OUTFLOW OF THE BIOGENIC SUBSTANCES IN THE DRAINAGE AREA OF SŁAWSKIE LAKE

Bioģēno vielu noplūde Slawskie ezera drenāžas rajonā

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Abstract
The intent of the author is to familiarize the readers with the results of the research on the anthropogenic eutrophication of the Sławskie Lake where it is impossible or difficult to apply technical measures preventing the pollution. It is a shallow, eutrophic lake where, the structure and functioning – especially the accessibility of easily assimilated biogenic compounds, especially the phosphorus – depends significantly of the fate and speed of decay of the organic matter brought to that ecosystem from the drainage area. For the last several years observed was (in that researched lake) strong blossoming of algae and cyanosis constituting the proof of its periodically sudden eutrophication. A proper description of the volume of the area pollution and determination of the outflow indicators for the water transferring lakes is difficult because the volume of the outflow of the wastes is influenced not only by their diversified contents – being the result of the combination of individual components in varying proportions – but also their influence as a result of certain local conditions. Thus, the results obtained by different authors show big differences and even discrepancies. On the basis of the conducted research it was determined that the most adequate relation (with a similar character of the area) is for the researched drainage area the one between the load of the biogenes and the volume of the indicators of their unit outflow.
Key words: ***anthropopressure, area and spot pollution, trophic, biogenes***

Introduction

The area pollution constitute an ever more serious peril for the surface waters. The loads caused by them often significantly exceed the norm in force for individual areas. Especially, the peril results from the fact that they are much more difficult to eliminate than the spot or line pollutions. Thus, the knowledge of the indicators of the outflow of the area pollution from the drainage area and factors that influence its volume is indispensable in the processes of a balanced development in which, just like in all projects related to the environmental protection, the starting point should be a list of pollutants in the water and, what's most important, a list of biogenic substances within the drainage area. The impact of the man on the natural environment is related to the development of agriculture as well as urban and industrial development. The human interference in the natural systems is not limited to the actions that directly modify the contents and structure of ecosystems but includes also indirect actions related to, for example, upsetting the biogeochemical cycles and induction of the changes in the scale of the whole biosphere. Those changes are generated by a complicated system of feedbacks strengthening the effects of the initial factor that upsets the biological balance.

Materials and methodology

The drainage area of Sławskie Lake (208 km^2) is located within the drainage area of Obrzyca River (1808 km^2) whose waters are used for the needs of the city of Zielona Góra. That system provides approximately 30,000 m^3 of treated water daily and covers 70% of the needs of Zielona Góra.

The rest of the drainage area of the Sławskie Lake is located within the communities of: Nowa Sól, Kolsko and Wijewo. Within that drainage area located are typically agricultural and tourism oriented villages. The town of Sława functions as an administrative and service centre.

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Within the researched drainage area one can notice a strong anthropopressure. Within it located are 46 vacation centres and approximately 600 cottages and a dense system of settlements (a town and six villages) with an undeveloped water and sewage management. In a direct vicinity of the Sławskie Lake live 4300 persons. During the time of vacations approximately 40,000 people spend their free time there. That means 1.5 persons for 1 meter of the shore, and 1 person for 2 m^2 of the area of the direct vicinity of the lake.

The arable land constitutes 41.7% and forests 48.3% of the drainage area. Also an improper management of the arable land and animal wastes is visible in a low quality of the surface waters of many lakes (7 lakes of a total area of 989 ha, Table 2) and six water-courses of the total length of 41.2 km (Table 1). The research was conducted within partial drainage areas of the main drainage area of the Sławskie Lake (Dr. 1) within two hydrologic periods: 1999 and 2000.

Table 1.

Water-courses located within the drainage area of the Sławskie Lake [the Author]

No. of the partial drainage area	Name of the water-course	Length of the river [km]	Drainage area [km^2]	Usage (%)		P/L	Exit to
				Agri-cultural land	Forest		
$1b_1$	Sarnka - 19	6,8	61,7			P	Czernica
$1b_1$	Czernica - 20	41,0				P	Sławskie Lake
1c	Radzyńska Struga - 22	3,3	16,5			L	Sławskie Lake
$1d_1$	Cienica - 21	12,2	65,0			L	Sławskie Lake
1a	A ditch from Myszków -23	0,7	2,1			L	Sławskie Lake
1a	A ditch from Jeziorno - 24	3,0	4,2			L	Sławskie Lake
1e	Dębogóra - 25	7,2	20,5			P	Sławskie Lake
$1b_2$	Direct drainage area	27,34* 817,3ha	37,8			-	Sławskie Lake
-	**TOTAL**	**74,2**	**207,8**	41,7	48,3	-	-
113B - Obrzyca		49,6	1808,4	49,3	35,6	P	Odra

Explanations: numbers of the drainage areas after Podział Hydrograficzny Polski (Stachy, 1983); *, length of the shore line, Jańczak, 1996; P/L, right or left part of the drainage area.

Table 2.

Number and areas of the lakes within the drainage area of the Sławskie Lake [The Author]

Specification	Area in ha					**Total**
	1-5	5-20	20-50	50-100	>1000	
Number of lakes	-	4	1	1	1	7
% of the total area	-	57,14	14,28	14,28	14,28	100
Total area	-	45,0	35,7	91,6	817,3	989,6
% of the total area	-	4,54	3,60	0,92	82,58	100

The conducted research had the goal to determine, for the partial drainage areas, the indicators of the outflow/runoff of the biogenic substances (nitrogen and phosphorus). The

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loads of the total nitrogen and total phosphorus outflowing from the areas of the said drainage areas were determined on the basis of the results of the markings of the contents of those compounds in the waters flowing through the frames closing the said partial drainage areas carried out once a month. During the sampling of the water measured was the volume of the flow (Małacki, 2001). The characteristics of the researched partial drainage areas were determined on the basis of existing materials and own research. The quality of the researched waters and level of their load of biogenes were determined on the basis of the relations between their concentration and volume of flow. The annual load constituting the basis for determination of a unit indicator of the biogenes' outflow/runoff was determined on the basis of an average daily flows through the said frames. The unit indicator of the biogenes' outflow was determined dividing the annual load by the area of the drainage area.

Results

The highest level of agricultural usage is in the partial drainage areas of the rivers of Czernica and Dębogóra. Within the other partial drainage areas the percentage share of the arable land is from 16% to 47%. The location of forest areas is also diverse. The largest forest areas are within the direct drainage area: Rów Myszkowski and Rów Jeziornej.

The load of biogenes in the lake coming from the residential areas, arable land, animal breading and tourists is: phosphorus, approximately 6.1 t in 1999 and 6.9 t in 2000; nitrogen, approximately 67.4 t in 1999 and 76.2 in 2000. From the whole amount of nitrogen 36.5% constitutes the load inflowing via surface waters; 18% via underground waters and 45.5% via precipitations in 1999. The waters of Czernica river inputted approximately 79% of the nitrogen load. In 2000, 52% constituted the nitrogen inflowing with the surface waters, 19% with the underground waters and 31% with precipitations. The Czernica river brought in approximately 77% of the surface waters' load. When deducting the volumes of loads outflowing in the first year of research what was left in the lake was 42.5 t and in the next year, 45.7 t of the total nitrogen.

The total load of the nitrogen in 85% comes from the surface waters, 6% from the underground waters and approximately 9% from precipitations. In 1999, 93% of the nitrogen came from the Czernica river. In the next year the total load of that biogens in 82% was coming from the surface waters (including approximately 90% from the Czernica river), 7% was from the underground waters and approximately 11% from precipitations. When deducting the volume of the loads outflowing in the first year of research what was left in the lake was 5.0 t and in the next year, 5.5 t of the total nitrogen.

The level of threat for the lake by the nitrogen – basing on the Vollenweider research (1968, 1974) – was approximately 8 g/m^{-2}/year in the first year of research and 9.2 g/m^{-2}/year in the second year of the research. Those values exceed 4 times and 4.5 times the value considered as critical one.

The load of nitrogen constitutes a load for the lake of the value of 0.75 g/m^{-2}/year in the first year and 0.84 g/m^{-2} in the second year of research and both exceed 5.7 and 6.5 times the value considered by this Author as a critical one.

The agriculture and residential areas are responsible for most of the total load of the drainage area with biogenes. In that case, one has to take into account also the impact of tourism both for the lake and drainage area.

In the case of nitrogen the biggest load comes from the animal breading and residential areas. But the researched area is impacted by the precipitations as well 'thanks' to the vicinity of the Głogów and Legnica Coper Mining Complex and mostly south-western winds. The similar conclusions are drawn by Florczyk 1987 and Schmidt 1974.

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Summary

A proper determination of the volume of area pollution and determination of the outflow indicators for the water transferring lakes is difficult because the volume of the outflow of pollutants is influenced not only by their complex contents but also by their impact as a result of certain local conditions. Thus the results achieved differ a lot or are even contrary to one another. In Table 4 included are the unit outflows of the biogenes from the drainage areas of differing characteristics (after Florczyk, 1978).

Table 4.

Unit runoff/outflow of biogenic substances from drainage areas with different characteristic

Author	Characteristic of the drainage area	Unit runoff (kg/ha/year)	
		N	P
Florczyk 1997 after Bernhard, Sasen, Husch (1975)	51% arable land, 28% forest; 31% forest	14,5-29,2 4,1-7,0	0,5-0,85 0,03-0,06
Florczyk 1978 after Kolenbrander (1971)	Agricultural drainage areas, silt soils +300kg NPK/ha Agricultural drainage area, sand soils +300kg NPK/ha	over 20 up to 50	average 0,065
Florczyk 1978 after Gachter,Furrer (1972)	Agricultural drainage areas	16-21	0,35-0,69
Juhrma, (1966)	Forests Not fertilised pastures Fertilised meadows	8,4 16,5 19,4	0,04 0,74 1,02
Florczyk 1978 after Dillon, Kirchner (1975)	Forests on volcanic rocks Forests on sedimentary rocks Forests + pastures on volcanic rocks Forests + pastures on sedimentary rocks Agricultural and forest areas on volcanic rocks Agricultural land on sedimentary rocks		0,026-1,07 0,067-0,145 0,081-0,160 0,205-0,370 0,059-0,50 0,11-1,13
Kowalczak at all (1997)	From the point sources From the roads From the areas without sewage systems From the space sources Inputted as a result of bath From precipitations	1,19% 0,10 13,4% 51,49% 0,05% 33,78%	3,06% 0,52% 46,55% 38,11% 0,03% 11,73%
Florczyk(1978) after (Ohle,1955)	60kg/ha superphosphate and annual precipitation of 650mm		0,24-0,47
Florczyk (1978) after Vollenweider (1968)	The losses are	10-25%	1-5%
Florczyk (1978)		1,02-38,95%	0,19-3,36%

On the basis of the conducted research it was determined that the most adequate relation at similar character of the surfaces is, for a given drainage area, the relation between the load of the biogenes and volume of the indicators of their unit runoff/outflow.

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The research showed that both the volume of the outflowing annual load as well as momentary load of biogenes is for the purposes of the research a function of the flow and it increases with its increase. No correlations given in the literature (Gachter, Firrer 1972; Bernhardt 1973; Omernik, after Kowalczak 1997) were determined between the percentage share of the arable land and concentration of the researched biogenes, nor between the percentage share of the arable land and indicators of the outflow/runoff of those compounds from the drainage area.

If the grains take from the soil approximately 160 kg of NPK at the harvest of 30dt (average one for Poland) and usage of fertilisers in 2000 – as per the Main Statistics Office – was approximately 87.4 kg/ha, then the load of nitrogen in the surface waters for sure comes to a large degree from the precipitations. The most of the load of nitrogen entering the surface waters comes from the natural contents of the soils and not from the loads introduced in the form of fertilisers. On the other hand it is worth to consider whether it does not mean stilling for the soils and harvesting on credit.

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