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Long term variations of the hydrochemical composition of deep thermal ground water in the Lower Bavarian Molasse Basin – Causes and Perspectives

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The European Water Framework Directive (WFD) commits EU member states to achieve a good qualitative and quantitative status of all their water bodies. WFD provides a list of actions to be taken to achieve the goal of good status. However, this list disregards the specific conditions under which deep (> 400 m b.g.l.) groundwater aquifers form and exist. In particular, deep groundwater fluid composition is influenced by interaction with the rock matrix and other geofluids, and may assume a bad status without anthropogenic influences. Thus, a new concept with directions of monitoring and modelling this specific kind of aquifers is needed. Their status evaluation must be based on the effects induced by their exploitation. Here, we analyze long-term real-life production data series to detect changes in the hydrochemical deep groundwater characteristics which might be triggered by balneological and geothermal exploitation. We aim to use these insights to design a set of criteria with which the status of deep groundwater aquifers can be quantitatively and qualitatively determined. Our analysis is based on a unique long-term hydrochemical data set, taken from 8 balneological and geothermal sites in the molasse basin of Lower Bavaria, Germany, and Upper Austria. It is focused on a predefined set of annual hydrochemical concentration values. The data range dates back to 1937. Our methods include developing threshold corridors, within which a good status can be assumed, and developing cluster analyses, correlation, and piper diagram analyses. We observed strong fluctuations in the hydrochemical characteristics of the molasse basin deep groundwater during the last decades. Special interest is put on fluctuations that seem to have a clear start and end date, and to be correlated with other exploitation activities in the region. For example, during the period between 1990 and 2020, bicarbonate and sodium values displayed a clear increase, followed by a distinct dip to below-average values and a subsequent return to average values at site F. During the same time, these values showed striking irregularities at site B. Furthermore, we observed fluctuations in several locations, which come close to disqualifying quality thresholds, commonly used in German balneology. Our preliminary results prove the importance of using long-term (multiple decades) time series analysis to better inform quality and quantity assessments for deep groundwater bodies: most fluctuations would stay undetected within a < 5 year time series window, but become a distinct irregularity when viewed in the context of multiple decades. In the next steps, a quality assessment matrix and threshold corridors will be developed, which take into account methods to identify these fluctuations. This will ultimately aid in assessing the

sustainability of deep groundwater exploitation and reservoir management for balneological and geothermal uses.