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Climate change impacts on the hydrology of a small lowland catchment and the leaching of a heavy metal contamination

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The objective of this study was to assess the potential effects of climate change on the hydrology of the small partially-irrigated agricultural lowland catchment of the Keersop, in south of the Netherlands, as well as the transport of a pre-existing spatially extensive trace metal contamination. The area surrounding the Keersop has been contaminated with heavy metals by the atmospheric emissions of four zinc ore smelters. This heavy metal contamination, with Cd and Zn for example, has accumulated in the topsoil and leaches towards the surface water system, especially during periods with high groundwater levels and high discharge rates.

Daily time-series of precipitation and potential evapotranspiration were derived from the results of eight regional climate model experiments under the SRES A2 emissions scenario. They each span 100 years and are representative for the periods 1961-1990 ("baseline climate") and 2071-2100 ("future climate"). The time-series of future climate were characterized by lower precipitation (-1% to -12%) and higher air temperatures (between 2˚C and 5˚C), and as a result higher potential evapotranspiration, especially in summer. The time-series were used to drive the quasi-2D unsaturated-saturated zone model (SWAP) of the Keersop catchment (43 km^2). The model consisted of an ensemble of 686 1D models, each of which represented a 250x250 m area within the catchment.

Simulation results for the future climate scenarios show a shift in the water balance of the catchment. The decrease in annual rainfall is nearly compensated by an increase in irrigation in the catchment, if present day irrigation rules are followed. On the other hand, both evaporation and transpiration fluxes increase. This increase is compensated by a decrease in the drainage flux and groundwater recharge. As a result, groundwater levels decline and the annual discharge of the Keersop stream decreases under all future climate scenarios, by 26% to 46%.

Because Cd and Zn have accumulated in the top soil, the concentrations in the Keersop stream under present day climate react to groundwater level fluctuations. As a result of lower groundwater levels under future climate scenarios, the transport of Cd and Zn towards surface water is projected to decrease. The mass balance of Cd and Zn for the catchment changes towards more storage (adsorption to the soil) and less leaching. Overall, the soils in the catchment function as a sink for Cd and Zn, both under baseline and future climate conditions.

In conclusion, climate change leads to an intensification of the soil-plant-atmosphere coupling and a slowing-down of the groundwater system. This results in a positive impact on a limited aspect of surface water quality. To provide useful advice to water managers on the impact of future climate on water quality, all aspects of water quality should be considered.