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CHEMISTRY OF WATERS OF SMALL WATER BODIES IN THE AGRICULTURAL LANDSCAPE OF THE WESTERN WIELKOPOLSKA REGION

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Summary. The chemistry of the water of small water bodies located in agricultural areas with different levels of anthropogenic transformation was analysed. Due to differences in the chemical features of waters, 2 groups of water bodies were distinguished: in anthropogenically transformed agricultural landscape and in natural agricultural area. The common feature of all the ponds was neutral or light alkaline pH and total hardness placing their waters within the group of medium hard. The TSI index indicated a high trophy. In most of the examined reservoirs considerable amounts of dissolved organic matter (DOM), including humic substances, were recorded.

Key words: agricultural landscape, mid-field lake, trophy, hydrochemistry, DOM

INTRODUCTION

Small water bodies and watercourses may create important biogeochemical barriers which effectively restrict free migration of mineral and organic substances [Szpakowska and Życzyńska-Bałoniak 1994]. The significant role of mid-field ponds has greater practical meaning for the planning of pastoral areas when considering how to control the processes of self-cleansing of the environment. This is particularly important in districts where grey-brown podzolic soils prevail, with a shallow level of the ground waters, and which may be places potentially vulnerable to accelerated pollution of ground waters by chemical compounds filtered through the soil [Szpakowska 1999]. Although large bodies of water are objects of permanent monitoring, in the case of small water bodies such examinations are often made accidentally. However, to prepare a proper strategy of protection based on the rules of the functioning of the agricultural landscape, thorough knowledge considering the quality conditions of waters of such reservoirs is required. This view is now gaining special significance in areas with water deficit, among which the agricultural areas of Wielkopolska region are placed.

The aim of the study was to determine the physical and chemical features of the waters of small mid-field water bodies situated in an agricultural landscape with a differentiated level of anthropogenic transformation.

STUDY AREA, MATERIAL AND METHODS

The area of the study is located in the neighbourhood of the agglomeration of the city of Poznań, in the macro-region of the Wielkopolska Lake District [Kondracki 1998] in which a thick net of rivers, lakes of various sizes and post-glacial water bodies appear. Within the urban areas of Poznań there are about 150 water bodies. Besides those, mainly in the outer-urban agricultural landscape (of different level of human-impact transformation), there are several outflow-less ponds whose area is no larger than 5 ha and depth no greater than 3 m.

The research was carried out in the summer season of 2004 and 2005 in seven ponds located within the agricultural landscape: degraded (group I, ponds No 1, 2, 3, 4) and natural (group II, ponds No 5, 6, 7). The pH, conductivity, dissolved oxygen, temperature (Sension 156 Hach) and water transparency were measured *in situ*. Total reactive phosphorus (TRP), total phosphorus (TP), nitrate, nitrite and ammonium nitrogen, total hardness, water colour, dissolved organic matter as UV absorbance [Hermanowicz *et al*. 1999] and chlorophyll *a* concentration [Wetzel and Likens 2000] were determined in the laboratory. The trophy status of waters was determined using the TSI index [Carlson 1977], using its mean value TSI_{Mean}. The level of the trophic conditions TSI_{Mean} was related to the ranges proposed by Kraska *et al*. [1999].

RESULTS

In the chemical composition of the waters a great quality differentiation was recorded, which suggested a variation of natural conditions of the surrounding environment on one hand, as well as transformation of the chemical features of the soils as a result of intensive agro-chemical treatments on the other. The studied waters were well oxygenated, which related to both groups of ponds – those of the anthropogenically transformed landscape (gr. I) – 11.1 mg O_2 l^{-1} on average, as well as those of natural surroundings (gr. II) – 7.7 mg O_2 l^{-1}. Only in one pond was the oxygen concentration lower than 4 mg O_2 l^{-1}. A sign of the harmful influence of the catchment area on the quality of the investigated waters was the high level of their mineralization, which was indicated by high – usually reaching 1000 μS cm^{-1} – values of the electric conductivity in both groups of water bodies; however, greater differentiation was found in relation to particular minerals (Fig. 1). Another feature of the ponds was considerably high concentration of nitrites (higher in the group of natural water bodies – 0.006 mg l^{-1} N_{NO2} on average) and relatively high concentration of nitrates (gr. I 241 μg l^{-1} N_{NO3} on average, gr. II 290 μg l^{-1} N_{NO3}) and ammonium (1352 and 874 μg l^{-1} N_{NH4} respectively). The values of the ponds' pH classified them usually among neutral or light alkaline waters, while the total hardness located their waters in the group of medium hard (Tab. 1).

The trophy of the ponds water was high – generally eutrophy with the values of TSI_{mean} from 61.5 to 70.7, with the exception of the pond No. 1, where α-mesotrophic conditions (56.7) were recorded. A common feature of the chemical composition of the studied waters of the ponds were high values of the participation of total reactive phosphates in the total phosphorus bank (TRP/TP). In the ponds of group I the mean values were much higher than in the ponds of group II (0.7 and 0.4, respectively), which confirms a higher level of pollution of their waters. The obtained results of TRP/TP indicate the

direction of the quality changes of the environment in the catchment areas of water bodies, especially in relation to the agricultural landscape undergoing anthropogenic impact (gr. I).

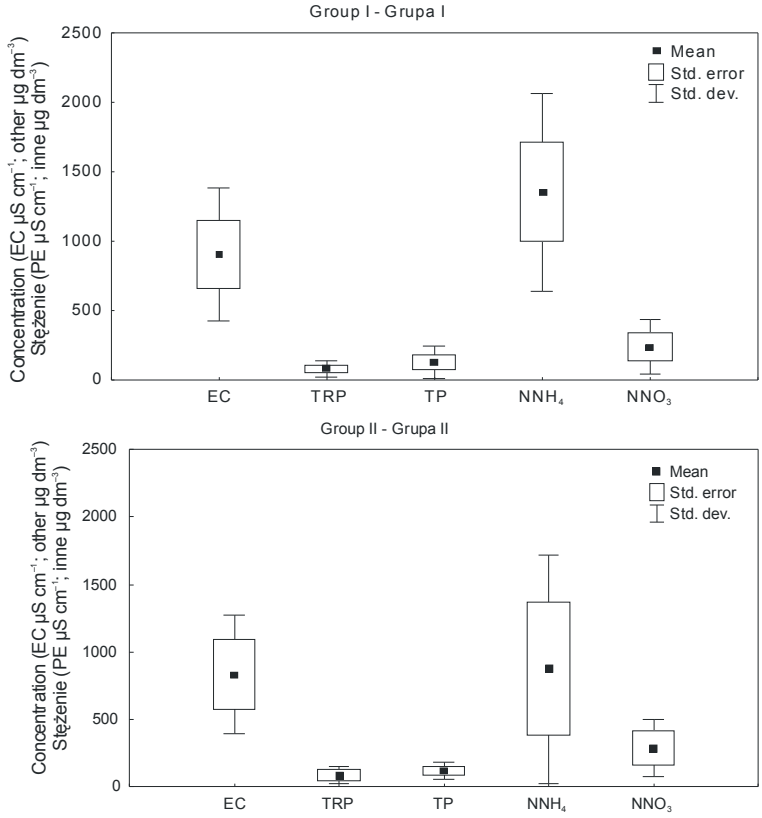

Fig. 1. Concentration of mineral substances in the examined water bodies: group I – degraded landscape, group II – natural landscape (EC – electric conductivity)
Rys. 1. Stężenie składników mineralnych w wodach badanych zbiorników: grupa I – krajobraz zdegradowany, grupa II – krajobraz naturalny (PE – przewodnictwo elektrolityczne)

Table 1. Results of hydrochemistry analysis of water in the ponds
Tabela 1. Wyniki analizy hydrochemicznej wód stawów

Pond Staw	EC PE (µS cm^{-1})	pH	Hardness Twardość (mg $CaCO_3$ l^{-1})	Oxygen Tlen (mg O_2 l^{-1})	Colour Barwa (mg Pt l^{-1})	TRP	TP (µg P l^{-1})	TRP/TP	N_{NH4}	N_{NO3} (µg l^{-1})
1	1318	8.4	598	9.1	7	67	69	0.97	620	92
2	217	9.6	9	12.3	41	8	15	0.53	1410	185
3	1091	8.2	551	8.6	39	113	168	0.67	1080	157
4	998	9.9	274	14.5	75	141	275	0.51	2300	530
5	788	7.7	327	3.9	26	116	139	0.83	183	118
6	417	6.6	43	11.6	51	13	50	0.26	1820	221
7	1296	9.1	138	7.7	21	135	169	0.8	620	530

EC – electric conductivity, TRP – total reactive phosphorus, TP – total phosphorus
PE – przewodnictwo elektrolityczne, TRP – fosforany ogólne, TP – fosfor całkowity

The examination revealed a high differentiation in the content of dissolved organic substances absorbing ultraviolet radiation of wavelength of 254 nm. The obtained values indicated a higher content of dissolved organic matter (DOM), including humic substances. Among the two distinguished groups of ponds, in relation to their content of DOM, the water bodies located within the natural landscape (gr. II) were characterized by abundant amounts of organic substance, while the ponds of group I by lower content of DOM (Fig. 2).

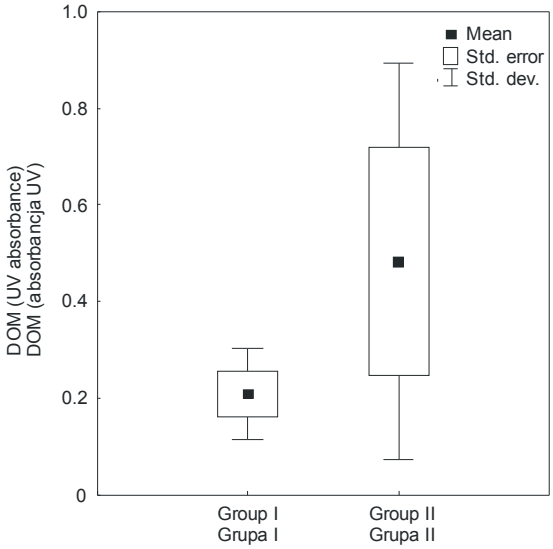

Fig. 2. Comparison of dissolved organic matter content in water of the examined water bodies (group I – degraded landscape, group II – natural landscape)
Rys. 2. Porównanie zawartości rozpuszczonej substancji organicznej w wodach badanych zbiorników (grupa I – krajobraz zdegradowany, grupa II – krajobraz naturalny)

DISCUSSION

The conducted research confirmed that the waters of the small water bodies were a reservoir of elements and inorganic compounds, as well as of organic substances. It seems that organic matter originating from ground waters or from surface run-off was a combining feature influencing the chemical composition of pond waters. The washing out of organic substances and their transport into the reservoirs of inland waters is a common process depending on a variety of factors, including the type of soils, the method of catchment area management and on hydrogeological and climatic conditions [Kajak 2001]. The presence of lower concentrations of DOM in water bodies within a mid-field landscape, undergoing human impact, confirms the disruption of their flow, caused not only by the restriction of precipitation.

Ground waters under fields and meadows contain weakly humified organic substances with a high concentration of aliphatic structures [Szpakowska 1999], which helps them to bind with biophilic metals (Ca, Fe, Mn). The abundance of such compounds, and especially of high-molecular humic substances, leads to the binding of mineral elements,

especially phosphorus compounds, ammonium and nitrates [De Haan 1992]. At the same time, ground waters (along with surface flow) supplying the water bodies may have comprised an important source of mineral and organic substances, which was a key factor for the pond functioning, particularly in the context of their eutrophication. The obtained neutral and slightly alkaline pH of the pond waters was of an essential meaning for maintenance of the sorptive abilities of humic acids, which increase in such conditions, which in turn accelerates the exchange of cations [Myśliwska 2001].

As already mentioned, precipitation plays an important role in determining the values of DOM concentrations in the mid-field water bodies and in their chemical activity. The moisture periods favour the outflow of DOM and dissolved humic substances from fields, while dry seasons tend to cause a decrease in their concentrations [Szpakowska 1999]. This is why many authors state that further analysis along with the examination of the impact of external factors should help to resolve the uncertainty concerning the direction of changes of the chemical composition of waters caused by DOM. The continuation of such studies and collection of a greater body of results will lead to a comprehensive view of the characteristics of the hydrochemical features of water bodies within an agricultural landscape of differentiated human transformation level.

CONCLUSIONS

1. Water bodies within the natural agricultural landscape was characterized by higher concentrations of DOM, but lower of mineral elements, especially of nitrogen forms, compared to the ponds anthropogenically transformed.

2. The feature of the chemical composition was participation of total phosphate in the total phosporus bank, which indicated negative quality changes in the cathment areas.

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CHEMIZM WÓD MAŁYCH ZBIORNIKÓW KRAJOBRAZU ROLNICZEGO ZACHODNIEJ WIELKOPOLSKI

Streszczenie. Analizowano skład chemiczny wód małych zbiorników wodnych krajobrazu rolniczego o różnym stopniu przekształcenia antropogenicznego. Różnice chemizmu wód umożliwiły wydzielenie dwóch grup zbiorników: krajobrazu rolniczego antropogenicznie zmienionego i rolniczego naturalnego. Cechą wód stawów było obojętne lub słabo alkaliczne pH i twardość ogólna lokująca ich wody w grupie średnio twardych. Indeks TSI wskazywał na wysoką trofię wód. W większości zbiorników notowano duże ilości rozpuszczonych substancji organicznych (RSO), w tym substancji humusowych.

Słowa kluczowe: krajobraz rolniczy, zbiornik śródpolny, trofia, hydrochemia, RSO