**Seasonal variations of Tritium, Uranium and stable isotopes in groundwater and spring waters**

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**Abstract**

Groundwater constitute a vital source of fresh water worldwide (Alley et al. 2002). However, it is vulnerable to climate change, mismanagement and human activities. Many studies have been focused on spatio-temporal variations of groundwater storage. However, groundwater quality can be also variable at the hydrological year scale, even in storm-event scale. Usually, it is considered insignificant in comparison with its spatial variability, while the high cost constitutes a limiting factor for frequent monitor of groundwater quality (Rouxel et al. 2011). Nevertheless, seasonal variability of groundwater quality can define the recharge and hydrogeochemical process of groundwater and function of springs. Another approach to determine the characteristics and origin of groundwater is the study of stable isotopes, tritium and isotopic ratios such as 234U/238U (Noli et al. 2016). Variation of stable isotopes, tritium and isotopic ratios such as 234U/238U has been widely used to determine the characteristics of groundwater and spring water. In this study, the hydrochemical and isotopic composition of groundwater and spring water was studied during the critical periods of a hydrological year in the Anthemountas basin in Northern Greece. The samples were collected from two springs and three boreholes during the period of September 2016, February, June and September of 2017. The highest value of 234U/238U ratio was 3.8 during the period of June and observed in groundwater impacted from geothermal fluids, while in spring waters the ration was up to 1.3. The highest concentration of Tritium was observed in Voskina spring during the February of 2017. According to the stable isotopes the recharge elevation of the springs and the aquifer is up to 350 m. In this study is highlighted the contribution of isotopes to determine the recharge and hydrogeochemical process of groundwater and spring water. The knowledge of these process is the base for a sustainable water resource management plan and protection of the aquifer systems o the Anthemountas basin.

**Key words:** Groundwater, Karst springs, Geothermal fluids, Porous aquifer, Greece

**Table 1.** Results of isotopic analysis in groundwater and spring water.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sample** | **U-238**  **counts** | **± %s** | **U-235**  **counts** | **± %s** | **U-234 counts** | **± %s** | **[U-238] (mBq/l)** | **[U-234]/ [U-238]** | **[U] (ppb)** | **3Η (TU)** |
| September 2016 | | | | | | | | | | |
| 1 | 85 | 11 | 6 | 41 | 77 | 11 | 10 | 0.9 | 0.8 | - |
| 2 | 1638 | 3 | 57 | 13 | 1667 | 3 | 50 | 1.0 | 4.0 | - |
| 3 | 37 | 16 | 5 | 45 | 43 | 15 | 6 | 1.2 | 0.5 | - |
| 4 | 30 | 18 | 7 | 38 | 39 | 16 | 8 | 1.3 | 0.7 | - |
| 5 | 320 | 6 | 20 | 22 | 572 | 4 | 8 | 1.8 | 0.7 | - |
| February 2017 | | | | | | | | | | |
| 1 | 35 | 17 | 3 | 58 | 46 | 15 | 4 | 1.3 | 0.3 | 0.96 |
| 2 | 791 | 4 | 47 | 15 | 880 | 3 | 38 | 1.1 | 3.1 | 1.45 |
| 3 | 24 | 20 | 6 | 41 | 29 | 19 | 3 | 1.2 | 0.2 | 0.45 |
| 4 | 5 | 45 | 0 | 0 | 9 | 33 | 5 | 1.8 | 0.4 | 0.51 |
| 5 | 93 | 10 | 10 | 32 | 158 | 8 | 10 | 1.7 | 0.8 | 0.10 |
| June 2017 | | | | | | | | | | |
| 1 | 42 | 15 | 4 | 50 | 50 | 14 | 4 | 1.2 | 0.3 | 1.4 |
| 2 | 1141 | 3 | 31 | 18 | 1179 | 3 | 52 | 1.0 | 4.2 | 1.4 |
| 3 | 5 | 45 | 4 | 50 | 19 | 23 | 1 | 3.8 | 0.1 | < 0.6 |
| 4 | 5 | 45 | 3 | 58 | 6 | 41 | 2 | 1.2 | 0.1 | 0.7 |
| 5 | 93 | 10 | 2 | 71 | 182 | 7 | 10 | 2.0 | 0.8 | < 0.6 |
| September 2017 | | | | | | | | | | |
| 1 | 17 | 24 | 2 | 71 | 22 | 21 | 3 | 1.3 | 0.3 | 0.92 |
| 2 | 1109 | 3 | 36 | 17 | 932 | 3 | 34 | 0.8 | 2.8 | 1.21 |
| 3 | 17 | 24 | 5 | 45 | 12 | 29 | 4 | 0.7 | 0.3 | 0.36 |
| 4 | 15 | 26 | 2 | 71 | 16 | 25 | 3 | 1.1 | 0.2 | 0.60 |
| 5 | 329 | 6 | 16 | 25 | 448 | 5 | 10 | 1.4 | 0.8 | 0.28 |

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