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Algal distribution in different blocks of Keoladeo Ghana bird sanctuary, Bharatpur, Rajasthan, India

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Abstract
In the current investigation, algal flora was identified at 5 Ramsar sites (blocks B, D, E, K and L) of Keoladeo national Park, Bharatpur, Rajasthan. Water samples were collected over a period of two years (2020-2021, 2021-2022) during the pre-monsoon, monsoon and post monsoon season. As a result, total number of algae belonging to various families (Chlorophyceae, Cyanophyceae, Bacillariophyceae, Xanthophyceae and Euglenoidae) at different sites (B, D, E, K and L) of Keoladeo national park during different seasons (Pre-monsoon, monsoon and Post-monsoon) of the year 2020-2021. For nearly all the algal species belonging to different sites- B, D, E, K and L, maximum number of algae was found during the monsoon season followed by post-monsoon season and minimum number during pre-monsoon season.

Keywords: Algal flora, Ramsar site, Keoladeo National Park, different seasons *etc.*

Introduction

Algae are simple, thalloid organisms that are green and capable of photosynthesis. They are typically found in water, but can also be found in many damp environments, including marine and freshwater ecosystems, desert sands, hot springs, and even snow and ice. They are regarded as the foundation of the aquatic food chain, serving as primary producers and also generating oxygen for other aquatic organisms by absorbing excessive amounts of carbon dioxide from the environment. Algae can cause widespread death of other animals during algal blooms, but they also play a significant role in supporting the economy through the production of food, medicine, fertilizer, and other valuable industrial products (Shrestha and Rai, 2017) [5].

The Keoladeo National Park, designated as a world heritage site and Ramsar site, is renowned for its population of paleartic waterfowl during the winter season. It is recognized as a significant wintering habitat in India for the Critically endangered Siberian Crane Grus leucogeranus. It is a significant tourist site situated along the prominent tourist route of Delhi-Agra-Jaipur.

Keoladeo National Park, a well-known waterfowl habitat and freshwater wetland, is located in eastern Rajasthan, between 27º 7.6' to 27º 12.2' N and 77º 29.5' to 77º 33.9' E. It is situated around 2 km southeast of Bharatpur city and 56 km west of Agra. It is located at an equal distance of around 180 kilometers from both New Delhi and Jaipur, as seen in Plate 2.2. The location is located in the Punjab plains biotic province inside the semi-arid biogeographical zone (Rodgers and Panwar, 1988). This region is characterized by its flat and dry landscape, situated in the Indus-Yamuna watershed. The area is also situated inside the Aravalli region (Prusty, 2008) [4].

In the present study, algal flora was identified at B, D, E, K, and L blocks of Keoladeo National Park.

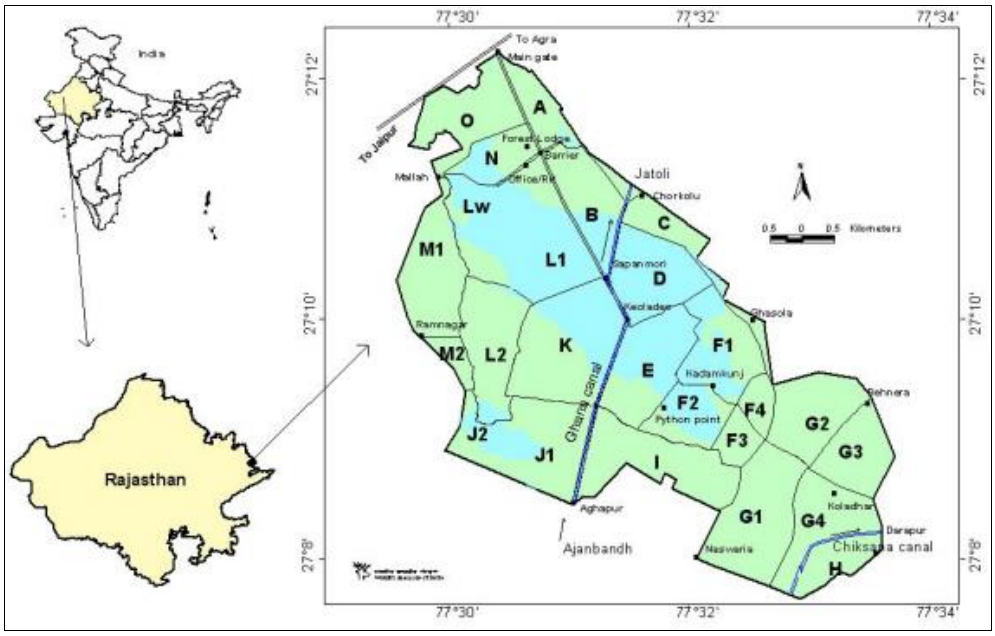

Fig 1: The study area

Materials and methods

The water samples were obtained using sanitized sampling vials with a volume of 250 ml, which were labelled with stickers over a period of two years (2020-2021, 2021-2022) during the pre-monsoon, monsoon and post monsoon season. The collected water samples were brought to the laboratory for present research. To differentiate between the blue green and green algae, dilute iodine solution and methyl blue, 1% solution of neutral red crystal and iron haematoxylin stain were used. The gelatinous sheath was stained by chloro-zinc iodide solution, iron-haematoxylin (1%) and iodine solution. Samples were then rinsed with distilled water and collected by centrifugation, using two successive runs at 3000 r·min-[1]. Temporary objective slides of 0.10 ml fresh and preserved water sample were prepared and observed specimens under light microscope **(**Leica DM 100). Micrographs were taken with Nikon D-3300 camera at 100X, 400X and 1000X magnification. The algae were examined mostly in living condition.

Identification was done on the basis of their external appearance, colour, morphological characteristics, size, cellular structure, pigments and reproductive characteristics. The taxa were first assigned to the orders, then the families and genera were determined and the diagnostic keys for the species prepared.

Results

The results in Table 1 show total number of algae belonging to various families (Chlorophyceae, Cyanophyceae, Bacillariophyceae, Xanthophyceae and Euglenoidae) at different sites (B, D, E, K and L) of Keoladeo national park during different seasons (Pre-monsoon, monsoon and Post-monsoon) of the year 2020-2021. For nearly all the algal species belonging to different sites- B, D, E, K and L, maximum number of algae was found during the monsoon season followed by post-monsoon season and minimum number during pre-monsoon season.

The results revealed that maximum species of algae found in different sites of Keoladeo national park belonged to the family Chlorophyceace (22) followed by Bacillariophyceae (8), Cyanophyceae (8), Euglenoidae (3) and Xanthophyceae (3).

A total of 22 algal species corresponding to various classes of the family Chlorophyceae were found in different sites (B, D, E, K and L) of Keoladeo national park. The algae of the family Chlorophyceae belonged to different classes- Chlamydomonadaceae, Chlorellaceae, Chlorococcaceae, Scenedesmaceae, Desmidiaceae, Closteriaceae, Cladophoraceae, Hydrodictyaceae, Zygnemataceae, Oedogoniaceae, Chaetophoraceae and Ulotrichaceae. A total of 8 algal species corresponding to various classes of the family Cyanophyceae were found in different sites (B, D, E, K and L) of Keoladeo national park. The algae of the family Cyanophyceae belonged to different classes- Aphanizomenonaceae, Rivulariaceae, Chroococcaceae, Merismopediaceae and Oscillatoriaceae

A total of 8 algal species corresponding to various classes of the family Bacillariophyceae were found in different sites (B, D, E, K and L) of Keoladeo national park. The algae of the family Bacillariophyceae belonged to different classes- Fragilariaceae, Pleurosigmataceae, Melosiraceae, Bacillariaceae, Gomphonemataceae and Cymbellaceae. A total of 3 algal species corresponding to various classes of the family Xanthophyceae were found in different sites (B, D, E, K and L) of Keoladeo national park. The algae of the family Xanthophyceae belonged to the class Vaucheriaceae.

For algae belonging to Xanthophyceae, maximum number of algae was found in site D followed by B, K, E and L. For site B and E, the algae number was highest in the year 2020-21 whereas for site D, K and L, the algae number was highest in the year 2021-22. A total of 3 algal species corresponding to various classes of the family Euglenoidae were found in different sites (B, D, E, K and L) of Keoladeo national park. The algae of the family Euglenoidae belonged to the class Euglenaceae

Table 1: Taxonomy of the identified algae from the study area.

Name of algae	Family	Class
Anabaena utermohlii Geitler	Cyanophyceae	Aphanizomenonaceae
Calothrix javanica de Wilde.	Cyanophyceae	Rivulariaceae
Chroococcus turgidus (Kutz.) Nag.	Cyanophyceae	Chroococcaceae
Chlamydomonas mucicola Schmidle	Chlorophyceae	Chlamydomonadaceae
Chlorella vulgaris Beijerinck	Chlorophyceae	Chlorellaceae
Chlorococcum humicola (Naeg.) Raben.	Chlorophyceae	Chlorococcaceae
Coelastrum microsporum Naeg.	Chlorophyceae	Scenedesmaceae
Cosmarium margaritatum Malham	Chlorophyceae	Desmidiaceae
Chlosterium parvulum Naegali	Chlorophyceae	Closteriaceae
Chlosterum acerosum (Schroeder) Her.	Chlorophyceae	Closteriaceae
Cladophora glomerata (L.) Kuertz.	Chlorophyceae	Cladophoraceae
Cymbella tumida (Breb.) V.H.	Bacillariophyceae	Cymbellaceae
Euglena convolute Korshikov	Euglenoidae	Euglenaceae
Euglena acus Ehrenberg	Euglenoidae	Euglenaceae
Euglena sanguinea Ehrenberg	Euglenoidae	Euglenaceae
Euastrum spinulosum Delp.	Chlorophyceae	Desmidiaceae
Fragilaria intermedia Grun.	Bacillariophyceae	Fragilariaceae
Fragilaria tenera (WM Smith) Lange-Bertalot	Bacillariophyceae	Fragilariaceae
Gomphonema lanceolatum Ehr.	Bacillariophyceae	Gomphonemataceae
Hydrodictyon indicum Iyengar	Chlorophyceae	Hydrodictyaceae
Hantzschia amphioxys (Ehr.) Grun.	Bacillariophyceae	Bacillariaceae
Merismopedia elegans A. Braun	Cyanophyceae	Merismopediaceae
Melosira granulate (Ehr.) Ralfs.	Bacillariophyceae	Melosiraceae
Mougeotia scalaris Hassall	Chlorophyceae	Zygnemataceae
Oscillatoria princeps	Cyanophyceae	Oscillatoriaceae

Oscillatoria nigra Vaucher	Cyanophyceae	Oscillatoriaceae
Oscillatoria agardhii Gomont	Cyanophyceae	Oscillatoriaceae
Oedogonium pyriforme	Chlorophyceae	Oedogoniaceae
Oscillatoria acuminata Gomont	Cyanophyceae	Oscillatoriaceae
Pleurosigma elongatum Smith	Bacillariophyceae	Pleurosigmataceae
Scenedesmus dimorphus (Turpin) Kuetzing	Chlorophyceae	Scenedesmaceae
Stigeoclonium tenue (C. A. Ag.) Kuetzing	Chlorophyceae	Chaetophoraceae
Spirogyra rhizoides	Chlorophyceae	Zygnemataceae
Scenedesmus dimorphus (Turpin) Kuetzing	Chlorophyceae	Scenedesmaceae
Scenedesmus platydiscus (G.M. Smith) Chodat	Chlorophyceae	Scenedesmaceae
Scenedesmus arcuatus (Lemmermann)	Chlorophyceae	Scenedesmaceae
Scenedemus opoliensis P. Richter	Chlorophyceae	Scenedesmaceae
Synedra ulna (Nitz.) Ehr.	Bacillariophyceae	Fragilariaceae
Spirogyra nitida (Dillw.) Link	Chlorophyceae	Zygnemataceae
Tolypothrix tenuis (Kutz.) Johs. Schmidt.	Bacillariophyceae	Fragilariaceae
Ulothrix zonata Kuerzing	Chlorophyceae	Ulotrichaceae
Voucheria amphibia Randhawa	Xanthophyceae	Vaucheriaceae
Voucheria hamata Walz.	Xanthophyceae	Vaucheriaceae
Voucheria sessilis f. genuina Hansg.	Xanthophyceae	Vaucheriaceae
Zygnemopsis indica Randhawa.	Chlorophyceae	Zygnemataceae.

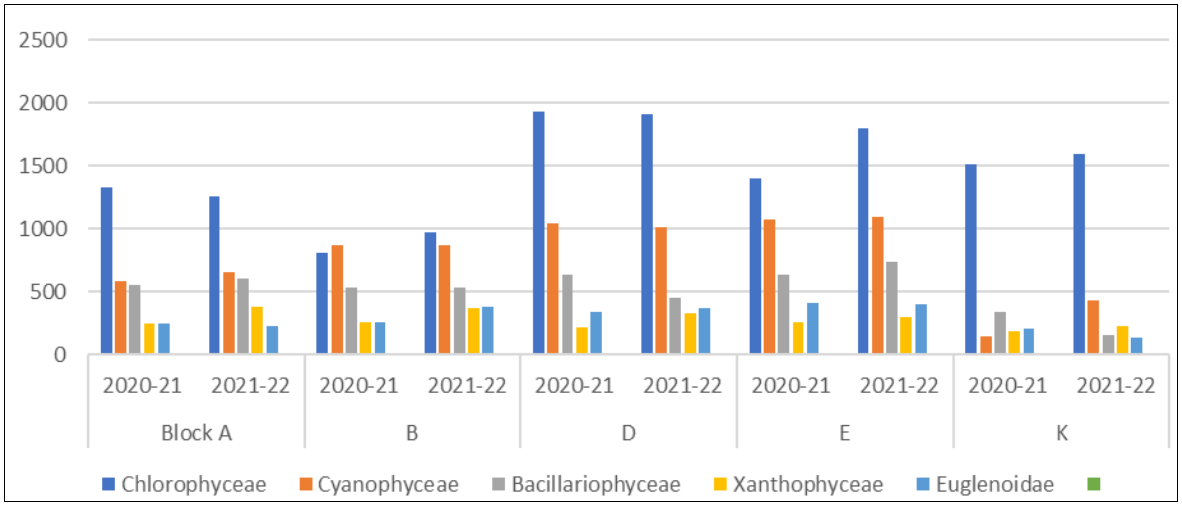

Fig 2: Class- wise distribution of algae

Discussion

Another important factor that aids in algal growth and multiplication is availability of optimum sunlight. Since algae are photosynthetic organisms, any compromise with the light intensity hampers algal growth by disrupting photosynthesis. Increased algal growth during the monsoon season is indicative of optimum light intensity. Moreover, the results show increased dissolved oxygen content in water of all the sites during monsoon season, in comparison to pre-monsoon and post-monsoon. High dissolved oxygen content in water is both favourable for algal growth as well as indicative of high algal density, Since algae being photosynthetic autotrophs, photosynthesize during the day and produce oxygen. This oxygen is essential for sustenance of aquatic flora and fauna, which are dependent on photosynthetic algae for their oxygen demand. However, the situation turns anarchical when algal growth exceeds the required limit, since the same algae that photosynthesize and produce oxygen during the day, compete with other organisms for utilizing oxygen for respiration, thus leading to creation of hypoxic conditions.

Also, algal growth is particularly high during the monsoon season due to improved gaseous availability. The turbulent mixing of gases during torrential rainfall aids in mixing of gases and promote algal growth. Salinity is also an important factor for assessing algal growth in aquatic ecosystems. Salinity refers to the presence of sodium in the water bodies. Sodium is naturally present in water bodies owing to leaching from sodium containing rocks and sediments by the flowing water. Low amount of sodium in water bodies is essential for osmoregulation, however, increase in amount of sodium, owing to anthropogenic activities may have maleficent effects, both on the health of aquatic organisms as well as the migratory birds and other species. Optimum amount of sodium is needed for algal growth and multiplication in water bodies. Occurrence of salinity stress may greatly affect algal growth and its biochemical composition. Exposing algae to high salinity stress may compromise their photosynthetic efficiency and adversely affect their growth kinetics (Srivastava *et al.*, 2021) [7].

The results show optimum sodium concentration during the monsoon season, which is lower than both pre-monsoon and post-monsoon season. Also, most of the algae belonging to the families considered in this study (Chlorophyceae, Cyanophyceae, Bacillariophyceae, Xanthophyceae and Euglenoidae) are freshwater and intolerant to extreme salinity conditions. Therefore, high algal density during the monsoon season maybe attributed to optimum water salinity, which is favorable for algal growth and division.

Apart from nutrient availability, dissolved oxygen and salinity, temperature also plays a key role in determining the algal density in an aquatic ecosystem. Extremely low or extremely high temperatures limit the algal growth and productivity. The temperature of water in aquatic bodies is regulated by a number of natural factors like hydrological factors, regional, structural and climatic factors as well as anthropogenic factors like thermal discharge from power stations, effluent waste discharge from factories, curtailing of riparian vegetation cover from river sides, global warming and others. Water at 0° C holds 14.6 mg/l of oxygen which declines by almost 50% when water temperature reaches 30° C thereby greatly limiting the oxygen supply and creating hypoxic condition in the aquatic ecosystems. This is indicative of the fact that even a slight alteration in water temperature affects the solubility of oxygen and other dissolved gases in water, which in turn affects the algal density and productivity. Not only this, water temperature also affects the rate of metabolic physiological processes (respiration and photosynthesis) in the water bodies. The results in chapter 5 show optimum water temperature during the monsoon season (27-32º C), which Favors the growth of microalgae. Hence, the results showed in this study corresponding to highest algal density during the monsoon season are in perfect alignment with the optimum temperature conditions during monsoon. The crucial effect of temperature on algal growth and productivity of different algal species have also been highlighted in previous studies (Béchet *et al.,* 2013 [1]; Singh and Singh, 2015) [6].

Besides these, algal growth may be due to presence of good nitrate in the water. Nitrate acts as a major nutrient for algal growth and its crucial role as an indispensable macroelement in algal metabolism and growth has been highlighted in a number of previous studies (Crawford, 1995 [2]; Taziki *et al.,* 2015 [8]; Domingues *et al.*, 2011) [3].

Conclusion

From the results of the current study, it can be concluded that all block of the study regions are rich in algal flora belonging to five different families- Chlorophyceae, Cyanophyceae, Bacillariophyceae, Xanthophyceae and Euglenoidae. Results indicated significant algal growth in water of all the Ramasar sites, with maximum algal numbers observed in case Chlorophyceae followed by Cyanophyceae, Bacillariophyceae, Xanthophyceae and Euglenoidae. Maximum number of algal species at all the sites was found during the monsoon season owing to high dissolved oxygen, high availability of nitrogen and phosphorus as well as optimum water temperature supporting algal growth. Maximum algal growth was observed in case of Chlorophyceae due to the fact that Chlorophyceae is the most abundant algal form on earth.

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