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Estimation of Absorbed dose Results from Radioactive Waste Sampling

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Abstract

There has been great concern about the health risks associated with exposure to radioactivity present in soil, thus In this present study, absorbed dose rate measurements were carried out at some selected samples of contaminated soil. The purpose is to examine to what extent such measurements can be used to delineate the effect radiation to the workers and to assess the radiation risk of radioactive waste management personnel by calculating the annual dose of external radiation exposure and the amount of radioactive dose absorbed by the workers. Ludlum detector used to measure the exposure dose rate (μR/h). The germanium system was used to analyze the samples collected from the decontamination processes, the activity concentration ranged from (1026.21 to 25961.5) Bq/kg. The value of the annual dos rate vary between (5.55E-05 to .40E-03) Sv/h.

Keywords: External dose rate; Absorbed Dose rate; Activity concentration

Introduction

Radioactive waste (RW) generated from various processes related to nuclear programs. As well as industrial, agricultural and scientific research and oil and gas extraction fields, as well as by increasing the natural radioactivity of natural radionuclides in the soil from the permissible limits [1]. These isotopes can seep into the soil due to natural or abnormal factors (neglect), lack of knowledge to deal with them, as well as ignorance of radiation protection methods. The risk of such cases leads to exposure to radiation. Therefore, the two main pathways that lead to exposure to radiation to the general public are external exposure to radionuclides deposited on the ground and internal exposure by eating contaminated food produced in polluted

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areas. It is very important to assess environmental pollution as well as the risks of external and internal exposure caused by these possibilities for the purpose of radiation prevention and public health. On the other hand, the risk of external exposure near residential areas has become a key issue for ensuring the safety of life.

Therefore, in order to assess current environmental pollution and contributions from external exposure due to radioactive radioactive radionuclides contaminated with soils and therefore should be treated as contaminated areas and decontamination operations may be used and decontamination activities to achieve several objectives, such as reducing exposure to occupational radiation, reducing potential release of contaminants into the environment, allowing reuse of components, and facilitating waste management. For effective management properly, acceptance requirements, standards or waste specifications must be implemented for further waste treatment and general protection criteria for occupational radiation. [2]. The main purpose of the safety assessment is to determine whether an appropriate level of safety of a facility or activity has been achieved and whether the basic safety objectives and safety standards developed by the designer, operator, and regulator have been met.

The objective of this paper is to calculate the rate of absorbed dose in selected soil models and their effect on workers. The unit used to measure the absorbed dose is gray (Gy).

Method

For the evaluation of external radiation exposure, undisturbed surface soils were collected by a core sampling technique (12 samples at soil depths of 0-5 and 5-10 cm). The quantity of soil collected in each sample was 500 g. After collection, all samples were dried by a fixed temperature dryer (12°C, 24 h) and sieved for pebbles and organic materials (2 mm) before measurement of radionuclide activity. After preparation, samples were put in plastic containers made of polypropylene and analyzed with a high-purity germanium detector (ORTEC, Ortec International Inc., Detector efficiency calibration for different measurement geometries was performed using mixed activity standard volume sources (mix standard sample).

The relative detection efficiency of this instrument was 40%. The calibration was carried out by counting standard radionuclides of known activities with well-defined energies within the energy range of interest from 60 keV to 2000 keV and used standard source for efficiency calibration of a gamma-ray spectrometer in measuring large volumes of low specific activity materials [4]. Sample collection, processing, and analysis were executed in accordance with standard methods of IAEA.

The following steps have been adopted:

1. Measurements of specific activity

The activity concentration of radionuclide at the soil was measured using spectrometer with a coaxial high purity germanium detector (GC2018-7500 SL). It has a relative efficiency of 40%, and a resolution of 1.8 keV for 1332 keV gamma-ray emission of 60Co. Gene software for gamma spectrum analysis a gamma spectrometer and relevant accessories were supplied by [5].

2. Doses from external exposure

The external exposures, kinds of radiation of concern are those sufficiently penetrating to traverse the overlying tissues of the body and deposit ionizing energy in radiosensitive organs and tissues. Penetrating radiations are limited to photons, including bremsstrahlung, and electrons.

The radiation dose depends strongly on the temporal and spatial distribution of the radionuclide to which a human is exposed.

The external dose from exposure to radionuclides in the soil can be calculated with the following equation [6]:

Equation

$$D_{EXT} = C_{soil} * \rho_{soil} * DCC_{EXT} * H$$

Where,

D_{jext} is the dose from the j-th radionuclide via external exposure [Sv/y],

C_{jsoil} is the concentration of the j-th radionuclide in soil [Bq/kg],

ρ_{soil} is the soil density [kg/m^3],

H is the exposure time to external radiation [h/y],

DCC_{jext} is the dose coefficient for external exposure of the j-th radionuclide [Sv/h per Bq/m^3] [7].

The value density of the soil is 1600 kg/m^3, dos conversion Coefficients (DCC) is 1.3E–13 Sv/h per Bq/m^3) for external exposure.

While the exposure time for the worker in the field (radiation characterization) per year is 260 hours.

3. Absorbed Dose Rate

Absorbed radiation dose at selected of the contaminated soil samples, were measured using a survey meter. Ludlum Model 19 Micro R Meter, USA was used to measure the gamma dose rates at 1 meter above the ground of sampling location.

The instrument has linear energy responses to gamma radiation between 0.08 and 1.2 MeV [8]. It covered the majority of gamma-ray emissions from major sources. The instrument uses scintillator, 2.5 × 2.5 cm (1 × 1 in.) (Dia × L) thick Nal.

The survey meters were calibrated at the Malaysian Nuclear Agency, which is recognized by the IAEA as a Secondary Standards Dosimetry Laboratory. The meter display was in microroentgen per hour (μR h^{-1}). The gamma dose rate in unit μR h^{-1} was converted to unit μGy h^{-1} (1 μR h-1=0.00964 μGy h^{-1}).

A radionuclide, ingested or inhaled, and distributed in various parts of the body.

One can measure the absorbed dose rate in the medium by using formula (1).

Absorbed dose (nGy/h) in medium=Dose rate (μR/h)* 9.64E-3 (1)

Many radionuclides follow specific metabolic pathways, acting as a chemical element, and localize in specific tissues. If an internally deposited radionuclide emits particles that have a short-range, then their energies will be absorbed in the tissue that contains them. The rate of energy absorption per gram tissue is AE (MeV $g^{-1}s^{-1}$).

The absorbed dose rate calculated using equation [9]:

$$D = 1.60 * 10^{-10} * A * E \; Gy \; s^{-1}$$

Where

D. is the absorbed dose rate in $Gy.s^{-1}$, A is the average concentration, in Bq g^{-1}, of the radionuclide in the tissue and E is the average beta-particle energy, in (0.696 MeV per disintegration).

Results and Discussion

Exposure to ionizing radiation may cause biological hazards to workers in the processes and practices of radioactive waste management, including the removal of areas contaminated by industrial isotopes due to poor control of radiation or unintentional neglect.

The method has been used to calculate the absorbed dose rate and annual dose rate of gamma dose rate in this study area by taking specific models. The reading was taken from far at 50 cm from the radioactive waste sample by using Ludlum detector. The exposure dose rate of gamma ranges was from 103 to 5560 µR. h^{-1} as shown in **TABLE 1.**

TABLE 1. **Data base of external exposure dose.**

Item	Dose Rate (µR/h)	Activity concentration (Bq/kg)	External dose (Sv/y)
1	103	6649.57	3.60E-04
2	920	7551.30	4.08E-04
3	228	3074.75	1.66E-04
4	325	6014.65	3.25E-04
5	135	1026.21	5.55E-05
6	5560	25961.5	1.40E-03
7	650	7012.73	3.79E-04
8	730	7724.24	4.18E-04
9	458	5305.125	2.87E-04
10	320	4077.77	2.21E-04
11	830	8613.62	4.66E-04
12	924	9449.64	5.11E+00

The annual external radiative exposure values for the workers were from (5.55 E-05 to .40E-03) Sv/h. In view of the calculated values, we conclude that the readings are within the permissible limit of exposure of workers, which is 20 mSv/y approved in the publications of the International Atomic Energy Agency (IAEA) and the International Commission on Radiological Protection (ICRP).

From **FIG. 1** one can show the value of annual external dose rate in a sample (6) is the higher value and value of sample (5) is the lower value. The values of the absorbed dose were among the values that are not of concern and are among the permissible values. The value of absorbed dose one can show in **TABLE 2.**

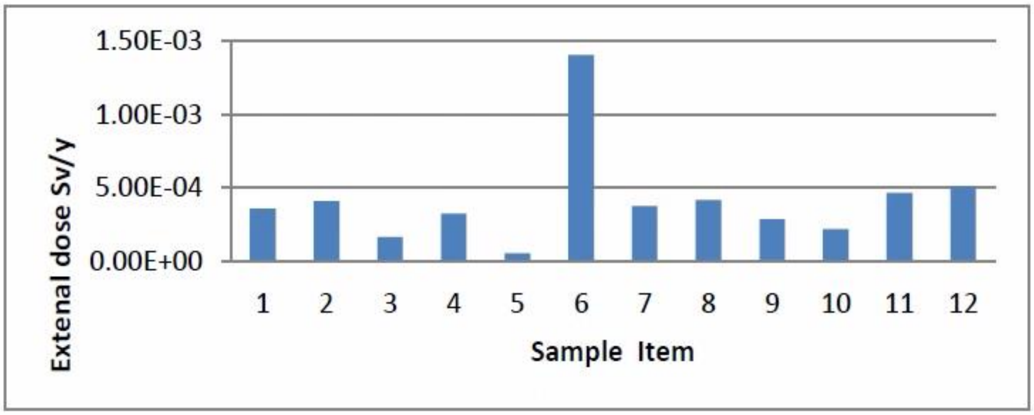

FIG. 1**: The external dose rate value of the sample.**

TABLE 2. **The value of absorbed dose rate.**

Sample Item	Exposure Dose Rate (µRlh)	Absorbed dose rate (nGy/h)
1	103	988.8
2	920	8832
3	228	2188.8
4	325	3120
5	135	1296
6	5560	53376
7	650	6240
8	730	7008
9	458	4396.8
10	320	3072
11	830	7968
12	924	8870.4

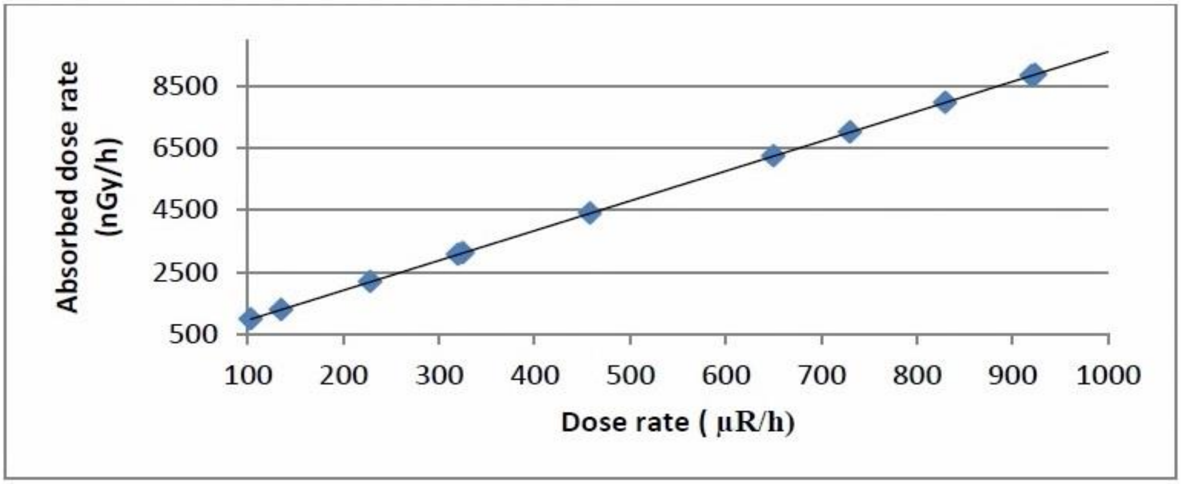

FIG. 2: **The relation between Absorbed dose rate and exposure dose rate of the sample.**

From **FIG. 2**, we observe a direct increase between the values of radiation exposure and the absorbed dose from exposure to the workers.

Finally, all values for the external exposure or the dose allowed for workers resulting from dealing with the radioactive waste under study are within acceptable limits.

Conclusion

One of the main things in dealing with radioactive materials and their waste is to know the method of measurements of conducting field radiation, in addition to the measurements of the samples of contaminated models and the method of analysis in the right way. From this, we will ensure the safety of workers in the field of radiation or in the laboratory of the risk of unjustified radiation exposure.

In this work, we note from the attached results, whether related to radiological doses from different types of radiological analysis of the models taken from the work area, not found any radiation exposure to the workers requires other operations to ensure the safety of workers, in comparison with [10,11].

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