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IMPACT OF LAND USE METHODS ON THE WATER QUALITY OF SMALL PONDS

WPŁYW SPOSOBU UŻYTKOWANIA TERENU NA JAKOŚĆ WÓD OCZEK WODNYCH

Abstract: The objective of this paper was the impact assessment of land use methods on the surface water quality. The small ponds selected for research are located in agricultural, rural, and forested areas. The studies were conducted in the period of two hydrological years eg 2006 and 2007 in order to determine: nitrates(V), nitrates(III), ammonia, phosphates, sulphates, chlorides, calcium, magnesium, dissolved oxygen, reaction and electric conductivity.

Analysis of the collected data allows to affirm that land use methods of the neighbouring area of the reservoir have a direct impact on the water quality of the small ponds. Rural settlements have the most negative influence on the deterioration of the water quality followed by typical agricultural use. Based on the direct quality evaluations of water samples, it has been found that only water of the small pond localised in forested areas can be qualified as belonging to the 1st class of the very good quality water.

Keywords: land use, small ponds, water quality

The stagnant waters, including small ponds, are an important element of the rural areas. They are the integral part of a rural landscape as well as the water reservoir which influence on the waters relations of adjacent terrains. The small pond that is the small reservoir, which area does not exceed 1 ha, it contributes also to increasing species diversity within agrocenosis [1]. Despite so many important functions which small ponds fulfill in the environment, they are subjected to the impact of many negative factors [2, 3]. The main threat for small water reservoirs is their susceptibility to degradation, which can, cause in the extreme case, their disappearance [4, 5]. Rising living standards as well as increasing urbanisation have become the reasons for significant, not always favourable, impact of humans on the natural environment, in this on water resources quality. For this reason protecting water resource quality from pollution is one of the main problems of contemporary civilisation [6, 7].

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The objective of this paper is to compare the water quality of small ponds located in the terrains where the land is used in various ways.

Material and methods

In the work a collation has been made of the impact of land use methods on the water quality of small ponds. For this purpose three small ponds were selected which were located in the agriculturally used land, rural settlements and forested areas, and from which water samples were subjected to physical-chemical analyses which determined 11 quality indicators.

The investigated research sites are located in the Malopolska province, in the district of Bochnia (Bochnia and Nowy Wisnicz communes) and in the district of Brzesko (Brzesko commune) situated within two meso-regions, eg the Bochenski and Wisnicki Foothills [8]. Analysing assigned area around the small pond which was located in agriculturally used area, it has been found that 94 % of the area consist of farm land with a quite large share of meadows and pastures (17 %) and orchards (17 %). With the small pond, located in a settlement-agricultural area, from the south and western side directly border on: internal road and settlements and compacted residential built-up. Examining the whole area adjoined to this small pond, it was found that 86 % of the area makes up agricultural land of what on meadows and pasture falls 16 % and on orchard 15 %. The terrain adjoining the small pond located in a woody area, in 60 % is utilized as forest; meanwhile 36 % of the area is used as farmland, with sufficiently large share of meadows and pastures (20 %) as well as orchards (5 %).

The field studies were conducted from November 2005 to October 2007. Reaction (pH), electric conductivity and dissolved oxygen were determined by equipment from the Elmetron Company. Nitrates(V), nitrates(III), ammonia, phosphates, chlorides were determined by the flow method of colorimetric analysis, and sulphates were determined by a gravimetric analysis (precipitation). Calcium and magnesium were analysed by an atomic absorption spectrophotometer of Unicam Solar M 6 [9].

Based on results obtained by the direct method, the quality of the water was assessed and classified according to regulations established by the Minister of Environment [10].

Results and discussion

The results obtained which concerned the values of selected quality indicators of small ponds located in widely utilised land showed a large difference (Table 1).

The mean values from the investigated period were in the range: for nitrates(V) – 0.77–1.26 mg · dm^{-3}, nitrates(III) – 0.02–0.05 mg · dm^{-3}, ammonium from 0.02 to 1.25 mg · dm^{-3}, phosphates – 0.06–0.86 mg · dm^{-3}, sulphates – 38.25–68.57 mg · dm^{-3}, chlorides – 8.80–52.58 mg · dm^{-3}, calcium – 38.41–176.7 mg · dm^{-3}, magnesium – 11.56–19.18 mg · dm^{-3}, dissolved oxygen – 6.59–9.46 mg O_2 · dm^{-3}, electric conductivity – from 354.54 to 722.21 μS · cm^{-1} and reaction – pH 7.60–7.76. The concentrations of nitrates(V), nitrates(III), ammonium and phosphates were

characterised by the highest variability. The smallest coefficient of variability was recorded in the case of reaction, electric conductivity and dissolved oxygen content.

Table 1

The values of selected quality indicators of water in the small ponds located in the various land areas

The quality indicator	Unit	Site	Minimum	Maximum	Mean	Standard deviation	Variability coefficient [%]
NO_3^-	[mg · dm^{-3}]	1	0.035	3.934	0.77	1.13	147
		2	0.095	5.674	1.26	1.50	119
		3	0.063	4.632	1.14	1.46	128
NO_2^-		1	0.003	0.144	0.02	0.03	150
		2	0.007	0.266	0.05	0.07	140
		3	0.003	0.055	0.02	0.01	50
NH_4^+		1	0.006	0.149	0.02	0.04	200
		2	0.203	4.580	1.83	1.25	68
		3	0.007	0.186	0.06	0.04	66
PO_4^{3-}		1	0.018	0.598	0.12	0.13	108
		2	0.037	2.047	0.82	0.66	80
		3	0.006	0.266	0.06	0.08	133
SO_4^{2-}		1	47.38	101.74	68.57	13.23	19
		2	28.00	116.39	50.87	22.94	45
		3	14.23	64.90	38.25	13.88	36
Cl^-		1	36.51	82.00	52.58	12.92	24
		2	24.94	60.00	40.01	7.45	19
		3	4.76	22.46	8.80	3.41	38
Ca^{2+}		1	48.0	150.2	92.57	29.32	32
		2	38.6	176.7	96.63	44.09	46
		3	18.1	78.4	38.41	12.78	33
Mg^{2+}		1	4.8	22.5	13.08	3.65	28
		2	10.8	39.1	19.18	8.13	42
		3	3.6	17.3	11.56	2.70	23
Dissolved oxygen		1	6.45	9.46	8.03	0.78	9
		2	5.21	8.60	6.59	0.83	13
		3	6.14	9.28	7.84	0.74	9
Conductivity	[μS · cm^{-1}]	1	443	715	576	114	19
		2	455	873	722	108	15
		3	118	716	354	105	29
Reaction	pH	1	6.87	8.46	7.76	0.37	5
		2	6.74	8.43	7.60	0.42	5
		3	6.95	8.28	7.75	0.35	4

Explanations for Tables 1 and 2: 1 – small pond located in typical agricultural area, 2 – small pond located in agricultural and rural settlement area, 3 – small pond located in forested land.

The small ponds located within agricultural and forest area, are characterized by low eutrophication. During the studies, it has not been found long-lasting water blooms, caused by blue-green algae, as well as a decrease of diversity, abundance of macrophytes and invertebrate fauna. In the small pond located in rural settlement area, numerous water blooms were found, what makes up the base, according to the criteria contained in regulation established by the Minister of Environment [10] to classify its water to high eutrophication degree.

In the work the direct quality assessment of single water samples collected in the period of 24 dates (Table 2) were conducted. Based on this one can conclude that only water in the small ponds located in forested terrain in 5 dates fulfils the criteria of the 1st class of very good quality water. It was shown that the most polluted water was in the small ponds situated in the agricultural-rural settlement areas, which most frequently were classified in the 5th class of bad quality water.

Table 2

Water sample dimensions from the small ponds in particular quality classes, established by a direct method

Site	The number of the sampling collection dates	Water quality classes									
		I		II		III		IV		V	
		n_1	[%]	n_2	[%]	n_3	[%]	n_4	[%]	n_5	[%]
1	24	0	0	12	50	12	50	0	0	0	0
2	24	0	0	2	8.3	4	16.7	7	29.2	11	45
3	24	5	20.8	19	79.2	0	0	0	0	0	0

The greatest impact on lowering water quality of the small pond situated in the area with advantage of farm land had calcium (Fig. 1), which content often fulfilled the criteria of 3rd class of satisfactory quality water. Electric conductivity and contents of phosphates, nitrates(III) and dissolved oxygen decided about classifying water of small

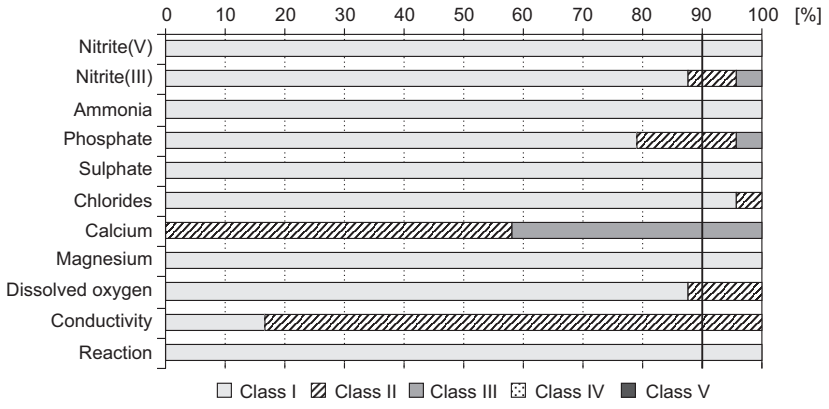

Fig. 1. Distribution frequency [%] of selected quality indicators of water in a small pond located in a typical agricultural land

pond in a typical agricultural terrain to the 2nd class of good quality water. The remaining analysed indicators (concentration of NO_3^-, NH_4^+, SO_4^{2-}, Cl^- and Mg^{2+} as well as pH) placed the water of the small ponds often in the 1st class of very good quality water.

The water quality of the small pond located in rural settlements – agricultural land (Fig. 2) was lowered in the highest degree by excessive concentrations of phosphate (to the 5th class of bad quality water), ammonium (to the 4th class of unsatisfactory quality water) as well as calcium and to low dissolved oxygen concentration (to the 3rd class of satisfactory quality water. Nitrates(III) and magnesium concentrations lowered the water quality to the 2nd class of good quality water. It was established that concentrations of nitrates(V), sulphates and chlorides as well as values of electric conductivity and pH allow for ranking the water of this small pond to the 1st class of very good quality water.

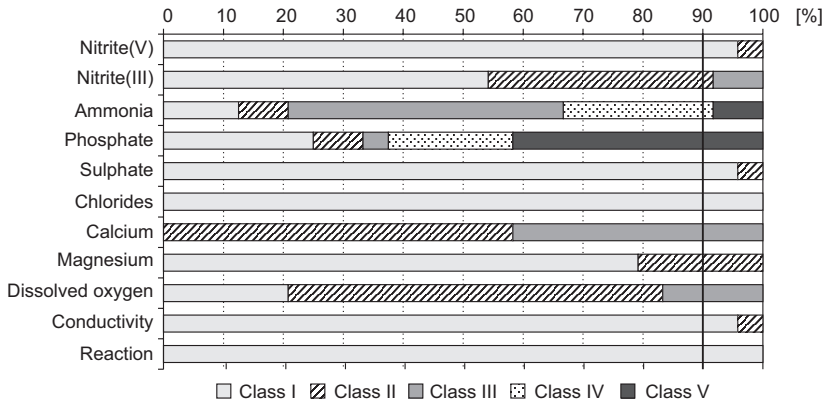

Fig. 2. Distribution frequency [%] of selected quality indicators of water in a small pond located in a rural settlement and agricultural land

Majority of analysed indicators for the water quality of the small pond located in forest area allow, classifying them to the 1st class of very good quality water (Fig. 3). Only calcium qualified often its water to the 2nd class of good quality water. It was found that incidental concentrations of phosphates and dissolved oxygen qualified the water of the small pond also to the 2nd class of good quality water. The remaining analysed quality indicators (NO_3^-, NO_2^-, NH_4^+, SO_4^{2-}, Cl^-, Mg^+, electric conductivity and pH) classified the water of small ponds in forest area to the 1st class of very good quality water.

During the study period, the water quality analysis of stagnant water in variously used land based on a direct method (for frequency 90 %) showed that only nitrates(V), sulphates and chlorides contents as well as pH qualified the water of 3 research sites to the 1st class of very good quality water (Fig. 1).

The tendency for a larger decrease in the water quality of small ponds located in rural settlements and in a typical agricultural area than in the case of woody areas confirmed the results of research conducted by Skwierawski and Szyperek [11]. Based on own

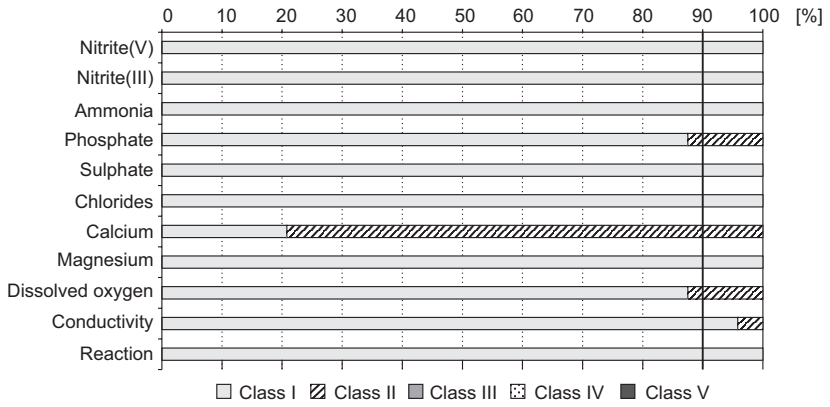

Fig. 3. Distribution frequency [%] of selected quality indicators of water in a small pond located in forest land

studies Koc et al [12] justified it by the impact of agricultural land use, the vicinity of farms, and the lack of sewage systems in compacted built-up areas or scattered housing in which the often encountered practice is the delivery of domestic sewage directly into the small ponds. An unfavourable impact is also caused by leaky sewage tanks, collecting tanks for liquid manure that are not tight enough, and pits.

Conclusion

1. On the basis of a direct quality assessment of single water samples it was found that only water in the forest areas can qualify to the 1st class of very good quality water. The most polluted was water from rural settlements and agricultural areas, which qualified most frequently to the 5th class of bad quality water.

2. The quality analysis by a direct method proved that the indicators which lowered the water quality the most were biogenic compounds and calcium, and the least were sulphates, chlorides and reaction.

3. It has been shown that in the case of small ponds situated in rural settlements and agricultural areas, the water quality was lowered most by excessive phosphate contents (to the 5th class of bad quality water) and ammonia (to the 4th class of unsatisfactory quality water). In small pond located in a typical agricultural area, its quality was decreased only by calcium (to the 3rd class of satisfactory quality water).

4. Water of small ponds in forest areas was characterised by decidedly the better quality. The water quality of this water pond was decided chiefly by calcium, phosphates, and dissolved oxygen, which caused the lowering the water quality to maximum the 2nd class of good quality water.

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WPŁYW SPOSOBU UŻYTKOWANIA TERENU NA JAKOŚĆ WÓD OCZEK WODNYCH

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Uniwersytet Rolniczy im. Hugona Kołłątaja w Krakowie

Abstrakt: Celem badań była ocena wpływu użytkowania terenu na jakość wód powierzchniowych. Wybrane do badań oczka wodne są zlokalizowane na terenie typowo rolniczym, osadniczo-rolniczym i leśnym. Pobrana woda została poddana analizie fizykochemicznej pod względem stężeń: azotanów(V), azotanów(III), amoniaku, fosforanów, siarczanów, chlorków, wapnia, magnezu, tlenu rozpuszczalnego oraz wartości odczynu i przewodności elektrycznej właściwej. Badania wykonano w ciągu dwóch lat hydrologicznych 2006 i 2007.

Uzyskane wyniki badań pozwoliły na stwierdzenie, że na jakość wód oczek wodnych bezpośredni wpływ wywiera sposób użytkowania terenu sąsiadującego ze zbiornikiem wodnym. Największy wpływ na pogorszenie jakości wód mają tereny osadniczo-rolnicze, drugie miejsce zajmują tereny typowo rolnicze. Na podstawie bezpośredniej oceny jakości próbek wody stwierdzono, że tylko wody oczka zlokalizowanego na terenie leśnym mogą być zakwalifikowane do pierwszej klasy wód o bardzo dobrej jakości.

Słowa kluczowe: użytkowanie terenu, oczka wodne, jakość wód