Trophic State Index of Rankala Lake, Kolhapur (MH) India

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ABSTRACT
Rankala Lake is situated in the heart of Kolhapur city of Maharashtra, India. Five samples are collected from five different locations of Rankala Lake to assess tropic state index (TSI) of the lake. A sample of water is taken from just below the surface water in the morning time. The parameters like Secchi disc Transparency, Dissolved Oxygen (DO), Most Probable Number (MPN), phytoplankton, Net Primary Productivity, Gross Primary Productivity, Chlorophyll-A, Algal Biomass, Phosphates and Pesticide content parameters are studied. The correlations between Trophic Index (TI), chlorophyll (Chl), phosphorus (P), Secchi Depth (SD) are derived and use Carlson's Trophic Indices to arrive at the tropic state Index of the lake. The phytoplankton types are observed under trinocular light microscope while genera observed are classified and listed according to Palmer (1969). The primary organic production is studied by 'Dark' and 'Light' bottle method and by extraction of chlorophyll. As per these guidelines of Carlson's TSI, Rankala lake (TSI = 80.84) can be classified as Hyper-eutrophic water body and are totally unfit for drinking purpose due to it polluted excessively. This is mainly due to excessive discharge of untreated sewage, agricultural runoff, industrial wastes and other wastes which affects the aquatic ecosystem of the Rankala Lake.

Keywords: Tropic state index, Rankala Lake, Hyper-eutrophic, Primary Productivity

I INTRODUCTION

Lakes, water reservoirs and streams are the most valuable drinking water sources for the world's population and they are vulnerable to pollution and degradation of water quality, particularly to eutrophication. The studies of spatial distribution of phytoplankton in relation to various physico-chemical factors are helpful to understand freshwater ecology of the lake. The inland water bodies are closed ecosystems in which phytoplanktons hold a key position in the productivity of water bodies, trophic levels, food chains and energy flow.

Planktons, both producers and consumers, play an important role in the transformation of energy from one tropic level to the next higher trophic level ultimately leading to fish production which is the final product of the aquatic environment. The occurrence and abundance of Phytoplankton in freshwater ecosystem depends on its productivity, which in turn is influenced by physico-chemical parameters and level of nutrients. (Berde 2015)

Classification of lakes based on various methods and indices have been made by various scientist. The classical and most commonly used method developed by Carlson (1977) which is based on the productivity of the water body is the biomass related trophic state index. Carlson's Trophic State Index (TSI) is a common method for characterizing a lake's trophic state or overall health. Carlson's trophic state index mainly uses algal biomass involving three variables that is 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 range of the trophic state index is from 0 to 100. It is easier to memorize units of 10 rather than the decimal fractions of raw phosphorus, chlorophyll-A and secchi's depth values. The three index variables are incorporated 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 (Carlson, 1980).

II STUDY AREA

Fig. 1 - Rankala Lake, Kolhapur, MH (I)

Kolhapur city lies in between 15°43' – 17°17'North Latitude to 73°40' –74°42' East Longitude and located at 550 m above the mean sea level with an area about 66. 82 sq. kms. The Kolhapur city has historical importance because of goddess Mahalaxmi or Ambabai, the deity of Kolhapur hence and it is known as "Dakshin Kashi" Owing to several lakes and water tanks in the city it is also recognized as 'City of Lakes' (Wikipedia)

Rankala Lake is one of the famous lakes and situated in south west of the city. It covers an area of 5.21 sq. km and depth is about 9.5 m (30 feet). This lake developed during 1877 – 1883 by Maharaja (Emperors) of Kolhapur Sansthan, hence Rankala Lake has historical importance. This wide and spacious lake is so called because at its centre lies the temple of Rankabhairav. There is constructed wall around the lake. The total water spread area and the catchment area of the lake is 107 and 700 ha respectively. The average annual rainfall in the lake catchments area is 1000 mm.

This lake provides water for irrigation for about 80 hectares of land in and around the city of Kolhapur. Source of water to the lake is from two major streams flow from southern side. There are three out-lets from which water drains to irrigate about 80 hectares of land of Phulewadi, Mirabag, Dhunyachi Chavi. (MoEF, 2010)

Table 1:
Morphometry of Rankala Lake

Location	:	At Kolhapur, Maharashtra (India)
Name of the Lake	:	Rankala Lake
Year of Impoundment	:	1883
Purpose	:	Initially for Drinking Water Supply, however now for Irrigation and recreation.
Geographical Features	:	The lake has an elevation of @ 567 M above the Mean Sea Level (MSL) and situated on 16° 42' N latitude and 74° 14' E longitude.
Water Spread (Area)	:	10,70,000 Sq. m (1.07 sq. km)
Catchment Area	:	700 Ha (7.0 sq. km)
Max Depth (Meters)	:	approx. 15 m
Total Reservoir Capacity	:	43, 50,141 m^3
Useful Capacity	:	27,45,042 m^3
Length of the stone wall fence	:	3620 m
Shape of the sloping side	:	Like Fan Shape
Circumference	:	approx.4.2 Km

Being the location of Rankala Lake is in the middle of the city, so many sewage drains pouring untreated sewage collected from catchment of the lake hence it is heavily polluted lake. This sewage is contributing organic matter, silt and other toxic material, which accelerate the pollution of the lake. The Rankala Lake is in degraded condition due to pollution from various sources and siltation of the lake bed.

Most of the area in the Rankala watershed is without any provison of sewers and drains. There are certain channels/drains in the catchment area of the lake, which are major wastewater contributors (4.6 to 5.4 MLD) to the lake especially during non-power supply and rainy season. Wastewater flows into the lake through various drains entering the lake on its southern, western and southeastern sides. Excessive nutrient loading has resulted in extensive growth of submerged vegetation as well as free floating weeds. (MoEF, 2010)

III MATERIALS AND METHODS

Sampling was carried out from 05 stations, 5 between 09.00 and 10.00 hr. at sub-surface (0.1 m) water Standard methodology as per APHA (1985) has been used for sample collection, physicochemical and biological analysis of lake water. Surface water sampling was done using 05 liter polythene cans. The can was washed in ambient water before sampling. Sampling was done by carefully dipping the bottles inside, preventing entry of air bubbles.

IV SAMPLING LOCATIONS AND CO-ORDINATES

Table 2
Coordination of sampling locations

Sr. No.	Stations	Co-Ordinates
1	Station – I	16^{0}69’114”N and 74^{0}21’109”E
2	Station – II	16^{0}68’882”N and 74^{0}20’844”E
3	Station – III	16^{0}68’669”N and 74^{0}21’143”E
4	Station – IV	16^{0}68’605”N and 74^{0}21’402”E
5	Station - V	16^{0}69’365”N and 74^{0}21’363”E

Fig. 2 - Sampling Locations on Google Map

To measure water clarity depth, transparency measurements were taken with the help of a Secchi disc of 20cm diameter. The average of two readings for the depth at which the disc disappears during its descent and reappears on ascent was adopted.

The water samples for phytoplankton were fixed immediately after collection using Lugol’s iodine and brought to the laboratory. The phytoplankton types were observed under trinocular light microscope. The genera observed were classified and listed according to Palmer (1969). The primary organic production was studied by ‘Dark’ and ‘Light’ bottle method and by extraction of chlorophyll. A sample of water was taken in the morning just below the surface, with water samplers already described. This was then immediately poured into three bottles (L.D.I.) of 300ml. each with ground glass stoppers. The bottle ‘I’ was used for immediate determination of initial oxygen content. The second bottle ‘D’ was wrapped in black cloth bag. The bottle ‘L’ was left transparent. The bottles ‘L’ and ‘D’ were removed after 06 hours. The oxygen content of the bottles, ‘L’ and ‘D’ changed during the experimental exposure a compared with the initial oxygen value in bottle ‘I’. It decreased in the bottle ‘D’ and increased in ‘L’

The difference between L - D = Gross primary production

I – D = Respiration (oxygen consumed)

Net primary productivity = Gross primary productivity – Respiration.

To convert the ‘mg/l’ oxygen values to ‘mg/carbon/m^3’ multiply the mg/l values by 375.36. This will give mg carbon/m^3 for the duration of the test period.

Fig. 3 - Sampling Photographs

The plastic containers were rinsed thoroughly before use. The collected samples were analysed by following standard methods (APHA, 1989) and by using online water testing kits manufactured by Rakiro Biotech System Pvt. Ltd., Mumbai, India.

The trophic scale 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).

Based on the values of Carlson's TSI the lakes are classified as oligotrophic (low productive), mesotrophic (moderately productive) and eutrophic (highly productive). The range of the Carlson's trophic state index values and classification of lakes are presented in below table 3.

Table 3
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	Hypereutrophic	Heavy algal blooms possible throughout the summer, often hypereutrophic
>80	Hypereutrophic	Algal scum, summer fish kills, few macrophytes

V RESULTS AND DISCUSSION

The study of physico-chemical parameters and their effects on the biological parameters are important in understanding the trophic state of a water body. Each factor plays its role in regulating the ecosystem of the water body. The concentration of the various constituents along with factors such as rainfall, agricultural runoffs are also of equal importance. The change in one factor is directly or indirectly related to the other factors.

Table 4
Analysis data for various parameters pertaining various stations

Sr. No.	Parameters	Units	Station I	Station II	Station III	Station IV	Station V	Drinking Water Standard BIS:10500
1	Colour (apparent)	….	Greenish	Greenish	Greenish	Greenish	Greenish	…..
2	pH	….	7.5	7.4	7.4	7.5	7.6	6.5 to 8.5
3	Secchi disc Transparency	cm	26.4	26.3	26.5	26.8	26.2	….
4	Dissolved Oxygen	mg/l	3.4	3.2	3.3	3.5	3.2	….
5	MPN	No.	240	240	240	240	240	<10
6	Net Primary Productivity	mg C/m3 /day	225.21	375.36	300.29	300.28	593.78	……
7	Gross Primary Productivity	mg C/m3 /day	450.43	675.64	600.57	525.50	894.06	…….
8	Chlorophyll-a	ug/l	40	38	41	36	46	…….
9	Biomass	Gm/ m3	2680	2546	2747	2412	3082	……..

Note:- MPN – Most Probable No

Table 5
Phytoplankton observed in Rankala lake water

Sr. No.	Scientific name	Family
1	Spirogyra sp.	Chlorophyceae
2	Fragillaria sp	Bacillariophyceae
3	Nitzschia sp	Bacillariophyceae
4	Scenedesmus sp	Chlorophyceae
5	Microcystis sp	Cyanophyceae
6	Oscillatoria sp	Cyanophyceae
7	Melosira sp	Bacillariophyceae

Table 6
Algal Cell Density for all algae groups (number of cell/l)

Sr. No.	Species	Station-I	Station-II	Station-III	Station-IV	Station-V	Mean
	Chlorophyceae						
1	*Spirogyra sp.*	80	96	115	76	64	86.2
2	*Scenedesmus sp*	84	136	106	98	92	103.2
	Total	164	232	221	174	156	189.4
	Bacillariophyceae						
1	*Fragillaria sp*	40	58	62	45	24	45.8
2	*Nitzschia sp*	56	72	68	94	38	65.6
3	*Melosira sp*	24	32	30	18	10	22.8
	Total	96	130	130	139	62	134.2
	Cyanophyceae						
1	*Microcystis sp*	160	192	156	165	148	164.2
2	*Oscillatoria sp*	348	312	346	484	292	356.4
	Total	508	504	502	649	440	520.6
	Total Algae	768	866	853	962	658	844

Calculating the Trophic State Index (TSI) of Carlson:

TSI for Chlorophyll-a (CA) TSI = 30.6 + 9.81In Chlorophyll-a (ug/l)

TSI for Secchi depth (SD) TSI = 60 - 14.41In Secchi depth (meters)

TSI for Total phosphorus (TP) TSI = 14.42 In Total phosphorous (ug/l) + 4.15

$$\textbf{Carlson's TSI} = \frac{[\textbf{TSI (TP)} + \textbf{TSI (CA)} + \textbf{TSI (SD)}]}{\textbf{3}}$$

Table 7
Average value of Transparency, Chlorophyll-A, and Total Phosphorus of Rankala lake

Sr. No.	Parameters	Units	Station I	Station II	Station III	Station IV	Station V	Average
1	Secchi disc Transparency	cm	26.4	26.3	26.5	26.8	26.2	26.4
2	Chlorophyll-A	ug/l	40	38	41	36	46	40.2
3	Total phosphorus	mg/l	0.53	0.61	0.72	0.60	0.60	0.612

Table 8
Trophic State Index (TSI) of Rankala Lake

Name of Ponds/ Lakes	Total P, mg/l	Total Chl-A mg/l	Secchi Depth in cm	Total P, µg/l	Total Chl-A µg/l	Secchi Depth in mtr	TSI (TP)	TSI (T Chl)	TSI (SD)	TSI	Trophic State
Rankala lake	0.612	0.0402	26.4	612	40.2	0.264	96.58	66.79	79.16	80.84	Hyper-eutrophic

VI CONCLUSION

As per the guidelines of Carlson's TSI (ref table no. 2), Rankala lake (TSI = 80.84) can be classified as "Hypereutrophic" water body and are totally unfit for drinking purpose due to it polluted excessively. This is mainly due to excessive discharge of untreated sewage, agricultural runoff, industrial wastes and other wastes which affects the aquatic ecosystem of the Rankala Lake.

Also Dissolved Oxygen (DO) is an important limnological parameter indicating status of water quality and organic production of any lake. Survival of aquatic organisms, especially fishes, depends upon the suitable concentration of dissolved oxygen in water. The DO values once excellent in Rankala Lake now have been gradually reduced to alarming level. Low concentration of oxygen in lake water has created anaerobic conditions. Decaying of organic matter releases the free carbon dioxide and it causes depletion of oxygen which usually leads to anaerobicity resulting in foul smell and fish mortality. Hence it is necessary to stop inflow of pollutant into the lake, removal of floating and sub-merged aquatic weed and revival of ecosystem of the Rankala Lake by developing sustainable catchment treatment plan.

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