Asian Journal of Scientific Research

ISSN 1992-1454

Asian Journal of Scientific Research 6 (1): 129-134, 2013
ISSN 1992-1454 / DOI: 10.3923/ajsr.2013.129.134

The Role of Temperature on Radio Iodine Adsorption Behavior in the Sandy-loam Soil

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ABSTRACT

The sorption capability of the Sandy-Loamy soil for radio nuclides can be improved substantially by physical factors. Therefore, the present study was conducted to determine the effect of different temperatures on adsorption and desorption of radio iodine in the sandy-loamy soil. To the end, cultivated and non-cultivated soil samples were collected from Pardis (student's dormitory) and Kalate razagh zadeh, in Zahedan, Iran. Furthermore, the samples were tested in batch experiments with radio iodide. Prior to the actual experiment phase, the samples were pre-treated under low and high temperature with 20 cc radio iodine 125. The results indicated that, an increase in temperature has a remarkable effect on iodide adsorption. In other words, in batch experiments with equilibrium temperatures of -10, -8, 0, 5, 60 and 70°C, iodide adsorption increases with increasing temperature. However, higher temperatures raise radio iodide adsorption only to a certain extent, but this is more pronounced for cultivated soils. In conclusion, the role of temperature was found to be the same as effects of organic matter in the soil.

Key words: Radionuclide, temperature, radio iodine 125, cultivated soil, none cultivated soil, organic matter

INTRODUCTION

The study of ^{129}I concentrations underscores the importance of identifying the appropriate in situ stabilization technologies for all source contaminants (Kaplan *et al*., 2011). The disposal of radioactive material requires a technical, engineered and geological study (McCombie *et al*., 1995). Organic matters combine with soil particles and result combinations which are useful for other soil particles. Organic matter is selected because of their excellent adsorption capabilities (Bors *et al*., 2000; Koch-Steindl and Prohl, 2001). Soils compounds might have different impacts. Although clay is generally ineffective in adsorbing anions (Madsen, 1998), the weak adsorptive capabilities of clays for iodide can be improved substantially by the organic matter. The resulting organic-clay minerals are capable of adsorbing iodide (Madsen, 1998; Riebe *et al*., 2001). The clay minerals exhibit increasing adsorption capabilities for anions with increasing organic matter (Bors and Martens, 1992; Bors *et al*., 2000). In order to optimize sorption characteristics, a soil with organic matter is considered to combine with clay materials in a new set of tests (Dultz *et al*., 2005; Hosseini and Qureshi, 2011). Radio iodate form is readily adsorbed on soil with abundant organic matter, while carrier-free radioiodine is adsorbed on soil independent of soil properties (Brake *et al*., 2002).

Temperatures have been proposed for changing iodine radionuclide in soil. Temperature is expected to be variable at the soil surface. The present study focused on the adsorption of radio nuclides by soil compounds exposed to different temperature, representing temperature impact and organic matter as well as radio iodine 125.

MATERIALS AND METHODS

Site and soil: The cultivated and non-cultivated soil samples were collected from Pardis (dormitory of students) and Kalate razagh zadeh, in Zahedan, Iran. Table 1 displays the detailed sample mineralogy, determined by a soil laboratory.

Sampling: In the first stage, the soil was filtered and dried. Then, 200 grams of the dried and filtered soil was separated and poured in to a special container. In the next stage, the soil was homogenized using a high-speed homogenizer for 15 min. To make a mixture, 20 cc radio iodine 125 was added to 200 g of the soil sample, and stirred with a wooden spoon. After centrifugation and decantation, iodide adsorption tests were performed at elevated temperatures of -10, -8, -5, 0, 5, 50, 60 and 70°C. Note that, one group of the soil samples have been sub-divided into case and control sub samples. In order to reach the desired temperature, the sub samples were stored in a freezer with temperatures below -10, -8, -5, 0, 5, °C, for 24 h. In the same manner, the other group of soil samples was also divided into case and control sub samples, and put in an incubator with temperatures under 50, 60 and 70°C. However, different elevated temperatures are applied: for case sub-samples prior to the adsorption tests, but for control sub-samples, adsorption tests are performed without the heating treatment. Soil samples are achieved by keeping in a ventilator for 24 h at fixed temperatures of (22±1°C) temperature. The subsequent adsorption tests are carried out at laboratory temperature (22±1°C).The procedure of iodide adsorption tests for samples is done twice.

Experiments: The adsorption experiments are performed using the batch technique, where adsorption is characterized by the distribution coefficient (K_d value). K_d (L kg^{-1}) is defined as the ratio between the concentration of solute adsorbed on the solid matrix (mol kg^{-1}) and the concentration of the solute in the equilibrium solution (mol L^{-1}). For certain practical considerations, however, it may be more useful to have information on the amount of radioactive substances adsorbed per mass or volume of soil in case of an impact of different temperatures, cultivated and non cultivated soils. Therefore, measuring results have been processed to yield the relative sorption,

Table 1: Composition of the soil

Clay (%)	OC (%)	pH	EC	P (ppm)	Mn (ppm)	Cu (ppm)	Fe (ppm)	Zn (ppm)	Soil structure
9	0.17	7.72	3.42	6. 62	5.6	0.68	4.46	1.16	Sandy-loam

which is the percentage of added adsorptive actually adsorbed by the soil in different temperatures and organic matter. K_d (L kg^{-1}) of radio iodide in cultivated and non cultivated soils can be calculated after temperature pretreatment up to 70°C.

Organic samples: Organic samples (0.5 g) are dispersed in 9 mL of bi distilled water in 30 mL centrifuge tubes. Iodide adsorption is carried out with 1.4 kBq (~2×10^{-13} mol L^{-1}) of ^{125}I. As an inactive carrier of iodide, 1 mL of KI-solution in concentrations ranging between 10^{-8} and 10^{-1} mol L^{-1} is used. Tracer and carrier are added after 3 days of equilibrating the minerals with bi distilled water.

Depth profiles of radionuclide: Finally, the sub samples are carried to another lab in a special container to be tested.

The actual iodide concentration was 20 cc and the incubation time for the adsorption process took 15 min. After this stage, the solid and liquid phases are separated by centrifugation and the radioactivity of the liquid phase is measured by gamma-counting machine (The model name is Automatic Gamma Counting system: Made in Switzerland).

Adsorption K_d values and relative adsorption were calculated from the measured radio activities in the solution before and after incubation and freezing. For the desorption process, carrier-free solution was added and analyzed after 24 h of shaking. All experiments were carried out in duplicates. The overall mean error was <5%.

RESULTS AND DISCUSSION

The effective adsorption is increased due to ascending the temperatures from low to high in cultivated and non cultivated soil, but adsorption in non-cultivated soil is higher than cultivated soil (Fig. 1). Although the K_d (L kg^{-1}) increases in cultivated and non cultivated soil in different temperature -10, -8, -5, -3, 0°C to 5, 50, 60 and 70°C, but K_d rises more in non cultivated soil (Fig. 2). Table 2 shows changes in K_d and iodide adsorption in cool and warm temperatures of non cultivated and cultivated soils.

Temperature effects K_d in non-cultivated and cultivated soil due to iodide adsorption. The iodide adsorption is also related to the organic matter which is available less or more in cultivated soil and non cultivated soil during the adsorption process. Iodide adsorption is hardly influenced by soil particles of non cultivated soil, whereas anion adsorption is slightly decreased in non cultivated soil. The soil particles are able to cause an appropriate expansion of the interlayer spaces,

Table 2: K_d Temperature and adsorption in cultivated and non cultivated soil

Noncultivated				Cultivated			
Temperature (°C)	Adsorption CPM	K_d (L kg^{-1})	K_d (%)	Temperature (°C)	Adsorption CPM	K_d (L kg^{-1})	K_d (%)
-10	170	138750	72	-10	185	138750	88
-8	235	157500	87	-8	210	157500	11
-5	270	138750	120	-5	185	138750	86
-3	225	161250	91	-3	215	161250	91
0	245	176250	84	0	235	176250	111
5	290	157500	109	5	210	157500	79
50	265	198750	106	50	265	198750	100
60	250	198750	91	60	265	198750	96
70	275	206250		70	275	206250	

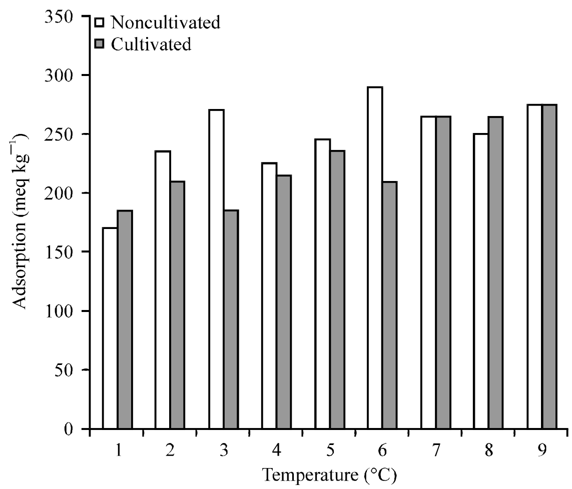

Fig. 1: The effect of temperature on adsorption in soil

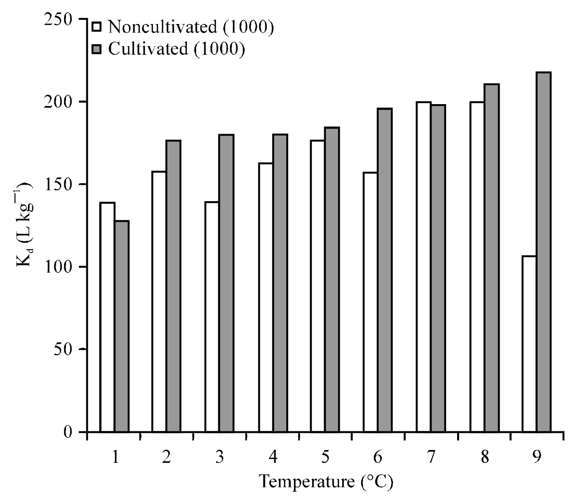

Fig. 2: The effect of temperature on K_d

which is needed for inserting a sufficient amount of organic matter and radio iodine 125 (Bors *et al.*, 1994; Koch-Steindl and Prohl, 2001). Sufficient iodide adsorption is the main criterion for selection, but practical aspects of handling, solubility and purchase costs are also influential. Organic matters reveal a high iodide adsorption with soil particles and proved to be satisfying with respect to the criteria (Muurinen, 1994; Bors, 1990). For cultivated soil, the relative adsorption is increased from about 93 to 96% of the available iodide at a concentration of 10^{-5} mol L^{-1} iodide in the solution. The increase in adsorption for the cultivated soil starts earlier than non cultivated soil under the same conditions, but it is more in none cultivated soil is 72 and 120% of available iodide under the same conditions.

The decrease of adsorption starting at 50°C, is more pronounced in non cultivated than cultivated soil. Relative adsorption of iodide by the cultivated soil is slightly between 86 and 113% at cool temperature and 96 and 79% at 60 and 5°C. In contrast, the non cultivated soil shows a pronounced decrease of the adsorption from 109 to 90%, starting at 5°C. The results of the present study indicate that, high temperatures prior to adsorption have a small effect, K_d values is increasing with rising organic matter in soil and Changes during heating indicate that the tested organic matter are stable in non cultivated soil to a temperature of about 5 and 50°C (Dultz *et al.*, 2005; Pusch and Karnland, 1990). Organic matter compounds show increased adsorption capabilities for radio iodine 125 (Dai *et al.*, 2004). With respect to radio iodine 125 adsorption and thermal stability, organic matter seems to be especially suitable. In experiments with different equilibrium solutions, containing competing anions (Pusch and Karnland, 1990; Riebe *et al.*, 2001) organic matter revealed a sufficient selectivity for iodide. There are some other factors which affect on contaminants adsorption and K_d values. The results of Ashworth and Shaw (2006) indicated the advantages of the mini-column approach in assessing the environmental behavior of radioactive and soil contaminants.

CONCLUSIONS

Temperatures impacts radio iodide adsorption in cultivated soils when it is at high. Radioactive matter will not be active during an advanced cooling stage, so that the soil will be exposed to higher temperatures prior to expected leakage of radio nuclides.

ACKNOWLEDGMENTS

The author wishes to acknowledge gratefully the assistance of Mr. Dabiri and Mrs. Irani with the experimental work. The work was supported by the Medical Physics group in 2010.

REFERENCES

Ashworth, D.J. and G. Shaw, 2006. Effects of moisture content and redox potential on in situ Kd values for radioiodine in soil. Sci. Total Environ., 359: 244-254.

Bors, J. and R. Martens, 1992. The contribution of microbial biomass to the adsorption of radio iodine in soils. J. Environ. Radioact., 15: 35-49.

Bors, J., 1990. Sorption of radioiodine in organo-clays and soils. Radiochim. Acta, 51: 139-143.

Bors, J., S. Dultz and A. Gorny, 1994. Some factors affecting the interactions of organophilic clay minerals with radioiodine. Radiochim. Acta, 66/67: 309-313.

Bors, J., S. Dultz and B. Riebea, 2000. Riebe, Organophilic bentonites as adsorbents for radionuclides: I. Adsorption of anionic and cationic fission products. Applied Clay Sci., 16: 1-3.

Brake, A.H., F.P. Moet, R.E. van der Zwart, J.L. Eersels and J.D. Herscheid, 2002. Adsorption of radioiodine on platinum: A fast and simple column method to obtain concentrated and pure radioiodide in either water or anhydrous solvents. Appl. Radiat. Isot., 57: 475-482.

Dai, J.L., M. Zhang and Y.G. Zhu, 2004. Adsorption and desorption of iodine by various Chinese soils: I. Iodate. Environ. Int., 30: 525-530.

Dultz, S., B. Riebeb and C. Bunnenberg, 2005. Temperature effects on iodine adsorption on organo-clay minerals: II. Structural effects. Applied Clay Sci., 28: 17-30.

Hosseini, S.A. and M.I. Qureshi, 2011. The effect of physical property variation on radio iodine adsorption in soils. Asian J. Applied Sci., 4: 81-88.

Kaplan, D.I., K.A. Roberts, K.A. Schwehr, M.S. Lilley and R. Brinkmeyer *et al.*, 2011. Evaluation of a radioiodine plume increasing in concentration at the Savannah River site. Environ. Sci. Technol., 45: 489-495.

Koch-Steindl, H. and G. Prohl, 2001. Considerations on the behavior of long-lived radio nuclides in the soil. Radiat. Environ. Biophys., 40: 93-104.

Madsen, F.T., 1998. Clay mineralogical investigations related to nuclear waste disposal. Clay Miner., 33: 109-129.

McCombie, C., I. McKinley, A. Lambert, M. Thury and P. Birkhauser, 1995. The Swiss strategy for HLW siting: Parallel investigation of two alternative host rocks. Sci. Basis Nucl. Waste Manage., 18: 1363-1370.

Muurinen, A., 1994. Diffusion of anions and cations in compacted sodium bentonite. P.hD. Thesis, University Helsinki, Finland.

Pusch, R. and O. Karnland, 1990. Preliminary report on longevity of montmorillonite clay under repository-related conditions. Swedish Nuclear Fuel and Waste Management Co., Stockholm, Report.

Riebe, B., J. Bors and S. Dultz, 2001. Retardation capacity of organophilic bentonite for anionic fission products. J. Contam. Hydrol., 47: 255-264.