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ESTIMATION OF RIVER TROPHY IN THE KUJAWSKIE LAKELAND USING MEAN TROPHIC RANK AND CHEMICAL INDEX OF TROPHY

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ABSTRACT. The aim of the studies carried out in the year 2000 was evaluation of Mean Trophic Rank (MTR) method for water trophy assessment in the Kujawskie Lakeland and estimation of necessary changes in list of bioindicators. During researches results from MTR were compared with Chemical Index of Trophy (CIT) created for conditions of the Kujawskie Lakeland. Obtained results were very promising and both methods could be used in this region in the future.

Key words: Mean Trophic Rank, biological indicators, macrophytes, river trophy, Chemical Index of Trophy, the Kujawskie Lakeland

Research area

Researches were carried out in watercourses localised in watershed of Brdowskie Lake (Kujawskie Lakeland). Arable lands cover about 74 percent of analysed area with 14.5% of meadows and some enclaves of coniferous forests (about 1.7%). Duration of vegetation period is 170-180 days. This part of Poland has particularly low precipitation with average annual sum of 538 mm for period 1951-1980 and average annual air temperature in Koło of 7.9°C (**Woś** 1994). The composition of plant communities in research area is simplified and vegetation shows synantrophic symptoms (**Kucharski** 1986, **Staniszewski** and **Szoszkiewicz** 2000, **Staniszewski** 2001 a).

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Methods

Studies on river trophy using Mean Trophic Rank (MTR) were carried out in the year 2000 at 16 selected sites. In that year two sites (6 B and 19, Fig. 1) did not fulfil demands of the method (lack of water in watercourses) and analyses could not be realised. The MTR procedures were adopted form **Dawson** et **al.** (1999) and **Holmes** et **al.** (1999). The system based on plant species (algae, mosses, horsetails, liverworts, monocotyledonous and dicotyledonous plants) which have some value as biological indicators of water trophy.

List of plant species used as bioindicators in MTR method
(original names from **Dawson** et **al.** 1999 were cited)

Acorus calamus
Alisma lanceolatum
Alisma plantago aquatica
Amblystegium fluviatile
Amblystegium riparium
Apium inudulatum
Apium nodiflorum
Azolla filiculoides
Batrachospermum sp.
Berula erecta
Blindia acuta
Brachytecium plumosum
Brachytecium rivulare
Brachytecium rutabulum
Bryum pseudotriquetum
Butomus umbelatus
Calliergon cuspidatum
Callitriche hamulata
Callitriche obtusangula
Carex acuta
Carex acutiformis
Carex riparia
Carex rostrata
Carex vesicaria
Catabrosa aquatica
Ceratophyllum demersum
Chiloscyphus polyanthos
Cinclidotus fontinaloides
Cladophora agg.
Dichodontium flavescens
Dichodontium pellucidum
Dicranella palustris
Eleocharis palustris
Elodea canadensis
Elodea nutuallii
Enteromorpha sp.
Equisetum fluviatile
Equisetum palustre
Fontinalis antipyretica
Fontinalis squamosa
Glyceria maxima
Groenlandia densa
Hildenbrandia rivularis
Hippurus vulgaris
Hydrocharis morsus-ranae
Hydrodictyum reticulatum
Hygrohypnum luridum
Hygrohypnum ochraceum
Hyocomium armoricum
Iris pseudacorus
Juncus bulbosus
Lemanea fluviatilis
Lemna gibba
Lemna minor
Lemna trisulca
Littorella uniflora
Lotus uliginosus
Marsupella emarginata
Menyanthes trifoliata
Montia fontana
Myriophyllum alterniflorum
Myriophyllum spicatum
Nardia compressa
Nasturtium officinalis
Nuphar lutea
Nymphaea alba
Nymphoides peltata
Oenanthe crocata
Oenanthe fluviatilis
Pellia endivifolia
Pellia epiphylla
Philonotis fontana
Phragmites australis
Polygonum amphibium
Polytrichum commune
Potamogeton alpinus
Potamogeton berchtoldii
Potamogeton crispus
Potamogeton freisii
Potamogeton gramineus
Potamogeton lucens
Potamogeton natans
Potamogeton obtusifolius
Potamogeton pectinatus
Potamogeton perfoliatus
Potamogeton polygonifolius
Potamogeton praelongus
Potamogeton pusillus
Potamogeton trichoides
Potentilla erecta
Racomitrium aciculare
Ranunculus penic. subsp. *peniculatus*
Ranunculus penic. subsp. *pseudofluitans*

Ranunculus penic. subsp. *vertumnus*	*Rorippa amphibia*	*Spirodela polyrhiza*
Ranunculus aquatilis	*Rumex hydrolapathum*	*Stigeoclonium* sp.
Ranunculus circinatus	*Sagittaria sagittifolia*	*Thamnobryum alopecurum*
Ranunculus flammula	*Scapania undulata*	*Typha angustifolia*
Ranunculus fluitans	*Schoenoplectus lacustris*	*Typha latifolia*
Ranunculus hederaceus	*Scirpus fluitans*	*Vaucheria* sp.
Ranunculus omiophyllus	*Scirpus maritimus*	*Veronica anagalis-aquatica*
Ranunculus peltatus	*Solenostoma triste*	*Veronica catenata*
Ranunculus sceleratus	*Sparganium emersum*	*Veronica scutellata*
Ranunculus trichophyllus	*Sparganium erectum*	*Viola palustris*
Rhynchostegium riparioides	*Sphagnum* sp.	*Zannichellia palustris*

Species Trophic Rank equal to 1 or 2 means that plant is very tolerant for high trophy. For example some algae as *Cladophora* agg. and *Enteromorpha* sp. have STR equal 1 and together with *Potamogeton pectinatus* (STR = 1) are perceived as very tolerant for high trophy. Plants living in mesotrophic and moderatly eutrophic waters have STR equal to 5 or 6, e.g. *Fontinalis antipyretica* (STR = 5) and *Nymphaea alba* (STR = 6). Species Trophic Rank equal to 10 means that plant is not tolerant for higher trophy and good example are *Sphagnum* sp. and *Juncus bulbosus*. Species Trophic Ranks of all plants occurring in studies are indicated in Table 1. The MTR list of bioindicators consists of over 100 species and their tolerance for water trophy and cover of river area in sampling site are taken into account (Formula 1). Species Cover Value varied from 1 to 9 and depends on area covered by plant species as follows: covered area < 0.1% – SCV = 1, 0.1-1% – SCV = 2, 1-2.5% – SCV = 3, 2.5-5% – SCV = 4, 5-10% – SCV = 5, 10-25% – SCV = 6, 25-50% – SCV = 7, 50-75% – SCV = 8 and covered area > 75% – SCV = 9. Basically, MTR is dividing rivers into four categories shown in Table 2.

Formula 1. Calculation of MTR
Wzór 1. Obliczanie MTR

$$MTR = \frac{\sum (STR \times SCV)}{\sum SCV} \times 10$$

where: MTR – Mean Trophic Rank, STR – Species Trophic Rank (range 1-10), SCV – Species Cover Value (range 1-9).

In the same sites where macrophytes and other plants were analysed, water samples were taken according to Chemical Index of Trophy (CIT). Chemical analyses were done three times in period 2000-2001 and index was calculated due to the procedures adopted from **Staniszewski** (2001 b). CIT consists of following components: total phosphorus (TP), soluble reactive phosphates (SRP) and nitrates concentrations in water and final result is calculated from at least three measurements from different seasons of year or longer period.

Table 1

The values of STR, SCV and MTR after research carried out in several sites in the year 2000
Wartości STR, SCV i MTR uzyskane na podstawie badań przeprowadzonych na wybranych odcinkach w 2000 roku

Indicators Gatunki wskaźnikowe	STR	3 B	4	6 a	7	9	10	20	21	24	25	27 a	27	28	29
Cladophora agg.	1		3											5	
Vaucheria sp.	1	1								1					1
Potamogeton pectinatus	1	1			1				1	2				1	
Ceratophyllum demersum	2	4	2			5		2	2	1		5	5	2	1
Acorus calamus	2		1	1	1	1				1				3	2
Spirodela polyrhiza	2	1	1						1			2		1	3
Typha latifolia	2		1	1		1		1		1					
Nuphar lutea	3		5							1				4	
Rorippa amphibia	3	1				1		1	1		2			1	1
Rumex hydrolapathum	3	1	1	1		1	1	1	1	1	2		1	1	1
Alisma plantago aquatica	3	1		1	1					1			1		
Glyceria maxima	3	7	5	6	6	1		6		6	7		3	2	6
Sagittaria sagittifolia	3												1		
Sparganium erectum	3				3										2
Polygonum amphibium	4				2			2					1	2	1
Carex riparia	4			1	1	2				1	1		2	2	
Lemna minor	4	5	5	7		1	9	2	2	5	2	7		5	5
Lemna trisulca	4	1	1				1			1		1		1	
Phragmites australis	4	1	2	3	1	7		5	1			7	2	5	1
Potamogeton perfoliatus	4		3									1			
Fontinalis antipyretica	5		1											1	
Equisetum palustre	5						1								
Berula erecta	5												1	3	
Elodea canadensis	5	4	2							2		5	4		3
Iris pseudoacorus	5			1	1	1		2	1	1	2	1	2	1	1
Potamogeton natans	5											1			
Eleocharis palustris	6													2	1
Hydrocharis morsus-ranae	6		3		1	1				1		2	6	3	1
Ranunculus fluitans	7									1					1
Potentilla erecta	9				1										
Sphagnum sp.	10													2	
MTR		32.1	34.2	35.0	36.3	33.6	40.0	34.5	30.0	34.0	34.4	39.1	41.0	37.7	35.5

Table 2

Trophic categories and recommended actions (Dawson et al. 1999)
Kategorie troficzne i proponowane działania zaradcze (Dawson i in. 1999)

Band Kategoria troficzna	Range of MTR scores Przedziały MTR	Recommended action Proponowane działania zaradcze
1	> 65	Nutrient reduction not required – monitor changes Redukcja dopływu biogenów nie jest wymagana – monitorowanie zmian
2 a	45-65	Monitor diffuse or direct pollution inputs Monitorowanie przestrzennych lub punktowych dopływów związków biogennych
2 b	25-45	Monitor direct nutrient and diffuse inputs and formulate proposals for nutrient reduction Monitorowanie źródeł punktowych i rozproszonych oraz sformułowanie propozycji ograniczenia tego dopływu
3	< 25	Nutrient reduction measures required Konieczne są środki zaradcze

Results

Research shows that MTR and CIT gave similar results, although obtained in different way. During field studies 31 plant species from MTR list of bioindicators were found. On this basis water in rivers was classified in band 2 b according to the British system (Fig. 1). It means that monitoring of the direct nutrient and diffuse inputs is necessary as well as formulating proposals for nutrient reduction in water and sediments. This statement is very close to the situation observed in Brdowskie Lake watershed where many households have not connection to water treatment plants and discharge effluents to the ground or directly to open waters (**Staniszewski** 2001 b). In Mean Trophic Rank typical terms of trophy as, e.g. oligotrophy, does not exist but rivers classified in band 2 b are related to rivers with moderate level of trophy.

The Chemical Index of Trophy shows that watercourses have meso- and eutrophic waters (Fig. 2, Tab. 3). Chemical results varied in seasons mostly due to the water discharge, agricultural activities and plant cover of surrounding area.

Table 3

Results of chemical analyses carried out in years 2000 and 2001
Wyniki analiz chemicznych prowadzonych na przełomie lat 2000 i 2001

Location Miejsca poboru prób	TP Fosfor ogólny	SRP Fosforany	Nitrates Azot azotanowy	TP Fosfor ogólny	SRP Fosforany	Nitrates Azot azotanowy	TP Fosfor ogólny	SRP Fosforany	Nitrates Azot azotanowy
	mg PO_4 $\cdot dm^{-3}$	mg PO_4 $\cdot dm^{-3}$	mg $N\text{-}NO_3$ $\cdot dm^{-3}$	mg PO_4 $\cdot dm^{-3}$	mg PO_4 $\cdot dm^{-3}$	mg $N\text{-}NO_3$ $\cdot dm^{-3}$	mg PO_4 $\cdot dm^{-3}$	mg PO_4 $\cdot dm^{-3}$	mg $N\text{-}NO_3$ $\cdot dm^{-3}$
	August 2000 – sierpień 2000			September 2000 – wrzesień 2000			April 2001 – kwiecień 2001		
3 B	0.70	0.24	1.40	4.58	4.56	0.12	0.89	0.22	1.00
4	0.35	0.33	0.44	0.37	0.35	0.09	0.84	0.02	1.04
6 a	1.80	1.05	0.49	0.85	0.75	0.38	0.17	0.16	0.25
7	0.15	0.08	0.28	0.21	0.14	0.10	0.42	0.40	1.34
9	0.25	0.22	0.44	0.34	0.16	0.08	0.36	0.32	1.32
10	1.00	0.63	0.15	1.53	0.69	0.08	0.37	0.36	1.34
20	0.63	0.61	1.19	0.80	0.78	0.12	0.54	0.36	3.13
21	0.37	0.34	1.31	3.52	3.25	0.08	0.40	0.10	4.70
24	0.30	0.28	0.63	0.54	0.38	0.04	0.50	0.02	2.38
25	0.26	0.24	0.29	0.29	0.28	0.08	0.25	0.02	1.25
27 a	0.38	0.38	0.34	0.22	0.14	0.18	0.33	0.32	1.31
27	0.20	0.19	0.18	0.17	0.15	0.14	0.28	0.24	1.01
28	0.22	0.19	0.20	0.22	0.21	0.14	0.36	0.34	1.33
29	1.41	1.32	0.54	0.59	0.58	0.28	0.58	0.44	2.13

Discussion

Using plant species as indicators of water trophy the same results in all sites were obtained. The probable reason is that individual plants and plant communities are present in watercourses for several years and they are an answer of nature for specific ecological conditions in period longer than only one year. Obtained results were very promising and using Mean Trophic Rank in Kujawskie Lakeland and other parts of Poland seems to be possible. Of course further researches on adaptation to Polish vegetation are necessary. For instance *Apium nodiflorum*, *Callitriche obtusangula*, *Elodea nutualli* and some other plants do not exist in Poland and could be replaced by other plant species, typical for Polish rivers. Such an investigation is in progress and in the future full adaptation would be accessible as a printed paper. MTR could be a great complement to existing system of water quality monitoring in Poland because until now there is any national system for water quality or trophy monitoring basing on biological indicators.

The Chemical Index of Trophy needs to be tested in other parts of Poland and after that could be used in water monitoring practice and should be helpful in other activities e.g. in feasibility studies and thesis.

Comparison of Mean Trophic Rank and Chemical Index of Trophy is possible but one should know about differences in describing water trophy by these methods. It is among others, because MTR does not use typical terms as oligotrophy or eutrophy (Tab. 4) which can create some problems in such analyses. Both methods gave similar results and can be use the same time to obtain more complete picture of water trophy in rivers.

Table 4

Relations between trophic categories established using MTR and CIT. Trophic categories observed during studies are shaded
Relacje pomiędzy kategoriami troficznymi określanymi metodami MTR i CIT. Zacieniono kategorie troficzne stwierdzone podczas badań

MTR	CIT
1	OLIGOTROPHY OLIGOTROFIA
2 a	MESOTROPHY MEZOTROFIA
2 b	EUTROPHY EUTROFIA
3	HYPERTROPHY HYPERTROFIA

Conclusions

Mean Trophic Rank is used in Great Britain by NERC Institute of Freshwater Ecology for rivers monitoring and in the future could be one of obligatory methods in EC. The implementation of MTR in Poland needs further researches and they are carried out in Department of Ecology and Environmental Protection of August Cieszkowski Agricultural University in Poznań. The research would be focused on plant species common in Poland, which could replace some plants from MTR occurring very rarely or never seen in our country.

CIT was established for conditions of the Kujawskie Lakeland and seems to be a useful tool in river quality monitoring, especially because all parameters are measured in standard survey carried out by national and local institutions involved in water quality monitoring practice.

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OCENA TROFII WÓD PŁYNĄCYCH NA POJEZIERZU KUJAWSKIM METODĄ MEAN TROPHIC RANK ORAZ NA PODSTAWIE CHEMICZNEGO INDEKSU TROFII

S t r e s z c z e n i e

Celem niniejszej pracy było porównanie brytyjskiego systemu oceny trofii wód płynących Mean Trophic Rank ze wskaźnikiem chemicznym oraz sprawdzenie przydatności MTR na terenie Pojezierza Kujawskiego.

Mean Trophic Rank opiera się głównie na rozpoznaniu gatunków wybranych roślin jedno- i dwuliściennych, mchów i glonów oraz określeniu ich procentowego udziału w pokryciu powierzchni badanego cieku. Gatunki roślin wykorzystywane w MTR mają przyporządkowane sobie wartości od 1 (wysoka trofia) do 10 (oligotrofia) w zależności od tolerancji na żyzność wód.

Ocenę żyzności wód rzecznych w zlewni Jeziora Brdowskiego przeprowadzono w 2000 roku w 16 wytypowanych odcinkach cieków. Badania przeprowadzone metodą bioindykacyjną oraz analizy chemiczne potwierdziły, że wody powierzchniowe badanej zlewni wykazują na ogół umiarkowany poziom trofii. Uzyskane wyniki świadczą o możliwości wykorzystania Mean Trophic Rank w warunkach Pojezierza Kujawskiego, po pewnych zmianach związanych z różnicami pomiędzy florą Polski i Wielkiej Brytanii.