FUNCTION OF THE HYPORHEIC ZONE IN THE Cd AND Zn TRANSFER IN THE BIAŁA PRZEMSZA RIVER VALLEY

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Keywords: groundwater; surface water; sediment; floodplain; metals

Introduction

The hyporheic zone, the interface of groundwater and surface water, is characterized by large gradients of nutrients and trace metal concentrations, and contrasting environmental conditions (Boulton et al., 1998). It plays very important role as a physical, chemical and biological filter capable of transforming pollutants (Bourg & Bertin 1993). Intensity of these transformations is influenced at a number of scales by water movement, permeability, substrate particle size, resident biota, and the physiochemical features of the overlying stream and adjacent aquifers (Ward 2016). The presented work couples water and sediment chemistry in the contaminated by metals Biała Przemsza River valley in southern Poland in order to reveal the role of the hyporheic zone in pollutants transfer.

Methods

Studies of water and sediment pollution were carried out on the floodplain in the middle reach of the Biała Przemsza River near Sławków town (Upper Silesia Upland, southern Poland). Five boreholes were drilled at points located in a cross-section perpendicular to the river channel. At each point one piezometer was installed and the sediment core collected. Groundwater samples from piezometers as well as river water samples were collected four times every two months. Values of pH and conductivity were established *in situ*. Concentrations of Cl^-, NO^{3-}, SO_4^{2-}, PO_4^{3-}, CO_3^{2-} and Ca^{2+}, Mg^{2+}, Na^+, K^+ ions were determined using Ion Chromatography (DIONEX 1000). Content of metal ions (Zn, Cd, Pb, Cu, Fe and Mn) were measured using ICP-MS method. Sediment cores were divided into 10-30 cm long sections. Values of pH were measured on-site while other parameters were analyzed right after transport to the laboratory. The fine fraction samples (<0.063 mm) were digested wet in closed system in a mixture: 10 cm^3 of 65% HNO_3 and 2 cm^3 of 30% H_2O_2. The concentrations of heavy metals were determined using the F-AAS method.

Results

River waters, supplied with mine waters from the Zn-Pb mine, are characterized by rather neutral pH, the high conductance (~860 µS/cm) and concentration of: SO_4^{2-} (220–230 mg/L), Ca^{2+} (127–134 mg/L), Mg^{2+} (39–41 mg/L) and CO_3^{2-} (273–295 mg/L). Conductance value is lower than 100 µS/cm for groundwater collected from the channel and decreases markedly away from the SIII core. Generally, the same distribution pattern is observed for most of ions. Only Ca^{2+}, Mg^{2+} and $CO_3^{2-}$with increase of their content from the channel appears the opposite distribution pattern. Also Cd and Zn concentrations are highest in the river water (0.277 µg/kg and 0.449 µg/kg respectively) and decreases rapidly with the distance from the channel but in the last position (SV) some increasing can be observed.

Sediments were generally weakly acidic to neutral (pH 5.7–7.1). They contained very low amounts of organic matter and carbonates (below 1%). Concentrations of mine-originated heavy metals varied within broad range: Cd (1.9–167.3 mg/kg) and Zn (4.7–36,990.8 mg/kg). Generally, their content are the highest in the top stratum and decreased progressively down the core and in the same time are the highest in cores drilled in the channel bottom and decreased away from the channel (Fig. 1).

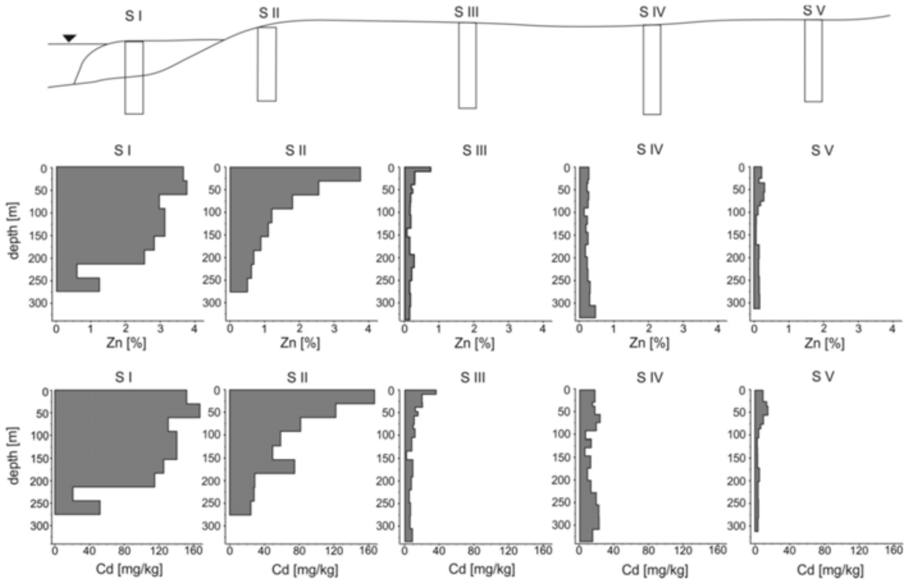

Figure 1. Distribution of zinc and cadmium concentrations in profiles in the studied cross-section.

The similar content of chlorides in groundwater from SI-SIII points and in the river water can indicates the hyporheic flow. For all investigated parameters chemistry of groundwater in the point furthest from the channel (SV) represents values of contrasting with other points which can indicated water originating r from the valley slope. This high pollution of sediments reaches the depth of almost 3 m below the river bed and contrasts with the order of magnitude lower pollution of the floodplain. This situation can be related to infiltration of the river water into the river bed.

Conclusion

Losing of river waters through the river bed causes strong pollution of sediments with heavy metals under the channel over the depth of about 3 meters where high concentrations of metals are stated. These can indicated some role of the hyporheic zone in the metals transfer in the polluted rivers reaches. Furthermore groundwater is suggested to have the important role for river-to-floodplain contaminant transfer. High sediment and groundwater contamination of the levee zone can indicated the essential role of a riparian zone in entrapment of river-borne contaminants.

Acknowledgement: *The work was supported by National Science Centre project no. 2012/05/B/ST/10/00235 and by statutory research project no. 11.11.140.199 of the University of Science and Technology in Krakow.*

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