabaena* and *Calothrix* also indicates that the stream supports an ecosystem where these organisms contribute significantly to nitrogen cycling. A single species from the class Euglenophyceae, *Euglena acus*, was recorded in high abundance (++). Euglenoids are generally found in organically enriched waters, suggesting that the Lingti Stream may have certain nutrient inputs supporting their growth (Hameed et al., 2019). Their abundance indicates a moderate level of organic matter and possibly mild pollution levels, as some Euglenophyceae species thrive in slightly disturbed waters (Ganai & Parveen, 2014). The class Zygnematophyceae was represented by *Zygnemopsis indica*, which was found in high abundance (++). Members of this class are commonly found in freshwater bodies with good water quality, indicating that Lingti Stream provides favorable conditions for its proliferation. The overall diversity of algal species in the Lingti Stream reflects a well-balanced freshwater ecosystem with varying nutrient conditions. The high abundance of species belonging to Chlorophyceae and Cyanophyceae suggests a nutrient-rich environment, while the presence of Bacillariophyceae and Zygnematophyceae further supports the notion that the stream provides diverse ecological niches. The dominance of *Oscillatoria agardhii* and *Euglena acus* suggests that there may be periodic nutrient influxes, possibly from natural or anthropogenic sources. The presence of nitrogen-fixing cyanobacteria such as *Anabaena* and *Calothrix* highlights the role of the stream in nitrogen cycling, which is essential for primary productivity. Furthermore, the absence of *Gomphonema lanceolatum* and the lower abundance of *Cladophora glomerata* indicate that specific environmental factors may be limiting their growth.

TABLE 1: SHOWING ALGAL SPECIES DIVERSITY IN LINGTI STREAM.

Sr.no.	*Name of Algal Species*	*Lingti Stream*
Bacillariophyceae		
1.	*Fragilaria intermedia* (Grunow) Grunow	+
2.	*Gomphonema lanceolatum* Ehrenberg	+
3.	*Hantzschia amphioxys var. intermedia* Grunow	++
Chlorophyceae		
4.	*Chlamydomonas mucicola* Schmidle	++
5.	*Cladophora glomerata* (Linnaeus) Kützing	+
6.	*Hydrodictyon indicum* M.O.P.Iyengar	++
7.	*Oedogonium pyriforme* Wittrock ex Hirn	+
8.	*Scenedesmus dimorphus* (Turpin) Kützing	++
9.	*Stigeoclonium tenue* (C.Agardh) Kützing	++
Cyanophyceae		
10.	*Anabaena utermoehlii* Geitler	++
11.	*Anabaena fertilissima* C.B.Rao	+
12.	*Calothrix javanica* De Wildeman	++
13.	*Oscillatoria agardhii* Gomont	++
Class: Euglenophyceae		
14.	*Euglena acus* (O.F. Muller) Ehrenberg	++
Class: Zygnematophyceae		
15.	*Zygnemopsis indica* (Randhawa) Randhawa	++

("+" indicates presence, "-" indicates absence, while "++" indicates dominance.

TABLE 2: SHOWING PHYSICO-CHEMICAL PARAMETERS.

Sr.no.	Parameters	Lingti Stream
1.	**Temperature (°C)**	26.2
2.	**pH**	7.8
3.	**TDS (in ppm)**	84
4.	**EC (in μm/cm)**	144
5.	**DO (in ppm)**	25.3
6.	**Total hardness (mg/L)**	109.2
7.	**Hardness due to Ca^{2+} (mg/L)**	61.2
8.	**Mg^{2+} Hardness (mg/L)**	48
9.	**Alkalinity**	88

PHYSICO-CHEMICAL PARAMETERS OF LINGTI STREAM

The physico-chemical parameters of the Lingti Stream were analyzed to assess water quality and its suitability for supporting aquatic life. The recorded values for various parameters are presented in Table 2. The water temperature plays a crucial role in regulating the metabolic activities of aquatic organisms and influencing the solubility of gases such as oxygen. The recorded temperature of 26.2°C suggests moderately warm water, which is typical for freshwater streams in temperate regions. Temperature fluctuations can impact algal growth, and the presence of diverse algal species indicates that the stream provides a stable thermal environment (Kaplan & Bott, 1989). The pH value of 7.8 indicates that the water is slightly alkaline. This pH range is optimal for the growth of most aquatic organisms, including algae and fish (Abu-Rezq et al., 1999). Alkaline conditions generally support higher productivity, and the presence of various algal groups, such as Chlorophyceae and Cyanophyceae, aligns with this pH range. The recorded TDS of 84 ppm is relatively low, suggesting that the Lingti Stream has good water quality with minimal dissolved impurities. A low TDS level supports a balanced aquatic ecosystem and prevents excessive algal blooms caused by nutrient overload (Islam et al., 2017; Ramachandra & Solanki, 2007; Sutton, 2020). The recorded EC of 144 μm/cm is within the acceptable range for freshwater bodies, indicating a moderate level of dissolved ions. This value is consistent with the presence of various algal species that thrive in nutrient-rich conditions. Dissolved oxygen is a critical parameter that influences aquatic life (Schneider et al., 2013). The high DO value of 25.3 ppm indicates well-oxygenated water, which supports diverse aquatic organisms, including algae, fish, and invertebrates. This high DO level is likely due to strong water movement and photosynthetic activity by algae, which release oxygen into the water. The dominance of oxygen-producing algal groups such as Chlorophyceae further supports this observation (Weenink et al., 2015). The recorded hardness of 109.2 mg/L indicates moderately hard water. Moderate hardness levels help maintain the ionic balance in aquatic ecosystems and provide essential minerals for organisms (Boyd et al., 2016). Calcium (Ca^{2+}) and magnesium (Mg^{2+}) are the primary contributors to water hardness. The Ca^{2+} hardness of 61.2 mg/L and Mg^{2+} hardness of 48 mg/L suggest that both minerals are present in balanced concentrations. . Alkalinity represents the water's buffering capacity, helping to maintain a stable pH. The recorded alkalinity of 88 mg/L suggests that the Lingti Stream has a good capacity to resist pH fluctuations, which is beneficial for aquatic life. Stable alkalinity levels prevent drastic pH changes that could harm sensitive species. The physico-chemical analysis of the Lingti Stream indicates that the water is of good quality, with favourable conditions for aquatic life. The balanced calcium and magnesium concentrations ensure the availability of essential minerals, while the low TDS and EC values suggest minimal pollution or external contamination (Boyd et al., 2016). The high DO levels are particularly notable, as they suggest active photosynthesis, possibly influenced by the abundance of algae (Juneja et al., 2013). This also indicates that the stream has a self-purifying ability, which helps in maintaining ecological stability.

CONCLUSION:

In conclusion, the study of algal species diversity in the Lingti Stream provides valuable insights into the ecological status of the water body. The presence of diverse algal groups suggests a dynamic aquatic ecosystem, while the dominance of certain species indicates potential nutrient variations. Future studies should focus on seasonal variations in algal diversity and their correlation with Physico-chemical parameters to better understand the health of the stream ecosystem. However, future studies should monitor seasonal variations in these parameters to assess any potential impacts from environmental changes or anthropogenic activities. Overall, the findings suggest that the Lingti Stream provides a well-balanced ecosystem for algal growth and aquatic biodiversity.

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