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The Effect of Temperature Variation on Radio Iodine Adsorption in Soils

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ABSTRACT

The purpose of this research was study of Radio iodine adsorption, under changes in temperature variation in different soils of Iran. Six types of soil from nine different parts with alternative climate were used as a sample. In the laboratory, the samples were weighed, homogenized and sieved with 2 mm sieve. The temperature variation was provided by electrical heater for 15 min. Both case and control sub sample soils were put on electrical heater. The effect of physical property as temperatures on I^{125} of soils was changed. It was resulted that the radio iodine adsorption values decreased in 5, 10 and 15°C in humus soils but it increased in clay soil, coarse sand-clay soil, loamy soil, fine sand-clay soil, salty soil, fine sand-coarse sand soil in 20, 30 and 40°C temperatures. Knowledge of physical property as temperature variation effect on radio-iodine adsorption of soils is particularly essential for estimating iodide group, especially I-129 transfer to fluvial systems and for successfully measuring radio-iodine enthalpy and entropy in soil studies.

Key words: Temperature, radio iodide 125, adsorption, soils, enthalpy, entropy

INTRODUCTION

The worldwide operation of nuclear power and reprocessing plants leads to the evitable release of radioactive matter which contaminates soil layer. Radio-iodine would be an important element in polluting soil surface layer and extremely efficient accumulation in the thyroid gland. Special attention has been focused on I^{129} with half life more than 15 million years which leads to a permanent acumulation in the environment. There are many factors which affect on radio iodine adsorption in soil. Hosseini and Qureshi. (2010) results demonstrated that soil thermal energy can affect radio iodine adsorption in the soil. The contaminant concentration in soil usually decreases as a result of different chemical and transport mechanisms (Shan and Javandel, 2005). Ban-Nai and Muramatsu (2003) resulta very high TF is found for water dropwort, because the plant is cultivated under a waterlogged condition, in which iodine desorb from soil into soil solution with a drop in the Eh value. A desorption generally occurs upon cooling, but assembly (equilibrium polymerization) may arise either upon cooling or heating (Dudowicz *et al.*, 2009). The roles of microorganisms in radio iodine adsorption or desertion from soils are studied (Amachi *et al.*, 2003); Tao *et al.* (996) revealed that the soil biomass shows a striking effect on the adsorption of radioiodine. Among the clay minerals, the highest distribution ratio value is found for chlorite-illite clay mixture. Radioiodine in iodides form is more readily adsorbed on soil which is abundant in organic matter (Koch-Steindl and Prohl, 2001). Desertion pattern of iodine is influenced by the soil types and therefore it exist for a long period of year in the soil (Seki *et al.*, 2000). Conversely, variations in local rainfall during individual rainstorms are likely effect in the radio nuclides deposition. The parameters such as contact time, stirring speed, initial pH, ionic strength, acid-activation and calcinations is investigated for other radionuclide except radio iodine. Bell and Shaw (2005) tested on lowland agricultural soils with high clay and low organic matter contents. The overall message as the importance of a fundamental understanding of biogeochemical pathways in different ecosystems is proposed when attempting to predict the impacts of large-scale contamination. Ashworth and Shaw (2006) revealed that the soil solid-liquid distribution coefficient (Kd) value is of great significance in understanding and modelling the environmental behaviour of soil contaminants. The interaction of radionuclide in soil with environmental factors, such as temperature is important on its behavior (Flores *et al.*, 2009).

This study aims to tested the adsorption of radio iodine under different temperature variation in soils. For this purpose, iodine is used in the form of iodide (as I^{125}) which has been found to be the dominant species in rain water. The effect of temperature on soil radio iodine should be important for understanding the adsorption of radio iodine as well as for the assessment of long-lived radioactive iodine (I^{129}) in the environment.

MATERIALS AND METHODS

The soils are collected from an area which they are confronted with different rain and covering. The soil samples of region are from topsoil to 20 cm depth during June and July 2007. Sampling points are located in clinic and hospital. These places have a heavy traffic by patients, patient helper and other responsible people daily. They were Zahedan Emam Reza clinic (clay soil), Fasa Farstan clinic 1 (coarse sand-clay soil), Gorgan clinic No.1 (humus soil), Zahedan Emam Ali Hospital (loamy soil), Fasa Farstan clinic4 (fine sand-clay soil), Mirjaveh clinic 1 (fine sand soil), Ladiz clinic 2 (salty soil), Chahbahar clinic 1 (fine sand- clay) and 2 (fine sand-coarse sand).

There are many advantages and potential usefulness of the mini-column approach in assessing the environmental behaviour of radioactive and other soil contaminants the soil sample is provided with a 50 mm-diameter stainless steel corer to a depth of 20 cm. Three soil samples are collected at each location where are mixed. They are put in a plastic bag for transportation to laboratory. In the laboratory, the samples are weighed, homogenized and sieved with a 2 mm sieve. The temperature variation is provided by electrical heater for 15 min. Both case and control sub sample soils are put on electrical heater.

In the experiment, 500 g of sub sample clay soil, coarse sand - clay soil and humus soil are put in 500 mL polyethylene containers as case sub sample soil. Electrical furnace is used for providing 5, 10, 15°C temperature within 15 min. From clay soil, coarse sand-clay soil and humus sample soil as control, 500 g sub sample soil is poured in polyethylene containers and then it is put on electrical furnace for the same time without using I^{125}. A few drops of liquid containing 445 Bq of I^{125} are added to them. This corresponds with a total I^{125} activity 26720 CPM in tube test if I^{125} losses from the tube test due to passing time and putting in tube are neglected. The polyethylene containers are put on temperature, 20, 30, 40°C by electrical furnace for fifteen minutes as case soil. Sub sample of soil in other polyethylene containers were not put on electrical furnace for the same time but I^{125} is added to sub sample soil as control. The absorption of radio iodide is estimated at 20, 30 and 40°C.

After shaking in 140 rpm for 3 min of 500 g soil sample of case and control soil sample, 50 g of case and 50 g of control soil sub samples are put in test tube. The radio iodine in soil sub samples is determined by gamma counting for 20 sec. The counts are carried out for 20 sec for each sample. Model name was Automatic Gamma Counting systemwith Serial No. GM1 8335 S 307. Manufacturer name is KONTRON Location: in which it is made in Switzerland. This set was calibrated by a standard activate solution of radio iodine and compare the curve. This counting method is chosen considering that it is not so important to identify the radio nuclides involved into the reactions, since the objective is to shift all the isotopes producing significant doses of radiation. I^{125} activity concentrations are corrected for variation in sample self-absorption (Slavik, 1990) and converted to area activities with the total weight of the sample fraction less than 2 mm and the total sampling area. Duplicate sampling shows that the relative error due to homogenization and analysis is less than 10%.

The absorption of radio iodide by soils is investigated under different temperature values. In order to elucidate the influence of the temperature itself on the I^{125} values, sub samples soils are heated at different temperature 5, 10 and 15°C by electrical heater but no radio iodine are added to them.

Experiments on sub sample of humus soil, coarse sand-clay soil and clay soil have been undertaken. Iodine-125 is added sub sample of soil as case soil but iodine-125 has not been added to sub sample of soil as control soil. Iodine-125 react with sub sample soils at 5, 10 and 15°C.

RESULTS

Type of sub sample soil affects on radio iodine absorption. The radio iodine adsorption by sub sample of soil materials in coarse sand - clay soil is ascending as case; it is so for control sub-sample of soil with lower values (Table 1). Adsorption of radio iodine in clay soil as case is measured at larger amounts than in coarse sand - clay soil as case. As control soil adsorption of radio iodine 125 is same as each other. Desertion of radio iodine in sub-sample soil of humus is more than coarse sand clay and clay soil as case (Table 1). The adsorption of radio iodine sub sample soil is same and less values for each three soil in control soil. The average values of radio iodine adsorption under temperature 5, 10, 15°C are decreased in humus sub sample of soil as case, but are the same values of adsorption in control soil (Table 1).

The control sub sample of salty soil and fine sand soil have same values at 20, 30 and 40°C temperatures (Table 2). Radio iodine adsorption is increasing in salty soil and fine sand sub sample of soil as case. Average values of radio iodine adsorption in sub sample soil at temperatures 20, 30, 40°C are also increasing. The same values are in case and control of fine sand soil (Table 3).

Table 1: Adsorption of radio iodine in different soils under various temperatures

Temperature of sub sample soil (°C)	Coarse sand clay soil in Fars-Fasa -farstan clinic Bq kg $^{-1}$ dry soil		Clay soil in Zahedan-emam Raza emam clinic Bq kg $^{-1}$ dry soil		Humus soil in Gorgan- clinic 3 Bq kg $^{-1}$ dry soil	
	Case	Control	Case	Control	Case	Control
5	2.5±0.75	1.2±0.75	34±3	4.0±1	616±60	3±1
10	3.5±0.25	2.7±025	79±2	5.0±0.3	235±22	3±1
15	14.1±9.1	6.7±3.75	87±7	2.2±1.2	194±18	3±1

The trend of adsorption of radio iodine is ascending under 20, 30 and 40°C temperature in loamy sand clay soil (Table 4). The sub sample of soil as case at 20, 30 and 40 are two times relative to each other. But values is same in control sub sample of soil at the temperature 20 C and 30 and 40°C (Table 4). In the Table 5, the adsorption of radio iodine in 20, 30 and 40°C temperature is more than Table 4. As control, radio iodine adsorption sub sample of soil in Table 5 is same. Table 6 shows that adsorption of radio iodine by soil material is ascending under 20 30 and 40°C. Table 6 reveals adsorption of radio iodine in sub sample of soil as case in fine sand clay soil is increasing under 20, 30 and 40°C. The adsorption is same and less values in control sub sample of soil. Fine-coarse sand soil under 20, 30 and 40°C was lower than humus soil at 5, 10 and 15°C. In control sub sample soil, it is same figures and is less figures (Table 7).

Table 2: Adsorption variation of radio iodine in different soils Under various temperatures

	Ladiz clinic 1 (salty soil)	
Temperature of sub sample soil (°C)	Case (Bq kg $^{-1}$ dry soil)	Control (Bq kg $^{-1}$dry soil)
20	19±7	19±2
30	22±0.3	16±2
40	29.5±1.5	17±2

Table 3: Adsorption variation of radio iodine in Mirjaveh Clinic1 Soils under various temperature

	Fine sand soil in mirjaveh clinic1	
Temperatire of sub sample soil (°C)	Case (Bq kg^{-1} dry soil)	Control (Bq kg $^{-1}$ dry soil)
20	19±2	19±0.75
30	28±5	16±16
40	46±1	14±58

Table 4: Adsorption variation of radio iodine in Fars-Fasa- clinic 4 Soil under various temperatures

	Loamy sand clay soil in Fars- Fasa- clinic 4	
Temperature of sub sample soil (°C)	Case (Bq kg^{-1} dry soil)	Control (Bq kg^{-1} dry soil)
20	12±0.75	4.0±0.91
30	28±0.2	3.0±0.75
40	47±4	3.5±3.5

Table 5: Adsorption variation of radio iodine in Zahedan-emam Ali hospital soils under various temperatures

	Loamy soil in Zahedan-emam Ali hospital	
Temperature of sub sample soil (°C)	Case (Bq kg^{-1} dry soi)	Control (Bq kg^{-1} dry soi)
20	34±3	4±0.42
30	79±2	5±0.36
40	87±7	17±12

Table 6: Adsorption of radio iodine in Soil under various temperatures Chahbahahar

	Fine sand clay soil in Chahbahar-clinic 1	
Temperture of sub sample soil (°C)	Case (Bq kg^{-1} dry soil)	Control (Bq kg $^{-1}$ dry soil)
20	71±33	2±0.8
30	84±0.2	2±0
40	97±0.3	2±0

Table 7: Adsorption variation of radio iodine in Chahbahar clinic 2 Soil under various temperatures

	Fine coarse sand in Chahbahar-clinic 2	
Temperature of sub sample soil (°C)	Case (Bq kg^{-1} dry soil)	Contro l (Bq kg^{-1} dry soil)
20	18±14	3.7±1
30	49±4	2.9±0.42
40	120±0.3	2.0±0.36

DISCUSSION

Radio iodine adsorption in sub sample of soil changes with temperature variation and soil type. Humus soil sub sample is full of organic matter. Radio iodine adsorption values decreased in humus soil by increasing temperatures at 5, 10 and 15°C (Table 1). Adsorption of radionuclide 125 in coarse sand clay soil and clay sub sample of soil compared to humus soil. Its result revealed that organic matter could effect on increased temperature leading to be decreased radio iodine adsorption because there is more organic matter in humus soil than coarse sand clay soil and clay soil. According to Table 2, adsorption of radio iodine in salty soil under 20, 30 and 40°C is ascending. The figures of control subsample soil are same as each other. Due to the organic matter factor, the penetration depth of radio iodine into the soil would be changeable. The vertical ^{125}I distribution over the soil profile is usually approximated by an exponential decrease with sub sample soil depth with most of I^{125} in top few centimeters (Ashworth and Shaw, 2006). Sorption exhibit consecutive steps ascribed to humic acids (HA) monolayer and bilayer formation, respectively. Increasing temperature changes site capacity in which suggest different HA molecular conformations on the soil. Linearly correlated enthalpy and entropy changes for HA sorption point to the importance of hydration and dehydration in the sorption mechanism (Ghabbour *et al*., 2004).

Other factors would affect on penetration of radio iodine in soils (Ashworth and Shaw, 2006; Ashworth *et al*., 2003). Radioiodine adsorption from the contaminated soil increased with increasing temperature 20, 30 and 40°C for loamy soil. The free energy of iodine exchange ion on the soil material had an enthalpy at 20, 30 and 40°C for the high and low-affinity exchang e sites (Liu *et al*., 2003). According to scientist researches, thermodynamic requires chemical equilibrium. It enables us to compute the entropy and enthalpy of the adsorbed phase, the heat of adsorption, specific heat capacity and the adsorbed phase volume thoroughly (Chakraborty *et al*., 2009). Adsorption of radio iodine-125 under the temperatures variation in fine sand soil and salty sub sample of soils are nearly the same. Increasing temperature of soil sub sample increase adsorption of radio iodine in salty-clay soil sub sample.

The content and chemical characteristic of the Soil Organic Matter (SOM) was considered to be one of the important factors which affect on temperature of soil and lead to be differences in sorption capacity of soil. Meanwhile, the extent of radio iodine adsorption in soil is at rather descending level under low pH value conditions and ascending level with increasing pH value. The findings of other researchers reveals that increasing of temperature in soils adsorption of radio iodine is observed in most of tested soils (Hosseini and Qureshi, 2010; Chakraborty *et al*., 2009). It showed that organic matter in humus sub sample soil was more than salty soil and fine sand soil. Available organic matter of sub sample soil could play a role on temperature (Ashworth *et al*., 2003). Radio iodine adsorption values also increased in 20, 30 and 40°C in salty-clay sub sample soil. From the view point of radio iodine adsorption, salty-clay sub sample soil was compared to coarse sand clay soil in 5, 10 and 15 °C. It seems to be a suitable temperature that causes to increase the activity of biological system in soil. Radio iodine values for clay sub sample of soil increased in 5 to 10, 15°C. As the temperature increased, the number of strong adsorption sites remained relatively constant while the number for the weak adsorption sites increased. These results indicate that the net gain in adsorption capacity and the decreased adsorption irreversibility at elevated temperatures were due to the increase in available weak adsorption sites.

The quantity of radio nuclide can be Martens changed by microbial mass and food in soil sample. Previous finding of Bors and Martens (1992) support the results. Therefore, some of factors in sub sample soil can effect on the variation of temperature in which it would change iodine 125 (Spalding, 2001). Microorganism biomass in the soil can lessen the amount of iodine-125 in soil (Amachi *et al.*, 2003; Bors and Martens, 1992). The I^{125} activity concentration of sub samples soils decreases at 20 to 30 and 40°C. This showed temperature could affect radioiodine adsorption in soil and increased temperature could decrease microorganism and then, it decrease soil radio iodine adsorption.

Mixing operation on soil sub sample causes the I-125 of upper soil sub sample to be Tran located and the temperature would be changed in soil sub sample. The intensity of sub sample of soil redistribution of radio iodine by mixing operations depends strongly on attributes sub sample of soil and management. Soil sub sample attributes and management in these soil sub sample varied less compared with the entire soil.

Mixing operation on soil would also result in a reduction of the amount of radio iodine redistribution per successive mixture event. Although this effect was less pronounced if mixing caused the I^{125} to be more or less uniformly distributed over the soil sample layer, the radio-nuclides such as I^{125} activity concentration of the topsoil changed due to progressive lowering soil surface sub sample temperature and the incorporation of soil sub sample containing no radio-nuclide from below the mixing layer (Shan and Javandel, 2005). Also, the occurrence of different patterns of mixture and deposition caused by different temperature depending on intensity of mixing and type of soil sub sample, cause complex the activity concentrations in the topsoil.

The I^{125} activities was probably due to temperature during ^{125}I deposition, in which the I^{125} was not able to come into contact with the soil sample particles and preferentially flowed to the lower positions of the tube soil sample. Temperature during mixing events might have resulted in a much greater proportion of I^{125} being deposited in the average soil sub sample (salty soil and Fine sand soil sub soil sample). Furthermore, it might be due to the effects of soil sub sample redistribution and mixing operations. However, this study showed that mixing and deposition would affect temperature variation of soil sub sample and did change the temperature of soil sub samples.

Soil sub sample temperature contributed to the variation in I^{125} activity in sub sample soil of the central part of the study area. In the part of the study area humus soil, the large-scale of increased I^{125} values was probably the result of variation in initial temperature of I^{125} deposition over the soils following mixing. Apparently, the soil sample received larger amounts of radio-nuclide, which has resulted in an increase of values of compared with the other soil sub samples. This suggests that the I^{125} has probably been caused by local variability in the mixing the soil sub sample (Ames and McGarrah, 2001) and would be improved with increased concentration in initial solution and depended significantly on SOM.

CONCLUSION

This study demonstrates a few factor would change the temperature that affect on I^{125} in some soil sample. The method provided a better understanding of the contribution of various temperatures that caused the I^{125} adsorption in the soil sample.

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REFERENCES

Amachi, S., M. Kasahara, S. Hanada, Y. Kamagata, H. Shinoyama, T. Fujii and Y. Muramatsu, 2003. Microbial participation in iodine volatilization from soils. Environ. Sci. Technol., 37: 3885-3890.

Ames, L.L. and J.E. McGarrah, 2001. High-temperature determination of radionuclide distribution coefficients for Columbia River basalts1980. Dec 01 RHO-BWI-C-111 Technical Report Rockwell International Corp, Richland, WA (USA). Rockwell Hanford Operations 29 NTIS, PC A03/MF A01 May 13.

Ashworth, D.J. and G. Shaw, 2006. A comparison of the soil migration and plant uptake of radioactiv e chlorine and iodine from contaminated groundwater. J. Environ. Radioact., 89: 61-80.

Ashworth, D.J., G. Shaw, A.P. Butler and L. Ciciani, 2003. Soil transport and plant uptake of radio-iodine from near-surface groundwater. J. Environ. Radioact., 70: 99-114.

Ban-Nai, T. and Y. Muramatsu, 2003. Transfer factors of radioiodine from volcanic-ash soil (andosol) to crops. J. Radiat. Res., 44: 23-30.

Bell, J.N. and G. Shaw, 2005. Ecological lessons from the Chernobyl accident. Environ. Int. Aug., 31: 771-777.

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.

Chakraborty, A., B.B. Saha, K.C. Ng, S. Koyama and K. Srinivasan, 2009. Theoretical insight of physical adsorption for a single-component adsorbent+adsorbate system: I. Thermodynamic property surfaces. Langmuir, 25: 2204-2211.

Dudowicz, J., J.F. Douglas and K.F. Freed, 2009. Competition between self-assembly and surface adsorption. J. Chem. Phys., 130: 084903-084903.

Flores, C., V. Morgante, M. González, R. Navia and M. Seeger, 2009. Adsorption studies of the herbicide simazine in agricultural soils of the Aconcagua valley, central Chile. Chemosphere, 74: 1544-1549.

Ghabbour, E.A., G. Davies, M.E. Goodwillie, K. O'Donaughy and T.L. Smith, 2004. Thermodynamics of peat, plant and soil-derived humic acid sorption on kaolinite 11. Environ. Sci. Technol., 38: 3338-3342.

Hosseini, S.A. and M.I. Qureshi, 2010. The effect of physical property variation on radio iodine adsorption in soils. Asian J. Applied Sci., 4: 81-88.

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

Liu, C., J.M. Zachara, O. Qafoku and S.C. Smith, 2003. Effect of temperature on Cs+ sorption and desorption in subsurface sediments at the Hanford Site, USA. Environ. Sci. Technol., 37: 2640-2645.

Seki, R., E. Kimura, T. Takahashi and N. Ikeda, 2010. Distribution and behavior of long-lived radioiodine in soil chemistry and materials science. J. Radioanal. Nucl. Chem., 138: 17-31.

Shan, C. and I. Javandel, 2005. A multilayered box model for calculating preliminary remediation goals in soil screening. Risk Anal., 25: 339-349.

Slavik, O., 1990. Exploration of semiconductor gamma spectrometry for radiation control of nuclear power plant surroundings. Ph.D. Thesis, Comedies University, Bratislava, Slovakia.

Spalding, B.P., 2001. Fixation of radionuclide in soil and minerals by heating. Environ. Sic. Technol., 35: 4327-4333.

Tao, Z., W. Dong, J. Du and Z. Guo, 1996. Sorption and desorption of radioiodine on calcareous soil and its solid component. J. Radioanal. Nucl. Chem., 214: 147-157.