FREQUENCY OF SAMPLING IN LAKE TROPHY ESTIMATION BASED ON TSI INDICES

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Abstract: Variations of biological and chemical parameters within and between years can affect negatively on lake quality assessment. The aim of this work was to determine the sampling frequency in the estimation of lake trophy using Trophic State Indices (TSI). TSI indices were calculated based on chlorophyll-α concentration, water transparency, total phosphorus and total nitrogen concentrations. Some options of data collection were taken into consideration. The results suggest, that sampling during two years, versus one year, ensure adequately trophy estimation. The most effective choice of the study terms should consider at least two-year period, even if only one sample will be taken every year.

Key words: *eutrophication, TSI indices, ecological state.*
Słowa kluczowe: eutrofizacja, wskaźniki TSI, stan ekologiczny.

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1. Introduction

Some biological and chemical parameters are used in the assessment of the ecological status of surface water, according to the EU Water Framework Directive (EC Parliament and Council, 2000). It takes into account, amount others, also the concentration of chlorophyll-α, total nitrogen, total phosphorus and Secchi disk visibility as a measure of water transparency, which are also the basis in the estimation of trophic status according to Carlson's indices. Variations of biological as well as chemical parameters can lead to the considerably changes of Carlson's indices in time (Carlson, 1977, Kratzer and Brezonik, 1981).

Hence, frequency of sampling can affect the estimation of lake trophic status, often leading to underestimation or overestimation of lake trophy. Carlson (1977) stated, that some periods should be identified, during which samples should be taken, for lake classification and considered sampling frequency in whole year. Therefore, the influence of sampling frequency on evaluation reliability and determination of study terms in the estimation of lake trophic status, were taken into consideration.

2. Materials and methods

The studies were carried out in Lake Maśluchowskie (51°28'03" N, 22°56'43" E), located in the Łęczna–Włodawa Plain in Eastern Poland (Kondracki, 2002). This is the small (surface area – 27 ha), shallow (maximum depth – 9.4 m), dimictic and eutrophic lake (Radwan and Kornijów, 1998), with the catchment basin area of 113.9 ha, 75% of which is under agricultural use (Furtak et al., 1998).

Lake Maśluchowskie was sampled biweekly from May to August in two years 2010 and 2011. During two years of the study chemical analyses of total nitrogen (TN) and total phosphorus values (TP), biological analyses of chlorophyll-α values as well as water transparency were determined.

Sampling point was located in pelagial zone of the lake. Water samples to the analyses were always taken from epilimnion, using a Ruttner type water sampler (2.0 dm^3 capacity), at depth intervals of 1 m (from the surface to 3 m) and poured into one collective sample.

The concentration of chlorophyll-α, as a measure of the phytoplankton amount, was determined according to the standard method (Nush, 1980). The chemical analyses of total values (TN and TP) were estimated in a laboratory according to colorimetric methods described by Hermanowicz et al. (1999). The water transparency was measured in situ using Secchi disk (SD).

On the basis of chemical and biological data, trophic state indices (TSI) were calculated using the equations described by Carlson (1977) and Kratzer and Brezonik (1981).

On the basis of calculated Carlson's indices, reliability of different sampling options was evaluated, in order to determine the most effective choice of study terms that ensure accurate estimation of lake trophic state. The assumption was, that long-time observations were representative in determination of lake trophy.

The options taken into consideration were: 1 – two samples at the same terms in two years, 2 – monthly during one year (four samples), 3 – monthly, at the same terms in two years (eight samples). The results of the particular options were compared to the general TSI indices obtained from two-year study (16 samples). The variance of each option in relation to the general TSI was calculated to evaluate the reliability of the particular sampling options (Sokal and Rohlf, 1995). The options were assumed as reliable, if presumably ca. 70% of TSI indices didn't exceed the general TSI more than 4, what means that maximum variance s2 = 16 and standard deviation s = 4 were acceptable. This level of acceptance ensure that the results are highly consisted with estimated trophic state.

3. Results

The trophic state indices TSI based on chlorophyll-α and TP concentrations, which average values were respectively 62.2 and 58.2, indicated eutrophic state of the lake. The mean value of TSI (SD) was 53.2 and revealed moderate eutrophy. The highest values of TSI was calculated for TN concentration (mean 73.8), which pointed relatively high trophic state (hypertrophy).

During the study period TSI indices considerably changed indicating higher trophy in 2011, than in 2010. Especially, TSI (TN) changed from eutrophy to hypertrophy (Fig. 1). The values of TSI (SD) occasionally showed mesotrophic character of the water body. Sporadically, there were also values TSI (TP) and TSI (Chl), which indicated higher trophic status (hypertrophy).

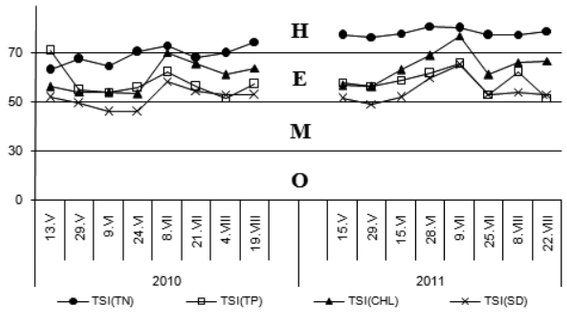

Fig. 1. The values of Carlson's indices in Lake Maśluchowskie: H – hypertrophy, E – eutrophy, M – mesotrophy, O – oligotrophy
Rys. 1. Wartości indeksów Carlsona w jeziorze Maśluchowskim: H – hypertrofia, E – eutrofia, M – mezotrofia, O – oligotrofia

Particular sampling options, analysed in the present study, were differentiated with respect to agreement with mean values of TSIs obtained from 16 samples (Tab. 1). Only two options (no. 1 – two samples at the same terms in two years and no. 3 – monthly, at the same terms in two years) were very close to the mean TSIs values received for two years and fulfilled the assumptions taking into consideration in this work. The option no. 2 – monthly during one year was evaluated negatively, because the variance of TSI (TN) was beyond the acceptance level.

Tab. 1. Variances of the trophic state indices (TSI) from mean values of TSI (TN) = 73.8, TSI (TP) = 58.2, TSI (Chl) = 62.2, TSI (SD) = 53.2 (based on 16 samples) in Lake Maśluchowskie
Tab. 1. Wariancje indeksów troficznych (TSI) względem średnich wartości TSI (TN) = 73,8, TSI (TP) = 58,2, TSI (Chl) = 62,2, TSI (SD) = 53,2 (otrzymanych na podstawie 16 prób) w jeziorze Maśluchowskim

Options *Opcje*	**TSI (TN)**	**TSI (TP)**	**TSI (Chl)**	**TSI (SD)**
1*	8	6.9	11.8	5.9
2	23	5.5	6.7	3.2
3*	0.4	5.2	0.8	0.7

* acceptable option

* *dopuszczalna opcja*

4. Discussion

Different indices e.g. TSI (Carlson 1977), OECD (1982) or parameters based on microbial activities (Kiersztyn et al., 2002) can be used in lake trophy estimation. Calculation of Carlson's trophic state indices is commonly used method that can give fast information about trophic status of the aquatic environment. Values of TSI indices calculated on TP, TN, chlorophyll-α and visibility (SD) are generally correlated, but considerable differences between them are often observed, as can be seen in Lake Maśluchowskie. Values of TSI can be differentiated spatially including changes across the water column and varied also within and between years (Messyasz, 2001; Zykubek, 2006; Lenard and Solis, 2009). Hence, its estimation can be subjected by significant error, especially when the frequency of sampling is too rare or samples are collected at inadequate period (Carlson, 1977; Kratzer and Brezonik 1981).

The result suggest, that sampling during two years ensure adequately estimation of lake trophic state. Frequent data sampling contribute to better estimation of lake trophy. In this case the best results were obtained for two years of the study (option no. 3). The most effective choice of the study terms should consider at least two-year period, even if only one sample will be taken every year (option no. 1). It can be more adequate than taking samples more often, but during only one vegetation season (option no. 2).

In conclusion, correct assessment method is important to right estimation of lake ecological state. It can be useful in lake management, especially in environment protection or fishery and recreational use.

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CZĘSTOŚĆ POMIARÓW W OCENIE TROFII ZBIORNIKA WODNEGO NA PODSTAWIE INDEKSÓW TSI

Streszczenie

Zmienność elementów biologicznych i parametrów chemicznych w ciągu roku i między latami mogą wpływać negatywnie na dokładność oceny jakości stanu troficznego jeziora. Celem pracy było określenie częstości pobierania prób niezbędnej do prawidłowej oceny stanu zbiornika wodnego z wykorzystaniem wskaźników stanu troficznego wg Carlsona (TSI). Wskaźniki TSI obliczane były z wykorzystaniem stężenia chlorofilu-α, przezroczystości wody oraz stężenia fosforu i azotu ogólnego. W pracy testowano kilka opcji częstości i terminów zbioru danych. Wyniki wskazują, że zbiór danych w ciągu dwóch lat, w przeciwieństwie do okresu jednego roku, zapewniał adekwatną ocenę trofii jeziora. Najbardziej efektywny dobór terminów w ocenie trofii zbiornika wodnego powinien uwzględniać przynajmniej dwuletni okres badań, nawet jeśli każdego roku próby pobierane są tylko raz.