Radiation Survey of an Area Suspected to be Contaminated by Depleted Uranium Released from Industrial Radiography Camera

Abstract

This case was undertaken to measure and identify radiation contamination in soil samples consist of waste generated from industrial radiography camera . Another aim of the present work is to raise awareness of the hazards of radiation among the public and worker of industrial radiography testing. Handheld radiation survey meters and gamma spectrometry based on high-purity germanium detectors (HPGe) have been used for radioactivity measurement. The survey has resulted in the detection of ^{238}U, ^{235}U and ^{137}Cs in the samples. The values of ^{238}U and ^{137}Cs lie within the range 7.780-88.665 Bq/kg and 0.720-11.730 Bq/kg with an average value of 33.003 ± 21.023 Bq/kg and 3.719 ± 2.767 Bq/kg respectively. The average value of the ^{238}U in the current investigation was found to be higher than the reported world-wide data35 Bq/kg. ^{235}U was detected in 9 samples out of 18 samples and ranged from 5.23-104.160 with an average value of 23.199 ± 32.072 Bq/kg. On the other hand, depleted uranium (DU) was investigated and found to be in 9 samples out of 18 on the basis of the natural $^{235}U/^{238}U$ activity ratio that was determined to be 0.046. The presence of depleted uranium could be attributed to the depleted uranium which are used in shielding of ^{192}Ir in industrial radiography cameras. Based on the results, it can be concluded that the waste generated from industrial radiography cameras constitutes a serious source of DU contamination.

Keywords: ^{238}U; ^{235}U; ^{137}Cs; Radiographic cameras and soil

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Introduction

Radiological pollution is an existence of undesirable radioactive materials into the environment (air, water, earth) as a result of human activity [1]. Such pollution presents risk due to the radioactive decay of the pollutants, that emit dangerous ionizing radiation [2]. The level of risk is evaluated by the concentration of the pollutants. It is significant to be clear that the contamination gives rise to the radiation hazard [3].The application of radiation technology in the Sudan has been growing rapidly since the beginning of oil extraction, because it has many uses in the petroleum industry (e.g. in well logging pipelines and quality-control tests for welding inspections). Industrial radiographic tests have recently become very popular in the Sudan in different industrial quality-control applications e.g. steel manufacturing, concrete construction etc. Such applications require highly stringent radiation protection programmes in order to protect the workers, the public and the environment due to the inherent health risks of such material. Many radiological pollution instant globally taken places have caused serious injury to workers and the public [4]. Cameras used in industrial radiography are shielded with depleted uranium for gamma ray attenuation, an ideal metal for such a task due to its high atomic number (92). Many workers have observed black waste coming loose from cameras during the cleaning process; however, this has raised no concerns. Over long times in which the industrial radiography cameras have been repeatedly cleaned, a considerable waste has been released and spread out in the soil over a wide area, and contamination monitors have indicated that high radiation background has observed. This work intends to identify the presence of depleted uranium that might be released from the industrial radiography cameras. Finally, this survey will help the radiation worker to conserve the safety and protection against DU.

Materials and Methods

Study area nd samples collection

Surface soil samples were collected from 20 points at a depth of 10 cm covering an area of 1000 m^2 using a grab oil-sampler. The radiation survey meters Radiagem 4000 and RADOS-120 were used to identify the area of high radiation level. These dosimeters were previously calibrated at the Secondary Standard Dosimetry Laboratory (SSDL) of the Sudan Atomic Energy Commission. The calibration factor for Radiagem 4000 was 0.89 μSv/h, while that for RADOS-120 was 0.88 μSv/h. The background radiation was measured in three different environments, far away from any artificial source. The samples were collected in plastic bags, transported to the laboratory and stored in plastic bottles for analysis [5].

Radioativity measurement

Radioactvity concentrations in the samples were measured using the gamma-ray spectrometry system equipped with high-purity germanium detectors (HPGe) of 20% relative efficiency and 2 keV relative resolutions. The detector was calibrated in terms of energy and efficiency for 500 ml Marinelli geometry using custom mixed gamma standard with a serial number MW 651 and MW 652 from International Atomic Energy Egncy (IAEA). The samples were counted for 24 h and the spectra were saved in a computer hard disk for further analysis. The analysis of the gamma spectra was carried out using Gamma-200 software package provided by Silena International. The measurement has resulted in identified gamma-emitting radionuclide from ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs The activity concentration of 228U and ^{232}Th were calculated from their progeny photo peaks: ^{214}Bi (609 keV) and ^{214}Pb (352 keV), and 228Ac (911 keV), ^{208}Tl (583 keV) respectively. ^{235}U was determined from the photo-peaks of (143.77 keV) keV. The activity of ^{40}K, and ^{137}Cs was measured directly through their gamma-energies and 662 keV, 1461 respectively, for comperhinsive deitals of samples measurement see refernaces [6,7].

Results and Discussion

Table 1 presents the backround activity concentration of ^{238}U and ^{137}Cs. These measurement were measured before as baseline data for the area monitoring. In the currnt case the survey has resulted in identified gamma-emitting radionuclide from ^{238}U, ^{235}U and ^{137}Cs as shown in Table 1. In these measurements, close observation at individual data site revealed that there are remarkable variations seem in activity concentrations of ^{238}U and ^{137}Cs. The values of ^{238}U lie within the range 7.780-88.665 Bq/kg with an average value of 33.003 ± 21.023 Bq/kg Activity concentration of the anthorpoginc radionuclide ^{137}Cs ranged from 0.720-11.730 Bq/kg with an average value of 3.719 ± 2.767 Bq/kg as shown in as shown in Table 1. It has been reported that the activity concentaration of ^{238}U in the studied area before contamination ranged from 14.242 ± 4.919 Bq/kg with an average value of 14.242 ± 4.919 Bq/kg as shown in Table2. The Significant concentrations of ^{238}U and ^{137}Cs indicates the presence of contamination. The world average value for ^{238}U in surface soils were 35 Bq/kg. Which means that the average value of ^{238}U in this study is much higher than the reported world-wide data [8]. Upon comparing the results of ^{137}Cs with global data it was found that the obtained values of ^{137}Cs after contamination are far below the reported range investigated by many researcher around the world [9-11]. However, the range of ^{137}Cs concentrations observed in this study is significantly high relative to similar data reported from Libya 0.9 - 1.7 Bq/kg [12]. ^{235}U was detected in 9 samples out of 18 samples and ranged from 5.23 - 104.160 with an average value of 23.199 ± 32.072 Bq/kg.Moreover , depleted uranium (DU) was investigated on the basis of the natural 235U/238U activity ratio that was determined to be 0.046 . Only if the obtained ratio is higher than the given value can the presence of DU be recorded [6-13]. DU was detected at 9 ut of 18 samples see Table 1. The presence of depleted uranium coud be attrabited to the depeletd uranium which are used in shielding of ^{192}Ir in industrial radiography cameras. Of course, DU has had a wide range of peaceful applications, such as the provision of radiation shielding for medical sources, industrial radiography cameras, or as counter weights in airplanes [14]. Contamination of soil with DU has increased public health concerns due to the chemical toxicity of DU at elevated dosages [15]. Inhalation of DU aerosols are recognized as a distinct human health hazard and have been suggested to be responsible in part for illnesses of populations that may exposed [16]. Thefore DU was removed from contaminated area using decontamination equipment, and transportation to a radioactive waste management facility for conditioning. The main problem associated with radioactive waste is the fact that it cannot be degraded or treated chemically or biologically. Therefore, the only options are to contain the waste by storing it in tightly closed containers shielded with radiation-protective materials such as lead [16]. For the more safety preventive measures were carried out to ensure that background radiation levels do not exceed the permissible limits.

Table 1: The average concentrations with associated standard deviations of ^{238}U, ^{235}U, ^{235}U/ ^{238}U and ^{137}Cs in soil samples contaminated with waste from industrial radiography camera.

Samples	^{238}U	^{137}Cs	^{235}U	^{235}U/^{238}U
1	66.715	6.9	44.92	0.673
2	23.36	2.47	Not detected	Not detected
3	40.135	2.96	Not detected	Not detected
4	30.95	4.6	Not detected	Not detected
5	63.28	2.29	Not detected	Not detected
6	29.91	3.26	Not detected	Not detected
7	16.48	4.65	5.23	0.317
8	29.68	3.39	Not detected	Not detected
9	33.86	3.15	Not detected	Not detected
10	40.3	1.6	Not detected	Not detected
11	22.82	3.13	49.11	2.152
12	23.2	2.63	Not detected	Not detected
13	11.81	2.37	25.76	2.181
14	11.81	3.1	54.91	4.649
15	88.665	8	104.16	1.175
16	31.72	11.73	82.4	2.598
17	21.575	Not detected	32.4	1.502
18	7.78	0.72	18.7	2.404
Min	7.78	0.72	5.23	-
Max	88.665	11.73	104.16	-
Average	33.003	3.719	23.199	-
Std	21.023	2.767	32.072	-

Conclusion

From the measurements of radionuclide activity concentrations in soils from aera contaminated by the waste from industrial radiographic camira , the external radiation exposure from the ground has been calculated. To sum up, the following conclusions canbe drawn:

a. The waste generated by industrial radiography camera constitute a serious source for public and worker exposure to depleted uranium.

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b. The average value of ^{238}U in this study is higher than the reported world-wide data (UNSCEAR) which is 35 Bq/kg.

c. Depleted uranium was detected at 9 location base on $^{235}U/^{238}U$.

d. Legislation making radiation monitoring of maintenance of industrial radiography in the country mandatory in order to protect workers and the public from the dangers posed by DU contamination.

Table 2: The background activity concentration around the industrial radiography unit before waste from industrial radiographic camera.

Location	^{238}U	^{137}Cs
1	23.91	2.04
2	8.9	< 0.720
3	14.24	< 0.720
4	11.496	< 0.720
5	21.72	< 0.720
6	10.91	< 0.720
7	10.92	< 0.720
8	11.13	< 0.720
9	14.26	< 0.720
10	14.93	< 0.720
Min	8.9	-
Maximum	23.91	-
Average	14.242	-
Std	4.919	-

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