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# Phenological studies and Morphological characterization of *Marsilea quadrifolia* L. from Mansar lake, Ramtek, Nagpur District, Maharashtra (India)

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## ABSTRACT

Nagpur is the third-largest city in the state of Maharashtra, India. The district is located at 21.1458° N latitude and 79.0882° E longitude. It lies on the Nagpur Plain at the southern foothills of the Satpura Hills. Nagpur has numerous natural and man-made lakes that support rich aquatic biodiversity. Invasive plant species are non-native plants that spread rapidly in new environments. They compete with native plant species for space, nutrients, sunlight, and water. These plants grow quickly, reproduce abundantly, and establish dense populations. They alter aquatic habitats and disturb the natural balance of lake ecosystems. Their spread leads to loss of biodiversity, reduced ecosystem productivity, and ecological damage. Invasive plants can also negatively affect water quality, fisheries, recreation, and local livelihoods. In this article, efforts are taken to gather the information of character of *Marsilea quadrifolia* L.which is the invasive plants species and study of pheonological characteristics on the Mansar lake, Ramtek, Nagpur District, Maharashtra (India).

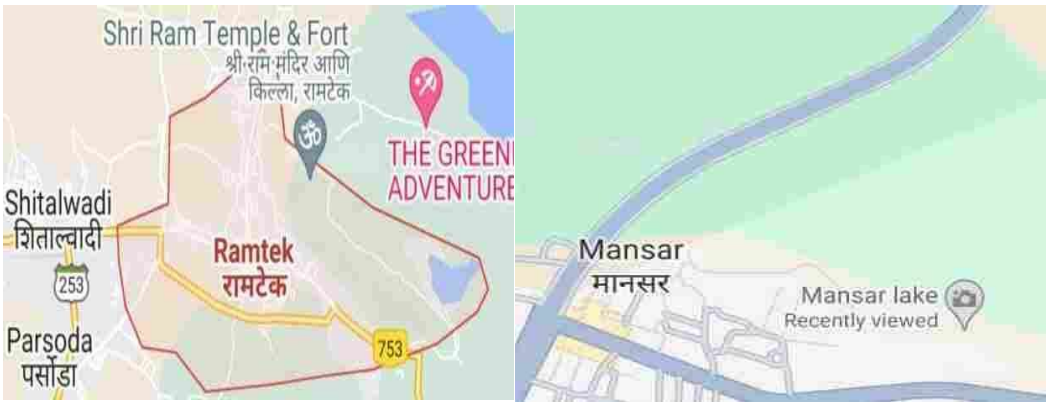
***Keywords:*** *Marsilea quadrifolia L., It's Characteristics, Phenological characteristics.*

## Introduction

Ramtek is a city and municipal council in Nagpur district of Maharashtra, India. Located at the foot of a prominent hill north-east of Nagpur, Ramtek is an important Hindu pilgrimage centre associated with the god Ram. Ramtek is situated 7Km east of Mansar. Mansar is a census town in Ramtek tehsil of Nagpur district in the Indian state of Maharashtra. This town is located 5 Km West Ramtek and 45 Km northeast of Nagpur City, Ramtek thesil is having 21.3929° N latitude and 79.3268° E longitude. Mansar lake, Ramtek, a wetland area in Nagpur, Maharashtra. The lake is one of the key water resources in the area and is critical for both economy and local climate. Scientific studies have raised concerns about the lake's water

quality, primarily due to human activities like sewage disposal, encroachment, and contamination from agricultural and industrial resources. These is the high rate of pollution is a significant problem that could lead to water issues in the future. Despite pollution issues, the lake is supporting a variety of aquatic flora and fauna, including zooplankton, fish, birds and phytoplankton. Due to the high rate of pollution there is growth several of invasive plants species, but *Marsilea quadrifolia* L. .is the major problem.

**RAMTEK (MANSAR LAKE)**




*Marsilea quadrifolia* L.is an aquatic fern that grows in shallow freshwater lakes, ponds, marshes, and wetlands. Although it is a native species in many parts of Asia, it can behave like an invasive plant under nutrient-rich (eutrophic) conditions by spreading rapidly and forming dense mats along lake margins. Perennial aquatic or semi-aquatic fern belonging to the family Marsileaceae .Grows in shallow water, muddy shores, and the littoral zone of lakes. Has creeping rhizomes that spread quickly through the sediment. Leaves consist of four clover-like leaflets borne on long stalks. Reproduces by both spores (sporocarps) and vegetative rhizome growth. Dense growth can cover the water surface and shoreline vegetation. Competes with native aquatic plants for light, nutrients, and space. Excessive growth may reduce water circulation and alter aquatic habitats. Commonly becomes abundant in lakes receiving nutrient-rich runoff or sewage. Impact on lake ecosystem Suppresses native aquatic vegetation. Contributes to ecological succession in shallow lake margins. Reduces habitat diversity for aquatic organisms when it forms dense stands. Indicates nutrient enrichment and poor water quality in affected areas.


***Marsilea quadrifolia* L.**

**Kingdom:** Plantae
**Division:** Pteridophyta
**Class:** Polypodiopsida
**Order:** Salviniales
**Family:** Marsileaceae
**Genus:** Marsilea
**Species:** *Marsilea quadrifolia*.L.
**Habitat**

*Marsilea quadrifolia* L., primarily inhabits wet or marshy habitats such as the edges of lakes, ponds, rivers, and ditches, typically in shallow, still, or slow moving water. It is an aquatic or amphibious fern with roots anchored in mud or damp soil, and its leaves can float on the water's surface. Primarily found in freshwater environments. It is also known to tolerate shade but prefers full sun. In its native range, the species is threatened by habitat loss, degradation, and issues like water eutrophication.

**Habit**

*Marsilea quadrifolia* L., has an aquatic or amphibious habit, growing rooted in mud or shallow freshwater bodies like ponds, lakes, and streams. It forms dense, mat-like stands with thin, green stems and long-petioled, clover-like leaves that may float on the water's surface or emerge above it. It often forms monotypic stands, growing in dense, carpet-like beds. The plant requires a permanently moist or wet soil to thrive and develop a dense, healthy carpet.

## Morphological Characteristics

### Root

The roots of *Marsilea quadrifolia* L. *a*re fleshy, creeping adventitious roots that grow from the nodes of the plant's rhizome, anchoring it in wet, muddy soil. They absorb water and minerals for the plant and serve as a point of origin for lateral roots, which emerge from modified endodermis cells. The plant's root system, which extends from a substantial rhizome, also plays a role in vegetative propagation. The roots anchor the aquatic fern in the mud of shallow waters, lakes, and ditches. The roots arise from the nodes of a creeping, fleshy rhizome, which grows through the substrate. In these, lateral roots are initiated from specialized cells in the endodermis of the parent root. The fern's roots can partially counteract the negative effects of moderate organic enrichment in water sediments.

### Stem

The stem is long, slender and freely-branched rhizome of indefinite growth that grows on or just below the soil surface. The stem of it is a rhizome that grows along substrate. The rhizome grows indefinitely, branching both axillary and laterally, and is characterized by a central stele with surrounding pith, phloem and xylem, and a cortex containing parenchyma cells and air space(lacunae). The stem is differentiated into nodes, where roots and leaves arises, and internodes, which are typically long in aquatic forms. The internodes are generally long in aquatic species but are short in subterrestrial or terrestrial species. The stem also bears the plant’s distinctive four-leaflet leaves and sporocarps, which are the reproductive structures.

### Leaf

*Marsilea quadrifolia* L. leaves are distinctive four-lobed, green leaves that resemble a four-leaf clover, although they come from an aquatic fern, not a clover plant. These leaves float on water in deeper areas and can be erect on land or in shallow water, creating an attractive carpet-like appearance in aquatic gardens.

### Inflorescence

*Marsilea quadrifolia* L. does not have a typical flower-based inflorescence; instead, it produces sporocarps, which are hardened, capsule-like structures containing spores that develop at the base of the leaf stalks. These sporocarps are derived from modified leaflets or a modified part of the leaf stalk and serve as the plant's reproductive bodies, containing the spores for reproduction. Sporocarps are typically brown or black, oval-shaped, and can be hairy when young. The sporocarps contain the spores and serve as the primary means of reproduction in the absence of vegetative propagation. These structures can remain dormant for long periods. Instead of a flower-like inflorescence, the reproductive mechanism of plant involves the formation and release of spores from these distinctive sporocarps.

**Flower**

*Marsilea quadrifolia* L. does not have large, showy flowers but produces small, trumpet-shaped, edible flowers with five petals. These delicate blooms are noted for their beauty and are rich in alkaloids, ascorbic acid, and other compounds, making them a magnet for bees and butterflies. The blooms are described as radiant and white. The flowers have the ability to bloom year-round.

**Floral Parts**

*Marsilea quadrifolia* L.is an aquatic fern that does not produce flowers; instead, it reproduces via spores contained in bean-shaped, capsule-like structures called sporocarps. These sporocarps, which contain the spore-producing tissues (sporangia), grow on a stalk (peduncle) from the petiole of the leaves. The plant's other parts are a rhizome (underground stem), roots, and leaves, which typically consist of four leaflets. four leaflets arranged in a clover-like pattern, giving the plant its common name, water-clover. Sporocarps of these are the spore-producing structures, resembling bean-shaped or capsule-like sacs, that are characteristic of Marsilea and its relatives. Peduncle of the stalk that attaches the sporocarp to the leaf. Raphe is the point of attachment of the peduncle to the sporocarp. Tubercles is small, tooth-like structures found on the sporocarp, just above the raphe. Rhizome is a horizontal, creeping underground stem that anchors the plant and from which roots and leaves emerge. Roots of these develop from the nodes of the rhizome.

**Reproduction**

*Marsilea quadrifolia* L. reproduces both vegetatively and sexually. Vegetative reproduction occurs through the formation of tubers on its rhizome, which can store food and survive unfavourable conditions. Sexual reproduction involves producing heterosporous sporocarps bean shaped structures containing both microspores and megaspores, which develop into new gametophytes and eventually sporophytes. The creeping rhizome, a subterranean stem, produces tubers during dry or unfavourable conditions. These tubers accumulate food in the form of oil droplets. When favourable conditions return, the tubers germinate and sprout new plant bodies. The plant is a heterosporous fern, meaning it produces two different types of spores. These spores are housed within specialized structures called sporocarps. When the sporocarp is injured (e.g., by external factors), it absorbs water and splits open. A gelatinous ring protrudes, carrying the sori (containing the sporangia) with it.

**Adaptation**

*Marsilea quadrifolia* L. exhibits various adaptations, including heterophylly (different leaf forms for aquatic and terrestrial environments), a creeping rhizome for growth and anchoring. The plant is also capable of thriving in a range of soil and water conditions, from sandy to loamy and shallow pools to waterlogged areas. The plant displays heterophylly, meaning it has different leaf shapes and structures depending on its habitat. Aquatic leaves are flexible and have floating leaflets, while terrestrial leaves have short, rigid petioles and crenate leaflets. The four leaflets exhibit diaphototropic movements in the morning and late afternoon, orienting

themselves perpendicular to the light, and paraphototropic movements at noon, aligning parallel to the light. The placement of stomata varies, aquatic leaves are epistomatic (stomata on the upper surface), while terrestrial leaves are amphistomatic (stomata on both surfaces). A freely branched rhizome with adventitious roots at the nodes allows for indefinite growth, anchorage in soil or mud, and spread in aquatic environments. Nutrient Tolerance is the plant is adapted to nutrient-rich waters and can tolerate moderate organic enrichment in sediments. It possesses phytoremediation properties, able to absorb excess nutrients and heavy metals from water, which can help reduce water pollution. Young leaves display circinate venation, a characteristic of ferns where the frond curls inward from the tip before unfurling.

**Ecological significance**

*Marsilea quadrifolia* L., plays an ecological role by facilitating wetland restoration and nutrient mitigation in freshwater systems, and it serves as a food source for various organisms and livestock. It can also become a problematic weed in rice fields and is vulnerable to habitat loss and water pollution due to its sensitivity to environmental changes. The plant's ability to absorb heavy metals makes it valuable for phytoremediation in mining areas, while its phytochemical properties also give it medicinal uses. By participating in nutrient cycles and providing food, the plant helps to maintain the ecological balance in its aquatic environment. It possesses medicinal properties, including antioxidant effects, and its spores are a good source of Vitamin B12, making them a potential nutritional supplement. As a heterosporous pteridophyte, it plays a significant role in plant evolution, as heterospory is an ancestral trait that led to the evolution of seeds.

**Phenology of *Marsilea quadrifolia* L.**

**Species name:-***Marsilea quadrifolia* L.

**Growth form:-** Creeping, rhizomatous growth form

**Overwintering:-** By using its durable underground rhizomes to survive the dormant winter month.

**Vegetative growth:-**During the rainy season (June to November)

**Sexual reproduction:-**Wet or Rainy season

**Asexual reproduction :-**During the dry season

**Flowering:-**Does not flowering season because it is an aquatic fern not a flowering plant.

**Fruiting:-**During the monsoon and Post-monsoon season(July to November)

**Senescence:-**During dry season

**Environment Tigger:-**Primarily tiggered by the monsoon which governs water availability.

**Conclusion:**

*Marsilea quadrifolia* L.is a perennial aquatic fern characterized by creeping rhizomes, long petioles, and distinctive four-leaflet leaves. It grows well in shallow freshwater habitats such as lakes, ponds, wetlands, and marshy areas. Its ability to spread through rhizomes and produce long-lived sporocarps enables it to survive changing environmental conditions.

Phenologically, the plant shows active growth during the monsoon season, reaches peak development from late monsoon to early post-monsoon, produces sporocarps during the growing season, and enters dormancy during the dry months. This seasonal life cycle allows rapid regeneration when water becomes available again.

Overall, the morphological adaptations and seasonal growth pattern of *Marsilea quadrifolia* L. contribute to its successful establishment and persistence in freshwater ecosystems.

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