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INVESTIGATIONS OF THE SORPTION OF RADIONUCLIDES BY RAISED BOG PEAT

Abramenkovs A., Alksnis J., Klavins M.*, Popelis A. and Rudzitis J.

Ministry of Environment, Latvian Environment, Geology and Meteorology Centre, 165 Maskavas Street, LV-101, Riga, Latvia, ph.+371-29103220, andris.abramenkovs@lvgmc.lv; * Faculty of Geographical and Earth Sciences, University of Latvia, 19 Rainis Boulevard, LV-1586, Riga, Latvia.

SUMMARY

This study examines the sorption of radionuclides ^{137}Cs, ^{55}Fe, ^{63}Ni and ^{14}C by the raised bog peat. The sorption experiments were performed using a batch mode and a flux mode. The initial radioactivity of the peat samples was studied before the experiments. The influence of pH and fraction's size on the sorption of radionuclides has been studied. It was found, that pH of the liquid phase significantly influences on the sorption process of radionuclides. Experimental data confirms that peat can significantly up to 10 times reduce the concentration of radionuclides in liquid phase after 15 hours treatment.

KEYWORDS: Sorption, radionuclides, peat, humic substances.

INTRODUCTION

The sorption of radionuclides on peat materials was investigated by (Sanchez et al. 1988; Helal et al. 2006). Investigations of Sire (2011) confirmed that humic substances are formed during the humification process of the peat. Humic substances can be divided into humic acids (HA), fulvic acids (FA) and humin (Stevenson 1982). The authors Wang et al. (2006); Jain et al. (2007) stressed, that humic acids strongly affect on wide range of environmentally processes due to complexation ability with radionuclides. HA participate in the complex formation with metals ions and influence on immobilization of these pollutants by the peat. Wang et al. (2006) reported that the presence of HA influence on the sorption of Eu (III) on alumina surface, depending on pH values. Sorption process is one of the methods to study interaction behavior between peat and radionuclides. Authors Reiller et al. (2003);Lubyte & Antanaitis (2004); Nagao et al. (2007); De Vleeschouwer et al. (2010);Le Roux & Marshall (2010/11) investigated the distribution of radionuclides in the environment and influence of humic substances on migration of radionuclides. In this paper, the sorption of radionuclides ^{137}Cs, ^{55}Fe, ^{63}Ni and ^{14}C by peat samples was studied for radioactive waste management purposes. Organic sorbents like a peat can be successfully used for purification of radioactive waste waters due to the economical and technical considerations. The peat filters also are friendlier to the environment since the manufacturing of such filters is a low emission's process.

MATERIALS AND METHODS

Peat samples were prepared from Dzelves raised bog using near surface and milled peat. The samples were oven dried during 24 hours at 105°C and were ground and sieved using a sieve shaker to obtain peat fractions with size: <0.25 mm, 0.25-0.5 mm, 0.5-2.0 mm and >2.0 mm. The chemicals were used of analytical grade. Radionuclides solutions were prepared using deionized water and appropriate radionuclide composition from Salaspils research reactor's stock water. Solution's pH and conductivity were measured using universal METTLER TOLEDO's pH meter/conductivity meter with computer control. Batch sorption studies were performed in isothermal conditions at temperature 20±0.1°C using mechanical mixer and 350 ml glass flask. 5 g peat sample was inserted into 250 ml of radioactive solution and mixed during all experimental time. The solution sample 2 ml was taken after defined time interval and was centrifuged at 10.000 min^{-1} during 10 minutes. Flow experiments were performed using sorption column with 50 g peat load. The radioactive solution was pumped through the column by the peristaltic pump with flux rate 0.4 l/h. An Ortec gamma spectrometer with high purity germanium probe was used for the measurement of gamma radionuclides concentration in solutions and peat samples. Radioactivity of beta and alpha radionuclides was measured using liquid scintillation counter Canberra-Packard TriCarb 2700/SL.

RESULTS

Experimental studies indicated that the peat samples contain gamma radionuclides, which must be taken into account for correct explanation of the results (Table 1).

Table 1. Dzelves raised bog peat samples radioactivity.

No.	Fraction, mm	^{210}Pb	^{152}Eu	^{137}Cs	^{40}K	^{60}Co	^{214}Bi
Milled peat, mBq/g							
1	0.5-2.0	126	4	8	76	<MDL	48
2	0.5-0.25	120	4	8	75	<MDL	28
3	>0.25	119	4	10	93	3.15	38
Near surface peat, mBq/g							
4	0.5-2.0	130	2	41	45	0.20	26
5	0.5-0.25	155	4	53	49	0.06	32
6	>0.25	159	3	52	48	0.40	36

It was found, that in all cases of peat samples, the main natural radionuclides were ^{210}Pb,^{40}K and ^{214}Bi. The artificial radionuclides ^{152}Eu, ^{137}Cs and ^{60}Co also were determined in the peat samples from the Dzelves bog. Experimental results indicated that the concentration of radionuclides is the same for different peat fractions for the both types of the peat samples. Near surface peat samples have the increased radioactivity of ^{137}Cs and ^{60}Co radionuclides. Batch sorption mode studies indicated that during the first 5 hours of the experiments, the initial radioactivity of the solution decreases in the case of ^{63}Ni and ^{14}C radionuclides within a factor 10, but in case of ^{55}Fe radionuclide within a factor 4. It shows (Fig.1) that peat samples can effectively remove the radionuclides from radioactive water solutions. The same results were observed in case of the flow sorption mode experiments.

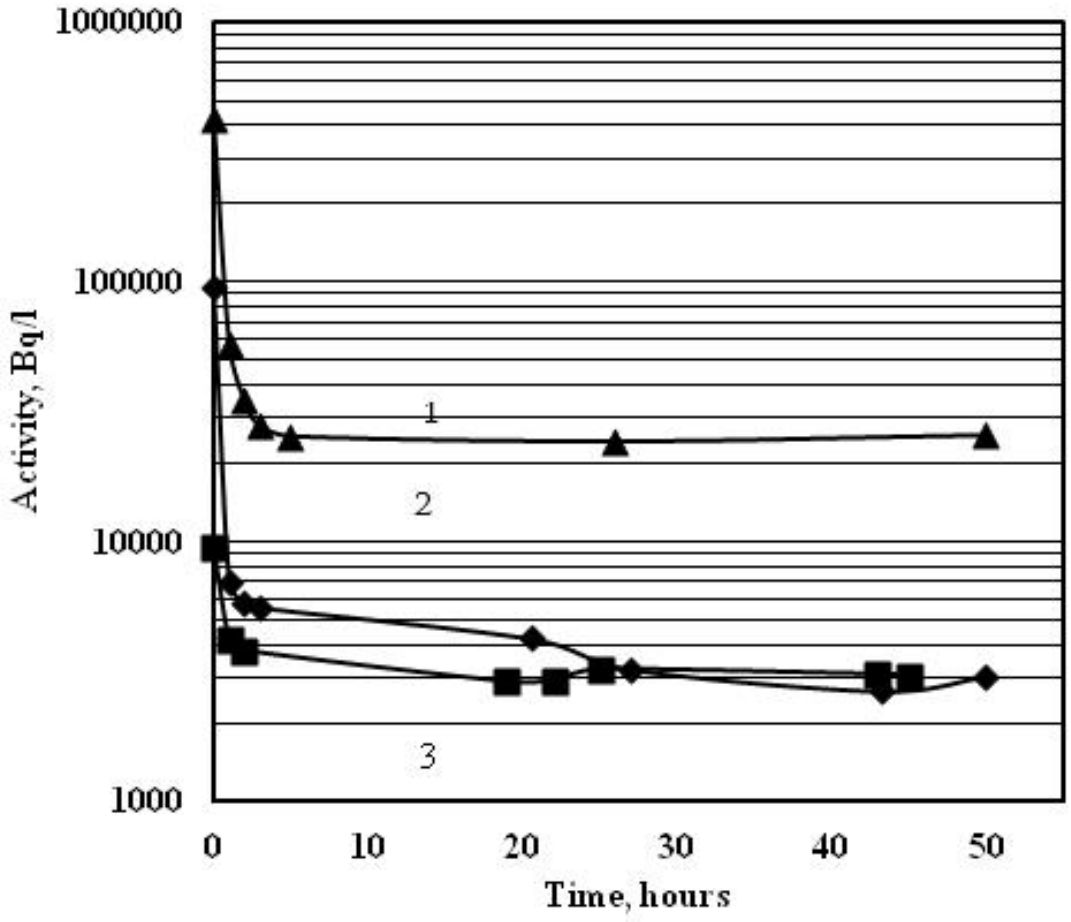

Fig.1. Radioactivity in the liquid phase for batch sorption studies. Temperature 20±0.1°C: 1 – radionuclide ^{63}Ni; 2– radionuclide ^{14}C ; 3– radionuclide ^{63}Ni. Near surface peat samples, fraction 0.5-0.25.

It was shown, that radionuclide ^{137}Cs sorption ability by the peat samples decreases significantly during the first 3 hours (Fig.2). Experimental data indicated that the pH of the solution also decreases from 9.0 up to 3.8 at this time period. The pH changes in the water solution proceed due to the acidic properties of the peat samples. It was shown (Fig.2) that the sorption efficiency is stabilized in pH region around value 4.0, but the rise of pH at the next stages of experiments causes the decreasing of the sorption efficiency.
Observed experimental data confirms the high sorption's efficiency of the radionuclides by the Dzelves raised bog peat. The results of both experimental modes are in a good agreement

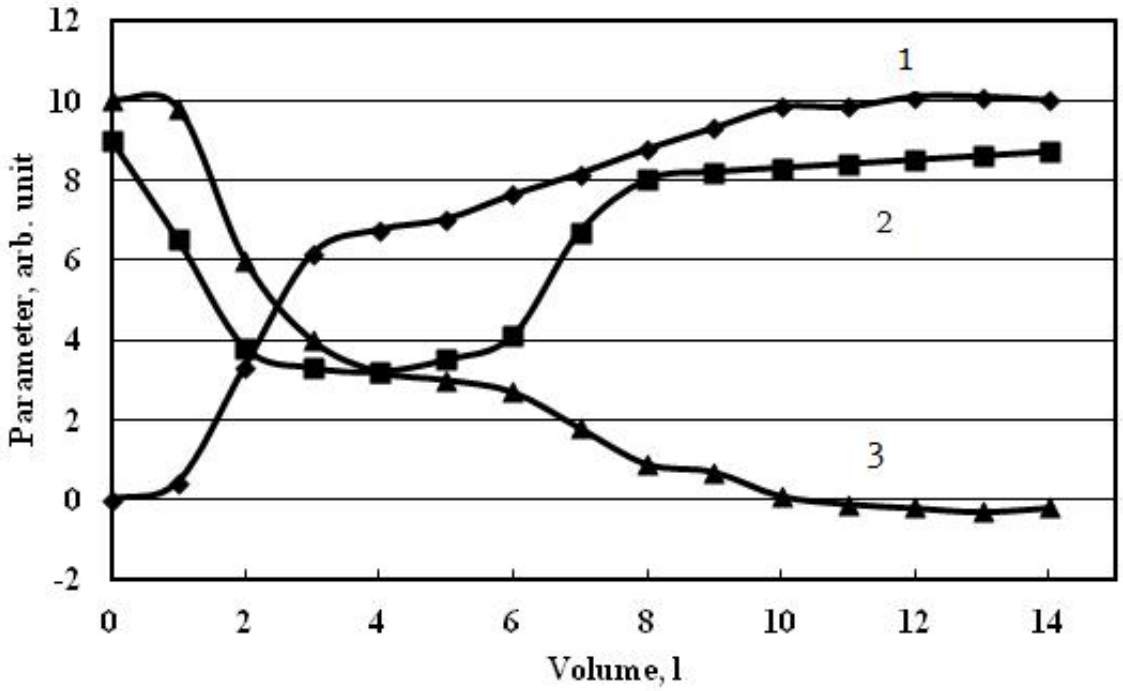

Fig.2. Parameters change for flux sorption studies. Temperature 20±1.0°C: 1 – Sorption of radionuclide ^{137}Cs x 10, arb.units; 2– pH values during experiment; 3– efficiency of the sorption of radionuclide ^{137}Cs x 10^{-1}, %. Near surface peat samples, fraction 0.5-0.25.

with the results of the investigations performed previously (Sanchez et al. (1988); Wang et al. (2006), Helal et al.; (2006); Jain et al. (2007)). Obtained results certified the role of humic substances in the immobilization of radionuclides. It is an important phenomenon for developing of a new purification systems for radioactive waste management purposes.

CONCLUSIONS

1. The radioactivity of the Dzelves raised bog's peat was studied. The presence of artificial radionuclides ^{152}Eu, ^{137}Cs and ^{60}Co was determined in the peat samples.
2. It was shown that the initial radioactivity of solution decreases during the batch sorption experiments in the case of ^{63}Ni and ^{14}C radionuclides within a factor 10, but in case of ^{55}Fe radionuclide within a factor 4. It confirms the high sorption ability of the investigated peat samples.
3. It was found, that radionuclide ^{137}Cs sorption ability by the peat samples during flow sorption experiments significantly depends on pH of the solution. Experimental studies indicated the complicated mechanism of the solution's pH influence on radionuclide ^{137}Cs immobilization processes.
4. Despite the experimental evidence of the high sorption efficiency of radionuclides by peat samples, additional efforts must be taken for clarification of the influence's mechanisms of external factors on the radionuclide sorption by the peat.

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