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TROPHIC STATUS OF THE RUSAŁKA LAKE IN SZCZECIN IN YEARS 1999–2010

Abstract

Trophic status of the Rusałka Lake wartes in inflow zone of Osówka Stream to Rusałka Lake reservoir in month April in years 1999, 2001, 2003, 2005, 2007 and 2010 – based on data of TP concentrations in water – was as hypertrophic determined, for except year 2007 whenas the thaw waters thinned the investigated waters that they waters were eutrophic. The added results with lead simultaneously with measurements concentrations TP the signs pH, concentration DO, COD-Cr as well as the concentrations NO_3^-, NH_4^+, TN, SRP and Ca^{2+} and Cl^- – permitted on performance the general biotope characteristic of Rusałka lake water in early spring period in high exchange years and the proof, that the quality of investigated waters estimated on the basic of high exchange coefficients was stabilized, meanwhile the occurrence statistically significant differentiations the individual values of determined coefficients in next years in reference to year

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1999 – was connected with changes weather influencing in changes size and date of rafting thaw waters.

Keywords: lakes, lakes in town, trophic status, Rusałka Lake, Szczecin

Introduction

The Rusałka Lake (Fig. 1) situated in recreation areas in the Kasprowicza Park and being considered to be the most beautiful city park in Szczecin is a water reservoir formed by ponding the waters of the Osówka stream flowing through the Niemierzyn Valley from the hills in the Osów city district. Like other water reservoirs in urban agglomerations (Osmólska-Mróz 1992) the Rusałka Lake is included into municipal storm-water drainage system where it functions as a storage reservoir as well as, of necessity, a sedimentation pond and a biological sewage treatment plant since it collects the waters of the aforesaid Osówka stream being polluted by discharges of different types of waste waters. Due to the threat connected with pollution of the waters of the the Rusałka Lake, its water and bottom deposits were quite frequently examined in the past. Among others, the following parameters were examined: basic indices of surface water quality (Hłyńczak et al. 1995; Poleszczuk et al. 1994, 1996; Poleszczuk, Wawrzyniak 2002), pollution of water and deposits with heavy metals (Hłyńczak et al. 1998, 2008; Niedźwiecki et al. 2007), microbiological water pollution (Nahurska, Deptuła 2004; Stapf, Deptuła 1994) and activity of water organic matter mineralisation processes (Poleszczuk, Bucior 2009). Despite considerable pollution, among others with heavy metals and petroleum derivatives, the surface waters of the Rusałka Lake have been always inhabited by numerous phytoplankton populations. To determine the reasons for such a situation, the total status of water trophy and the total status of pollution of this water body by organic matter should have been investigated among others and therefore a concise characteristics of the biotope of its reservoir of water should have been made at least. Determination of the water trophy within the recharge zone of the Rusałka Lake waters by the waters of the Osówka stream and preparation of a short characteristics of the biotopes of the reservoir of water of the Rusałka Lake in the time period 1999–2010 was the objective of this study.

Characteristics of the water body under examination

The Rusałka Lake (Fig. 1) is an artificial water reservoir being formed by damming up and ponding the waters of the Osówka stream in the Kasprowicz Park in Szczecin. The lake is elongated in shape (600 m long, 25–60 m wide) and is a reservoir with an average depth of approximately 2.0 m. The Rusałka lake is being supplied by the waters of streams flowing down from the hills in the Osów city district and the Warszewo Hills which flow to the lake in the channels being constructed within the urban built-up areas. The waters from the lake flow to the Western Odra River in similarly built-up water channel. Considering the inflow volume of waters feeding the reservoir of the Rusałka Lake, while estimating the water retention time in it to about 30 days on average, it can be seen as a stream pool or as a lake (Giercuszkiewicz-Bajtlik 1990). The Rusałka Lake together with the streams feeding this reservoir have been still included into municipal storm drainage system of the city of Szczecin.

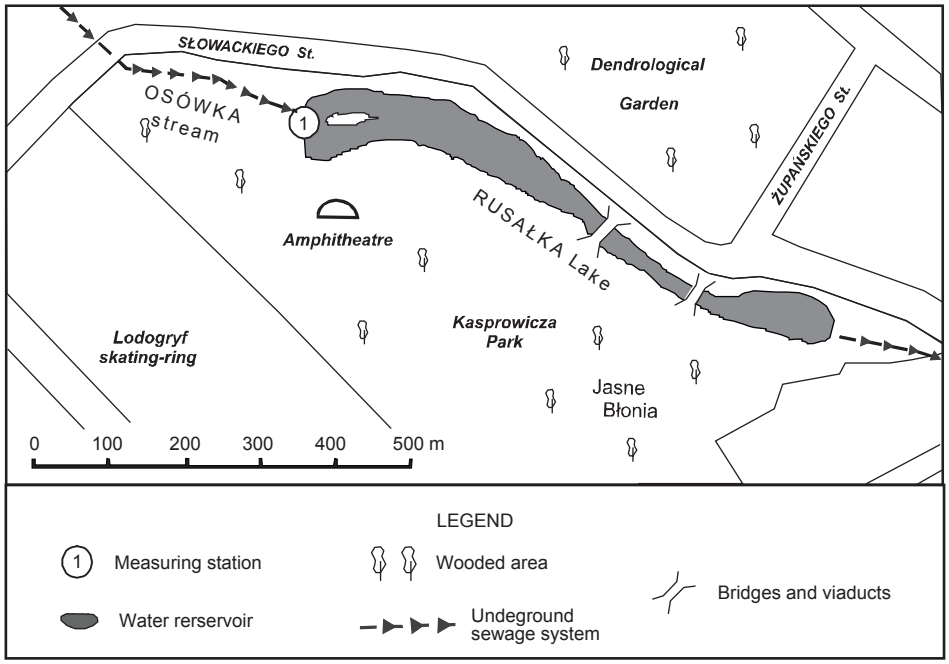

Fig. 1. The Rusałka Lake in Szczecin municipality (after Hłyńczak et al. 2008) – sampling station location

Material and methods

Water samples for analyses were drawn from the water surface layer of the Rusałka Lake within the inflow zone of the waters of the Osówka stream in the western part of the reservoir from the depth of approximately 25 cm below the water table. The samples were collected once a month, always in April, in arbitrary selected time periods in successive years: 1999, 2001, 2003, 2005, 2007 and 2010. Temperature and pH of the investigated water were determined at the place of sample collection using mercury thermometer and pH-meter CP-315 M with and glass and saturated calomel electrodes – respectively. In order to determine the total phosphorus (TP) concentration after minaralisation and soluble reactive phosphates (SRP) by methods with molybdate ammonium and $SnCl_2$ as reducer near length wave $\lambda = 690$ nm, as well as the dissolved O_2 (DO) by Winkler methods, and total organic matter concentration as COD-Cr, and total nitrogen (TN) concentrations as nitrate after mineralisation with ammonium peroxydisulphate, separate samples were collected. The concentrations of NO_3^- by method with phenoldisulphate acid near length wave $\lambda = 410$ nm and NH_4^+ by indophenol colorimetric method near length wave $\lambda = 630$ nm. All colorimetric analysis was realisation using spectrophotometer Spekol 11. The Ca^{2+} concentration by EDTA method – complexometrically, and Cl^- by Mohr method – argentometrically, were determined in the water samples being filtered through a Whatman **Polydisc** Filters with micropore filter 0.45 μm in diameter. All determinations, apart from those being made at the place of water sample collection, were conducted at the laboratory. Analytical procedures recommended by Hermanowicz et al. (1999) were applied according the implementing provisions described in the Polish Standards being currently in force.

The trophic status of the investigated waters was determined based on the TP concentrations basing on the criteria being used for evaluation of the lake water trophy in spring reported by Lampert and Sommer (2001, p. 354).

In order to discern the changes in the TP concentrations in successive years, as well as those in other water quality indices of the Rusałka Lake being determined, the following type of regression equations was used:

$$y_i = y_{1999} + \sum_{i=1}^{n} t_i \, \alpha_i + SEE,$$

where: y_{1999} – value of the concentration of the index being determined in 1999; t_i – time period of the parameter being determined in 0–1 notation, i.e. 1 – when measurement was done in a given time period (year), 0 – when measurement was done in other time periods (years); α_i – numerical coefficient, SEE – residual term.

The results of statistical calculations being performed allowed systematic investigation of the changes in the water quality indices under investigation and undertaking an attempt to determine the reasons for the changes in these indices in the study years in which numerical coefficients α_i for respective indices had significantly statistically different value, i.e. were larger ($\alpha_i > 0$) or smaller ($\alpha_i < 0$), which meant that the value of a given index in a given year was larger or smaller when compared to its value in April 1999 (this year was the year of reference). All statistical calculations were conducted using a regression package of Statistica 6.0 computer software.

Results and discussion

The results of TP concentration analyses, which were used for determination of the water trophy size and selected water quality indices characterising the acid-base equilibrium (i.e. pH), primary oxidant (concentration DO), reducing substances (COD-Cr) and the abundance in biogenic substances (NO_3^-, NH_4^+, SRP) as well as the TN concentration which, on the one hand, may be treated as a measure of total organic matter quantity in water and, on the other one, as a potential quantity of assimilable nitrogen in the reservoir of water after mineralisation, as well as the indices characterising the water salinity, in particular Ca^{2+} and Cl^- concentrations, are presented in Figure 2 and in the form of statistical characteristics of the sets of determination results being compiled in Table 1.

These data characterise the content and the content changes in time of the aforesaid water quality indices of the Rusałka Lake. Table 1 shows that the values of these indices changes quite considerably (CV > 0.20); this refers first of all to almost all analysed parameters, except temperature (CV = 0.20), pH (CV = 0.05) and Ca^{2+} concentration (CV = 0.12). Sometimes, the changes were relatively small as, for example, in the case of Cl^- concentrations (CV = 0.27). The highest variability was characteristic of the values of NO_3^- concentrations (CV = 1.28).

As far as the water trophy size is concerned, it is apparent after conversion of the measurement data from mg PO_4 dm^{-3} to μg P dm^{-3} that the waters being investigated were mostly hypertrophic. Only in 2001, the TP concentrations allowed their classification as eu-hypertrophic ones, while in 2007 – exceptionally – as eutrophic ones. It results from the regression equation being given in Table 2 that the TP concentrations in the waters being investigated can be considered as stabilised ones, while the relationship being determined describes the changes in the TP concentrations with the coefficient of determination $R^2 = 96\%$. An exceptional decrease in the water trophy in the Rusałka Lake in spring 2007, in the inflow zone of the Osówka stream waters, may be easily explained based on the climatic data for the first quarter of 2007 reported by the Institute of Meteorology and Water Management-National Research Institute (IMGW 2004, 2009, 2010, 2011). In fact, the first three months of 2007 had been characterised by exceptionally low temperatures and large amount of precipitation (32 days with precipitation) due to which the precipitation waters flew to the Rusałka Lake in large amounts by the end of March and at the beginning of April, which induced dilution of all substances contained in the waters, including also TP, in that part of the lake. This is confirmed by the quoted data comprised in Tables 1 and 2. The values of other selected water quality indices changes differently in successive years when compared to the data of 1999. For example, the waters of the Rusałka Lake in 2001 were characterised by lower pH values, higher NO_3^- concentration values and lower Cl^- concentration ones, which supports the fact that winter 2000/2001 had been milder (higher temperatures and less precipitation) and was reflected in more active organic matter mineralisation processes and a smaller use of the salt being sprinkled on the streets in the lake drainage basin. However, its waters in 2003 were characterised by lower DO concentrations, higher NO_3^- and TN concentrations, as well as higher Ca^{2+} ones, which also supports the fact that winter 2002/2003 had been also milder.

In 2005, the concentrations of SRP and Cl^- were higher, while higher values of COD-Cr, lower values of TN and TP concentrations and higher values of Cl^- ones occurred in 2007. Therefore, during snowy and cold winter – as we have commented above – more salt had been sprinkled on streets, while spring melt-water deposited considerable amounts of organic matter from its drainage basin. We wish to emphasise that the data being collected in this study were referred to those of April 1999, i.e. from the time period which was preceded by a relatively mild winter (IMGW 2000).

Table 1. Statistical characteristics collected results of investigated waters quality indices on inflow to Rusałka Lake in Szczecin in April 1999, 2001, 2003, 2005, 2007 and 2010

No.	Statistical characteristics / Water quality indices (unit)	Min.	$\bar{x}$	$\tilde{x}$	Max.	SD	CV
1	$P_{tot.}$ (mg $PO_4.dm^{-3}$)	0.21	0.48	0.48	0.75	0.21	0.45
2	Temperature (°C)	7.0	9.3	9.3	12.0	1.8	0.20
3	pH (jednostki pH)	7.47	8.10	8.16	8.56	0.38	0.05
4	$O_{2\ diss}$ (mg $O_2.dm^{-3}$)	4.6	8.5	9.5	11.2	2.7	0.32
5	COD-Cr (mg $O_2.dm^{-3}$)	38.7	79.6	65.5	135.6	36.6	0.46
6	NO_3^- (mg N-$NO_3.dm^{-3}$)	0.04	0.58	0.22	1.85	0.74	1.28
7	NH_4^+ (mg N-$NH_4.dm^{-3}$)	0.04	0.34	0.29	0.65	0.25	0.75
8	$N_{tot.}$ (mg $N.dm^{-3}$)	0.27	1.54	1.64	2.99	0.91	0.59
9	$PO_4^{3-}{}_{diss}$ (mg $PO_4.dm^{-3}$)	0.03	0.23	0.18	0.48	0.20	0.86
10	Ca^{2+} (mg $Ca.dm^{-3}$)	108	123	122	149	15	0.12
11	Cl^- (mg $Cl.dm^{-3}$)	40	61	60	84	16	0.27

Table 2. Value of components in calculated equations of regression

$$y_i = y_{1999} + \sum_{i=1}^{n} t_i \, \alpha_i + SEE$$

y_i	Values significant parameters (significant level)	From analysis regression	
		SEE	R2 (%)
$P_{tot.}$	y_{1999} =0.640 ± 0.000 (0.03128) α_{2007}= –0,769±0,100 (0.05224)	0.042	96.01
temperature	y_{1999} = 10.000 ± 0.000 (0.00460)	1.041	67.82
pH	y_{1999} = 7.950 ± 0.000 (0.00001) α_{2001} = –0.721 ± 0.224 (0.04875)	0.186	75.85
$O_{2\ diss}$	y_{1999} = 10.600 ± 0.000 (0.02821) α_{2003} = –0.841 ± 0.118 (0.05882)	0.636	94.42
COD-Cr	y_{1999} = 38.700 ± 0.000 (0.01872) α_{2007} = 0.657 ± 0.165 (0.05814) α_{2010} = 0.915 ± 0.166 (0.03131)	12.875	87.62
NO_3^-	y_{1999} = 0.050 ± 0.000 (0.07045) α_{2001} = 0.582 ± 0.005 (0.00523) α_{2003} = 0.996 ± 0.005 (0.00305) α_{2010} = 0.168 ± 0.005 (0.01807)	0.007	99.99
NH_4^+	y_{1999} = 0.620 ± 0.000 (0.07198)	0.195	39.00
$N_{tot.}$	y_{1999} = 1.760 ± 0.000 (0.01480) α_{2003} = 0.571 ± 0.031 (0.03470) α_{2007} = –0.652 ± 0.031 (0.03040)	0.57	99.61
$PO_4^{3-}{}_{diss.}$	y_{1999} = 0.100 ± 0.000 (0.15596) α_{2005} = 0.840 ± 0.073 (0.05500)	0.028	97.88
Ca^{2+}	y_{1999} = 108.000 ± 0.000 (0.00007) α_{2003} = 0.834 ± 0.235 (0.03826)	7.572	73.44
Cl–	y_{1999} = 52.000 ± 0.000 (0.00618) α_{2001} = –0.293 ± 0.022 (0.04785) α_{2005} = 0.827 ± 0.022 (0.01696) α_{2007} = 0.394 ± 0.022 (0.03553) α_{2010} = 0.496 ± 0.022 (0.02826)	0.707	99.81

Conclusions

1. The Rusalka Lake waters were hypertrophic one in successive years, i.e. starting with 1999 and further on in 2001, 2003, 2005, 2007 and 2010, in spring (April), except 2007 when they were eutrophic ones, when evaluating them according to the criteria being applied in evaluation of lake waters based on the TP concentrations in spring lake waters.
2. A decrease in the water trophy of the Rusałka Lake in the inflow zone of the Osówka stream in April 2007 was connected with the occurrence of low temperatures in January, February and March and large amounts of precipitation, which induced an inflow of large amounts of melt-water to the lake diluting its waters on the turn of March and April.
3. Similar values of other indices being analysed allowed showing that the values primary water quality indices in April in successive years changed relatively slightly when compared to 1999, whereas statistically significant alterations being observed were connected with the changes in basic climatic parameters in winters preceding the flow of melt-water.

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STATUS TROFICZNY JEZIORA RUSAŁKA W SZCZECINIE W LATACH 1999–2010

Streszczenie

Na podstawie oznaczonych w miesiącu kwietniu w latach 1999, 2001, 2003, 2005, 2007 i 2010 stężeń P_{og} dokonano oceny trofii wód jeziora Rusałka, wykazując, że wody tego zbiornika w strefie dopływu wód cieku Osówka zasilających jezioro były hipertroficzne, za wyjątkiem roku 2007, kiedy to wody roztopowe rozcieńczyły badane wody na tyle, że były one wodami eutroficznymi. Dołączone wyniki równolegle prowadzonych z pomiarami stężeń Pog oznaczeń pH, stężenia O_2 rozp, ChZT–Cr oraz stężeń NO_3–, NH_4+, N_{og}, $PO_4^{3-}{}_{rozp}$ oraz Ca^{2+} i Cl^- – pozwoliły na przedstawienie ogólnej charakterystyki biotopu toni wodnej jeziora Rusałka w okresie wczesnej wiosny w ww. latach i wykazanie, że jakość badanych wód oceniana na podstawie ww. wskaźników była ustabilizowana, zaś występowanie statystycznie istotnych zróżnicowań wartości poszczególnych oznaczanych wskaźników w kolejnych latach w odniesieniu do roku 1999 było związane ze zmianami pogodowymi wpływającymi na zmiany wielkości i terminu spływu wód roztopowych. Na przykład badane w okresie wczesnej wiosny wody miały podwyższone stężenia N_{og} i ChZT–Cr (wskazujące na znaczną zasobność w zawieszoną materię organiczną) po okresach zimowych z dużą ilością opadów i utrzymującymi się aż do końca marca ujemnymi temperaturami, co powodowało gwałtowny spływ – w okresie po ustą-

pieniu mrozów – wód roztopowych, niosących znaczne ilości zawiesin i równocześnie rozcieńczających rozpuszczone składniki mineralne.

Słowa kluczowe: jeziora, jeziora miejskie, status troficzny, jezioro Rusałka, Szczecin