Radon equilibrium factor variations in pumped well water

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Motivation

Preliminary results about radon and radon progeny at radon wells (Geophysical Research Abstracts, Vol. 19, EGU2017-4535, 2017) revealed that the variation of the equilibrium factor k between radon and its decay products requires a lengthy discussion and reveals valuable information.

Figure 1 Sibyllenbad, in the community of Neualbenreuth, 140 km NNE of Regensburg, currently collects radon-rich water from two wells.

Data: contiuous monitoring

New systematic measurements to understand the temporal variations of k at pumped wells were performed. Radon concentrations are continuously monitored at the main water storage tank of 42 m³, two km from the radon wells (Fig. 2) and at the wellhead (Fig. 3). At the Rn wells, the flow rate [L/s] of the discontinuously working pumps and the lowering of the water level in [m] is measured online.

#1 gamma **#2 gamma**

Figure 2 The probe at the tank consists of a 51 mm x 76 mm NaI (Tl) scintillator with photomultiplier, immersed in continuously flowing water in an 8 liter pot. A multi-channel analyser registers the pulses between 200 and 650 keV of the Rn decay products Pb-214 and Bi-214.

Figure 3 The probe at the wellhead consists of a 36 mm x 76 mm NaI (Tl) scintillator with photomultiplier, immersed in continuously flowing water in a 2 liter pot. Total counts are stored in a CR23X datalogger. Sampling interval is 10 minutes.

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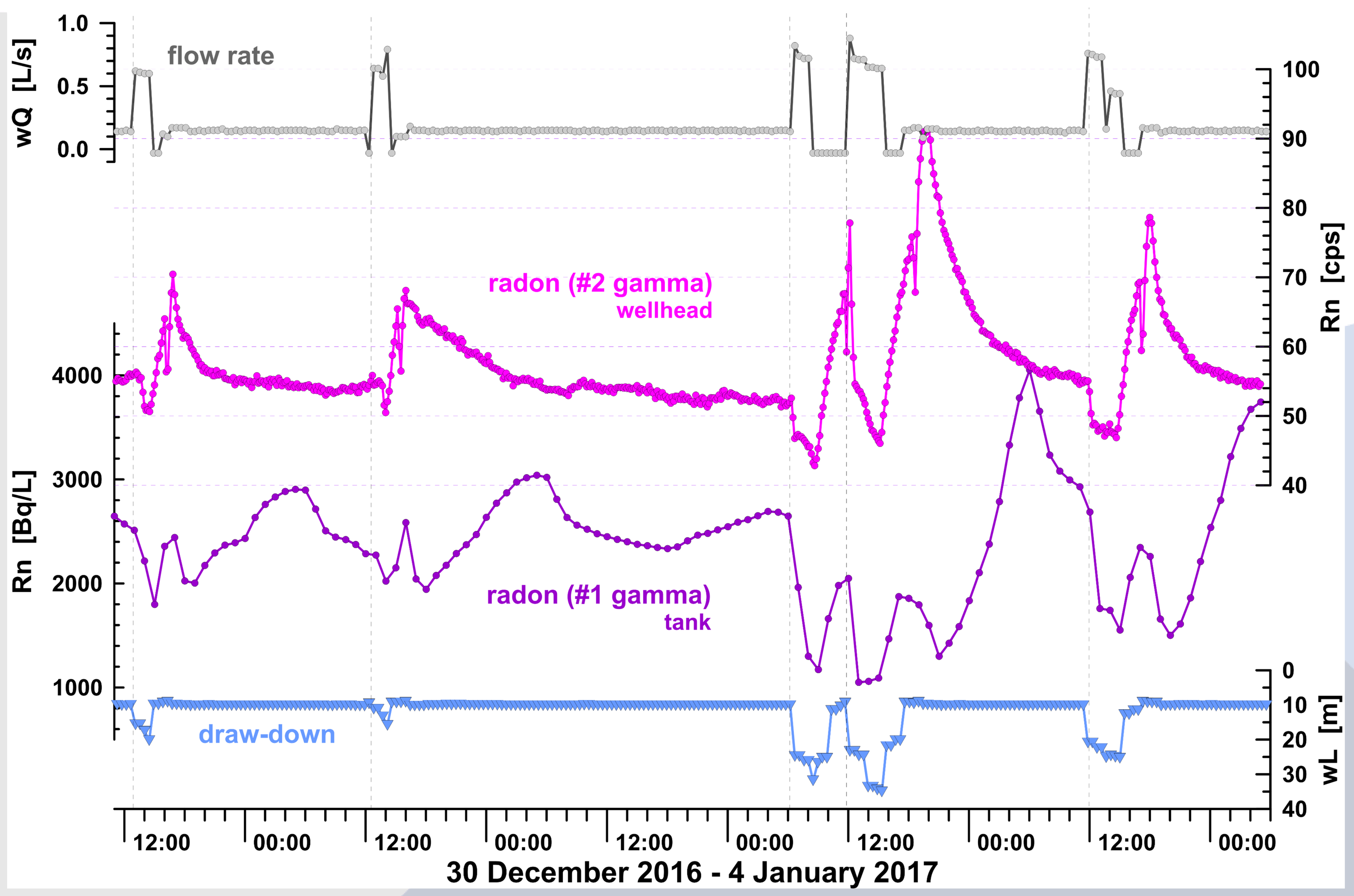

Figure 5 Gamma activity of radon progeny continuously monitored at Sibyllenbad. Shown are: Flow rate, gamma #2 (wellhead), gamma #1 (tank), and the water level (draw-down) in the pumped well.

Data: grab sampling

Furthermore, we repeatedly took discrete water samples, both at the well head and at the water tank. The following measurements were performed: (i) direct radon measurements using a degassing unit and a ZnS(Ag) scintillation counter (Fig. 4 left), (ii) radon progeny collected on special filters, and (iii) radon progeny determined immediately after sampling and after 2-3 hours (to allow equilibration between radon and its decay products) (Fig. 4 right).

#3 alpha **#4 gamma**

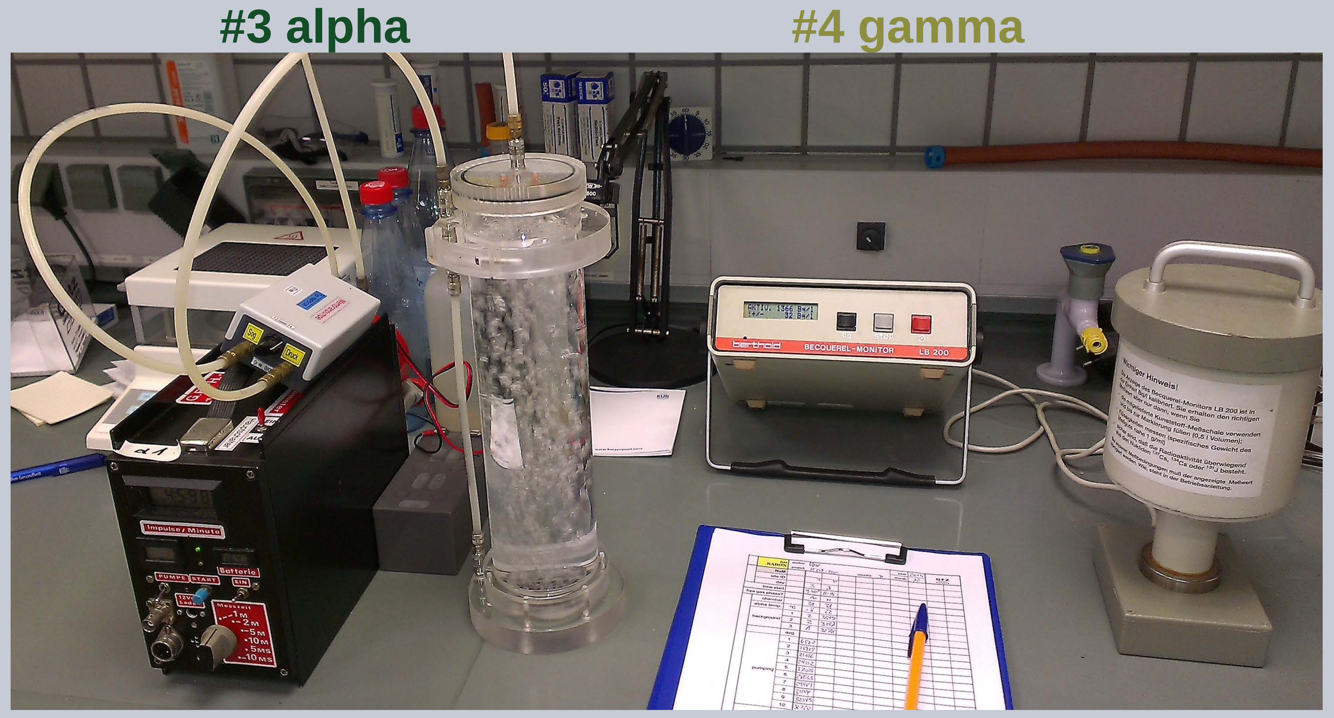

Figure 4 (left) An Alphameter (manufactured by Heger/g.b.h.) detects photons emitted from ZnS (Ag) in a scintillation chamber. Radon dissolved in 1 Liter of water is extracted via a circulating air stream for 10 minutes (for details see Woith, 1996), (right) Gamma rays emitted from 0.5 L of water inside a shielded Marinelli beaker are counted by a Becquerel-Monitor (Berthold LB200).

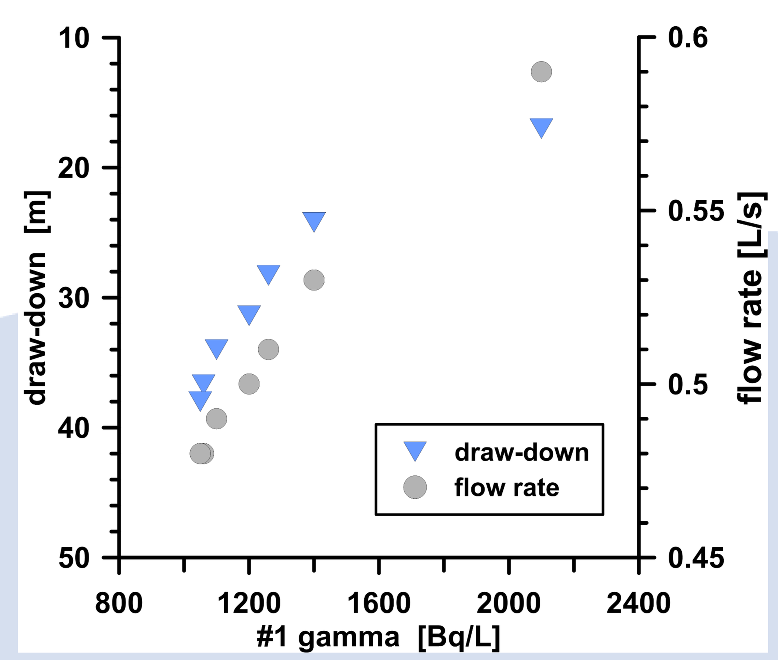

Figure 6 Gamma activity measured at the tank (#1 gamma) as a function of draw-down.

Questions:

1. Why are gamma at the well (#2) and gamma at the tank (#1) (see Fig. 5) not synchronized?
2. Why is gamma at the tank (#1) positively correlated with flow rate and draw-down (Fig. 6+7)?
3. Why is equilibrium factor k systematically lower at the tank (#4 tank) compared to the well (#4 well) (Fig. 8)?

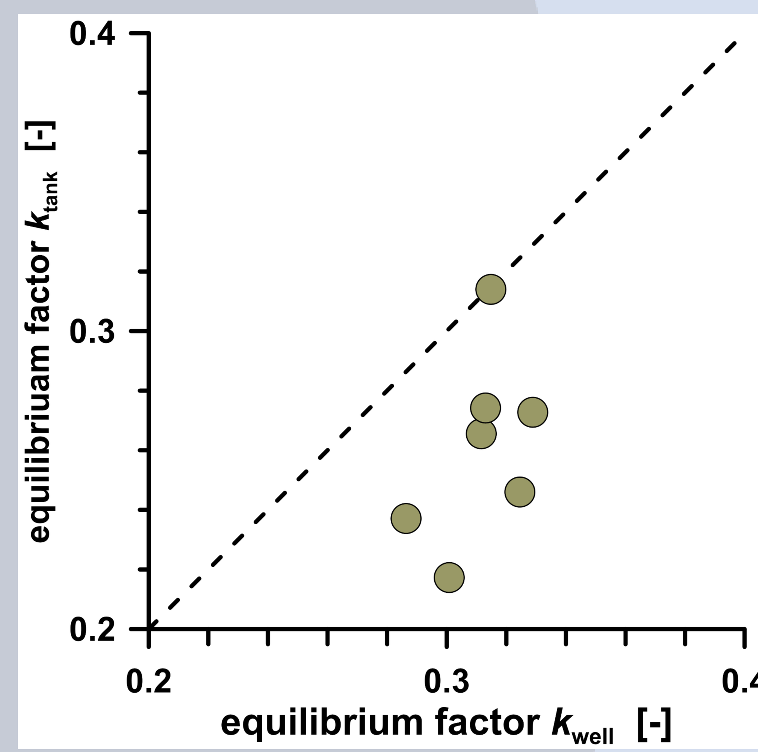

Figure 8 Equilibrium factor k determined at the well vs. tank.

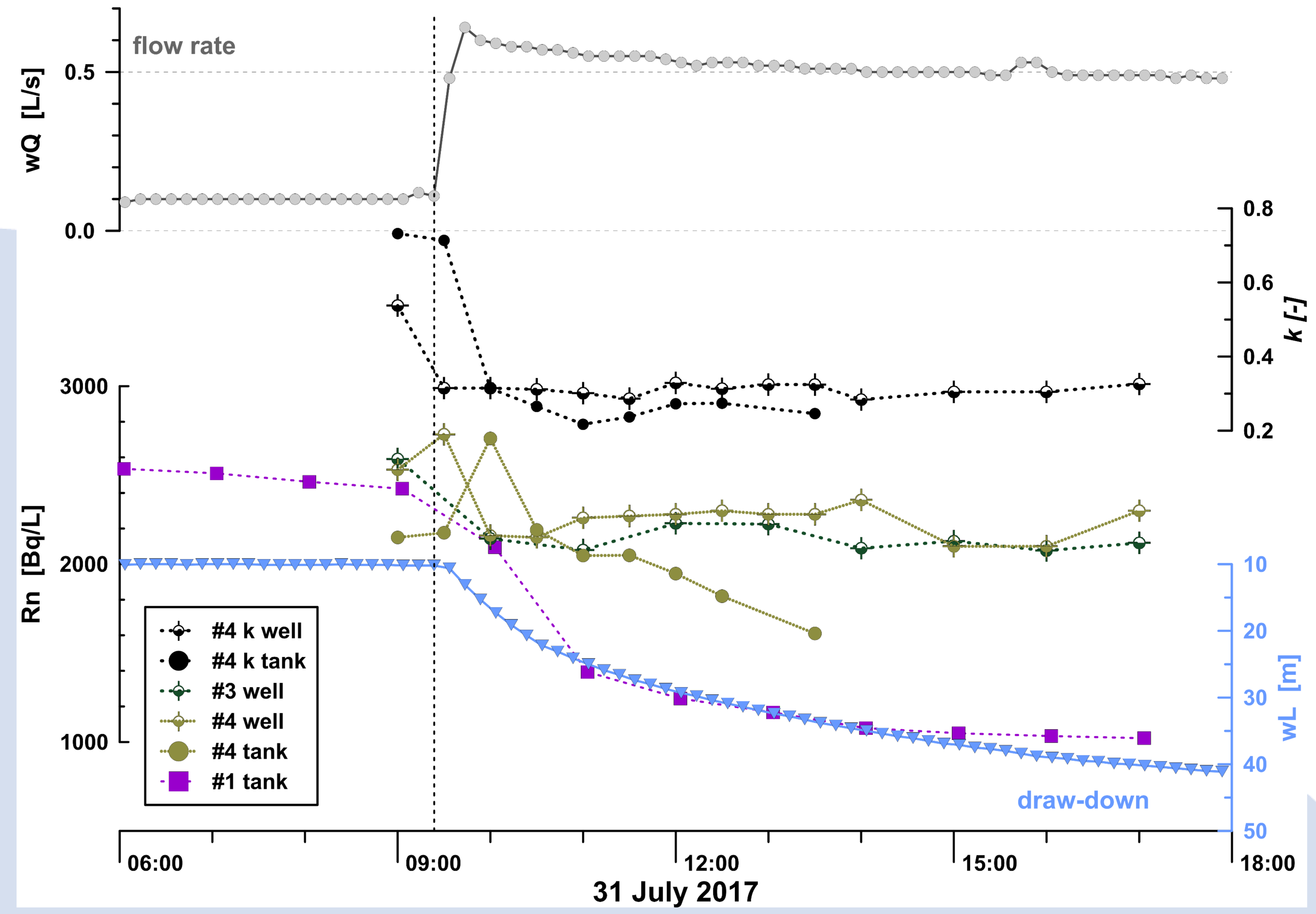

Figure 7 Evolution of radon and radon progeny during a "pumping test" at well T2 of Sibyllenbad. From top: flow rate, equilibrium factor k determined at the well and the tank; radon concentration at the wellhead (#3); gamma activities of radon decay products at the well (#4 well) and the tank (#1 and #4 tank); water level in the well T2.

Conclusions

This new data set allows to examine temporal variations of radon, and radon progeny as a function of the flow rate and the water table.

Factors of equilibrium k between Rn and the decay products as low as 0.3 were determined. This explains strong, but systematic fluctuations in gamma recordings. The true Rn-222 concentrations – essential for radon therapy - fluctuate much less.

Acknowlegements

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References

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