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Early warning risk assessment for drinking water production: decoding subtle evidence

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Due to increasing demands for high quality water for drinking water supply all over the world there is acute need for methods to detect possible threats to groundwater resources early. Especially drinking water production in complex geologic settings has a particularly high risk for unexpected degradation of the groundwater quality due to the unknown interplay between anthropogenically induced hydraulic changes and geochemical processes. This study investigates the possible benefit of the Principal Component Analysis (PCA) for groundwater and drinking water management using common sets of physicochemical monitoring data. The approach was used to identify the prevailing processes driving groundwater quality shifts and related threats, which might be masked in anthropogenically impacted aquifer systems.

The approach was applied to a data set from a waterworks located in the state of Brandenburg, NE Germany, which has been operating since nearly four decades. The region faces confronting and increasing demands due to rising peri-urban settlements. The PCA subdivided the data set according to different strengths of effects induced by differing geochemical processes at different sites in the capture zone of the waterworks and varying in time. Thus a spatial assessment of these processes could be performed as well as a temporal assessment of long-term groundwater quality shifts in the extracted water.

The analysis revealed that over the period of 16 years of water withdrawal the geochemistry of the extracted groundwater had become increasingly more dissimilar compared to the characteristics found at the majority of observation wells. This component could be identified as highly mineralized CaSO4 dominated water from unexamined deeper zones of the aquifer system. Due to the complex geochemical and hydraulic interactions in the system, this process was masked and was not evident in the data set without validation by the applied statistical analysis. The findings give a clear indication of a potential threat to the groundwater resources in this region with danger for drinking water contamination in a medium-term period.