NUCLEAR SAFEGUARDS THROUGH MEASUREMENTS OF RADIOACTIVITY OF NUCLEAR MATERIAL AROUND NUCLEAR FACILITIES

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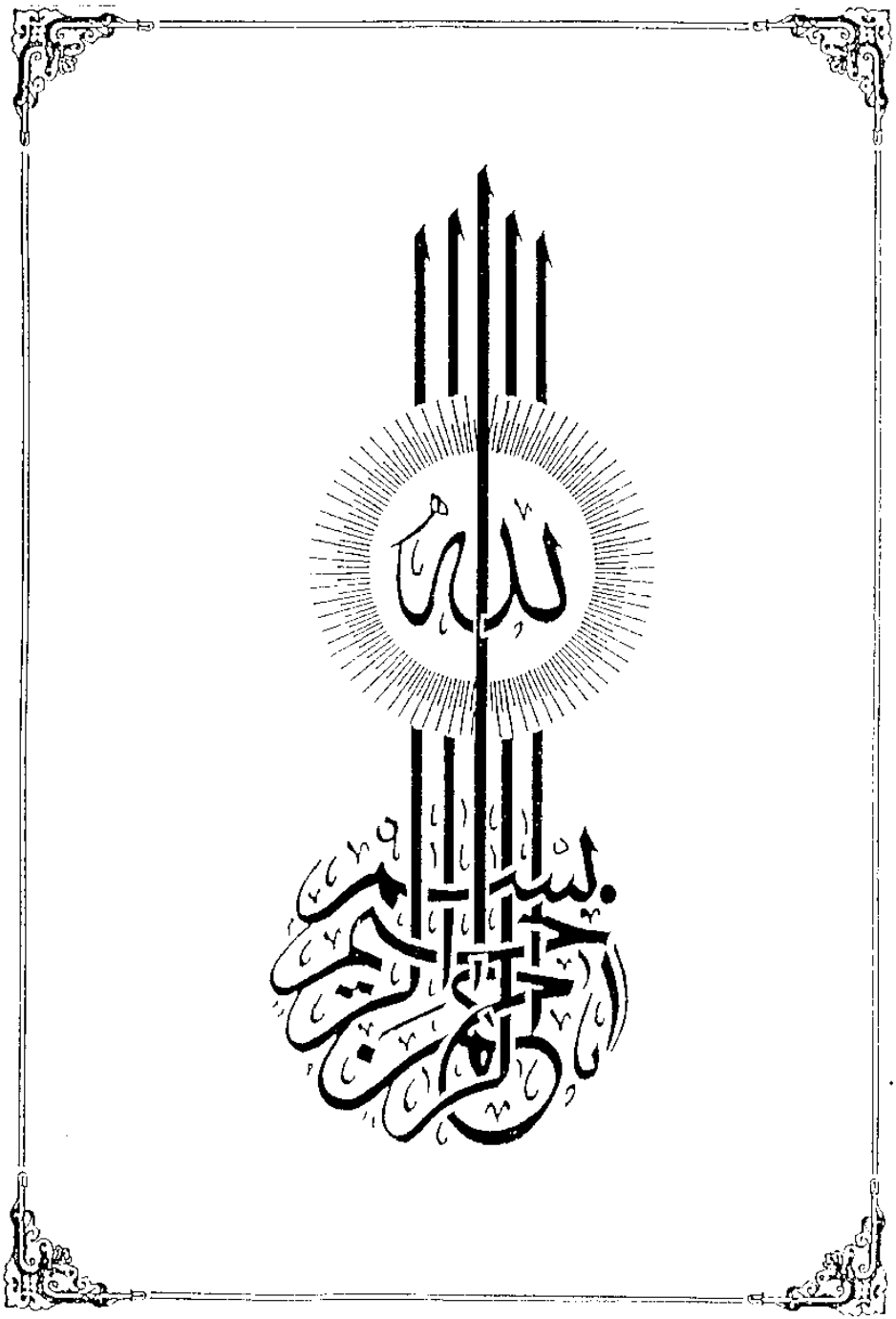

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ABSTRACT

The purpose of the environmental monitoring is to estimate the public dose equivalent, the accumulation of the radioactivity in the environment and to estimate the environmental impact due to abnormal release around the hot regions (e.g. nuclear facilities). Recently, environmental monitoring is used by IAEA as one of the safeguards tools for discovery any undeclared nuclear activities.

The objective of this work is to determine and evaluate the natural and artificial radioactivity levels around the Egyptian nuclear facilities: two research reactors (2 MW and 22 MW), one fuel manufacturing pilot plant and a nuclear fuel research laboratory, as preoperational and postoperational radioactivity monitoring.

the Dimona reactor which is not under the international safeguards, is also radiologically studied.

Soil, water, plant and foodstuffs samples have been collected, prepared and analyzed by using very sensitive techniques; gamma spectrometry, alpha spectrometry, laser fluorimetry and liquid scintillation counter.

The radioactivity concentrations of (measured by gamma spectrometry) ^{40}K, ^{226}Ra (of ^{238}U), ^{232}Th and ^{137}Cs in the soil samples which were collected around the **second reactor** (and the fuel fabrication pilot plant (FFPP)) are in the range from 99.6 to 140.1 Bq/kg, from 9.6 to 14 Bq/kg, from 7.7 to 13.8 Bq/kg and from <DL to 9.2 Bq/kg respectively.

The average radioactivity contents of uranium in soil as measured by alpha spectrometry, are 8.7 Bq/kg, 14.6 Bq/kg, 15.3 Bq/kg and 26.2 Bq/kg for the soil collected from west, north, east and south direction around the second reactor respectively. The radioactivity of ^{235}U as estimated by the same technique was about 0.7 % of the total uranium activity.

The average radioactivity concentrations of uranium, as measured by laser, were found to be 15.3 Bq/kg, 14.5 Bq/kg, 15.6 Bq/kg and 16.1 Bq/kg for the soil collected from west, north, east and south direction respectively.

The radioactivity concentrations of ^{40}K, ^{226}Ra (of ^{238}U), ^{232}Th and ^{137}Cs in the soil samples which were collected around the **first reactor** are in the range from 84.2 to 169.8 Bq/kg, from 6.3 to 10.9 Bq/kg, from 4.4 to 12.6 Bq/kg and 0.6 to 8.5 Bq/kg respectively.

The average radioactivity contents of uranium in soil as measured by alpha spectrometry, are 12.9 Bq/kg, 12.5 Bq/kg, 18.4 Bq/kg and 19.3 Bq/kg for the soil collected from west, north, east and south direction around the second reactor respectively. The average radioactivity concentrations of uranium, as measured by laser, were found to be 11.3 Bq/kg, 16.3 Bq/kg, 15.5 Bq/kg and 10.3 Bq/kg for the soil collected from west, north, east and south direction respectively.

The radioactivity concentrations of ^{40}K, ^{226}Ra (of ^{238}U), ^{232}Th and ^{137}Cs in the soil samples which collected from two locations in front of the fuel fabrication laboratory are 164.9, 9.7 Bq/kg, 11.3 Bq/kg and 0.3 Bq/kg respectively.

From the results obtained a good correlation between uranium measured by alpha spectrometry and laser fluorimetry was found. The slight difference might be attributed to the difference in the chemical recovery.

The observed artificial ^{137}Cs is mainly attributed to the global fallout due to the previous atmospheric nuclear weapon testing and nuclear accidents. Releases of detectable fission and activation products due to operation of the first reactor were not observed.

The man-made ^{238}Pu and $^{239-240}Pu$ in the analyzed soil samples were measured after radiochemical separation using alpha spectrometry based on surface barrier detector. The specific activity of ^{238}Pu was found 0.0104 and 0.0119 Bq/kg dry weight for the samples collected from Inshas site. The concentration of $^{239-240}Pu$ was found 0.096 and 0.156 Bq/kg dry weight respectively. Based on the results obtained, it is concluded that the Pu is mainly attributed to the global fallout and not to be the reactor operation releases.

From the results obtained, the activity ratio of ^{238}Pu to $^{239-240}Pu$ is 0.1, this ratio indicates that the measured plutonium is attributed to the global fallout.

The $^{239-240}Pu$ / ^{137}Cs activity ratio was found to vary between 0.12 and 0.25.

Neither fission products (^{134}Cs, ^{131}I, ^{135}Xe,.....) nor activation products (^{60}Co, ^{65}Zn, ...) were observed in the analyzed samples. This result leads to a conclusion that the 38 years first reactor did not increase the environmental radioactivity levels. Environmental impact due to operation of this facility was not detected.

Tritium content in collected samples at Inshas site underground and surface water was measured using liquid scintillation counter. The activity concentration of tritium is 1.02 and 1.48 Bq/l for the Inshas underground water and is less or equal to 0.6 Bq/l for the water samples collected from Ismailia canal. The observed tritium is mainly attributed to the global fallout.

The activity concentrations of total uranium in the collected Inshas water samples measured by laser fluorimetry ranged from 0.004 Bq/l to 0.007 Bq/l.

The calculated absorbed dose rates due to the soil around the two reactors (9.5 to 23.9 nGy/h) are in the same ranges of the corresponding values for the adjacent region (south part of Nile Delta); and lower than the international level; 57 nGy/h.

The average radioactivity concentrations of ^{40}K, ^{226}Ra (of ^{238}U), ^{232}Th and ^{137}Cs in the soil samples collected from **Sinai** are 173.5, 13.4 Bq/kg, 8.12 Bq/kg and 1.8 Bq/kg respectively.

The average radioactivity contents of uranium in the soil as measured by alpha spectrometry were found to be from 17.8 to 27.9 Bq/kg for the soil collected from Sinai region. The radioactivity of ^{235}U as estimated by the same technique was about 0.7 % of the total uranium.

The average radioactivity concentrations of uranium, as measured by laser flouremetry, were found to be from 14.2 to 31.14 Bq/kg for the soil collected from Sinai region.

The activity concentration of tritium is ranged from 0.6 to 1.3 Bq/l for the water samples collected from Sinai region. The observed tritium is mainly attributed to the global fallout.

The activity concentrations of total uranium for the collected Sinai water samples measured by laser fluorimetry ranged from 0.005 Bq/l to 0.18 Bq/l.

It is concluded that the measured radioactivity levels in the studied Sinai region are normal, natural and within the international levels. Periodical survey is going to be done to detect and evaluate any potential or accidental releases.

Based on the results obtained, radiological maps and tables with baseline data for the studied areas showing the radioactivity levels are obtained. They are considered as baseline and reference values to be used in case of emergency action.

Chapter 1

INTRODUCTION

Ionizing radiation are continuously present in the human environment. They may originate from natural and artificial sources. Natural Radiation sources are classified into Cosmic rays, Cosmogenic radionuclides, and Primordial radionuclides.

Some of the contributions to the total exposure from the natural radiation background are quite constant in space and time and practically independent of human practices and activities [1].

The rapid increase in technological development has brought extensive benefit to society but at the same time has caused certain environmental and socio-economic problems.

The release of radioactive materials to the environment is an inevitable consequence of the use of nuclear energy. The problem therefore is to so limit and control such releases as to reduce adverse effects on man and his environment to acceptable proportions.

Artificial sources of radioisotopes and radiation are largely associated with nuclear industries or with medical and research uses. The background radiation may change with the development of the nuclear and non-nuclear technology applications. There is a need to assess the impacts of the nuclear industry.

Environmental radiation Monitoring measurements may need to satisfy at least one of the several objectives :-

1- To assess pollution effects on man and his environment.
2- To obtain a historical record of environmental quality and provide a data base for future use in, for example, epidemiological studies.
3- To study and evaluate pollutant interactions and patterns.
4- To follow long-term trends.
5- To provide public assurance.
6- To demonstrate compliance with statutory limits and practice.
7- To establish and activate the emergency procedure.

Sources of natural and artificial radionuclides in different components of the environment (water, rock, soil, plant.....) are discussed below in details. Using of environmental sampling as safeguard tool is also discussed below in this chapter. The natural and international radioactivity levels in the environment are also surveyed.

1-1 NATURAL RADIOACTIVITY AND NATURAL RADIATION SOURCES

All material, living and dead contain at least traces of natural radioactivity. The relative abundance of the natural radioisotopes in the present terrestrial reservoirs are directly derived, though modified during geological time, from the isotopic composition at the time of formation of solar system.

Natural radioactivity is not distributed uniformly throughout the earth. For example, most mineral springs contain high concentrations of radium and its daughter, radon, with concentration about a million times greater than in normal water supplies. Similarly areas in Brazil and India demonstrate whole populations living on alluvial deposits of monazite sand containing 0.1 % thorium and its daughters. This lack of homogeneity, however, is an inverse function of the general chemical and physical uniformity of each terrestrial system so that the effect decreases from the earth's crust to oceans to the atmosphere, as mixing efficiencies increase.

Natural Radiation sources are classified into three components [1, 2]:

1- Cosmic rays,
2- Cosmogenic radionuclides.
3- Primordial radionuclides.

1-1-1 Cosmic rays :

It is classified into primary cosmic ray and secondary cosmic ray. The primary cosmic rays are coming from the outer space with high energy radiation. the primary cosmic ray are divided into :

a- Primary galactic cosmic rays which are high energy, and smaller portion of electrons, photons and neutrons.
b- Primary solar cosmic rays consisting mainly of protons and alpha particles that are released during solar flares.
c- Secondary cosmic rays which are produced through the interaction of the primary cosmic rays with atoms in the earth's atmosphere. They consists of electrons, meson and other reaction products.

1-1-2 Cosmogenic radionuclides :

A number of radionuclides that exist on the surface of the earth and in the atmosphere have been produced by the interaction of cosmic rays with atmospheric nuclei. The major production of cosmogenic radionuclides results from the interaction of cosmic rays products with the atmospheric gases. These radionuclides have half-lives ranging from minutes to millions of years. The most important of these radionuclides are ^{3}H, ^{14}C, and ^{7}Be, and of minor importance