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Carlson's Trophic State Index for the assessment of trophic status of two Lakes in Mandya district

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ABSTRACT

Carlson's Trophic State Index(CTSI) was applied to two lakes of Mandya. This index requires the determination only three physic chemical variables viz., Chlorophylla(CA), total phosphorus(TP) and Secchi disc depth transparency. The index values ranging from 0 to 100 and can be used for classification of trophic state of the lakes. The results of the study showed that the values of CTSI of these lakes ranged between35-53 indicating that they are mesotrophic. Periodic removal of algal mass and macrophytes may be helpful for minimize pollution and conservation of these still water ecosystems.

Keywords: Carlson's Trophic State Index, mesotrophic, Secchi disc depth transparency, total phosphorus, Chlorophylla

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INTRODUCTION

Classification of lakes based on various methods and indices have been made by various workers. Brown *et al*.(1970)developed National sanitation foundation water quality index for the assessment of water quality in united states. In Canada, the water quality index was introduced in mid-90'sby Water Quality Guidelines Task Group of the Canadian Council of Ministers of the Environment. The Task group included the environmental scientists such as Rocchini and Swain (1995), Dunn(1995) and Hebert(1996).ThisTask Group created the Water Quality Index Technical sub-committee that in turn modified the original British Columbia Water Quality Index into the CCME Water Quality Index (WQI), which was endorsed by the CCME (CCME, 2001).

The classical and most commonly used method is based on the productivity of the water body is the biomass related trophic state index developed by Carlson(1977). Carlson's Trophic State Index (TSI) is a common method for characterizing a lake's trophic state or overall health. This method uses Secchi's disc transparency, chlorophyll-a, and phosphorus measurements. Trophic state is defined as the total weight of the biomass in a water body at a specific location and time. Trophic state is the biological response for nutrient additions to the water bodies(Nauuman,1929). But this nutrient effects may be modified by parameters such as seasonal variations, grazing of phytoplankton by zooplankton and mixing depth of the water etc.,

Carlson's trophic state index mainly uses algal biomass involving three variables namely chlorophyll.a (CA), Secchi disc depth(SD) and total phosphorus(TP). The average values of TSI of these three parameters will be considered in determining the Carlson's trophic state index. The trophic continuum is divided into units based on the base 2 logarithmic transformation of SD. Each 10 unit division of the index represents a halving or doubling of the SD. Because TP often corresponds with the transparency, a doubling of TP often corresponds to halving of SD. CA doubles every seven units(Carlson,1980). The range of the index is from 0 to 100 and has an advantage over the use of raw variables. It is easier to memorize units of 10 rather than the decimal fractions of raw phosphorus, chlorophyll and secchi's depth values. The three index variables are integrated by linear regression modes. Any of

the three variables can therefore theoretically be used to classify the state of the water body. Chlorophyll.a is given higher priority for classification, because this variable is the most accurate among the three for the prediction of algal biomass.

MATERIALS AND METHODS

Arakerelake is located at the southeast side of the village. It is mainly rained and also receives canal water an outlet of river Cauvery during part of the year. The surface run off from the neighboring crop fields also enters the lake. The sewage of the village also joins the lake during rainy season. The total water spread area of the tank is 140ha. The anthropogenic activities such as cloth washing using detergents added to enrichment of the nutrient status of the water body. The macrophytes are not dense in the lake.

Thaggahallilakeis located at Northern side of the village. It receives water from the surface flow of the crop fields and the canal water throughout the year. The total water spread area of the tank is 50ha. The anthropogenic activities such as cloth washing are at the out lets of the lake. The macrophytes are dense in the lake.

The two lakes are economically important as fishing activities are being carried out in both the lakes. Beside Arakere lake is ecologically significant, because of its proximity to the bird sanctuaries such as Gendehosahalli and Ranganathittu.

The water samples were collected for the analysis of two parameters, total phosphorus and chlorophyll.a over a period of two years. Transparency of the water was measured by Secchi's disc of 20cms in diameter and the values are expressed in meters.The maximum depth at which the disc can be seen when lowered in to the water is marked and measured. Total phosphorus was analysed by the method prescribed in 4500-P; APHA,1995. Chlorophyll.a was estimated by Acetone method and measured using a spectrometer. Chlorophyll was extracted in 80% acetone and the absorption at 660 nm and 620 nm were read in a spectrophotometer. The amount of chlorophyll was calculated using the absorption co-efficient,. Chlorophyll present in the extract, mg of chlorophyll per gram tissue was calculated using the following equation.

$$\text{mgchla/g tissue} = 12.7(A_{660}) - 2.69\,(A_{620}) \times \frac{10}{1000 \times 10}$$

The trophic state index(TSI) of Carlson was calculated using the following formulae

a. TSI for Chlorophyll-a (CA)TSI = 9.81In Chlorophyll-a(ug/L)+30.6
b. TSI for Secchi depth (SD)TSI = 60-14.41In Secchi depth(Meters)
c. TSI for Total phosphorus (TP)TSI = 14.42 In Total phosphorous (ug/l) + 4.15

where TSI is Carlson Trophic State Index and In is Natural logarithm.

Carlson's trophic state index (CTSI) = [TSI (TP)+TSI(CA)+TSI(SD)]/3

TP and Chlorophyll-a in micrograms per litre, SD transparency in meters.

Based on the values of CTSI the lakes are classified as oligotrophic (low productive), mesotrophic (moderately productive) and eutrophic (highly productive). The range of the Carlson'strophic state index values and classification of lakes arepresented in the Table:1.

RESULTS AND DISCUSSION

The index for each of the parameters and their attributes for Arakere and Thaggahalli lakes over a period of two years are presented in the tables 2 to 5.The graphical representation of the Carlson's trophic state index of the two lakes is given in the figure.1. Carlson's trophic state index values of the two lakes recorded in between 35 to 53 and showed seasonal fluctuations. Our study revealed the fact that the CTSI values are higher during summer season, lesser during rainy season and moderate during winter. During 2009-10 Both lakes showed higher values between summer (May to july) and lesser values during autumn and winter. On the other hand during 2010-11, Thaggahallilake showed higher values during summer and Arakere lake showed a slight higher value during the middle of the rainy season and lowest values during other months. The average index data of the two years period classifies both the lakes as mesotrophic.

Table.1 : Carlson's trophic state index values and classification of lakes

TSI values	Trophic Status	Attributes
< 30	Oligotrophic	Clear water, oxygen throughout the year in the hypolimnion
30-40	Oligotrophic	A lake will still exhibit oligotrophy, but some shallower lakes will become anoxic during the summer
40- 50	Mesotrophic	Water moderately clear, but increasing probability of anoxia during the summer
50-60	Eutrophic	Lower boundary of classical eutrophy: Decreased transparency, warm-water fisheries only
60-70	Eutrophic	Dominance of blue-green algae, algal scum probable, extensive macrophyte problems
70-80	Eutrophic	Heavy algal blooms possible throughout the summer, often hypereutrophic
>80	Eutrophic	Algal scum, summer fish kills, few macrophytes

Table.2 : Carlson Trophic State Index , Arakere Lake 2009-10

Sl.No	Parameter	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Ave
1	TSI of SD	72.84	77.35	88.33	93.18	63.58	63.39	53.96	60.14	61.67	57.73	58.36	59.16	67.47
2	TSI of TP	9.06	8.02	9.80	20.57	15.27	9.42	16.43	18.35	16.43	11.40	14.20	14.20	13.60
3	TSI of CA	42.50	43.69	59.34	42.86	43.20	40.94	45.37	44.20	42.75	37.35	40.70	44.88	43.98
4	CTSI	41.47	43.02	52.49	52.20	40.68	37.92	38.59	40.90	40.28	35.49	37.75	39.41	41.68

Table.3 : Carlson Trophic State Index , Arakere Lake 2010-11

Sl.No	Parameter	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Ave
1	TSI of SD	56.55	56.33	59.85	67.12	70.57	57.37	56.90	55.99	60.58	62.51	60.89	60.58	60.44
2	TSI of TP	21.40	22.27	16.43	17.04	19.05	14.20	16.43	19.79	17.68	17.04	14.20	17.68	17.77
3	TSI of CA	38.81	35.02	34.44	33.09	33.90	32.78	30.98	35.57	34.83	34.70	40.41	46.73	35.94
4	CTSI	38.92	37.87	36.91	39.08	41.17	34.78	34.77	37.12	37.70	38.08	38.50	41.66	38.05

Table.4 : Carlson Trophic State Index , Thaggahalli Lake 2009-10

Sl.No	Parameter	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Ave
1	TSI of SD	75.12	69.15	69.70	83.93	64.93	65.55	63.03	67.12	66.65	65.98	65.98	67.36	68.71
2	TSI of TP	7.36	9.80	8.02	12.28	12.28	9.80	12.74	17.04	15.27	9.80	16.43	16.42	12.27
3	TSI of CA	43.11	41.82	43.08	39.58	38.01	42.86	40.77	46.41	39.97	49.67	48.26	52.96	43.88
4	CTSI	41.86	40.26	40.27	45.26	38.41	39.40	38.85	43.52	40.63	41.82	43.56	45.58	41.62

Table.5 : Carlson Trophic State Index , Thaggahalli Lake 2010-11

Sl.No	Parameter	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Ave
1	TSI of SD	69.15	65.98	66.65	64.93	63.95	67.84	64.33	55.67	59.85	61.67	60.14	59.16	63.28
2	TSI of TP	25.26	26.42	15.27	18.35	17.68	15.27	18.35	17.04	15.84	18.35	15.84	14.73	18.20
3	TSI of CA	46.17	41.66	40.80	38.77	39.85	32.30	40.63	40.01	38.72	33.54	46.71	52.01	40.93
4	CTSI	46.86	44.69	40.91	40.68	40.49	38.47	41.10	37.57	38.14	37.85	40.90	41.97	40.80

The average CTSI has shown that Arakre lake is mesotrophic during 2009-10 and oligotrophic during 2010-11.According to the indices though Arakere lake is oligotrophic during 2010-11, it has a tendency of becoming anoxic during march recording the CTSI value of 41.66. Thaggahallilake is categorized as mesotrophic during both the years. The water of the lake classified under this category is moderately clear and there is increasing probability of anoxia during summer.

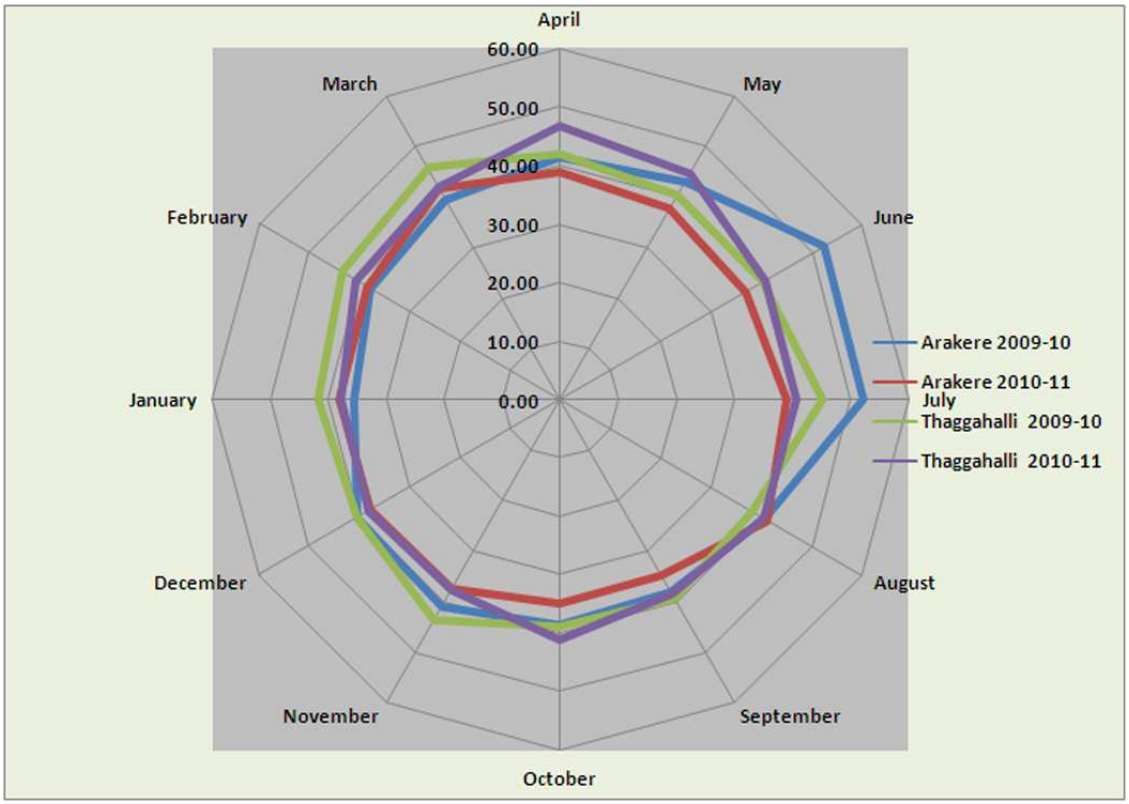
Arakerelake receives the canal water only during a part of the year and for the remaining period it is depended on rain. The CTSI value during the year 2010-11is lesser and it showed higher values during 2009-10. This may be attributed to the scanty rain falland dwindling of water level in the lake which has enhanced the nutrients concentrations. Although Thaggahallilake receives water from V.C canal, an outlet of Cauvery river throughout the year, it is classified as mesotrophic during both the years. This may be due to continuous inflow of nutrients from the neighbouring crop fields which in turn enhances the growth of phytoplankton and other macrophyesin the lakes. The enhanced growth and decay of planktons and macrophytes may lead the lake towards anoxic conditions.

The main parameter in deciding the trophic status of an aquatic water body is its phosphorus concentration. Any change in phosphorus concentration of fresh water ecosystem can also alter its trophic status. According to Carvalho and Kirika(2003) decline in inflow of nutrients reduces phosphorus concentration in lakes which in turn reduces phytoplankton biomass. This observation is found to be true from the present comparative study of Arakere and Thaggahalli lakes. Kleeberg and Dude (1977) have advocated the direct role of phosphorus in eutrophication of water bodies. But Bennion and Smith (2002) are of the opinion that phosphorus play no direct role in eutrophication. Bergmen(1999) observed pronounced decrease in Secchi's depth transparency with the increase in phosphorus and chlorophyll concentrations. Lech Kufe(2001) correlated chlorophyll with phosphorus in mesotrophic lakes. Xie*et al*,(2003) reported persistent coincidence between the occurrence of microcystis bloom and that of phosphorus.

Martynez*et. al.*(2005) found that oligotrophic nature of lake is indicated by the decreased concentration of total phosphorus.

Trophic state monitoring is an important part in assessing and managing lake ecosystems. As phosphorus is a limiting nutrient in algal growth(Horne and Goldman,1994), total phosphorus is commonly measured in the assessment of trophic state. Algal concentration can be estimated indirectly by determining the chlorophyll.a. The more chlorophyll corresponds to more phytoplanktons and more eutrophic state of the lake. Hosmani (2010) opines that measurement of chlorophyll.a can be used as a primary index for trophic state classification and to infer the functioning of the lake. Secchi's disc is used to measure the transparency of water. The transparency depends upon the density of algal populations and other suspended solids in water(Heiskary,1985). According to Steffanson*et. al.*(2001) although eutrophication is a natural process, over a period of time it is often accelerated by human activities which is termed as cultural eutrophication. Human beings influence lake ecosystems increasing the concentration of plant nutrients, primarily phosphorus(Harper,1992). The nutrients may enter in to lakes as agricultural run off, sewage or waste water and also by cattle ranching.This causes over enrichment of nutrients in the water bodies leading to the algal blooms. The decaying process of dead algal biomass may also result in the depletion of dissolved oxygen in the lakes causing anoxic environment.

Figure.1 :Radar diagram of Carlson's trophic state index(CTSI) of Arakere and Thaggahalli lake (2009-10 to 2010-11)



The major strength of TSI is the interrelationship between the variables can be used to identify certain conditions in the lake that are related to the factors that limit the phytoplankton biomass (Carlson,1980). Sandeep*et al*,(2008) have found that TSI as an important aspect in lake survey, water quality and this can be used as a tool to measure trophic state where the biomass is involved. Sharma *et al.*, have applied Carlson's TSI and Indiana TSI for the assessment of trophic status of lakes and found that both the systems can be very well used for the assessment of TSI of the lakes.

CONCLUSION

The progression of lake from oligotrophy to Eutrophic state is a gradual process in nature. The conversion from one life stage to the anotheris based on the changes in the degree of nutrient inflow and the productivity in the lake. The cultural eutrophication can significantly alter the rate of the natural process and shorten the life expectancy of the affected aquatic body. This can be avoided by adopting suitable conservation measures.

Carlson's Trophic State Index(CTSI) values recorded for Arakere and Thaggahalli lakes were in between 35 to 53. These values showed seasonal fluctuations and were not uniform. Carlson's Trophic State Index categorized Arakere lake as mesotrophic and oligotrophic during 2009-10 and 2010-11respectively. This indicates that the lake has the tendency of becoming anoxic during summer. Thaggahallilake is categorized as mesotrophic during both the years. It is evident from findings of the present study thaggahalli lake is facing more stress of cultural eutrophication as compared to Arakere lake. As both lakes are classified as mesotrophic, manual cleaning of macrophytes and algal biomass is needed to protect these water bodies from further degradation. As Carlson's Trophic State index needs minimum data and easy to understand, it is ideal for volunteer water conservation programmes and to educate the common man regarding the threats to the water bodies like lakes and conservation strategies that can be adopted.

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