TROPHIC STATE INDEX (TSI) IN CONSERVATION OF LAKE ECOSYSTEMS

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TROPHIC STATE INDEX

Trophic state is defined as the total weight of living biological material in a water body at a specific location and time.

Carlson Trophic State Index (TSI) requires minimum data and uses algal biomass as a basis for classification:

a) Chlorophyll-a pigment (CA)
b) Secchi’s Depth (SD)
c) Total phosphorus (TP)
THERE ARE NO LAKE TYPES

The trophic continuum is divided into units based on the base 2 logarithmic transformation of Secchi depth

a) Each 10 units division of index represents a halving or doubling of Secchi depth

b) TP often corresponds with transparency: Doubling of TP also corresponds to halving of SD

c) Chlorophyll-a pigment doubles every seven units

(Carlson 1980)
IMPORTANCE OF THE INDEX

The index ranges from 0-100 and has the advantage over the use of raw variables (Decimal fractions are converted to units of 10).

Any of the three variables can be used to classify the water body.

Chlorophyll-a is given highest priority for classification and is the most accurate of the three at prediction of algal biomass.
CALCULATING THE TROPHIC STATE INDEX (TSI) OF CARLSON

a. TSI for Chlorophyll-a (CA)
   
   \[ TSI = 9.81 \ln \text{Chlorophyll-a (ug/l)} \]

b. TSI for Secchi depth (SD)
   
   \[ TSI = 60 - 14.41 \ln \text{Secchi depth (Meters)} \]

c. TSI for Total phosphorus (TP)
   
   \[ TSI = 14.42 \ln \text{Total phosphorous (ug/l)} + 4.15 \]

Where TSI is Carlson Trophic State Index and \( \ln \) is Natural logarithm

Carlson’s TSI = \[ \frac{[\text{TSI (TP)} + \text{TSI (CA)} + \text{TSI (SD)}]}{3} \]

Where TP and Chlorophyll-a in micrograms/l and SD transparency in meters
<table>
<thead>
<tr>
<th>TSI</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30</td>
<td>Classic Oligotrophy; Clear water, oxygen through the year in the hypolimnion, salmonid fisheries in deep lakes.</td>
</tr>
<tr>
<td>30-40</td>
<td>Deeper lakes still exhibit classical oligotrophy, but some shallower lakes will become anoxic in the hypolimnion during the summer.</td>
</tr>
<tr>
<td>40-50</td>
<td>Water moderately clear, but increasing probability of anoxia in hypolimnion during summer.</td>
</tr>
<tr>
<td>50-60</td>
<td>Lower boundary of classical eutrophy: Decreased transparency, anoxic hypolimnion during the summer, macrophyte problems evident, warm-water fisheries only.</td>
</tr>
<tr>
<td>60-70</td>
<td>Dominance of blue-green algae, algal scums probable, extensive macrophyte problems.</td>
</tr>
<tr>
<td>70-80</td>
<td>Heavy algal blooms possible throughout the summer, dense macrophyte beds, but extent limited by light penetration. Often would be classified as hypereutrophic.</td>
</tr>
<tr>
<td>&gt;80</td>
<td>Algal scums, summer fish kills, few macrophytes, dominance of rough fish.</td>
</tr>
</tbody>
</table>
SECCHI DEPTH MEASUREMENT
CARLSON’S TROPHIC STATE INDEX

Graphic showing the relative ranking of the average trophic state
IMPORTANCE OF FRESH WATER
ALGAL DIVERSITY
Fresh water algae
Fresh water algae
Fresh water algae
Fresh water algae
Fresh water algae
Fresh water algae
Fresh water algae
MEASUREMENT OF DIVERSITY

a. Species richness: Total number of species found in a lake.

b. Species evenness: How equally represented the number of each species (Pielou’s evenness index J)

c. Diversity index of Shannon and Weaver (1949 H)

d. Species dominant: which species are dominant.
Species richness (d): It is the second major component of species diversity. It is a simple ratio between total species “S” and total number N (importance value). It is evaluated by a variety index (d) derived from Odum et. al., 1960.

\[ d = \frac{S-1}{\log N} \]
**Species Evenness (J):** It is the major component of species diversity, which shows the distribution (apportionment) of individuals among the species.

$H_{\text{max}}$ is the maximum diversity, which would occur if the individuals were evenly distributed among the species. It is calculated as follows Pielou (1966, 1969)

$$H_{\text{max}} = \log S$$

Where $S$ = species present, the evenness in the distribution of the individuals between the species may be calculated by an equitability index (Sheldon 1969)

$$J = \frac{H}{H_{\text{max}}}$$
**Species diversity (H):** Ratio between the number of species and importance value (number, biomass, productivity etc.) of individuals is called species diversity. It is computed according to Shannon and Weaver’s index

\[ H = \sum \frac{n}{N} \log \frac{n}{N} \]

Where \( N \) = Total number of individuals,

\( S = \) Species number

\( N = \) Number of individuals in \( i \) species

The information content or diversity (H) is expressed as number of bits / individual
Phytoplankton composition of Pielou’s evenness and Shannon and Weaver index.

Phytoplankton composition of evenness and diversity index values of Chikka Hunsur lake

Diversity index

Evenness index
Dominance values of species in Chikka Hunsur lake

- **Cymbella simulata**: 2%
- **N. venezulensis**: 4%
- **Cosmarium bengalense**: 3%
- **Amphora coffeetarmis**: 2%
- **Synedra ulna**: 5%
- **N. simplex**: 3%
- **Navicula disjuncta**: 2%
- **Gyrosigma scalpoides**: 2%
- **Caloneis amphisbaena**: 3%
- **Others**: 72%
Phytoplankton (%) in Chikka Hunsur

Fig. 1. Phytoplankton (%) of Hunsur lake

- Bacillariophyceae: 35%
- Chlorococcales: 14%
- Euglenophyceae: 15%
- Desmidaceae: 18%
- Cyanophyceae: 18%
Insect diversity in different lakes
(Example)
CARLSON TROPHIC STATE LEVEL OF DIFFERENT LAKES OF MYSORE

Fig 1 - Carlson’s trophic state level of different lakes around Mysore
<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Name of the lake</th>
<th>TSI</th>
<th>Trophy</th>
<th>Attributes and conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Varuna</td>
<td>46</td>
<td>Mesotrophy</td>
<td>Water moderately clear, increasing probability of hypolimnatic anoxic during summer, colour changes &amp; fish population decreases. Manual clearing of algal mass and hydrophytes</td>
</tr>
<tr>
<td>2</td>
<td>Darga</td>
<td>47</td>
<td>Mesotrophy</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Hadinunaru</td>
<td>50</td>
<td>Mesotrophy</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Karangi</td>
<td>50</td>
<td>Mesotrophy</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Santhe</td>
<td>51</td>
<td>Eutrophy</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Kukkarahally</td>
<td>60</td>
<td>Eutrophy</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Bogadi</td>
<td>66</td>
<td>Eutrophy</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Shetty</td>
<td>69</td>
<td>Eutrophy</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Belikere</td>
<td>72</td>
<td>Hypereutrophic</td>
<td>Range from hypertrophy to hypereutrophy, algal scums develop emitting foul smell, reduction in transparency, rise in phosphorous, reduced macrophytes, fish kill. Very difficult to conserve; Draining of water &amp; refilling during monsoon.</td>
</tr>
<tr>
<td>11</td>
<td>Dalvoi</td>
<td>82</td>
<td>Hypereutrophic</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Lingambudhi</td>
<td>84</td>
<td>Hypereutrophic</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Yelwala</td>
<td>84</td>
<td>Hypereutrophic</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>CFTRI pond</td>
<td>87</td>
<td>Hypereutrophic</td>
<td>14 and 15 very difficult to conserve (Use of ammonia nitrifiers)</td>
</tr>
<tr>
<td>15</td>
<td>Terrision pond</td>
<td>94</td>
<td>Hypereutrophic</td>
<td></td>
</tr>
</tbody>
</table>
FISH KILL IN YENNEHOLE LAKE OF MYSORE DISTRICT
ALGAL BLOOMS
SCENEDESMUS BLOOM IN MANDAKALLI LAKE
APHANOTHECE BLOOM
FISH KILL
FLOATING MATS OF FILAMENTOUS ALGAE
APHANOTHECE BLOOM
MICROCYSTIS AERUGINOSA
CONCLUSION

a. Carlson TSI is an important index in survey of lake

b. Chlorophyll-a is the primary index; some algae are of prime importance in eutrophication.

c. It is essential to modify the lake according to the user and not simply make water clean.
Count the black dots! :o)
PURE COLONIES OF NOSTOC MUSCORUM
Thank you