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Assessing the spatial and temporal variability of groundwater–lake exchange using DTS, seepage meters and natural tracers

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The rate of groundwater seepage into acid mine lakes can alter the biogeochemical conditions at the water-sediment interface, which control the release of acidity into the lake water. In turn long-term water quality depends on the rate of groundwater seepage. Therefore quantifying the spatial and temporal variability of lake-groundwater exchange is a great concern in remediation of such lakes.

Groundwater–lake exchange was investigated in an acid mine lake in Eastern Germany using seepage meters, vertical chloride and temperature profiles and fibre optic distributed temperature sensing (DTS). During a year with relatively constant lake level distinct spatial patterns of groundwater inflow and outflow could be detected by using seepage meters. Seepage rates were found to be steady in time but highly variable in space (2-3 orders of magnitude). A general pattern with influent conditions (groundwater inflow) in the north and effluent conditions in the south was observed. Along the eastern and western shores of the lake transitional conditions were found. Local hot spots with groundwater seepage rates in excess of 200mm/d were found in the deeper sections of the lake suggesting preferential seepage via high-conductivity zones in the underlying aquifer.

Local seepage rates from seepage meters could be verified with flux rates inverted from vertical chloride profiles obtained from pore water peepers at several locations. To identify further possible hot spots of groundwater seepage thermal anomalies were mapped on a smaller scale near the north shore using fibre optic distributed temperature sensing (DTS). Areas of preferential up-welling of groundwater are expected to show a lower daily temperature amplitude at the water-sediment interface than areas with little groundwater inflow. Areas with distinct anomalies in amplitude could be identified, which will serve as additional locations for further point measurements. In a planned lake-level manipulation experiment seepage rates will be altered to investigate the effects of temporal changes on biogeochemical processes and acidity generation.