Transient nature of riverbank filtered drinking water supply systems - a new challenge of natural radioactivity assessment

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In Hungary 97% of drinking water supply relies on groundwater resources.

Riverbank filtered systems represent 40% of drinking water supply.

In case of 11% of the settlements there are elevated gross alpha activity concentration.
Based on EURATOM drinking water directive → regulations in Hungary regarding the natural radioactivity of drinking waters

**Council Directive**
2013/51/EURATOM
- Tritium < 100 Bq/l
- Indicative dose < 0.1 mSv/year
- Radon < 100 Bq/l
- Gross alpha activity < 0.1 Bq/l
- Gross beta activity < 1 Bq/l

**Government Decree**
- Tritium < 100 Bq/l
- Indicative dose < 0.1 mSv/year
- Radon < 100 Bq/l
- Gross alpha activity < 0.1 Bq/l
- Gross beta activity < 1 Bq/l

Gross alpha activity > 0.1 Bq/l many cases in Hungary (11% of settlements) → nuclide specific measurements required

Hydrogeology and groundwater flow system approach can help to understand natural radioactivity of groundwater (geology is not enough): prediction of favorable conditions of elevated radionuclide content
Radionuclides in groundwater

- Uranium (sum of $^{238}\text{U} + ^{234}\text{U}$): mobile mainly in oxidizing environments: recharge limbs of groundwater flow systems
- Radium ($^{226}\text{Ra}$): mobile in reducing and acidic conditions (as $\text{Ra}^{2+}$): regional groundwater flow systems
- Radon ($^{222}\text{Rn}$): mobile (gas), short half life indicates short and/or fast travel time

Since the mobility of uranium and radium is strongly influenced by geochemical conditions, knowledge on the geochemical parameteres of water is required.
Nuclide specific measurements

- Uranium (\(^{238}\text{U} + {^{234}\text{U}}\)) and Radium (\(^{226}\text{Ra}\)) using selectively adsorbing nucfilm disc (Surbeck 2000) and alpha spectrometry method

- Radon (\(^{222}\text{Rn}\)) using liquid scintillation method
Case study - results

- The study areas selected by database provided by National Public Health Center where in case of one local waterwork gross alpha activity > 0.1 Bq/l
- Two riverbank filtered drinking water supply systems

**Area “A”**
- Radon values: <5 Bq/l – 36 Bq/l
- Radium values: <5 mBq/l – 38 mBq/l
- Uranium values: 15 – 253 mBq/l

**Area “B”**
- Radon values: <5 Bq/l – 10 Bq/l
- Radium values: <5 mBq/l – 6 mBq/l
- Uranium values: 29 – 150 mBq/l
Case study – Area „A”

Water level: 3.25 m asl
Uranium: 15-76 mBq/l
Radon: 1-36 Bq/l

Water level: 1.2 m asl
Uranium: 22-253 mBq/l
Radium: 1-38 mBq/l
Radon: 1-29 Bq/l

Low river water level → elevated uranium content
Gross methods compared to nuclide specific measurements

- Uncertainties related to gross methods (Jobbágy et al., 2014)
- Only nuclide specific analysis provides a sufficient insight to the interconnection between geological background, flow systems and the occurrence of natural radionuclides in groundwater

### Table 1

<table>
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<tr>
<th>#1</th>
<th>gross alpha (Bq/l)</th>
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<th>water level (m)</th>
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### Table 2

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#6

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</table>
Conclusion

- Hydrogeology and *groundwater flow system approach* can help to understand natural radioactivity of groundwater (geology is not enough): prediction of favorable conditions of elevated radionuclide content.

- Monitoring of gross alpha and beta activity should be adjusted to the *transient system* of the river bank filtered aquifer.

- Need of nuclide specific measurements: the only way to understand the interconnection between geology, groundwater flows systems and the occurrence of natural radionuclides in groundwater. *Nuclide specific measurements deliver more reliable results* compared to the gross methods.

- Wide range of uranium activity concentrations within the same aquifer (geological unit).

- Adjacent wells (in 5-10 m distance) show very different values → inhomogeneity of floodplain sediments - organic-rich layers may contain uranium.

- The *uranium activity concentrations* of the drinking water depend on the ratio of the groundwater and the surface water (level of the river).

- Elevated *gross alpha activity* are caused by uranium ($^{238}\text{U} + ^{234}\text{U}$).
Acknowledgement

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