*Ain Shams University*
*Faculty of Science*
*Chemistry Department*

# ***Remediation of Radioactively Contaminated Soil Produced in Petroleum Extraction Sites***

*A thesis Submitted*

*By*

***Yasser Ahmed Ali Ahmed Nasef***
*M.Sc. in Chemistry (2008)*
*Assistant Lecturer*
*Radiation Protection Department*
*Nuclear and Radiological Regulatory Authority (ENRRA)*

*To*

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*Board of Scientific Supervision*

***Prof. Dr.***
***Mostafa Mohamed H. Khalil***
*Prof. of Inorganic Chemistry,*
*Faculty of Science,*
*Ain Shams University*

***Prof. Dr.***
***Mohamed Reda M. Ezz El-Din***
*Prof. of Radiation Chemistry*
*Nuclear and Radiological Regulatory*
*Authority*

***Dr. Randa Mahmoud Mohamed***
*Lecturer of Radiation Physics*
*Nuclear and Radiological Regulatory Authority*

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**Yasser Ahmed Ali Ahmed Nasef**

| *Thesis Supervisors* | *Approval* |
|---|---|
| ***Prof. Dr. Mostafa Mohamed H. Khalil***<br>*Prof. of Inorganic Chemistry,*<br>*Faculty of Science, Ain Shams University* | ......... |
| ***Prof. Dr. Mohamed Reda M. Ezz El-Din***<br>*Prof. of Radiation Chemistry*<br>*Nuclear and Radiological Regulatory Authority* | ......... |
| ***Dr. Randa Mahmoud Mohamed***<br>*Lecturer of Radiation Physics*<br>*Nuclear and Radiological Regulatory Authority* | ......... |

***Prof. Dr. Ibrahim H. A. Badr***
*Head of Chemistry Department*
*Faculty of Science*
*Ain Shams University*

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*YASSER AHMED ALI AHMED NASEF*

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# Aim of the work

**The aim of the present work** is to studying the feasibility of using soil washing technique (a physical-chemical separation process) for removing radium-226 from the TENORM contaminated soils samples collected from different petroleum sites in Egypt. The physical separation/ activity distribution of the investigated soil particle sizes followed by soil chemical treatment has been also carried out. Treatment of the resulting contaminated solution with different methods in order to:

1) Minimize risks to oil companies' workers in accordance with acceptable levels recommended by the relevant regulatory bodies.
2) Reduce the volume of waste generated in order to facilitate the permanently disposal.
3) Estimate the radiation doses for workers of oil production companies because of exposure to these pollutants.
4) Propose some regulatory requirements necessary for treatment or disposal of such contaminants.

**The other aim of the present work** is devoted to assess the radiological hazards for the workers at oil and gas production fields by estimating radium equivalent activity ($Ra_{eq}$), absorbed dose rate (D), annual effective dose rate (AEDE), external hazard ($H_{ex}$), internal hazard ($H_{in}$) and Gamma radiation representative level Index ($I\gamma$).

The main objectives of this study were:

1. Collecting samples of radioactively contaminated soil from some sites of oil companies.
2. A physical separation of the contaminated soil particles depending on the particle size.
3. Treatment of contaminated soil;
4. Treatment of the solutions resulting from the process of remediation of contaminated soil.
5. Studying the factors affecting the treatment process.
6. Elaboration of the obtained data with the possible predictions of the treatment of waste solutions.
7. Radiological dose assessment due to remediation of radioactively contaminated soils.
    a) Calculation of the occupational exposure by different exposure pathways. (internal and external).
    b) Calculation of the radiological hazards indices.
    c) Compare the estimated dose with international guides in order to recommending the suitable cleanup level.

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# Radiological Hazards of TENORM Contaminated Soil at Oil and Gas Fields

YA.A. Ahmed(1), R.M.M. Mahmoud(1), M.R. Ezz El-Din(1) and Mostafa M. H. Khalil(2)
[1]*Nuclear and Radiological Regulatory Authority, Cairo, Egypt*
[2]*Faculty of Science - Ain Shams University, Cairo, Egypt*

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**The presence of large quantities of TENORM contaminated soil produced during the extraction and processing of crude oil at oil extraction sites exceeds the radiological reference levels assigned by the international organizations [1] TENORM may cause the exposure of workers at these sites to unusual radiation hazards. This is of a great importance for assessing the dose to the workers at these sites, which plays a vital rule in exploring the radiation health risks due to radiation exposure. This study aims to assess the TENORM activity concentration of the contaminated soil in some oil and gas production fields in Egypt. The assessment of the radiological hazards for the workers by estimating the annual doses and the radiation hazard indices were also studied. The obtained data show that the activity concentration of $^{238}$U, $^{232}$Th and $^{40}$K ranged from166 to 42567 Bq/Kg, 88 to 8358 Bq/Kg and 52.22 to 440 Bq/Kg respectively. The calculated absorbed dose rate ranged from 132.39 – 24732.67 nGy/h, and the calculated Annual Effective Dose Equivalent ranged from 0.16 – 30.33 mSv/y (depending on the activity concentration of NORM contamination). The radiation hazard indices were calculated and found to be much higher than the international values. From the obtained results, it has been concluded that the remediation/decontamination of the contaminated soils in the production sites that have activity concentration higher than 400 Bq/Kg is highly recommended. In addition, Egyptian regulations should be coherent to force companies to decontaminate NORM contamination to reduce as much as possible the radiation worker exposure.**

**Keywords:** *NORM activity concentration, Dose assessment, Radiation hazardous indices*

## Introduction

In recent decades, the development of new technologies in oil production fields has resulted in the generation of by-products and waste called technologically enhanced naturally occurring radioactive materials (TENORM) produced from several industries such as uranium mining, coal ash, phosphate ore processing, metal mining and processing, and petroleum industry [2-3]. Therefore, human technical activity can increase radiation exposure, not only to the person directly involved in these activities, but also to the local or even whole population and environment. The majority of radionuclides in TENORM are U, Th and their respective decay progenies. Usually, radium ($^{226}$Ra) and radon ($^{222}$Rn) are used to characterize the redistribution of TENORM that results from human activities [3-4]. In oil and gas production, the arising TENORM may be solid waste (scale and/or sludge) or produced waters [5]. The activity concentrations of $^{226}$Ra in TENORM can be much higher than the exemption levels established by IAEA [6]. The recommended exemption level for uranium series is $^{238}$U= 1 Bq/g and $^{226}$Ra= 10 Bq/g, while for thorium decay a chain is $^{232}$Th= 1 Bq/g, $^{228}$Ra = 10 Bq/g and $^{224}$Ra = 10 Bq/g [5]. The initial evaluations of occupational radiation exposure in the oil and gas industries were reported a few decades ago [7].

The presence of radium-226 at high concentrations in radioactive wastes that resulted from oil and gas

Corresponding author: yassernasef@yahoo.com
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