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**Makrofity zbiornika zaporowego w Goczałkowicach****Macrophytes of the dam reservoir at Goczałkowice**

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**Abstract** — The paper presents a continuation of the investigations on the process of overgrowing of the dam reservoir at Goczałkowice by higher plants. In recent years a further enlargement of the area overgrown by dominant species of submersed plants was observed. These changes may be explained by a very high average water level and its smaller variation and by an increased content of chemical compounds (chiefly nitrogen and phosphorus) in the water.

This work is a continuation of studies lasting many years on the higher vegetation formed in the Goczałkowice reservoir. After a period of dynamic development in the years 1956—1959 the vegetal cover of the reservoir gradually decreased in the rate of overgrowth and the qualitative composition slowly began to be stabilized. This state lasted up to 1965, when a period of sudden and unexpected changes followed. *Rorippa amphibia* may serve as an example: this was not noted in the reservoir until 1965, suddenly appeared in great numbers in 1966 (on about 1 hectare, Kuflikowski 1968), and in the next year disappeared completely and has not been found since.

The present paper contains a description of the investigation carried out in the period 1970—1975 on the process of further overgrowth and spread of plants in the reservoir. The rate of overgrowing by more important plants, whose area reached 0.20 ha, was determined for the first time. The calculations are based on estimates of all greater communities of the discussed plant species. Thus the results approximate the actual areas occupied by the individual species of plants. The investigation and measurements were carried out both from the land and from the surface of the water.

### Hydrological conditions of the reservoir

The water level and its fluctuations in the Goczalkowice reservoir play a particularly important role in the formation of macrophytes, since in this shallow water body a decrease in the water level by 1 metre from the average (254.5 m above sea level) uncovers about 500 ha of the bottom. Thus, in these places all plants die but also the species of submersed vegetation are killed if they emerge more than half their length over the water surface. This was observed in 1965 and 1972 when the water level was lowered in the reservoir in connection with the repair of bottom outlets.

In 1970—1972 considerable fluctuations of the water level occurred in the reservoir. In the vegetation period the water level ranged from 254.14—255.95 m above sea level (July and the beginning of August).

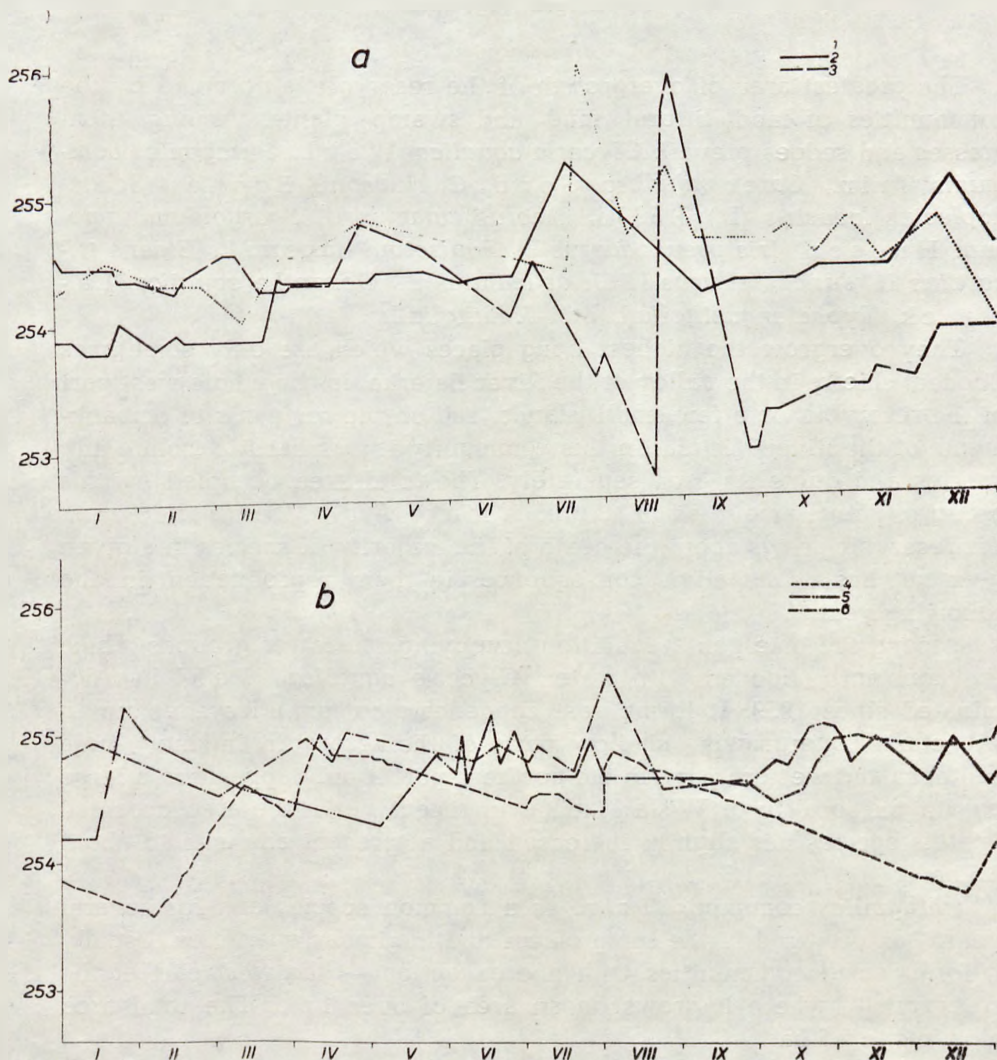
In 1972 a lowering of the water level to the ordinate 253 m above sea level was noted which, with the exception of a flood period (20th August — 5th September), lasted to the end of the year. In consequence a large area of the bottom (about 800 ha) was uncovered and the majority of plant species died, the exception being those which grew in the deepest parts of the reservoir, and a belt of land and littoral vegetation.

In 1973—1975 the water level was more uniform and fairly high, especially in the last two years. It proved very favourable for the development of the submersed vegetation, particularly for the species which settle the bottom at a small depth. Shallow places are exposed to strong rolling, this in a great measure preventing the overgrowth of these areas. Graphs 1a and 1b show the course of fluctuations of the water level in the reservoir from 1970—1975. The division of the graph into 2 parts was carried out on account of the great differences in the water level between the first year of the investigation and the subsequent years and also because in this form the graphs were more legible and easier to interpret.

#### The course of development of macrophytes in the reservoir

In the discussed work the macrophytes of the Goczalkowice reservoir were divided into 2 groups: emergent and submersed plants. This division was necessary because the emergent plants showed only insignificant qualitative and quantitative variability and settled the same places. The repetition of data about these plants could therefore be avoided since they had been described in an earlier paper (Kuflikowski





Ryc. 1. Wahania poziomu wody w Zbiorniku Goczałkowickim w latach 1970—1975  
 Fig. 1. Fluctuations of water level in the dam reservoir at Goczałkowice from 1970—1975  
 a — 1970—1972; b — 1973—1975; 1 — 1970; 2 — 1971; 3 — 1972; 4 — 1973; 5 — 1974;  
 6 — 1975

1968). The species were described in order of the size of the areas they overgrew.

The submersed plants were also discussed in order of their qualitative domination so as to maintain the uniformity and lucidity of the work. Other species which had an insignificant role in the process of overgrowing the reservoir were presented jointly.

### The emergent vegetation

The greatest area of overgrowth of the reservoir is occupied by the communities of land, littoral, mud, and swamp plants. Among them grasses and sedges prevail: *Glyceria aquatica* W a h l., *Phragmites communis* Trin., *Carex paludosa* G o o d., *C. Hudsonii* Bennet, *Schoenoplectus lacustris* (L.) P a l l a, *Acorus calamus* L., *Sparganium ramosum* H u d s o n, *Iris pseudoacorus* L., *Equisetum limosum* L., *Bidens tripartitus* L., *Juncus effusus* L., *J. articulatus* L., *Oenanthe aquatica* L a m a r c k, *Typha angustifolia* L. and *T. latifolia* L.

They overgrow the highest lying places which are only sometimes flooded, chiefly in the valley of the River Bajerka, in the whole west part of the reservoir, on a few small islands, and on the remnants of embankments of the River Vistula. In this community it was hard to isolate any species and quote its area separately. The total area occupied by this group of plants amounted to 130 ha. A marked fall in the water level in the reservoir brings about the death of the majority of species in a given year but has no negative consequences in their reproduction in the following year.

Among the emergent vegetation occupying the lower grounds which are constantly flooded with water, *Glyceria aquatica* W a h l has dominated since 1959. It forms vast congeneric communities even up to 2 hectares, overgrowing shallow parts of the reservoir in the whole southern and western part. In the northern part it only appears in a large bay in the locality of Wisła Wielka. In recent years the area occupied by this species has slightly increased and at present amounts to about 2.5 ha.

*Phragmites communis* Trin. is a common species and for several years has occurred in the same places and in similar quantities. Usually it forms small communities with one exception — the west part of the reservoir — where it grows on an area of over 1 ha. The total area amounts to 2.5 ha.

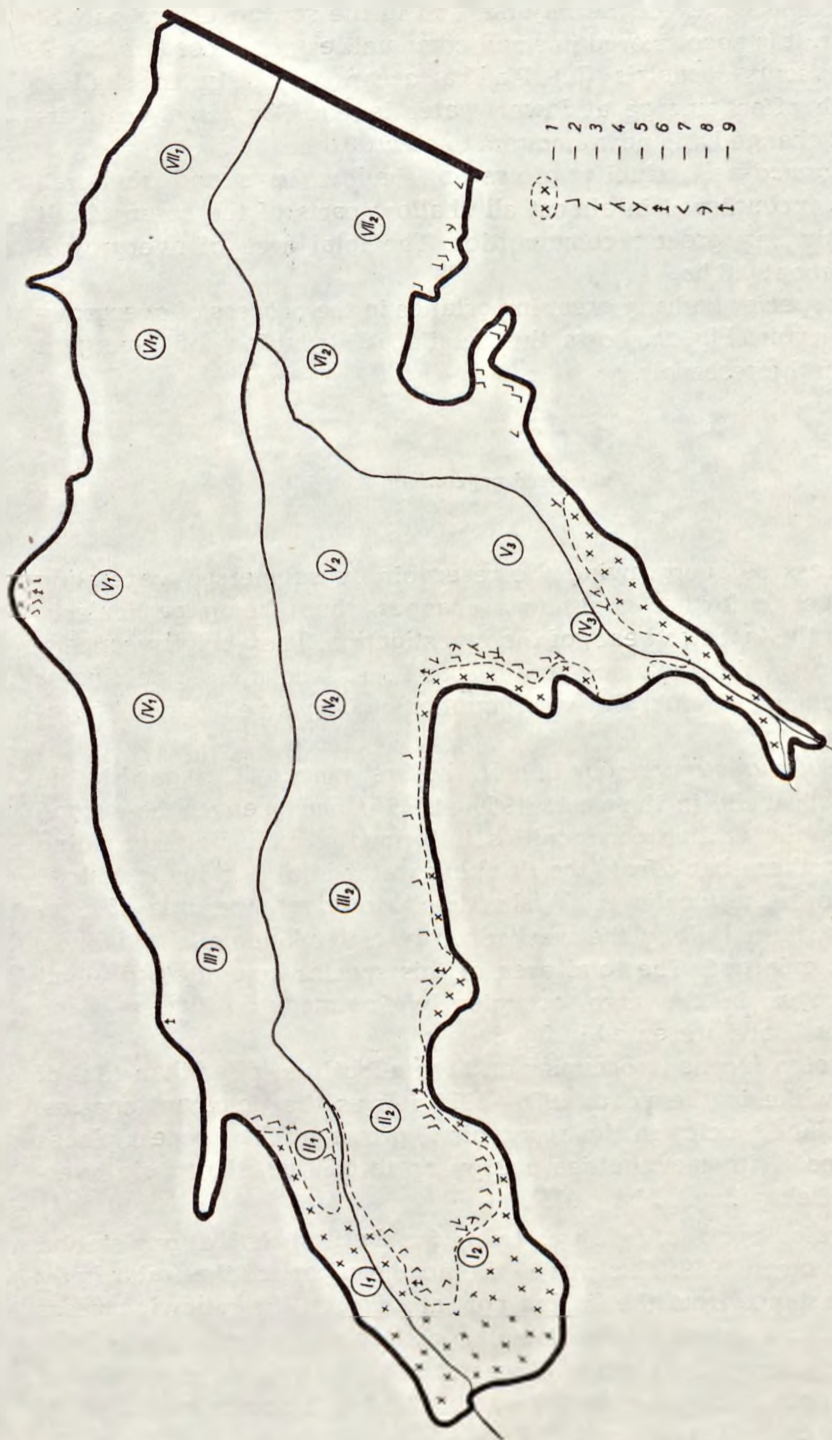
*Typha latifolia* L. is distributed in all parts of the reservoir, chiefly in bays and places sheltered by trees or bushes. Individual communities are very small and amount to no more than a few square metres. The area settled has increased in the last five years and at present has reached about 1.7 ha.

*Typha angustifolia* L. grows most frequently near the above species. The range of its distribution is smaller, the area amounting to about 1 ha.

*Equisetum limosum* L. grows on very shallow and muddy places, chiefly in the southern part of the reservoir. It forms fairly large communities covering up to 0.15 ha. Its area has not changed for some years, reaching about 1 ha.

*Acorus calamus* L. occupies an area of about 0.8 ha. It occurs most





Ryc. 2. Rozmieszczenie roślin wynurzonych w 1975 r.

Fig. 2. Distribution of emergent plants in 1975

1 — Rośliny łądowe i błotne — Land and mud plants; 2 — *Glyceria aquatica*; 3 — *Phragmites communis*; 4 — *Typha latifolia*; 5 — *T. angustifolia*; 6 — *Equisetum limosum*; 7 — *Acorus calamus*; 8 — *Schoenoplectus lacustris*; 9 — *Iris pseudoacorus*

frequently in the valley of the Bajerka and in the south-western part of the reservoir. It is encountered in small communities not exceeding 10 m<sup>2</sup>.

*Schoenoplectus lacustris* (L.) Palla occurs insularly in shallow places which often emerge at lower water levels. For some years its area has not changed and now amounts to about 0.8 ha.

*Iris pseudoacorus* L. chiefly grows in shallow bays and sheltered places. It is encountered in almost all shallow parts of the reservoir. It does not form any greater communities. The total area of overgrowth amounts to about 0.6 ha.

No other species had any great importance in the process of overgrowing the reservoir. Fig. 2 shows the detailed distribution of emergent vegetation in the reservoir.

#### Submersed vegetation

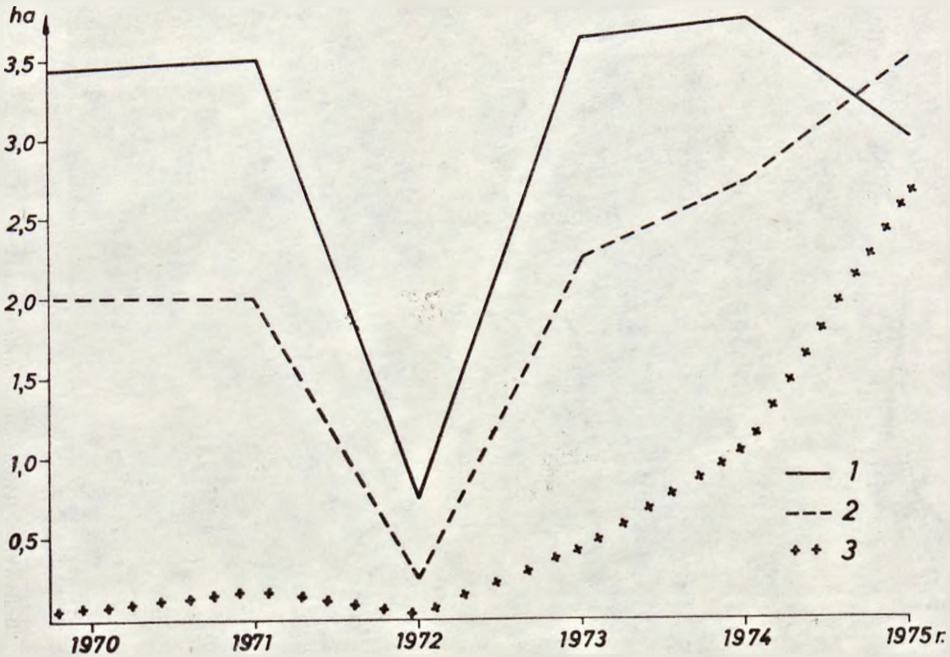
The process of overgrowing the reservoir by submersed vegetation is still subject to further continuous changes, these being particularly great during the last two years of the investigation. They chiefly concern the following species: *Potamogeton crispus* L., *P. lucens* L., *P. pectinatus* L., *Polygonum amphibium* L. var. *aquaticum* Leysser, and *Myriophyllum spicatum*.

In 1975 *Potamogeton crispus* L. held the first place with regard to the area occupied, while in the years 1969—1975 it had been in the second one. Besides the earlier communities it formed a wide belt spreading along the northern bank from the drinking water intake to the industrial water intake in the locality of Wisła Mała. Moreover, the area of communities distributed along the washed away embankments of the River Vistula was enlarged. The total area of this species amounted to about 3.5 ha. Changes in the area occupied by *Potamogeton lucens* L. and *P. perfoliatus* L. are presented in fig. 3.

*Potamogeton lucens* L. occupies an area slightly smaller than that of *P. crispus*, while in the years 1966—1975 it was the dominant species. Of all the plant species in the reservoir it grows at the deepest places (4.5 m). Some of its communities occupy up to 0.30 ha, the whole overgrown area being about 3 ha (1975).

*Potamogeton perfoliatus* L. was found for the first time at one station in the reservoir in 1969. This was in the northern part of the water body at a short distance from the fishing port at Łąka. In the following years a gradual but rather poor development of this plant was observed. In 1973 it was among the species characterized by the highest rate of spread and now its area amounts to about 2.7 ha. It occurs in almost all parts of the reservoir to a depth of 3 m.





Ryc. 3. Zmiana powierzchni dominujących roślin zanurzonych w latach 1970—1975  
 Fig. 3. Change of the area of dominant submersed plants in the period 1970—1975  
 1 — *Potamogeton lucens*; 2 — *P. crispus*; 3 — *P. perfoliatus*

*Polygonum amphibium* L. var. *aquaticum* Leysser was the dominant species in the reservoir in 1959—1964. In 1965, when the water level was lowered (by 2 m on the average), the area occupied by this species and the density per 1 square metre began to decrease. Since 1973 a change has been observed and the overgrown area is steadily increasing, amounting to about 2 ha in 1975.

*Potamogeton pectinatus* L. was not subject to such great changes as the above-mentioned species. In the south-eastern part of the reservoir it has formed a meadow of about 1 ha; besides it is distributed in the whole reservoir in shallow places not exceeding 1 m of depth. The total area overgrown by this species is at present about 1.5 ha.

Up to 1972 *Myriophyllum spicatum* L. occurred in insignificant quantities. Since that year a marked increase in the area of overgrowth has been observed. At present it amounts to about 1 ha. The species forms small communities and grows chiefly in the western part of the reservoir to a depth of 3 m.

Other species, such as *Batrachium aquatile* (L.) Dum., *Hottonia palustris* L., *Hydrocharis morsus ranae* L., *Potamogeton gramineus* L., *P. natans* L., *P. obtusifolius* Ment. et Koch, and *Najas marina* L. did not play any great role in the process of overgrowing the reservoir and at



Ryc. 4. Rozmieszczenie roślin zanurzonych w 1971 r. Cyfry rzymskie — stałe miejsca poboru

Fig. 4. Distribution of submersed plants in 1971. Roman numerals — permanent sampling stations

1 — *Potamogeton crispus*; 2 — *P. lucens*; 3 — *P. perfoliatus*; 4 — *Polygonum amphibium*;  
5 — *Potamogeton pectinatus*; 6 — *Myriophyllum spicatum*





Ryc. 5. Rozmieszczenie roślin zanurzonych w 1975 r. Cyfry rzymskie — stałe miejsca poboru

Fig. 5. Distribution of submersed plants in 1975. Roman numerals — permanent sampling stations

1 — *Potamogeton crispus*; 2 — *P. lucens*; 3 — *P. perfoliatus*; 4 — *Polygonum amphibium*; 5 — *Potamogeton pectinatus*; 6 — *Myriophyllum spicatum*

present they occupy a total area of 0.5 ha. The distribution of the more important species of submersed plants in the reservoir in the period 1970—1973 is shown in fig. 4 and from 1974—1975 in fig. 5.

### Discussion of results

In the period 1970—1975 in the dam reservoir at Goczałkowice the development of higher aquatic vegetation differed considerably from that in the previous years. The area occupied by the dominant species of submersed plants, such as *Potamogeton crispus*, *P. perfoliatus*, *P. pectinatus*, *Polygonum amphibium*, and *Myriophyllum spicatum* enlarged, while that overgrown by *Potamogeton lucens* (the species dominant up to 1974) decreased.

It seems that the very insignificant increase in the area overgrown by emergent plants was brought about by great and frequent changes in the water level and by the absence of a proper littoral zone in the reservoir.

In the years 1970—1971 the development of submersed plants was poorer than in subsequent years.

In 1972 almost all higher plants died out after the water level had been lowered by about 2 metres in connection with the repair of bottom outlets of the reservoir.

In 1973—1975 an intense growth of the submersed vegetation occurred. This may be explained by the fact that the average water level was high and did not change greatly and that the content of chemical compounds in the water increased (chiefly of nitrogen and phosphorus which are the basic nutrients of plants). It is hard to say definitely to-day which of these factors was decisive for the development of the discussed vegetation.

In the Goczałkowice reservoir the total area occupied by higher plants is at present about 178 ha, this constituting 6% of the water body, while 50% of the vegetation overgrows ground constantly rising above the water surface and thus does not take part in the process of eutrophication of the reservoir.

### STRESZCZENIE

W latach 1970—1975 przeprowadzono dalsze badania nad rozwojem roślinności wodnej i jej rozmieszczeniem w zbiorniku zaporowym w Goczałkowicach. W ciągu tych lat zaobserwowano dalsze zmiany, dotyczące szczególnie roślinności zanurzonej.



Od 1966 roku gatunkiem dominującym był *Potamogeton lucens*, który w 1975 r. zajął drugie miejsce. Największą powierzchnię porasta obecnie *Potamogeton crispus*, który poza dotychczasowymi stanowiskami utworzył długi pas w północnej części zbiornika, ciągnący się od ujęcia wody pitnej aż do portu harcerzy w Wiśle Małej.

Najintensywniej rozwijał się jednak *Potamogeton perfoliatus*, który pojawił się w zbiorniku dopiero w 1969 r. Uplasował się na trzecim miejscu co do zajmowanej powierzchni, ustępując tylko nieznacznie poprzednim gatunkom. Zwiększyła się również powierzchnia *Polygonum amphibium*, *Myriophyllum spicatum* i *Potamogeton pectinatus*.

Tak znaczne zmiany zachodzące w ostatnich latach wśród makrofitów tłumaczyć można przede wszystkim wyższym poziomem wody w zbiorniku oraz mniejszymi jego wahaniami, co szczególnie pozytywnie wpłynęło na rozwój roślinności zanurzonej, występującej na mniejszych głębokościach, jak również zwiększoną zawartością w wodzie azotu i fosforu.

W tej pracy określono po raz pierwszy wielkość zarastania ważniejszych gatunków roślin, których powierzchnia dochodziła do 0,20 ha. Obliczenia oparte zostały na pomiarach szacunkowych, wszystkich większych skupisk omawianych gatunków roślin.

Ogólna powierzchnia roślin wyższych w zbiorniku wynosi obecnie około 178 ha, co stanowi 6% powierzchni zbiornika, przy czym przynajmniej 50% roślinności wynurzonej zarasta tereny stale wynurzone ponad lustro wody.

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