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Study on Algal Diversity and Physico-Chemical Parameters in Two Streams of Rohru Region in Shimla District, Himachal Pradesh, India

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Abstract: The present study investigates the algal diversity and physico-chemical parameters in Shikdi Stream and Dogda Stream in the Rohru region of Shimla District, Himachal Pradesh, India. Algal samples were collected during three seasons: post-monsoon, winter, and spring, and a total of 21 algal genera were identified across Bacillariophyceae, Chlorophyceae, and Cyanophyceae. Bacillariophyceae exhibited the highest seasonal stability, indicating broad ecological tolerance, whereas Chlorophyceae and Cyanophyceae displayed notable seasonal variability. Physico-chemical analyses revealed seasonal patterns: water temperature dropped in winter and peaked in spring; pH remained slightly alkaline throughout; and both total dissolved solids (TDS) and electrical conductivity (EC) were highest post-monsoon and decreased in spring, particularly in Dogda stream. Shikdi stream consistently recorded higher TDS, EC, hardness, and alkalinity, suggesting greater mineral input, possibly due to geological or anthropogenic factors. The correlation between environmental parameters and algal distribution underscores the influence of temperature, nutrient availability, and water chemistry on stream algal communities. These findings enhance the understanding of freshwater algal ecology and may inform stream monitoring, conservation, and watershed management strategies in the region.

Keywords: Algal diversity, freshwater, physico-chemical parameters, seasons, stream, water quality.

I. Introduction

Algae are among the most varied groups of organisms. Algae are aquatic and may live in both fresh and salty water (Andersen, 1992). They can be found in a variety of environments, including lakes, ponds, rivers, and oceans. Algae play a critical role in aquatic ecosystems, serving as the base of the food chain (Shalaby, 2011). Freshwater ecosystems, such as rivers and streams, are vital components of the natural environment, supporting a wide range of aquatic organisms and providing essential ecosystem services (Andersen, 1992). The diversity and distribution of algal communities in freshwater habitats are closely influenced by a variety of physico-chemical parameters, including temperature, pH, dissolved oxygen, conductivity, and nutrient concentrations (Kumar & Thomas, 2019). Water's quality is determined by its physical and chemical qualities (Fernández et al., 2004; Patil et al., 2012). Water pollution occurs when organic and inorganic pollutants are thrown into bodies of water, altering their natural chemistry and physicochemical properties (Madhav et al., 2020). It may also be caused by specific meteorological or environmental factors. Fluctuations in aquatic life can indicate pollution caused by humans (Akhtar et al., 2021). The season influences the distribution and amount of algae. Seasonal changes affect physicochemical parameters, leading to changes in algal diversity and abundance (Vajravelu et al., 2018). Human activities, such as agricultural runoff, continuously bring waste into the environment, potentially impacting physico-chemical factors across seasons (Kumar et al., 2021). The Rohru region of Shimla district in Himachal Pradesh, located in the western Himalayas, presents a unique ecological setting characterized by its altitude, climatic conditions, and relatively undisturbed freshwater systems. This region supports a variety of perennial streams that serve as important water sources for local communities, agriculture, and biodiversity. However, despite the ecological significance of these streams, there is limited scientific data on their algal diversity and the factors influencing it. This study investigates the algal diversity and its relationship with selected physico-chemical parameters in Shikdi Stream and Dogda Stream of the Rohru region. By analyzing seasonal variations in algal communities and water quality, the research seeks to enhance our understanding of ecological health and provide a baseline for future monitoring and conservation efforts in these sensitive Himalayan aquatic ecosystems.

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II. Materials and Methods

Study Area

Himachal Pradesh, a picturesque state nestled in the northern part of India, is renowned for its breathtaking landscapes, rich biodiversity, and cultural heritage. Himachal Pradesh is not only a popular tourist destination but also an ecologically significant region, contributing to India's natural wealth and environmental stability. Geographically, Himachal Pradesh lies in the western Himalayan region between 32°5'3.1416" North latitude and 77°34'16.2012" East longitude. Covering an area of approximately 55,673 square kilometres, the state accounts for about 1.69% of India's total geographical area. It comprises 12 districts, each characterized by distinct topographical and climatic conditions. Among the twelve districts of Himachal Pradesh, Shimla holds a prominent place, not only as the state capital but also as a region of ecological, historical, and administrative importance. It lies between the latitudes of approximately 30°45′ to 31°44′ North and longitudes 77°0′ to 78°19′ East, covering an area of about 5,131 square kilometres. One of the significant sub-regions within Shimla district is Rohru, situated in its eastern part. Rohru is known for its elevated terrain, lying on the banks of the Pabbar River, and is surrounded by dense deodar and pine forests. The Pabbar River is important in the region, and it originates from the Chanshal range in the Himalayas. It flows through the Rohru area and eventually joins the Tons River, which is a major tributary of the Yamuna River. Thus, hydrologically, the Shikdi and Dogra stream contributes to the Pabbar River system and are ultimately part of the larger Yamuna River basin.

Stream 1: Shikdi Khad is a tributary of the Pabbar River and has an elevation of 1547 metres. Shikdi Khad is situated nearby to the locality of Gangtoli. It is situated between latitude 31.208364° North and longitude 77.747405° East.

Stream 2: Dogra Khad is also a tributary of the Pabbar River and has an elevation of 1525 meters. Dogra Khad is situated nearby to the village of Patsari. It is situated between latitude 31.152742° North and longitude 77.737909° East.

Algal Sample Collection

Algal samples were collected from both streams in Shimla. Forceps and needles were employed to collect samples. To avoid contamination, all algal samples were kept in polycarbonate vials containing a 4% formalin solution. Fresh samples were used, which reduced the risk of contamination. After being transferred to the lab, fresh algae samples were collected and placed in petri plates. Add one or two drops of glycerol to a glass slide. Next, use forceps and a needle to transfer a little sample to the glycerol. Finally, cover the glycerol with a cover slip. Under a microscope, the samples were examined and identified using approved references. The identification of taxa was made by the following standard manuals (Philipose, 1967), (Prasad, 2008),(Prescott, 2008), (Guiry, 2013), (Aysel, 2005), (Anagnostidis, 1985).

Figure: 1

Figure:2

Figure 1 & 2: Shows the collection of algal samples in the Shikdi stream and Figure 2 shows the collection of algal samples in the Dogda stream.

Water Sample Analysis

Standard methodologies were utilised to conduct physicochemical analyses on water samples (Association, 1926). Water samples from the Pun stream were collected for physicochemical analysis. Temperature, pH, TDS, and electrical conductivity were measured immediately with a water testing meter (Singh et al. 2013). Titration was used to determine the total hardness of the samples, as well as the hardness caused by Ca^{2+} and Mg^{2+}. The Indian Standard Method of Water Testing was used for the titration of water samples.

III. Results and Discussion

Algal Diversity: The present study assessed the seasonal diversity of algal genera across two freshwater streams, Shikdi and Dogda, in three distinct seasons: post-monsoon, winter, and spring (Table 1). A total of 21 algal genera were identified. Out of which 7 genera are found under the class Bacillariophyceae, 9 are under Chlorophyceae, and 5 are under Cyanophyceae. The identified

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genera belonged to three major algal classes: Bacillariophyceae (diatoms), Chlorophyceae (green algae), and Cyanophyceae (blue-green algae). The occurrence of each genus is represented by presence/abundance indicators (++: abundant, +: present, -: absent). The Class Bacillariophyceae showed widespread occurrence in all seasons, especially during the post-monsoon and spring seasons. Genera like *Navicula spp.*, *Cymbella spp.*, and *Fragillaria sp.* were consistently present across both streams and all seasons, suggesting a strong adaptability to varying environmental conditions. *Amphora spp.* was abundant in Dogda post-monsoon and appeared consistently in both streams during spring (Douglas, 1958). *Cocconeis spp.* peaked in Shikdi during post-monsoon and winter, but was absent in Dogda during spring, indicating possible sensitivity to warmer spring temperatures or competitive exclusion (Breton et al., 2021). *Gomphonema spp.* was absent in post-monsoon but appeared during winter and spring, notably in Dogda stream, possibly due to changes in substrate and nutrient availability (Snoeijs, 1990). Chlorophyceae displayed high seasonal variability, with some genera like *Ulothrix spp.* and *Cladophora spp.* showing clear seasonality. *Cladophora spp.* and *Ulothrix spp.* were more frequent in the post-monsoon, particularly in Shikdi, but became absent during winter and spring, possibly due to reduced light and temperature. *Oedogonium spp.* and *Cosmarium spp.* were more common in spring and winter, suggesting a preference for relatively stable and cooler environments (Breton et al., 2021). *Chlorella spp.* and *Chlamydomonas spp.* were widely distributed and consistently present, with slightly higher abundance in post-monsoon and spring, indicating tolerance to variable nutrient levels and temperatures (Snoeijs, 1990). *Zygnema spp.* showed a spring peak in Dogda, possibly linked to increased sunlight and nutrient availability (Hafner et al., 2018). Cyanophyceae showed greater dominance during winter and spring, particularly in Dogda, likely due to increased light, higher temperature, and nutrient availability. *Anabaena spp.* was consistently abundant in both streams and across all seasons, indicating high adaptability and potential nitrogen-fixing ability, contributing to its widespread distribution (de Fátima Fiore et al., 2005). *Microcystis spp.* and *Chroococcus spp.* were absent in post-monsoon but became increasingly abundant in winter and spring, particularly in Dogda. This trend may suggest their bloom-forming tendencies under favorable conditions (Curatti et al., 2024). *Calothrix spp.* was most abundant in Dogda post-monsoon and in spring, hinting at site-specific preferences or microhabitat conditions. *Nostoc spp.* showed consistent presence across seasons and sites, similar to *Anabaena spp.*, reflecting a robust ecological niche (Giraldo-Silva et al., 2020). The dominance of cyanobacteria in the later seasons (winter and spring) suggests that increased nutrient loading, light, and temperature play a significant role in promoting their growth (Richardson et al., 2019). Their presence also indicates potential eutrophication or nutrient enrichment in stream water during these periods.

Physico-chemical Parameters: The physico-chemical parameters of two streams, Shikdi (Stream 1) and Dogda (Stream 2), were monitored across three seasons: post-monsoon, winter, and spring to assess the temporal variation in stream water quality and its potential influence on algal diversity. In the Post-Monsoon season, temperatures were relatively moderate (22.2°C in Shikdi and 23.4°C in Dogda). In the winter season significant drop was observed, especially in Shikdi (19.1°C) and further to 13.1°C in Dogda, reflecting typical seasonal cooling. In spring, a noticeable rise in temperature (23.7°C in Shikdi and 28.8°C in Dogda), likely due to increasing solar radiation and lower water flow. Temperature plays a vital role in controlling metabolic rates, algal productivity, and species composition (Rühland et al., 2015). The sharp drop during winter correlates with a shift in algal genera (e.g., dominance of diatoms), while the spring increase supports the proliferation of cyanophyceae in Dogda (Saros & Anderson, 2015). The pH remained within a slightly alkaline range throughout all seasons (7.6–8.4). It showed a gradual increase from post-monsoon to spring in both streams. The alkaline nature of the streams supports the growth of most freshwater algal taxa (Wyatt & Stevenson, 2010). The increase in spring may be associated with heightened photosynthetic activity, leading to CO_2 reduction and subsequent pH rise (Moss, 1973). The highest TDS was recorded post-monsoon in Shikdi (128 ppm). Lowest in Dogda during spring (73 ppm). TDS levels reflect the dissolved ionic load, which is influenced by runoff, erosion, and anthropogenic inputs (Hellar-Kihampa et al., 2013). The reduction in TDS during spring, especially in Dogda, may be due to increased algal uptake of nutrients and reduced surface runoff (Diwan, 2025). EC values followed a pattern similar to TDS, with higher values post-monsoon and lower values in spring. Shikdi generally had higher EC than Dogda across all seasons. EC is directly related to the ionic content of water. Higher EC post-monsoon may result from leaching and surface runoff, while its decline in spring suggests nutrient assimilation by primary producers and lower input from the surrounding land (Jargal et al., 2021). Total Hardness (mg/L) is highest in winter at Shikdi (102.4 mg/L). Lowest in post-monsoon at Dogda (64 mg/L). Hardness is influenced by the concentration of Ca^{2+} and Mg^{2+}. Higher values during winter may result from increased mineral dissolution due to low flow conditions, while lower values post-monsoon can be attributed to dilution effects from rainfall (Manikandan et al., 2020). Calcium Hardness (Ca^{2+}, mg/L) is highest in winter at Shikdi (66.8 mg/L), lowest in spring at Dogda (45.6 mg/L). Shikdi maintained consistently higher Ca^{2+} levels than Dogda. Calcium hardness is essential for algal cell wall formation, particularly in diatoms and green algae (Kumar et al., 2021). Its higher presence in winter may have supported the dominance of diatom species during that season (Moss, 1972). Magnesium Hardness (Mg^{2+}, mg/L) shows noticeable seasonal fluctuation with the highest values in spring at Shikdi (34.4 mg/L) and winter (35.6 mg/L). Significantly low in Dogda during winter (8 mg/L). Magnesium contributes to water hardness and algal metabolism (Salman et al., 2023). The low level in Dogda during winter may indicate reduced mineral input or higher uptake by microbial/algal communities (Szelag-Sikora et al., 2016). Alkalinity (mg/L) is a marked increase in alkalinity during winter and spring, particularly in Shikdi (184–190 mg/L). Dogda showed comparatively lower but rising alkalinity over the seasons. Alkalinity indicates the buffering capacity of water and is often linked to bicarbonates (Mushtaq et al., 2020). The high alkalinity in Shikdi during spring supports conditions favorable for algal bloom, especially cyanobacteria, which thrive in alkaline, nutrient-rich waters (Boyd & Boyd, 2020). Shikdi Stream generally showed higher concentrations of physico-chemical parameters (TDS, EC, hardness, alkalinity), suggesting higher mineral input or geochemical weathering. Dogda Stream, especially in spring, had lower TDS and EC, which may be due to higher algal activity and nutrient uptake, coinciding with cyanobacterial dominance.

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Table 1: Seasonal Occurrence of Algal Genera in Shikdi and Dogda Streams across three seasons.

Sr.no.	Name of Algal Genera	Post-Monsoon		Winter		Spring	
		Stream 1 Shikdi	Stream 2 Dogda	Stream 1 Shikdi	Stream 2 Dogda	Stream 1 Shikdi	Stream 2 Dogda
Class: Bacillariophyceae							
1.	*Amphora spp.*	+	++	-	+	+	+
2.	*Cocconeis spp.*	++	+	+	++	-	-
3.	*Cocconema spp.*	+	-	-	+	+	++
4.	*Cymbella spp.*	+	+	+	-	+	+
5.	*Fragillaria sp.*	++	+	+	++	-	++
6.	*Gomphonema spp.*	-	-	++	-	+	+
7.	*Navicula spp.*	+	+	+	+	+	+
Class: Chlorophyceae							
8.	*Chlamydomonas spp.*	+	++	-	+	+	+
9.	*Chlorella spp.*	+	++	-	+	+	+
10.	*Cloadophora spp.*	++	+	+	-	-	-
11.	*Cosmarium spp.*	+	-	-	+	+	++
12.	*Hydrodictyon spp.*	-	+	+	-	-	++
13.	*Oedogonium spp.*	-	-	++	++	+	+
14.	*Spirogyra spp.*	+	+	+	+	+	+
15.	*Ulothrix spp.*	++	+	+	-	-	-
16.	*Zygnema spp.*	+	-	-	+	+	++
Class: Cyanophyceae							
17.	*Anabaena spp.*	++	+	++	++	++	++
18.	*Calothrix spp.*	+	++	-	-	+	+
19.	*Chroococcus spp.*	-	+	+	++	-	++
20.	*Microcystis spp.*	-	-	++	++	+	+
21.	*Nostoc spp.*	+	+	+	+	+	+

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

Table 2: Seasonal Variation in Physico-Chemical Parameters of Shikdi and Dogda Streams during three seasons.

Sr.no.	Parameters	Post-Monsoon		Winter		Spring	
		Stream 1 Shikdi	Stream 2 Dogda	Stream 1 Shikdi	Stream 2 Dogda	Stream 1 Shikdi	Stream 2 Dogda
1.	**Temperature (°C)**	22.2	23.4	19.1	13.1	23.7	28.8
2.	**pH**	7.6	7.9	8.1	8.2	8.3	8.4
3.	**TDS (in ppm)**	128	86	121	93	103	73
4.	**EC (in µm/cm)**	236	176	242	186	228	146
6.	**Total hardness (mg/L)**	88	64	102.4	72	88	69.6
7.	**Hardness due to Ca^{2+} (mg/L)**	58.4	50.4	66.8	64	53.6	45.6

8.	**Mg^{2+} Hardness (mg/L)**	29.6	13.6	35.6	8	34.4	24
9.	**Alkalinity**	98.8	109.6	184	132.8	190	146

IV. Conclusion

The Present study highlights the significant seasonal variation in both algal diversity and physico-chemical parameters of the Shikdi and Dogda streams in the Kangra district. A total of 21 algal genera were identified across three seasons—post-monsoon, winter, and spring—belonging to Bacillariophyceae, Chlorophyceae, and Cyanophyceae. Bacillariophyceae were found to be consistently present across all seasons, indicating their broad ecological tolerance. Chlorophyceae showed distinct seasonal shifts, with genera like *Cladophora* and *Ulothrix* being more common in post-monsoon, while *Oedogonium* and *Cosmarium* peaked during winter and spring. Cyanophyceae, particularly *Anabaena*, *Microcystis*, and *Chroococcus*, were more dominant in winter and spring, likely due to increased temperature, light, and nutrient availability. The physico-chemical data revealed clear seasonal trends: water temperature was lowest in winter and highest in spring, pH remained slightly alkaline throughout, and TDS and EC values peaked post-monsoon and declined in spring—especially in Dogda—suggesting nutrient uptake by algae. Shikdi stream consistently exhibited higher values for TDS, EC, hardness, and alkalinity compared to Dogda, indicating greater mineral input, possibly from surrounding geology or land use. Increased alkalinity in Shikdi during spring likely favored cyanobacterial growth, correlating with their observed dominance. Overall, the seasonal fluctuations in algal composition were closely linked to variations in environmental parameters, underlining the importance of temperature, nutrient concentration, and water chemistry in shaping stream algal communities. The findings suggest that Dogda may experience more rapid nutrient assimilation, possibly due to higher algal productivity in spring, while Shikdi's higher mineral content may support a different assemblage of species. These dynamics are crucial for understanding stream ecosystem health and can inform conservation and management practices in the region.

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Conflict of interest

The authors declare that they have no conflicts of interest.

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