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Department Inland Water Research
UFZ Centre for Environmental Research Leipzig-Halle

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Effect of a lock-and-weir system on suspended particulate matter (SPM) in the river Saale (Germany)

MARTINA BABOROWSKI, THOMAS R. NEU
UFZ - Centre for Environmental Research Leipzig-Halle, Department of River Ecology, Brueckstraße 3a, D-39114 Magdeburg, Germany, martina.baborowski@ufz.de, thomas.neu@ufz.de

The river Saale (length 413 km, catchment area 24 079 km^2) is one of the most important tributaries of the river Elbe. The Saale affects the lower course of the Elbe both, in water quantity and quality. The lower Saale reach (87 km) is regulated by five lock-and-weir systems to allow navigation. Typically, water flow through a lock-and-weir system of the Saale is divided into three pathways: over a weir, through a lock gate (for shipping), and via a diversion (used for powering water mills in pre-industrial times). The last lock-and-weir system is located at Calbe, approximately 20 km upstream from the mouth of the Saale into the river Elbe.

The spatial and temporal variation of SPM concentration and composition plays an important role in pollution transport. Therefore the influence of hydrological and morphological stress on SPM concentration and composition as well as the structure of aggregates was investigated at the lock-and-weir systems Calbe. From January to June nine random samples ware taken at two sampling points above (km 20,8) and below (km 18,5) the lock-and-weir system.

Results from chemical analyses (dry weight, loss on ignition, particle concentration, POC, PN, silicate, chlorophyll-a concentration) and laser microscopy analysis (bacterial biomass, polymer biomass, algal biomass, architecture of aggregates) were evaluated.

During the sampling period the flow rate of the river Saale was between mean water flow (115 m^3/s) and mean high-water flow (374 m^3/s). Chemical analyses showed in the majority of samples that the concentration of dry substance (Figure 1, left site), POC, PN and particle numbers below the lock-and-weir system was higher than above. The lower current velocities above the system may have allowed the coarse mineral particles and aggregates to settle. This is indicated by the loss on ignition of SPM which was higher above than below the system (Figure 1, right site). In general the chlorophyll a content was higher below the system than above. The most probably reason may be the oxygen input by the weir. Chlorophyll a was also higher in the second half of the sampling period, which was confirmed by higher water temperature. Conductivity measurements proofed the high salt concentrations in the river which was also indicated by the presence of diatoms in the phytoplankton.

Diatom growth was also reflected by the decreasing silicate concentrations due to the incorporation into diatom frustules (Figure 2, left site). However, the fraction of algae in the aggregates was not corresponding to the presence of diatoms in the water column. Polymer concentration in the aggregates (Figure 3) seems to be related mainly to the presence of bacteria as algal concentration in the aggregates was low. Nevertheless, the decrease of chlorophyll a and the increase of polymer in the aggregates by the end of the sampling period (Figure 2, right site) may be related to the release of polymer by dying algae and the subsequent incorporation into aggregates.

Thus under mean flow conditions, the flow over the weir and through the diversion represents the main flow through and thus had the largest effect on downstream material transport. During mean high flow the weir became more important due to the fact that the flow through the diversion backed up. The flow through the lock gate is negligible as shipping was very rare. In conclusion, it is suggested that in both cases the erosion downstream from the weir became important for SPM quality and quantity.

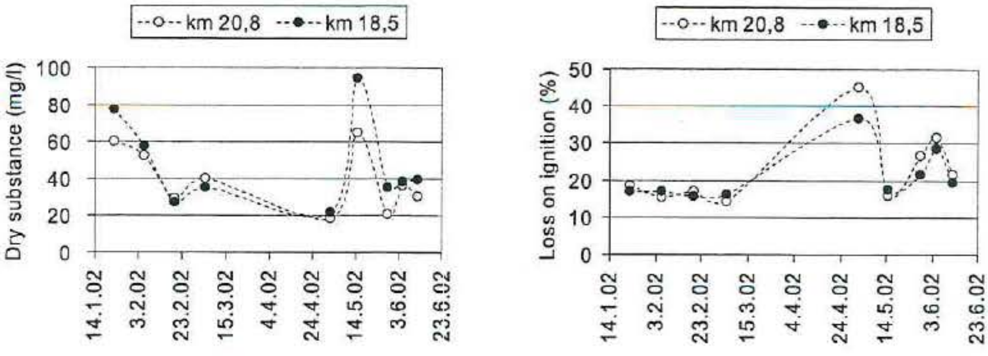

Figure 1: Dry substance (left site) and loss on ignition (right site) above (km 20,8) and below (km18,5) the lock-and-weir system Calbe, river Saale.

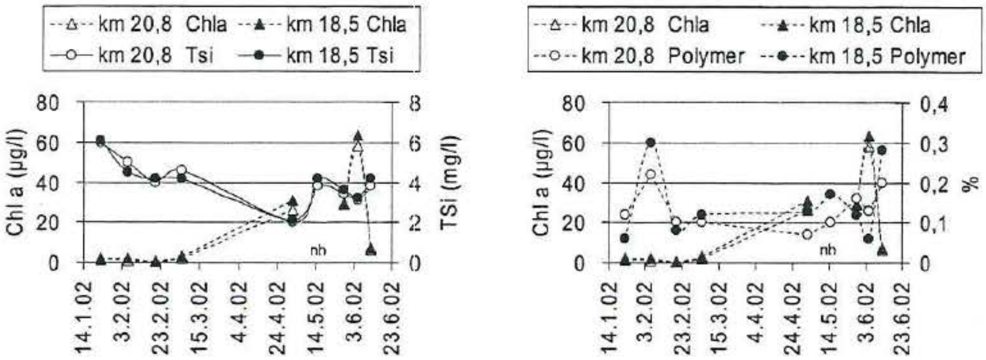

Figure 2: Trend of chlorophyll-a and silicate concentrations (left site) as well as chlorophyll a concentrations and polymer content of the aggregates (right site) above (km 20,8) and below (km18,5) the lock-and-weir system Calbe, river Saale.

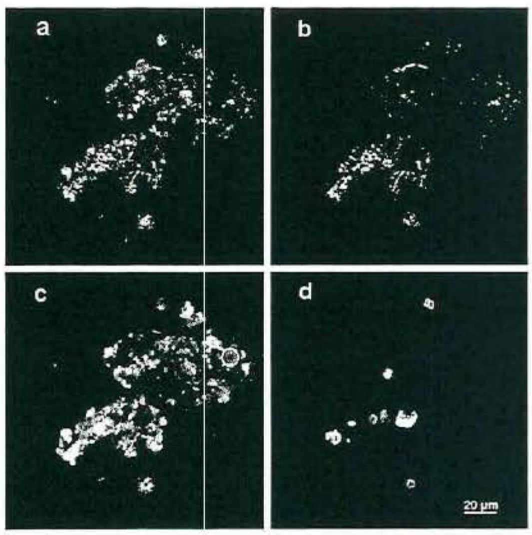

Figure 3: Confocal laser scanning microscopy of river Saale aggregate. The signals were collected from one aggregate in 4 separate channels. a) reflection signal, b) nucleic acid staining of bacteria, c) polymers after lectin staining, d) autofluorescence of chlorophyll a