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The effect of biochar amendment on chlorinated phenols retention in alluvial sediments during river bank filtration

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Amendment of alluvial sediments with carbon rich materials such as biochars can be an effective method for controlling the penetration of hazardous substances from river water into drinking water sources during river bank filtration (RBF). In this work, the transport of chlorinated phenols (CPs) during simulated RBF through Danube alluvial sediment with and without biochar amendment was studied. In order to assess the effect of the biochar amendment on CPs retention in the alluvial sediment, column experiments were carried out, with the addition of biocide to exclude the influence of biodegradation. Four CPs that differ in polarity were used as sorbates: 4-chlorophenol (4-CP), 2,4-dichlorophenol (2,4-DCP), 2,4,6-trichlorophenol (2,4,6-TCP) and pentachlorophenol (PCP). For the column packing, Danube alluvial sediment was used, characterized as a mesoporous sandy material with low organic carbon content (1.57 %) and small specific surface area (1.65 m^2/g). In contrast, the material used as the amendment in the column experiment is a biochar with high organic carbon content (89.8 %) and large specific surface area (341 m^2/g). The breakthrough curves obtained for the alluvial sediment column without biochar amendment showed poor retention of all investigated CPs. Retardation factors (R_d) for 4-CP, 2,4-DCP and 2,4,6-TCP were 1.65, 1.98 and 1.48, respectively, whereas for PCP, R_d was somewhat higher (4.28) most likely due to the fact that it's nonpolar nature greatly affects its distribution between the solid and aqueous phase. The addition of biochar into the alluvial sediment at a 0.5 % mass ratio significantly increased the retardation of all investigated CPs. The obtained R_d values for 4-CP, 2,4-DCP, 2,4,6-TCP and PCP were 102, 83, 78 and 92, respectively. The general increase in retardation of all investigated CPs can be explained by the increase of organic carbon content in the alluvial sediment by the addition of biochar, which is known to be the main fraction for organic components sorption in sediments and soils. In addition, the enhanced affinity of the alluvial sediment to retain the more polar CPs after biochar amendment indicates that sorption is carried out not only through nonpolar interactions, but also by electrostatic interactions between the CPs and functional groups on the surface of the biochar. The results show that biochar amendment of alluvial sediments could have a great potential for organic contaminants retention in the RBF zone, thus decreasing the risk of groundwater and drinking water sources contamination.

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