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Numerical groundwater models calibrated with isotope hydrological ages: a way around legal cases?

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Groundwater pumped from a quaternary sand and gravel aquifer at a drinking water plant in an agriculture area in Northern Germany with screen depths between 20 and 40m below ground surface showed rising nitrate values, meanwhile above the boundary value for drinking water. Discussions on the origin of this nitrate contamination followed and did not yet grow up to be a legal case. Water supply engineers attributed the nitrate content to manure from pig farming spread to the agricultural area as “fertilizer”. Farmers in contrast explained the nitrate with land ameliorations at the beginning of the last century: the former swampy area was drained and deep-ploughed to change the swamp soils into arable land. This geochemical change in soil conditions might have triggered a degradation of organic matter, releasing fixed nitrogen and leading to rising nitrate values. This conceptual model was in contradiction to numerical flow and transport calculations indicating short particle tracking times between recharge and well. Since these were calibrated by time series of the hydraulic heads, the calibration is not unique for the transport case: any factor applied to recharge and transmission results in identical hydraulic heads but very different travel times of any contamination. Isotope hydrological measurements of the transient tracers T/3He and CFC/SF6 were applied to decide for one scenario.

Tritium was found in all samples, ranging from 5 TU to 33 TU and confirming recharge after 1960, or at least 25% modern rain in a binary mixture with tritium-free old water. CFC/SF6 and T/3He in more than 80% of the wells give a very good agreement if interpreted as “age” assuming there was no mixture at all. Admixtures of

older tritium free water are clearly discernible only in the discharge area downstream of the production wells where groundwater drains into artificial drainage channels. More than 80% of the ages “measured” confirm particle tracking ages derived from the numerical studies. Since 15 out of 24 wells gave tracer ages smaller than 20 years, the results are in clear contradiction to the “soil amelioration” scenario. The combination of classical flow-model calibration by hydraulic heads together with transport calibration using isotope hydrological data gives a reliable prognostic tool e.g. to calculate how long nitrate will prevail in the aquifer after different scenarios of nitrate input reduction. Presupposition of such a study is a good spatial and depth resolution of groundwater observation wells with screen sections not longer than 2m.