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A rapid method for determining ^{89}Sr and ^{90}Sr by Cerenkov counting

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ABSTRACT

A new combination of simple preparation techniques for determining ^{89}Sr and ^{90}Sr in water and milk samples using alginate has been developed and tested. By means of Cerenkov counting without a long ingrowth period for ^{90}Y, results can be obtained within 4 days. The detection limit is about 1 Bq/l for a sample volume of 0.2 l. Milk samples can be prepared without ashing. A Liquid Scintillation Counter TRI-Carb 3170TR/SL in low-level mode has been used for counting.

1. Introduction

A rapid method for determination of ^{89}Sr and ^{90}Sr has been developed at the Saxon state laboratory for environmental radioactivity. The laboratory assignment is environmental monitoring according to the German Radiological Protection Precautions Act (StrVG) in the framework of the "Integrated Measuring and Information System for Environmental Radioactivity Monitoring" (IMIS). ^{89}Sr determination is required in emergency operation mode within IMIS.

During the last years, several techniques for the determination of strontium isotopes have been published and established methods were improved. Comparisons of standard methods were done by Wilken and Joshi (1991), Brun et al. (2003) and AKU (2008).

Searching for a simple, cost-effective and not hazardous separation, we tested alginate for the extraction of strontium. The first results of interlaboratory comparison tests were successful.

2. Sample preparation

For straightforward handling, alginate spherules made from water soluble sodium alginate powder (Protanal LF 20/40, Fa. IMCD) were used Marburger (2003), Tait et al. (2001) Ca saturated spherules with high content of guluronic acid have a strong affinity for alkaline earth cations. The calcium saturation prevents absorption of calcium contained in the sample. Dried spherules can be used 1 year or longer. Before analysis, the dried spherules have to be swelled out in deionised water. Manufacturing alginate spherules is done according to the following simple steps:

- Dropping solved sodium alginate into a $CaCl_2$ solution.
- Stirring for 90 min.
- Washing the alginate spherical pellets with deionised water (free of calcium).
- Drying the alginate spherical pellets.

In order to achieve a better separation from interfering ions an extraction of the alkaline earth metals by a chelating resin is done at first. Following Tait and Wiechen (1993), the sample is treated in a batch procedure with 18 g Chelite P (Serva company, www.serva.de). Strontium is eluated with 60 ml 5 M nitric acid. After evaporating of the eluate to dryness and dissolving the residue, pH ≈ 7–8 was adjusted. Then alginate spherules in batch procedure were used for ion exchange. The strontium is eluted from the alginate with 3 × 25 ml 0.1 M $BaCl_2$ solution in order to avoid interfering ions from the sample such as barium and lead. The complete sample preparation takes 8 h (Fig. 1).

Cs and Na do not bind onto the Chelite P. U, Am, Y, Ce, Eu and Be remain very firmly (>50%) on the Chelite P. Fig. 2 shows that Na, Cs, Am, Ce, Eu and Be are also not extracted by alginate. Ba, Ra and Pb bind very strongly to the alginate and remain on it during the elution of the Sr with the $BaCl_2$ solution. The eluted strontium solution contains partial amounts of Mn, Co and Zn too. The yields given in Fig. 2 are an average of different samples with various elements; see also Table 1.

Activities of interfering radioelements in samples of interlaboratory test are presented in Table 1. The Sr-results of these samples were all in the confidence intervals of the interlaboratory test. For higher activities, further tests are in progress.

Larsen (2001) describes ^{90}Sr determination by Cerenkov radiation with counting correction for the presence of Co and/or

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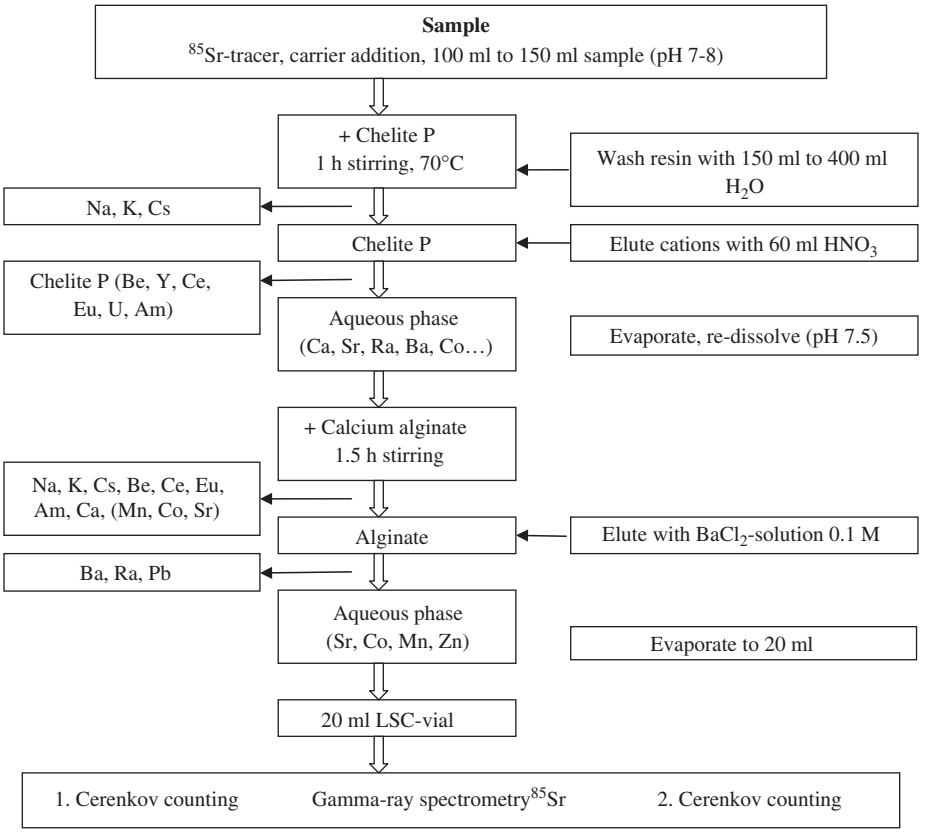

Fig. 1. Schematic flow-sheet of the method.

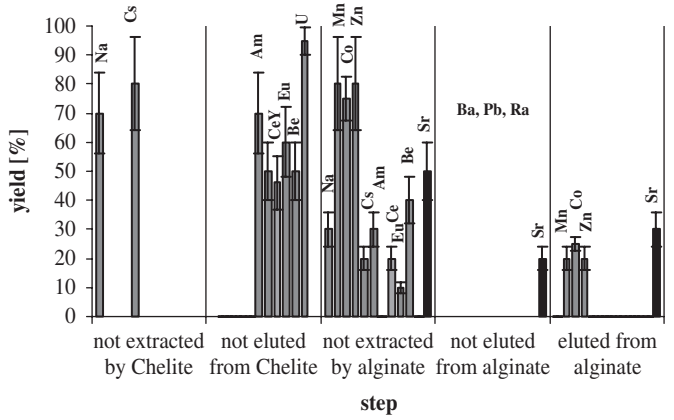

Fig. 2. Separation of strontium from other elements.

Table 1
Activities of interfering elements.

Isotope	Sample activity	Activity *A* in analysed sample (sub-sample)	Activity *A* in measured solution (vial)
	Bq/l	Bq	Bq
^{22}Na	10.0±0.6	0.12±0.06	
^{54}Mn	4.9±0.5	0.49±0.05	0.15±0.01
^{57}Co	18.0±0.8	3.6±0.2	0.80±0.02
^{60}Co	9.2±0.4	1.80±0.07	0.40±0.01
^{65}Zn	0.7±0.1	0.20±0.02	0.05±0.004
^{134}Cs	13.0±0.7	2.6±0.1	
^{137}Cs	17.0±0.4	3.40±0.08	
^{241}Am	5.9±0.5	1.3±0.1	
^{7}Be	21.0±0.6	4.2±0.1	
^{235}U	3.0±0.3	0.40±0.04	
^{99}Mo	12.0±1.7	2.5±0.4	
^{140}Ba	0.6±0.04	0.10±0.01	

Cs. Interfering isotopes (^{54}Mn, ^{60}Co, ^{65}Zn) can be measured by gamma-ray spectrometry simultaneous with ^{85}Sr tracer to correct the Cerenkov count rate.

Fig. 3 summarizes the chemical yields obtained when different water and milk samples were analysed with various amounts of alginate used in the extraction step. The chemical yield varies with the amount of alginate. By using 3 g alginate for a 150 ml sample the average yield is 30%. Maximum yields of up to 50% can be achieved with 9 g alginate. Samples with a high salt content gave yields in the range of 15–22%.

To get better yields further tests and experience are still in progress.

It is necessary to check for and to determine the radium impurities of the $BaCl_2$ if detectable. Table 2 presents ^{226}Ra

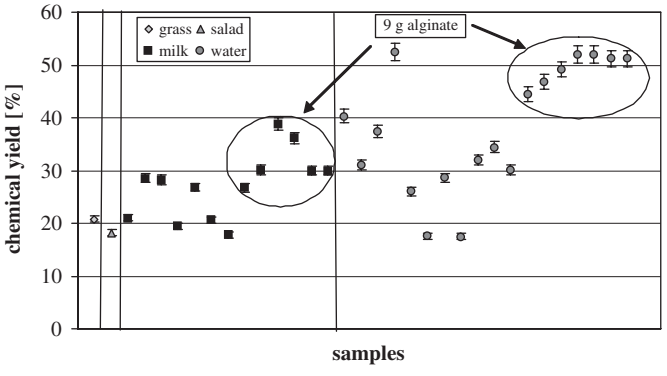

Fig. 3. Chemical yield.