Geophysical Research Abstracts
Vol. 17, EGU2015-15220-1, 2015
EGU General Assembly 2015

Paleoclimate signals and age distributions from 41 public water works in the Netherlands

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Knowing the age distribution of water abstracted from public water supply wells is of prime importance to ensure customer trust and to underpin predictions of water quality evolution in time. Especially, age distributions enable the assessment of the vulnerability of well fields, both in relation to surface sources of contamination as in relation to subsurface sources, such as possibly related to shale gas extraction. We sampled the raw water of 41 large public supply well fields which represents a mixture of groundwaters and used the a discrete travel time distribution model (DTTDM, Visser et al. 2013, WRR) in order to quantify the age distribution of the mixture. Measurements included major ion chemistry, 3H, 3He, 4He, 18O, 2H, 14C, 13CDIC and 13CCH4 and the full range of noble gases. The heavier noble gases enable the calculation of the Noble Gas Temperature (NGT) which characterizes the temperature of past recharge conditions. The 14C apparent age of each mixture was derived correcting for dead carbon sources and included carbonate dissolution and methanogenesis as the defining processes. The DTTDM used the 3H and 4He concentrations, the 14C apparent age and the NGT as the four distinctive tracers to estimate the age distributions. The use of 18O was less effective because the processes that led to more enriched values are too uncertain . Especially 4He and NGT provide extra information on the older part of the age distributions and showed that the 14C apparent ages are often the result of mixing of waters ranging between 2.000 and 35.000 years old, instead of being discrete ages with a limited .variance as sometimes assumed.
The results show a large range of age distributions, comprising vulnerable well fields with >60% young water (< 100 yrs) and well-protected well fields with >85% very old groundwater (> 25 kyrs) and all forms of TTD's in between. The age distributions are well in correspondence with the hydrogeological setting of the well fields; all well fields with an age distribution skewed towards older ages are in the Roer Valley Graben structure, where fluvial and marine aquitards provide protection from recent recharge. Especially waters from this graben structure exhibit clear paleoclimate signals, with a clear relations between NGT (ranging from 2,8 -9 °C), 4He (up to 3.3E-6 cc STP/g) and 18O (range from -8.5—5.5‰.