

Are polluted sediments a source of contaminants for the water column?

Bataillard P.¹, Bru K.¹, Bizi M.¹, Guézennec A.-G.¹, Gaboriau H.¹, Zebracki M.² and Alary C.²

¹BRGM, Environment & Process Division, 3, avenue Claude Guillemin, BP 36009, 45060 Orléans Cedex 2, France

Phone: +33-(0)-2.38.64.46.31

²ENSMD, Environment & Civil Engineering, 941, rue Charles Bourseul, BP 10838, 59508 Douai, France

E-mail: p.bataillard@brgm.fr

Introduction: In the last decades, many sources of industrial contaminants for rivers have been removed thanks to appropriate national and European policies. However, many aquatic ecosystems keep the threat of a possible remobilisation of pollutants accumulated in the riverbed sediments during a century of industrialisation. Until now, this aquatic compartment has been considered as a sink for most pollutants. But, in regard to the objectives of quality aimed by the Water Framework Directive for 2015, this interaction between sediment and water need some improvements. Any disruptive event of water/sediment equilibrium, including anthropic operation (dredging, re-location of sediment...), may induce a contaminant release in the water column. In this study, a laboratory experiment was performed to understand the sediment ability to release metals in solution during re-deposition following re-suspension. Special care was given to the kinetics of the phenomena involved by coupling physical and chemical mechanisms

Methods: A contaminated silty sediment (Zn: 3350 mg/kg, Pb: 676 mg/kg et Cd: 88 mg/kg), originating from a channel in the North of France, was re-suspended in river water, sampled the same day at the same site (L1/S(kg) : 35/2). The suspension was put in two types of columns and left for decantation. Chemical parameters (pH, Eh, dissolved O₂, ions concentrations) of the forming water column were monitored for 3 months thanks to a squared section column (2 m x 0.14 m x 0.14 m) equipped with a septum along its entire height. A syringe especially designed for this experiment, including Eh and O₂ electrodes (Fig. 1), allowed the sampling of water at any depth of the column without disturbance. Chemical parameters were monitored by sampling at 3 different depths in the water column (top, middle and 2 cm above the water/sediment interface). In parallel, mechanical parameters (sedimentation kinetic, concentration in suspended matter, density profile in the sediment column), were monitored in circular section columns (2 m high x 0.10 m in diameter).

Results: Sedimentation monitoring showed a sedimentation velocity of 0.3 m/h. The sediment consolidation occurs a few hours after the beginning of the experiment.



Fig. 1: overview of column set and sampling operation during the experiment

However, the density profiles (measured with a gamma-densimeter) showed that after 3 or 4 days the sediment density decreases, which can be attributed to the formation of gas. The chemical monitoring showed that the gas released from the sediment is accompanied by a decrease in Eh and pH at the sediment/water interface (Fig. 2). Simultaneously, total [Ca], [Mg], [Mn], [Fe] and [PO₄³⁻] increase while [SO₄²⁻] decreases compared to the rest of the water column. Except some peaks encountered during the first 20 days, total [Zn], [Cd] and [Pb] remained low and constant all over the experiment (Zn: 50 µg/l, Pb: 2 µg/l, and Cd: 0.3 µg/l). Finally, after about 50 days of experiment, all the samples have the same chemical composition regardless of the depth of sampling.

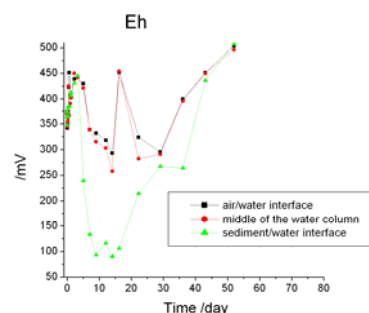


Fig. 2: Evolution of Eh in water at different depths

Discussion: Gas production results from the respiration of bacteria, which impose reduced conditions in the sediment after a period of oxidation in the water column. Degassing leads to the release of metals in solution due to colloidal detachment. After 70 days, equilibrium is reached again and sediment acts as a closed system with limited exchange with the water column.