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Physico-chemical Variability of Alluvial Sediments in a Floodplain Area of the Downstream Vltava (Moldau) River in the Czech Republic after the Most Recent Catastrophic Flood in 2013

Ivan Suchara[a]*, Julie Sucharová[a], Marie Holá[a]

[a] *Silva Tarouca Research Institute for Landscape and Ornamental Gardening, Květnové náměstí 391, CZ-252 43 Průhonice, Czech Republic*

Abstract

The physico-chemical parameters of the Fluvisols that have developed in long-term deposited river sediments at a depth of 0–10 cm (topsoil) and 30–40 cm (subsoil) were determined immediately after the catastrophic flood in 2013 across the area of Veltrusy Castle (290 ha), which is situated in the inundation zone of the downstream Vltava River. We investigated the soil texture, the active and exchange reaction, the total electric conductivity, the content of total carbon and nitrogen, the available content (Mehlich 3) of selected nutrients (Ca, Cu, Fe, K, Mg, Mn, Na, P and Zn), and the total content of risk elements (As, Be, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, V and Zn), for which the maximum allowed content in soils is laid down in the relevant legislation. An analysis was also made of a sample of the most recent coarse sandy-gravel mineral sediment and of the fine organic-clay sediment. A comparison was made between the data for topsoil affected by the most recent erosion and by the accumulation of sediments, on the one hand, and the subsoil, which was probably unaffected by this most recent flood. The comparison was made on woody plots (42), grassy plots (19) and ploughed field plots (31). The results showed that the most recent flood in the area had mainly affected the texture of the soil cover by accumulation of sandy-gravel sediments and to some extent the content of some elements present in organic clayey sediments. Surprisingly, it was detected a low effect of the most recent flood, and on the salinity and the content of total carbon, nitrogen and other elements.

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The detected properties of the sandy soil covers and the good supply of available nutrient contents (P, K, Ca, Mg) were not limiting factors for crop production in the area. However, the total Cd and Zn content in the topsoil has been increased by accumulation of the fine river sediment, and it frequently exceeded the maximum legally permitted total content of these

* Corresponding author. Tel.: +420 296 528 256.
E-mail address: suchara@vukoz.cz

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elements in agricultural soils. The current content of total As, Cd, Cr, Hg, Ni, Pb, Tl and Zn reached the indication values specified in the prepared legislation, which requires further input of these risk elements in sandy soil covers to be controlled and prevented.

1. Introduction

The Vltava is the longest river (433 km) in the Czech Republic, with a river basin area of 28 090 km^2. The area near the confluence of the biggest rivers in the territory - the Vltava (Moldau in German) and the Labe (Elbe) - has been clogged by river sediments, rendering it liable to catastrophic flooding. The river catchment comprises geochemically considerably variable subsoil's developed on variable bedrock types. Many industrial areas have been introduced along the Vltava and its main tributaries, and the river flows through several major towns, including Prague. Brázdil et al. (2005) reported that more than 40 catastrophic floods since 819 in the downstream Vltava area are mentioned in ancient texts. The most recent catastrophic floods took place in summer 2002 and in spring 2013. There is generally a shortage of multi-element data about the properties of the soil cover and about contamination levels of long-term accumulated sediments in the Vltava inundation area.
The aim of our study was to detect the physical and chemical properties of the Vltava sediments in the area devastated by the catastrophic flood in 2002 and 2013. Knowledge about the properties of the soil cover and about the state of soil pollution should help in renewing and determining the long-term utilization of the study area.

2. Materials and methods

2.1. Study area

The study area (290 ha) is situated 15 km northwest from Prague on the eastern bank of the downstream Vltava River, near the town of Veltrusy (50.283□N; 14.333□E) and 16 km south of the confluence of the Vltava and the Labe. The study area used to be a river island, formed during the flood in 1720. The island became a part of the former Veltrusy castle demesne at that time. A castle, a farm, a landscape park, fields, an orchard and a fallow deer enclosure were constructed on the island between 1720 and the end of the 18th century. In 1784, the inflow in the lateral arm of the river was blocked by flood sediments. A small permanent fabricated stream in the bed of the former arm of the river was constructed subsequently. Former river sediments have been repeatedly eroded and new sediments have been accumulated in the study area during floods. During the flood in 2002, the area was locally deeply eroded or covered by river sediments. Since 2002 revitalization, work has been carried out on the castle, the ornamental landscape park and the orchard, and in support of sustainable field and grassland farming. During the flood in 2013, more than 95% of the study area was covered mainly by a thin layer (0.3 – 5 cm) of fine organo-clay sediments and partly along the river by a thicker coat of sandy gravel sediments.

2.2. Collection and analysis of samples

Soil cover samples were collected throughout the study area in June 2013. Material from the soil covers with approximately the same volume of 25×25×10 cm was cut out from the soil surface at a depth between 0 - 10 cm, and from a depth of 30 - 40 cm. Soil probe pits were dug into the following types of the land cover: woody plots (42), ploughed field sites (31) and grassy plots (19). On one woody plot, sandy gravel material accumulated in 2013 was collected. In parallel, a composite sample from the layer of fine organic clayey sediments approximately 2 - 3 cm in thickness was collected. The collected samples were air dried, and were then sieved through a nylon mesh of 2 mm apertures (fine earth). A part of each homogenized sample was further sieved through a plastic sifter for a finer fraction with particle size ≤ 0.25 mm.
The grain size distribution in the samples was determined after proper dispersion of the samples in a sodium hexametaphosphate solution by a simplified pipette method (Kettler et al., 2001). The active reaction (pH-H_2O) and the total electric conductivity ($\mu S\ cm^{-1}$) were determined directly in a suspension of fine earth (10 g) and deionised water (50 ml) after the suspension had been shaken for 30 minutes. A combined glass electrode was used for determining the active reaction, and a platinum conductivity electrode was used for determining the electric conductivity. The exchange reaction (pH-$CaCl_2$) was detected with the combined glass electrode in a suspension of fine earth (10 g) and a 0.1M $CaCl_2$ solution (50 ml) after the suspension had been shaken for 30 minutes. The pH