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An Improved Method for the Simultaneous
Determination of ^{224}Ra , ^{226}Ra and ^{228}Ra
in Water, Soils and Sediments

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INTRODUCTION

The naturally occurring concentrations of radium (^{226}Ra and ^{228}Ra) in public and private water supplies have been studied for many years. Both general surveys and local studies have established the geographical regions where well waters exceed 3 pCi/L (1-17). In general, the ^{226}Ra was determined by the emanation method, while the ^{228}Ra was determined from the beta activity of the ^{228}Ac daughter. In a recent review (18) of the methods used "a number of approved analytic methods can bear improvement, especially the method for ^{228}Ra ." The purpose of the work described here was to develop an improved method for the simultaneous determination of ^{226}Ra and ^{228}Ra .

Experimental Method

The radium selective complexer was originally developed to remove soluble radium from uranium minewaters (19). This material is unique because it retains radium in a permanently complexed state (20). We use this resin to concentrate the radium from 20 to 100 L water samples, then place it in a metal can, seal the can, and count the resin with a NaI(Tl) gamma spectrometric system. The amount of both ^{226}Ra and ^{228}Ra is determined by a least squares method (21,22).

Discussion of Method

The retention of radium on a normal cation exchange resin depends

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on the volume and hardness of the water, as well as the flow rate. Before the "Radium Selective Complexer" was available, other resins were used to concentrate the radium. The data obtained with water softener grade Dowex 50-X8, 20-50 mesh resin is summarized in Table 1. For water with a hardness of 20 to 34 grains, 95% retention could be routinely obtained at a flow rate of 20 mL/m and a volume of 20 L. Increasing the flow rate to 50 mL/m or the volume to 50 L reduced the retention efficiency to 92% and 61%, respectively.

As shown in Table 2, the retention of radium on the Radium Selective Complexer is considerably better than for the Dowex 50 cation exchange resin. In fact, the retention on as little as 10 mL of resin was equal to that for 200 mL of Dowex 50. While it is expected that conditions will be found in which the radium retention will be reduced, this should not occur for potable waters.

The accuracy and precision of the least squares radium analysis was determined by adding known amounts of ^{226}Ra and ^{228}Ra to 20 L of tap water. As shown in Table 3, the amounts found are within normal statistical limits of the amount added. From this study, we conclude that the accuracy of this method can approach $\pm 2\%$ and that the limit of sensitivity is about 0.5 pCi/L for ^{226}Ra and ^{228}Ra .

The possible extension of this method to soils, sludges and other samples was evaluated by adding known amounts of uranium and thorium ore standards to "sea sand". The samples were mixed by stirring and by shaking. The results are also included in Table 3 and indicate that this method can be used to process samples of all types. The reported value for the "Th soil" sample is expected to be reduced on further shaking and mixing.

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Table 1. Radium Retention by Dowex 50 Cation Exchange Resin^a

Flow Rate (mL/m)	Sample Volume (L)	Retention (%)
20	20	96±2
20	20	95±2
20	20	93±2
50	20	92±2
50	50	63±2

^a200 mL of Dowex 50-X8, 20-50 mesh.

Table 2. Radium Retention by Radium Selective Complexer Resin^a

Flow Rate (mL/m)	Sample Volume (L)	Resin Volume (mL)	Retention (1%)
20	20	10	96±2
200	20	10	61±2
20	20	100	>99.6
100	100	100	>99.6
100	100	100	>99.6

^aDowex XFS-43230 resin.

Table 3. Accuracy and Precision of the Method

Experiment	^{226}Ra (pCi/L)		^{228}Ra (pCi/L)	
	added	found	added	found
WSSP04	2.49	2.6 ± 0.1	0.24	0.2 ± 0.3
WSSP05	2.52	2.7 ± 0.1	0.24	0.3 ± 0.3
WSSP06	0.24	0.4 ± 0.2	2.47	2.7 ± 0.2
WSSP07	0.24	0.6 ± 0.3	2.46	2.4 ± 0.2
WSSP08	0.51	0.4 ± 0.2	0.48	0.6 ± 0.2
WSSP09	0.50	0.5 ± 0.2	0.49	0.5 ± 0.2
WSSP10	0.50	0.6 ± 0.2	0.49	0.5 ± 0.2
WSSP12	105.2	104.8 ± 0.3	0.0	-0.2 ± 0.6
WSSP21	102.5	102.3 ± 0.3	0.0	0.2 ± 0.4
WSSP13	0.0	-0.2 ± 0.3	113.4	102.4 ± 0.4
WSSP22	0.0	-0.6 ± 0.6	92.4	94.0 ± 0.4
U (Soil)	13,158	$13,214 \pm 77$	?	48 ± 36
Th (Soil)	?	$1,048 \pm 86$	15,646	$16,297 \pm 128$