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FOI

Efficiency of ion exchange columns for precipitation sampling

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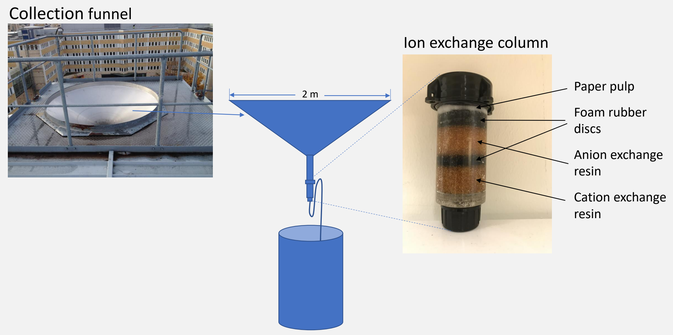
As a complement to measurement of radioactivity in air, collection and measurement of radioactivity in deposition is performed within many national surveillance systems. Deposited radioactivity can give an estimate of external dose to the public and can also be used to calculate transport factors for radionuclides.
The collection method currently used in Sweden consists of a large collection funnel and the collected precipitation is passed through an ion exchange column. The collection efficiency for the ion exchange column has been investigated together with a test of a new ion exchange resin in a downscaled laboratory setup.
The effects of ashing at different temperatures has also been investigated for the two types of ion exchange columns.



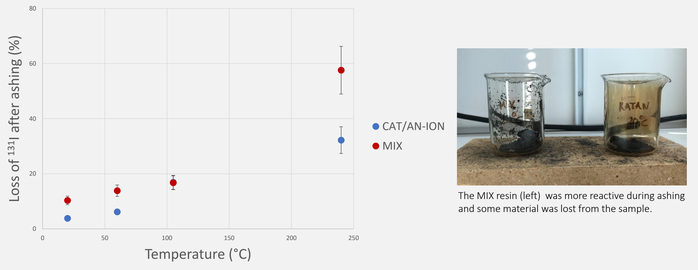
Precipitation collection method

Within the Swedish national surveillance system the method used for precipitation sampling consists of a large funnel from which the precipitation is passed through a column with ion exchange resin.
The columns are sent to a central laboratory at FOI where the content is ashed before being measured with gamma spectroscopy. The measurements give the total deposited radioactivity with no separation of wet and dry deposition.

		Distribution of radionuclides ^{125}Sb, ^{131}I, ^{133}Ba, ^{137}Cs and ^{152}Eu		
Column Type	**Nuclide**	**Column (before ashing)**	**Water (first litre)**	**Water (second litre)**
CAT-/ANION	^{125}Sb	12(4)%	33(6)%	54(3)%
	^{131}I	94(4)%	2(1)%	4(1)%
	^{133}Ba	92(2)%	6(1)%	2(1)%
	^{137}Cs	93(2)%	3(1)%	4(1)%
	^{152}Eu	92(2)%	6(2)%	3(1)%
MIXED ION	^{125}Sb	38(3)%	12(1)%	50(3)%
	^{131}I	95(1)%	0.9(0.2)%	4(1)%
	^{133}Ba	95(1)%	1.0(0.1)%	4(1)%
	^{137}Cs	96(1)%	0.5(0.1)%	4(1)%
	^{152}Eu	96(1)%	0.8(0.2)%	3(1)%

Collection efficiency - radionuclides

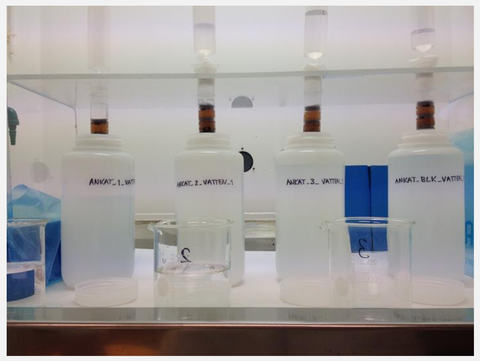
Two liters of synthetic rain water spiked with a radionuclide mix (see table) was passed through the column and the water was collected after the passage in two equal fractions.
The two water fractions were measured with gamma spectroscopy on HPGe-detectors. The column material was placed in a glass vial and measured with gamma spectroscopy before and after ashing for 24 hours at 240°C.



The MIX resin (left) was more reactive during ashing and some material was lost from the sample.

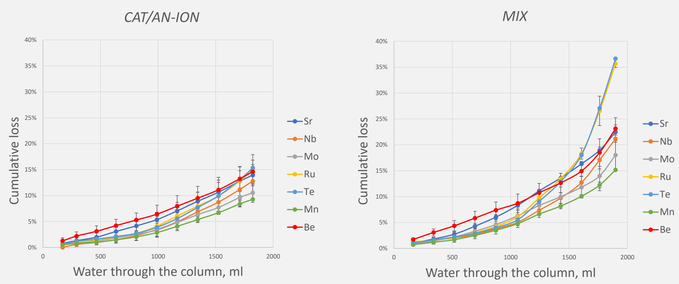
Temperature dependence

Synthetic rain water spiked with only ^{131}I was passed through the columns and ashing were performed at different temperatures (20°C, 60°C, 105°C and 240°C) to study the temperature's impact on the loss if iodine from the column material.
Loss off iodine is observed already at low temperatures and is significant at 240°C.
There was no significant loss during ashing at 240°C for any of the other radionuclides in the study.



Experimental setup

Two different ion exchange columns were investigated, one with an anion and a cation exchange resin and one with a mixed ion exchange resin. The total amount of ion exchange resin and water volumes used were the same for both set-ups.
A synthetic rain water with added radionuclides or stable nuclides was used for the study. Radionuclides used were: ^{125}Sb, ^{131}I, ^{133}Ba, ^{137}Cs and ^{152}Eu and stable elements used were: Be, Mn, Mo, Nb, Ru, Sr and Te.



Collection efficiency – stable elements

Synthetic rain water (~2 litres) spiked with Be, Mn, Mo, Nb, Ru, Sr and Te was passed through the column and the water was collected after the passage in elven fractions. The different water fractions were measured with ICP-OES.
The column material was not measured with ICP-OES.

Conclusions

- The collection efficiency for the radionuclides tested (except ^{125}Sb) were high, between 92-96% for both column types.
- The collection efficiency for the stable nuclides tested were higher for the column with separated cat-/anion exchange resins (85-91 % efficiency) than for the mixed ion exchange resin (63-84 % efficiency).
- The poor efficiency for ^{125}Sb indicates that the nuclide is not present in ion form in the solution. An extra absorption layer to collect non-ion nuclides might need to be added to the column.
- A significant loss of iodine is seen when ashing, increasing with temperature. If iodine is expected in the sample, measurement of the wet column material can give a more correct estimate of deposited iodine.
- The overall collection efficiency are good for both column types, however the separate cat-/anion resins are a better choice than the mixed resin if samples are to be ashed before measurement.
- It has also been shown, in a small field study, that the funnel can be contaminated and should be rinsed between samples to avoid cross-contamination.