

# **SIGNIFICANCE OF KARST WATER OUTFLOWS TO THE SPONTANEOUS REGENERATION OF BIOCECENOSIS IN THE SIEMONIA SANDPIT, POLAND**

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## **Summary**

The Silesian Upland has been intensively exploited by industry, and particularly by the mining industry. Since 1937, an ever increasing demand for supplies of sand to be used by the construction and mining industry has been met by increased sand exploitation and growth of working areas. Exploitation of the deposits is accompanied by process such as: drastic transformation of the environment, losses of biocenosis, and considerable areas of bedrock exposure. As the sand is extracted from lower and lower levels, the resulting deep sandpits are often flooded with karst water from the Triassic deposits and characteristic ecological conditions occur at the bottom of these pits. The high dissolved calcium carbonate of the groundwater inputs, waterlogging of the ground and modification of the ground temperature regime by water inflows have a great influence on the formation of unusual plant associations as well as on the whole biocenotic structure at the bottom of workings. The annual temperature range is reduced, especially in the lower layers of the ground, because of the small temperature range of the water inflows (from 7-9°C in winter and up to 11°C in summer). This affects the near-ground layer microclimate which in turn has a great influence on the development of vegetation cover. The initial plant associations are a result of environmental conditioning and by the large number of variegated horsetail, *Equisetum variegatum* which belongs to the characteristic plant species associations that appeared in the area after glacier recession. Large numbers of rare and protected species of flora and fauna are associated with such initial biocenotic systems and where there has been no reclamation the flora in the excavations also consists of many rare and protected species.

## **Introduction**

The Silesian Upland has been one of the most intensively exploited areas of Poland, particularly by the mining industry. The immense demand for supplies of sand to be used by the construction and mining industry has caused the manifold increase of sand exploitation and constant growth of working areas (Greszta, Morawski 1972, Wrona 1977, Furdyna 1979). The deposit exploitation has been always connected with a process such as: drastic transformation of the environment, devastation and losses of biocenosis and mother rock exposure in the considerable areas. During a process of step working of sand it frequently happens that layers are ruptured, causing the creation of peculiar hydrologic preconditioning at sandpit bottoms (Greszta, Skawina 1965, Wrona 1973, Dwucet, Krajewski, Wach 1992). What is more, the change determines the direction and rate of the natural regeneration of biocenotic systems.

## Research area

The Siemonia sandpit was at work from 1939 to 1959 and the area was under examination from 1997 to 1999. The research work had the aim to state the influence of karst water flowing into the bottom of excavations on the formation process of biocenosis. The sandpit lies in the western part of the Silesian province, about 11-km north-west to Będzin City. The investigated surface workings are situated at the western roadside leading Będzin - Tarnowskie Góry, in the lowering of the Jaworzniak valley, in the immediate vicinity of the left tributary of the Brynica River. Pleistocene and Holocene Quaternary deposits (mainly: sand and gravel originating from river-glacier accumulation, sandy clay, dune sand) are underlain by the Carboniferous and Triassic in part exposure deposits in the area of the sandpit. Amongst the Triassic occur: shelly limestone of the lower Triassic (building the neighbouring hills) limestone, sand, gravel and clay of the Bunter, the Rhaetian limestone and dolomite, which are outcropped here and there. The Carboniferous deposits of the Siemonia sandpit consist of coal shells and coal sandstone (Doktorowicz-Hrebniński 1954, Zielinski 1960). There are three water-bearing stages connected with the Palaeozoic, Mesozoic and Carboniferous deposits in the investigated area. The Triassic stage is of the greatest importance, but only the Rhaetian limestone and dolomites have hydrological meaning. The Quaternary water bearing stage with an unconfined water table is derived from fluvial-glacier accumulation. The Quaternary waters are in contact with slates and sandstone and characterised by high minerals and high iron content (Zarzycka 1993).

The research area is about 1152 ha in area, of which about 70 ha was exposed to the reclamation in order to restore park and forest areas. Besides, two shallow water basins connected by a sluice occupy about 40 ha and are supplied by the Jaworzniak stream as well as smaller watercourses. The natural regeneration has been observed in the rest of the area, flooded and lower lying (about 40 ha).

## Biotope Conditioning

The most important factors, which decided of habitat conditions in a floor of the surface workings in the area of the Siemonia sandpit, were water inflows penetrating the Triassic limestone and dolomites. The waters were characterised by high minerals and calcium ion content, with slight alkine reaction and belonged to types:  $\text{HCO}_3\text{-SO}_4\text{-Ca-Mg}$  and  $\text{HCO}_3\text{-SO}_4\text{-Ca}$ . The water temperature ranged from  $7^\circ\text{C}$  to  $11^\circ\text{C}$ . The water physical-chemical properties of three chosen inflows are presented in *Table 1*.

Moistening, one of the biotope conditions, was modified by discharge and consequently ground conditions. In summer, the temperature, which was taken near the water seepage, fluctuated from  $7^\circ\text{C}$  to  $11^\circ\text{C}$ , (*Fig. 1*). That is why the decrease in the annual temperature range was observed, especial in higher layers of the ground within inflows (*Fig. 2, 3*).

Table 1 Physical and chemical properties of investigated water seepage in scarps within the vicinity of the Siemonia sandpit

Nr	pH	TH	Ca <sup>2+</sup>	Mg <sup>2+</sup>	Na <sup>+</sup>	K <sup>+</sup>	C	HCO <sub>3</sub> <sup>-</sup>	SO <sub>4</sub> <sup>2-</sup>	NO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>
		mg/l	mg/l	mg/l	mg/l	mg/l	μS/cm	mg/l	mg/l	mg/l	mg/l
I	7,4	315	120,2	3,7	3,85	0,67	557	268,4	73,7	-	4,89
II	7,2	360	108,2	21,8	7,1	1,32	584	262,4	77,0	-	9,4
III	7,3	415	140,3	15,8	7,6	3,27	736	317,0	92,4	-	4,75

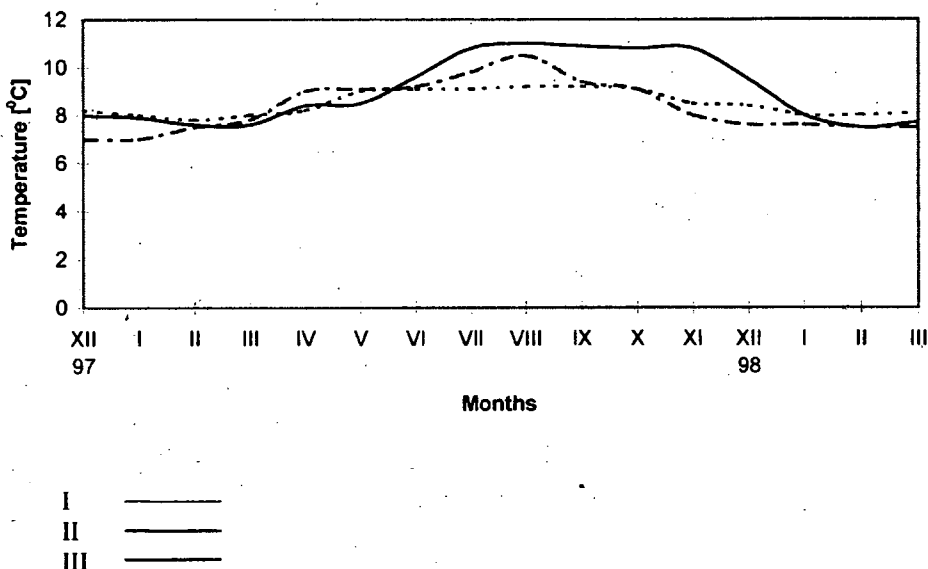


Fig. 1 Temperature conditions of investigated water seepage during the period December 1997 to March 1999 (for water seepage from Table 1)

In winter, even if the temperature dropped to  $-20^{\circ}\text{C}$  for seven days, the frost penetration were noticed in 3-4 cm layer of the surface ground. It implies that the frost penetration either in such low air temperatures or in the absence of snow blanket depends strictly on the level of ground water. The studies suggest, in the above mentioned water conditions, that the ground did not freeze at all or only in 1cm in depth, but only in the sites, where the water plane wasn't lower than 10 cm. The frost penetration up to 4 cm was recorded in the sites, where water was kept in 4cm - 40 cm in depth. So, the frost penetration depended on the species compositions and the rate of plant coverage in the sites, where the water table included about 10-50 cm.

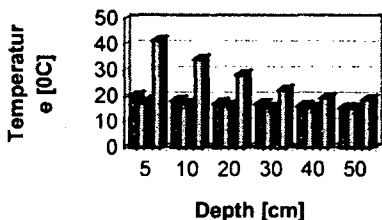


Fig. 2 Ground surface temperature in selected plots from the Siemonia Sandpits in July 1998.

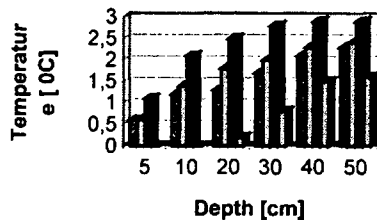


Fig. 3 Ground surface temperature in selected plots from the Siemonia Sandpits in January 1998

- Siemonia Sandpit - Community with *Equisetum variegatum* (7m above the bottom of an excavation).
- Siemonia Sandpit - Community with *Equisetum variegatum* growing in the bottom of an excavation.
- Siemonia Sandpit - Community with *Equisetum variegatum* growing in the bottom of an excavation
- Siemonia Sandpit - dry, psammophilus grasslands with *Corynephorus* - controlled plot

The process of soil cover formation at the bottom of the sandpit reflected the hydrological conditioning. Observations of soil profiles indicated intense growth of topsoil  $A_0$  (up to 25 cm for 40 years) and were made in areas with differential moisture rate and habitats of plant communities. The results referred to the fragment with variegated horsetail occurring in swampy and periodic flooded grounds. The external aspect of the particular plant associations was connected with unfrozen inflows, which modified the microclimate of the surface ground layers.

An interesting phenomenon was the formation of large naleds, connected with the small ground water outflows (class1, according to Aleksejew classification 1987), that affected plants, especially in severe winters. This phenomenon was also observed in other excavations (in Pogoria I, Maczki Bór and near Ogrodzienic). The influence of karst water discharge in the floor of the Siemonia sandpit is shown in Fig. 4.

## Vegetation

The above mentioned hydrological conditionings in common with the interaction of the local climate were modified by the influence of concave landforms such as surface excavations (Kozłowska-Szczęśna 1990). And the holistic impact determined the generation process of characteristic phytocenosis occurring in wet floor areas and bog-springs. In the process of natural succession appeared pioneering communities. They consisted of anemochores (bryophytes, horsetails, orchidaceous) and communities with considerable percentage of variegated horsetail *Equisetum variegatum*. The glacial epoch survivor occurs in a periglacial zone in Alaska and the Arctic region (Crocker, Major 1955, Świąś 1988) whereas Polish botanists regard it as mountain species (Walas 1939, Szafer 1986, Zajac 1996). From the conservation point of view, it is worth recording that pioneering stages of the succession created biotops for many rare and vanishing species such as: *Malaxis monophyllos*, *Liparis loesela*, *Drosera rotundifolia*, *Pinguicula bicolor*, *Tofieldia calyculata*. Plant communities occurring in the floor of the excavations were also observed in other sandpits (Pogoria I, Kuźnica Warężyńska, Maczki - Bór and Jaworzno - Szczakowa) in the eastern part of the province (Celiński, Czyłok 1995, Czyłok 1997). The

encroachment of shrubby communities with *Salix rosmarinifolia* (resemble the association *Betulo-Salicetum repentis* and the association from the class *Scheuchzerio-Caricetea fuscae*) was noticed in the later stages of the succession. The stage depended on microhabitat factors (groundwater level, topographic features, vegetation). In the transition stage of overgrowing, the great participation had the communities from the alliance of *Magnocaricion* and appeared in flooded ground lowerings.

In the oldest parts of the outcrop workings, there were particular forest associations with predominant *Equisetum variegatum* in the ground flora and with predominant *Salix rosmarinifolia* in the undergrowth, however, in other places the ground cover contained a lot of species from the class *Scheuchzerio-Caricetea fuscae*. *Molinia coerylea* encroached on small areas together with the mesotrophic and the oligotrophic vegetation from the alliance of *Molinion* what was caused likely by storing thin layers of cap-rocks. In other areas, where the considerable differences of the groundwater level (up to 60 cm) caused the temporary process of rotting and realising biogenic and thus nutrient enrichment, also occurred the plants.

Also interesting was the process of overgrowing in unfrozen streams and the all-year vegetation. These species belonged to the alliance of *Sparganio-Glycerion fluitantis* and contained fully- stocked plant surfaces with *Berula erecta*, *Veronica anagalis* and *Veronica becabunga*. The results of the studies suggest that the space distribution depended on: distance of outflows, stream flow, river bed features, vegetation.

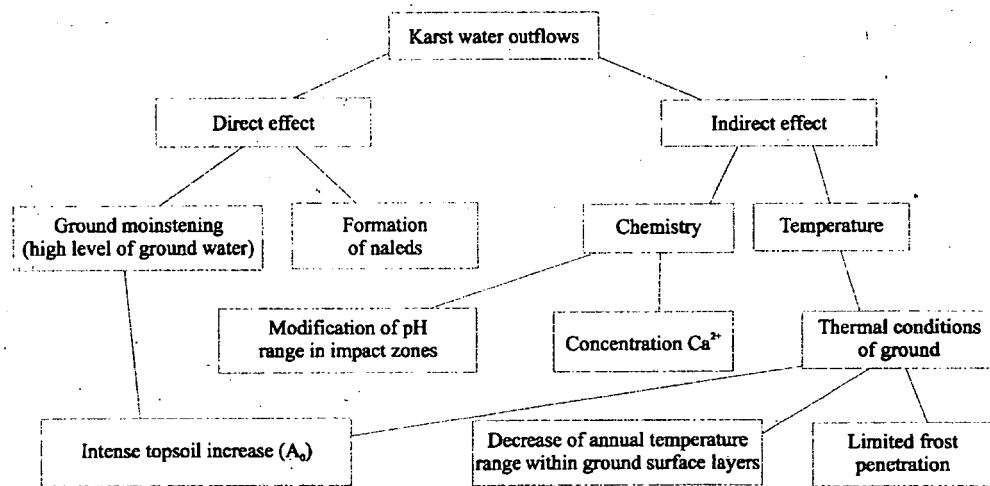


Fig. 4 Influence of karst water outflows on habitat conditions in the excavation floor of the Siemonia sandpit

In the Silesian province, the area of sand workings is estimated to be about 1200 ha and may increase in the future. This is why further studies on the natural regeneration of biocenosis are necessary. The research work indicates that a unique biocenosis develops as a result of natural succession in areas flooded by carbonate karst water and the basal complex is built of impermeable layers under the Quaternary deposits. This kind of substratum structure causes the high level of ground water and enables the creation of habitats for plant communities.

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