Journal of Advances in Science and Technology
Vol. 22, Issue No. 2, April-2025, ISSN 2230-9659

DOI: https://doi.org/10.29070/s1cst346

Study Of Algae in Ponds and Tube well of Surrounding Area at Hapur.

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Abstract: The current study was conducted to collect, classify, and examine freshwater algal species from a range of ecological habitats in the Hapur district. The samples were obtained in sterilized containers from tube wells and ponds. The study will explore the relationship between algal communities and key environmental parameters such as water chemistry (pH, nutrient levels, etc.) and physical characteristics (temperature, light availability). The samples were analysed for pH and temperature. After collection, they were transferred to the laboratory and kept in an open tank under natural sunlight for a week. Algal species were observed and recorded through binocular microscopic examination. This analysis will help to determine how these factors affect the types and abundance of algae found in different locations. Many different varieties of algal species were found from samples collected. The total of 10 species were recorded that belong to 9 orders, 9 families and 10 genera from different sites of Hapur. Those samples were collected from mid of March to the beginning of April. The study of algae provides an effective approach for evaluating water quality across aquatic environments and enhances understanding of ecological functioning and aquatic resource management. From this, we can conclude that tube wells and ponds act as reliable sources of algal diversity, offering a sustainable environment for algal growth and serving as indicators for monitoring pollution levels.

Keywords: Algae, Diversity, Habitat, Parameters, Binocular

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INTRODUCTION

Algae are essential components of aquatic ecosystem, contributing to oxygen production and serving as the base of the food chain and serve as indicators of environmental conditions. Their size ranges widely, from tiny unicellular forms only visible under a microscope to large seaweeds such as kelp, which can be observed with the naked eye. The growth of algae depends on numerous factors such as light intensity, photoperiod, temperature, salinity, pH, depth of water bodies and amount of nitrogen (Gani et al., 2019). Surface water bodies like ponds typically support diverse algal communities due to exposure to sunlight and nutrient. The evolutionary origin of algae can be traced back to the Precambrian era, nearly three billion years ago. Green algae are one of the most diverse groups of Algae with at least thousands of species (Nelson and Garcia-Pichel, 2021). Green Algae are distinguished by morphological traits such as filamentous forms, colonial structures, branched growth types, motile and non-motile stages, and thallus forms resembling blades (Leliaert et al., 2012). Chloroplast contained Chlorophyll a, b and accessory pigments including Carotene and Xanthophylls which are surrounded by double membrane with Thylakoid arrange in lamella. Within the chloroplast, pyrenoids are embedded and surrounded by starch, functioning as centers of carbohydrate storage (Forjan et al., 2015). Green algae have variations in their morphology ranging from microscopic flagellated unicells to complex macroscopic thalli with varying degree of morphological differentiation.

Microalgae are a diverse group of aquatic photosynthetic organism having variations in Cell morphologies, Life Cycle, and Growth pattern and favoring a variety of Habitats (Alam et al., 2019). As a photosynthetic organism, they are responsible for absorbing carbon from atmosphere and putting back oxygen acting as the sink of carbon sequestration (Jyothi et al., 2016). Terrestrial habitats also host many green algae, though some species thrive only under particular ecological conditions. For instance, flagellated chlorophytes often occur in nutrient-rich standing waters. Filamentous conjugating green algae commonly inhabit stagnant roadside pools and pond margins, while littoral zones of lakes often contain free-floating mats that may also attach or mix with other algae. Desmids, which prefer moderate nutrient conditions, are frequently associated with macrophytes (Haworth, 2016).

Certain algae possess adaptive mechanisms to tolerate harsh environmental conditions, while others are less capable of withstanding such stresses. Some green algae can utilize organic carbon sources in the absence of light (heterotrophic growth), allowing them to survive and even grow more rapidly than under strict autotrophic conditions. The freshwater algae can be found in different forms such as unicellular, colonial form, pseudo filamentous, filaments, pseudoparenchymatous forms, coenocytic or siphonous forms. They can be free floating or forms associated with a substrate.

Within the algae, there is an enormous range of vegetative morphologies, including the following:

Unicells:

Species that occur as solitary cells, which can be either motile or non-motile. Motile forms may move using one or more flagella or by gliding mechanisms assisted by mucilage or similar secretions. Unicellular types occur in diverse structural forms, such as those enclosed in a gelatinous covering, cells with unique wall textures and markings, cells with flexible outlines, and those equipped with equal or unequal flagella. In some cases, the cells extend into horn-like projections or may be protected within rigid coverings like lorica.

Colonies:

An aggregation of cells that are held together in either a loose or highly structured manner. Depending on the algal taxon, colonies may consist of a variable or fixed number of cells (coenobium). Colonies may be flagellated or non-flagellated. The intercellular association in colonies can occur through different mechanisms such as an enclosing gelatinous substance, a gelatinous stalk, or a shared parental wall. The cells may be systematically arranged at their margins, centrally joined, or in some cases, linked through protective coverings such as loricas.

Filaments:

A chain or series of cells in which the cells are arranged end to end, with adjacent cells sharing a common cross wall. Traditionally, linear colonies can be distinguished from true filaments do not. However, some chain-forming diatoms, such as *Melosira*, may also be referred to as filaments. Filaments may occur in a single row (uniseriate or uniaxial) or in multiple rows (multiseriate or multiaxial). They can be simple and unbranched, or in certain groups may show branching. False branching, seen in some cyanobacteria like *Scytonema*, results from breakage in the trichome enclosed within a sheath and differs from true branching, which arises by direct cell division. In some cases, the primary axis produces branches that resemble the main axis, while in others heterotrichous forms occur, where the main axis differs from the smaller side branches. Branching patterns may be alternate, opposite, dichotomous, or whorled. Specialized cells may also be present, such as heterocytes in cyanobacteria, which are responsible for nitrogen fixation.

Coenocytic or siphonous form:

These are large multinucleate forms of varying shapes that lack internal cross walls to divide nuclei and organelles. A common example is the yellow-green alga *Vaucheria*. During the development of reproductive structures such as oogonia, cross walls may form, separating them from the main filament.

Pseudofilaments:

An arrangement of cells positioned in a sequential manner, where the cells are not directly joined but remain separated and often enclosed in a gelatinous covering. Some pseudofilamentous cyanobacteria may also form visible crust-like layers on surfaces such as rocks.

Parenchymatous forms:

These represent true tissue structures made up of a compact mass of cells that are three-dimensional, variable in shape, and not filamentous or colonial in organization. The cellular arrangement is often distinguished into an outer photosynthetic region (cortex) and an inner non-photosynthetic region (medulla). In freshwater habitats, these forms are usually simple in appearance, often resembling tubular or blade-like green algae.

Pseudoparenchymatous structure:

These thalli appear tissue-like but actually result from tightly packed branches of filaments arranged in either a single row (uniseriate) or multiple rows (multiseriate). In the red alga *Lemanea*, the central axis is covered by a layer of small cells termed cortication. Crust-like growth forms develop from short, compact filaments, as observed in species such as the green alga *Gongrosira* and the brown alga *Heribaudiella*.

Freshwater algae display a wide variety of structural forms; however, the larger pseudoparenchymatous and parenchymatous types are generally smaller compared to their counterparts in marine environments. Planktonic (free-floating) algae are usually minute, often microscopic, and primarily represented by simpler morphological forms. In contrast, benthic (attached) algae encompass a broad spectrum of sizes and structural diversity, although species with flagella occur less frequently than those in planktonic communities.

MATERIAL AND METHOD

Study Area Selection – Samples of green algae were collected from various locations in Hapur. The sampling was carried out in mid-March, and specimens were taken from both ponds and tube wells. The specific collection sites included Nizampur, Dhaulana, Phagota, Accheja, Khera, Sikhera, Kandola, Banokhar, and Dheekri.

Collection of Samples – The algal samples were obtained in liquid form. For collection, basic laboratory and field equipment were used such as forceps, gloves, falcon tubes, plastic bottles, polythene bags, permanent markers, notebooks, and thermometers. During fieldwork, environmental details including habitat, temperature, pH, and water color were noted on-site.

Microscopic Observation – The collected samples were examined taxonomically using a compound light microscope with magnifications of 10X, 40X, and 100X. For microscopic study, each specimen was placed on a glass slide with the help of a micropipette or dropper, then covered with a coverslip. To prevent dehydration, a drop of distilled water was added, and immersion oil was applied for observations under 100X magnification. Morphological characteristics such as color, shape, presence of pyrenoids, filamentous or non-filamentous structure, branching pattern, unicellular or colonial form, arrangement of chloroplasts, and presence or absence of mucilage sheath were documented.

Identification:

1. **Taxonomic Keys:** Use taxonomic keys (identification guides) specific to algae to identify the different species present in the samples.

2. **Literature Review:** Consulting scientific literature, such as research papers and taxonomic guides, is crucial for accurate identification.

3. **Other Techniques:**

4. **pH and Temperature Measurement:** Water samples may be tested for pH and temperature, as these parameters can influence algal growth and distribution.

5. **Growth Studies:** In some cases, algae are grown in controlled environments (e.g., open tanks under sunlight) to study their growth patterns and responses to different conditions.

6. **Automated Image Processing:** Computer-based image processing techniques are being developed to automatically detect, recognize, and identify algae from images.

RESULT AND DISCUSSION

Algal Diversity and Classification-

In the present study a total of 10 algal species of green algae belonging to 9 orders, 9 families, and 10 genera, were identified from fresh water bodies (ponds and tubewell) of surrounding area of Hapur.

- Chlamydomonadaceae- e.g., Clamydomonas
- Chlorellaceae- e.g., Chlorella

- Cladophoraceae- e.g., Cladophora
- Oedogoniaceae- e.g., Oedogonium
- Zygnemataceae- e.g., Spirogyra, Zygnema
- Tetrasporaceae- e.g., Tetraspora
- Ulothrichaceae- e.g., Ulothrix
- Vaucheiaceae- e.g., Vaucheria
- Volvocaceae- e.g., Volvox

Habitat-wise Distribution-

1. **Ponds:** Ponds showed the highest abundance and diversity of green algae due to stagnant water, high organic nutrient content, and sunlight exposure, mat forming species are common. E.g., Spirogyra, Chlamydomonas, Chlorella, Tetraspora, Volvox.

2. **Tubewell:** Tubewell show minimal algal presence. Mostly unicellular algae are present. The lack of sunlight and low organic nutrient limited algal growth tolerant species occur.e.g., Chlorella.

Seasonal Variation-

Algal population peaked in summer months (April-June) with higher temperature and light intensity, rapid photosynthesis and algal growth. Ponds with stagnant water had dense algal mats and blooms. E.g., Spirogyra, Chlorella, Cladophora, Ulothrix.

Physio-chemical correlation –

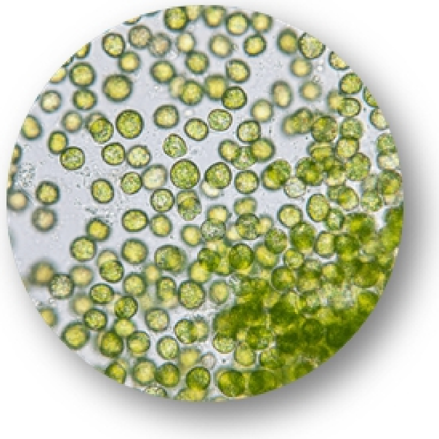
1. Temperature: Green algae thrive in moderate to warm temperature (200C-350C) Peak growth observed in summer when temperature favor rapid metabolic and photosynthetic activity.

2. pH Level- Optimal pH 6.5-8.5. Slightly alkaline water favors green algal growth. Highly acidic or highly alkaline water reduce green algal diversity and abundance.

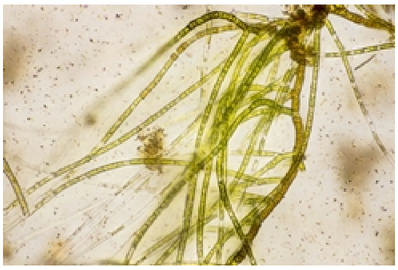
3. Light Intensity- Green algae require ample light for photosynthesis. High light intensity in shallow ponds and tube well enhances growth of filamentous algae.

We isolate, identify and characterized 10 freshwater algae these are: -

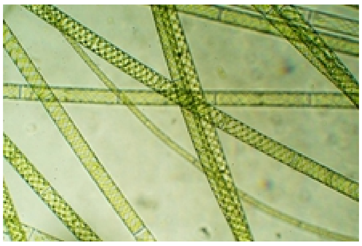
Chlorella – Colonial form, Cup shaped chloroplast is present, single or parietal pyrenoids is visible under microscope, circular in shape, unicellular, green in color, thin cell wall young cells are spherical in shape, presence of chlorophyll a and b, lack of flagella (non-motile).



Cladophora – Branched multicellular filamentous thallus, Chloroplast is present with single pyrenoids, chloroplast reticulate in shape(net-like), cells are cylindrical in shape, grass green in color, multinucleate, coenocyte,

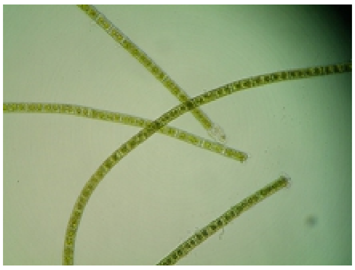


Spirogyra – Unbranched multicellular filamentous thallus contains a nucleus, pyrenoids present visible under microscope, cell wall is composed of two-layer, chloroplast is ribbon-shaped and arranged in spiral pattern.



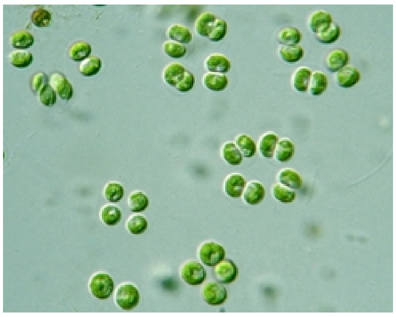
Oedogonium – Unbranched unicellular filamentous thallus, narrow and cylindrical in shape, cells contain a single chloroplast, single nucleus, reticulate chloroplast with one or more pyrenoids, cap cell present, hold fast cell is present, flagella are absent (non-motile).

Zygnema – Unbranched filament, cell is cylindrical or rectangular, chloroplast contain pyrenoids and visible under microscope, lake of flagella, two stellate (star shaped) chloroplast per cell.

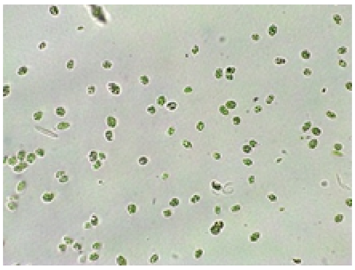


Volvox – spherical, multicellular colonies, forms large spherical colonies called Coenobia, flagella are present, cup shaped chloroplast, pyrenoids is present and visible under microscope, nucleus, vacuoles, eye spot present.

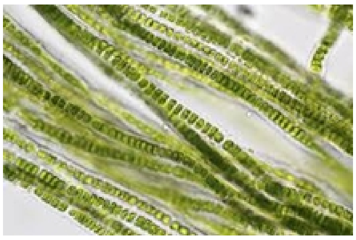
Tetraspora – Spherical or elliptical in shape, non-motile, they posses a pair of pseudoflagella, unicellular, colony of cells, cup shaped chloroplast, single pyrenoids.



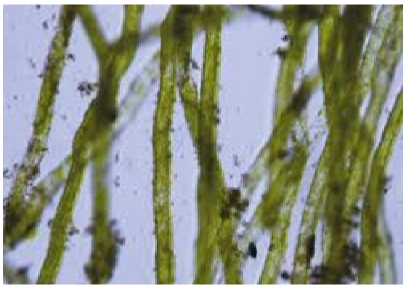
Chlamydomonas – Unicellular cell, motile oval, spherical, single cup shaped chloroplast, pyrenoids present, cell wall is present, characterized by two flagella.



Ulothrix – Unbranched, filamentous green algae, uniseriate, single girdle shaped chloroplast, pyrenoids present, cylindrical or barrel shaped cell



Vaucheria- Filamentous, branched, coenocytic thallus, multinucleate, siphonaceous, aseptate, chloroplast discoid or oval shape located periphery in the cytoplasm.



Comprehensive Table: Algae Taxnomy, Ecology, and Morphology

Table 1: Freshwater Algal Diversity and Characteristics

Alga	Thallus Type	Chloroplast Shape	pH	Temp (°C)	Water Colour	Taxonomic Characters	Ecological Factors
Chlamydomonas	Unicellular, motile	Cup-shaped	6.5–8.0	20–30	Green, clear	Flagellated, eye spot, pyrenoid, single nucleus	Stagnant, sunlit water bodies like ponds, tanks, ditches
Chlorella	Unicellular, non-motile	Cup/parietal	6.5–8.5	20–30	Green, turbid	Spherical, lacks flagella, single cup-shaped chloroplast	Found in nutrient-rich ponds, tanks, and artificial culture systems

Cladophora	Branched filamentous	Reticulate (net-like)	6.0–8.5	15–30	Green, attached to rocks	Multinucleate, coenocytic, firm cell wall	Attached to stones or submerged objects in clean, oxygenated freshwater
Oedogonium	Unbranched filamentous	Girdle-shaped	6.5–8.5	20–30	Green, floating	Apical caps, holdfast cell	Attached or free-floating in clean, still freshwater ponds
Spirogyra	Unbranched filamentous	Spiral ribbon-like	6.0–8.5	20–30	Green, floating mats	Mucilaginous sheath	Forms mats in stagnant freshwater; prefers moderate nutrients
Tetraspora	Colonial in mucilage	Cup-shaped with pyrenoids	6.5–8.5	20–30	Greenish, gelatinous	Non-motile colonial cells embedded in mucilage	Shallow, still water in ponds and ditches

Ulothrix	Unbranched filamentous	Girdle-like	6.5–8.0	10–25	Green, attached to rocks	Holdfast cell, uninucleate cells, grows from base	Prefers cold, oxygen-rich freshwater; often in streams or early spring ponds
Vaucheria	Tubular, siphonous	Parietal/discoid	6.0–8.0	15–30	Greenish-yellow, slimy	Multinucleate, no cross walls	Moist soil, pond edges, or shallow waters; tolerates semi-terrestrial habitats
Volvox	Spherical colonies	Cup-shaped	6.5–8.5	20–30	Bright green, floating	Flagellated cells in a spherical colony; daughter colonies inside	Nutrient-rich, sunlit stagnant freshwater like ponds

Zygnema	Unbranched filamentous	2 Stellate (star-shaped)	6.0–8.5	15–25	Green, floating mats	Mucilaginous sheath	Found in clean, still waters; often in high-altitude or seasonal water bodies

CONCLUSION

Algae represent a diverse group of aquatic organisms capable of performing photosynthesis and releasing oxygen into the environment. They require moist conditions for survival and occur widely across different habitats. Freshwater algae form an essential component of aquatic ecosystems and are commonly distributed in ponds, rivers, lakes, tube wells, and other inland water bodies. These photosynthetic organisms vary greatly in size, from microscopic phytoplankton to macroscopic forms such as filamentous green algae.

The present study highlights the diversity and ecological significance of freshwater algae in ponds and tube wells. Results indicated that ponds supported a greater variety of algal species compared to tube wells. Lentic ecosystems such as ponds provide favorable conditions for the growth and proliferation of algae, while in lotic systems, even though environmental parameters may be supportive, the continuous water flow restricts extensive algal settlement. Furthermore, the study reveals that variations in physicochemical characteristics among habitats influence algal distribution in distinct ways. The recorded genera displayed a wide range of ecological adaptations and taxonomic features. Their ability to tolerate fluctuations in pH and temperature underscores their ecological importance and their potential role as bioindicators in water quality monitoring.

ECOLOGICAL SIGNIFICANCE AND FUTURE OPPURTUNITIES OF FRESHWATER GREEN ALGAE-

Some of the ecological significance and future opportunities are as follows:

1 . **Primary producer-** Algae form that base of the aquatic food web through photosynthesis, they convert sunlight into energy, producing oxygen and organic matter that support aquatic organism, including zooplankton and fish. E.g., Chlorella.

2 . **Oxygen Production**- Algae contribute significance to the oxygenation of freshwater system during daylight hours, which is essential for the survival of aerobic aquatic organisms. E.g., Spirogyra.

3. **Nutrient cycling-** Algae plays a key role in cycling nutrient like Nitrogen and phosphorous.

4 . **Bioindicator of water quality-** Certain algal species are sensitive to pollutants and nutrient levels. The presence or absence can indicate the health of a freshwater ecosystem.

5 . **Contributing to soil and sediment formation**- Dead algal biomass settles to the bottom, enriching sediments help in the formation of organic-rich bottom layers. Support benethic decomposers and nutrient cycling.

6 . **Climate regulation**- By absorbing CO2 during photosynthesis, green algae contribute to carbon sequestration at a local level in aquatic system. Regulation of carbon balance in shallow water bodies.

7 . **Food for Aquatic organisms-** Algae serve as direct or indirect food for various organisms zooplankton graze on unicellular algae chlorella. Herbivorous fish and invertebrates feed on filamentous algae like Ulothrix and Spirogyra.

8 . **Biofuel Production:** Ongoing research examines green algae as possible resources for biofuel generation, to enhance lipid production effectiveness and fine-tuning growth conditions for extensive farming. Genetic alterations in green algae could also increase their biofuel production, making them a more feasible renewable energy option.

9 . **Food and Nutraceuticals:** For many years, algae, especially Chlorella and Spirulina, have been utilized as nutritional additives. Ongoing research is assessing the alleged health advantages of green algae, including their antioxidant, anti-inflammatory, and immune-boosting characteristics. The marketing of algae-derived foods is expected to expand, especially as a sustainable nutrition option for an increasing worldwide population.

10. **Carbon Sequestration:** Green algae are essential for carbon fixation via photosynthesis, aiding in the reduction of climate change. Studies are centered on employing algae for extensive carbon sequestration systems to reduce atmospheric CO2 levels. The incorporation of algal carbon sequestration may play a role in upcoming strategies for mitigating climate change.

LIMITATIONS OF THE STUDY

Some of the major limitations of the study are as follows:

1 . Limited Sampling Sites – The study was confined to selected ponds and tubewells in Hapur, which may not fully represent the algal diversity of other freshwater habitats in the region.

2 . Seasonal Restriction – Sampling was done during specific seasons, so temporal variations in algal distribution throughout the year may not have been fully captured.

3 . Physicochemical Parameters – Only a limited number of water quality parameters were analyzed; additional factors (such as nutrient flux, heavy metals, or organic pollutants) could further influence algal growth and community composition.

4 . Microscopic Identification Constraints – Algae were primarily identified through morphological

characteristics, which may cause difficulty in differentiating morphologically similar species without molecular tools.

5 . Absence of Molecular Confirmation – DNA-based taxonomic confirmation was not performed, limiting the accuracy of species-level identification.

6 . Limited Ecological Interactions Studied – The study focused mainly on algal occurrence and distribution, without detailed analysis of their interactions with bacteria, protozoa, or aquatic fauna.

7 . Short Study Duration – As the research was conducted over a limited period, long-term ecological trends and successional patterns of algal blooms could not be established.

8 . Potential Sampling Bias – Manual collection and preservation techniques may have led to under representation of fragile or less abundant algal species.

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