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TRACE METAL POLLUTION AND MICROTOPOGRAPHY IN A FLOODPLAIN, THE HÁROS ISLAND (Budapest)

ABSTRACT: SZALAI Z., *Trace metal, pollution and microtopography in a floodplain, the Háros Island (Budapest).* (IT ISSN 0391-9838, 1998).

Floodplains are particularly vulnerable environments to pollution. In the vicinities of cities heavy metals transported by rivers accumulate in floodplain deposits and vegetation. In the paper the results of investigations directed at the filtering capacities of floodplain deposits during two flood waves. From the analyses of groundwater samples it was found that Pb, Cd and Co contents of groundwater grow with depth in alluvial soils. The observation is explained by the spread of contamination upwards from deeper horizons.

KEY WORDS: Trace metal, Floodplain, Groundwater, Háros Island (Budapest).

RIASSUNTO: SZALAI Z., *Inquinamento da metalli e microtopografia in una piana di esondazione, l'Isola di Háros (Budapest).* (IT ISSN 0391-9838, 1998).

Le pianure di esondazione sono particolarmente vulnerabili all'inquinamento. In vicinanza dei centri urbani i metalli pesanti trasportati dai fiumi si accumulano nei depositi delle piane di esondazione fluviale e nella vegetazione. In questo articolo sono esposte le ricerche volte a conoscere le capacità di filtraggio e assorbimento dei depositi alluvionali dell'Isola di Háros lungo il Danubio presso Budapest, durante due ondate di piena. Dall'analisi di campioni di acqua della falda idrica è stato constatato che il contenuto in piombo, cadmio e cobalto aumenta con la profondità del suolo. Ciò si spiega con la propagazione della contaminazione dagli orizzonti più profondi.

TERMINI CHIAVE: Metalli in tracce, Piana alluvionale, Falda idrica, Isola di Háros (Budapest).

INTRODUCTION

Recently public awareness of the hazards of environmental contamination through trace metals has increased. Several publications deal with this problem in various disciplines, e.g. agricultural sciences, pedology, plant physiology, ecology and physical geography. Investigations of the impacts of heavy metals on the environment have been carried out in various areas, but only few of them in floodplains. The test area selected for the present study is the Háros Island, a peninsula in the Danube section at Budapest, near Budatétény. The Háros Island seemed to be ideal for this kind of examination, because although it is close to the industrial and residential areas of Budapest, the Island itself remained in quasi-natural conditions, and, despite its small area, it includes all typical floodplain features.

MATERIAL AND METHODS

The soil types were identified from soil profiles and samples collected from auger holes. Soil profile sites and groundwater level observation wells were located next to the quadrats (units of detailed vegetation survey). The colour of soil samples was determined using the Munsell Color Chart. In the laboratory humus content, grain size composition, pH and $CaCO_3$ content of the samples were measured. The $CaCO_3$ content was determined using Scheiber calcimeter and the humus content applying the calorimetric method. The positions (horizontal coordinates and altitudes) of quadrats were determined by triangulation.

There occurred two small flood waves on the Danube following each other within a short period in August and September 1996. Groundwater was sampled twice during each flood wave, first in the beginning and again in the final phase of the wave. Lead, cadmium and cobalt contents of groundwater were identified with a Zeiss AAS 30 graphite furnace atomabsorption spectrophotometer. The samples were deposited 1:8 HNO_3/H_2O. We measured the chemical oxigen demand (COD) with a Merck SQ 118 spectrophotometer.

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THE STUDY AREA

The Háros Island is located near the right bank of the Danube along its section at Budapest (fig. 1). Recently the island is a peninsula since at the beginning of this century as its northern bank was filled and Hunyadi Island was connected to its right bank. The peninsula extends in the foreground of the Late Pleistocene terrace (Pécsi, 1959). On the riverbank surfaces low (terrace I/a) and high floodplain (terrace I/b) levels are found. Among landforms on the margins of the peninsula man-made features prevail, while in the central part natural features are common. The bank of the main channel was raised and stone-paved, while oxbow edges were also embanked with deposits dredged from the river bed. These embankments enclose the major part of the low floodplain and narrow down the active floodplain. The high floodplain is dissected by old abandoned channels. From their alignments the locations of several Early Holocene islands can be detected. Consequently, Háros Island probably originated from the joining of a series of terrace islands.

SOILS AND MICROFEATURES

In deposits near the surface clay and silt fractions are typical. Sandy layers occur 150 cm below the surface. The influence of groundwater has left distinct marks on sediments and soils. Since the groundwater level is lower than 3 m, there are not even gleyic spots in deeper horizons. Iron oxidated from its ferrous to its ferric form. Including most of the previous low floodplain, the major part of the peninsula is now protected from flooding and siltation. The lower-lying areas enclosed between flood-control dykes and embankments are inundated by excess groundwater and, thus, sedimentation ceased there.

In the oxbows of the high floodplain calcareous humic alluvial soil and calcareous alluvial soil with a double humic horizon are found. In the calcareous humic alluvial soil the humic layer is more than 40 cm deep, but the humus content is less than 2 per cent. In the case of calcareous alluvial soil with a double humic horizon the humus content in the layer between 80 and 120 cm is above 2 per cent. Probably it is a buried humic layer (A_2 horizon).

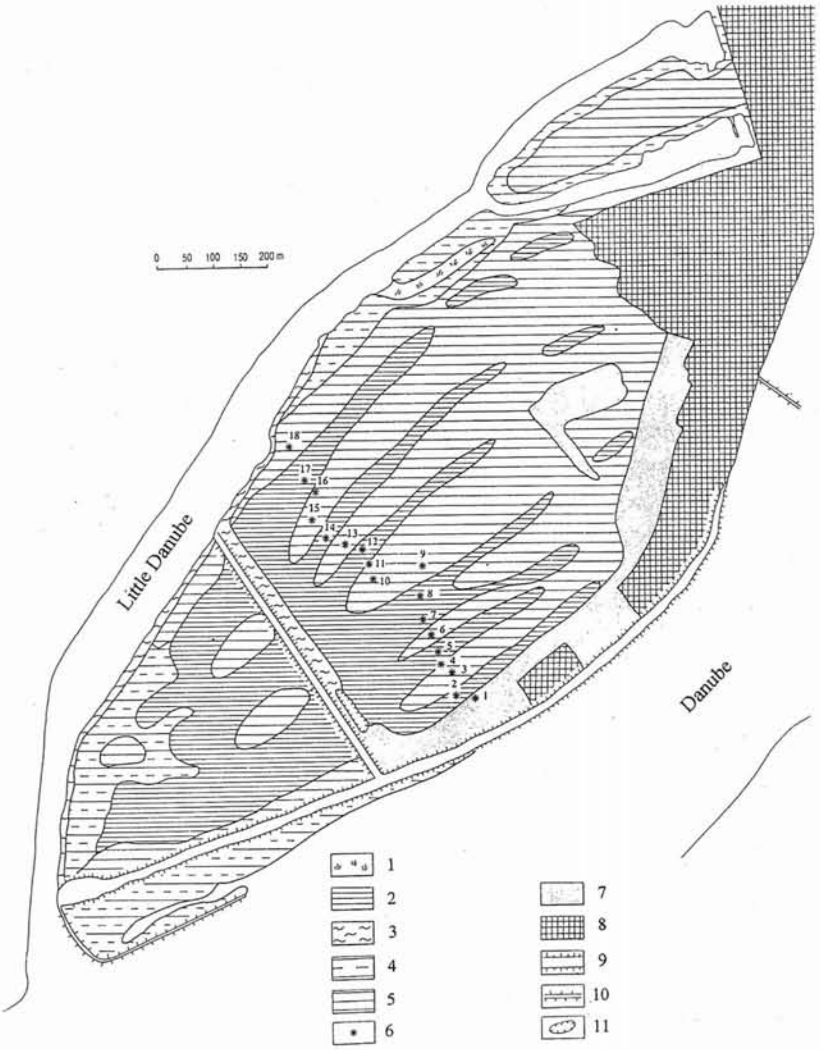

FIG. 1 - Geomorphological map of Háros Island (Budapest). 1) meander filled with alluvium; 2) high floodplain oxbow with vegetation cover; 3) sediment dredged from channel, with vegetation cover; 4) low floodplain; 5) high floodplain; 6) positions of wells and quadrats (with numbers); 7) levelled area; 8) built-up area; 9) dyke; 10) spurdyke; 11) man-made hollow.

The slightly more elevated areas of the high floodplain between abandoned channels are of different nature. The humic layer with 2 per cent humus content lies much deeper than 40 cm, and that indicates transition from alluvial to meadow soils. The Ca^{2+} content and the pH value are increasing with depth. The deposits of the Danube are calcareous, this is the reason why only the change of pH value points to eluviation. The CaCO$_3$ content does not regularly follow the change of the pH value and, thus, it is difficult to distinguish the (B) horizon of the calcareous alluvial soil and the B horizon of meadow alluvial soil from the C horizon (Szalai, 1996).

SOURCES OF TRACE METALS

In the environs of study area two sources of trace metal can be identified. One is the sewage water of Budapest. Sewage always includes pollutant metals (Förstner, 1991) and the lack of sufficient waste water treatment explains the observed high levels of trace metal contents in the Danube in the vicinity of Budapest. The second source is a former non-ferrous metallurgy plant, called Metallochemia, which has already been closed down. Although Metallochemia does not operate any more, but its open waste depot remains to be a source of pollutants to our days, and its previous contamination still has an influence on the broader environment. Heavy metals spreading in the air with dust can precipitate in the area (plants, soil and sewage system) and from there they can directly reach the water of the oxbow on Háros Island. The silt of the oxbow fixes metal ions from the water and thus it becames a depository of contaminants.

TRACE METAL LEVELS IN GROUNDWATER

In non-floodplain areas heavy metals deposit in the humic layer of the soils. From the position of an accumulation zone of heavy metals in the soil conclusions can be made for the source from where the heavy metals derive. If accumulation takes place directly under the soil surface, the heavy metal content is probably of human origin (Farsang, 1996). According to Heres (1994), in the soil the Cd and Pb levels decrease abruptly at 50 cm depth. In acidic soils the accumulation zone is also on the soil surface, but Co levels do not decrease in the soil profile so considerably as Pb and Cd (Krüger, A. & *alii*, 1995).

In the floodplains heavy metals may also deposit on the soil surface. Clay particles adsorb trace metals and the accumulation zone will shift into the deeper layers of alluvial deposits. Since alluvial soils are poor in humus, the surface soil accumulation zone is indistinct, with the exception of the meadow alluvial soil. In the case alluvial soils with multiple humic horizons, the deeper-lying humic layers (next to horizons with high clay contents) can filter groundwater, thus in the soil profile several accumulation zones may develop, but metal contents decrease towards the surface (except in the case of certain level of atmospheric pollution, in the surface soil horizon a higher metal level may be observed).

During the flood waves trace metal contents change in groundwater. In the starting stage of the flood wave Pb and Cd concentrations were higher than the values of the Dutch List «B value» (tab. 1). In the case of the deeper wells (nos 2, 4 and 11, fig. 2) 65 ppb Pb and 2.7 ppb Cd values were found.

TABLE 1 - Reference (A), threshold (B) and limit values (C) (from the Dutch List, after Förstner, 1991)

Metal	Groundwater µg/l		
	A	B	C
Lead	15	50	200
Cadmium	1.5	2.5	10
Cobalt	20	50	200

The lowest contamination can be measured in the higher located wells and in wells lying lower, where the groundwater is filtered by the humic alluvial soil with double horizon and where hydrogen-sulphid fixes heavy me-

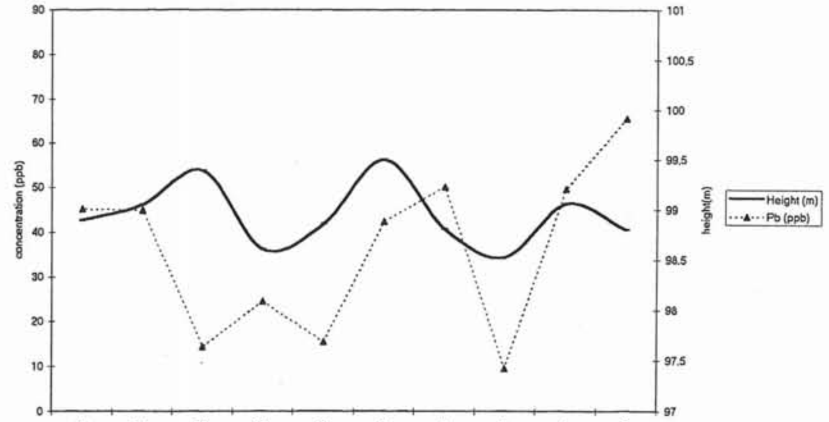

FIG. 2 - Lead content of groundwater in wells of various altitude.

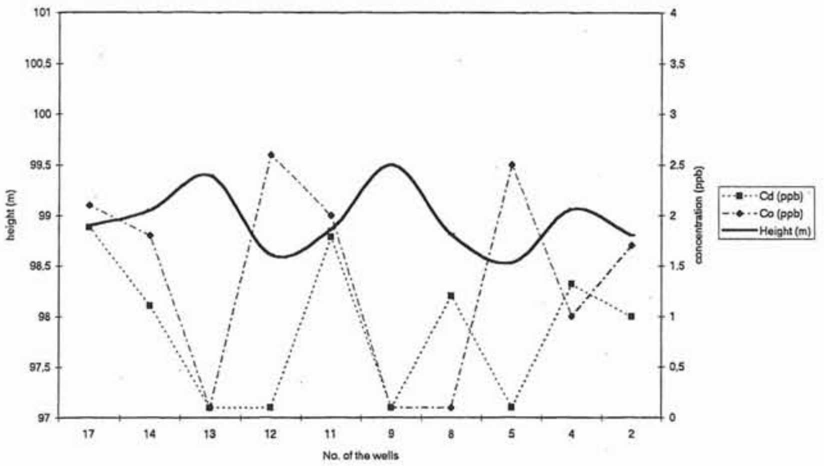

FIG. 3 - Cadmium and cobalt contents of groundwater.

tals. Wells placed in high-floodplain oxbows may contain hydrogen-sulphid, probably because the wells are above buried channel pools where the organic matters decompose under anaerobic conditions.

CONCLUSION

The trace metal content of groundwater decreased to 10 per cent within two weeks by the end of the flood wave. Heavy metals were fixed by fine alluvial deposits and by vegetation. The measurements show that in the floodplains, Pb, Cd and Co contents of groundwater grow with depth in alluvial soils. Wells of lower bottom level present higher trace metal contents than other wells. The observation is explained by the spread of contamination upwards from deeper horizons.

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