3.5. Environmental history of oxbow ponds: a sediment geochemical study of Marót-zugi-Holt-Tisza, NE-Hungary

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3.5.1. Introduction

Until the mid-19th century the landscape of the Hungarian lowland "Alföld" was characterised by vast areas of backwaters, oxbows, marshland, wet meadows and riparian forests associated with floodplains of major watercourses. Since then the number and extent of these have decreased greatly and the floodplains have become restricted to narrow belts along the main stream channel between dykes (IUCN, 1995). In the flood control operations through the second half of 19th century most of the bends (meanders) of river Tisza were cut off the main channel which lead to the formation of oxbow ponds both on the reclaimed side and on the remaining (active) floodplain. These two basic types are characterised by highly contrasting hydrologies, the former being completely or largely independent of flood regimes and fed by groundwater whereas the latter being exposed to flood disturbance. In such systems deposition of allogenic particles, erosion, and accumulation of authigenic material seem to dominate different periods and occur with different intensity (Brunet and Astin, 1999). The rate and character of sediment accumulation in oxbows are a key factor in determining the future (e.g. terrestrialization, eutrophication) of these water bodies.

Despite their artificial origin oxbows have become important features of the landscape (Ward *et al.*, 1999). The original wildlife has largely been preserved by oxbow ponds, a type of shallow, less disturbed water bodies with a general abundance of aquatic vegetation (Abernethy and Willby, 1999, Müller *et al.*, 1999, Amoros *et al.*, 2000). According to a recent survey, the number of oxbows with a surface area over 5 ha is around 70 along the river Tisza (Pálfai, 1995). Owing to diverse plant and animal communities many of them have been regarded as wildlife sanctuaries (IUCN, 1995).

Because of their critical role in flood control, nutrient cycling and the maintenance of biodiversity, floodplain wetlands either provide or influence many landscape functions that are valued by society. Hence we studied the environmental history of a reference oxbow pond, Marót-zugi-Holt-Tisza, to demonstrate the usefulness of palaeolimnological methods, and particularly sediment geochemical analysis, in reconstructing past aquatic environments.

3.5.2. Methods

Marót-zugi-Holt-Tisza is a smallish oxbow pond (length 1.8 km; width 60 m; area 10 ha, position 48°10'28''N, 21°37'09''E) near the village Gávavencsellő in NE Hungary. Owing to the richness of the biota it has been registered as a nature reserve and wildlife

sanctuary, and selected as part of the pilot project area for the PHARE-sponsored Hungarian National Biodiversity Monitoring Programme (Dévai *et al.*, 1998). The basin of the oxbow was created in 1860 when a large bend of river Tisza was cut through in the frame of the water regulation.

A sediment sequence was taken by using a rod operated piston sampler (Walker, 1964) which provides 100 cm long undisturbed core samples even from shallow water. Sampling was carried out from ice at the deepest point around the centre of the curved basin, on March 8 1997. Water depth was 190 cm and the corer stopped in the bottom fluvial sand at 590 cm relative to the surface ice. The cores were wrapped first in polyethylene (PE) then in aluminium foil. To avoid sample contamination volumetric subsamples (0.785 cm^3) were taken from the centre of the cores at 5 cm intervals using a small sampler tube and then processed individually. Sediments were described and labelled following Troels-Smith (1955). Organic dry matter (ODM) was determined as loss on ignition at 500 °C (Engstrom and Wright, 1984).

Subsamples were dried at 105°C for 24h, weighed and digested with a mixture of 20 cm^3 65% (m/m) HNO_3 and 2 cm^3 30% (m/m) H_2O_2. The samples were heated on hot plate at 100°C until dryness and then diluted to 10 cm^3. Before analysis sample solutions were filtered and stored in plastic reagent tubes. Concentrations of Al, Ca, Cr, Cu, Fe, K, Mg, Mn, Na, P, Pb, S, Sr and Zn were determined by inductively coupled plasma atomic emission spectrometry (ICP-AES) using a Spectroflame instrument (Spectro GmbH, Cleve, Germany). Photosynthetic pigments were extracted with acetone, pigment concentration were determined spectrophotometrically and expressed as sedimentary pigment degradation units (SPDU) following the simple method of Wetzel and Likens (1991).

Against-depth plots of sediment composition data were produced by using Psimpoll 3.0 (Bennett, 1997).

3.5.3. Results and Discussion

The entire length of the sediment sequence was 400 cm which represented about a 130 yr time span (Fig. 1). The average rate of deposition therefore was estimated at 2-3 cm/yr. Radiometric dating of this sediment core has been in progress and expected to provide a more detailed and accurate estimation (e.g. Owens *et al.*, 1999).

The lower third section (590-450 cm relative to ice) of the obtained core was characterised by alternating layers of coarse sand and clayey silt (Fig. 1) which indicates that the basin was incompletely isolated from the main river channel. The sediment section between 450-350 cm was found to have high clay content which suggests slow current velocity but still a fairly continuous water supply. Through this period the organic content of sediments remained very low (c. 4%).

A remarkable change in the history of the oxbow took place at 350 cm where clearly recognisable remains of submersed macrophytes, mostly the hornwort *Ceratophyllum demersum* appeared (Fig. 1). This indicates a shift toward a permanent, less disturbed pond stage. From 350 cm upwards the lacustrine system continued which was shown by a two-fold increase in the organic content. Concentrations of sulphur and phosphorus showed a similar pattern against depth (Fig. 1). However, fossil pigment concentration increased earlier (at 400 cm) than the appearance of macrophyte remains, together with peaks of phosphorus and sulphur. This is likely to imply that in the first stage the dominant process

was planktonic eutrophication which was followed by a burst of aquatic macrophytes and probably periphyton, i.e. benthonic eutrophication (Lakatos and Kiss, 1983). From 350 cm upwards to the topmost 190 cm, *Ceratophyllum* was found to appear as 7 distinct peaks. Moreover, SPDU values in the topmost 20-30 cm still increased twofold.

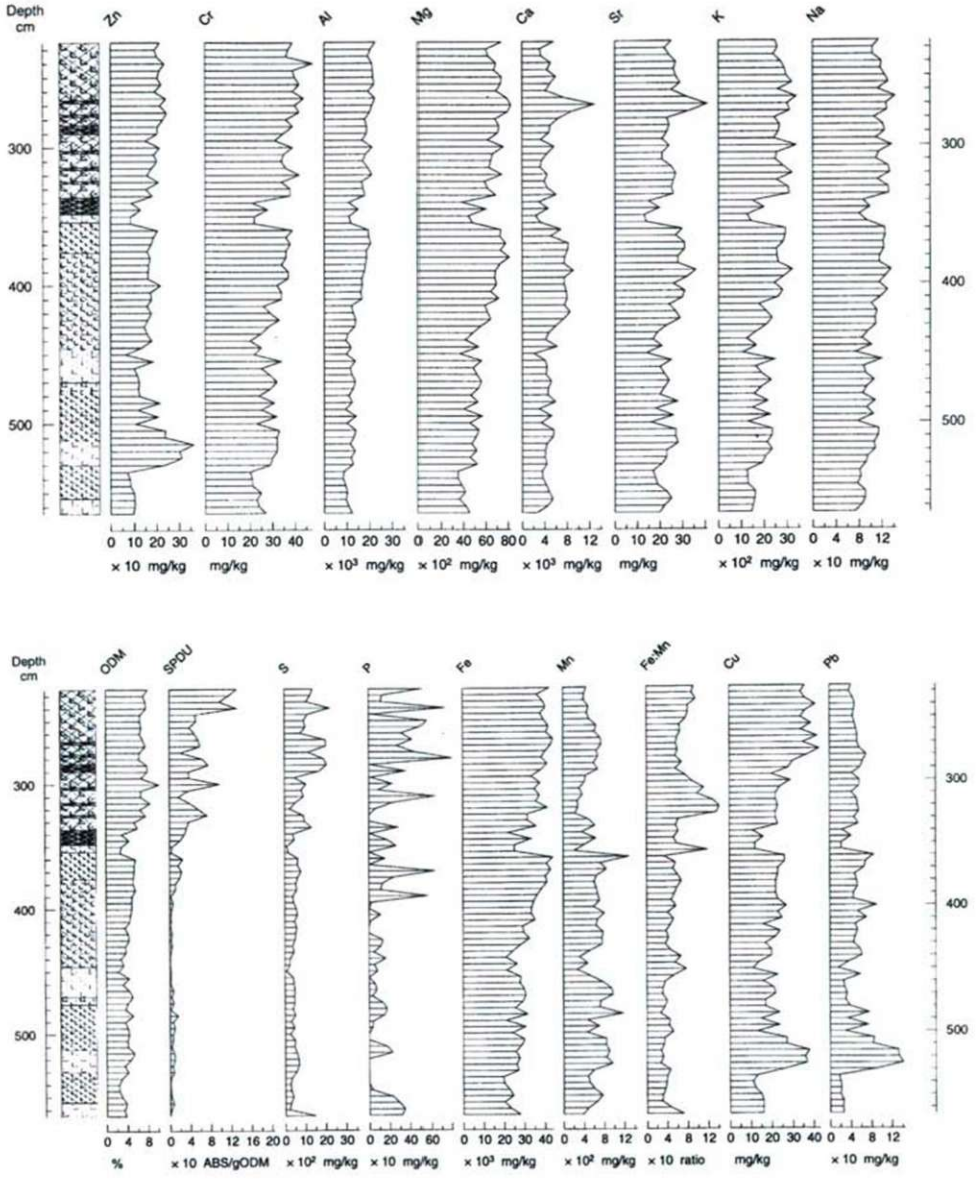

Fig. 1. Sediment description and geochemical data plotted against depth for the oxbow pond Marót-zugi-Holt-Tisza, NE-Hungary; depth measured relative to surface ice.

On the very top of the whole sequence a 1-2 cm thick yellow clayey layer was detected which marked the unusual yet significant winter flood of Tisza a few month before the time of coring (early March, 1997). We suggest that similar events may have resulted in the repeated dieback and burial of aquaphytes detected in the upper section of the sediment.

On the basis of sediment chemistry, 14 recurrent floods were identified in the whole sequence which is in agreement with our earlier results for the oxbow Tiszadobi-Holt-Tisza (15 floods) and also historical records on major, often catastrophic, floods of Tisza (Braun *et al.*, 1996).

In river water, iron and manganese are known to be present as oxides and hydroxides bound to suspended matter (Hoyer *et al.*, 1982, Tóth *et al.*, 1998). Consequently, concentrations of both iron (20-40 g/kg) and manganese (0.4-0.8 g/kg) were found to be fairly high in the sediment. These elements are regarded as subtle indicators of palaeoredox conditions (Mackereth, 1966) as well. The large peak of the Fe:Mn ratio at 330-300 cm was due to a decrease of manganese relative to a constant level of iron. This reflects a relatively oxygen-deficient environment in the water column of the oxbow which occurred closely after the dieback and burial of aquaphytes.

Concentrations of Al, Mg, Cr, Na, K, Ca, Sr along the sequence showed a dull, similar pattern (Fig. 1.) which is primarily determined by the input of allochtonous riverine matter. However, peaks of Cu, Pb and Zn between 540-500 cm reflect increased heavy metal loads probably associated with intense ore mining in the second half of the 19th century. In the upper 50 cm of sediment, representing the last 20-25 yr, concentration of copper was again found to be significant (30-40 mg/kg) whereas levels of Pb and Zn did not differ from the normal values. This suggests that either the source of pollution or the mining technology changed.

3.5.4. Conclusion

The chemical composition of sediment sequences from oxbow ponds are valuable records of floods, trophic state, redox conditions and pollution history. Perspectives of future palaeolimnological investigations on oxbows and other floodplain wetlands should include the radiometric dating techniques (^{137}Cs and ^{210}Pb) of sediment cores, refinement of palaeoenvironmental reconstruction by considering pollen, diatoms, molluscs other aspects of the fossil biota, as well as the ecological comparison of oxbows on the active floodplain and the reclaimed land, including managed and unmanaged ones.

3.5.5. Summary

We studied the usefulness of sediment geochemical analysis as a tool for reconstructing the environmental history of oxbow ponds. >From the deepest point around the centre of Marót-zugi-Holt-Tisza, a smallish oxbow near the village Gávavencsellő (NE Hungary), an undisturbed sediment core of 400 cm length was taken, representing a 130 yr period. Sediment chemical data revealed a crucial change in the history of the oxbow at 350 cm (around the 1920's?) where recognisable remains of submersed macrophytes, mostly *Ceratophyllum demersum* appeared. This indicates a shift toward a permanent, less

disturbed pond stage. It seems likely that planktonic eutrophication was followed by a burst of aquatic macrophytes and probably periphyton (benthonic eutrophication). Through the entire sediment sequence, evidence for 14 major floods were found, in agreement with our earlier results and historic records. Concentration peaks of Cu, Pb and Zn between 540-500 cm suggested enlarged heavy metal loads, probably associated with intense ore mining in the second half of the 19th century. In the upper 50 cm of sediment (the last 20-25 yr), concentration of copper was again significant (30-40 mg/kg) whereas levels of Pb and Zn did not differ from the normal values which implies that either the source of pollution or the mining technology changed. Perspectives of future palaeolimnological investigations on oxbows are discussed.

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3.5.7. References

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