Using radon as tracer of an old NAPL contamination in groundwater (Roma, Italy)

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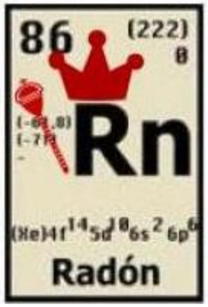
A Good Environmental Tracer

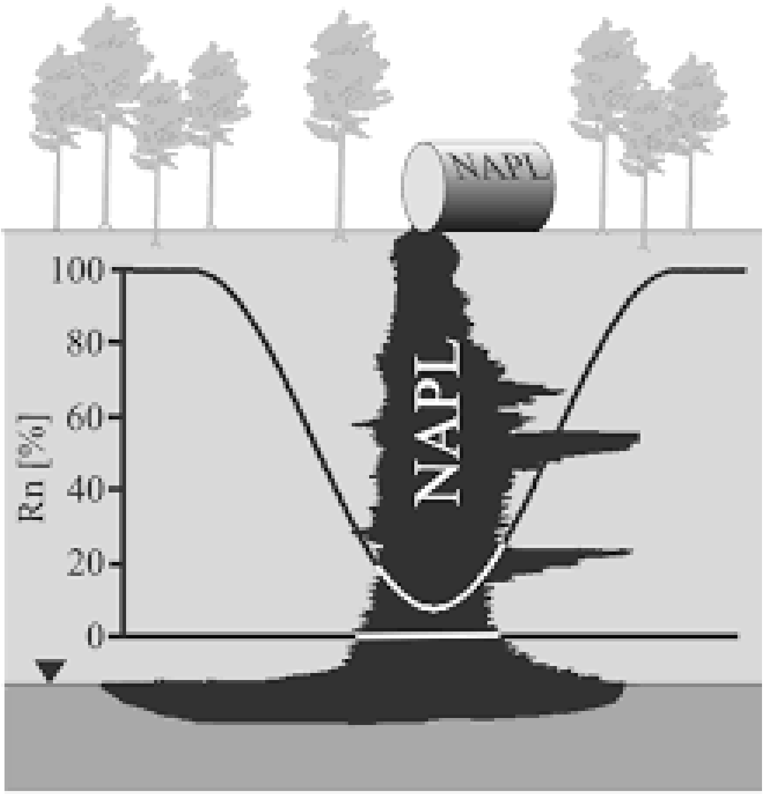


Modified by https://www.pinterest.it/pin/346917977517059818/

- Widely present in natural environments
- Inert gas
- Easy to measure in lab and on field

Rn is highly soluble in NAPLs

Radon as tracer for NAPL contamination of groundwater and soils



from Schubert et al. (2002)

BEFORE REMEDIATION

Localization of a NAPL plume

DURING/AFTER REMEDIATION

Determination of residual NAPL

Quantification of residual NAPL

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THE EUROPEAN PHYSICAL JOURNAL SPECIAL TOPICS

Review

Using radon as environmental tracer for the assessment of subsurface Non-Aqueous Phase Liquid (NAPL) contamination – A review

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NAPL quantity is expressed as saturation!

Estimation of Residual NAPL

$$S_{NAPL} = (1 - \Delta C_{\infty}) / [(\Delta C_{\infty} \cdot K_{NAPL/W}) - \Delta C_{\infty}]$$

Schubert (2015)

where:

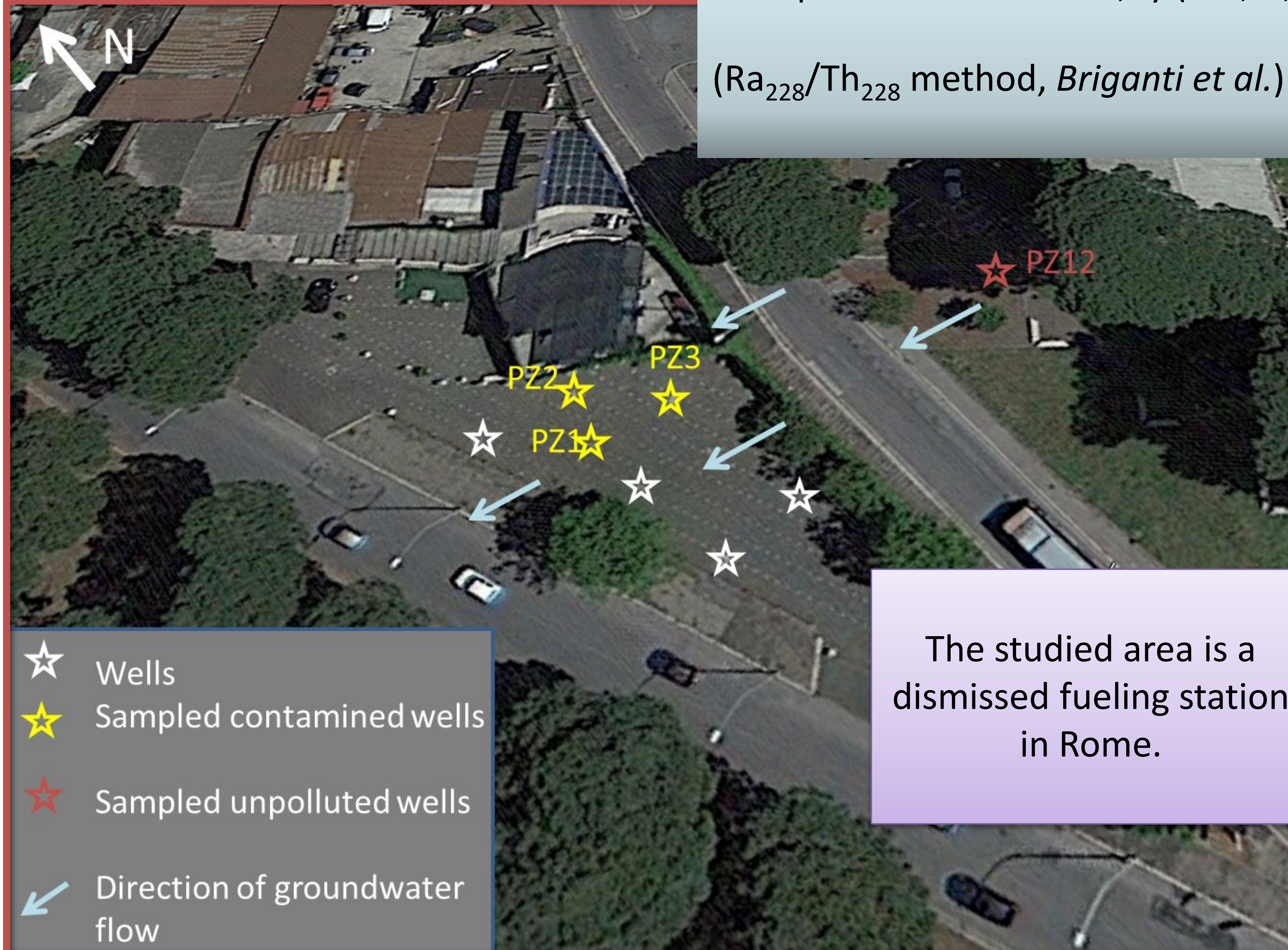
S_{NAPL} is NAPL saturation (dimensionless);

ΔC_{∞} is a dimensionless radon deficit factor;

$K_{NAPL/W}$ is radon partition coefficient between NAPL and groundwater (dimensionless).

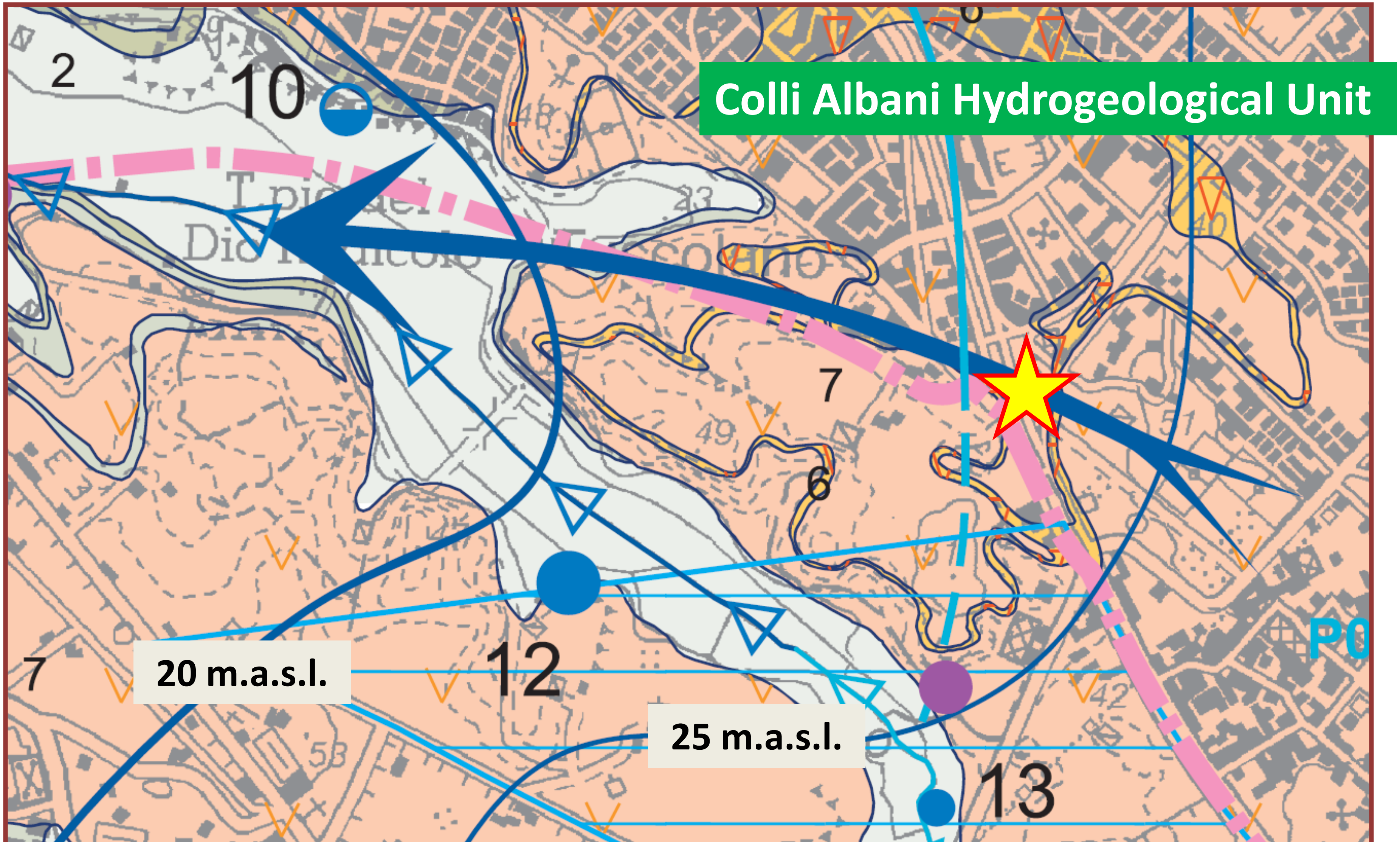
The spill was occurred 16,3y (+∞;-5,2)

(Ra_{228}/Th_{228} method, *Briganti et al.*)



The studied area is a dismissed fueling station in Rome.

Hydrogeological Map of the Area



Dismissed fueling station

(La Vigna et al., 2016)

List of Field and Lab Activities

Date	Activity	Piezometer	Analyses
May 25th 2018	Groundwater sampling	1	Rn by RAD7
May 25th 2018	Oil-socks sampling	1	Rn by gamma-spec
May 25th 2018	Input of PDMS-AC disk	1	-
June 4th 2018	Collection of PDMS-AC disk	1	Rn by gamma-spec
June 4th 2018	Input of 3 larger PDMS-AC disks	1 , 2, 3	-
June 4th 2018	Groundwater sampling	12	Rn by RAD7
June 11th 2018	Collection of 3 PDMS-AC disks	1, 2, 3	Rn by gamma-spec
July 2th 2018	Sampling groundwater with purging of piezometer	2, 3	Rn by RAD7

Field (part1)

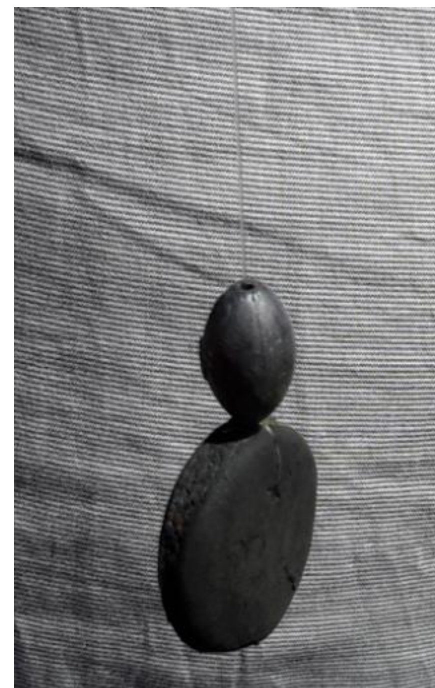
- Water table level *–10.28 m* below ground level.

- Sampled 1 liter of water.

Field (part1)

- Sampling of 1000g of «Oil Sock»

- Input of PDMS-AC disk and its extraction after a week.



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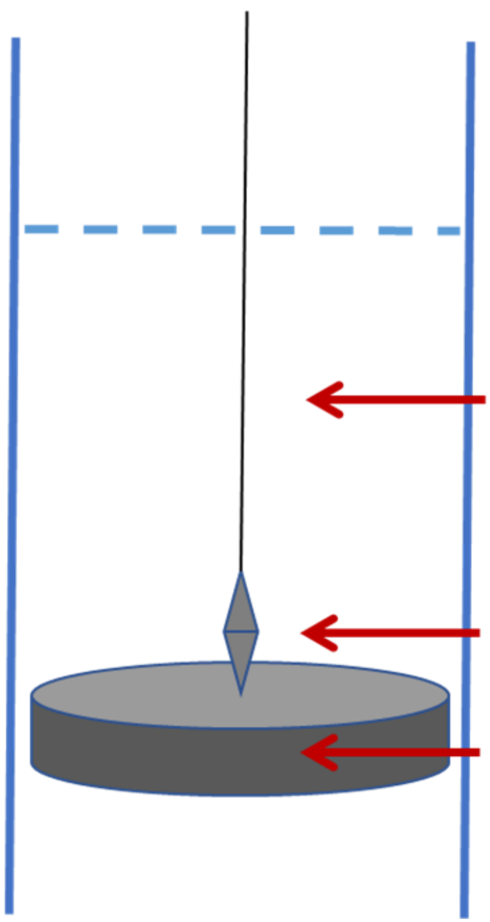
Field (part 2 and 3)



- Input of larger PDMS-AC in three wells and their extraction after a week.
- Sampling of unpolluted groundwater.
- Sampling of polluted water in piezometers 2 and 3 after a purging of the two wells.

Lab Activities

Rn content was measured by:

- RAD7+RADH2O accessory → - water samples

- High resolution (HGeD) gamma-spectrometry → - Rn adsorbed onto the passive accumulators

Results (field data-**no purging**)

Measured

- Rn content in uncontaminated water 24 Bq/L (*pz12*)
- Rn content in contaminated water from 0.4 to 7 Bq/L (*pz1,2,3 passive Rn accumulators*)

Calculated

- $K_{NAPL/W} \approx 7.22$ (*ratio between Rn concentration (pz1)in water and oil sock*)
- Radon Deficit estimated is from 0.016 to 0.292 (*ratio between uncontaminated and polluted water*)

All data collected by intercalibration between by RAD7 and passive accumulators!

Estimation of Residual NAPL

$$S_{NAPL} = (1 - \Delta C_\infty) / [(\Delta C_\infty \cdot K_{NAPL/W}) - \Delta C_\infty]$$

Schubert (2015)

The comparison between our field data and the chemical analyses performed on contaminated water shows that the NAPL saturation of the soil was

NOT REPRESENTATIVE

Results (field data)

Problems regarding collected dat

The value of Rn concentration (ΔC
realistic without the well purging.

Oils drops in the water samples (pz
the calculated value of $K_{NAPL/W}$.

Results (field data-**with purging**)

$$S_{NAPL} = (1 - \Delta C_\infty) / [(\Delta C_\infty \cdot K_{NAPL/W}) - \Delta C_\infty]$$

$\Delta C_\infty = C_{clean} / C_{polluted}$

C_{clean} = 94 Bq/L
(*Tuccimei et al., 2014*)

$C_{polluted}$= from 37.9 to 75.4 Bq/L

$K_{NAPL/W} = 70$

A reasonable selection from literature database *(Schubert,2015)*

The new estimated value of NAPL saturation: **0.0036 - 0.02**

Overestimated

CONCLUSIONS

- Passive accumulators are useful, but they have to be inserted in the well after purging and the contact span of time has to be reduced.

- Radon Deficit Technique is applicable to assess S_{NAPL}, considering the used values of ΔC_{∞} and $K_{NAPL/W}$ critically.

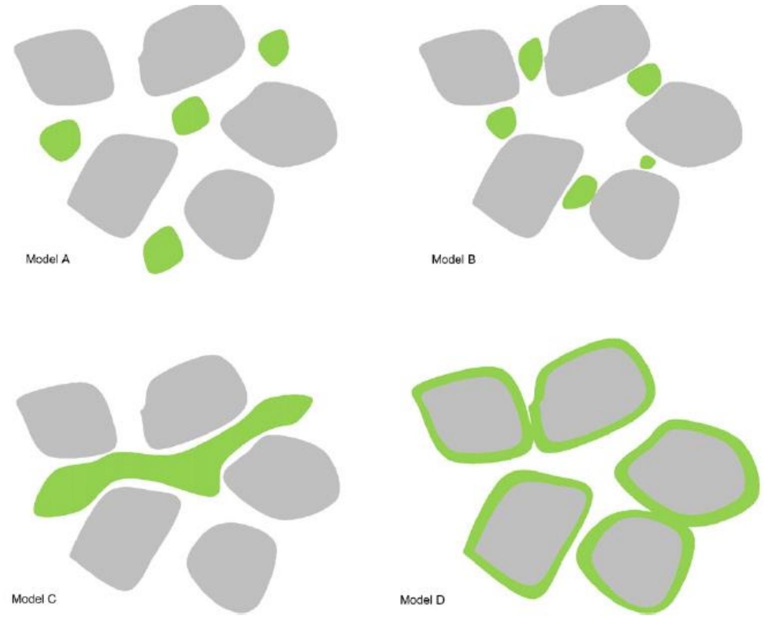
Further developments

- Further investigations on the site to assess the extension of contamination.

- Quantifying the residual NAPL in terms of NAPL weight or volume and not only as soil saturation.

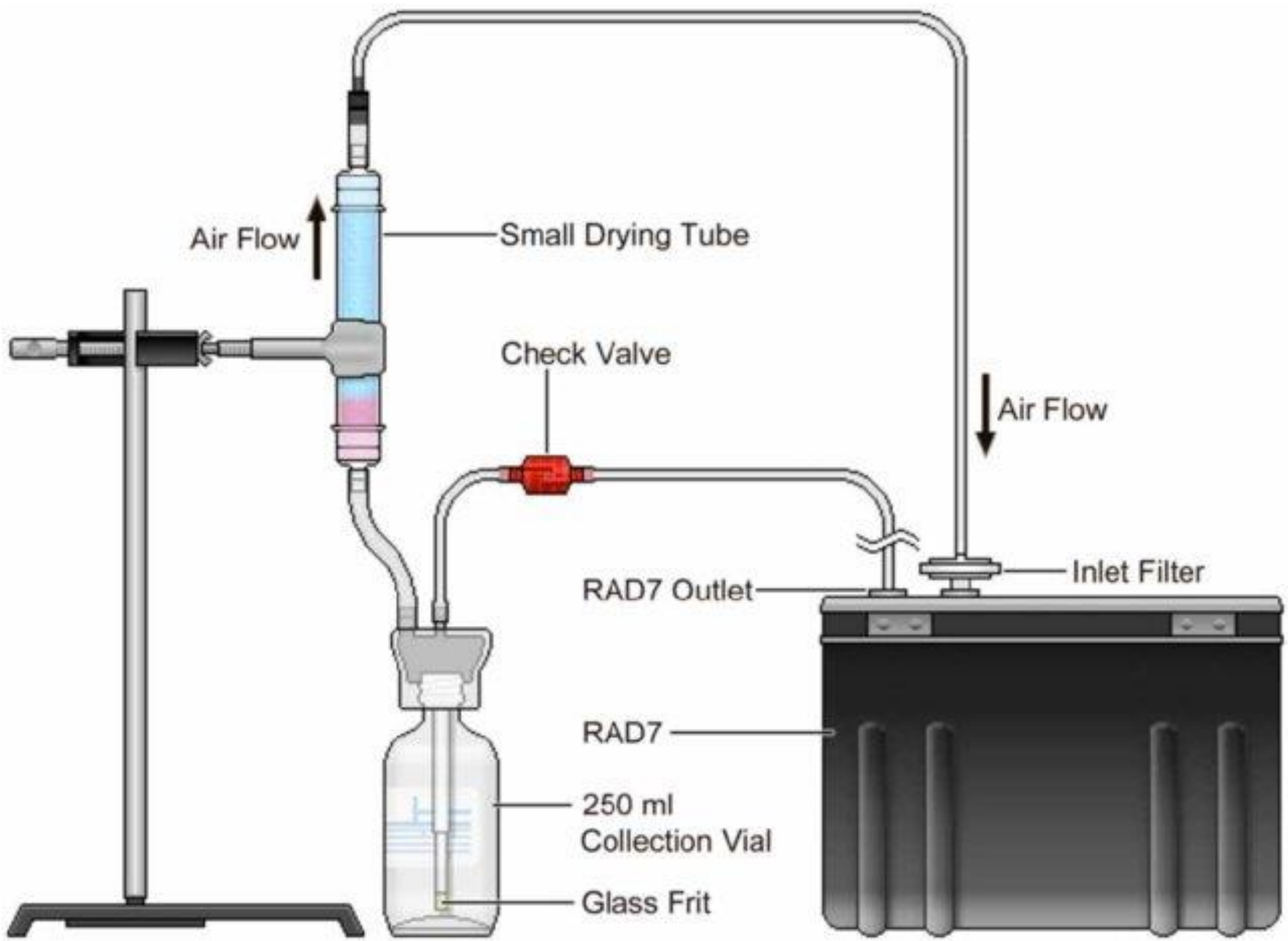
Further developments

- Understanding the effect on *Rn deficit* and *residual NAPL quantification* of the changing NAPL distribution in soil due to degradation (ageing).



S. Johansson et al. / Journal of Applied Geophysics 123 (2015) 295–309

Special thanks to *Mares Italia S.r.l.* for the access to the site and for collaboration



https://www.researchgate.net/publication/292178290_Application_of_Rn-222_isotope_for_the_interaction_between_surface_water_and_groundwater_in_the_Source_Area_of_the_Yellow_River/figures?lo=1