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# Floristic inventory and ecological diversity of algal flora of Lotkuh District Lower Chitral, Khyber Pakhtoon Khwa, Pakistan

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**Authors' Contribution** | **Madad, A., A. H. khan** & I. Hayat collected ana analyzed the samples. **H. Ullah**, **W. Lili** & **H. Xiangxiang** identified the Specie..

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**ABSTRACT**

The study was conducted to explore the algal biodiversity of Lotkoh, District Lower Chitral, a landscape of glaciers, springs, freshwater streams, and ponds. The study concluded that the algal community studied 13 orders, 17 families and 62 species. The current study was conducted to evaluate the algal flora and ecological parameters of various areas of Lotkoh. The study was conducted from March 2020 to October 2020. A total of 62 taxa were discovered from different areas of Lotkoh valley. The total algal flora discovered is distributed over 17 families. Family *Zygnemataceae* is the leading family with the total contribution of 17% followed by *Oedogoniaceae* (10%), *Oscillatoriaceae* (9%) and *Scenedesmaceae*, *Hydrodictyaceae*, *Chlamydomonadaceae*, *Cocconeidaceae* (7% each), while *Cladophoraceae*, *Vaucharicea*e 5%, *Cocconeidaceae*, *Cymbellaceae*, *Gomphonemataceae*, *Fragilariaceae* (1%). The pH for the algal community ranges from 5.7 the lowest to 8.00 the highest. The water analysis for pH suggested that during a year, most of the times, water remains alkaline. Though river Lotkoh is added by different tributaries, but most of the time of the year, their pH remains uniform and does not alter rapidly. The deviation of the pH from 7 has different consequences on the dissociation of solutes, availability of nutrients, and ultimately the growth of the algae. Temperature is one of the crucial factors of algal distribution and community development. The study showed that most of the algae were distributed between temperature 20°C- 30°C. In the study area, the different collection areas have water bodies with different temperatures. The lowest temperature was recorded for the alga Spirogyra dent reticulata which was 15.

**Keywords**: Landscape, fresh water, streams, parameters, spirogyra, alkaline, reticulata.

**INTRODUCTION:** Algae is a complex group of organisms and autotrophic. They are used in agriculture as fertilizer, especially seaweeds are provided to the land to ramp up fertility, prevent soil erosion, provide nutrients to the soil, and regulate water proportion in the soil. Human being depends on agriculture since long time ago. Algae has an important role in increasing agricultural yield. Algae are different from other plants structurally and are they similar to other plants as they possess chlorophyll and proteins etc. Blue-green algae accelerate plant growth by the secretion of some important substance like auxin, so protein concentration in many parts like seed increases. When the salt concentration of soil increases, it badly harms the fertility of the soil and plant life on the soil. Algae controls the salt concentration and many other factors that affect the soil quality. Many dead algae are mixed in the soil and produce useful compounds which can be used by the plants for better nourishment (Abdel-Raouf *et al.*, 2012). The algae, all over the world, are divided in different climatic conditions as well as the most ancient plant. Due to this, the algae has been fascinating for researchers. Like other countries, algae are present in any area of Pakistan and some study has been carried out about the algae in freshwater. Due to increase in pollution, some species are extinguished, and some species of freshwater algae increases the impurity of water making it unfit for drinking purpose (Khan *et al.*, 2011). The algae have different habitat marines, aquatic (freshwater, lakes, and stream), etc. Different type habitats have different concentrations of compounds and minerals. Cyanobacteria have high concentration protein content than other algae. The floating algae require 20 -30°C temperature for its normal growth condition and when drops below 16°C its growth rate decreases and sometimes stops. The majority of algae are found in ponds especially in open ponds. They convert the waste product to useful products and leads to the cleaning of the land environment. In the atmosphere, the algae produce oxygen and carbon and help human and plant life. They obtain nutrition from human and animal waste. The algae have both positive and adverse effects on humans and the environment (Menetrez, 2012). Algal proteins have enzymatic proteins. Few types of algae are used on large scale and some are used on small scale. When the algae are dried they are not used in foods. Microalgae are used in health caring and against different types of diseases. The microalgae are used by an animal like fish because they contain high quality of protein (Becker, 2007). When the temperature is maximum the improvement of the algae is affected. In the summer season, the growth of algae is the highest because of increasing temperature with monsoon rainfall and the water PH 7.3 as well as maximum light. The land algae growth is less as compared to the algae present in the water. Some algae breed in the summer and rainy season and their number is increased (Khalid *et al.*, 2014). In the initial stage, the algae could not be differentiated from each other because modern tools like electron. The examination of algae depends upon the size. Some algae are examined and collected easily while some are very small and hard to identify and collect (Belcher and Swale, 1976). Asexual and vegetative reproduction is made rapid and produces more offspring's as compared to sexual reproduction (Barsanti *et al.*, 2008). Microalgae are used on large scale for energy than other algae. They mostly occur in marine and freshwater. Different types of algae include in the microalgae because they cannot be seen with the necked eye. The microscope is the tool used to see and identification of the microalgae. Their function is the fixation of carbon dioxide in organic compounds and the production of oxygen by using sunlight. Some are present in association with other plants and animals and some algae cause diseases in plants and animals like malaria which are The production of oil in algae is slow and the limitation of nitrogen is needed. Algae are used to clean water and remove waste from water (Lundquist *et al.*, 2010). When the value of algae is increased the large-scale farming of microalgae is started. Because they are used for different purposes like human and animal's nutrition. They are used in many tablets and capsules. The microalgae are used to solving health issues they suppress hypertension, control renal failure, etc. Among the microalgae Arthrospira; the most maximum protein is present in them used for nutrition purposes. In animals, they are used as food for aquatic animals like fishes and other animals. They also help in the farming purpose of fishes and produce the large scale and provide the improvement. The dogs, cats, and many birds also use algae as food especially the Arthrospira. Different algae are used in skin-caring compounds used in foreign countries like Paris, France, etc. They protect skin and hair (Spolaore *et al.*, 2006). In the present time, the utilization of fish on large scale has increased all over the world. 90 million tons of fish species cannot fulfill the requirement of the people of the world. The most fruitful algae for the survival and larva stage of the shrimp is the Chaetoceros as compared to the Tatraselmis (Khojasteh *et al.*, 2013). In the present time, the activity of humans and the development of technology the environment is affected and damaged. Phytoremediation is the modern method as compare to bioremediation. The algae are also used for the purification of water. They remove the waste from water (Rao *et al.*, 2019). Algae plays an important role in large scale fuels production because they rapidly grow and complete their life cycle in short period than other plants (Sander and Murthy, 2010). The farming algae is required the pH between 7 and 9. The high and low pH both effect the growth of algae. Likewise, temperature plays important role in algal farming the specific temperature is 20 and 24°C. The growth of algae is affected when the temperature is above 35°C, and below 16°C (Coutteau *et al.*, 1996).

**OBJECTIVES:** The objectives of this study were as follows: (1) to determine the functionality and localization of DEGs (2) Identification of hub genes. (3) Interaction network analysis of hub

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genes and other genes in human being. (4) Identification miRNA for the hub genes regulation.

**MATERIAL AND METHODS: Description of the study area:** Chitral previously known as Qashqar is in the north-western territory as shown in Figure 1 of Khyber Pakhtunkhwa, Pakistan. It is located at 322 kilometers from the provincial capital Peshawar. Geographically, Chitral lies between at 36°15′ N, and 72°15′E with an altitude of 1128 meters at town Chitral.

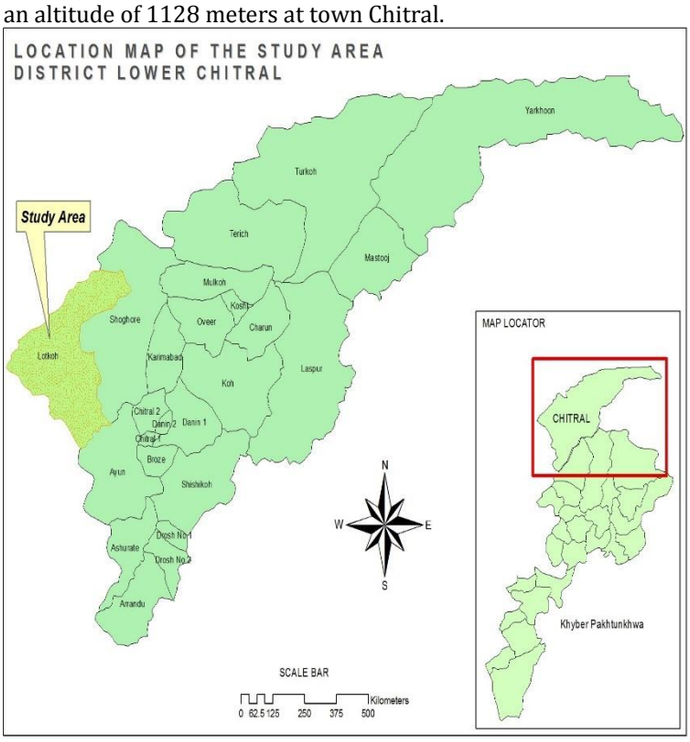


Figure 1: Map of District Chitral showing targeted Spots.

**Sample collection**: A total number of 35 samples were collected keeping in view microalgae, macroalgae, benthic algae, and periphyton (Wehr *et al.*, 2015). The sample was collected over an average area of 20 square meters with the help of plastic mesh. The samples were shifted to the laboratory of the Department of Botany, University of Chitral, in standard-sized plastic bottles stored in an icebox.

**Preservation of samples**: The samples were subjected to long-term preservation in a 3% formaldehyde solution in glass bottles (Edler and Elbrächter, 2010). For identification of microalgae a pipette was used while fine needle and forceps were applied to pick macroalgae.

**Physicochemical properties of water**: **a) Electrical conductivity, TDS and temperature:** These were measured with Adwa-330 TDS meter.

**The pH:** It was measured with HANNA-HI 83141pH meter.

**d) Altitude and geographical coordinates**: For altitude and geographical parameters, Garmin-ETrex 30 was used.

**Identification of the specimens**: For identification, the specimens were mounted on the glass slides and examined under a compound microscope. The specimens were identified with standard identification manuals (Collins, 1909; Transeau, 1951; Tiffany and Britton, 1952; Prescott *et al.*, 1962; Wehr, 2002; Bellinger and Sigee, 2015) and updated with algaebase.org).

**RESULTS AND DISCUSSION**: Algae play a crucial ecological role on the surface of the earth. Their role is tremendous as they make the base of the food chain. They play their role through the regular addition of oxygen to the planet when it is loaded with carbon dioxide. They are the direct or indirect source of food for fish and other aquatic organisms. Temperature is one of the key environmental factors responsible for the distribution of all the aquatic macrophytes and thus acts as one of the key factors to control the population of algae. As described by Welch and Nichol (1952), the quantity of oxygen dissolved in water decreases with the increase in the average temperature. Increasing temperature influences the metabolism as it increases all the metabolic activities and thus has a crucial effect on the types of reactions taking place in an aquatic habitat. Thus, temperature affects the community types and growth of the community of an alga in a specific area. The dissolved contents of oxygen depending on the velocity of water, pollution, water temperature, addition of water from other sources, consumption, and production of oxygen by plants, animals, and bacteria.

**Temperature range and distribution of Algae:** Temperature is one of the crucial factors of algal distribution and community development. The study showed that most of the algae were distributed between temperature 20°C- 30°C. In the study area, the different collection areas as shown in table 1 have water bodies with different temperatures. The lowest temperature was recorded for the alga Spirogyra dentireticulata which was 15°C as shown in table 1.

Table 1: Locality, pH, temperature, and electrical conductivity of algal species of Chitral.

| Taxon | Locality | pH | Temp (℃) | ECE (µs) |
|---|---|---|---|---|
| ***Spirogyra dentireticulata*Rom.** | Gajal | 5.7 | 11 | 401 |
| ***Spirogyra aequinocitialis*G. S. West.** | Droshp | 6.8 | 23 | 450 |
| ***Spirogyra crassa*Kuetzing.** | Duaba | 7.5 | 9 | 600 |
| ***Spirogyra inflata* (Vauch.) Kuetzing.** | Garumchashma | 7.5 | 10 | 800 |
| ***Spirogyra longata*Vauch.** | Murdan | 6.8 | 6 | 1290 |
| ***Spirogyra neglecta*Kuetzing.** | Murdan | 6.8 | 4 | 701 |
| ***Spirogyra reflexa* Trans.** | Kandujal | 8 | 27 | 1447 |
| ***Oscillatoriaacuminata*Gomont.** | Ziyarart | 6.6 | 28 | 545 |
| ***Oscillatorianigra*Vauche.** | Gajal | 8 | 20 | 1219 |
| ***Cocconeisplacentula* L.** | Droshp | 5.9 | 8 | 350 |
| ***Phormidiumautumale*Gomont.** | Enjigan | 8 | 15 | 306 |
| ***Phormidiumfragile*Gomont.** | Ziyarat | 6.4 | 9 | 561 |
| ***Phormidiumtinctorium*Kuetzing.** | Bashqar | 7.2 | 23 | 1915 |
| ***Cymbellakappii* L.** | Karimabad river | 6.5 | 22 | 1749 |
| ***Navicularadiosa* L.** | Bagusht | 7.2 | 17 | 1555 |
| ***Mougeotiacalcarea* (Cleve) Wittr.** | Droshp | 7.5 | 24 | 865 |
| ***Mougeotiamesocarpeana*Wittrock.** | Duaba | 7.3 | 11 | 1413 |
| ***Fragilaria ulna* L.** | Qalamdar | 7.5 | 9 | 761 |
| ***Oedogoniumangustissimum*W. & W.** | Bagusht | 6.7 | 8 | 1545 |
| ***Oedogoniumacrospirum*Skuja C.** | Garumchashma | 7.4 | 36 | 1512 |
| ***Oedogoniumalatum*C.-C.Jao C.** | Narkote | 7.6 | 27 | 655 |
| ***Oedogoniumalpinum*Kützing C.** | Garumchashma | 7.3 | 41 | 1650 |
| ***Cocconeispediculus* L.** | Ovirik | 6.1 | 12 | 1156 |
| ***Cocconeisscutellum*Erhenberg.** | Garumchashma | 5.9 | 45 | 1908 |
| ***Cocconeisflexilis* (Kuetzing) Cleve.** | Zargarandeh | 6.0 | 23 | 2110 |
| ***Stigeocloniumtenue*Kuetzing.** | Kandujal | 6.0 | 7 | 2900 |
| ***Stigeocloniumaestivale* Hazen.** | Jitur | 6.8 | 10 | 1210 |
| ***Stigeocloniumsubsecundum*Kuetzing.** | Mough | 6.8 | 24 | 1447 |
| ***Vaucheriageminata*Vaucher.** | Ovirik | 7.5 | 11 | 545 |
| ***Vaucheriaborealis*Hirn.** | Garumchashma | 7.5 | 47 | 1219 |
| ***Vaucheriadisperma* De Candolle.** | Awlan | 6.8 | 13 | 350 |
| ***Cladophoracrystallina*Kuetzing.** | Parabag | 6.8 | 15 | 306 |
| ***Cladophoracrispata* (Roth.) Kuetzing** | Mough | 6.8 | 16 | 655 |
| ***Cladophoragraminea*Coll.** | Garumchashma | 7.5 | 25 | 1650 |
| ***Ulothrixaequalis*Kuetz.** | Izhh | 6.7 | 14 | 1156 |
| ***Ulothrix. subconstricta*West.** | Shoghore | 7.4 | 27 | 1908 |
| ***Ulothrixtenuissima*Kuetz.** | Izhh | 7.6 | 12 | 2110 |
| ***Ulothrixzonata*Kuetz.** | Bilphuk | 7.3 | 22 | 2900 |
| **Ulothrixtenerrima L** | Bashqar | 6.1 | 12 | 1210 |
| ***Didymospheniageminata* L.** | Awlan | 6.8 | 8 | 655 |
| ***Zygnema sterile* Transeau.** | Mogh | 6.8 | 23 | 1650 |
| ***Gonium pacturale*Mueller** | Owirk | 7.5 | 16 | 1156 |
| ***Eudorinaelegans*Ehr.** | Narkote | 6.7 | 14 | 1908 |
| ***Pandorinamorum*(Muell.) Bory** | Garumchashma | 7.4 | 36 | 1156 |
| ***Pleodorinaillinoisensis*Kafoid.** | Parabag | 6.8 | 23 | 1908 |
| ***Chlamydomonasepiphytica*Smith** | Bashqar | 6.8 | 28 | 2110 |
| ***Chlamydomonasglobosa*Snow** | Garumchashma | 6.8 | 23 | 2900 |
| ***Chlamydomonaspseudopertyi*Pasch.** | Mogh | 7.5 | 28 | 655 |
| ***Chlamydomonaspolypyrenoideum*Pr** | Murdan | 6.7 | 23 | 1650 |
| ***Geminellacrenulatocolis*Prescott** | Kandujal | 7.4 | 26 | 1156 |
| ***Geminellaordinata*Heering.** | Arkari river | 6.8 | 28 | 1908 |
| ***Scenedesmusabundans*Kirch.** | Owirk | 6.8 | 27 | 1219 |
| ***Scenedesmusacutiformis*Scroeder.** | Garumchashma | 7.2 | 23 | 350 |
| ***Scenedesmus. arcuatus*Lemm.** | Bashqar | 6.5 | 15 | 306 |
| ***Scenedesmusarcuatus*Smith.** | Narkote | 7.2 | 23 | 561 |
| ***Scenedesmusbijuga*(urp.** | Izhh | 7.5 | 28 | 1915 |
| ***Oedogoniumangustissimum*W& W.** | Murdan | 7.3 | 15 | 2900 |
| ***Bulbochaetegigantea*Pringsheim** | Awlan | 7.5 | 26 | 655 |
| ***Tetraedronasymmetricum*Prescott** | Begusht | 7.4 | 28 | 1650 |
| ***Tetraedroncaudatum*Hansgirg.** | Garumchashma | 6.8 | 44 | 1156 |
| ***Tetraedron. muticum*A. Braun.** | Izhh | 6.8 | 10 | 1908 |
| ***Tetraedronmuticum*Reinsch.** | Duaba | 7.2 | 16 | 1219 |

Most of the algae belonging to Chlorophyceae can thrive in cold water. Their physiological activities are best resumed upon the arrival of favorable conditions. According to the study the highest temperature algae was recorded to be Cocconeisplacentula L., Oedogoniumangustissimum W. & W., thriving at the temperature of 30°C. Most of the alpine algae thrive best at a temperature ranging between 20- 30°C (Atkins and Harris, 1925).

**The pH range of the algal flora:** The pH for the algal community ranges from 5.7 the lowest to 8.0 the highest as shown in table 1. The

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water analysis for pH suggested that most of the year the water remains alkaline. Although river Chitral is added by different tributaries but most of the time of the year their pH remains uniform and does not alter rapidly. The deviation of the pH from 7 has different consequences on the dissociation of solutes, availability of nutrients, and ultimately the growth of the algae. The variation in the pH is also the result of the different gases dissolved in the water like $CO_2$, $H_2S$, and ammonia. The decrease in pH below the value of 8 indicates that the amount of $CO_2$ in water is greater than equilibrium with air. The present study shows that the water of the study area is mostly slightly basic but not strong basic (Ali *et al.*, 2021).

**Electrical Conductivity Relationship:** The quantity of ionic particles in water determines the electrical conductivity of water. Many of the studies have suggested that there is a greater impact of ionic balance on the distribution and growth of algal communities. As investigated by Krogh and Keys (1931), chlorides are an important source of food for aquatic life including algae and other macrophytes. The total hardness of water depends on the presence of Mg and Ca ions in water. In most of the cases, the growth of the algae is favored by the presence of Mg than calcium while in other cases the growth depends mainly on the ratio of both (Akhtar *et al.*, 2008). In the present study as shown in table 1, the electrical conductivity of the habitat ranges 350µs- 2900 µs which is relatively higher than most of the study. It shows that the amount of the dissolved ionic solids in the tributaries of the river Lotkoh is higher.

**CONCLUSION**: The study revolved around the algal community: 13 orders, 17 families, and 62 species. The current study was conducted to evaluate the algal flora and ecological parameters of various localities of Chitral. The study was conducted from March 2020 to December 2020. A total of 62 taxa were discovered from different areas of Garam Chashma Valley. The total algal flora discovered is distributed over 17 families. Family Zygnemataceae is the leading family with the total contribution of 17% followed by Oedogoniaceae (10%), Oscillatoriaceae (9%) and Scenedesmaceae, Hydrodictyaceae, Chlamydomonadaceae, Cocconeidaceae (7% each), while Cladophoraceae, Vaucheriaceae 5%, Cocconeidaceae, Cymbellaceae, Gomphonemataceae, Fragilariaceae (1%) The pH for the algal community ranges from 5.7 the lowest to 8.00 the highest. The water analysis for pH suggested that most of the year the water remains alkaline. Although river Lotkoh is added by different tributaries but most of the time of the year their pH remains uniform and does not alter rapidly. The deviation of the pH from 7 has different consequences on the dissociation of solutes, availability of nutrients, and ultimately the growth of the algae. Temperature is one of the crucial factors of algal distribution and community development. The study showed that most of the algae were distributed between temperature 20°C- 30°C. In the study area, the different collection areas have water bodies with different temperatures. The lowest temperature was recorded for the alga Spirogyra dentireticulata which was 15°C.

**RECOMMENDATIONS**: The study came up with the following policy recommendation: 1) Chitral is the region of algal biodiversity and expands over a vast area of land. Therefore, extensive studies are needed to explore the algal diversity of the region. 2) For the preservation of the algal flora of the alpine region, it is imperative to conserve habitats. 3) Most of the water bodies during the study have been seen polluted. If the same ratio of pollution extends, it may endanger some of the algae. 4) Measures should be taken to grow algae on a sustainable basis to harvest useful commercial products.

**CONFLICT OF INTEREST:** The authors declared no conflict of interest.

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