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Can radon, $\delta^{18}O$ and electrical conductivity serve as reliable tracer to quantify groundwater inputs into surface waters?

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Groundwater–surface water interactions play a fundamental role in water resources management, particularly under current climate change conditions. Understanding these exchanges is crucial because rivers/lakes may either gain water from aquifers or lose water to them depending on hydraulic conditions. Groundwater inputs into surface waters can be quantified using natural tracers whose concentrations differ between them. Such tracers are: radon-222 (^{222}Rn), oxygen-18 ($\delta^{18}O$) and electrical conductivity (EC) and they are widely used because they behave conservatively during mixing and provide measurable contrasts between water sources. This multi-tracer approach was carried out on three rivers in north western and central Croatia: the Plitvica, Drava and Česma. All three rivers are located within alluvial aquifers, the Plitvica and Drava Rivers are situated in unconfined while the Česma River is situated in a confined aquifer. Groundwater inflow was estimated using a radon mass-balance approach and mixing models based on $\delta^{18}O$ and electrical conductivity with decay correction applied to radon concentrations. The results show that ^{222}Rn and EC are reliable indicators of groundwater inflow, reflecting clear contrasts between groundwater and surface water signatures. Radon is particularly effective because its concentrations are typically one to three orders of magnitude higher in groundwater than in surface water. Groundwater dominated streamflow during low flow periods, especially in the Česma and Plitvica rivers, where it accounted for up to 100% of discharge. During high flow periods, its relative contribution declined but remained significant at the beginning of the event. Overall, the findings demonstrate that combining these parameters provides a reliable approach for quantifying groundwater inflow to rivers and it can be recommended for sustainable water management planning.

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