A European-wide ^{222}Radon and ^{222}Radon progeny comparison study

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European ^{222}Rn Monitoring Network

^{222}Radon (^{222}Rn) is an excellent tracer for regional and continental scale transport model validation. The number of atmospheric ^{222}Rn measurement stations has thus largely increased, with two fundamentally different measurement systems applied: two-filter-systems with large volume decay chambers, allowing direct ^{222}Rn daughter measurements and one-filter-systems with ^{222}Rn daughter accumulation on a filter and in situ α- or β-detection, estimating the atmospheric ^{222}Rn activity concentration assuming a site-specific disequilibrium factor. Within the EU-funded project InGOS we have conducted a European-wide comparison between the different instrumentation currently in use at nine stations. The Heidelberg radon monitor (HRM, one-filter-system) was applied as the reference.

Comparison Results

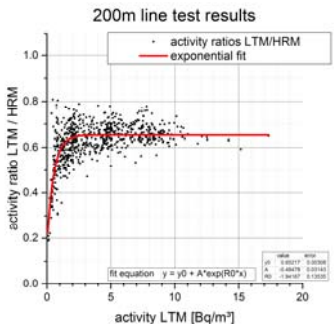
Two-Filter-Monitors (ANSTO)	Comparison Period	activity range	slope		
Lutjewad 60m	1.1.2007 - 1.10.2007	0 - 6 Bq/m³	1.11	+/-	0.02
Cabauw 20m	27.6.2012 - 10.1.2013	0 - 12 Bq/m³	1.23	+/-	0.01
Cabauw 180m	10.7.2012 - 26.8.2012	0 - 8 Bq/m³	1.11	+/-	0.04
Heidelberg 30m	25.4.2015 – 31.7.2015	0 - 15 Bq/m³	1.22	+/-	0.01
One-Filter-Monitors					
Schauinsland (BfS)	24.9.2013 - 10.12.2013	0 - 8 Bq/m³	1.12	+/-	0.02
Hohenpeißenberg (tracelab)	1.1.2014 - 24.3.2014	0 - 12 Bq/m³	1.03	+/-	0.02
Mace Head (LSCE)	4.3.2013 - 20.5.2013	0 - 4 Bq/m³	0.95	+/-	0.07
Gif-sur-Yvette (LSCE)	27.2.2014 - 28.4.2014	0 - 9 Bq/m³	0.68	+/-	0.03
Helsinki 2014 (FMI-1)	20.5.2014 – 2.6.2014	0 - 10 Bq/m³	1.03	+/-	0.04
Pallas 2014 (FMI-2)	11.6.2014 - 20.8.2014	0 - 6 Bq/m³	1.45	+/-	0.06

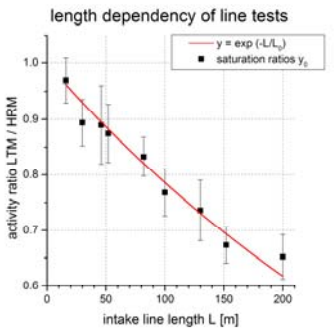
Mean ^{214}Po activity ratios "local instrument/HRM" of one-filter-instruments were ranging between 0.68 and 1.45. Ratios of two-filter-instruments with HRM were between 1.23 at 20m and 1.11 at 60m and 180m a.g.l. This height-dependent difference indicates a non-negligible disequilibrium of ^{214}Po measured with the HRM and ^{222}Rn, at least at levels below 60m. The deviation from 1.0 at 180m which is the same as at 60m is interpreted as calibration difference between the ANSTO and the HRM detectors.

Laboratory Line Tests

Without correction, one- and two-filter-systems measuring via long tubing are not comparable because one-filter-systems are sensitive to aerosol loss while two-filter-system inlets only depend on gaseous ^{222}Rn transport. The loss of ^{222}Rn progeny-carrying aerosol in long tubing, which may happen if one-filter-systems were installed at the base of tall tower stations, was investigated in the lab for Synflex tubing (8.2 $Ø_{inner}$, 16m - 200m). The reduction in the activity measured via tubing, a_{meas} (line test monitor, LTM), compared to measurement without intake line is shown in the upper graph for 200m tubing. The ratio LTM/HRM falls off towards low activities, while it is rather constant for activities higher than 3-5 Bq m^{-3}. The saturation values of other lengths are plotted against the line length in the lower figure. Together with the activity dependency, a correction function was derived for ^{214}Po sampling via long tubing:

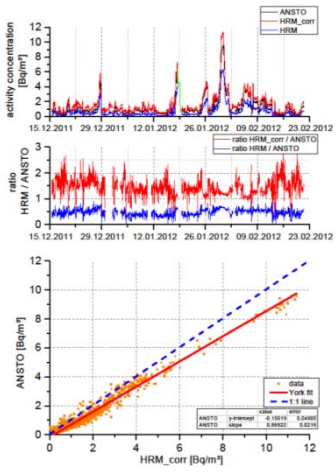
$$a_{corr} = \frac{a_{meas}}{\exp\left(-\frac{L}{L_0}\right) + A \cdot \exp(R_0 \cdot x)}$$





Evaluation of Line Correction at Cabauw

The empirical correction function was tested with direct observations at the Cabauw tower. For this comparison, the HRM sampled air from the 180m platform through a 200m Synflex tubing leading down to the basement of the tower. The uncorrected comparison yielded a slope of ANSTO_Cabauw/HRM = 1.53. After applying the correction for activity loss in the tubing, the slope improved to 0.97. However, if we adjust the HRM data by the assumed calibration difference of 1.11, the slope changes to 0.87. This would imply that the activity loss if solely based on our laboratory tests is over-corrected.



Conclusions

The results from our ^{214}Po/^{222}Rn comparison study allow adjusting ^{214}Po/^{222}Rn measurements performed with different instrumentation. An important unknown still remains the site-dependent disequilibrium factor required for one-filter systems to estimate atmospheric ^{222}Rn.

Correction for aerosol loss in long tubing is possible in principle. However, our validation measurements with more or less straight tubing show less aerosol loss than what was derived from the laboratory experiments performed with bended tubing. Here aerosol loss is probably larger due to additional inertial and gravitational deposition. More field experiments are, therefore, required.

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