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Assessment of Ecological Health of Tilyar Lake, India

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ABSTRACT

Tilyar Lake in Rohtak district of Haryana state, India is selected for the purpose of assessing its ecological health. A multi-index system has been used to assess the ecological health which includes Carlson's Trophic State Index (CTSI), Simpson's Diversity Index (SDI) and Water Quality Index (WQI). The results indicated that the lake health is average but is approaching to bad condition as indicated by EHI of 2.93. Suitable conservative measures should be adopted to arrest its further degradation. Certain conservative measures are also suggested.

Keywords: Ecological Health Index (EHI), Carlson's Trophic State Index (CTSI), Simpson's Diversity Index (SDI), Eutrophication, Secchi depth

INTRODUCTION

In India, the number of degraded water bodies is increasing, thereby, posing serious water scarcity problems for various uses. Assessment of ecological health of fresh water bodies like rivers, lakes, wetlands etc. is carried out by several workers but no scientific attempts were made in India. Environmental conditions were determined in respect to allocation of epilithic diatoms in the Nairobi River, Kenya (Ndiritu et al.).[8] In a study assessing Odonata distribution in a lowland river catchment in eastern England, phosphate concentrations, BOD and low velocity were found to influence larval assemblages (Hoffmann and Mason).[9] Azrina et al.[10] studied the impacts of anthropogenic activities on the distribution and biodiversity of benthic macro-invertebrates and water quality of the Langat River (Peninsular Malaysia) and analyzed the data by Pearson correlation analysis and multiple stepwise regression analysis to establish relationships between the physicochemical and the macro benthic data. The health of water was measured by[6] based on water quality, habitat of plants and animals, river flow patterns, physical shape of the water body diversity and abundance of plants and animals.Ecological health of rivers was assessed using land use data, hydrology, stream side zone, physical habitat, water quality, aquatic life and ecosystem processes data.[7] Other works include the assessment of water quality and phytoplankton density [11], assessment of physio-chemical characteristics [12], study of Avian & plant species [13] of Tilyar Lake. In India, Ahar Lake in Rajasthan and Buddha Nala in Ludhiana (Punjab) was ecologically assessed based on multi-indexing system.[18] The above literature reveals that considerable work is reported on ecological health of water bodies in other countries but very little work is available in India. Large number of studies is devoted to water quality assessment. The present paper deals with the ecological health assessment of Tilyar Lake of Haryana, India. The paper covers the water quality, Trophic State Index and Simpson's Diversity Index which were converted to overall Ecological Quality Index to define the ecological status of Tilyar Lake.

ECOLOGICAL HEALTH

Ecological health can be used to assess the pollution level of water bodies on the basis of water quality and biological components surrounding it. The ecological health assessment differs from water quality assessment in that the later includes only physico-chemical water quality parameters whereas, the former tells about the suitability of the given water body to support the biological life in & around the lake and energy and material balances in different food chains of the ecosystem.

Healthy water body holds the physico-chemical and biological aspects in balanced form i.e. the water body is supportive to biological life. The water body should be in good health indicated by good biological diversity. Tilyar Lake is located in Rohtak district of Haryana, India. Its area is about 5, 34,185 m^2 with Latitude as 28.8820° N and Longitude as 76.6370° E. The lake is surrounded by trees, shrubs, herbs and weeds etc imparting a flawless green belt

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in the whole area of the lake complex. The lake was developed by the Haryana Tourism Development in 1976 to attract tourists, mainly, in winter season. Looking at number of tourists visiting the lakes and lack of proper management, growth of weeds, dumping of wastes and receipt of nutrients from the catchment are found associated the main problem of the lake. The water is found highly turbid, especially, during monsoon season and there is continuous reduction in lake depth. Apparently, the lake appears to have huge algal growth.

MATERIALS AND METHODS

The water sampling was carried out at 12 locations as shown in Figure 2. Sampling was done in November, 2013 about 50 cm below the surface except the location 4, 7 & 8 where the samples were taken at 2 depths to assess the vertical profile. Water samples were collected in duplicate to minimize the error. The water samples were analyzed for water quality parameters as per the standard methods.[1] The sampling locations are shown in Figure 1.

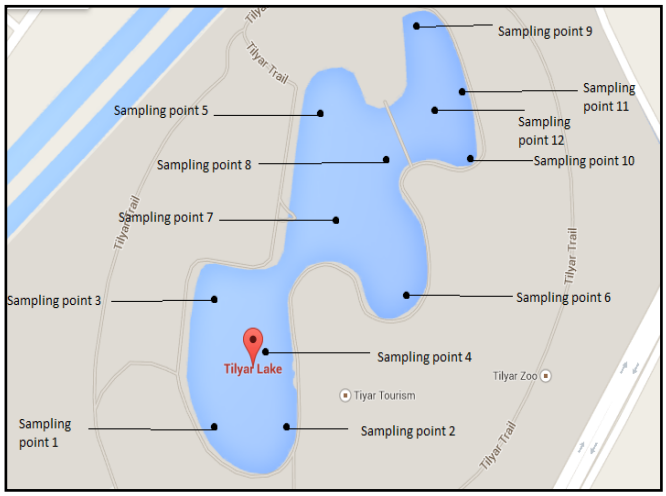

Figure 1. Location of all sampling points in Tilyar Lake

ECOLOGICAL HEALTH ASSESSMENT

The entire work is based on water quality, Carlson's Trophic State and Simpson's Biodiversity Index assessment. Each is briefly discussed as follows:

WATER QUALITY INDEX (WQI): The water samples were analyzed for the various physico-chemical parameters. Water quality index was calculated on the basis of physico-chemical parameters of the lake water. The WQI for the lake is calculated using two methods:

National Sanitation Foundation (NSF-WQI): The water quality index was calculated as per the NSF guidelines. The WQI for all the sampling points were calculated from the online WQI calculator[1- 14-19] using pH, Turbidity, Nitrate, Total solids, DO, BOD and Temperature. WQI at all locations is shown in Figure 2.

Weighted Arithmetic Mean (WAM-WQI): WAM-WQI method gives the water quality in respect of drinking purpose while NSF-WQI gives the water quality status for drinking as well as for other users. WAM-WQI at all locations is shown in Figure 3.[17]

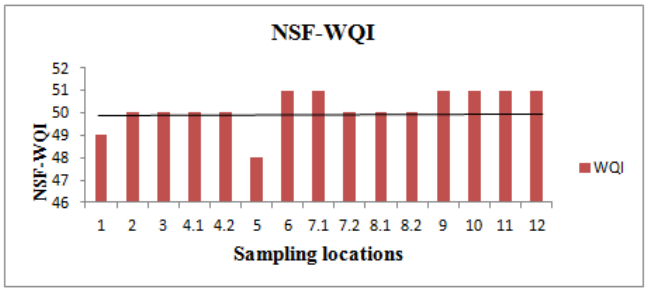

Figure 2. NSF-WQI at all locations

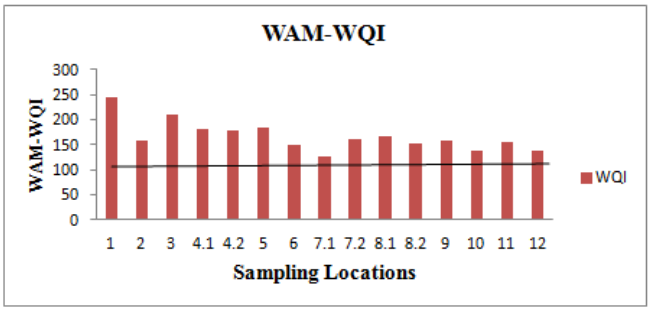

Figure 3. WAM-WQI at all locations

The average NSF-WQI for the lake is 50.2 in the medium range[14] which indicates that the water cannot be used for drinking and other purposes and lake water is approaching to bad condition. Large amount of total solids and turbidity of water is also enhancing. Therefore, measures are seriously required to avoid further degradation of lake. WAM-WQI (Figure 3) shows that WQI for all locations is higher than 100 indicating again the bad water quality and thus, unsuitable for drinking purposes.[17]

CARLSON TROPHIC STATE INDEX (CTSI)

Carlson[15] developed a most commonly used method based on the productivity of the water body. It is used to classify the lakes based on trophic states. CTSI cannot be directly determined by measuring algal bloom in the lake but by measuring Total phosphorus, Total nitrogen, Chlorophyll-a and Secchi depth.[1] The following equations were used to compute the TSI and the results are given in Figure 4.

- TSI based on TP = 14.42 In TP (µg/l) + 4.15 [16]
- TSI based on SD = 60 – 14.41 ln SD (m) [16]
- TSI based on CA= 9.81 ln {Chlorophyll-a} +30.6 [16]
- Log chl-a (mg/m^3) = -0.267* log SD (meters) + 2.075 [2]

The Carlson's TSI can be computed as follows:

$$CTSI = \frac{TSI(TP) + TSI(CA) + TSI(SD)}{3}$$

The average CTSI for Tilyar Lake is found as 74 which indicate that the CTSI for all locations is indicative of the eutrophic state of the lake. The average CTSI is above 60 indicating that the lake is rich in nutrients, leading to heavy growth of algal boom and is approaching to hyper eutrophic state, which is normally making the lake irreversible and is

on the verge of disappearance if suitable conservation measures are not adopted.

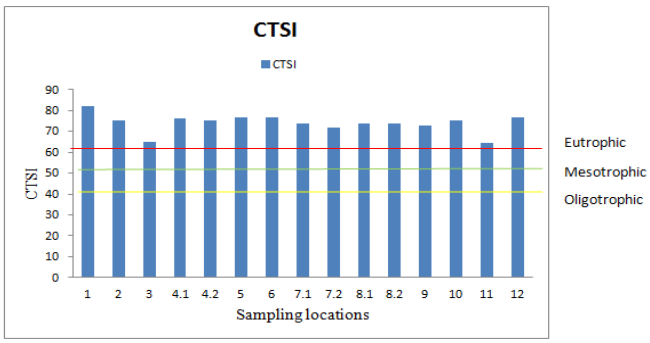

Figure 4. CTSI at all sampling locations

SIMPSON'S DIVERSITY INDEX (SDI) FOR RIPARIAN VEGETATION

Riparian vegetation includes the trees, herbs, shrubs, weeds etc. around the water body and is a function of instream habitat. The two areas of 1 m^2 area each was selected on the bank of the lake. The different types of plant species were collected and counted. Woody and Non-woody trees as riparian vegetation were observed. The abundance ratio of each species for Non-woody and Woody were calculated using the results given in Table 1 and Table 2 respectively. The pictures of four Non-woody plants are given in Table 1. The species of trees were identified by local name and botanical name is assigned to each tree species given in Table 3. For calculating Simpson's Diversity Index following equation is used:

$$SDI = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Where, n = the total number of organisms of a particular species, N = the total number of organisms of all species. The SDI ranges between 0 and 1. 1 represents infinite bio-diversity and 0, no/poor bio-diversity.[4]

The average SDI of Non-woody and woody is 0.507 and 0.209 respectively. On its basis, it can be concluded that the biodiversity around the lake is poor. Water is not supporting the biological life in and around the lake. The species being supported are mostly exotic species not supporting the valuable vegetation that can be helpful in establishing proper food chain.

ECOLOGICAL HEALTH INDEX (EQI) [16]

All WQI, CTSI & SDI determined can be converted into by the equation:

$$\text{Ecological Health Index (EHI)} = \frac{[\text{Status no.for EQI of CTSI} + \text{Status no.of EQI of WQI} + 1/\text{SDI}]}{3}$$

EHI = (3+ 3+ 1/0.358)/ 3 = 2.93

EHI ranges from 0 to 5, where 0 reflects excellent and 5 reflects very bad ecological health. Using the above equations, EHI is calculated as 2.93. From the range given [18-20]. It is clear that the Tilyar Lake has average ecological health i.e. the water is not suitable for drinking but can be used for irrigation. Further EHI of 2.93 is approaching to 3 indicating the likely change of lake status from average to bad. The lake water does not support the growth of fresh water macro-invertebrates as well as the proper growth of riparian vegetation due to very low biodiversity. Suitable conservation measures like dredging, desilting, dewatering etc. would be required to bring the lake to good health.

Table 1. Types of species observed in riparian vegetation of the lake

Type 1

Type 2

Type 3

Type 4

Table 2: Types and number of grass (non-woody) species available as riparian vegetation

Location 1

Type	Number	Abundance Ratio
1	76	0.704
2	18	0.167
3	9	0.083
4	5	0.046
Total	108	
∑SDI		0.528

Location 2

Type	Number	Abundance Ratio
1	82	0.667
2	23	0.187
3	11	0.089
4	7	0.057
Total	123	
∑SDI		0.486

Average SDI for Non-woody = 0.507

Table 3. Number and type of trees (woody species) available

S. no	Scientific Name	Common Name	Number	Abundance Ratio
1	*Azadirachta indica*	Neem	4	0.047
2	*Sesamum indicum*	Sesame	32	0.376
3	*Morus nigra*	Mulberry	1	0.012
4	*Ficus religiosa*	Peepal	3	0.035
5	*Psidium guajava*	Guava	3	0.035
6	*Ficus benghalensis*	Banyan	1	0.012
7	*Acacia nilotica*	Babool	5	0.059
8	*Arecaceae*	Palm	13	0.153
9	*Saracaasoca*	Ashoka	6	0.071
10	*Unknown Name*	Unknown	17	0.200
∑SDI				0.209

Overall Riparian SDI= (0.507+ 0.209)/2 = 0.358

CONCLUSIONS

Tilyar Lake selected as a study area to assess the ecological health has significance for the tourists and local public. As per the NSF-WQI and WAM-WQI, it is found that the water quality of Tilyar Lake is not suitable for drinking or other purposes. CTSI is found as 74 representing the lake in Eutrophic State indicated by high productivity and increased algal biomass. Riparian vegetation and trees based on biodiversity shows poor diversity of woody (0.209) and non-woody (0.507). EHI of 2.93 is found in the range of average ecological heath but it is approaching towards bad condition. Looking at the bad/eutrophic condition, the suitable conservative measures are needed to restore its health. Suggested measures includes water evacuation, desilting, catchment area development, refilling with fresh water which will allow the lake to take 3-4 months to develop life in the lake. Management of tourists and their activities should also form the main part of conservation. Direct flow of nutrients from the catchment can be checked by constructing a channel around the lake so that run offs may not reach directly to the lake. The public awareness and regular lake management will be helpful in improving the lake health. Further work can be done using other indices for

1trophic state assessment & Biodiversity or observation of macro-invertebrates can be included.[3]

REFERENCES

1. N.S Yadav, M.P. Sharma, A. Kumar. Assessment of Water Quality Changes at Two Locations of Chambal River: M.P. *J. Mat. Environmental Science.* **2014**, 5, 1781-1785.
2. S. Balali, S.A. Hoseini, R. Ghorbani, S. Balali. Correlation of chlorophyll-A with Secchi Disk Depth and Water Turbidity in the International Alma Gol Wetland, Iran'. *World J. Fish Marine Sci.*, **2012**, 4, 504-508**.**
3. http://insects.about.com/od/water-quality-monitoring/qt/Water-Quality-Monitoring-Using-Aquatic-Macroinvertebrates.htm assessed on 3/03/2014.
4. Bibi, F., Ali, Z., 2013. Measurement of Diversity Indices of Avian Communities at Taunsa Barrage Wildlife Santuary, Pakistan. *J. Animal & Plant Sci*., **2013** 23, 469-474**.**
5. The International Water Centre. 'Ecological health assessment of large freshwater rivers, lakes and reservoirs: study design options, sampling methods and key issues'. Australia-China Environment Development Partnership River Health and Environmental Flow in China, Project Code: P0018**,** 2012.
6. http://www.melbournewater.com.au/Pages/home.aspx assessed on 03/03/2014.
7. http://www.watercentre.org assessed on 03/03/2014.
8. B.C. Chessman, Diatom flora of an Australian river system: spatial patterns and environmental relationships. *Freshwater Biol.*, **1986**, 16, 805-819**.**
9. T.A Hoffmann, C.F. Mason. Habitat Characteristics and the Distribution of Odonata in a Lowland River Catchment in Eastern England. *Hydrobiologia*. **2005**, 539, 137-147.
10. M.Z. Azrina, C.K. Yap, R. Ismail, A. Ismail, A., S.G. Tan. Anthropogenic Impacts on the Distribution and Biodiversity of Benthic Macro invertebrates and Water Quality of the Langat River, Peninsular Malaysia. *Ecotoxicology Environmental Safety*. **2006**, 64, 337-347.
11. Singh, A., Laura, J.S., Rana, A., International conference: Energy-waste-water nexus for Environmental Management, Chaudhary Devi Lal University, Sirsa, 28th to 30th January, **2012**, 1-10.
12. A. Singh, J.S. Laura. An Assessment of Physico-Chemical Properties and Phytoplankton Density of Tilyar Lake, Rohtak (Haryana). *Int. J. Curr. Res.*, **2012**, 4, 047-051.
13. A. Singh, J.S Laura. Avian and Plant Species Diversity and their Inter-relationship in Tilyar Lake, Rohtak (Haryana). *Bull. Environ. Pharmacol. Life Sci*. **2012**, 1, 65-68
14. http://www.water-research.net/watrqualindex/ assessed on 16/02/2014.
15. R.E Carlson. A trophic state index for lakes. *Limnology and Oceanography*. **1977**, 22, 361-369.
16. N.S Yadav, M.P. Sharma, A. Kumar. Ecological Health Assessment of Chambal River using Water Quality Parameters. *J. Integr. Sci. Technol.*, **2014**, 2, 52-56.
17. K. Yogendra, E.T. Puttaiah. Determination of Water Quality Index and Suitability of Waterbody in Shimoga Town, Karnataka'. Proceedings of Taal 2007: The 12th World Lake Conference. **2008**, 342-346.
18. S. Joshi, Ecological Quality Index: Standardized Method for Judging the Ecological Health of Rivers and Lakes. *SERI* 7(8), http://blog.seriecotech.com/?p= 377 (assessed on 10th August, 2013).
19. N.S Yadav, M.P. Sharma, A. Kumar., Ecological Health Assessment of Chambal River, India. *J. Mat. Environment. Sci.*, **2015**, 6, 613-618.
20. N.S Yadav, M.P. Sharma, A. Kumar. Assessment of Ecological health of Chambal River using plant species diversity. *J. Mat. Environment. Sci*, **2015**, 6.