Sorption of strontium on bentonites from Slovak deposits

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Sorption on bentonite will play an important role in retarding the migration of radionuclides from a waste repository [1]. Bentonite is characterized by low permeability, water swelling capability and excellent sorption potential for cationic radionuclides. Thus, bentonite was frequently adopted as a potential buffer or backfill material in the construction of repositories for the disposal of the radioactive waste [2]. To correctly assess the sorption potential of radionuclides on bentonite is essential for the development of predictive migration models.

The sorption on bentonite from different Slovak deposits – Jelšový potok, Kopernica and Lieskovec has been investigated under various experimental conditions, such as contact time, pH, sorbate concentrations, presence of complementary cation.

The sorption of strontium from aqueous solutions was investigated using a radiometric determination of the distribution coefficient, Kd. The individual solutions were labelled with radiotracer ^{85}Sr. For each experiment 0,05g of the sorbent was shaken for 2 hours with 5 ml of the aqueous solution in ampoules of 10 ml volume). The activity of 1 ml of the individual solutions was measured by a gamma spectrometer (Modumatic III, Packard, USA) after centrifugation at 3500 rpm for 10 minutes, resp. 12 000 rpm for 5 minutes.The effect of amonium, potassium, sodium, calcium, magnesium and barium on strontium sorption behaviour was studied in range 5.10^{-2} - 1.10^{-6} mol.dm^{-3}, after adjustment to constant 1.10^{-4} mol.dm^{-3} concentration of strontium.

The sorption isotherm is a convenient way to express the sorption behaviour of a radionuclide on bentonite [3, 4]. Two characteristics in a sorption isotherm, the sorption capacity and affinity, can be used to represent the sorption potential. Langmuir isotherm model was used to fit the data of sorption experiments.

The sorption isotherm points were calculated from the mass balance in the batch:

$$\Gamma = \frac{C_0 - C_e}{m} \cdot V \quad \left[mmol.g^{-1} \right]$$

Γ - sorbed concentration of strontium ions on bentonite
C_0 – initial strontium concentration
C_e – equilibrium strontium concentration
m - sorbent mass, [g]
V - aqueous phase volume, [cm^3]

The distribution ration Kd was calculated as:

$$K_d = \frac{A_i - A_e}{A_e} \cdot \frac{V}{m} \quad \left[cm^3.g^{-1} \right]$$

A_i – initial volume activity (or count rate) of solution , [ml^{-1} s^{-1}]
A_e – equilibrium volume activity (or count rate) of solution , [ml^{-1} s^{-1}]

The uptake of Sr was rapid and equilibrium was reached almost instantaneously. The instantaneous uptake of strontium may be due to adsorption and/or exchange of the metal with some ions on the surface of the adsorbent. The percentage sorption for Sr decreased with increasing metal concentration. The sorption increased by increasing pH.

The best sorption characteristics among natural bentonites distinguish bentonite Kopernica /tab.1/, sorption capacity of the fraction under 45 μm is 0,48 mmol.g^{-1}. The highest values of distribution coefficient were reached for the bentonite Jelšový potok. The lowest sorption capacity was attained for the bentonite Lieskovec.

Bentonites were chemically treated and sodium forms (BJ, BK, BL) were prepared and tested for the sorption characteristics. In all cases the colloids were observed in the supernatant after the shaking and values of pH after the sorption are shifted to alkaline area. The modification of the bentonite is not recommended, because alkaline pH combined with presence of potassium and temperature above 100°C can cause illitization of the smectite and loosing of sorption characteristics.

Radiation stability has been investigated, the higher sorption parameters were observed for the irradiated bentonites /tab.1/, which can be explained by the increase of specific surface and change of solubility of the irradiated samples of bentonite.

Tab. 1 Values of K_d a sorption capacity Γ

Bentonite	K_d [ml.g^{-1}]	Γ [mmol.g^{-1}]
J 15	7579	0,40
J 45	9793	0,45
K 15	6079	0,29
K 45	6863	0,48
L 15	3965	0,34
L 45	4083	0,31
BJ 45*	1296	0,54
BK 45*	912	0,72
BL 45*	1348	0,47
J250	3785	0,37
J250 – irradiated	3604	0,49
L250	1787	0,19
L250 – irradiated	1900	0,32

The presence of complementary cations, Na^+, K^+, NH_4^+, Ca^{2+}, Mg^{2+} and Ba^{2+} depresses the sorption of Sr on bentonite. In the case of bentonite Kopernica the effectiveness in reducing the sorption of strontium by cations followed the order $K^+ < NH_4^+ < Na^+ < Mg^{2+} < Ca^{2+} < Ba^{2+}$. Results indicate that the sorption of Sr^{2+} on bentonite will be affected by the presence of high concentrations of various salts in the waste water effluents.

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