Hydrol. Earth Syst. Sci. Discuss., 4, S648–S651, 2007
www.hydrol-earth-syst-sci-discuss.net/4/S648/2007/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Tracing and quantifying groundwater inflow into lakes usingradon-222" *by* T. Kluge et al.

T. Kluge et al.

Received and published: 1 August 2007

We thank M. Schubert for the constructive and detailed comments. We think that many of the comments can easily be taken into account in a revised version and will certainly improve the manuscript. In the following we discuss mainly the general comments of the reviewer and some specific comments that give us the opportunity to add some supporting material, which was not included in the manuscript for reasons of brevity.

General Comments:

- Where it is possible the assumptions will be justified by data (s. specific comments). However, some of the assumptions are made to estimate limiting cases. For example, the sediment flux is neglected in the budget calculation of the hypolimnion in order to derive the maximum inflow.

- We agree that sampling and sample handling is a rather critical point. We performed some lab experiments to check the sample handling and worked out an optimized routine. The buckets are filled underwater in a large barrel which is slowly filled by water flowing out from a tube. The lid is handled in a way that no bubbles are remaining and afterwards it is put on the bucket also below the water in the barrel.

- If a confusion is possible between decay equilibrium and solubility equilibrium we will clarify this.

- Not only the excess radon is of importance to derive groundwater inflow rates. An important term in the budget calculation is the outgassing of radon to the atmosphere. The gas exchange with the atmosphere is not only supported by excess radon but by the total radon including the fraction originating from the decay of dissolved radium.

Specific Comments:

Title: We will consider alternative titles and shortening the section about the exemplary on-site application.

Page 1522, line 10/11: The radon value of the springs investigated by Tuccimei et al. (2005) are in the interval we reported for groundwater. However, the lake values are higher because the rather small ponds investigated by Tuccimei et al. are directly fed by springs or a strong inflow of groundwater. As these lakes (or effectively springs, as Tuccimei et al. find) are situated in a karstic environment, the groundwater inflow is likely to be more important, and the radon concentration higher, than in most other lakes. Willersinnweiher, which is situated in an aquifer composed of gravel and sand, has less groundwater inflow and a larger volume, thus radon values are significantly lower. Comparable values to our result have been found for example by Corbett (1997, s. reference) and Stringer, C.E., Assessment of groundwater discharge to Lake Barco via radon tracing, master thesis, Florida State University, 2004.

Page 1523, line 23: We mean decay equilibrium. Therefore we refer to the half life

HESSD

4, S648–S651, 2007

of the intermediate nuclides of Polonium-218. We will specify “equilibrium” to avoid confusion between decay- and solubility equilibrium. The chamber sensitivity is given by the factory for our instrument as 1 cpm at 151.7 Bq/m^3.

Page 1524, line 19: The counting time depends on the activity concentration of the water sample and the desired precision. If the error should be smaller than 10 % then at least 100 decays should be counted. If we have about 1 count per minute this will need 100 minutes.

Page 1525, line 25: From other drying materials like Silicagel adsorption effects are known (Gübeli O., K. Stammbach: Zur Adsorption von Radon an Aktivkohle und Silicagel, Helvetica Chemica Acta 34(154), 1257-1263, 1951 or Burtt P.; J. Kurbatov: Mixed Adsorption of Radon and Argon on Silica-Gel, American Chem.Soc. 70, 1948.). Therefore we checked the CaSO4 drying material. We made an experiment, in which the desiccant was measured in a closed loop with RAD 7. The system and the desiccant were purged before with nitrogen for 40 minutes. However a constantly increasing activity could be observed, while only the desiccant and the detection chamber were attached to the loop. The radon signal increased linearly from a mean activity concentration of 11 Bq/m^3 (value of a preceding background measurement without desiccant) to about 50 Bq/m^3 at the end of the measurement period of 20 hours. Other experiments showed that this value depends on the preceding measurement.

Page 1525, line 28ff: The time required to equilibrate the whole gas loop with the water takes up to several hours, depending on the water flow rate (compare Burnett et al, 2001, see reference). For a water flow rate of 0.25 l/min he needed about 2 hours to equilibrate the gas loop with the water flowing through the exchanger

Page 1529, line 11: The lake with its recent morphology was formed in 1975 (s.reference: von Rohden, 2007). Therefore the sediment layer is rather thin, especially on the steep flanks. In the deepest lake parts sediment layers with a thickness of 15 - 20 cm can be expected (S. Laukenmann, Transport und Austausch re-

HESSD
4, S648–S651, 2007

doxsensitiver Elemente zwischen Freiwasser und Sediment in einem eutrophen Hartwassersee (Willersinnweiher, Ludwigshafen), unter besonderer Berücksichtigung des geochemischen Verhaltens von Uran, Thesis, Universität Heidelberg, 2002). However, the groundwater is entering the lake at the steep flanks, where very few ($<$5 cm) or no sediment layer is found and not in the deep bottom layer. Therefore the radon activity of the inflow will rather reflect the activity of the aquifer material than the sediment layer.

Page 1531, line 2: RAD7 is not suitable for measurement of ambient air with an activity concentration of about 2 - 20 Bq/m^3. If an activity of 150 Bq/m^3 causes one count per minute, we would only obtain 4 counts during a counting time of one hour at an air activity concentration of 10 Bq/m^3. Hence, the uncertainties are too large for quantitative statements.

Page 1532, line 4: Of course we measured temperature and conductivity at every sampling site, this is the basis of the separation in epilimnion, thermocline, and hypolimnion, as discussed on p. 1532 and shown in Fig. 5. In order to keep the manuscript short, we did not include these data in detail.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 1519, 2007.