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Phytoplankton analysis and assessment of reservoir water quality at Rena Medium Reservoir, Godavari Basin, India

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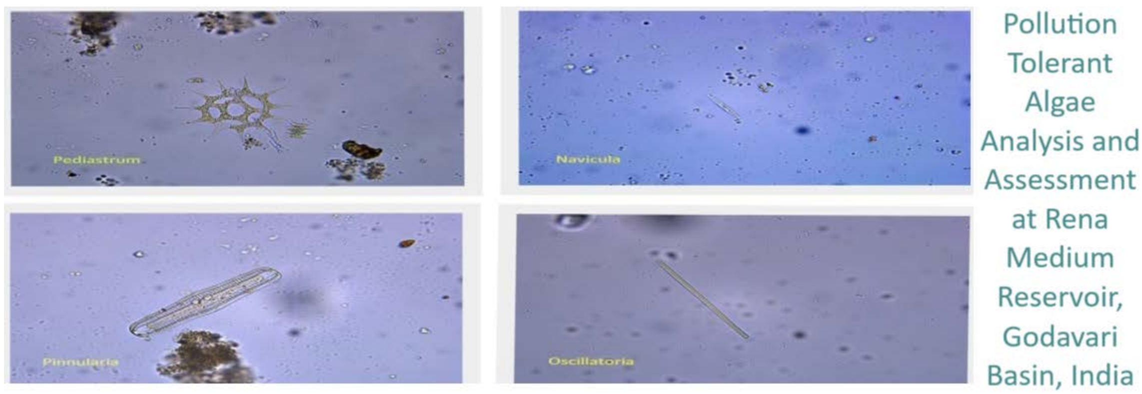
Article



ABSTRACT

One of the greatest environmental issues is phytoplankton development in reservoirs. Reservoirs, and other bodies of water used for residential uses with minimal water circulation support the most intense phytoplankton development. This process results in a severe decrease in potable water quality and an increase in the overall amount of hazardous chemicals in water. The variance in the growth of phytoplankton species must be determined to monitor the status of water quality. Moreover, an appropriately designed and operating system of data collection and analysis is urgently required for the improvement of the existing setup for water quality monitoring of reservoirs. The present investigation is conducted to know the rate of variation in the phytoplankton population of 'Rena Medium Reservoir', Godavari Basin, Maharashtra, India. The research analysis and assessment is conducted for a period of six months from December 2021 to May 2022 comprising winter and summer seasons with five sampling sites in three different zones of the reservoir. The water quality is affected by dilution during monsoon and the high evaporation rate during summer. There is fluctuation in the reservoir water quality at the same monitoring locations. These variations are attributed to the increasing influence of anthropogenic activities. This analysis assessment helps the authorities to identify the best and most sustainable uses of the reservoir and decide the future course of the Godavari River Basin.

Keywords: *Rena River, Rena Medium Reservoir, Godavari Basin, Pollution Tolerant Algae Analysis, Phytoplankton Assessment, Water Quality*

INTRODUCTION

The water resource projects provide assured water for agriculture, power generation, domestic uses, and industrial growth. Moreover, the water resource projects have played a vital role in the development of agriculture and in making India self-reliant in food grains production. Water quality is a sensitive term that depends on various factors and needs to be checked periodically to preserve the water bodies.[1] This information also helps to concern authorities in the treatment of water supplied for domestic and irrigation purposes.[2]

The quality of warter[3] is measured for different aspects such as dissolved oxygen contents, presence of heavy or toxic metal salts in the water,[4–6] presence of quantity and type of weeds and algae, and measure of phytoplanktons and zooplanktons.[7] All these points help in ascertaining the suitability of water for use in domestic and/or agriculture irrigation.[8] Periodic analysis of different water bodies also indicate the impact of changing climate besides the local factors.[9]

In this study, the Rena Medium Reservoir (RMR) was selected for water quality analysis by due considering its significance in locality which comes under Renapur Tehsil of Latur district, Maharashtra, India as shown in Figure 1 which serves nearby fifty

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villages for their water requirements. The RMR is located on the stretch of Rena River, which is a tributary of the Manjra River at Godavari Basin.

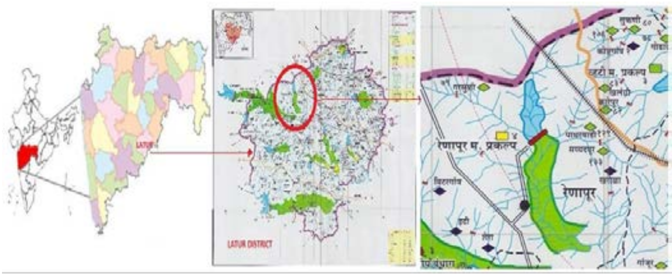

Figure 1. Location of Rena Medium Reservoir

Literature Review

Hegde G.R. (1985)[10] revealed that the distribution of phytoplankton in natural water bodies is not random. They react to environmental conditions. Phytoplankton groups such as Chlorophyceae, Euglenophyceae, Cyanophyceae, and Bacillariophyceae, and their genera have been examined at different water bodies. Microcytic, Nostoc, Anabaena, Lyngbya, and Oscillatoria, blue-green algae species that create biotoxins and impact biota.[10] Aijaz R. Mir, et al.(2004)[11] studied with a focus on phytoplankton from March 2002 to February 2004, phytoplankton at Wullar Lake in the Bandipora district of Shrinagar, Jammu, and Kashmir, using five sampling sites and twenty four water samples were analyzed. A total of hundred phytoplankton species identified, with Bacillariophyceae accounting for forty two, Chlorophyceae accounting for forty three, Cyanophyceae accounting for ten, Euglenophyceae accounting for three, and Dinophyceae accounting for one. The extremely high Nitrate and Phosphate concentrations in the lake indicated contamination. The values for diversity range from (-0.66) (-0.53) at site 1 to (-0.59) (-0.27) at site 2, (-0.57) (-0.39) at site 3, (-0.56) (-0.46) at site 4, and (-0.45) (-0.34) at site 5. A statistically significant positive association was discovered between phytoplankton numbers and dissolved oxygen. While Nitrate and Phosphate had a negative correlation (NO_3-N-0.34) and (PO_4P=-0.49), respectively. According to Shanon's index, Wular Lake is eutrophic.[11] Kankaria Lake's water quality research was conducted from March 2009 to February 2010 by Verma P.U., et al.[12] which is Ahmedabad's second largest lake, is located on the city's south-eastern outskirts. The samples were taken in the morning and evaluated monthly for a variety of factors. APHA (1985) standard procedures were used to analyze physical, chemical, and botanical parameters. The phytoplankton biomass was counted using a Sedgwick Rafter counting cell, and the phytoplankton were identified using standard methods. *Cylinderospermum sp.*, *Microcystis sp.*, *Phormidium sp.*, *Pediastrum sp.*, *Cosmarium sp.*, *Ankistrodesmus sp.*, *Cymbella sp.*, *Navicula sp.*, and *Synedra sp*. were the phytoplanktons[13] with the highest abundance in Kankaria Lake.[12] The researchers discovered that the greatest number of physical and chemical parameters were within the ideal limit, as specified by WHO and BIS. Chlorophyceae outgrew cyanophyceae, bacillariophyceae, and euglenophyceae in algal development. These variations are attributed to the increasing influence of anthropogenic activities. The water quality is affected by dilution during monsoon and the high evaporation rate during summer. There is fluctuation in the reservoir water quality. However, a research study is required to assess the Phytoplankton of Reservoir Water Quality at Rena Medium Reservoir, Godavari Basin, India to define the best and most sustainable uses of the reservoir.

Methodology

The total 16.5 km stretch of Rena River is considered for research study including the area under upstream and downstream of the reservoir. Four sampling locations are selected in the three zones of the reservoir as the riverine zone, transition zone, and lacustrine zone respectively; and one location is selected in downstream of the reservoir to check the impact of human intervention on the water quality. Monthly biological sampling as per Central Pollution Control Board, India (CPCB norms is done on these identified locations followed by phytoplankton analysis at WQAM Division, CW&PRS, Khadakwasla, Pune, Maharashtra, India. Figure 2 demonstrates Methodical flowchart for the Analysis and Assessment of Phytoplankton Rena Medium Reservoir.

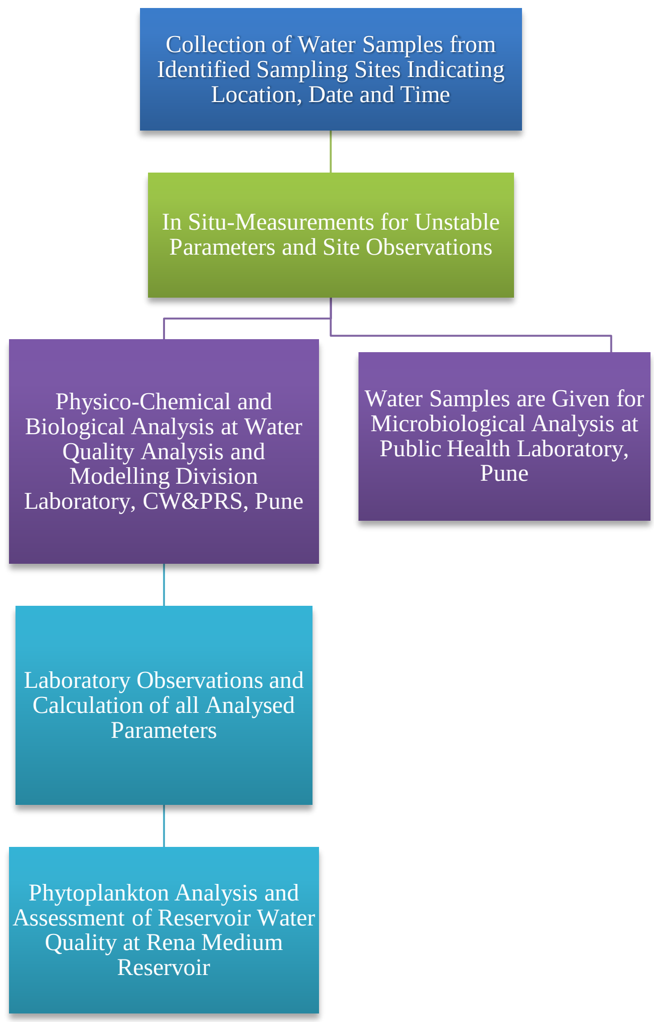

Figure 2. Methodical flowchart for Analysis and Assessment of Phytoplankton Rena Medium Reservoir

Results and Discussion

Phytoplankton Analysis: Biological Parameters

Like many other countries, in India too; the assessment of water quality is done usually after studying the physical and chemical characteristics of water. Even though in many instances the purpose of studying physico-chemical characteristics are to know their effects on biological amenities, biological method of assessing water quality has not been used so extensively.[14,15]

The biological method for assessing water quality should get more weightage. This is a more direct method to integrate different environmental factors. Production and composition of indigenous populations of aquatic organisms depend upon water quality, the nature and health of the aquatic communities is a direct expression of the water quality. Also, the biological analysis helps in the interpretation of chemical analysis and indicates the progress of self-purification of bodies of water. So, in this research study one biological parameter i.e. plankton's were analysed monthly during entire study period. In a reservoir producers may be of two main types:[13] (1) rooted or large floating plants, generally growing in shallow water only and (2) minute floating plants. Usually algae called phytoplankton (phyto = plant; plankton = floating), distributed throughout the reservoir as deep as light penetrates. Phytoplankton consists of individual cells, filaments and colonies. In abundance, the phytoplankton gives the water a greenish color; otherwise, these producers are not visible to the casual observer and their presence is not suspected by the layman. Algae constitute a major part of aquatic vegetation; they being primary producers support growth of aquatic fauna, produce oxygen by photosynthesis process, some of them cause pollution by changing the quality of water in which they grow. Large populations of them are found as water blooms on surfaces of various water bodies while few others from large continuous mats on flowing water. Vigorous growths of algae have been known to reduce the water hardness by one-third. Algae growth in water may be limited by any of several factors, including light and the physical characteristics of habitat. In many cases, the limiting factor is the availability of inorganic nutrients, particularly phosphate. Increased input of nutrients therefore triggers increased algal growth which, if excessive leads to changes in the biological characteristics of the receiving water. The discharge of organic matter to water is an important source of plant nutrients since aerobic decomposition of organic matter results the release of phosphate, nitrate and. other nutrients. Phosphates are essential for growth of diverse algal types. Addition of fertilizers to water induces production of planktons and filamentous algae forming mats on water surface. Nitrogen, phosphate and potassium cause abundant production of diatoms and flagellates. Depth of the water has an influence upon certain planktons. The blue-green algae and the green phytoplankton (myxophyceae and chlorophyceae) usually have their maximum concentration at higher level than do the diatoms. In some situations, and at certain seasons the growth of diatoms is much greater, in the region of deep water than in the shallows. The maximum populations of the total chlorophyll-bearing phytoplankton are usually at some level below the surface stratum. Algal blooms, especially of blue greens are obnoxious. They impart green, blue or other coloration types of water.[16,17] Euglena, Gonium, Chlamydomous, Synedra and few others are notorious odor producing algae. Such polluted water with automatic smell and disagreeable taste are not suitable for food, drink and industries besides being unacceptable on aesthetic grounds. Synedrais observed at Rena medium reservoir. Excessive growth of bloom forming blue-greens like Microcystis, Oscillatoria, spirulina, Anabeana, Gleotricha, Scytonema and several others often deplete oxygen causing fish to die of suffocation. In many cases they choke fish grills to death. Luxuriant growth of diatoms (Tabellaira, Synedra) and other algae (Oscillatoria, Spirogyra) clog water filters and reduce length of filter runs in the system causing huge economic loss. Anacystis. Produce carbomic acid and oxalic acids, which seriously damage the metallic pipe walls and other machinery parts of industrial plants of corrosion. Agmenellum, Ankistrodesmus, Elakatothrix, Navicula, Pinunllaria, Pediastrum, Scenedesmus, Tabellaria, Synedra and Oscillatoria were observed in Rena medium reservoir with large density. Unless they are controlled with their increase in density, they may affect water filtration system. The structure of phytoplankton population in aquatic ecosystems is a dynamic one and is constantly changing in species composition and biomass distribution. Change in species composition and biomass may affect photosynthetic rates, assimilation efficiencies, rates of nutrient utilization and so on. A detailed analysis of phytoplanktonic populations requires estimation of numbers and volume of each species. The population density at all locations is observed more than the diversity in December 2021. The maximum density was observed at location S1 in May 2022. When compared with other locations, location S1 i.e. riverine zone of reservoir shows more richness in diversity and density. In February 2022 and March 2022, it is observed that the population density in some locations increased and correspondingly diversity decreased. Increase in density may be due to the addition of nutrients through run off during monsoon and less turbidity during this period. It is also observed that in Rena medium reservoir; there is no significant difference between the total numbers of species grown during different seasons but as density is varying significantly, diversity also varied correspondingly. A total of 34 genera of algae are recorded in Rena medium reservoir and most of these represent three major classes of algae namely Bacillariophyceae, Chlorophyceae and Cyanophyceae. The group-wise composition as percentage in total plankton is shown in Figure 3**.** Pollution tolerant algae found at Rena medium reservoir are shown in Figure 4. Pollution sensitive algae (Cymbella, Cocconeis) are also found at location S1 and location S2 in December 2021 and at location S4 in summer.

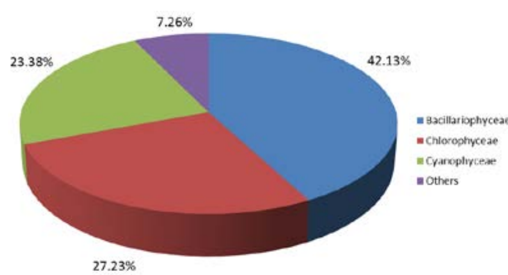

Figure 3. Group-wise Composition of Algae at Rena Medium Reservoir

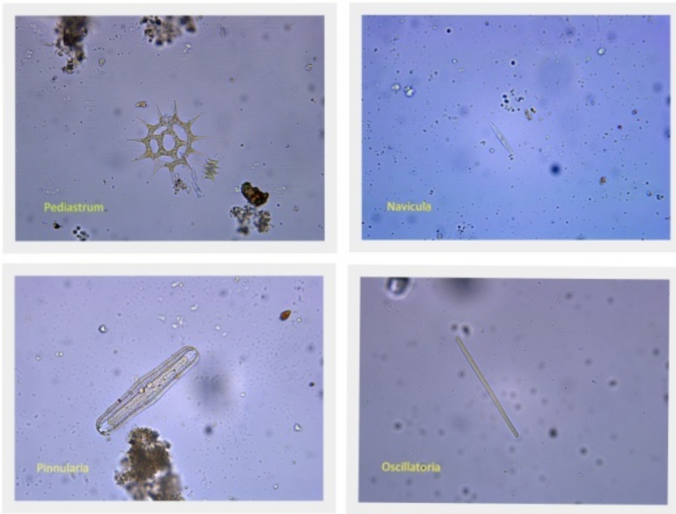

Figure 4. Pollution Tolerant Algae Observed at Rena Medium Reservoir

From the results of algal studies, it appears that Rena reservoir water pollution density is varying at different zones of reservoir. The quit high representation of Cyanophyceae at Rena reservoir (23.38%) may indicate polluted nature of reservoir water. Also, the presence of Pediastrum, Navicula, Pinunlaria, Oscillatoria at Rena medium reservoir indicates higher level of pollution at some locations. Among the phytoplanktons diatoms are observed to be dominant in pre-winter season where in post-winter and summer season, the green algae dominate over the other groups. The obtained plankton samples were allowed to stand in Cans for at least 24 hours. Following that, an aliquot of sample is extracted from the settled plankton using a graduated pipette, and one drop (0.05 ml) of sample is deposited on a clean glass slide for qualitative and quantitative analysis. To avoid air bubbles, a glass cover slip is placed on the slide. The cover slip is sealed with clear nail polish to prevent the drop from drying out while being examined under a microscope. The slide is mounted on the movable stage of a microscope and then moved from one side to another for counting the plankton numbers in each microscopic visible field. The numbers of phytoplankton in several fields are counted. Groups of phytoplankton were identified with the help of freshwater algae key prepared by Palmar (1980).[18] Photographs of the plankton are taken using the photographic attachment of the microscope. For each sample, five slides were prepared and the averages of the values/numbers were taken. The plankton number is estimated by using the following formula.

$$Organism\ (1^{-1}) = A \times \frac{1}{L} \times \frac{n}{V}$$

Where,
A= Number of organisms per drop, L= Volume of the original sample (ml),
n = Total volume of the concentrated sample (ml), V= Volume of one drop (ml).

The biological analysis is a more direct method to integrate different environmental factors. The character and health of aquatic communities are a direct expression of water quality,[8,14,19–22] as is the production and composition of indigenous populations of aquatic creatures. Also, the biological analysis helps in the interpretation of chemical analysis and indicates the progress of self-purification of water bodies. In this research study, the numbers of phytoplankton in several fields are counted. Groups of phytoplankton were identified with the help of freshwater algae key prepared by Palmar, 1980 (Palmer, C.M., 1980).[18]

Algae make up a significant portion of aquatic vegetation; as primary producers, they aid in the establishment of aquatic species, provide oxygen through the photosynthesis process, and some of them pollute the water in which they grow. The blue-green algae and the green phytoplankton (*Myxophyceae* and *Chlorophyceae*) usually have their maximum concentration at a higher level than do the di-atoms. In some situations and at certain seasons the growth of di-atoms is much greater; in the region of deep water than in the shallows. Algae development in water can be hampered by a variety of variables, including light and habitat characteristics. In many cases, the availability of inorganic nutrients, notably phosphate, is the limiting factor. Greater nutrient intake causes greater algal development, which, if excessive, affects the biological features of the receiving water. Because aerobic decomposition of organic matter results in the release of phosphate, nitrate, and other nutrients, the discharge of organic matter into a water stream is an essential source of plant nutrients. The addition of fertilizers to water induces the production of plankton and filamentous algae forming mats on the water surface. Nitrate, phosphate, and potassium cause abundant production of diatoms and flagellates. The results of algal studies reveal that the population density of Rena Medium Reservoir varies at different zones of the reservoir. The quite high representation of *Cyanophyceae* at Rena reservoir (23.38%) indicates the polluted nature of reservoir water. Also, the presence of *Pediastrum, Navicula, Pinunlaria, Oscillatoria* at Rena Medium Reservoir indicates a higher level of pollution at identified locations. Among the phytoplankton, diatoms are observed to be dominant in the pre-winter season whereas in post-winter and summer seasons, the green algae dominate over the other groups.

Conclusions

Greater length, more irregularities of shoreline, and greater shallow water zone are the physical features that influenced the phytoplankton composition of Rena Medium Reservoir. The number of species and their diversity varied significantly from one season to another season. Higher growth of phytoplankton makes the reservoir more supportive for the growth of more fish and other fauna fauna. The presence of pollution-tolerant algae (*Navicula*, *Pinnularia*) at identified locations indicates deteriorated reservoir water quality.

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Conflict of interest

The authors declared no conflict of interest for the publication of this work.

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