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Constraints for Using Radon-in-Water Concentrations as an Indicator for Groundwater Discharge into Surface Water Bodies

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The radon (222-Rn) activity concentration of surface water is a favourable indicator for the detection of groundwater discharge into surface water bodies since radon is highly enriched in groundwater relative to surface waters. Hence, positive radon-in-water anomalies are interpreted as groundwater discharge locations. For this approach, usually, radon time-series are recorded along transects in near-surface waters. Time-series of radon-in-water concentration are commonly measured by permanent radon extraction from a water pump stream and continuous monitoring of the resulting radon-in-air concentration by means of a suitable radon detector. Radon-in-water concentrations are derived from the recorded radon-in-air signal by making allowances for water/air partitioning of radon.

However, several constraints arise for this approach since undesirable factors are influencing the radon-in-water concentration. Consequently, corrections are required to remove the effect of these undesirable factors from the radon signal. First, an instrument inherent response delay between actual changes in the radon-in-water concentration and the related radon-in-air signal was observed during laboratory experiments. The response delay is due to (i) the water/air transfer kinetics of radon and (ii) the delayed decay equilibrium between radon and its progeny polonium (218-Po), which is actually being measured by most radon-in-air monitors. We developed a physical model, which considers all parameters that are responsible for the response delay. This model allows the reconstruction of radon-in-water time-series based on radon-in-air records. Second, on a time-scale of several hours the tidal stage is known as a major driver for groundwater discharge fluctuations due to varying hydraulic gradients between groundwater and surface water during a tidal cycle. Consequently, radon-in-water time-series that are detected on tidal coasts are not comparable among each other without normalization since these time-series are usually observed at varying tidal stages. The normalization of the radon signal was performed by applying a regression model derived from a sensitivity analysis. For this purpose, the sensitivity of radon-in-water concentration for water level changes was analysed for a radon time-series measurement at a fixed location over two tidal cycles. Third, additional sources for radon release into the surface water body e.g., discharge of a radon bearing river, also need to be considered when evaluating radon-in-water concentrations.

To sum up, radon-in-water concentrations act as a precise indicator for groundwater discharge localization if the effects of the instruments response delay, the tidal influence and the presence of additional radon sources are removed from the recorded radon signal.