International Journal of Botany Studies
www.botanyjournals.com
ISSN: 2455-541X
Received: 28-05-2023, Accepted: 14-06-2023, Published: 29-06-2023
Volume 8, Issue 6, 2023, Page No. 55-58

# Evaluation of pollution by palmer's algal pollution indices and physico-chemical analysis of kayamkulam lake, Kerala, India

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**Abstract**
The present investigation was carried out in Kayamkulam Lake near National Thermal Power Corporation (NTPC) industrial area, Alappuzha district, Kerala, India, with regard to the pollution status by using Palmer's algal pollution indices and water quality analysis. The sampling sites were selected on the basis of their importance. Monthly variations in physico- chemical parameters like pH, Total Alkalinity (TA), $CO_2$, Dissolved oxygen (DO), Total Hardness (TH), Phosphate, Sulphate, Nitrate, Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were recorded. Organic pollution was assessed by employing Palmer's algal pollution indices. The total score of generic pollution index is 29, 32 and 31 for Sites I, II and III respectively. The total score in species pollution index is 21, 23 and 22 for Sites I, II and III respectively. The total score in both the indices were greater than 20, confirming high organic pollution, which can be substantiated by the physico chemical analysis of water. Results of the study showed that the lake water is not suitable for irrigation and domestic purpose without proper treatment. The results are discussed in the text.

**Keywords:** Palmer's algal pollution indices, NTPC and Physico- chemical paramete

## Introduction
Among the fresh water resources of the world, lakes, rivers, reservoirs and wetlands deserves special mention because they supply water for the population in the whole year. A total of 300 million natural lakes occupy about 4.2 million $Km^2$, globally (small lakes less than 1 $Km^2$ were the most dominating) and the constructed lakes occupy about 335,000 $Km^2$ (Bassem, 2020) [2]. Lakes represent one of the most resourceful ecosystems on the Earth with distinct physical, chemical and biological properties. Lakes are superb habitats for the study of ecosystem dynamics: interactions among biological, chemical and physical processes are frequently either quantitatively or qualitatively distinct from those on land or in air (Bhateria and Jain, 2016) [3]. Environmental contamination and degradation are consequences of anthropogenic influences in majority of lake ecosystems. Domestic sewage and agricultural wastes stimulate the growth of microorganisms which often increase the Biological Oxygen Demand (BOD) of the lake water and reduce the amount of dissolved oxygen available for aquatic flora and fauna. Besides, these wastes give birth to a number of pathogenic bacteria which may cause serious epidemics to animals and human beings. The nutrients entering into the lakes favour the growth of algae and eutrophication in lakes (Vasistha and Ganguly, 2020) [18]. The evaluation of the water quality is the fundamental aspect in the management of aquatic resources. Several pollution indices are used for the evaluation of water quality. These are based either on Physico-chemical characteristics or on biological information. The physico-chemical indices are based on the values of various Physico-chemical variables of water. The biological informations are calculated by using the data of species composition the species diversity, their pattern of distribution and dominance. The present study is an attempt to investigate the pollution status of Kayamkulam lake by using biological and chemical methods.

## Materials and methods
The present study was carried out by selecting three sites from Kayamkulam lake, lying in the west coast of India between latitude 9º 7'and 9º 16'north and longitude 76º 20'and 76º 29'east. The lake is 14.5 Km long stretching between the Vembanad of Alleppy District in the north and Ashtamudi of Kollam district in the South and the width varies from 1 to 1.5 Km. The first sampling site (SI) is at Karthikappally. Second sampling site (S II) is at the effluent discharge point from NTPC and it is 4.5 Km away from the first site. Third sampling site (S III) is at Kanakakunnu and there is domestic waste discharge in this area.

Water and Algal samples were collected at an interval of one month for a period of two year from October 2018 to September 2020 between 9.30 to 10.30 am. Samples for DO and BOD were fixed at the sampling site immediately after collection following Winkler method. Remaining parameters were analyzed in the laboratory within 8 hours by following standard methods (APHA, 2005) [1]. The algal taxa of different groups were identified with the help of taxonomic descriptions given in Standard monographs (West and West, 1908 [21]; Hustedt, 1930 [7]; Pochman, 1942 [14]; Desikachary, 1959 [6], Scott and Prescott, 1962 [17]; Philipose, 1967 [13]; Iyengar and Desikachary, 1981 [18]; Prasad and Srivastava, 1992 [15]; Krishnamurthy, 1998 [10]) and research publications. List of genera and species of algae tolerant to organic pollution from Kayamkulam lake was prepared according to the list provided by Palmer (1969) [12].

## Results and discussion
The Physico-chemical parameters of the three selected sites of Kayamkulam Lake showed variations. The results obtained from the analysis of water quality parameters are shown in Table 1.

**Table 1:** Physico chemical parameters of lake water.

| SITE I | | | SITE II | | | | SITE III | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **No** | **Parameters*** | **Range** | **Average** | **SD** | **Range** | **Average** | **SD** | **Range** | **Average** | **SD** |
| 2. | pH | 7.2-7.5 | 7.3 | 0.140 | 6.5-7.3 | 6.8 | 0.29 | 6.9-7.5 | 7.3 | 0.187 |
| 3. | Total Alkalinity | 43-140 | 90.08 | 32.70 | 23-112 | 74.2 | 22.85 | 46-163 | 106.9 | 33.63 |
| 4. | Free $CO_2$ | 3.9-9.8 | 6.7 | 2.14 | 1.6-6.1 | 3.8 | 1.16 | 4.9-12.8 | 9.8 | 2.07 |
| 5. | Dissolved Oxygen | 4-7.8 | 5.8 | 0.86 | 1.9-3.6 | 2.9 | 0.48 | 2.4-6.6 | 4.8 | 1.46 |
| 6. | Total Hardness | 31-297 | 1127.9 | 94.76 | 49-1100 | 257.7 | 266 | 33-412 | 161.09 | 117.3 |
| 7.. | Phosphate | 0.11-1.62 | 0.76 | 0.45 | 1.3- 4.1 | 2.42 | 0.67 | 0.9-3.4 | 2.04 | 0.62 |
| 8. | Sulphate | 29-64 | 46.5 | 12.03 | 78-97 | 85.3 | 4.71 | 82.8-108 | 92.7 | 5.31 |
| 9. | Nitrate | 0.16-0.84 | 0.48 | 0.235 | 0.4-3.7 | 2.3 | 0.96 | 0.24-1.7 | 0.69 | 0.415 |
| 10. | BOD | 1.7-3.6 | 2.66 | 0.376 | 5.1-8.5 | 6.19 | 1.26 | 3.2-5.4 | 3.58 | 0.954 |
| 11. | COD | 42-61 | 50.5 | 6.34 | 158-273 | 204.5 | 25.6 | 51-77 | 64.06 | 6.89 |

*All parameters except Temperature and pH are expressed in mg/l

The pH of lake water at sites I and III are remained alkaline throughout the study. But at site II the pH values decreased up to 6.5 during June 2019 and it is below the permissible limit (WHO, 1993) [22]. The Total Alkalinity (TA) of lake water ranged from 23 to164 mg/l. The highest value (164 mg/l) was observed at site III in April 2020 and is beyond the permissible limit of 120 mg/l. At all the three sites the higher values were recorded in months of February, March and April. Alkalinity above 100 mg/l is considered highly productive and less than 50 mg/l as oligotrophic as per the study reports from Valanthakad backwater (Meera and Nandan, 2010) [11]. The free $CO_2$ of the lake water ranged from 1.6- 12.8 mg/l. At all the three stations the maximum values were observed during non monsoon months and minimum values were observed during the period of June to September. The higher values during pre -monsoon may be due to high temperature which favours decomposition of organic matter and there by release CO2. The warm temperature also increases the metabolism of all organisms and their respiration rate is high during pre- monsoon months as observed by Vishnu (2005) [20]. Dissolved Oxygen (DO) of the lake water ranged from 1.9 to 7.8 mg/l. Biological Oxygen Demand (BOD) ranged from 1.7 to 3.6 mg/l with an average value of 2.66 mg/l at site I, 5.1 to 8.5 mg/l with an average value of 6.19 mg/l at site II and at site III it ranged from 3.2 to 5.4 mg/l with an average value of 3.58 mg/l. The BOD values of site II were higher than the remaining stations. The Chemical Oxygen Demand (COD) values varied from 42 to 61 mg/l with an average value of 50.5 mg/l, 158 to 273 mg/l with an average value of 204.5 mg/l and from 51 to 77 mg/l with an average value of 64.06 mg/l at sites I, II and III respectively. According to BIS (1991) the maximum permissible limit of COD for the discharge of effluent into the surface water is 250 mg/l. The estimated average values of phosphate were 0.79, 2.42 and 0.62 in the lake water at sites I, II and III respectively. According to WHO (1993) [22] the maximum permissible limit of phosphate in drinking water is 0.1 mg/l. The phosphate concentration was much higher and exceeded the maximum permissible limit at all the three sites. The sulphate concentration ranged from 29 to 64 mg/l with an average of 46.5 mg/l at site - I, 78 to 97 mg/l with an average of 85.3 mg/l at site - II and 82.8 to 108 mg/l with an average of 92.7 mg/l at site- III. The values of all the samples were found within the maximum permissible limit of 400 mg/l (BIS, 1991). The average values of nitrate were 0.48, 2.3 and 0.69 mg/l at sites - I, II and III respectively. The nitrate values of the samples were found to be within the permissible limit of 50 mg/l given by WHO (1993) [22]. The Total Hardness (TH) of the lake water ranged from 31 to1100 mg/l. The highest value of 1100 mg/l was observed in April 2019 at site II and the lowest of 31 mg/l was noted in August 2020 at site I. TH of water increases due to industrial discharge of effluent and also due to run off fertilizers from agricultural lands. TH decreases with the onset of monsoon. TH of the lake water is comparatively higher during the second year of study and it reached beyond the permissible limit of 300 mg/l (WHO, 1993) [22] at site II and III during summer months.

Palmer's (1969) [12] Pollution index of algal genera and species were used for rating water samples for high or low organic pollution in Kayamkulam lake. The results are summarized in Tables-2-3. Out of 20 genera and species listed by Palmer, 13 pollution tolerant genera and 9 pollution tolerant species were recorded from Kayamkulam lake. The total score of generic pollution index is 29, 32 and 31 for Sites I, II and III respectively. The total score in species pollution index is 21, 23 and 22 for Sites I, II and III respectively. The total score in both the indices were greater than 20, confirming high organic pollution.

**Table 2:** Pollution index of algal genera (Palmer, 1969) [12]

| Sl.no | Genera | Pollution index | Site I | Site II | Site III |
|---|---|---|---|---|---|
| 1. | *Ankistrodesmus* | 2 | + | + | + |
| 2. | *Chlorella* | 3 | + | + | + |
| 3. | *Closterium* | 1 | + | + | + |
| 4. | *Cyclotella* | 1 | + | + | + |
| 5. | *Euglena* | 5 | + | + | + |
| 6. | *Gomphonema* | 1 | + | + | + |
| 7. | *Melosira* | 1 | + | + | - |
| 8. | *Navicula* | 3 | - | + | + |
| 9. | *Nitzschia* | 3 | + | + | + |
| 10. | *Oscillatoria* | 4 | + | + | + |
| 11. | *Phacus* | 2 | + | + | + |
| 12. | *Scenedesmus* | 4 | + | + | + |
| 13. | *Synedra* | 2 | + | + | + |
| | Total | 32 | 29 | 32 | 31 |

**Table 3:** Pollution index of algal species (Palmer, 1969) [12].

| Sl. No. | Algal species | Pollution index | Site I | Site II | Site III |
|---|---|---|---|---|---|
| 1. | *Chlorella vulgaris* | 2 | + | + | + |
| 2.. | *Cyclotella meneghiana* | 2 | + | + | + |
| 3. | *Gomphonema parvulum* | 1 | + | + | - |
| 4. | *Oscillatoria chlorina* | 2 | - | + | + |
| 5. | *Oscillatoria limosa* | 4 | + | + | + |
| 6. | *Oscillatoria princeps* | 1 | + | + | + |
| 7. | *Oscillatoria tenuis* | 4 | + | + | + |
| 8. | *Scenedesmus quadricauda* | 4 | + | + | + |
| 9. | *Synedra ulna* | 3 | + | + | + |
| | Total | 23 | 21 | 23 | 22 |

List of genera and species of algae tolerant to organic pollution from Kayamkulam lake was prepared according to the list provided by Palmer (1969) (Table 4-5)

**Table 4:** Pollution tolerant genera of Algae encountered from Kayamkulam lake in the order of decreasing emphasis (Palmer, 1969).

| Sl No. | Algal species | | Site I | Site II | Site III |
|---|---|---|---|---|---|
| 1. | *Euglena* | 1 | + | + | + |
| 2. | *Oscillatoria* | 2 | + | + | + |
| 3. | *Scenedesmus* | 4 | + | + | + |
| 4. | *Chlorella* | 5 | + | + | + |
| 5. | *Nitzschia* | 6 | + | + | + |
| 6. | *Navicula* | 7 | - | + | + |
| 7. | *Synedra* | 9 | + | + | + |
| 8. | *Ankistrodesmus* | 10 | + | + | + |
| 9. | *Phacus* | 11 | + | + | + |
| 10. | *Melosira* | 13 | + | + | - |
| 11. | *Gomphonema* | 14 | + | + | + |
| 12. | *Cyclotella* | 15 | + | + | + |
| 13. | *Closterium* | 16 | + | + | + |
| 14. | *Pediastrum* | 24 | + | + | + |
| 15. | *Fragilaria* | 29 | + | - | + |
| 16. | *Lyngbya* | 34 | + | + | + |
| 17. | *Spirulina* | 37 | + | + | + |
| 18. | *Cymbella* | 39 | + | + | + |
| 19. | *Coelastrum* | 41 | + | + | + |
| 20. | *Achanthes* | 47 | + | + | + |
| 21. | *Pinnularia* | 49 | + | + | + |
| 22. | *Chlorococcum* | 50 | + | - | + |
| 23. | *Cosmarium* | 53 | + | + | + |
| 24. | *Selenastrum* | 57 | + | + | + |

**Table 5:** Pollution tolerant Species of Algae encountered from Kayamkulam lake in the order of decreasing emphasis (Palmer, 1969).

| Sl No. | Algal species | | Site I | Site II | Site III |
|---|---|---|---|---|---|
| 1. | *Oscillatoria limosa* | 3 | + | + | + |
| 2. | *Scenedesmus quadricauda* | 4 | + | + | + |
| 3. | *Oscillatoria tenuis* | 5 | + | + | + |
| 4. | *Synedra ulna* | 7 | + | + | + |
| 5. | *Oscillatoria chlorina* | 10 | - | + | + |
| 6. | *Chlorella vulgaris* | 11 | + | + | + |
| 7. | *Melosira varian* | 13 | + | + | - |
| 8. | *Cyclotella meneghiniana* | 14 | + | + | + |
| 9. | *Oscillatoria princeps* | 18 | + | + | + |
| 10. | *Gomphonema parvulum* | 20 | + | + | - |
| 11. | *Euglena oxyuris* | 24 | + | + | - |
| 12. | *Oscillatoria formosa* | 33 | + | + | + |
| 13. | *Nitzschia sigma* | 59 | + | + | - |
| 14. | *Coelastrum microporum* | 60 | + | + | + |
| 15. | *Scenedesmus dimorphus* | 63 | + | + | + |
| 16. | *Pediastrum duplex* | 69 | + | + | - |
| 17. | *Fragillaria capucina* | 74 | + | - | + |

Palmer pollution index were extensively used to understand the quality criteria of water (Jabbar Toma, 2019 [2]; Vishal and Meeta, 2020 [19]). In the present study, the values obtained in species pollution index was less than that for the generic pollution index. This can be explained in part by the fact that several genera have been excluded in species pollution index. For example *Navicula* is given a higher value (3) in the generic pollution index but none of the species of *Navicula* is listed in the species pollution index. Similarly, *Euglena* is given a value of 5 in generic pollution index. But none of the species of *Euglena* is included in the species pollution index. So there is always a chance for getting such type of results. In the present study the presence of blue green algae dominated by species of *Oscillatoria* during summer season in the lake water indicates the possibility of organic pollution. The presence of *Spirogyra* and *Microcystis aeruginosa* further support this inference (Das and Pande, 2010) [5].

## Summary and conclusion

All the values of Palmer pollution indices of algal genera and species of Kayamkulam lake were above 20 confirming high organic pollution in lake water, which can be substantiated by Physico chemical analysis of lake water.

## Acknowledgement

The authors would like to thank Principal, Sree Narayana College, Kollam for offering facilities to carry out this project and grateful to the government of Kerala for financial assistance.

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