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Habitat conditions of astatic pools and differentiation of vegetation connected with them

MAŁGORZATA NIECKUŁA, WIESŁAW PODYMA

Department of Phytogeography, Institute of Botany, Warsaw University, Al. Ujazdowskie 4, 00-478 Warszawa, Poland

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Abstract

In 12 astatic pools, each of which was characterised by the dominance of phytocenoses of one of three plant associations, investigations were performed on the physico-chemical properties of the water and bottom sediments, in order to establish the relations between the habitat conditions and vegetation. The criterion of the degree of saltiness of the bottom sediments and the specific conductivity of water in these water bodies allows to order them according to their decreasing fertility as follows: 1) water bodies with dominant phytocenoses of the association *Equisetetum limosi*, 2) with *Caricetum elatae*, 3) with *Typhetum latifoliae*. The type of vegetation indicates also connections with other properties of the water (hardness, oxidability, pH, chloride content) and of the bottom sediment (organic matter content, chlorides, magnesium and various forms of nitrogen). Correlation between the chemical composition of the water and depostis has only been demonstrated in the case of chlorides.

Key words: astatic pool, plant community, environmental conditions

INTRODUCTION

Podbielkowski and Tomaszewicz (1979) describe by the term astatic pools small water bodies at the bottom of various terrain depressions. Their specific features are very wide changes in water level, frequently leading to periodical drying up, considerable changes in other conditions of the habitat (water chemism and sediments), freezing to the bottom in winter.

In the Polish pertinent literature there are quite many papers dealing with the vegetation of anthropogenic water bodies or those intensively utilised by man: clay pits (Podbielkowski 1969, 1970), peat hags (Podbielkowski 1960, 1970, Krzywańska and Krzywański 1972) melioration ditches

(Podbielkowski 1967, 1970), fishery ponds (Podbielkowski 1968). Data concerning small natural water bodies are in general fragmentary. The authors either study the fauna (Chodorowska and Chodorowski 1958) or some selected features of the habitat such as temperature, rate of decomposition, buffering curves, oxygen content in water (Paschalski 1959) or flora (Solińska 1963, Kloss and Wilpiszewska 1983).

In the literature of other European countries, beside publications concerning vegetation of small natural water bodies, exclusively (Horn af Rantzien 1951a, b) and anthropogenic ones (Jilek 1956), there are many papers dealing with the different ecological conditions in surface waters and their connection with the presence of definite plant communities or species. In these papers, usually monographs of a definite territory, astatic pools are described against the background of other water environments or together with them (Olsen 1950a, b, Spence 1964, Wiegleb 1978, Vangenechten et al. 1981).

In view of the increased intrest in the problems of ecology of plant communities, the relations between abiotic conditions and phytocenoses, and their comparison with similar data for lakes seemed of interest. Noteworthy are also the relations between the chemism of water and bottom sediments which have not been noted in lakes (Januszkiewicz 1970a, b) as well as in other surface waters (Olsen 1950a). In the water bodies investigated by the present authors the relation between these two environments may be closer, on account of intensive stirring of the water and its small depth.

The present publication contains part of the results included in theses for master's degree at the Department of Phytogeography of the Warsaw University.

CHARACTERISTIC OF THE TERRAIN AND OF THE OBJECT INVESTIGATED

The astatic water bodies were investigated in the environs of the village Sajzy between the lakes Łaśmiady and Krzywe and to the north-east of Krzywe. This territory belongs to the mesoregion of the Ełk lakeland within the macroregion of the Mazury Lakeland, according to the physical-geographical division of Poland by Kondracki (1965). A more precise characteristic of this region is given by Kondracki (1972).

The studied water bodies mostly occupy natural depressions, ice holes. They are surrounded by crop fields, meadows and pastures, less frequently by small wooded areas. These water bodies are supplied mainly by run-off waters and their properties are mainly developed under atmospheric conditions. The hydrological balance comprises, on the one hand, precipitation falling directly into the bowl, and surface and underground run-off from the catchment and, on the other hand, the effect of evaporation. Owing to the small dimensions and high fertility of the habitat of the astatic pools, the phytocenoses occurring here occupy small areas (even as little as several m^2) and occur in mosaic arrangement. In some few (including the 12 pools chosen for habitat analysis) it was possible to distinguish the dominant community. Like most of the studied objects they are overgrown mainly by rush and meadow vegetation of the class *Molinio-Arrhenatheretea* with intruding *Salicetum pentandro-cinereae* associations. Frequently wide areas in the bowl of the water body are occupied by communities with a specific species composition, and their syntaxonomic appurtenance is difficult to establish.

METHODS

The investigations were performed during two vegetation seasons: 1979 — study of vegetation and 1980—habitat analyses. A total of 70 water bodies were examined.

The phytosociological method was applied in **investigations of the vegetation** (Fukarek 1967, Scamoni 1967, Pawłowski 1977). The systematic classification of the plant communities of Matuszkiewicz (1967) was adopted and for rush and aquatic communities according to Tomaszewicz (1979). In the accumulated material (478 phytosociological records) 64 syntaxonomic units were distinguished: 30 associations and 34 unidentified ones, for 13 of which their taxonomic appurtenance could not be established. The full documentation and tables of associations are included in the theses for master's degree (Walczak 1981, Podyma 1982). For the synthetic phytosociological description of the studied pools and the characteristic of the phytocenose arrangement in them the sigma-association method was used (Gehu 1976, 1977). The results are shown in Table 1. A scale analogous to the quantitative one in the Braun-Blanquet method gives the ratio of the surface occupied by the phytocenosis to the whole surface area covered by vegetation (in the present case within the water body bowl).

Habitat investigations: measurements of water level variations, of pH and specific conductivity of water (Hermanowicz et al. 1976) and of saltiness of the sediments were conducted from mid April to mid November at 1-2 week intervals. For detailed analysis of the habitat 12 pools were chosen with distinct dominance of phytocenoses of one of the three associations: *Caricetum elatae* (3 pools), *Typhetum latifoliae* (4 pools), *Equisetetum limosi* (2 pools). Data concerning the remaining objects may be found in the theses of Podyma (1982) and Walczak (1981). For simplification a different notation of the pools was adopted in the present publication, consisting of the first letter of the name of the dominant association and the serial number. They correspond to the following notations in the theses: C1 — W42, C2 — G3, C3 — W32, T1 — G22, T2 — W23B, T3 — W23A, T4 — W5, E1 — G13, E2 — W2.

Water and sediment samples for analysis were collected three times in the course of the vegetation season: at the beginning of May, in mid August and in mid November. Water and sediment analyses were carried out according to the Polish standard methods (Hermanowicz et al. 1976). Total and ammonium nitrogen, organic and nitrate nitrogen, phosphates, sulphates, chlorides, general and carbonate hardness, oxidability in acid medium, total iron, colour and pH were determined. Samples of bottom sediments were taken by means of a pipe bottom scoop. The upper 10-cm layer was used for analysis. In the sediments were determined: total and nitrate nitrogen, phosphates, sulphates, chlorides, total iron, calcium, magnesium, sodium, potassium, soluble silica and organic matter.

The percentual salt content in the dry weight of sediments (saltiness) was determined by the formula: $S = 0.064 \times EC \times SP \times 0.01$, where $EC =$ = specific conductivity of sediment filtrate adjusted previously to maximal saturation with water, $SP =$ degree of saturation of the sediment with water expressed as per cent.

The results of the water and sediment analyses are listed in Tables 2, 3 and 4.

For elaboration of the results of chemical analyses, the standard deviations and correlations between the content of the particular components in the water and the bottom sediments were utilised according to the methods of Oktaba (1976). For comparing the three types of water bodies as regards chemism of water and bottom deposits the significance test F for the difference of two variances was applied. When the difference between the variances was significant, the significance test *C* was used for the difference of two means with various variances and numbers of samples, with no significant differences between variances — Student's *t* test. The results of tests are shown in Table 5.

RESULTS

The curve of changes in the water level in the pools is not typical for water bodies of this kind. In general in summer the water level was minimal, however, in the course of our investigations a maximum was observed between July and August. This was due to an exceptionally high amount of precipitation in that period. Wide differences in the course of changes between the particular pools result from the different permeability of the substratum, different size of the catchment and melioration activity. Amplitudes of water level variation are wide and in the T1 water body which periodically dried up they exceed 0.6 m (Fig. 1). The pools with *Equisetum limosi* as dominant association are characterised by a minimal variation of the water level.

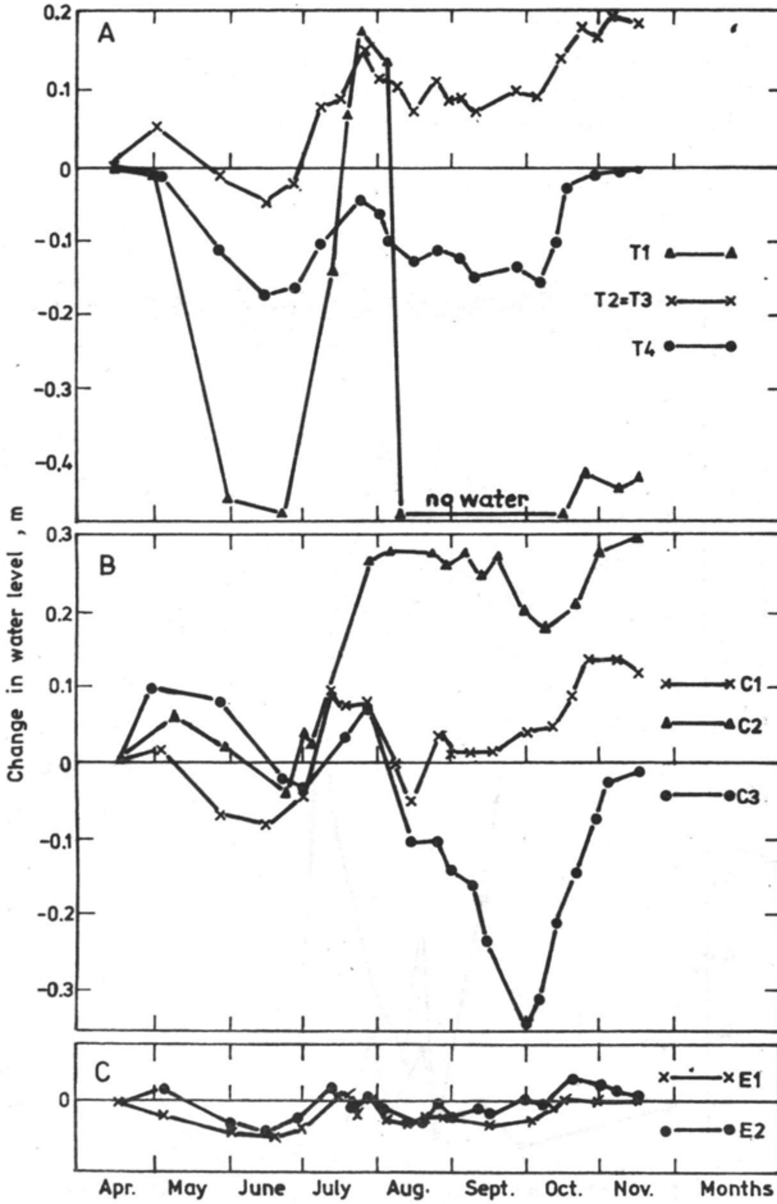

Fig. 1. Variability of water level in the course of the vegetation season in three types of astatic pools. The value O.O corresponds to the water level on April 15, 1980. A — *Typhetum latifoliae*, B — *Caricetum elatae*, C — *Equisetetum limosi*

Specific conductivity of water and the degree of saltiness of the deposits served as general indexes of the fertility and variability of the environment (Spence 1964, Erixon 1979).

The salt content in the sediment is a highly variable characteristic, (Fig. 2) differentiating the three selected types of water bodies (Tables 2 and 5). If we assume this feature as a measure of fertility of the habitat, the examined groups of pools may be ordered from the poorest to the richest as follows: 1) with dominant *Typhetum latifoliae* association, 2) with *Caricetum elatae*, 3) with *Equisetetum limosi*. The pool E2,

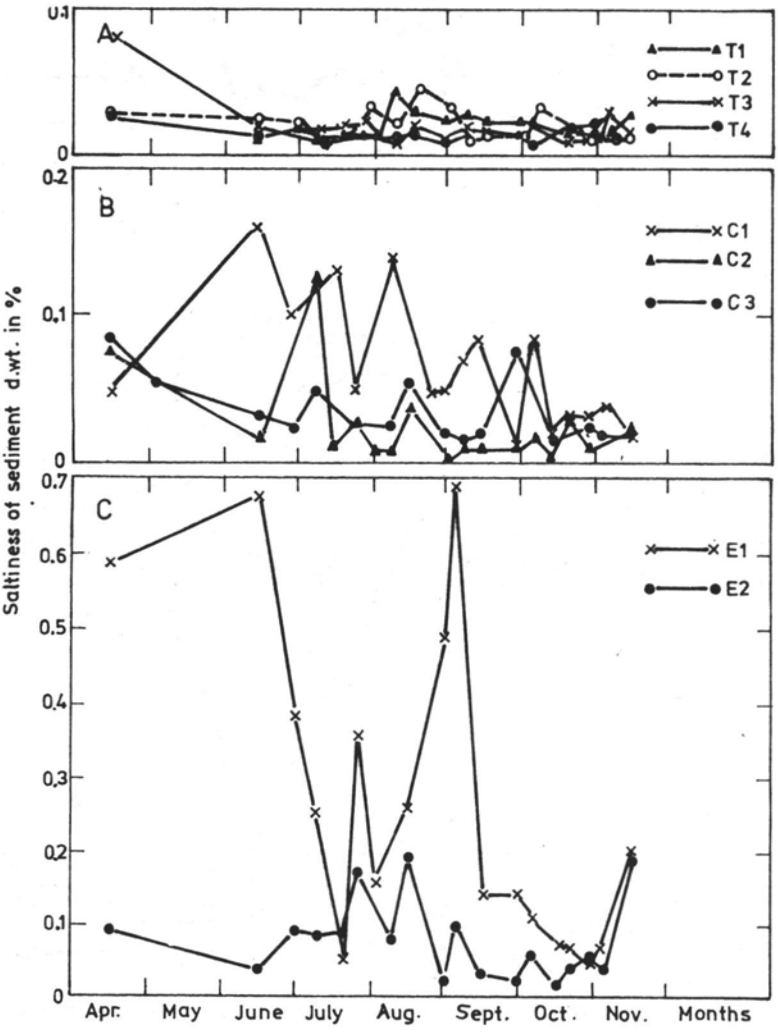

Fig. 2. Variability of salt content in bottom sediments in the course of the vegetations season in the three types of astatic pools. A — *Typhetum latifoliae*, B — *Caricetum elatae*, C — *Equisetetum limosi*

in spite of dominance of the phytocenosis of the *Equisetetum limosi* association, shows saltiness values close to the pool C1. This finds its reflection in the overgrowing vegetation (Table 1). Beside the dominant

Table 1
Vegetation of three selected types in astatic pools

Plant community dominating in pool	*Typhetum latifoliae*				*Equisetetum limosi*		*Caricetum elatae*		
Pool number	T1	T2	T3	T4	E1	E2	C1	C2	C3
Maximal water depth, m	0.57	0.80	1.00	0.60	.	0.80	0.20	0.6— —1.2	0.45
Amplitude od water level variations, m	0.57	0.25	0.26	0.16	0.05	0.06	0.20	0.32	0.45
Surface of pool occupied by vegetation, %	100	70	100	100	100	95	100	100	100
Pool surface area, m^2	160	750	1500	250	490	750	160	3700	300
Typhetum latifoliae	4	4	4	4	2				
Caricetum elatae						2	5	4	5
Equisetetum limosi					3	4			
Salicetum pentandro-cinereae		3	2		3	+			
Caricetum vesicariae							1	2	
Phalaridetum arundinaceae								1	
Community with *Calamagrostis canescens*								1	
Community with *Galium palustre*									+
Community with *Menyanthes trifoliata*						1			
Acoretum calami				3					
Lemno-Spirodeletum				1					
Riccietum fluitantis			+			+			
Community with *Utricularia vulgaris*			+						
Phragmitetum			+						
Community with *Bidens cernuus* and *B. tripartitus*		2							
Community with *Alisma plantago-aquatica*		+							
Community with *Juncus conglomeratus*		+							
Community with *Equisetum arvense*	3								
Community with *Polygonum nodosum*	1								

The values given in the table inform on the proportion of the surface area occupied in the pool by the phytocenoses of the particular plant associations and communities with unidentified syntaxonomic appurtenance, to the whole surface area of the pool overgrown with vegetation, according to the scale: 5 — 75-100%, 4 — 50-75%, 3 — 25-50%, 2 — 10-25%, 1 — 1-10%, + — below 1%.

phytocenosis, a large part of the surface is covered by the community *Caricetum elatae*. The presence of the phytocenosis of the *Typhetum latifoliae* association, on the other hand, in the E1 pool, in spite of the extremely high saltiness of the sediments, confirms the observations of Kłosowski (1983) on the appearance of this association in extreme, that is very poor and very fertile habitats.

The variability of specific conductivity of water in the small pools is much wider than in the nearby lakes (Fig. 3). The highest conductivity, evidence of the highest overall ion content, was noted in waters of the pools with *Equisetetum limosi* as dominant association, especially in the pool E1 (Tables 2 and 5).

Table 2

Mean salt content in bottom deposits, specific conductivity and pH of water in three types of astatic pools

Dominant community in pools		*Equisetetum limosi*	*Caricetum elatae*	*Typhetum latifoliae*
Saltiness of sediments,	$\bar{x}$	0.1693	0.0416	0.0205
% d.wt.	S	0.1803	0.0372	0.0107
Specific conductivity	$\bar{x}$	715	413	343
of water, $S \cdot cm^{-1}$	S	210	405	164
Water pH	$\bar{x}$	7.15	6.86	7.10
	S	0.30	0.35	0.45

$\bar{x}$ — mean of all measurements performed for the given type of pools.

S — standard deviation.

The amplitudes of oscillations in the water pH of astatic pools and the neighbouring lakes, Krzywe and Łaśmiady are comparable (Fig. 4), although the lake water is more alkaline (pH ca. 8). Among the objects studied with lowest pH the group of pools with dominant *Caricetum elatae* association (Tables 2 and 5) stands out.

Among the analysed water (Table 3) and sediment components (Table 4) the most variable are: in water — ammonium and organic nitrogen, total iron and phosphates, and in sediments — chlorides, sodium, potassium and organic matter. Least variable were: in water — general hardness, oxidability and colour; in sediments — phospates and total iron. No dependence was revealed between the chemical compostion of the bottom sediments and water, the chloride content excepted (correlation coefficient 0.66), this confirming the earlier observations of Januszkiewicz (1970 a, b) and Solski (1964) as well as the results of Mortimer's experiments (1971) from which it results that intensive ion exchange between the sediment and water occurs only under anaerobic conditions. Analysis of the present results allows to give a general habitat characteristic of the three distinguished types of astatic pools on the studied territory.

Table 3

Content of some chosen components in bottom sediments of three types of astatic pools

Dominant community		*Typhetum latifoliae*					*Equisetum limosi*			*Caricetum elatae*			
Pool number		T 1	T 2	T 3	T 4	$\bar{x}$	E 1	E 2	$\bar{x}$	C 1	C 2	C 3	$\bar{x}$
Total nitrogen, $g \cdot kg^{-1}$ d.wt.	A	1.44	3.66	2.00	2.35		.	3.66		9.38	24.69	8.28	
	B	2.04	3.93	3.07	1.90	2.88	15.73	10.83	10.64	10.76	5.52	7.52	9.30
	C	1.24	3.97	1.93	7.28		14.76	8.21		7.38	3.31	6.90	
Nitrate nitrogen, $10^{-4} g \cdot kg^{-1}$ d.wt.	A	9	9	11	13		4	6		8	24	29	
	B	13	6	7	18	10	6	7	7	6	8	33	21
	C	6	8	9	7		7	12		27	32	25	
Phosphates, $g \cdot kg^{-1}$ d.wt.	A	0.485	0.670	0.494	0.681		0.520	0.389		0.408	0.444	0.709	
	B	0.793	0.346	0.692	0.587	0.554	0.323	0.542	0.439	0.376	0.756	0.495	0.492
	C	0.485	0.391	0.528	0.493		0.400	0.462		0.333	0.365	0.540	
Sulphates, $g \cdot kg^{-1}$ d.wt.	A	1.47	1.80	5.89	1.93		10.12	1.84		2.43	2.08	1.51	
	B	1.47	1.80	1.32	1.77	1.83	16.39	8.55	8.48	7.31	1.48	1.80	2.45
	C	1.16	1.63	0.62	1.15		10.41	3.58		2.36	1.87	1.20	
Chlorides, $g \cdot kg^{-1}$ d.wt.	A	0.046	n.f.	0.009	0.006		0.057	0.081		0.041	0.025	n.f.	
	B	0.006	0.035	0.003	0.003	0.010	0.082	0.035	0.059	0.035	n.f.	n.f.	0.011
	C	0.005	n.f.	n.f.	0.006		0.058	0.038		0.001	0.001	n.f.	
Total iron, $g \cdot kg^{-1}$ d.wt.	A	0.59	0.43	0.64	0.46		0.59	0.32		0.84	0.68	0.52	
	B	0.59	0.59	0.43	0.43	0.48	0.29	0.52	0.43	0.94	0.43	0.26	0.53
	C	0.62	0.40	0.32	0.30		0.44	0.39		0.49	0.29	0.30	
Magnesium, $g \cdot kg^{-1}$ d.wt.	A	1.07	0.36	0.43	0.33		1.59	0.60		0.89	1.20	0.32	
	B	2.23	0.43	0.33	0.33	0.61	1.49	0.94	1.24	1.34	0.33	0.30	0.60
	C	0.57	0.40	0.18	0.67		1.87	0.96		0.49	0.27	0.30	
Calcium, $g \cdot kg^{-1}$ d.wt.	A	4.8	2.8	3.7	0.9		24.5	2.6		5.1	20.3	3.1	
	B	12.1	2.7	2.8	1.3	3.4	23.3	7.0	15.9	4.5	2.4	2.2	4.9
	C	1.7	3.2	1.3	3.4		32.3	6.0		3.2	1.1	2.5	
Sodium, $g \cdot kg^{-1}$ d.wt.	A	0.029	0.026	0.100	1.011		0.163	0.077		0.027	0.170	0.058	
	B	0.073	0.015	0.050	0.066	0.035	0.143	0.092	0.130	0.065	0.041	0.015	0.048
	C	0.008	0.015	0.005	0.018		0.280	0.025		0.023	0.006	0.026	
Potassium, $g \cdot kg^{-1}$ d.wt.	A	0.048	0.011	0.258	0.014		0.362	0.144		0.066	0.456	0.113	
	B	0.110	0.017	0.234	0.178	0.092	0.257	0.588	0.291	0.167	0.163	0.035	0.130
	C	0.062	0.054	0.039	0.075		0.306	0.086		0.062	0.032	0.076	
Soluble silica, $g \cdot kg^{-1}$ d.wt.	A	0.030	0.031	0.032	0.029		.	0.032		0.50	0.039	0.031	
	B	0.105	0.031	0.026	0.029	0.040	0.067	0.147	0.084	.	0.019	0.030	0.031
	C	0.041	0.030	0.029	0.064		0.124	0.049		0.031	0.019	0.030	
Organic matter, % d.wt.	A	42.9	8.7	15.5	4.6		53.5	11.4		22.5	68.9	51.3	
	B	7.1	8.7	8.5	5.8	11.5	41.7	24.9	36.3	24.2	12.9	20.3	27.4
	C	3.3	10.7	4.3	17.8		58.6	27.4		19.3	8.9	18.1	

A — results of analyses of samples taken at the beginning of May. B — at Mid August. C — at mid November. $\bar{x}$ — mean values of particular components content for each type of pool in the course of the vegetation season, n.f. — not found.

Table 4

Physico-chemical properties and content of the chosen water components in the three typs of astatic pools

Dominant community		*Typhetum latifoliae*					*Equisetetum limosi*			*Caricetum elatae*			
Pool number		T 1	T 2	T 3	T 4	$\bar{x}$	E 1	E 2	$\bar{x}$	C 1	C 2	C 3	$\bar{x}$
Total nitrogen, $mg \cdot dm^{-3}$	A	0.98	0.91	0.91	4.08		2.04	0.84		0.70	1.41	2.04	
	B	w.d.	2.28	2.35	2.91	2.33	3.91	2.21	2.60	2.35	2.56	2.77	2.10
	C	2.16	4.79	.	1.88		4.72	1.88		0.90	3.81	2.35	
Ammonium nitrogen, $mg \cdot dm^{-3}$	A	.	.	.	0.130		0.493	0.352		0.110	0.140	0.250	
	B	w.d.	0.420	0.105	0.210	0.686	0.385	0.280	0.633	0.110	0.320	0.070	0.217
	C	0.140	1.687	2.350	0.448		2.079	0.210		0.180	0.490	0.280	
Organic nitrogen, $mg \cdot dm^{-3}$	A	.	.	.	0.95		1.55	0.49		0.59	1.27	1.79	
	B	w.d.	1.86	2.25	2.70	2.04	3.53	1.93	1.97	2.24	2.24	2.70	1.88
	C	2.02	3.10	.	1.43		2.65	1.67		0.72	3.32	2.07	
Phosphate, $mg \cdot dm^{-3}$	A	0.123	0.343	0.165	0.293		0.910	0.110		0.183	0.437	0.240	
	B	w.d.	0.460	1.030	1.130	0.612	0.410	0.200	0.358	0.580	0.410	0.440	0.404
	C	0.366	0.353	0.632	1.840		0.220	0.300		0.110	0.413	0.820	
Sulfates, $mg \cdot dm^{-3}$	A	26.0	16.3	10.3	18.0		20.5	15.0		25.0	14.0	49.0	
	B	w.d.	10.0	6.3	10.0	12.8	20.0	23.0	19.1	36.0	10.0	28.0	23.3
	C	30.0	4.3	5.0	4.3		19.6	16.5		30.0	5.0	12.9	
Chlorides, $mg \cdot dm^{-3}$	A	31.60	12.13	10.19	3.40		60.20	21.84		28.60	3.40	14.10	
	B	w.d.	11.27	11.76	0.49	11.23	38.71	22.05	41.59	23.03	5.39	5.88	14.81
	C	8.73	14.55	14.55	4.85		73.24	33.47		23.28	17.46	12.13	
Total iron, $mg \cdot dm^{-3}$	A	0.66	0.45	0.62	0.66		1.17	0.70		0.78	0.66	0.41	
	B	w.d.	1.90	1.34	3.80	1.76	1.85	1.42	1.73	3.40	2.00	0.78	1.35
	C	2.68	1.90	0.86	4.50		2.92	2.34		0.98	1.85	1.30	
Total hardness, $mval \cdot dm^{-3}$	A	3.6	2.3	4.0	1.8		7.3	5.7		6.2	1.4	2.3	
	B	w.d.	4.0	3.1	1.6	3.4	7.6	7.8	7.7	6.8	4.9	1.9	4.3
	C	7.1	4.7	3.4	2.2		9.5	8.5		7.9	4.1	3.1	
Carbonate hardness, $mval \cdot dm^{-3}$	A	2.85	1.55	3.05	1.10		6.20	4.50		4.20	0.80	1.20	
	B	w.d.	3.70	2.70	1.55	3.00	6.60	6.15	6.75	6.10	4.55	1.80	3.55
	C	6.95	4.40	3.20	2.10		9.50	7.60		6.80	3.60	2.75	
Oxidability, $mg\ O_2 \cdot dm^{-3}$	A	9.46	11.43	11.03	16.75		16.55	6.31		16.35	20.62	34.09	
	B	w.d.	18.99	31.16	31.32	19.14	22.61	11.56	16.68	28.98	50.50	48.74	35.04
	C	8.73	19.80	20.78	31.13		30.14	12.90		13.89	33.59	68.56	
Colour, acc. to platinum-cobalt scale	A	20	35	30	70		50	25		50	70	120	
	B	w.d.	70	50	80	55	70	50	52	120	100	200	114
	C	10	80	55	100		70	45		50	80	240	

A — results of analyses of samples taken at the beginning of May. B — at mid August. C — at mid November. $\bar{x}$ mean values for the given types of pools in the course of the vegetation season. w.d. — periodical water deficit in pool.

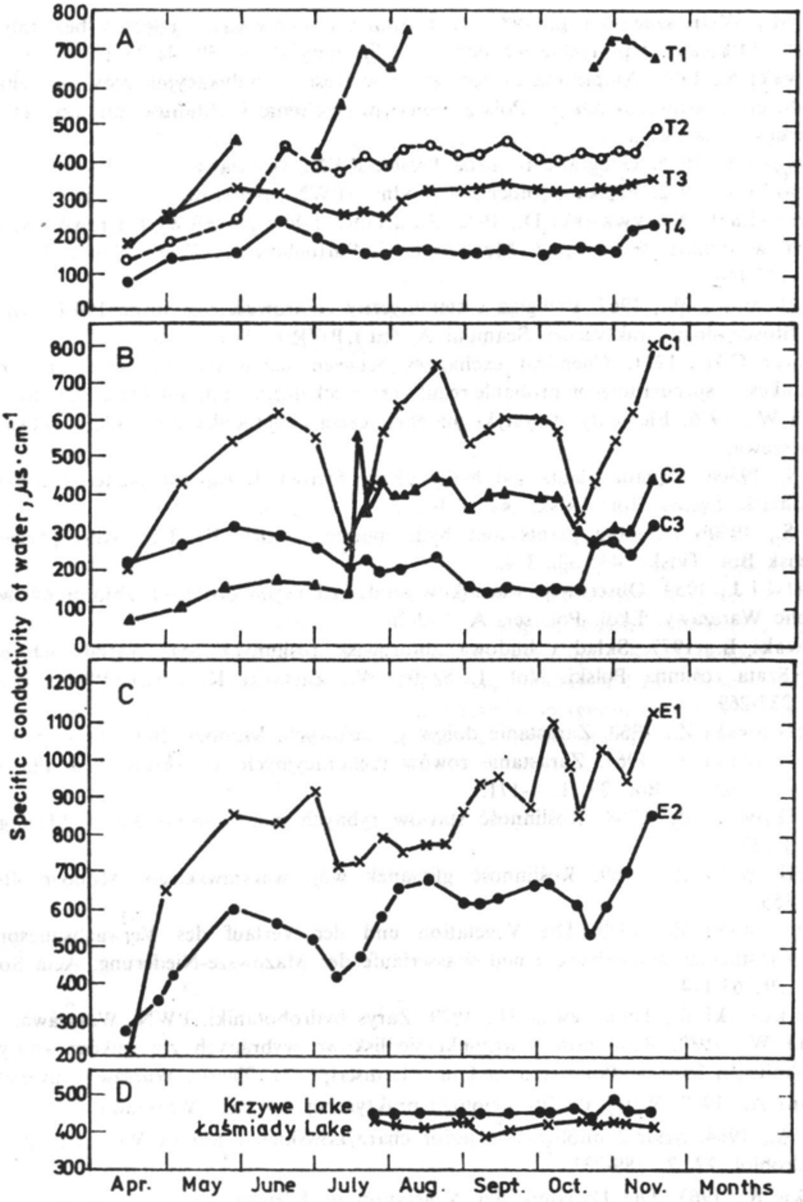

Fig. 3. Variability of specific water conduction in the course of the vegetation season in the three types of astatic pools and in the lakes Krzywe and Łaśmiady, A — *Typhetum latifoliae*, B — *Caricetum elatae*, C — *Equisetetum limosi*, D — lakes

Pools with dominant *Equisetetum limosi* association, considered, on the basis of salt content in the sediments and specific water conductivity, as the most fertile stand out among the remaining types of water bodies

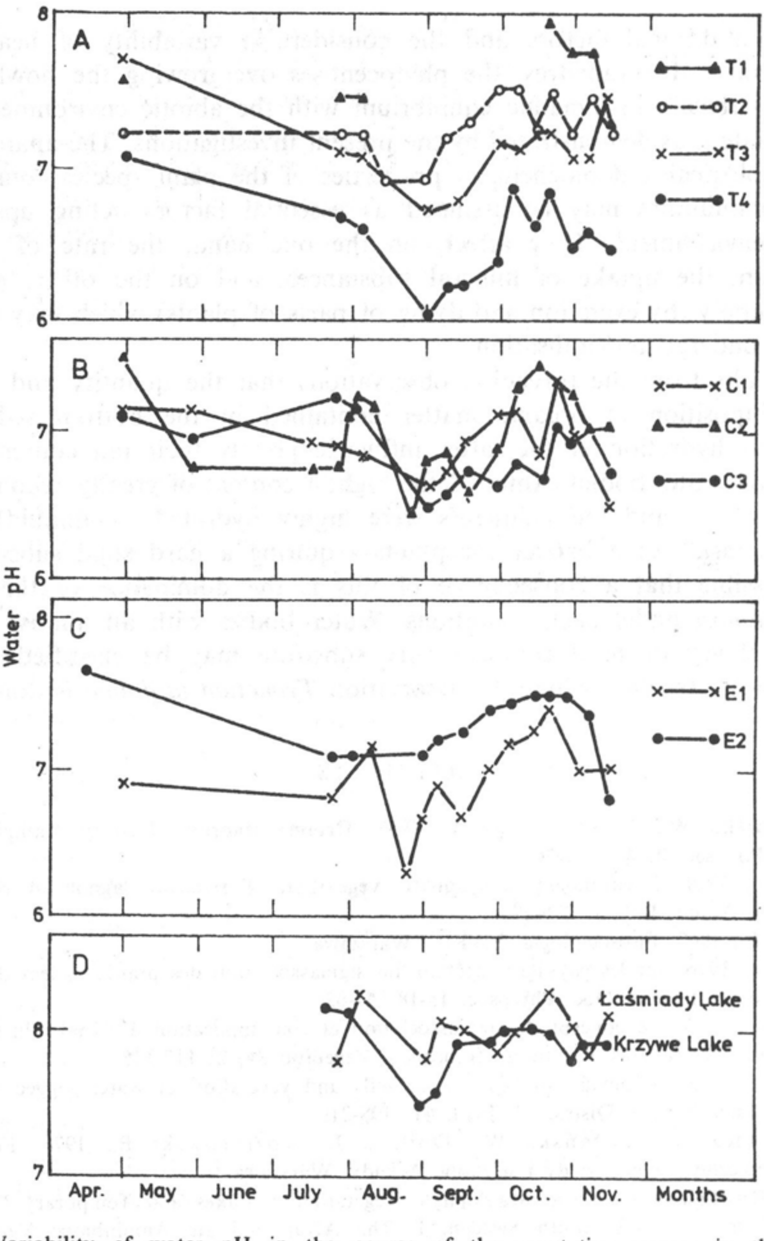

Fig. 4. Variability of water pH in the course of the vegetation season in the three types of astatic pools and in the lakes Krzywe and Łaśmiady. A — *Typhetum latifoliae*, B — *Caricetum elatae*, C — *Equisetetum limosi*, D — lakes.

by their high content of such components as: total nitrogen in sediments and water, sulphates in sediments (Table 5), calcium, potassium, sodium, magnesium (Table 5), soluble silica in sediments and chlorides in sediments and water (Table 5). In the examined objects of this group the proportion of organic matter is highest in the bottom sediments (Table 5). The high iron and ammonium nitrogen content in the water and its weak colouring and oxidability bring this type close to the poorest pools of *Typhetum latifoliae* type. Strange is the lowest phosphates content in the group of most fertile water bodies. This result, however, is in agreement with literature data (Kłosowski 1983).

Table 5

Significance of differences in properties of water and bottom sediments of three types of astatic pools

Properties of	T.l./E.l.		T.l./C.e.		E.l./C.e.	
	A	B	A	B	A	B
WATER						
pH	.	.	5.520	1.986	3.166	1.994
Chlorides	3.125	2.547	.	.	2.708	2.544
General hardness	5.395	2.131	.	.	3.095	2.160
Carbonate hardness	4.197	2.131	.	.	2.935	2.160
Colour	.	.	2.397	2.296	2.557	2.370
Specific conductivity	9.546	2.005	.	.	4.969	2.006
SEDIMENTS						
Total nitrogen	3.071	2.753	2.950	2.301	.	.
Nitrate nitrogen	.	.	2.748	2.299	3.466	2.329
Sulphates	2.797	2.561	.	.	.	.
Chlorides	66.407	2.120	.	.	4.512	2.160
Magnesium	2.227	2.120	.	.	2.509	2.160
Organic matter	3.405	2.120	.	.	.	.
Saltiness	4.879	2.030	4.103	2.003	4.135	2.029

T.l. — pools of *Typhetum latifoliae* type. E.l. — of *Equiscietum limosi* type, C. — of *Caricetum elatae* type. A — t_0 or C_0 values calculated from results of analysis according to tests: Student's test with equal variances or C test — with different ones, for establishing significance of differences between means. B — $t_{0.05}$ or $C_{0.05}$ values determined from tables of corresponding degrees of freedom at significance level 0.05. Dots denote lack of significant differences. Properties are disregarded for which differences between the three types of pools proved statistically unsignificant: in water — total nitrogen, ammonium and organic nitrogen content, content of phosphates, sulphates, total iron, oxidability; in sediments — phosphate, total iron, calcium, sodium, potassium and soluble silica content.

The pools with *Caricetum elatae*, moderately fertile, are characterised by a moderate content of most of the investigated components. The features distinguishing this type from the remaining ones are: lowest value of water pH, most intensive water colour and the highest oxidability (Table 5), this jointly indicating a high humic acids content in the water. At the same time these habitats show the lowest iron and ammonium nitrogen content and the highest proportion of sulphates in the water and nitrate nitrogen in the sediments (Table 5). The amount of organic matter in the bottom sediments classifies this type of pools as intermediate between the other two. The water bodies with *Typhetum latifoliae* are poorest and show the lowest content of the following water sediment components: total nitrogen in sediments, sulphates in sediments and water (Table 5), sodium, potassium and calcium in sediments. The low magnesium content is close to that in the pools with dominant *Caricetum elatae*. They are, however, the habitats richest in phosphates. The high total iron and ammonium nitrogen contents in the water and weak colouring relates them to the *Equisetetum limosi* type. A distinguishing feature is the lowest participation of organic matter in the bottom sediments. The substratum in these water bodies is clayey or silty.

DISCUSSION

The values of physico-chemical properties of water and bottom sediments revealed by the present authors mostly do not exceed those reported in the literature (Olsen 1950b, Gorham 1953, Solski 1964, Spence 1964, Januszkiewicz 1970 a, b, Vangenechten et al. 1981, Kłosowski 1983) although the chloride, sulphate and various forms of nitrogen contents in the water surpassed the amounts detected by the above quoted authors in various types of surface waters. On the other hand, the nitrate nitrogen amounts soluble silica, sodium, potassium, calcium and magnesium noted in the present study in the sediments are lower than those reported by Kłosowski (1983) for the associations *Equisetetum limosi*, *Caricetum elatae* and *Typhetum latifoliae* in the whole of north-eastern Poland.

As compared with the wide differentiation of the habitat conditions in the surface waters of various geographic regions, the here examined water bodies are a rather homogeneous group. This is most probably connencted with the geological, hydrological, climatic and pedological uniformity of the small area icluded in the investigations. As regards the pH, colour and even specific conductivity of water, the three distinguished types of pools belong to the same alkalinely-variable (Wiegleb 1978), polyhumic (Olsen 1950a), rich in electrolytes (Wiegleb 1978) group. On the other hand, water hardness exhibits a wide variability: from soft in the *Typhetum latifoliae* type over medium hard in *Caricetum elatae* to water of great hardness in the *Equisetetum limosi* type (Hermanowicz et al. 1976). In view of the great uniformity of abiotic factors, the differences connected with the differentiation of the vegetation may be all the more interpreted as the results of interaction of the vegetation and the environment.

The communities prevailing at the given moment in the pools most probably are not pioneering stages of succession. The conditions prevalent in them were, thus, brought about by the influence of the vegetation of earlier stages. The properties of small pools among fields are greatly influenced by economic activity (fertilisation, melioration, grazing). In spite of these additional factors and the considerable variability of nearly all the investigated parametres, the phytocenoses overgrowing the bowls with the pools remain in dynamic equilibrium with the abiotic environment and differentiate it as demonstrated by the present investigations. The anatomical, ecophysiological and biochemical properties of the plant species composing these communities may be assumed as essential factors acting upon the abiotic environment. They affect, on the one hand, the rate of matter circulation, the uptake of mineral substances, and on the other, organic matter supply (by excretion and dying of parts of plants) which may sooner or later undergo mineralisation.

It results from the foregoing observations that the quantity and degree of decomposition of organic matter contained in the bottom sediments as well as hydration of the latter influence greatly their ion content. The most fertile water bodies exhibited the highest content of greatly decomposed organic matter and the sediments were highly hydrated (semiliquid). This in turn constitutes a barrier for plants requiring a hard solid substratum. It is possible that a consequence of this is the dominance of the *Equisetetum limosi* under such conditions. Water bodies with an almost purely mineral clayey or hard compact silty substrate may be classified at the other pole of fertility, where the association *Typhetum latifoliae* is dominant.

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Warunki siedliskowe astatycznych zbiorników wodnych i ich związek ze zróżnicowaniem roślinności

Streszczenie

W 12 zbiornikach astatycznych, z których każdy charakteryzował się dominacją fitocenoz jednego z trzech zespołów roślinnych przeprowadzono badania właściwości fizyczno-chemicznych wody i osadów dennych, w celu ustalenia zależności między warunkami siedliskowymi a roślinnością. Kryterium stopnia zasolenia osadów dennych i przewodnictwa właściwego wody akwenów pozwala je uporządkować według malejącej żyzności w następujący sposób: 1) zbiorniki z dominującymi fitocenozami zespołu *Equisetetum limosi*, 2) z *Caricetum elatae*, 3) z *Typhetum latifoliae*. Typ roślinności wykazuje również związek z innymi właściwościami wody (twardością, barwą, utlenialnością, odczynem, zawartością chlorków) oraz osadów (zawartością substancji organicznych, chlorków, magnezu i różnych form azotu). Korelacja między składem chemicznym wody i osadów została stwierdzona jedynie w przypadku chlorków.