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Water – Isotope – Map (δ 18O, δ 2H, 3H) of Austria: Applications, Extremes and Trends

Stefan Wyhlidal (1), Martin Kralik (2), Ralf Benischke (3), Albrecht Leis (4), and Rudolf Philippitsch (5)

(1) AIT-Austrian Istitute of Technology, (2) University Vienna, (3) Joanneum Research, (4) Joanneum Research, (5) The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management

The isotopic ratios of oxygen and hydrogen in water (2H/1H and 18O/16O) are important tools to characterise waters and their cycles. This starts in the atmosphere as rain or snow and continues in surface water and ends in shallow groundwater as well as in deep groundwater. Tritium formed by natural cosmic radiation in the upper atmosphere and in the last century by tests of thermonuclear bombs in the atmosphere, is characterised by its radioactive decay with a half-life of 12.32 years and is an ideal age-marker during the last 60 years.
To determine the origin and mean age of waters in many projects concerning water supply, engineering and scientific projects in the last 45 years on more than 1,350 sites, more than 40,000 isotope measurements were performed in Austria.
The median value of all sites of oxygen-18 is δ 18O -10.7 ‰ and for hydrogen-2 δ 2H -75 ‰Às the fractionation is mainly temperature dependent the lowest negative values are observed in winter precipitation (oxygen-18 as low as δ 18O -23 ‰ and in springs in the mountain regions (δ 18O -15.1 ‰.
In contrast the highest values were observed in summer precipitation (up to δ 18O – 0.5 ‰ and in shallow lakes in the Seewinkel (up to δ 18O + 5 ‰.
The isotopic ratios of the Austrian waters are also influenced by the origin of the evaporated water masses. Therefore the precipitation in the region south of the main Alpine crest (East-Tyrol, Carinthia and South-East Styria) is approximately 1 ‰ higher in δ 18O-values than sites at the same altitude in the northern part. This is most probably caused by the stronger influence of precipitation from the mediterranean area.
The median value of all 1,120 sampling sites of decay corrected (2015) tritium measurements is 6.2 tritium units (TU). This is somewhat smaller than the median value of all precipitation stations with 7.2 TU. This can be explained by the fact that in most cases in groundwater the median value has been reduced by decay according to the residence time underground. The tritium concentration increases in the summer up to 10 – 11 TU and decreases in winter down to 3 – 4 TU. This is due to the better circulation in the atmosphere in spring which brings the tritium formed by cosmic radiation down to the lower atmosphere and precipitation.
A smaller mean tritium concentration in aquifers than approximately 3.5 TU indicates large amounts of water older than 60 years. Waters with approximately more than 12 TU contain still tritium from the 1960s and 1970s formed originally by thermonuclear bomb experiments. In Austria the highest Tritium values can be observed in the rivers Danube and March which show periodic or permanent tritium contamination up to 70 TU coming from nuclear power plants in the neighbouring countries.