Annales Universitatis Paedagogicae Cracoviensis
Studia Naturae, 7: 145–170, 2022, ISSN 2543–8832
DOI: 10.24917/25438832.7.9

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Water trophy assessment of the cooling system of the "Dolna Odra" power plant on the basis of algae indicator organisms

Introduction

Cooling waters are characterised by specific features with changed not only thermals, but very often they have also different hydrochemical parameters. The ecological factors of such habitats develop the quantity and quality of phytoplankton structure. Many indicators are used to determine water quality. One of them is saprobity. Sladeček and Sládečková (1996) describe it as the content in the aquatic ecosystem of organic matter capable of biochemical decomposition. Different levels of organic pollution are accompanied by specific biocenosis developing in the water column on its surface among the littoral vegetation or on the bottom of the reservoir.

The theoretical basis of the saprobes system are ecological relationships between the biocenosis and environmental factors. The system of indicator organisms was developed, proposed by Cohn (1853, 1875) and Mez (1898) and elaborated in full by Kolkwitz and Marson (1908, 1909) with subsequent multiple modifications. With this system, in a revised form by Liebmann (1951, 1962), the degree of water pollution is assessed on the basis of decomposable organic compounds (Turoboyski, 1979).

The studies of phytoplankton in heated waters were carried out e.g. in the ecosystems of lakes of the Konin-Pątnów power plant complex (central Poland). They were carried out by the Department of Hydrobiology of the Adam Mickiewicz University in Poznań (Burchardt, 1977). However, they are concerned mainly with the structure of phytoplankton and the qualitative and quantitative changes taking place in it. They did not include determining the trophic status of the lake's waters. Research on contaminated waters, including heated ones, was also carried out in Poland by Turoboyski (1967, 1969).

In this study, the analyses of algae diversity and the assessment of the degree of water trophy based on the indicator organisms of planktonic algae were performed within the hydrological system used for the cooling process of the technical infrastructure of the "Dolna Odra" power plant.

Study area

The research material was collected from four sites located in different parts of the Odra River (western Poland) ecosystem. All sites are located in the Międzyodrze zone and are associated with the waters of the Eastern Odra – known as the Regalica – 53°21′20′′N 14°33′18′′E (Fig. 1).

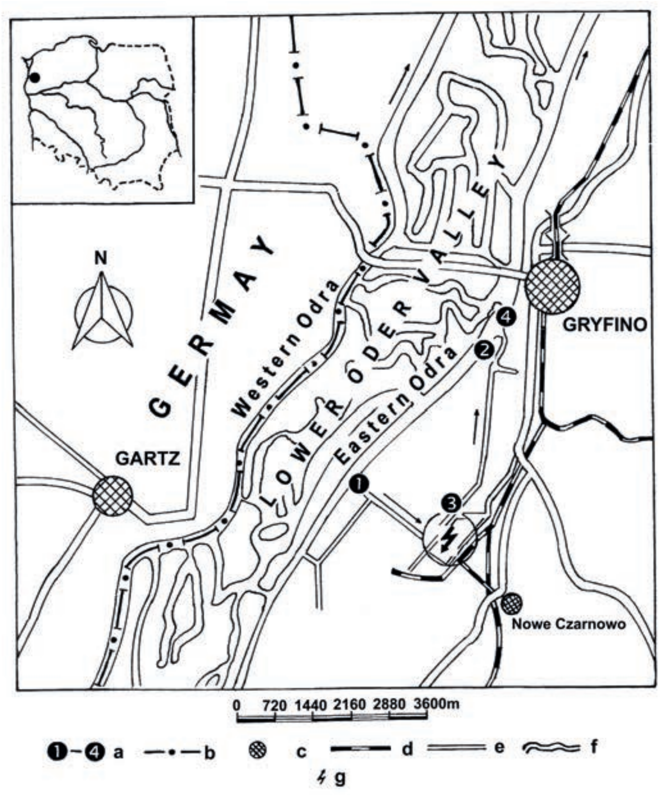

Fig. 1. Location of test stands of the cooling system of the „Dolna Odra";
a – test benches, b – state border, c – cities, settlements, d – railway lines, e – roads, f – canals, oxbow lakes, rivers, f – "Dolna Odra" power plant, g – power station

Site 1 – canal waters with natural thermals supplied to the power plant. The site is located in the area of the cold canal, adjacent to the river current, which supplies water with natural thermals to the "Dolna Odra" cooling system intake;

Site 2 – the waters of the East Odra River above the mouth of the warm canal. The station is located in the river’s waters above the point of the warm channel estuary to the mainstream of the Eastern Odra flowing along the main riverbed, characterised by unchanged thermals of discharge waters;

Site 3 – the waters of the warm canal discharging the cooling water. The station is situated in the channel which discharges the discharge water with increased thermal temperature from the cooling system of the “Dolna Odra” power plant. Plankton samples were collected in the area of the experimental fishing station WRMiTŻ ZUT in Szczecin, which is the place of ichthyological research;

Site 4 – the waters of the East Odra River downstream of the warm canal with elevated temperature due to post-cooling waters. The site is located in the Międzyodrze area slightly below the junction of the warm canal with the current of the East Odra River. In this part of the main current, the rivers with unchanged thermals mix with the waters flowing from the warm water discharge canal.

Materials and methods

The study focuses primarily on the assessment of water trophies based on the identified algae species. From each of the four sites located in different parts of the hydrological system, 4 samples with a volume of 18 litres of water were collected during the year and concentrated with a plankton mesh to 1 litre. From this volume, after thorough mixing of the sample, 3 microscopic slides were prepared to determine the qualitative composition and the value of the frequency of the organism occurrence (h) expressed by the number of specimens of individual species in the field of view (Starmach, 1955). The observed species were determined with the use of taxonomic literature.

The method of Pantle and Buck (1955) used here introduces the saprobic index (Sw) determined based on the so-called saprobial values of individual species (S) and frequency of the organism occurrence (h). The saprobic value for various types of water was assumed according to the criteria presented in table (1). The frequency of the organism occurrence (h) is determined based on the percentage of individuals about all individuals of all species (Tab. 2).

Tab. 1. Saprobic value [S] for various types of water

Zone	Designation	S
xenosaprobity	x	0
oligosaprobity	o	1
β–mesosaprobity	β	2
α–mesosaprobity	α	3
polisaprobity	p	4

Tab. 2. The frequency of the organism occurrence [h] for different percentage ranges

Percentage of a taxa	h
up to 1 %	1
1 – 3 %	2
4 – 10 %	3
10 – 20 %	4
20 – 40 %	5
40 – 100 %	6

The basis for the calculation of the saprobic index (S) for individual samples was the floristic analysis and determination of the frequency of taxa in the samples. The index of the saprobic value (S_i) and the indication weight of the taxon (I_i) was obtained based on data from the literature (Sladeček, Sládečková, 1996). The abundance of a taxon found (h) in the field of view was examined based on a scale according to Starmach (1989):

1 – rarely, when the species is present in about 1% of the fields of view;

3 – often, when the species is present in 5 – 30 fields of view;

5 – mass, when the species is present in 60 – 100 fields of view.

When determining the trophic status of ecosystem waters, only taxa with known saprobity were taken into account, the value and indicator values of which were presented and taken into account when determining the trophic status of ecosystem waters in the literature (Sladeček, Sládečková, 1996).

The Pantle and Buck (1955) saprobic index (S_w) is calculated according to the formula:

$$S_w = \frac{\sum(h \cdot S_i)}{\sum h} \tag{1}$$

where:

S_w – saprobic index, S_i – saprobic value of the species, h – the frequency of the species occurrence.

The product is calculated for each marked species.

The pattern of Panle and Buck (1955) with the modification of Marvan (after Sladeček, Sládečková, 1996) introduces the indication weight of individual species Ii:

$$S = \frac{\sum(S_i \cdot h_i \cdot I_i)}{\sum(h_i \cdot I_i)} \tag{2}$$

where:

S – saprobic index, S_i – saprobic value of the species, I_i – the indication weight of the individual taxon (range from 1 to 5, where 1 – oligosaprobity, 2 – β-mezosaprobity, 3 – α-mezosaprobity, 4 – polisaprobity, 5 – izosaprobity), h_i – the abundance of a taxon found.

The values of the saprobic index inform about the degree of water clarity. These values are classified in the following ranges: oligosaprobity S = 1.00, between oligo- and *β*–mezosaprobity S = 1.50, *β*–mezosaprobity S = 2.00, between β–mezo– and *α*– mezosaprobity S = 2.50, *α*- mezosaprobity S = 3.00, polisaprobity S = 3.50.

Results and discussion

Any aquatic organism can be used as an indicator. If we know at least their living environment, we can use their presence to determine the water quality (Sladeček, Sládečková, 1996; Ostrowska, 2012). According to Burchardt et al. (1994) a bioindicator is any taxon whose presence or item of number is associated with a specific set of physicochemical conditions that define the framework for the functioning of a specific state of the biocenosis.

Saprobic systems contain lists of species with their indicating value and saprobial values. Most system takes into account different systematic groups of organisms e.g. bacteria, algae or invertebrate animals. There are also those in which there is only one selected group e.g. diatoms, euglenophytes or benthic invertebrate. For the saprobial system, many lists of species have been developed, together with their saprobicity determination for the use of water quality research institutions.

The expression of the use of algae as indicators of environmental quality are systems of organisms based on practical observations of their occurrence in specific environmental conditions (Kawecka, Eloranta, 1994). Another measure of water quality is the trophy of the reservoir, determined both by the content of nutrients, characteristic organisms, chlorophyll concentration, biomass size, etc.

Many researchers have tried to improve and complete the Kolkwitz and Marsson system (1908, 1909); there have been many studies comprehensively developing the issue of biological assessment of pollutants, as well as attempts to modify the saprobes system and introduce other methods. In Poland, it was mainly Turoboyski (1970a, 1970b, 1973, 1976) who worked on it, which determined the index value of individual species. Indicating the ranges of the variability of species' quantitative occurrence in pollution zones, he contributed to the refinement of the classical methods results, concerning contaminated waters. Starmach (1955) divided the waters on the basis of the presence of certain species of algae into: spring waters – cataract, clean – oligosaprobic, slightly contaminated – β–mesosaprobic, heavily polluted – α–mesosaprobic, extremely contaminated – polysaprobial, partially poisoned, poisoned.

The classification of algae clearly differs, especially in the polysaprobic, oligosaprobic and cataract zones, the latter including waters not contaminated with any sewage. The zones of α– and β–mesosaprobic waters, due to their significant similarity, differ in more difficult to perceive features in the occurrence of individual algae taxa. This is due to the fact that eutrophic water species need a higher concentration of nutrients to achieve maximum growth compared to oligotrophic waters, where cells reach their maximum growth rate even at low nutrient concentrations.

Various species of algae are used to assess the environment. The most useful in bioindication are diatoms (Ostrowska, 2012). Other algae used as indicators of the characteristics of the aquatic environment are: green algae, including charophytes, desmidiales, and golden algae.

When determining water pollution zones on the basis of biological analyses performed, it is advisable to compare these results with chemical analyses, as the complete assessment of water consists of a complex of physical, chemical and biological factors.

The chemical definition of water pollution zones expressed by the value of BOD_5 and dissolved oxygen (Turoboyski, 1979) is as follows: polisaprobic zone: BOD_5 >15 mg/l O_2, dissolved oxygen < 2 mg/l O_2, α–mezosaprobic zone: BOD_5 5–15 mg/l O_2, dissolved oxygen 2–4 mg/l O_2, β–mezosaprobic zone: BOD_5 3–5 mg/l O_2, dissolved oxygen 5–9 mg/l O_2, oligosaprobic zone: BOD_5 < 3 mg/l O_2, dissolved oxygen > 9 mg/l O_2.

Species composition and saprobic value of the taxon

Altogether 101 algae taxa were identified in 16 samples collected from the cooling system of the „Dolna Odra" power plant. Representatives of the following phyla were distinguished: Cyanoprocaryota, Dinophyceae, Chrysophyceae, Bacillariophyceae, Euglenophyceae, and Chlorophyceae (Tab. 3 – Appendix 1; Fig. 2).

1. Species frequently found in the studied waters (Fig. 3–6 – Appendix 2)

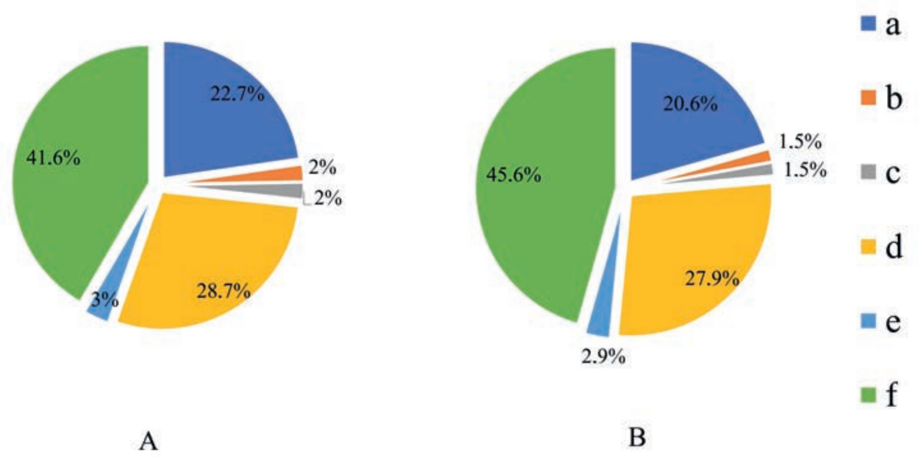

Fig. 2. Percentage share of all organisms (A) and indicator species (B) at studied sites: Cyanoprocaryota – a, Dinophyceae – b, Chrysophyceae – c, Bacillariophyceae – d, Euglenophyceae – e, Chlorophyceae – f

The most numerous group in the studied waters are green algae of the order Chlorococcales. Common planktonic species are *Pseudopediastrum boryanum, Pediastrum duplex* var. *duplex, Lacunastrum gracillimum*, *Tetradesmus lagerheimii, Desmodesmus communis, Desmodesmus opoliensis* and *Lemmermannia triangularis.*

Cyanobacteria are represented by: *Aphanocapsa delicatissima*, *Planktothrix agardhii*, *Limnothrix planctonica*, *Microcystis aeruginosa*, *Microcystis wesenbergii*, *Pseudanabaena mucicola*, *Dolichospermum flosaquae*, *Aphanizomenon flexuosum*.

Another group of algae abundant in these waters are diatoms: *Aulacoseira granulata* var. *granulata*, *Aulacoseira granulata* var. *angustissima*, *Fragilaria crotonensis*, *Stephanodiscus hantzschii*, *Asterionella formosa*, *Cyclotella meneghiniana*, *Actinocyclus normanii*, *Synedra ulna*, *Melosira varians*, *Nitzschia sigmoidea*, *Ulnaria danica*.

2. Indicator species in the studied waters

The qualitative taxonomic composition of the studied sites shows that the most numerous group of indicator species allowing for the calculation of the saprobic index (S) and determination of belonging to the β–mesosaprobic zone were the Chlorophyceae taxa (Tab. 4). Green algae represent approximately 42% of the total number of species. At the same time, among this group of algae, as much as 45.6% are bioindicators. The largest group is Chlorococcales. These data are consistent with previous studies (Sládeček, Sládečková, 1996). The small share of bioindication species from the order Volvocales is astonishing. Of the 57 taxa considered to be bioindication organisms of this order, only 2 were recorded. An important role in the assessment of the saprobic of these waters is also played by representatives of Bacillariophyceae (19 bioindicators) and Cyanoprocaryota (14 bioindicators).

Tab. 4. Share of indicator species at studied sites (1–4)

Taxonomy	Number of taxa/Number of site								Total number of species			
	1		2		3		4					
	Total	Indicator	Total	Indicator	Total	Indicator	Total	Indicator	During the research period	[%]	Indicator species	[%]
Cyanoprocaryota	16	8	15	8	16	9	14	10	23	22.7	14	20.6
Dinophyceae	-	-	-		2	1	1	2	2	2.,0	1	1.5
Chrysophyceae	-	-	1	1	2	-	1	2	2	2.0	1	1.5
Bacillariophyceae	15	11	16	10	19	12	18	14	29	28.7	19	27.9
Euglenophyceae	-	-	-	1	-	-	3	2	3	3.0	2	2.9
Chlorophyceae:	35	23	23	17	29	21	24	18	42	41.6	31	45.6

Volvocales	1	1	2	1	2	2	2	1	2	2.0	2	2.9
Chlorococcales	29	21	16	14	21	16	19	16	33	32.7	27	39.7
Desmidiales	5	1	5	2	6	3	3	1	7	6.9	2	2.9
Total	66	42	56	37	68	43	61	48	101	100	68	100

3. Saprobic index (S)

Species with a wide ecological spectrum, occurring in waters with different trophies and not having a specific saprobe value and indicator value in the calculations were not taken into account. For taxa occurring sparse in the analysed samples and having an indicator value assumes value 1 for the frequency of the species occurrence.

The degree of water pollution of individual sites was determined on the basis of bioindicators, i.e. species of algae with an indicator value. During the research cycle, the saprobic index fluctuated at individual sites (Fig. 7), reaching a value from 1.613 to 2.024 (Tab. 5). Its average values in waters with different thermal temperatures were on a similar level.

The value of the water saprobic index value of all sites indicates their belonging to the waters of the β–mesosaprobic. According to Sladeček and Sládečková (1996), the saprobic index value ranging from 1.51 to 2.50 (mean S = 2.0) indicates the waters of the β–mesosaprobic. This zone is characterised by the course of biochemical processes under aerobic conditions as a result of which complete oxidation of the intermediate products of decomposition of organic compounds takes place.

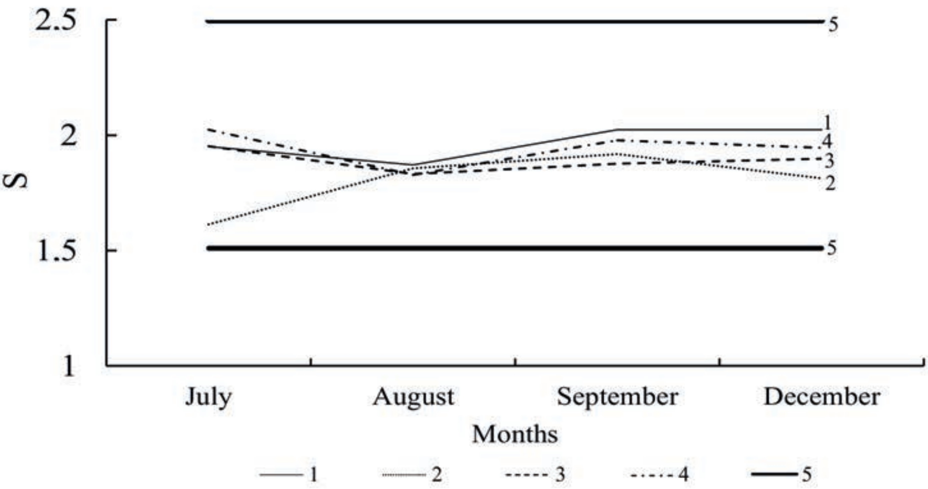

Fig. 7. Saprobic index [S] at four sites during the months July – December 2004;
1–4 – numbers of site (see in the text), 5 – min.-max. values of ß–mesosaprobic zone

Tab. 5. Saprobic index value in the test waters; 1–4 – study sites

Date	Site /Saprobic index			
	1	2	3	4
09.07.2004	1.951	1.613	1.952	2.024
10.08.2004	1.871	1.857	1.832	1.828
06.09.2004	2.024	1.919	1.877	1.978
07.12.2004	1.832	1.813	1.898	1.945
Average saprobic index	1.919	1.800	1.889	1.944

A characteristic feature of the waters of the β–mesosaprobic zone is the domination of chemosynthetic and photosynthetic autotrophs, nitrifying bacteria, and algae, mainly Bacillariophyceae and Chlorophyceae. The waters of the studied sites have a similar species composition of algae.

4. Influence of changes in water thermals on the quality composition of phytoplankton
The temperature of the aquatic environment is not only a factor influencing the development of phytoplankton but also its composition (Sládeček, Sládečková, 1996; Ostrowska, 2012). The analyses of the qualitative composition of phytoplankton showed slight differences between individual sites (Tab. 3 – Appendix 1). The structure of phytoplankton, as well as the percentage share of individual systematic groups during the research cycle remain similar and have insignificant differences in the quality composition of phytoplankton. This is visible not only in its structure but also in the percentage share between the individual systematic groups of algae. Such a structure of phytoplankton results from the presence of species with a wide ecological amplitude about the environmental thermals. An important factor here is also a more stable water temperature in large rivers in which there is a tendency to equalize it due to its constant mixing.

Conclusions

The obtained results allow the following conclusions to be drawn:
- average value of the saprobic index allows to classify of the analysed waters of the β–mesosaprobic zone;
- the highest saprobic index, as well as the average index, are found in the waters below the warm channel (site 4). This is surely a consequence of the increase in the temperature of the waters of this site by warm discharge waters from the power plant, as well as the probably changed chemical composition;
- the phytoplankton of the studied waters is typical for slowly flowing, medium fertile waters;
- planktonic species are the absolute dominant taxa. Benthic forms appear sporadically and their presence should be considered accidental;

- the material does not contain species that are rare for algae and the taxa that are present belong to eurobionts.

Conflict of interest

The authors declare no conflict of interest related to this article.

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Appendix 1

Tab. 3. Floristic spectrum of alage. The valid species names of the identified taxa were given on the basis of literature data and the *AlgaeBase database* (2022); Si – saprobic value of the taxon

Site 1 – canal water with natural thermals supplied to the power plant						
			Research terms			
No.	Taxonomy/Taxon	Si	09.07.2004	10.08.2004	06.09.2004	07.12.2004
	Cyanoprocaryota					
1.	*Aphanocapsa delicatissima* W. et G. S. West	.	+	.	+	.
2.	*Planktothrix agardhii* (Gomont) Anagnostidis et Kom.	1.6	+	.	+	.
3.	*Limnothrix planctonica* (Wolosz.) Meffert	.	+	.	.	+
4.	*Oscillatoria* sp.	.	+	.	.	.
5.	*Microcystis aeruginosa* (Kütz.) Kütz.	1.8	+	+	+	+
6.	*Dolichospermum sigmoideum* (Nygaard) Wacklin, L.Hoffmann & Kom.	.	+	.	.	.
7.	cf. *Anabaenopsis arnoldii* Apterarj	1.6	+	.	.	.
8.	cf. *Aphanizomenon flosaquae* Ralfs ex Bornet & Flahault	2.2	+	+	.	.
9.	*Chroococcus turgidus* (Kütz.) Nägeli	1.3	.	+	.	.
10.	*Microcystis viridis* (A. Braun) Lemm.	1.8	.	+	.	.
11.	*Microcysris wesenbregii* (Kom.) Kom. ex Kom.	1.8	.	+	+	+
12.	*Pseudanabaena mucicola* (Naumann & Huber-Pestalozzi) Schwabe	.	.	+	+	.
13.	*Aphanizomenon flexuosum* Kom. & Kováčik	2.2	.	+	+	.
14.	*Woronichinia compacta* (Lemm.) Kom. et Hindák	.	.	.	+	.
15.	*Merismopedia teniussima* Lemm.	2.5	.	.	+	.
16.	*Lyngbya attenuata* F. E. Fritsch	.	.	.	.	+
	Bacillariophyceae					
17.	*Aulacoseira granulata* var. *granulata* (Ehr.) Simonsen	1.8	+	+	+	+
18.	*Aulacoseira granulata* var. *angustissima* (O.F.Müller) Simonsen	1.8	+	+	+	+
19.	*Fragilaria crotonensis* Kitton	1.4	+	+	+	+
20.	*Stephanodiscus hantzschii* Grunow	2.7	+	+	+	.
21.	*Asterionella formosa* Hassall	1.4	+	+	.	+
22.	*Cyclotella meneghiniana* Kütz.	2.7	+	+	+	+
23.	*Actinocyclus normanii* (Gregory) Hustedt	.	+	+	+	+
24.	*Ulnaria danica* (Kütz.) Compère & Bukhtiyarova	.	+	+	+	+
25.	*Melosira varians* Agardh	1.6	+	+	+	+
26.	*Nitzschia sigmoidea* (Nitzsch) W. Smith	2.5	+	+	.	+
27.	*Synedra ulna* (Nitzsch) Ehr.	.	+	.	.	+
28.	*Diatoma tenuis* Agardh	1.5	+	+	.	.

29.	*Nitzschia acicularis* (Kütz.) W. Smith	2.4	+	.	.	.
30.	*Diatoma vulgaris* Bory de Saint-Vincent	2.2	.	.	+	.
31.	*Fragilaria* sp.	.	.	+	.	.
	Chlorophyceae					
32.	*Micractinium pusillum* Fres.	2.5	+	.	+	.
33.	*Mucidosphaerium* cf. *pulchellum* (H.C.Wood) C.Bock, Proschold & Krienitz	.	+	.	.	.
34.	*Coelastrum astroideum* De-Not De Notaris	2.0	+	+	+	+
35.	*Stauridium tetras* (Ehr.) E. Hegewald	1.8	+	+	+	.
36.	*Pseudopediastrum boryanum* (Turp.) E.Hegewald	1.9	+	+	+	+
37.	*Lacunastrum gracillimum* (West & G.S. West) H.McManus	1.9	+	+	+	+
38.	*Pediastrum duplex* Meyen	1.9	+	+	+	+
39.	*Monactinus simplex* (Meyen) Corda	1.5	.	+	+	+
40.	*Tetradesmus lagerheimii* M.J.Wynne & Guiry	2.2	+	+	+	.
41.	*Desmodesmus denticulatus* (Lagerh.) S.S.An, T.Friedl & E.Hegewald	.	+	.	+	.
42.	*Desmodesmus subspicatus* (Chod.) E.Hegewald & A.W.F.Schmidt	.	+	+	.	.
43.	*Verrucodesmus verrucosus* (Y.V.Roll) E.Hegewald	1.7	+	.	+	.
44.	*Desmodesmus communis* (E.Hegewald) E.Hegewald	2.1	+	.	+	.
45.	*Desmodesmus opoliensis* (P.G.Richt.) E.Hegewald	2.2	+	+	+	.
46.	*Tetradesmus obliquus* (Turp.) M.J.Wynne	2.8	.	.	+	.
47.	*Desmodesmus armatus* (Chod.) E.Hegewald	.	.	+	+	.
48.	*Desmodesmus intermedius* (Chod.) E.Hegewald	.	.	+	+	+
49.	*Desmodesmus spinosus* (Chod.) E.Hegewald	.	.	.	+	.
50.	*Lemmermannia triangularis* (Chod.) C.Bock & Krienitz	2.0	+	.	+	.
52.	*Tetrastrum staurogeniiforme* (Schröd.) Lemm.	2.2	+	.	+	.
53.	*Tetraedron caudatum* (Corda) Hansg.	2.0	+	.	+	.
54.	*Tetraedrom minimum* (A. Br.) Hansg.	2.0	.	.	+	.
55.	*Tetrastrum elegans* Playf.	1.5	+	.	+	.
56.	*Actinastrum hantzschii* var. *subtile* Lagerh. Wolosz.	2.3	+	+	+	.
57.	*Actinastrum hantzschii* var. *hantzschii* Lagerh.	2.3	+	.	+	.
58.	*Pandorina smithii* Chod.	2.0	+	+	+	.
59.	*Monoraphidium griffithii* (Barkeley) Komárkova-Lagnerová	2.2	.	+	.	.
60.	*Golenkinia radiata* Chod.	1.8	.	+	.	.
61.	*Quadricoccus ellipticus* Hortob.	.	.	.	+	.
62.	*Closterium nordstedti* var *polystictum* (Nygaard) Rúźička	.	+	+	.	.
63.	*Closterium acerosum* Ehr. ex Ralfs	.	.	+	.	.
64.	*Closterium cf. moliniferum* Ehr. ex Ralfs	2.1	.	+	.	.
65.	*Staurastrum gracile* Ralfs ex Ralfs	.	+	+	.	.
66.	*Staurastrum paradoxum* Meyen ex Ralfs	.	.	.	+	.

Number of taxa	Total	66	43	38	43	20
	Percentage share [%]	100	65.2	57.6	65.2	30.3
Number of indicators	Total	42	31	28	32	14
	Percentage share [%]	63.6	47.0	42.4	48.5	21.2
Dominant	*Aphanizomenon flexuosum*		.	.	+	.
	diatoms Centricae		.	.	+	.

Site 2 – the waters of the East Odra River above the mouth of the warm channel							
			Research terms				
No.	Taxonomy/Taxon	Si	09.07.2004	10.08.2004	06.09.2004	07.12.2004
	Cyanoprocaryota					
1.	*Aphanocapsa delicatissima* W. et G. S. West	.	.	.	+	.
2.	*Planktothrix agardhii* (Gomont) Anagnostidis et Kom.	1.6	+	.	+	.
3.	*Limnothrix planctonica* (Wolosz.) Meffert	.	+	.	.	.
4.	*Microcystis aeruginosa* (Kütz.) Kütz.	1.8	+	+	+	+
5.	*Dolichospermum affine* (Lemm.) Wacklin, L.Hoffmann & Kom.	2.0	.	+	.	.
6.	*Dolichospermum flosaquae* (Bréb. ex Bornet & Flahault) P.Wacklin, L.Hoffmann & J.Kom.	2.0	.	.	+	.
7.	*Microcystis marginata* (Menegh.) Kütz.	.	.	.	+	.
8.	*Microcystis wesenbergii* (Kom.) Kom. ex Kom.	1.8	+	+	+	+
9.	*Pseudanabaena mucicola* (Naumann & Huber-Pestalozzi) Schwabe	.	.	+	+	.
10.	*Aphanizomenon flexuosum* Kom. & Kováčik	2.2	.	+	+	.
11.	*Merismopedia tenuissima* Lemm.	2.5	.	.	+	.
12.	*Woronichinia compacta* (Lemm.) Kom. et Hindák	.	.	+	.	.
13.	*Chroococcus turgidus* (Kütz.) Nägeli	1.3	.	+	.	.
14.	*Anabaena* sp.	.	.	.	+	.
15.	*Snowella lacustris* (Chod.) Kom. & Hindák	1.5	.	.	+	.
	Bacillariophyceae					
16.	*Aulacoseira granulata* var. *granulata* (Ehr.) Simonsen	1.8	+	+	+	+
17.	*Aulacoseira granulata* var. *angustissima* (O.F.Müller) Simonsen	1.8	+	+	+	+
18.	*Fragilaria crotonensis* Kitton	1.4	+	+	+	+
19.	*Stephanodiscus hantzschii* Grunow	2.7	+	+	+	.
20.	*Asterionella formosa* Hassall	1.4	+	+	+	+
21.	*Cyclotella meneghiniana* Kütz.	2.7	+	+	+	+
22.	*Actinocyclus normanii* (Gregory) Hustedt	.	+	.	+	+
23.	*Ulnaria danica* (Kütz.) Compère & Bukhtiyarova	.	+	+	+	+
24.	*Melosira varians* Agardh	1.6	.	+	.	+
25.	*Nitzschia sigmoidea* (Nitzsch) W. Smith	2.5	+	.	.	+
26.	*Synedra ulna* (Nitzsch) Ehr.	.	+	.	+	+
27.	*Diatoma tenuis* Agardh	1.5	.	+	.	.
28.	*Amphora ovalis* (Kütz.) Kütz.	1.5	.	.	+	.
29.	*Gomphonema acuminatum* Ehr.	0.9	.	.	.	+
30.	*Fragilaria* sp.	.	.	.	.	+
31.	*Cymbella* sp.	.	.	.	.	+

	Chrysophyceae					
32.	*Dinobryon divergens* Imhof	1.8	+	.	.	.
	Euglenophyta					
33.	*Colacium vesiculosus* Ehr.	1.9	.	.	+	.
	Chlorophyceae					
34.	*Micractinium pusillum* Fres.	2.5	+	.	.	.
35.	*Schroederia setigera* (Schröd.)Lemm	1.7	+	.	.	.
36.	*Coelastrum astroideum* De-Not De Notaris	2.0	.	.	+	.
37.	*Pseudopediastrum boryanum* (Turp.) E.Hegewald	1.9	+	+	+	+
38.	*Lacunastrum gracillimum* (West & G.S. West) H.McManus	1.8	+	+	.	.
39.	*Pediastrum duplex* Meyen	1.8	+	+	+	+
40	*Monactinus simplex* (Meyen) Corda	1.5	+	+	+	.
41.	*Tetradesmus lagerheimii* M.J.Wynne & Guiry	2.2	+	.	.	+
42.	*Desmodesmus communis* (E.Hegewald) E.Hegewald	2.1	+	+	+	.
43.	*Desmodesmus opoliensis* (P.G.Richt.) E.Hegewald	2.2	+	+	.	+
44.	*Desmodesmus armatus* (Chod.) E.Hegewald	.	+	.	.	.
45.	*Desmodesmus spinosus* (Chod.) E.Hegewald	.	+	.	.	.
46.	*Verrucodesmus verrucosus* (Y.V.Roll) E.Hegewald	1.7	+	.	.	.
47.	*Lemmermannia triangularis* (Chod.) C.Bock & Krienitz	2.0	+	.	.	.
48.	*Tetraedron caudatum (*Corda) Hansg.	2.0	.	+	.	.
49.	*Actinastrum hantzschii* var. *subtile* Lagerh. Wolosz.	2.3	.	.	+	.
50.	*Pandorina smithii* Chod.	2.0	+	+	.	.
51.	*Eudorina elegans* Ehr.	2.2	.	+	.	.
52.	*Closterium nordstedtii* var. *polystictum* (Nygaard) Rúźička	.	+	+	+	.
53.	*Closterium strigosum* var. *strigosum* Bréb.	2.2	+	.	.	.
54.	*Closterium moliniferum* Ehr. ex Ralfs	2.1	.	+	.	.
55.	*Staurastrum gracile* Ralfs ex Ralfs	.	+	.	.	.
56.	*Staurastrum paradoxum* Meyen ex Ralfs	.	.	+	.	.
Number of taxa	Total	56	32	28	29	19
	Percentage share [%]	100	57.1	50.0	51.8	33.9
Number of indicators	Total	40	24	23	21	14
	Percentage share [%]	71.4	42.9	41.1	37.5	25.0
Dominant	*Microcystis* sp. div., *Aphanizomenon flexuosum*		-	-	+	-
	diatoms Centricae		-	-	-	+

Site 3 – water of the warm channel draining cooling water						
			Research terms			
No.	Taxonomy/Taxon	Si	09.07.2004	10.08.2004	06.09.2004	07.12.2004
	Cyanoprocaryota					
1.	*Aphanocapsa delicatissima* W. et G. S. West	-	.	.	+	.
2.	*Planktothrix agardhii* (Gomont) Anagnostidis et Kom.	1.6	+	.	+	+
3.	*Limnothrix planctonica* (Wolosz.) Meffert	-	+	.	.	.
4.	*Microcystis aeruginosa* (Kütz.) Kütz.	1.8	+	.	+	+
5.	*Dolichospermum cf.affine* (Lemm.) Wacklin, L.Hoffmann & Kom.	2.0	.	+	.	.
6.	*Dolichospermum flosaquae* (Bréb. ex Bornet & Flahault) P.Wacklin, L.Hoffmann & J.Kom.	2.0	.	+	.	.
7.	*Microcystis viridis* (A. Braun) Lemm.	1.8	.	+	.	.
8.	*Microcystis marginata* (Menegh.) Kütz.	-	.	+	+	.
9.	*Microcystis wesenbergii* (Kom.) Kom. ex Kom.	1.8	+	+	+	+
10.	*Pseudanabaena mucicola* (Naumann & Huber-Pestalozzi) Schwabe	-	.	+	+	+
11.	*Aphanizomenon flexuosum* Kom. & Kováčik	2.2	.	+	+	.
12.	*Aphanizomenon cf. gracile* (Lemm.) Lemm.	1.5	.	.	+	.
13.	*Lyngbya attenuata* F. E. Fritsch	-	+	.	.	.
14.	*Anabaena* sp.	-	+	.	+	.
15.	*Hapalosiphon* sp.	-	.	+	.	.
16.	*Snowella lacustris* (Chod.) Kom. & Hindák	1.5	.	.	+	.
	Bacillariophyceae					
17.	*Aulacoseira granulata* var. *granulate* (Ehr.) Simonsen	1.8	+	+	+	+
18.	*Aulacoseira granulata* var. *angustissima* (Ehr.) Simonsen (O. Müller) Simonsen	1.8	+	.	+	.
19.	*Fragilaria crotonensis* Kitton	1.4	+	+	+	+
20.	*Stephanodiscus hantzschii* Grunow (in Cleve & Grunow)	2.7	+	+	.	.
21.	*Asterionella formosa* Hassall	1.4	+	+	+	+
22.	*Cyclotella meneghiniana* Kütz.	2.7	+	+	+	+
23.	*Actinocyclus normanii* (Gregory) Hustedt	.	+	+	+	.
24.	*Synedra ulna* var. *danica* (Nitzsch) Ehr. (Kütz.) Hustedt	.	+	+	+	+
25.	*Melosira varians* Agardh	1.6	.	.	+	+
26.	*Nitzschia sigmoidea* (Nitzsch) W. Smith	2.5	+	.		+
27.	Synedra *ulna* (Nitzsch) Ehr.	.	.	.	+	+
28.	*Diatoma tenuis* Agardh	1.5	+	.	+	.
29.	*Nitzschia acicularis* (Kütz.) W. Smith	2.4	+	.	.	.
30.	*Nitzschia* cf. *littoralis* Grunow	.	.	+	.	.

31.	*Navicula cincta* (Ehr.) Ralfs in Pritchard	.	+	.	.	.
32.	*Pinnularia nobilis* (Ehr.) Ehr.	1.1	.	+	.	.
33.	*Gyrosigma attenuatum* (Kütz.) Rabenhorst	2.2	.	.	.	+
34.	*Fragilaria* sp.	.	.	+	+	+
35.	*Navicula* sp.	.	+	.	.	.
	Chrysophyceae					
36.	*Dinobryon sociale* Ehr.	.	+	.	.	.
37.	*Dinobryon divergens* Imhof	1.8	.	.	.	+
	Dinophyceae					
38.	*Ceratium hirundinella* (O.F. Müller) Schrank	1.2	+	.	.	.
39.	*Gymnodinium sp*	.	.	.	+	.
	Chlorophyceae					
40.	*Mucidosphaerium pulchellum* (H.C.Wood) C.Bock, Proschold & Krienitz	2.3		.	.	.
41.	*Coelastrum astroideum* De-Not De Notaris	2.0	+	+	+	.
42.	*Coelastrum microporum* Näg.	2.1	.	.	.	+
43.	*Stauridium tetras* (Ehr.) E.Hegewald	1.8	.	.	+	.
44.	*Pseudopediastrum boryanum* (Turp.) E.Hegewald	1.9	+	+	+	+
45.	*Lacunastrum gracillimum* (West & G.S. West) H.McManus	1.8	+	+	.	
46.	*Pediastrum duplex* Meyen	1.8	+	.	+	+
47.	*Monactinus simplex* (Meyen) Corda	1.5	+	+	+	.
48.	*Tetradesmus lagerheimii* M.J.Wynne & Guiry	2.2	+	.	+	.
49.	*Desmodesmus denticulatus* (Lagerh.) S.S.An, T.Friedl & E.Hegewald	.	.	.	+	.
50.	*Desmodesmus subspicatus* (Chod.) E.Hegewald & A.W.F.Schmidt	.	+	.	+	.
51.	*Desmodesmus communis* (E.Hegewald) E.Hegewald	2.1	+	.	+	+
52.	*Desmodesmus opoliensis* (P.G.Richt.) E.Hegewald	2.2	+	+	+	+
53.	*Desmodesmus armatus* (Chod.) E.Hegewald	.	+	+	.	.
54.	*Lemmermannia triangularis* (Chod.) C.Bock & Krienitz	.	.	.	+	.
55.	*Tetraedron caudatum* (Corda) Hansg.	2.0	+	.	.	.
56.	*Actinastrum hantzschii* var. *subtile* Lagerh. Wolosz.	2.0	+	.	.	.
57.	*Actinastrum hantzschii* var. *hantzschii* Lagerh.	2.3	+	.	+	.
58.	*Pandorina smithii* Chod.	2.0	+	.	.	.
59.	*Eudorina elegans* Ehr.	2.0	+	+	.	+
60.	*Golenkinia radiata* Chod.	2.2	+	.	.	.
61.	*Lagerheimia ciliata* (Lgerh.) Chod.	1.8	+	.	.	.
62.	*Closterium nordstedti* var. *polystictum* (Nygaard) Rúźička	2.0	+	.	.	.
63.	*Closterium acutum* Bréb.	.	+	.	+	.
64.	*Closterium srtigosum* Bréb.	.	+	.	.	.
65.	*Closterium moliniferum* Ehr. ex Ralfs	2.2	+	.	.	.
66.	*Staurastrum gracile* Ralfs ex Ralfs	2.1	.	.	+	.
67.	*Staurastrum paradoxum* Meyen ex Ralfs	.	+	.	.	.

68.	*Mucidosphaerium pulchellum* (H.C.Wood) C.Bock, Proschold & Krienitz	.	.	+	.	.
Number of taxa	Total	68	43	26	36	21
	Percentage share [%]	100	63.2	38.2	52.9	30.9
Number of indicators	Total	44	30	16	23	16
	Percentage share [%]	64.7	44.1	23.5	33.8	23.5
Dominant	*Microcystis* sp. div., *Aphanizomenon flexuosum*		-	-	-	-

No.	Taxonomy/Taxon	Si	Research terms 09.07.2004	10.08.2004	06.09.2004	07.12.2004
Site 4 – the waters of the East Odra River below the warm channel having increased thermals by cooling waters						
	Cyanoprocaryota					
1.	*Aphanocapsa delicatissima* W. et G. S. West	-	.	.	+	.
2.	*Aphanocapsa grevillei* (Berkeley) Rabenhorst	1.4	.	.	+	.
3.	*Merismopedia tenuissima* Lemm.	2.5	.	.	+	.
4.	*Chroococcus turgidus* (Kütz.) Nägeli	1.3	.	+	.	.
5.	*Planktothrix agardhii* (Gomont) Anagnostidis et Kom.	1.6	+	.	.	.
6.	*Limnothrix planctonica* (Wolosz.) Meffert	-	+	.	+	.
7.	*Microcystis aeruginosa* (Kütz.) Kütz.	1.8	+	.	+	+
8.	*Dolichospermum flosaquae* (Bréb. ex Bornet & Flahault) P.Wacklin, L.Hoffmann & J.Kom.	2.0	.	.	+	.
9.	*Microcystis viridis* (A. Braun) Lemm.	1.8	.	+	.	.
10.	*Microcystis marginata* (Menegh.) Kütz.	-	.	+	+	.
11.	*Microcystis wesenbergii* (Kom.) Kom. ex Kom.	1.8	+	+	+	+
12.	*Pseudanabaena mucicola* (Naumann & Huber-Pestalozzi) Schwabe	-	.	+	+	.
13.	*Aphanizomenon flexuosum* Kom. & Kováčik	2.2	+	+	+	.
14.	*Snowella lacustris* (Chod.) Kom. & Hindák	1.5	.	+	.	.
	Bacillariophyceae					
15.	*Aulacoseira granulata* var. *granulata* (Ehr.) Simonsen	1.8	+	+	+	+
16.	*Aulacoseira granulata* var. *angustissima* (O.F.Müller) Simonsen	1.8	+	+	+	+
17.	*Fragilaria crotonensis* Kitton	1.4	+	+	+	+
18.	*Stephanodiscus hantzschii* Grunow	2.7	+	+	+	+
19.	*Asterionella formosa* Hassall	1.4	+	+	+	+
20.	*Cyclotella meneghiniana* Kütz.	2.7	+	+	+	+
21.	*Actinocyclus normanii* (Gregory) Hustedt	.	.	+	.	.
22.	*Ulnaria danica* (Kütz.) Compère & Bukhtiyarova	.	+	+	.	.
23.	*Melosira varians* Agardh	1.6	.	+	+	+
24.	*Nitzschia sigmoidea* (Nitzsch) W. Smith	2.5	+	+	+	+
25.	*Synedra ulna* (Nitzsch) Ehr.	-	+	+	.	+
26.	*Diatoma tenuis* Agardh	1.5	+	+	+	.
27.	*Nitzschia acicularis* (Kütz.) W. Smith	2.4	.	+	.	.
28.	*Brebissonia lanceolata (Agardh) R.K.Mahoney & Reimer*	1.5	.	+	.	.
29.	*Cymatopleura solea* (Bréb.) W. Smith	2.3	.	.	+	+
30.	*Iconella biseriata* (Bréb.) Ruck & Nakov	1.5	.	.	.	+
31.	*Surirella elegans* Ehr.	1.3	.	.	.	+
32.	*Fragilaria* sp.	-	.	+	.	+

	Chrysophyceae					
33.	*Dinobryon divergens* Imhof	1.8	.	+	.	.
	Dinophyceae					
34.	*Ceratium hirundinella* (O.F.Müller) Dujardin	1.2	.	+	.	.
	Euglenophyceae					
35.	*Lepocinclis acus* (O.F.Müller) Marin & Melkonian	.	+	+	.	.
36.	*Lepocinclis oxyuris* (Schmarda) Marin & Melkonian	2.5	.	.	+	.
37.	*Colacium vesiculosum* Ehr.	1.9	.	+	.	.
	Chlorophyceae					
38.	*Micractinium pusillum* Fres.	2.5	+	.	+	.
39.	*Mucidosphaerium pulchellum* (H.C.Wood) C.Bock, Proschold & Krienitz	2.3	+	.	.	.
40.	*Coelastrum astroideum* De-Not De Notaris	2.0	.	+	+	+
41.	*Stauridium tetras* (Ehr.) E.Hegewald	1.8	.	.	+	.
42.	*Parapediastrum biradiatum* (Meyen) E.Hegewald	1.8	.	.	+	.
43.	*Pseudopediastrum boryanum* (Turp.) E.Hegewald	1.9	+	.	+	+
44.	*Lacunastrum gracillimum* (West & G.S. West) H.McManus	1.8	+	+	.	.
45.	*Pediastrum duplex* Meyen	1.8	+	+	+	+
46.	*Monactinus simplex* (Meyen) Corda	1.5	.	.	+	.
47.	*Tetradesmus lagerheimii* M.J.Wynne & Guiry	2.2	+	.	+	.
48.	*Desmodesmus denticulatus* (Lagerh.) S.S.An, T.Friedl & E.Hegewald	-	+	.	.	.
49.	*Desmodesmus communis* (E.Hegewald) E.Hegewald	2.1	+	+	+	.
50.	*Desmodesmus opoliensis* (P.G.Richt.) E.Hegewald	2.2	+	+	+	.
51.	*Desmodesmus armatus* (Chod.) E.Hegewald	-	+	+	.	.
52.	*Desmodesmus subspicatus* (Chod.) E.Hegewald & A.W.F.Schmidt	-	.	.	.	+
53.	*Lemmermannia triangularis* (Chod.) C.Bock & Krienitz	2.0	.	.	.	+
54.	*Tetrastrum staurogeniiforme* (Schröd.) Lemm.	2.2	+	.	.	.
55.	*Actinastrum hantzschii* Lagerh. var. *subtile* Wolosz.	2.3	+	.	+	+
56.	*Crucigenia fenestrata* (Schmidle) Schmidle	2.1	+	.	.	.
57.	*Pandorina smithii* Chod.	2.0	+	.	+	.
58.	*Eudorina elegans* Ehr.	2.2	+	.	.	.
59.	*Closterium nordstedtii* var. *polystictum* (Nygaard) Rúźička	-	+	+	.	.
60.	*Closterium moliniferum* Ehr. ex Ralfs	2.1	.	+	.	.
61.	*Staurastrum gracile* Ralfs ex Ralfs	-	+	+	.	.
Number of taxa	Total	68	43	26	36	21
	Percentage share [%]	100	63.2	38.2	52.9	30.9
Number of indicators	Total	44	30	16	23	16
	Percentage share [%]	64.7	44.1	23.5	33.8	23.5
Dominant	*Microcystis* sp. div., *Aphanizomenon flexuosum*					

Appendix 2

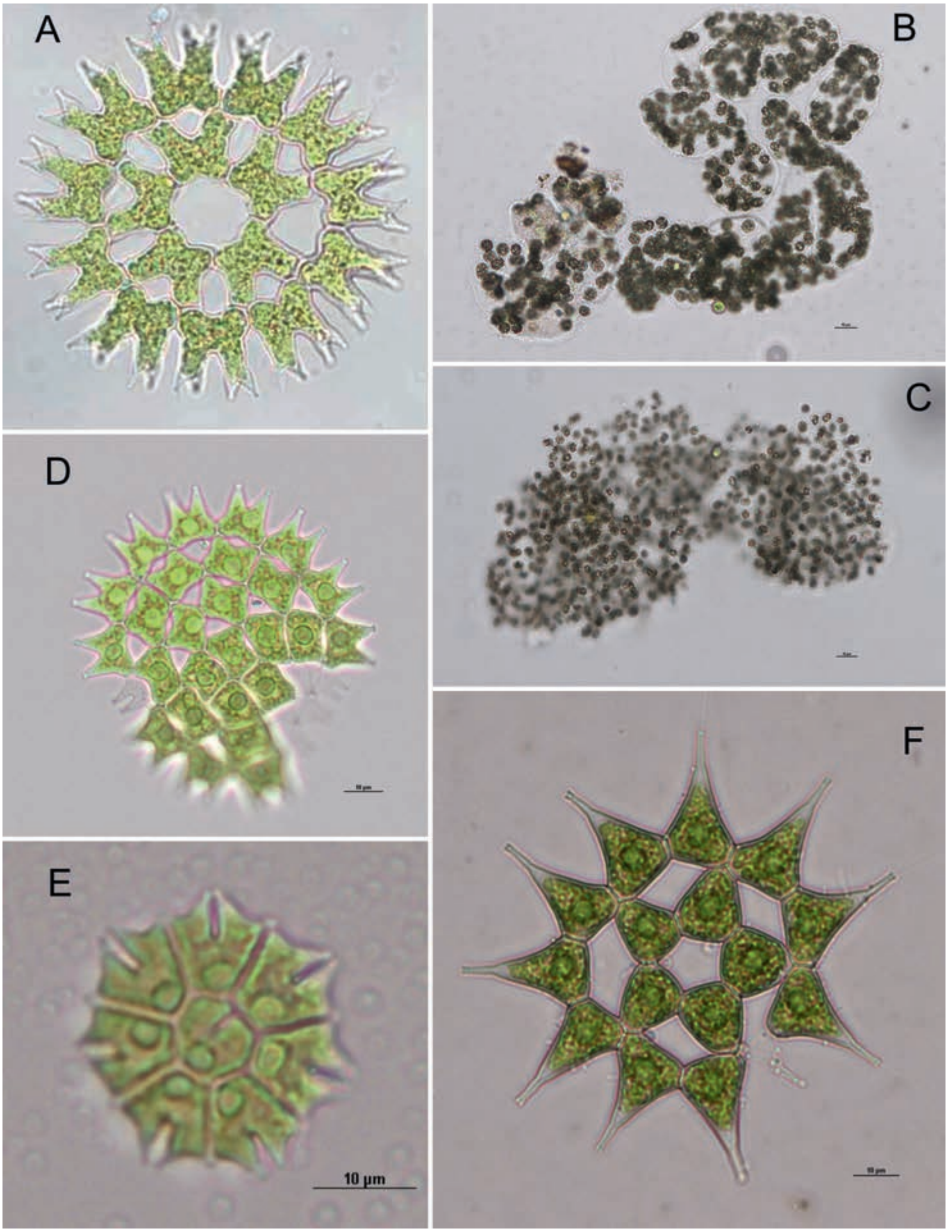

Fig. 3. *Parapediastrum biradiatum* (Meyen) E. Hegewald – A, *Microcystis wesenbergii* (Kom.) Kom. ex Kom. – B, *Microcystis aeruginosa* (Kütz.) Kütz. – C, *Pediastrum duplex* Meyen – D, *Stauridium tetras* (Ehr.) E. Hegewald – E, *Monactinus simplex* (Meyen) Corda – F

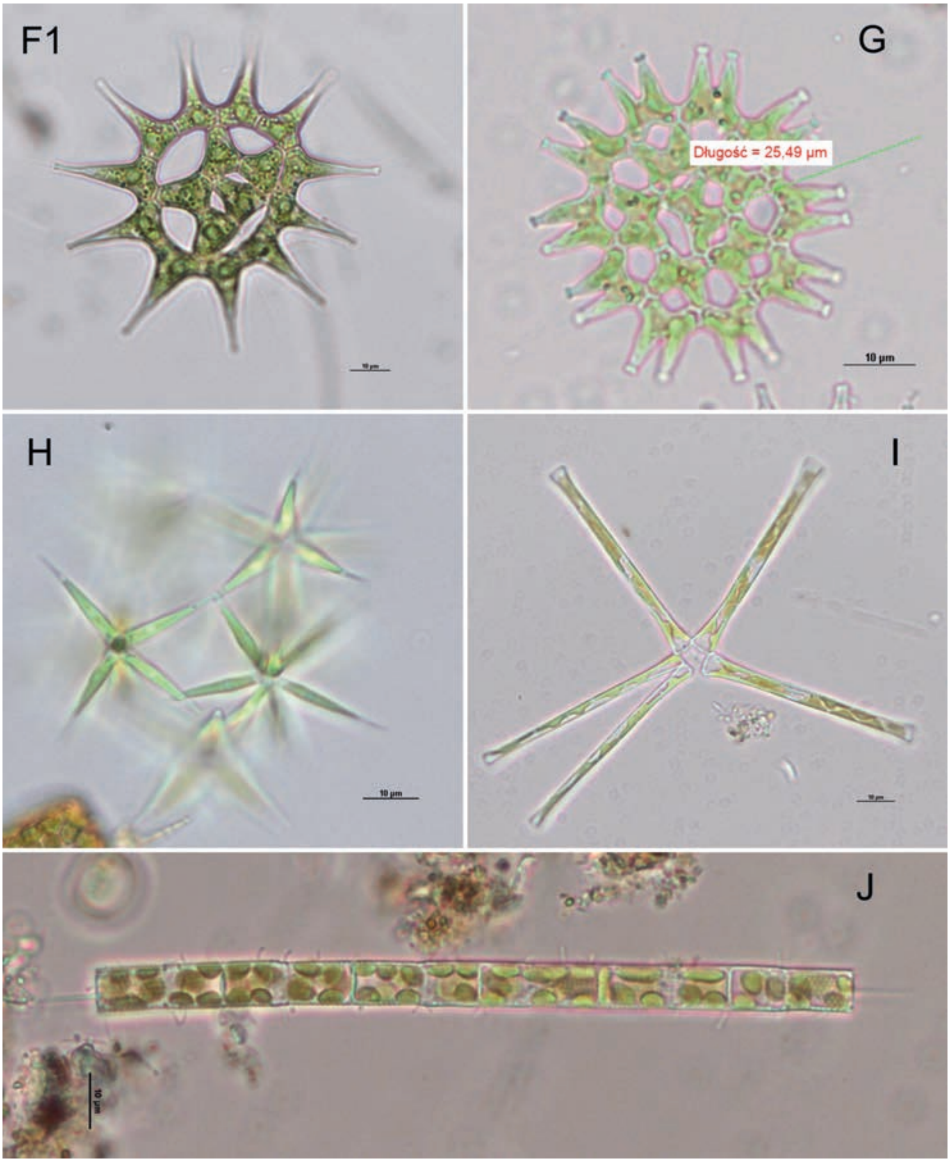

Fig. 4. *Monactinius simplex* (Meyen) Corda – F1, *Lacunastrum gracillimum* (West & G.S. West) H.McManus – G, *Actinastrum hantzschii* Lagerh. – H, *Asterionella formosa* Hassall – I, *Aulacoseira granulata* var. *granulata* (Ehr.) Simonsen – J

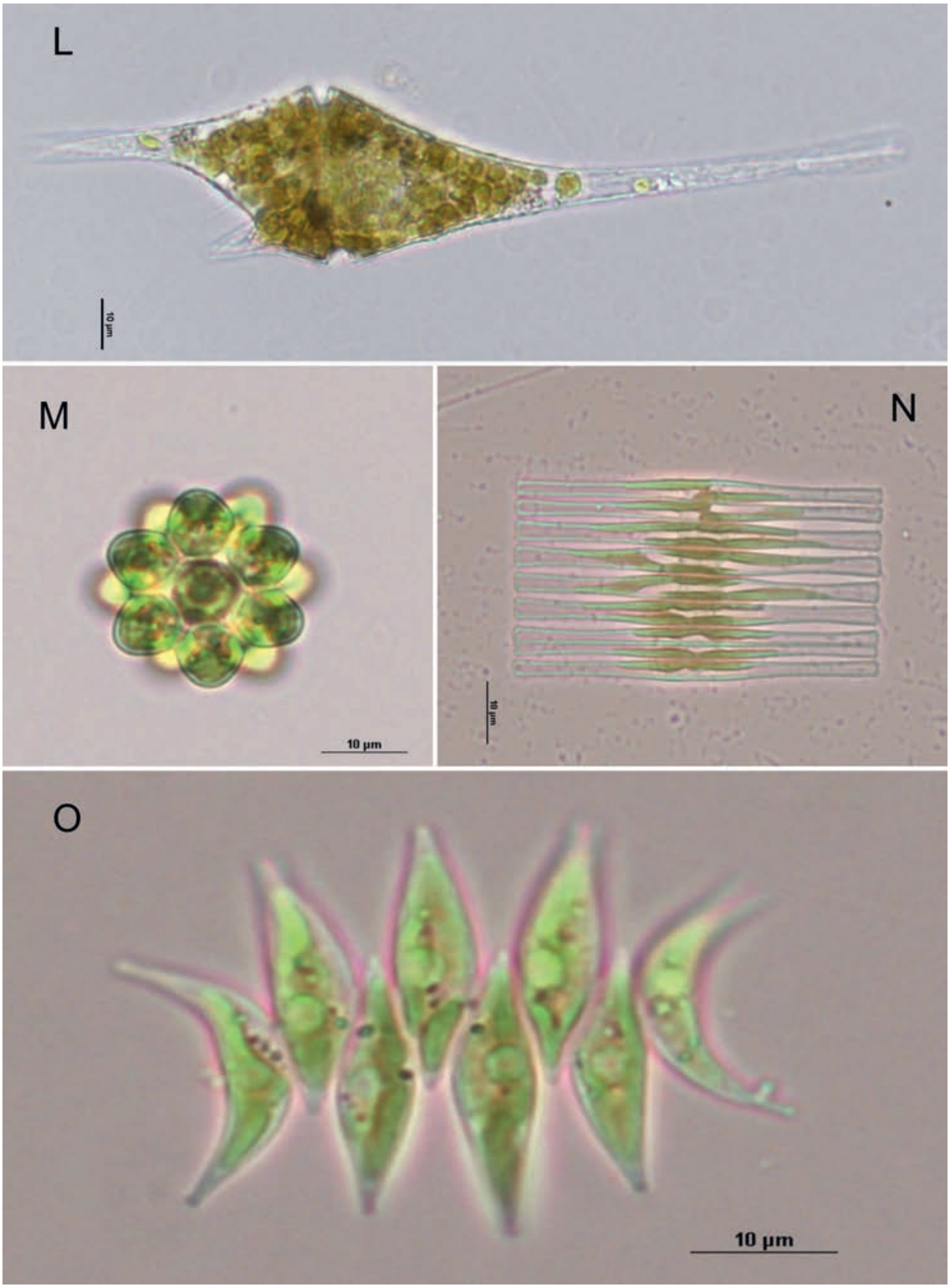

Fig. 5. *Ceratium hirundinella* (O.F. Müller) Schrank – L, *Coelastrum asteroideum* De-Not De Notaris – M, *Fragilaria crotonensis* Kitton – N, *Tetradesmus lagerheimii* M.J. Wynne & Guiry – O

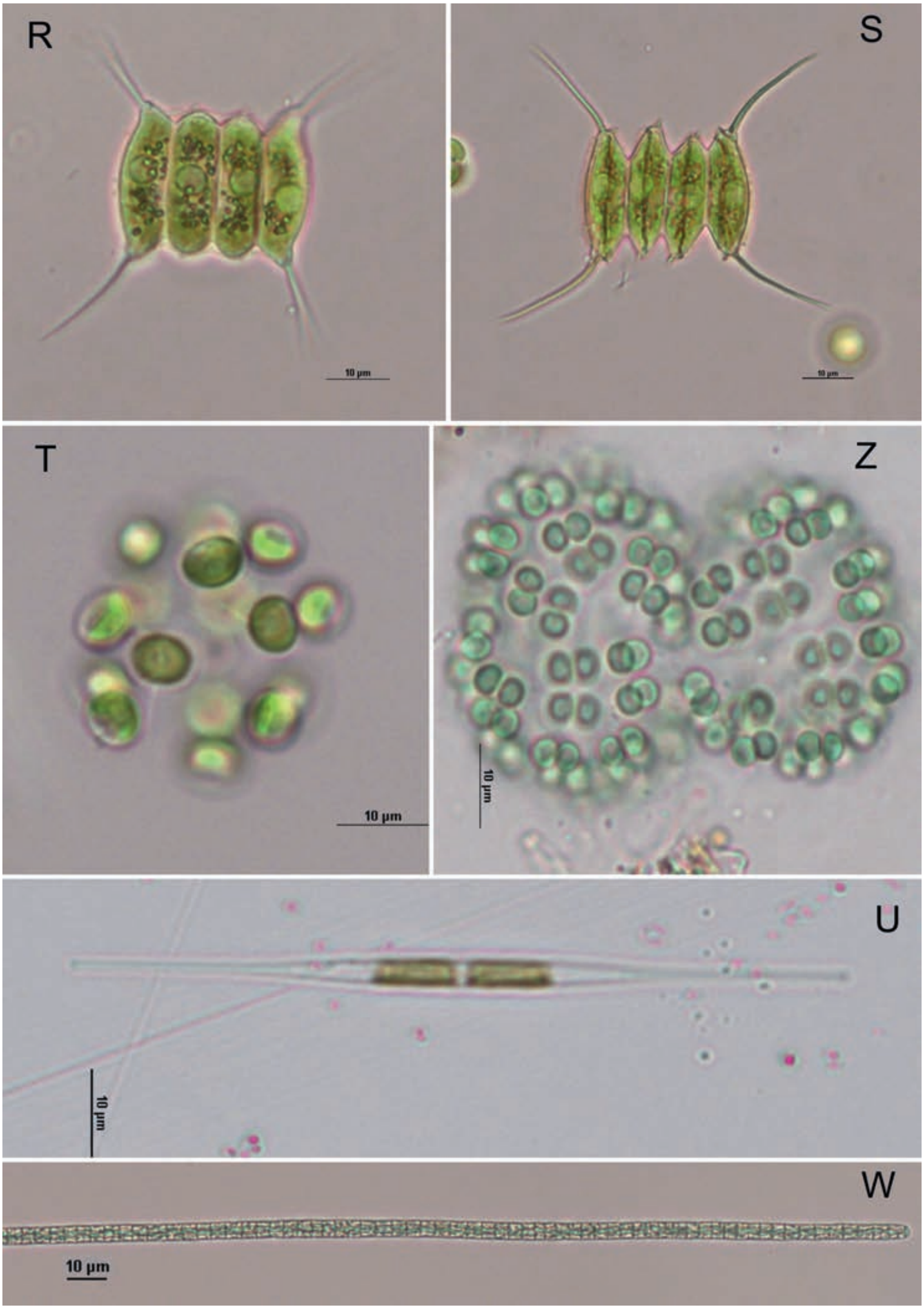

Fig. 6. *Desmodesmus communis* (E. Hegewald) E. Hegewald – R, *Desmodesmus opoliensis* (P.G. Richt.) E. Hegewald – S, *Mucidosphaerium pulchellum* (H.C. Wood) C. Bock, Proschold & Krienitz – T, *Nitzschia acicularis* (Kütz.) W. Smith – U, *Planktotrix agardhii* (Gomont) Anagnostidis et Kom. – W, *Snowella lacustris* (Chod.) Kom. & Hindák – Z

Abstract

The paper presents the results of water trophy assessment from various stations of the cooling system of the "Dolna Odra" (Poland) power plant. The assessment was made based on the indicator phytoplankton species collected four times at four sites located in different parts of the hydrological system cooling the technical infrastructure of the power plant. The sites were characterised by water with a natural temperature for individual seasons, as well as by thermals changed as a result of the discharge of cooling waters. For each site, the saprobic index was calculated based on indicator species. The analysis showed that the changes in trophic conditions, both in waters with changed thermals and in waters not subject to the influence of after-cool waters, are not subject to significant changes. The waters of all studied sites in the analysed periods of the year should be classified according to Sladeček and Sládečková (1996) to the waters of the β–mesosaprobic zone, with a saprobic index value ranging from 1.51 to 2.50 (average S = 2.0). This zone is characterised by the course of biochemical processes under aerobic conditions, as a result of which complete oxidation of the intermediate products of decomposition of organic compounds takes place.

Key words: after-cooling water, indicator species, phytoplankton, saprobic index, water trophy of the powerplant's hydrological infrastructure

Received: [2022.10.24]

Accepted: [2022.11.12]

Ocena trofii wód układu chłodzącego elektowni „Dolna Odra" na podstawie składu jakościowego organizmów wskaźnikowych glonów

Streszczenie

W pracy przedstawiono wyniki oceny trofii wód z różnych stanowisk układu chłodniczego elektrowni „Dolna Odra" (Polska). Oceny dokonano w oparciu o wskaźnikowe gatunki fitoplanktonu zebranego w czterech terminach roku na czterech stanowiskach, zlokalizowanych w różnych częściach systemu hydrologicznego, schładzającego infrastrukturę techniczną elektrowni. Stanowiska charakteryzowały się wodami o temperaturze naturalnej dla poszczególnych pór roku, jak i zmienną termiką w wyniku zrzutu wód pochłodniczych. Dla każdego stanowiska obliczono indeks saprobowy na podstawie gatunków wskaźnikowych. Analiza wykazała, że zmiany w zakresie trofii, zarówno w wodach o zmienionej termice, jak i wodach nie podlegających oddziaływaniu wód pochodniczych, nie ulegają istotnym zmianom. Wody wszystkich badanych stanowisk w analizowanych okresach roku należy zaklasyfikować wg Sladeček i Sládečková (1996) do wód strefy β–mezosaprobowej, mających wartość indeksu saprobowości w granicach od 1,51 do 2,50 (średnio S = 2,0). Strefa ta charakteryzuje się przebiegiem procesów biochemicznych w warunkach aerobowych, w wyniku których zachodzi całkowite utlenienie pośrednich produktów rozkładu związków organicznych.

Słowa kluczowe: wody pochłodnicze, gatunki wskaźnikowe, fitoplankton, wskaźnik saprobowy, trofia wodna infrastruktury hydrologicznej elektrowni

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