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## THE EVALUATION OF EUTROPHICATION LEVEL OF KOZŁOWA GORA DAM RESERVOIR BASE ON ASSEMBLAGES PLANKTONIC ALGAE

### OCENA STOPNIA ZEUTROFIZOWANIA ZBIORNIKA KOZŁOWA GÓRA NA PODSTAWIE ZBIOROWISK GLONÓW PLANKTONOWYCH

**Abstract:** In this publication the eutrophication level of Kozłowa Gora dam reservoir base on composition species of algae and biomass of phytoplankton, was defined. The evaluation of phytoplankton biomass was achieved by two methods (direct - for biovolume by comparing the shape of algae to geometrical figures and indirect - base on concentrations of chlorophyll *a*). The trophic estimation of reservoir water was achieved on the grounds of classifications, which included the boundary values of phytoplankton biomass and concentrations of chlorophyll *a*. These boundary values are characteristic for individual trophic types of water. The typical species for eutrophic water were observed in the samples of water taking from the Kozłowa Gora dam reservoir, also the highest average percentage share of Cyanophyta in whole biomass of phytoplankton was observed (it may indicate on the advanced eutrophication processes). The research concerning the average biomass of phytoplankton and average concentrations of chlorophyll *a* allowed classification water of this reservoir to eutrophic and hipertrophic.

**Keywords:** eutrophication, dam reservoir, biomass of phytoplankton, concentrations of chlorophyll *a*

## Introduction

Planktonic algae are microscopic photoautotrophic organisms, which live in the water column. In the opinion of Reynolds [1] this microscopic algae are very good bioindicators of water environment, because they well reflect trophic state of water ecosystems. Certain species can develop only in oligotrophic water, instead another species can develop in eutrophic water [2-7].

In oligotrophic water environment biomass of phytoplankton is usually rather small, but when the level of eutrophication goes up, biomass of phytoplankton increases and it can often achieve a dozen or even several dozen  $\text{mg}\cdot\text{dm}^{-3}$ . Then species diversity of phytoplankton as a rule decreases [8]. Planktonic algae pointing at the definite trophic state of water dam reservoirs must be stenobionts, that is they must develop in closely defined environment conditions. Only these organisms constitute good bioindicators of characteristic trophic level and the degree of water pollution.

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The aim of this research was to define of eutrophication level of Kozłowa Góra dam reservoir base on assemblages and biomass of the planktonic algae.

## Material and methods

The research was conducted on the area of Kozłowa Góra dam reservoir. This reservoir is located in centre area of Silesian Voivodeship. The territories around the reservoir are considerably industrialised, there is an also developed farming well. The numerous industrial centers are located in the catchment of this reservoir (for example: Swierklaniec, Miasteczko Śląskie and Tarnowskie Góry), and they expose the reservoir of the delivery of a lot of pollutants (mainly dusts of the industrial origin, the domestic and industrial wastewater and areas flows from fields) [9].

Table 1

Morphometric-hydrologic parameters of Kozłowa Góra dam reservoir

| The parameter  | The data   |
|--|--|
| River  | Brynica  |
| Catchment area to section of dam [km <sup>2</sup> ]* | 184.1  |
| Total capacity [mln m <sup>3</sup> ]*                | 18   |
| Depth average [m]*                                   | 4.6  |
| Depth maximum [m]*                                   | 7  |
| Retention time of water [days]**                     | 476.3  |
| Surface of reservoir bowl [ha]***                    | 587  |
| Functions of reservoir***                            | Supplying drinking water for Silesian agglomeration, fishing, flood protection |

\* - GPW - Katowice, department Goczałkowice

\*\* - It was calculated: total capacity / average daily inflow of the River Brynica (which is the main inflow)

\*\*\* - [9]



Fig. 1. Localization of Kozłowa Góra dam reservoir

The some morphometric-hydrologic parameters of reservoir, also the localization of Kozłowa Góra dam reservoir are presented appropriately in Table 1 and Figure 1. The contour of reservoir and localization places for taking samples are presented on Figure 2.

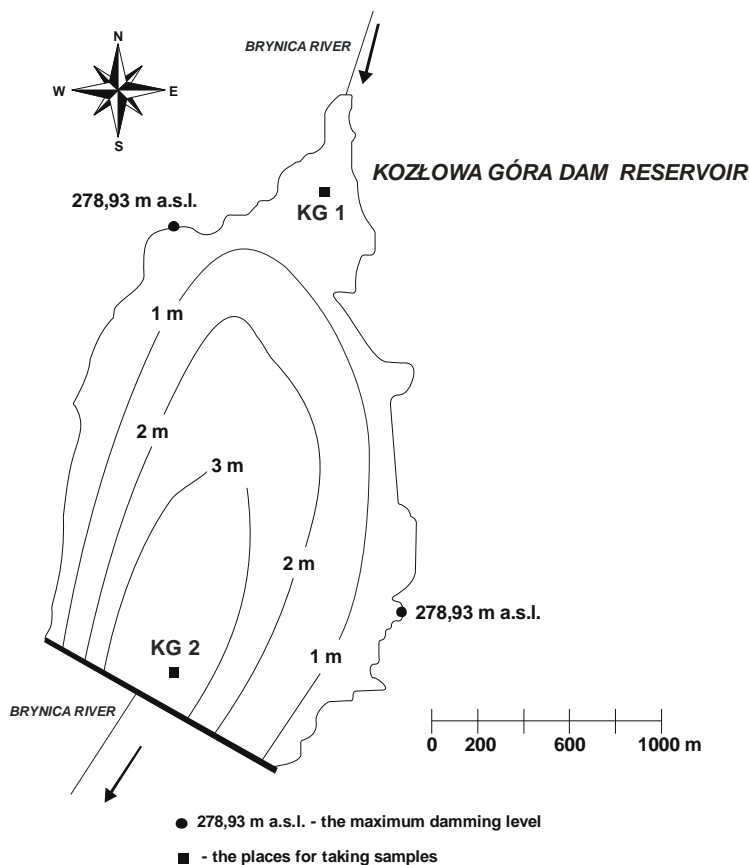


Fig. 2. The contour of reservoir and localization places for taking samples

The biological research of reservoir water was conducted in years 2004-2006. In addition, the analyses, which concern of chlorophyll *a* concentrations, were conducted in years 2007, 2009, 2011.

The biological analyses were conducted using the light microscope Nikon Eclipse 200 in the laboratory of University in Bielsko-Biala. For identification of phytoplankton species the following keys were used: Sieminska [10], Starmach [11], Hindak [12]. The phytoplankton biomass (in wet mass) was calculated for biovolume by comparing the shape of algae to their geometrical figures (direct method) [13] and based on concentrations of chlorophyll *a* (indirect method). For evaluation the phytoplankton biomass (by comparing the shape of algae to geometrical figures) the following converter was used [13]:

$$1 \mu\text{m}^3 = 1/1 \cdot 10^9 \text{ mm}^3 = 1/1 \cdot 10^9 \text{ mg} \tag{1}$$

The analyses of chlorophyll *a* concentrations were realized according to Polish Standards by Silesian Voivodeship Inspectorate of the Environmental Protection (WIOŚ), department in Bielsko-Biala. Results of chlorophyll *a* concentrations were also received from this Inspectorate.

The trophy of reservoir water was defined according to the species composition of phytoplankton (indicating species were used). Additionally, also the classification, which was suggested by Heinonen [14], was used. This classification includes biomass of phytoplankton [ $\text{mg} \cdot \text{dm}^{-3}$ ], which is counted by direct method. Furthermore, the OECD classification, which was given by Dojlido [15], was used. Then, this classification includes concentrations of chlorophyll *a* (indirect method) [ $\mu\text{g} \cdot \text{dm}^{-3}$ ] (Table 2).

Table 2

The ranges of average values the whole biomass of phytoplankton [14] and the boundary values for concentrations of chlorophyll *a* [15], which are characteristic for individual trophic types of water

| The trophic type of lake | The ranges of average values biomass of phytoplankton [ $\text{mg} \cdot \text{dm}^{-3}$ ] | The boundary values for concentrations of chlorophyll <i>a</i> [ $\mu\text{g} \cdot \text{dm}^{-3}$ ] |
|--------------------------|--|---|
| Oligotrophic lakes       | 0.14-0.68  | < 2.5   |
| Mesotrophic lakes        | 1.21-1.98  | 2.5-8   |
| Eutrophic lakes          | 3.45-6.93  | 8-25  |
| Hipertrophic lakes       | 17.5   | > 25  |

The each identified species of phytoplankton was consulted with specialists.

## Results

The microscopic analyses of phytoplankton proved appearance of species well developing in all types of reservoirs, in Kozłowa Góra dam reservoir. Among them are distinguished: diatoms: *Asterionella formosa* Hass., *Fragilaria acus* (Kütz.) Lange-Bertalot, *F. ulna* (Nitsch) Lange-Bertalot, green algae: *Tetrastrum glabrum* (Roll) Ahlstr. and Tiff., and cryptophyta: *Cryptomonas erosa* Ehr.

Amongst species appearing in this reservoir were also ascertained stenobionts. They live in closely defined conditions of environment. The observed numerous species of phytoplankton, typical for eutrophic water, expressly indicated on the advanced eutrophication of water in this reservoir. These species of phytoplankton constitute bioindicators of eutrophy. The strong development of cyanophyta (*Microcystis aeruginosa* (Kütz.) Kütz., *M. viridis* (A. Br. in Rabenh.) Lemm), *Aphanizomenon flos-aquae* (L.) Ralfs ex Born. i Flah., green algae (*Pediastrum* sp., *Coelastrum* sp., *Scenedesmus* sp.) and diatoms (*Aulacoseira granulata* (Ehr.) Ralfs (Ehr.) Simonsen), *Fragilaria crotonensis* Kitt., *Nitzschia palea* (Kütz.) W. Sm.) was ascertained in water of reservoir.

It is worth adding, that cyanophyta achieved the highest average percentage share amongst remaining groups of phytoplankton (55.4%) in years 2004-2006. The assemblages of green algae (mainly chlorococcal green algae) also acquired the high average percentage share in whole biomass of phytoplankton (16.5%) (Fig. 3).

As a result of conducted analyses was also ascertained, that the average biomass of phytoplankton in water of this reservoir achieved  $18.2 \text{ mg} \cdot \text{dm}^{-3}$  in years 2004-2006, instead the average concentrations of chlorophyll *a* acquired  $36.92 \mu\text{g} \cdot \text{dm}^{-3}$  in years

2004-2006. These values in both cases exceeded much boundary values for eutrophy. It allows classify water of this reservoir to eutrophic water, even hipertrophic water (Fig. 4).

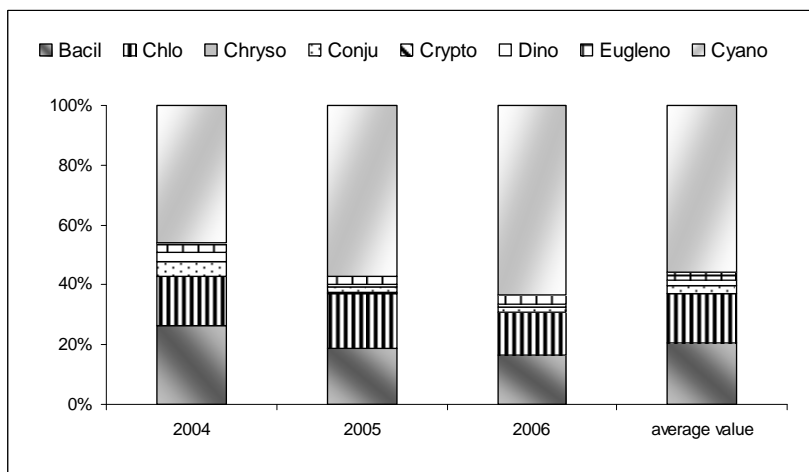


Fig. 3. The average percentage share individual groups of phytoplankton in whole biomass of phytoplankton in the Kozłowa Góra reservoir

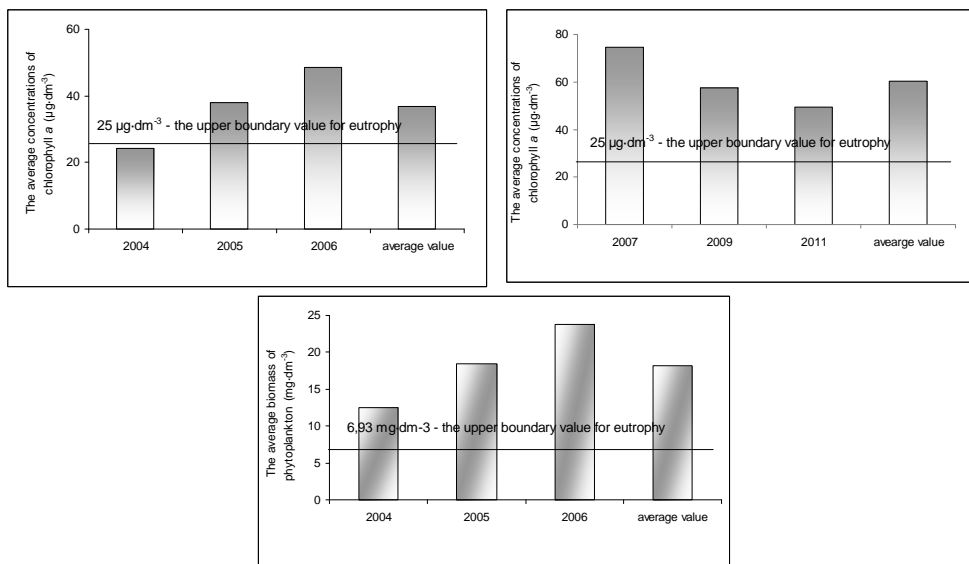


Fig. 4. The average values of phytoplankton biomass (in wet mass) in years 2004-2006 and the average concentrations of chlorophyll *a* in the reservoir in years 2004-2006 and 2007, 2009, 2011 years

In next years of research the average concentrations of chlorophyll *a* were higher and achieved following value 60.4 µg · dm<sup>-3</sup>. It is possible to suppose, that eutrophication process still advances (Fig. 4).

## Discussion

Kozłowa Góra dam reservoir is located on the industrial-agricultural area, thus it is exposed on inflow of a lot of pollutants. The municipal and industrial wastewater undeniably have a significant share in water pollution.

According to Boron [16] the anthropogenic factors (for example exploitation of the catchment) majorly cause soils degradation. Soils degradation contributes to increase of surface flows, in the consequence its a lot of biogenic substances (mainly nitrogen and phosphorus) is delivered to surface water. It causes deterioration of water quality and increase of eutrophication process [17, 18].

The appearance of various species of algae, characteristic for eutrophic water, testifies to high eutrophication level. In the water of this reservoir, cyanobacteria *Microcystis viridis* (A. Br. in Rabenh.) Lemm., *Microcystis aeruginosa* (Kütz.) Kütz., green algae *Coelastrum* sp. *Pediastrum* sp. and *Scenedesmus* sp., as well as diatoms *Fragilaria crotonensis* (Kitt.) were observed. Similar species of phytoplankton have been observed in the eutrophic Siemianówka reservoir by Grabowska [7] and Lepistö & Rosenstrom [19] in the context of eutrophic Finnish lakes. According to Reynolds [20] the cyanobacteria *Microcystis* sp. is characteristic for sunny and eutrophic water, instead Negro [4] opinion the development following green algae: *Coelastrum*, *Pediastrum* and *Scenedesmus* can indicate eutrophic status of water reservoir.

The conducted research was also proved the highest average percentage share of cyanophyta assemblages (55.4%) and chlorococcal green algae assemblages (16.5%) in whole biomass of phytoplankton, the high average biomass of phytoplankton was acquired as well. According to Ryding i Rast follow Wilk-Wozniak [21] the eutrophic reservoirs are characterized by the high level of phytoplankton biomass, frequent occurrence of water blooms and significant share of the cyanophyta and green algae in whole biomass of phytoplankton.

In addition, the concentrations of chlorophyll *a* (which achieved average  $36.92 \mu\text{g} \cdot \text{dm}^{-3}$  in years 2004-2006) indicated high degree of eutrophication, because the values of concentrations of chlorophyll *a* considerably exceeded upper boundary values for eutrophic water. According to Dojlido [15], the concentrations of chlorophyll *a* exceeding  $8 \mu\text{g} \cdot \text{dm}^{-3}$  indicate eutrophication, while the levels above  $25 \mu\text{g} \cdot \text{dm}^{-3}$  classify water reservoir as hypertrophic. The higher values of chlorophyll *a* concentrations, which were acquired in next years (2007, 2009, 2011), can still indicate on the advanced eutrophication processes in this reservoir. In opinion of Wolos and Wisniewolski [22] this reservoir has eutrophic status, because significant share of bream (typical fish in eutrophic water) confirms high level of eutrophication in this reservoir.

The high level of eutrophication in Kozłowa Góra dam reservoir is undesirable, because this reservoir fulfills supplying water for people. Intensive development of planktonic algae and cyanophyta (which often create water blooms) causes deterioration of organoleptic properties of water (then the taste of water, odour and colour of water are changed). In opinion of Pawelek and Bergel [23] the concentrations of chlorophyll *a* near value  $30 \mu\text{g} \cdot \text{dm}^{-3}$  additionally deteriorate quality of water, which is destined for drink (the average concentrations of chlorophyll *a* in this reservoir acquired  $36.92 \mu\text{g} \cdot \text{dm}^{-3}$  in years 2004-2006 and  $60.4 \mu\text{g} \cdot \text{dm}^{-3}$  in 2007, 2009, 2011 years).

The mass development of phytoplankton also impedes process of water treatment (by the blocking of waterwork filters and secreting toxic substances into the water by cyanophyta). These toxins are very dangerous to water animals and for health of people, because they can cause allergic reactions (mainly dermatotoxins), but also damage to deeper body tissues, *ia* liver cells (mainly hepatotoxins) [24-26].

The supplying functions of the reservoir obligate to its protection and the matter of water cleanness should be priority. The proper protection of Kozłowa Gora dam reservoir and possible undertaking remedial operations are essential.

## Conclusions

1. The mass development species of phytoplankton, typical for eutrophic water (for example *Microcystis aeruginosa* (Kutz.) Kutz., *M. viridis* (A. Br. in Rabenh.) Lemm), *Aphanizomenon flos-aquae* (L.) Ralfs ex Born. and Flah., *Pediastrum* sp., *Coelastrum* sp., *Fragilaria crotonensis* (Kitt.) points out high trophic status of Kozłowa Gora dam reservoir water.
2. The high average percentage share the assemblages of cyanophyta (55.4%) and assemblages of chlorococcal green algae (16.5%) in whole biomass of phytoplankton indicates on the advanced eutrophication processes.
3. The average biomass of phytoplankton and average concentrations of chlorophyll *a* in water of this reservoir significantly exceeded boundary values for eutrophic water.
4. Kozłowa Gora dam reservoir fulfils a function supplying water for people, so the water cleanness of this reservoir should be priority. Therefore, the remedial operations should be undertaken.

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## OCENA STOPNIA ZEUTROFIZOWANIA ZBIORNIKA KOZŁOWA GÓRA NA PODSTAWIE ZBIOROWISK GLONÓW PLANKTONOWYCH

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**Abstrakt:** W artykule określono stopień zeutrofizowania zbiornika Kozłowa Góra w oparciu o skład gatunkowy i biomasę fitoplanktonu. Oceny biomasy fitoplanktonu dokonano za pomocą dwóch metod (bezpośredniej - na zasadzie przyrównywania komórek do figur geometrycznych i pośredniej - chlorofilowej). W ocenie trofii wód zbiornika wykorzystano klasyfikację uwzględniającą graniczne wartości wielkości biomasy fitoplanktonu oraz graniczne wartości stężeń chlorofilu *a* dla poszczególnych typów troficznych. W próbkach wody pobranych ze zbiornika Kozłowa Góra zanotowano rozwój gatunków typowych dla wód eutroficznych, a także duży udział w ogólnej biomacie fitoplanktonu sinic (co może wskazywać na zaawansowanie procesów eutrofizacyjnych). Badania dotyczące średniej biomasy fitoplanktonu (określanej bezpośrednio i pośrednio) pozwoliły na zaklasyfikowanie zbiornika do eutroficznych, a nawet hipertroficznych.

**Słowa kluczowe:** eutrofizacja, zbiornik zaporowy, biomasa fitoplanktonu, koncentracja chlorofilu *a*