Sorption Studies of Selected Radioisotopes in Some Egyptian Soil Formations

Thesis Submitted
to

Faculty of Science
Ain Shams University

By

Mohamed Reda Mahmoud Mahmoud Ezz El-Din

Assistant Lecturer
Siting and Environmental Department
National Center for Nuclear Safety and Radiation Control
Atomic Energy Authority

For The Degree of
Doctory of Philosophy in
Chemistry

1995

SORPTION STUDIES OF SELECTED RADIOISOTOPES IN SOME EGYPTIAN SOIL FORMATIONS

Advisors

Prof. Dr. M.S. Abdel-Mottaleb

Prof. Dr. A.S. Abdel-Gawad

Prof. Dr. H.A. El-Naggar

Approved

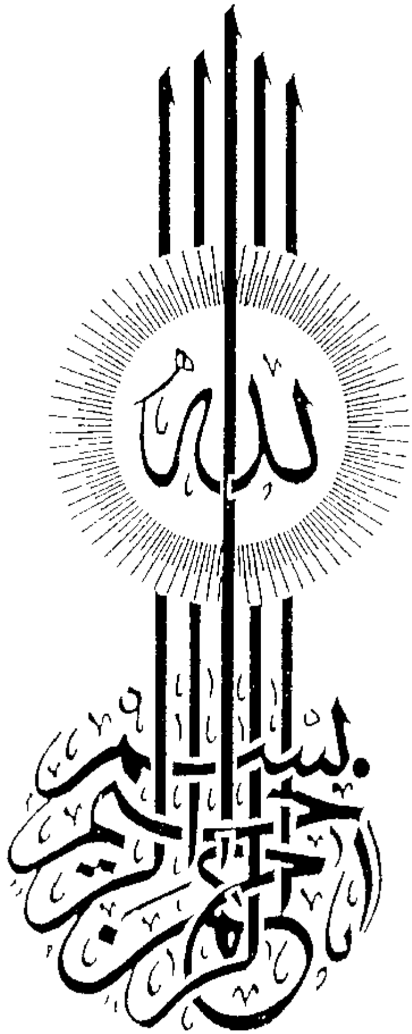
Abdel Gawad Emara

Hassan El Naggar

Prof. Dr. A.F.M. Fahmy

A. F. M. Fahmy

Head of Chemistry Dept.,
Faculty of Science,
Ain Shams University


بسم الله الرحمن الرحيم

Acknowledgment

The author wishes to express his deep gratitude to prof. Dr. M. S. Abdel-Motaleb Professor of inorganic chemistry , Faculty of Science, Ain Shams University , for sponsoring this work. The author is greatly indebted to Prof.Dr. A.S.Abdel-Gawad, Head of the Division of Safety of Nuclear Facilities, National Center for Nuclear Safety and Radiation Control, Atomic Energy Authority, for suggesting the problem, for his supervision, for scientific discussions and for his help in the final presentation of the thesis.

The author wishes to express his cordial thanks and gratitude to Prof. Dr. H.A. El-Naggar, Head of Nuclear Chemistry Department, Atomic Energy Authority, for his close supervision, for continuous help during all the stages of the development of the work. He is also acknowledged for scientific discussions, for his help in the accomplishment of the work.

Deep thanks are due to Prof. Dr. M., Hamza, Head of Siting and Environmental Department, National Center for Nuclear Safety and Radiation Control, Atomic Energy Authority, and Ass. Prof. Dr. M.K.Shehata, Ass.Prof. of radiation chemistry, Nuclear Chemistry Department, Atomic Energy Authority, for their interest, help, and encouragement.

All the members of the Laboratory of Actinide and Fission Product Elements , Nuclear chemistry Dept., are also acknowledged for their help and friendly atmosphere.

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Aim of The Work

The demonstration of the safe disposal of low level radioactive wastes over long time periods is often regarded as a prerequisite for the further development of nuclear waste disposal programs.

One of the most important approaches to the problem of low level radioactive waste is the disposal of the waste packages into the ground. Clays and soil minerals are typical naturally occurring materials which can absorb radioactive elements from waste solutions; thereby leading to their fixation into the respective soil matrices.

The aim of this work is to study the sorption behaviour of some radioactive elements on soil samples of Inshas area and to trace the possibility of their migration in the different strata of the terrestrial environment under conditions of eventual ground water flow. Of special importance in this process is the presence or absence of natural organic ingredients such as humic and fulvic acids in these media. The radioisotopes are supposed to be complexed by the organic acids; a process which affects the rate of migration of the radioisotopes resulting in a pronounced enhancement of their movement in the under ground environment. In this respect a number of migration models can be used to predict the location of the relevant radioisotopes injected to the soil strata after a given time period. The data obtained from the respective models are of great importance since they furnish the basis for assessing the radiological safety of near surface ground repositories assigned for the disposal of low level wastes. In the specific case of Inshas area the sorption-complexation data can be fed to a mathematical model simulating more or less the conditions at the studied area and the obtained results can be used to predict the migration rates and the respective concentrations of the radioisotopes at any distance from the point of injection of the radioisotopes.

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I. INTRODUCTION

Low-level radioactive wastes are normally disposed of by underground burial in trenches or pits designed and operated in accordance with governmental regulations. The wastes are normally packaged at the time of burial, although the packages, generally wood boxes or metal drams, are required to maintain their integrity for long periods of time. Thus, radioactive elements contained in the wastes can become exposed to the environment, unless their half lives are short enough that disappear by radioactive decay before the container integrity is breached. The effect of the environment is most represented by the effect of soil moisture on the waste packages, a process which can lead to leaching the radioisotopes incorporated in the waste matrix. The leached radionuclides may migrate in the terrestrial environment. In their migration the isotopes - depending on the prevailing condition may be sorbed on the soil particles and there movement is showed down. This retardation of radionuclide mobility by soil is one important factor in assuring the safety of low-level waste disposal [1,2].

The retardation of radionuclide migration by soils and rock has been studied for many years. Methods for determining retardation factors and their mechanisms were discussed by Relyea et al.[3]. Such mechanisms include sorption by ion exchange processes, physical adsorption on the surface of soil particles, precipitation of compounds of the element of interest, and carrying of the element of interest on precipitates of other elements. Other mechanisms may also be important.

Organic complexants can affect the retardation of radionuclide mobility. They can decrease the retardation "increase the mobility" by forming soluble complexes that shift radionuclide ion exchange, physical sorption, or solubility equilibria; by dissolving soil originated materials that were sorbing the radionuclide; or by the complexant itself sorbing onto the soil and " blinding" sorption sites. Organic complexants can also have the opposite effect, that is, increase the retardation "decrease the mobility " by forming insoluble complexes with the radionuclide. The potential influence of organic compounds on the transport of radionuclides in a geologic repository was studied by Silviera [4]

Several reports in the literature address organic complexants that affect the mobility of various radionuclides in soil/water systems. It is concluded that the presence of ethylenediaminetetraacetic acid (EDTA) could enhance the migration of ^{60}Co in waste disposal pits and trenches at Oak Ridge National Laboratory [5]. A large decrease in ^{60}Co sorption when ^{60}Co was complexed by EDTA was also observed [6]. The effect of several complexants on several radionuclides added to sediment/water systems from natural environments was studied and it was found that EDTA and humic acids decrease the sorption of ^{241}Am and ^{57}Co, while other complexants such as 1-nitroso-2-naphthol and 1,10-phenanthroline actually increased the affinity of these radionuclides to the sediments [7]. Some of the organic materials present in leachates from low-level radioactive waste disposal site have been characterized by Francis et al.[8].

The migration of radionuclides in the groundwater of shallow radioactive waste disposal sites has been shown to be enhanced by the presence of synthetic organic compounds, that are widely used in nuclear cleanup operation, such as EDTA, nitrolotriacetic acid (NTA), cyclohexane diaminetetraacitic acid (CDTA), and diethyenetriamine pentaacetic acid (DTPA) [9]. It is expected that natural organic compound in groundwaters, which can also have high complexing ability, may influence the migration of radionuclides [10]. The effect of natural organic substances present in the groundwater system on actinides and fission product elements that may escape from low-level radioactive waste repositories are of particular importance when assessing the safety of a repository. Available data show that the concentration of total dissolved organic carbon (DOC) in groundwaters from deep wells in granitic and basaltic rocks at potential waste repository site ranges from less than 1 mg/L to as much as 20 mg/L [11]. Concentrations of DOC reach much higher values (12 to 76 mg/L) in deep wells of oil producing basins [12]. Such high values are exceptional, and most deep groundwaters probably contain less than 2 to 3 mg/l total DOC [13]. In fact, Leenheer found that the mean concentration of DOC in 100 groundwaters from sandstones, limestones, and crystalline rocks at depths of 10 to 400 m was 1.2 mg/L. Samples from 100 surface water sites in the USA gave DOC values from 0.1 to 8 ppm [14]. Samples from fairly deep groundwaters in crystalline rock in 25 site in Sweden with samples from depths of 100 to 700 m also gave DOC values ranging from 1 to 8 mg/L [15]. In wells from potential waste repositories in Nevada, Texas, and Washington, DOC levels were in the rang of 0.1 to 10 ppm. In Ocean waters, the DOC ranges from 0.5 to 1.2 ppm, with the higher concentrations occurring in the surface waters. In addition, most waste waters contain an amount of suspended particulate organic matter which in ocean equals about 10 % of the DOC. In all water, there also can be suspended inorganic material with organic coating. A majority of the DOC as well as the particulate and sorbed organic matter fall within the classification of humic substances [16].

Many kinds of dissolved organic substances occur in groundwater, including amino acids, fatty acids, phenols, sterols, natural sugars, hydrocarbons, urea, and parphyrine; however, much of the organic carbon in groundwater is derived from humic substances and consists of humic and fulvic acids [17]. Humic substances are complex mixtures of organic species of high molecular weight and poor known structure that are generally classified on the basis of solubility. Humic acid is that fraction of humic substances that is soluble in a base; fulvic acid is that fraction that is soluble in both acid and base; and humin is the insoluble fraction that cannot be extracted by either acid or base.

The tendency of natural organic substances in groundwater, surface water, and soils to form complexes with radionuclides has been studied by several investigators [2,4,18,19,20].

A knowledge of the effects of organic complexants on the mobility of radionuclides in soils and groundwater environment is essential for accurate prediction of the migration of radionuclides from a disposal site.

Shallow ground disposal of radioactive wastes has been practiced since the 1940. This techniques can be safely applied when sites are carefully selected and repositories are designed and operated to take into account the characteristics of the siteand the waste.

In the next section a brief discussion of the important considerations in the site selection process, comprising the site characteristics of Inshas site, and the nature of the radioactive waste will be given.

I.1 Site Characteristics

The overall objective of the disposal of radioactive wastes in shallow ground is to contain the wastes in such a manner that any human exposure to radiation should be within acceptable limits. The site should have such characteristics as to provide sufficient retention of the radionuclides in order to keep the radiological impact below authorized limits. The repository should be located in an area of favorable climatic, topographic, geological and hydrogeological characteristics so that the wastes will be adequately isolated from the human environment for the period of time that they remain of radiological concern.

Analysis of past experience with several shallow ground repositories showed that many of the difficulties that resulted in inadequate containment of the waste products could be attributed to improper siting [21]. A number of problems, including water accumulation in trenches, breaches of trench cap integrity, erasion, high water tables, hydrogeological complexity, flooding and rapid migration of radinuclides in groundwater, can be avoided if appropriate criteria are applied in the site selection process.

However, it should be emphasized here that in practice it is difficult to find a site having all of the favorable attributes in a region of interest, and thus attention should be paid to the waste form, radionuclide content and repository design in order to provide the overall disposal system with more engineered barriers to compensate for the less favorable characteristics of the site. The important features in the site selection process at Inshas area are summarized briefly in the following.

I.1.1 Characterization of Inshas Site

I.1.1.1 Location:

The proposed area for the construction of the first repository in Egypt is Inshas area, which is a part of the east delta region, it is bounded by Ismailia canal to the north and west, the Cairo-Suez Highway to the south, Bitter lakes to the east, fig.(1). It is bounded by longitudes 31′ 20 and 31′ 40 E and latitudes 30′ 10 and 30′ 25 N. The area and its vicinity are considered as a developing agricultural area, where it accommodates more than 2000 residents. Recently, the industry started to play a role in the area and its vicinity where many factories have been built [22].

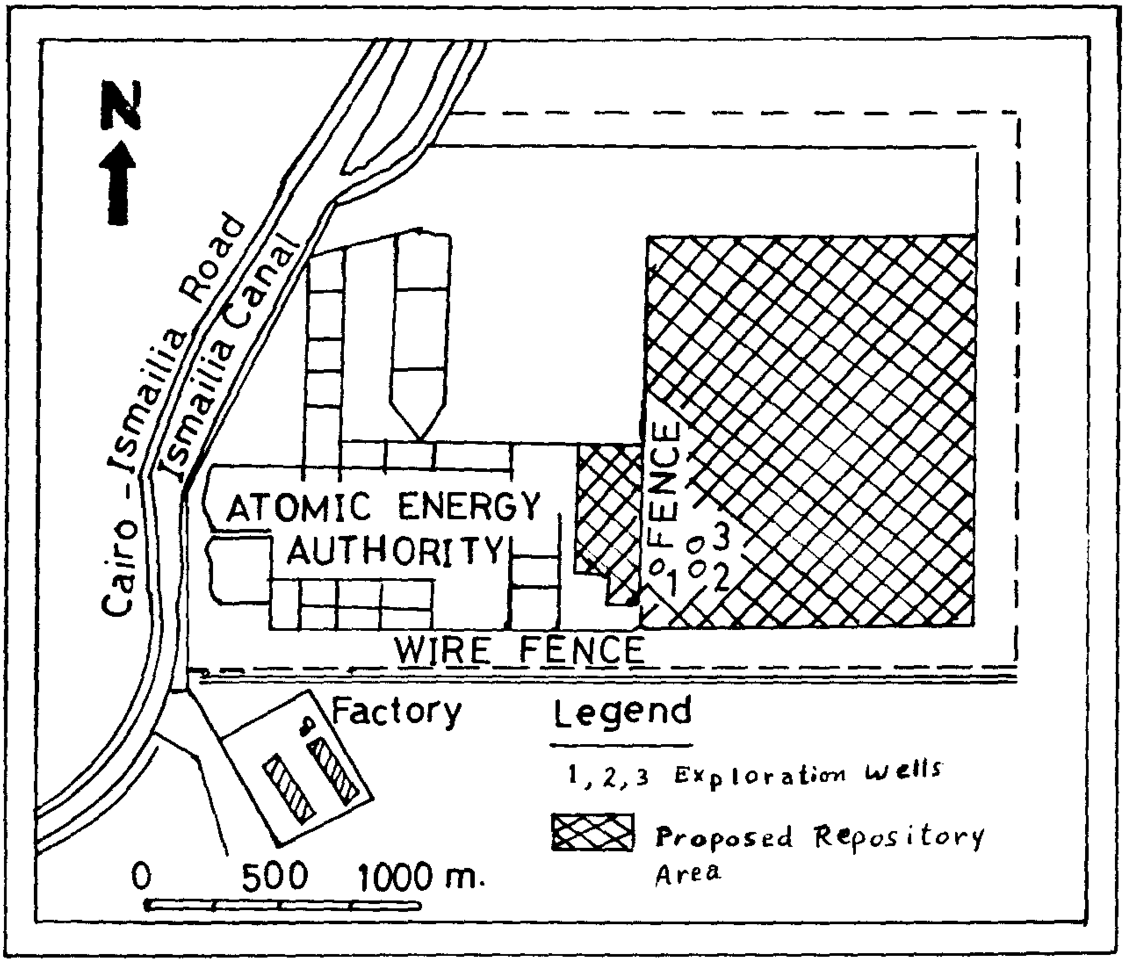

Fig.(1): Location map of the area under investigation