

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

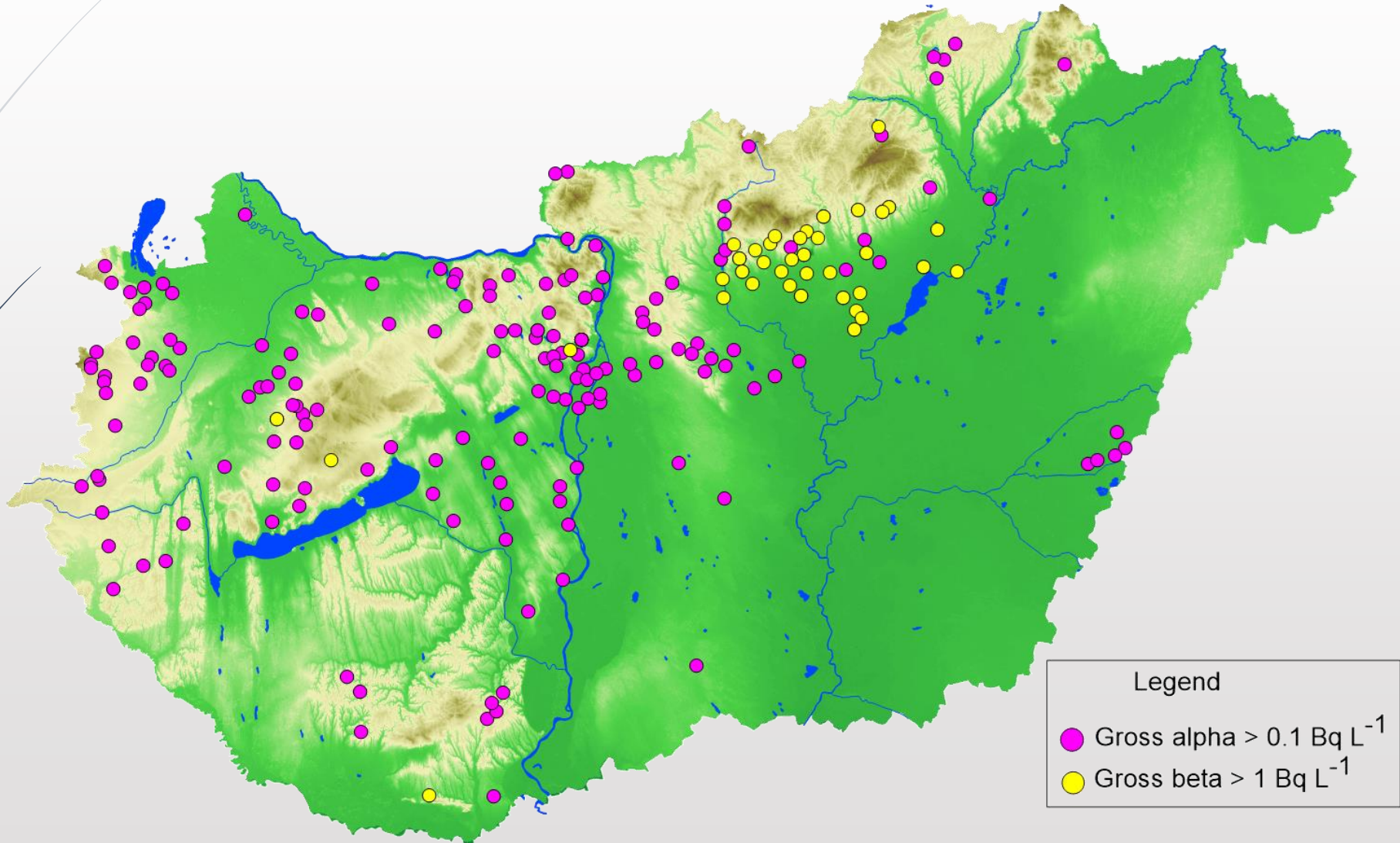
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József & Erzsébet Tóth Endowed Hydrogeology Chair and Foundation



- 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
201/2001 (25. Oct),
313/2015 (28. Oct)**

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



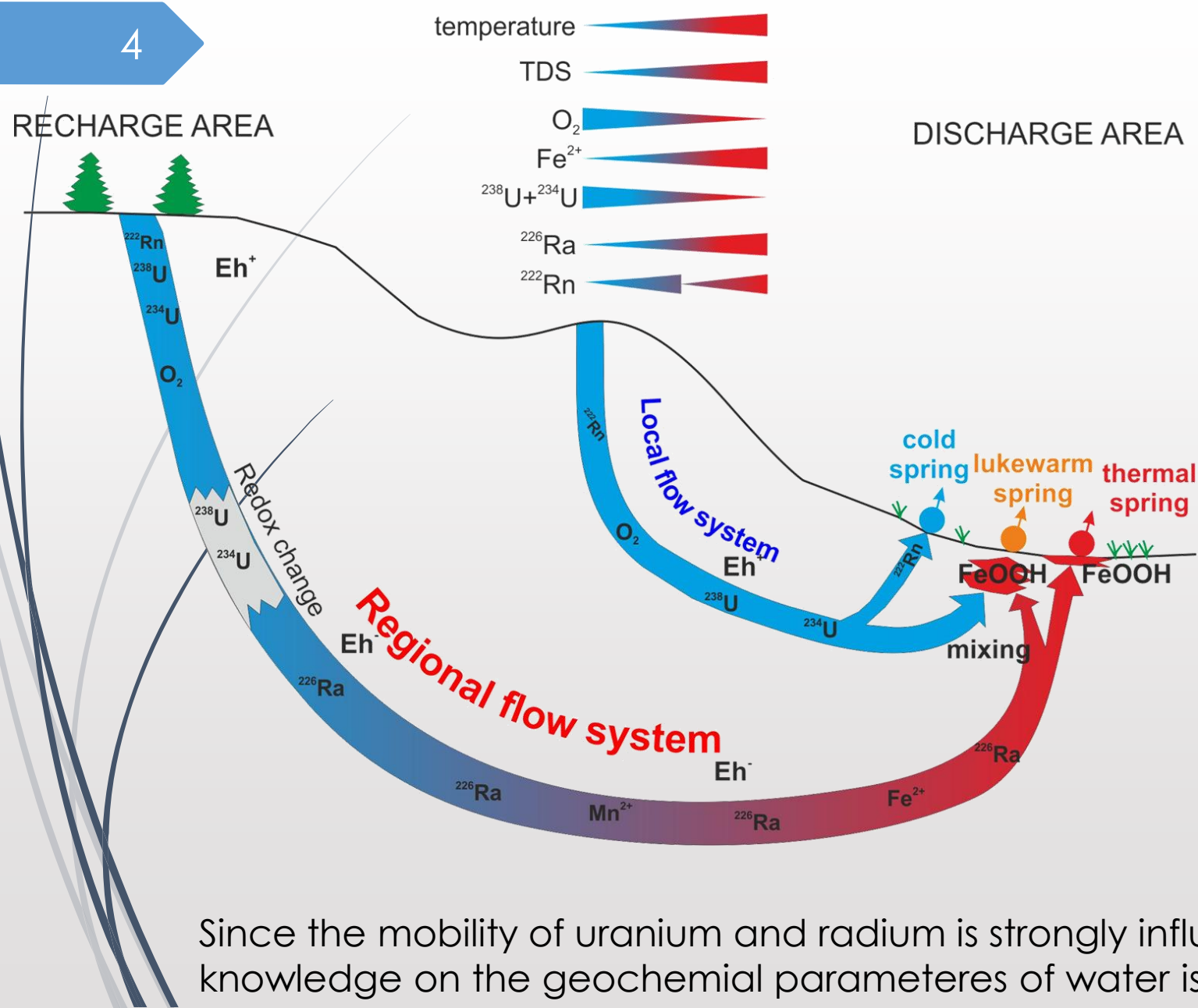
Gross alpha activity > 0.1 Bq/l
many cases in Hungary (11%
of settlements) → nuclide
specific measurements
required



**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

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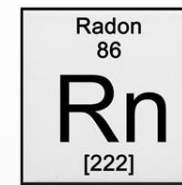
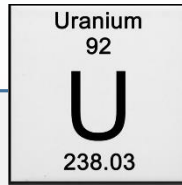
- ▶ Uranium (sum of $^{238}U + ^{234}U$): mobile mainly in oxidizing environments : recharge limbs of groundwater flow systems
- ▶ Radium (^{226}Ra): mobile in reducing and acidic conditions (as Ra^{2+}): regional groundwater flow systems
- ▶ Radon (^{222}Rn): mobile (gas), short half life indicates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

Since the mobility of uranium and radium is strongly influenced by geochemical conditions, knowledge on the geochemical parameters of water is required

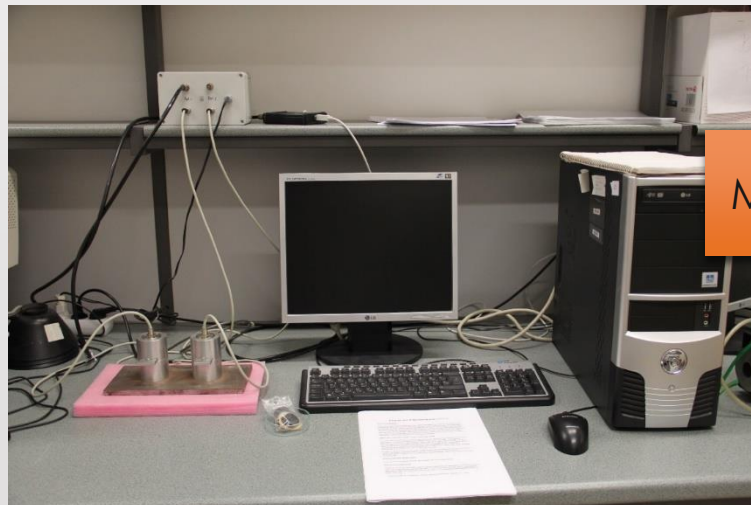
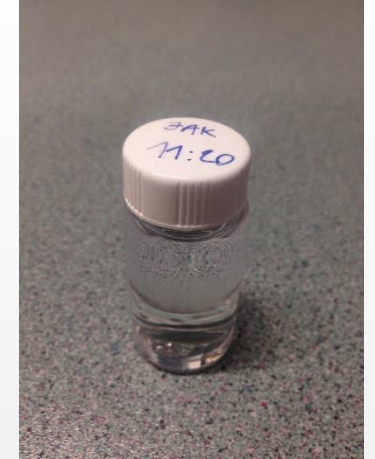
Nuclide specific measurements

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- ▶ Uranium ($^{238}\text{U} + ^{234}\text{U}$) and Radium (^{226}Ra): using selectively adsorbing nucfilm disc (Surbeck 2000) and alpha spectrometry method
- ▶ Radon (^{222}Rn): liquid scintillation method



SAMPLE
PRETREATMENT



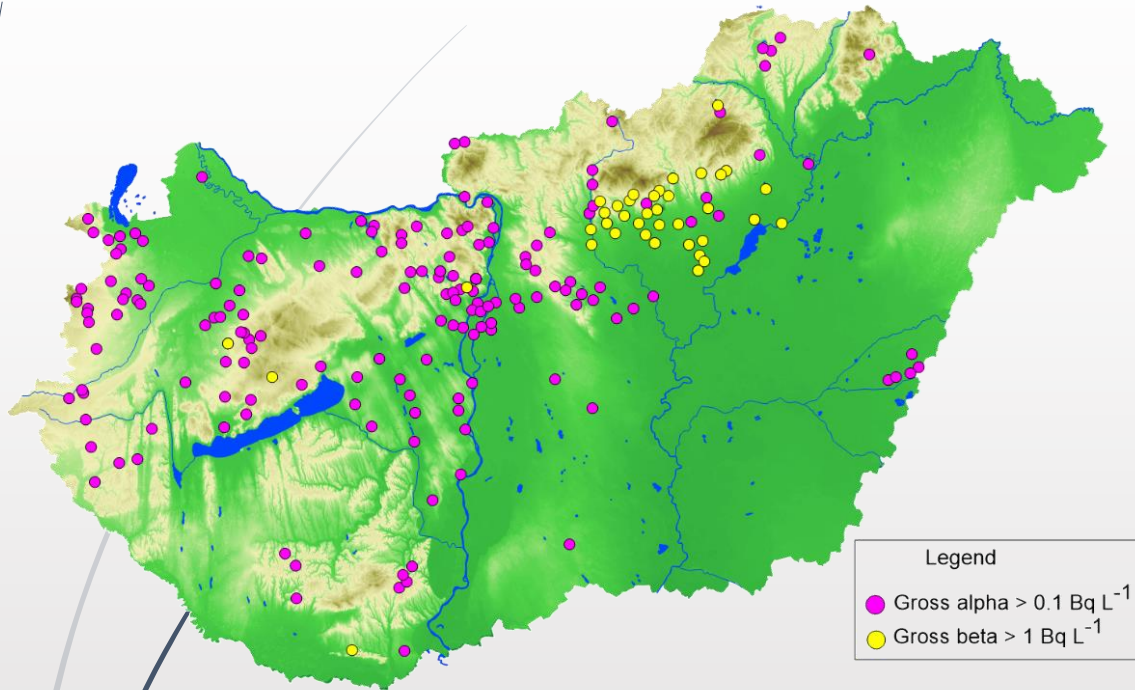
MEASUREMENT



(atomfizika.elte.hu)

Case study - results

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- 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”

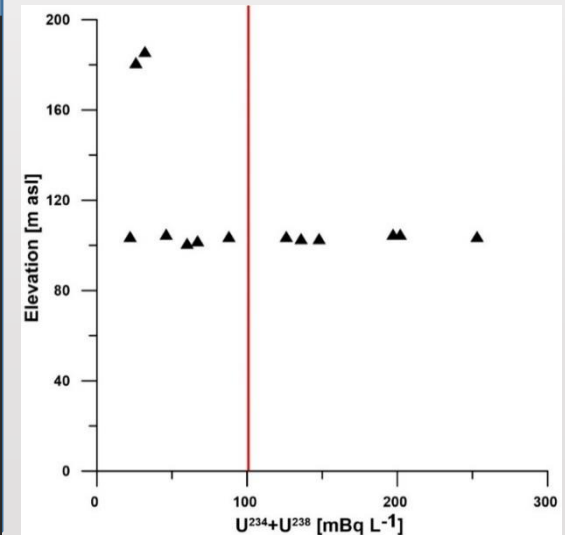
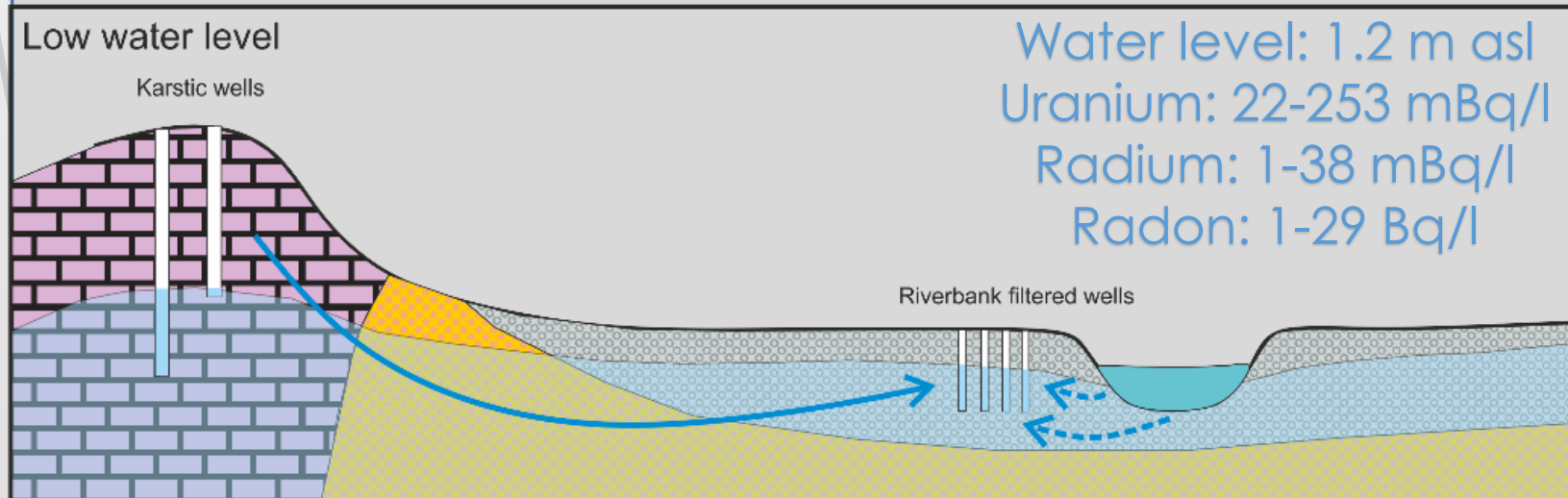
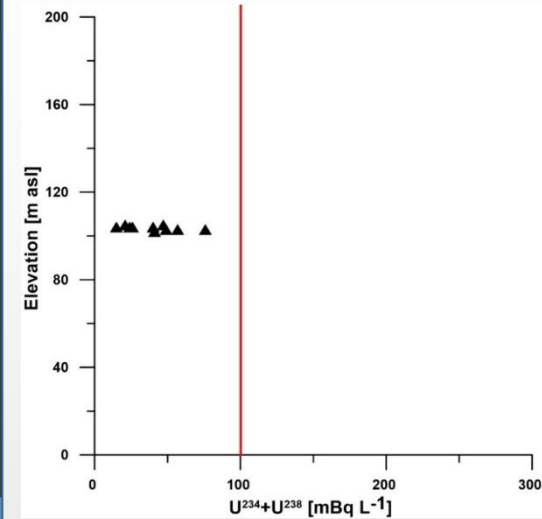
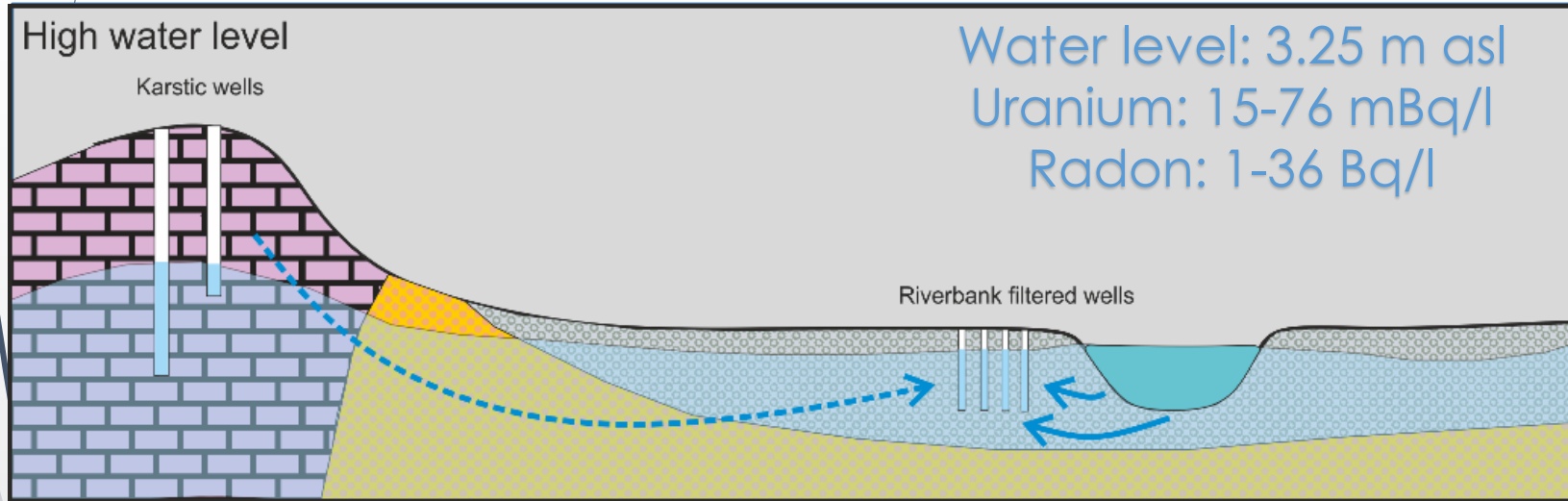
- Radon values: <5 Bq/l – 36 Bq/l
- Radium values: <5 mBq/l – 38 mBq/l
- **Uranium values: 15 – 253 mBq/l**

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”

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**Low river
water
level →
elevated
uranium
content**

Gross methods compared to nuclide specific measurements

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#1	gross alpha (Bq/l)	gross beta (Bq/l)	date	water level (m)
	0.12	0.16	Apr	2.16
	0.10	0.13	May	2.61
	0.17	0.12	Nov	1.48
	0.21	0.19	Febr	1.25
	0.15	0.15	May	4.17
	0.20	0.13	Oct	1.25
	0.05	0.10	Oct	1.25

#1	uranium	radium	radon	date	water level (m)
	0.01	0.026	13	Oct	120

- 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

#6	gross alpha (Bq/l)	gross beta (Bq/l)	date	water level (m)
	0.11	0.16	Febr	2.34

#6	uranium (Bq/l)	radium (Bq/l)	radon (Bq/l)	date	water level (m)
	0.25	0.01	9	Oct	1.20
	0.03	-	10	March	3.25

Conclusion

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- ▶ 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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