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Macrophytic Diversity as an indicator of Eutrophication; a case study of Rudra Sagar, Ujjain M.P., India

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Abstract: *Aquatic ecosystem is the most diverse ecosystem in the world. An aquatic ecosystem provide the food, water, shelter and space essential for the survival of aquatic animals and plants. Fresh water habitats occupy a relatively small portion of the earth's surface as compared to marine and terrestrial habitats, but their importance to man is a greater than their areas. Fresh water is the most suitable and cheapest source for domestic and industrial needs and they provide convenient waste disposal system.*
The increased demand of water as a consequence of population growth, agriculture and industrial development has forced environmentalists to determine the chemical, physical and biological characteristics of natural water resources. The by product of agricultural activities, urbanization and industrialization result in pollution and degradation of the available water resources.
Present study deals with the investigation of macrophytic diversity for making an assessment of water quality of Rudra Sagar which is one of perennial pond in Ujjain. The macrophytic species Eichhornia cressipes, Ipomea aquatic, Spirodella pilyrhiza, Limnophilla sessiliflora, Elodea sp., Ludwigia adscendence and Cyperus rotandus were observed. This study contributes to the limnology of this tropical aquatic ecosystem and will also help in conservation and better management of water bodies.
Key Words*: Ecosystem, Aquatic, Environmentalist, Macrophytic diversity, perennial pond, Rudra Sagar.*

I. Introduction

An aquatic ecosystem is an ecosystem in a body of water. Communities of organisms that are dependent on each other and on their environment live in aquatic ecosystems. Global aquatic ecosystem fall under two broad classes defined by salinity. An ecosystem composed of biotic communities that are structured by biological interactions and abiotic environmental factors.

Fresh water has become a scare commodity due to over exploitation and pollution. Pollution is caused when a change in physical, chemical or biological condition in the environment harmfully affect quality of human life including other animal's life and plant[1].

Ponds, as sources of water, are of fundamental importance to man. However pond may have been natural water sources exploited by man at different time to meet different needs or may have been created for a multitude of different purposes. The presence of different species of hydrophytes at a given site is multifactorial ecological question to evaluate, although the influence of limnological parameters as one of the functional environmental factors for species occurrence has received great attention.

Macrophytes are the largest plants of all types, they are sometimes attached to bottom (benthic), sometime totally submerged and sometimes partly emergent, complex types usually have root, stem and leaves[2]. These plants respond to the quality of the water in which they grow; thus their analysis is important for water quality evaluation. They often constitute a dominant factor in the habitat of other aquatic organisms[3]. Limnological investigations on water bodies aimed to assess the deterioration of water quality due to pollution. Eutrophic originally meant tending to promote nutrition.In the sense a vitamin supplement would be a eutrophic medicine. The term applied to describe the nourishment to natural waters as a contributor to the process of succession. In, nature as time passes, nearby mountains or hillside erode, and sediments are washed into all freashwater systems. These sediments carry nutrients which cause increase in productivity of systems. A lake with high productivity is called an eutrophic lake. It has a dense population of producers, often visible as a green scum on the surface of the murky water.

Eutrophication denotes the enrichment of a water body by input of organic material or surface run-off containing nitrates and phosphates which directly controls the growth of algae and other aquatic plants. The rate of photosynthesis exceeds than respiration activity in eutrophic body. It is characterized by a progressive accumulation of algae which ultimately leads to organic overloading.

In present study perennial pond named Rudra Sagar was selected for the investigation of Macrophytic diversity as indicator of eutrophication, which is situated in Ujjain, Madhya Pradesh. Macrophytic species of the pond were identified with % frequency during study period. The present study of the Rudra Sagar will be

contributing to the limnology of Tropical aquatic ecosystem and will also help in conservation and better management of this water body.

II. Materials and Method

The site for the present study was Rudra Sagar which is situated behind the Mahakaleshwar the famous temple and in front of the Harsiddhi temple. Its three sides are surrounded by the road. The depth of pond is approximately 5 to 6 meter and area is about 7 hectare. It is a perennial water body. Rudra Sagar is one of the amongst one of the ancient sapt sagar having historical and religious importance. Different species of macrophytes were collected on monthly basis throughout the year walking along the margin of the pond as well as from the boat. All collected plants were kept in plastic bags and transported to laboratory where they were washed thoroughly to remove silt, snails, epiphytes and other unwanted materials.

Identification was followed according to Sculthore C.D. (1971) [4] and Fassett (2006) [5]. Percentage frequency of macrophytic species was calculated by quadrat method. The size of quadrat was $1X1m^2$. Quadrat was thrown randomly on water surface of water body and calculated the Percentage frequency of macrophytes.

Calculation-

$$\%F = \frac{\text{Total number of quadrats in which species occurred}}{\text{Total number of quadrat studied}} \times 100$$

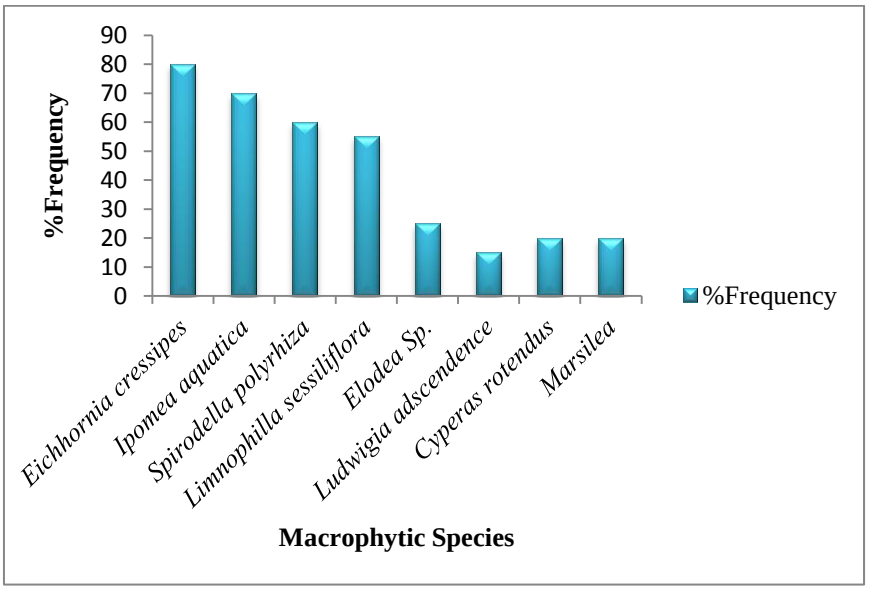
%F= Percentage frequency of macrophytic species.

III. Result and Discussion

The macrophytic diversity of the Rudra Sagar was investigated.

Table- Macrophytic species of Rudra sagar water body with %Frequency

S.No.	Name of the macrophytic Species	%Frequency
1	Eichhornia cressipes	80
2	Ipomea aquatica	70
3	Spirodella polyrhiza	60
4	Limnophilla sessiliflora	55
5	Elodea Sp.	25
6	Ludwigia adscendence	15
7	Cyperas rotendus	20
8	Marsilea	20
9	Algal Blooms	-



Several Features make **E. crassipes** easy to recognize, including rosettes of rounded and leathery, waxy, glossy green leaves attached to thick, spongy (often bulbous or inflated for floatation) petioles (stalks), dark feathery roots that typically hang suspended in the water below the floating plant and attractive lavender flowers when the plants are in bloom. The inflorescence is a distinct aerial spike growing to 30cm, the flowers have six stamens and the fruit is a 3-chambered seed capsule[6].

Ipomoea aquatic is a semiaquatic, tropical plant grown as a leaf vegetable. It is found throughout the tropical and subtropical regions of the world, although it is not known where it originated. This plant is known in English as water spinach, river spinach, water morning glory, water convolvulus, or by the more ambiguous names "Chinese spinach", "Swamp cabbage" and "Kangkong" in Asia. It is known as phak bung in Thai, trokuon in Khmer and kangkung in Malay and Indonesian. In the Philippine a variety of Kangkong is grown in canals dug by the Americans during the occupation after the Spanish American war. Another variety in the Philippines that grows on land is called "Chinese Kangkong" in the Philippines as opposed to the variety that is grown in water that is simply called Kangkong or "native" Kangkong. Ipomea aquatic grows in water or on moist soil. Its stems are 2-3 metres (7-10ft) or more long, rooting at the nodes and they are hollow and can float. The leaves vary from typically sagittate (arrow head-shaped) to lanceolate, 5-15cm (2-6 in) long and 2-8 cm (0.8-3 in) broad. The flowers are trumpet-shaped, 3-5 cm (1-2 in) diameter, usually white in colour with a mauve centre. The flowers can form seed pods which can be used for planting. **Spirodella polyrhiza** Spirodella is a genus of aquatic plant. It is one of several genera containing plants commonly called duckweed. Spirodela species are members of the Araceae under the APGII system. They were formerly members of the Lemnaceae. Spirodella species are free-floating thalli, 2-5 plants may remain connected to each other. Plants are green, but may have a red or brown underside. Multiple roots (7 to 12) emerge from each thallus. Spirodella is larger (10mm) than Lemna (2-5mm, one root per thallus). Certain species of spirodella overwinter as turions, a dormant form that lacks air pockets and so sinks to the bottom of the pond.

Limnophila sessiliflora is herbaceous perennial, strictly aquatic, "obligate" (requiring a wet habitat), in freshwaters, mostly submerged, partly emersed, growing from bottom to surface in water to 12 feet deep, forming dense stands of stems in the water, reproduces asexually (regrows from plant fragments), a flower of Limnophila sessiliflora may set 200-300 seeds with a germination rate as high as 96% (Spencer and Bowes 1985). Limnophila sessiliflora is a freshwater amphibious herb which has two distinctly different forms of leaves, submerged and emersed. It may form dense stands from the bottom to the top of the water.

Elodea is a genus of aquatic plants often called the waterweeds. It lives in freshwater. An older name for this genus is Anacharis, which serves as a common name in North America[7]. The American water weed lives entirely underwater with the exception of small white flowers which bloom at the surface and are attached to the plants by delicate stalks. It produces winter buds from the stem tips that overwinter on the lake bottom. It also often overwinters as an evergreen plant in mild climates. In the fall, leafy stalks detach from the parent plant, float away, root and start new plants. This is the American water weed's most important method of spreading, while seed production plays a relatively minor role. Silty sediments and water rich in nutrients favor the growth of American water weed in nutrient rich lakes. However, the plants will grow in a wide range of conditions, from very shallow to deep water and in many sediment types[8]. It can even continue grow unrooted, as floating fragments. It is found throughout temperate North America, where it is one of the most common aquatic plants. American water weed is an important part of lake ecosystems. It provides good habitat for many aquatic invertebrates and cover for young fish and amphibians[9]. Waterfowl, especially ducks, as well as beaver, muskrat and aquatic turtles eat this plant. It is also of economic importance as an attractive and easy to keep aquarium plant, although in the states or Oregon, South Carolina and Washington it has been deemed an invasive species and is illegal to sell. **Ludwigia adscendence** is a floating herb, rooting at the nodes and cluster of conspicuous white, spindle shaped, pnematophores at the nodes. Leaves 1.25-7.6 cm long, obovate or oblanceolate, obtuse. Flowers are white, slightly yellow at the base, axillary, solitary, petals about 1.25cm long, obovate. Capsule linear-cylindric, 1.27-3.8cm long. Leaves, stems and flower petals contain the flavonoid glycosides.

Cyperus rotundus is a species of sedge (Cyperaceae) native to Africa, Southern And central Europe (North to France and Austria) and Southern Asia. The word cyperus derives from the Greek (kuperos) and rotundus is from Latin meaning Ku-pa-ro, written in Linear B syllabic script. Cyperus rotundus is a perennial plant that may reach a height of up to 55 inches. The names "nut grass" and "nut sedge" (shared with the related species Cyperus esculentus) are derived from its tubers, that somewhat resemble nuts, although botanically they have nothing to do with nuts. As in other Cyperaceae, the leaves sprout in ranks of three from the base of the plant. The flower stems have a triangular cross-section. The flower is bisexual and has three stamina and a three stigma carpel. The fruit is a three angled achene. The root system of a young plant initially forms white, fleshy rhizomes. Some rhizomes grow upward in the soil, then form a bulb like structure from which new shoots and roots grow and from the new roots, new rhizomes grow. Other rhizomes grow horizontally or downward and form dark reddish-brown tubers or chains of tubers[10]. Cyperus rotundus is one of the most invasive weeds known, having spread out to a worldwide distribution in tropical and temperate region. It has been called "the world's worst weed" as it is known as a weed in over 90countries and infests over 50crops worldwide. In the United State it occurs from Floride north to New York and Minnesota and west to California and most of the states in between.

Marsilea is a genus of approximately 65 species of aquatic ferns of the family Marsileaceae. The name honours Italian naturalist Luigi Ferdinando Marsigli. These small plants are of unusual appearance and do not resemble common ferns. Common names include water clover and four-leaf clover because the long-stalked leaves have four Clover-like lobes and are either held above water or submerged. Sporocarps of some Australian species are very drought-resistant, surviving up to 100 years in dry conditions. On wetting, the gelatinous interior of the sporocarp swells, splitting it and releasing a worm-like mass that carries sori, eventually leading to germination of spores and fertilization.

The macrophytes were observed in high frequency. This unchecked growth of aquatic weeds in water body is a sign of pollution and it shows that the pond is on the verge of eutrophication. Most of the species present in the pond are eutrophic tolerant species specially Elodea, Lemna [11]. Eutrophication effects the physico-chemical properties of the water. It leads to increase in the growth of aquatic plants. Water quality also has been affected due to dense macrophytic vegetation which covered almost whole surface of water. It signifies the lowering or deterioration of water quality for domestic, recreation and other uses[12]. Due to its holy importance the water body must be taken care of so that its historical, religious and other important features should be protected.

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