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Triple isotope balance of groundwater controlled lake

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Stable isotopes of hydrogen and oxygen (^{2}H and ^{18}O) are often used for quantification of water budgets of lakes and other surface water bodies, in particular for the assessment of underground components of those budgets [1]. Recent advances in laser spectroscopy enabled simultaneous analyses of ^{2}H, ^{18}O and ^{17}O content in water, with measurement uncertainties comparable (^{18}O) or surpassing (^{2}H) those routinely achieved by off-line sample preparation methods combined with conventional IRMS technique [2]. This open up the doors for improving reliability of isotope-aided budgets of surface water bodies by adding third isotope tracer (^{17}O).

Here we present the results of a field study aimed at assessing water balance of a small groundwater-controlled lake (surface area ca. 40 ha, mean depth 5.2 m) located in southern Poland. The lake has no surface inflows and outflows and is heavily exploited for recreational purposes during the summer season. Thus, the renewal rate of water in the lake is of primary importance for proper management of this system.

The lake has been extensively monitored during one–year period (from October 2018 till September 2019). Four sampling campaigns were conducted on the lake to collect water samples for isotope analyses. In addition, regular observations of lake water temperature and meteorological parameters (air temperature, precipitation amount, relative humidity, wind speed) were conducted on the shore. Also, monthly precipitation samples were collected for isotope analyses.

The lake budget was constructed separately for each isotopic system (^{2}H, ^{18}O, ^{17}O), with groundwater inflow and outflow fluxes treated as unknowns. The isotopic composition of net evaporation flux was calculated using Craig-Gordon model [3]. Isotope mass balance calculations revealed that groundwater fluxes derived from ^{2}H-based budget deviate substantially from those obtained for ^{18}O and ^{17}O isotope. It turned out, that most likely reason of this discrepancy is the assumption generally made in constructing isotope balances of small lakes that atmospheric water vapor “seen” by the evaporating lake, is in isotopic equilibrium with local precipitation. Instead, when the local water vapor “seen” by the lake was assumed to be a mixture of local free atmospheric moisture (in equilibrium with local precipitation) and the vapor produced by the lake itself, consistent water budget for all three isotope systems could be obtained.

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