MEASUREMENT OF GAMMA RADIATION LEVELS IN THE DUST OF KHAMASEEN STORM HITTING JORDAN ON 15-APRIL 2015

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ABSTRACT:

The activity concentration of ^{40}k, ^{232}Th, ^{238}U, ^{137}Cs and ^{7}Be were measured for 9 samples of Khamaseen dust which were collected from a Northern Jordan town called AL-Sarih 32°52′N, 35°88′E lies 607m above sea level. High purity germanium (HPGe) spectrometer coupled to a PC was used to analyze the obtained gamma-ray spectra. The activity for each 9 samples was obtained and corrected for efficiency and background. The results showed that dust was radioactive. Considerable deposition of ^{137}Cs was observed reaching 12.9±3.1 Bq.Kg^{-1}. A high level of ^{7}Be of Cosmogenic origin at 580.9±191.5 Bq.Kg^{-1} was measured. The activity of ^{40}K was 600.8±261.5 Bq.Kg^{-1}. The activity of ^{232}Th and ^{238}U were 28.0±3.4 and 32.4±3.4 Bq.Kg^{-1} respectively.

Keywords: Sand Storm, Radioactivity, Concentration, HPGe,, Jordan , Khamseen.

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1. Introduction

There are three main types of Occurring Radioactive Materials: primordial, cosmogenic, and human produced. These three sources all produce a part of the earth's natural background radiation. The background radiation level varies across the world. In most parts of the world it is at a safe level, with no ill effects on humans or nature, however it is of utmost importance to be able to determine levels of background radiation, and to distinguish between safe and unsafe levels as well as to determine causes of each type of radiation (UNSCEAR, 2000).

Primordial radionuclides are radioactive materials that have been on earth since its formation. The most important for the purposes of radiation protection are those in the uranium-238 and thorium-232 decay series, and potassium-40. The daughter nuclei that result from the decay of primordial radionuclei are referred to as radiogenic nuclei or sometimes secondary primordial nuclei (IAEA, 2007).

Cosmogenic radionuclides are radioactive materials produced in the earth's atmosphere by the decay of primordial materials and by interactions between particles in the atmosphere and cosmic radiation. ^{7}Be is formed by the action of cosmic rays on the atmosphere; Spallation (N and O is the production mode of the isotope) (SCOPE 50 - Radioecology after Chernobyl, 1993). Cosmic rays cause spallation when a ray particle (e.g. a proton) impacts with matter, including other cosmic rays. The result of the collision is the expulsion of large numbers of nucleons (protons and neutrons) from the object hit. This process goes on not only in deep space, but in Earth's upper atmosphere and crustal surface (typically the upper ten meters) due to the ongoing impact of cosmic rays (Lal,1958; Lal,1967).

Human produced radionuclides are radioactive materials resulting from various man-made sources such as the Hiroshima and Nagasaki explosions, as well as medical waste and waste from the nuclear industry, nuclear weapon tests and some nuclear accidents, most notably the Chernobyl disaster (International Atomic Energy Agency, 1988). The major human produced radionuclides are strontium-90, caesium-137 and polonium-239 (OECD Nuclear Energy Agency, 2002). Among the many fission product nuclides, cesium-137 deserves attention because it possesses a unique combination of physical properties and historical notoriety. It is readily produced in large quantities during fission, has an intermediate half-life, decays by high-energy pathways, and is chemically reactive and highly soluble. These physical properties made cesium

137 a dangerous legacy of major nuclear accidents such as Chernobyl, but it also caused relatively small incidents as well (International Atomic Energy Agency, 1997).

Each year during spring the Eastern Mediterranean including Jordan, are influenced by Khamaseen dust storms. The term Khamaseen signifies that the dust storms are repeated several times during a period of around 50 days starting late March and ending in early May. The Khamaseen dust storms are driven by the Mediterranean cyclones from west to east. In winter, moist cyclones generally move over the Mediterranean and do not penetrate deep into the North African Sahara. However, by the onset of spring, the Sahara surface becomes warmer; consequently a relatively lower air pressure prevails over the central Sahara. The cyclones thus penetrate deeper south within the Sahara and mobilize dust from its dry surface from Algeria and Libya towards the east and northeast over the Eastern Mediterranean countries, including Jordan. These cyclones start warm and dusty, and end cool to cold with varying amounts of precipitation that wash out the dust and clear the sky. (Kutiel and Furman, 2003; Abed et al., 2009).

The investigation of radioactivity in dust has received considerable attention from many researchers in various regions of the world (Hamed et al, 2012; Papastefanou et al., 1989; Papastefanou et al., 2001)

The aim of this research is to evaluate the concentration level of natural and artificial radionuclides in 9 samples collected from Northern Jordanian town called AL-Sarih 32°52′N, 35°88′E lies 607m above sea level during an event of khamaseen sand storm occurred on 15/April/2015.

The data reported here will contribute to establishing abaseline level of natural and artificial radioactivity in sand storm and help to develop future guidelines in the country and region for radiological protection of the population.

2. Materials and Methods

Dust samples were collected from a Northern Jordanian town called AL-Sarih 32°52′N, 35°88′E lies 607m above sea level. The dust spread in a thin layer coat over the town. Nine samples of dust were collected from different smooth flat surfaces on the top of selected apartment buildings in the town, labeled A, B, C , …I. The flat surfaces were cleaned in early

April (few days before the storm occurred) and samples were collected from all layers of dust. Sampling locations were within a radius of about 1.5 km from the center of the town.

The samples were placed in 100 mL cylindrical cups of 2 cm radius and 6 cm height and sealed to ensure secular equilibrium between Ra-226 and Ra-228 and their respective daughters. After equilibrium was reached, activity concentration measurements were performed using a high-resolution, high-purity vertical coaxial germanium detector (Canberra, Industries Inc., USA). The analyses were performed using Genie 2000 software. The detector energy resolution is 1.9 Kev at 1.33 MeV of C0-60 gamma ray peak and relative efficiency at same energy peak is 25%. The background radiation at the laboratory is discarded since the detector is dressed by a 100-nm thick lead cylindrical shell. The adjustment of the energy and relative efficiencies for the detector was performed using multi-gamma ray reference standard (MGS-5,Canberra, USA), which emits gamma rays in the range of 60-1461 keV. The samples were counted for 86000s to increase the statistical counting accuracy and standard reference materials IAEA-315 marine sediment and IAEA-375 soil were used to carry out quality control tests .

3. Results and Discussion

The average value of activity concentrations of the samples are listed in table 1. The results show that all the samples of dust are radioactive, radioactive nuclides are divided into three categories:

- **Artificial or fission products** ^{137}Cs was detected in all samples. The activity of ^{137}Cs varied between 9.6 ± 0.9 Bq.Kg^{-1} and 20.0 ± 2.5 Bq.Kg^{-1} with an average value (±SD) 12.9±3.1 Bq.Kg^{-1}.
  - **Cosmogenic origin ^{7}Be was detected in all samples**.

The activity of ^{7}**Be** varied between 387.7± 41.3 Bq.Kg^{-1} and 926.4 ±125.8 Bq.Kg^{-1} with an average value (±SD) 580.9±191.5 Bq.Kg^{-1}.

A terrestrial origin ^{40}K, ^{232}Th and ^{238}U were detected in all samples.

Activity for ^{40}K varied between 420.0 ±39 Bq.Kg^{-1} and 1163.9± 144.5 Bq.Kg^{-1} with an average value (±SD) 600.8± 261.5 Bq.Kg^{-1}. The activity of ^{232}Th varied between 22.8 ±3.4 Bq.Kg^{-1} and 34.2±7.4 Bq.Kg^{-1} with an average value (±SD) 28.0±3.4 Bq.Kg^{-1}. While the activity of

^{238}U varied between 29.0±5.1 Bq.Kg^{-1} and 36.4±8.9 Bq.Kg^{-1} with an average value (±SD) 32.4±3.4Bq.Kg^{-1}.

Comparison of the activity concentrations of ^{137}Cs, and ^{7}Be (Bq.Kg^{-1}) in this study with previous case studies are listed in table 2.

As can be seen from the table: The activity concentrations of ^{137}Cs reported her is decreasing with time to fit well with its half life time while ^{7}Be is changing randomly according to the sun activity at the study period.

Table 1: Table gives the average value of activity concentrations of the samples

Sample	^{137}Cs	^{40}K	^{7}Be	^{232}Th	^{238}U
A	10.8±1.2	760±65.8	552.8±56.8	22.8±3.4	31.0±5.7
B	20.0 ±2.5	1163.9 ± 144.5	926.4±128.8	34.2±7.4	36.1±8.8
C	12.6±1.2	423.5±42.9	832.1±87.6	27.7±4.6	36.4±8.9
D	12.3±1.2	420±39	445.1±46.7	29.5±4.1	31.2± 5.5
E	10.7±1.2	438.4±40.2	450.9±45.2	27.7±4.2	29.0±5.1
F	9.6±0.9	451.3±39.5	586.3±57.1	23.7±3.6	31.2±5.4
G	15.2±1.5	485.7±50.6	647.3±70.9	29.4±4.8	31.7±6.3
H	12.0±1.2	436.6±41.9	399.2±41.3	29.2±4.3	31.45±5.7
I	13.2±1.4	828±74.5	387.70±41.3	27.9±4.4	33.25±6.3
Average ± STDEV	12.9±3.1	600.8±261.5	580.9±191.5	28.0±3.4	32.4±3.4

Table 2: Table shows comparison of the activity concentrations of ^{137}Cs, and ^{7}Be (Bq.Kg^{-1}) in this study with previous case studies.

Reference	Place	Position	Date of event	^{137}Cs	^{7}Be

In this study	Al-Sarih, Jordan	32°42′N, 35°48′E	May/ 2015	17.0± 2.0	2930± 500
Hamed et al., 2015)	Aqraba, Jordan	32°43′N, 35°48′E	April/2012	12.9±3.1	581±192
(Papastefanou, 2001)	Thessaloniki ,Greece	40°38′N, 22°58′E	April/2000	26.6±4	4580±40
(Papastefanou, 1988)	Thessaloniki ,Greece	40°38′N, 22°58′E	April/1988	1006±5	2200±2

4. Conclusions

The dust storm which occurred on 15/April/2015 was investigated in the present work and was found to carry an appreciable amount of radioactivity. In particular, an appreciable amount of artificial ^{137}Cs was measured (12.9±3.1 Bq/kg). The enrichment of the activity concentrations of ^{137}Cs in dust was attributed, mainly, to the abundance of fine-sized particles and is consistent with reported enrichment in the literature. In addition, activity concentrations of cosmogenic ^{7}Be was detected (580.9±191.5 Bq/kg). However, dose assessment of ^{7}Be inhalation from dust showed that it will not contribute significantly to the internal human dose. Terrestrial radioisotopes were detected with activity concentrations: ^{232}Th (28.0±3.4 Bq/kg), ^{238}U (32.4±3.4 Bq/kg) and ^{40}K (600.8±261.5 Bq/kg).

5. References

[1] Abed, A. M., Al Kuisi, M., Abul Khair, H., 2009, Characterization of the Khamaseen (Spring) Dust in Jordan. Atmos. Environ., 43. 2868-2876.

[2] Hamed S. Hamadneh , Zaid Q. Ababneh, , Khadeejeh M. Hamasha,Anas M. Ababneh, 2015, The Radioactivity of Seasonal Dust Storms in the Middle East: the May2012 Case Study in Jordan, Journal of Environmental Radioactivity, 140, 65-69.

[3] Hutchinson, S. M., 1994, Radioecology after chernobyl: Biogeochemical Pathways of Artificial Radionuclides (Scope 50), Sir Frederick Warner and Roy M. Harrison (eds), John Wiley & Sons (Chichester).

[4] IAEA International Atomic Energy Agency, 1988, Principles for the Exemption of Radiation Sources and Practices from Regulatory Control, Safety Series No. 89, IAEA, Vienna .

[5] Kocherov, N., Lammer, M and Schwerer, O., 1997, "Handbook of Nuclear Data for Safeguards," International Atomic Energy Agency INDC(NDS)-376 .Vienna .

[6] IAEA International Atomic Energy Agenc, 2007, Naturally Occurring Radioactive Material (NORM V), Proceedings of an International Symposium, Spain, Seville.

[7] Kutiel, H., Furman, H., 2003, Dust Storms in the Middle East: Sources of Origin and their Temporal Characteristics, Indoor Built Environ., 12 (6), 419-426.

[8] Lal, D., Malhotra, P. K., Peters, B., 1958, On the Production of Radioisotopes in the Atmosphere by Cosmic Radiation and their Application to Meteorology, J. Atmos. Terr. Phys., 12, 306-328.

[9] Lal, D., Peters, B., 1967, Cosmic Ray Produced Radioactivity on the Earth, In: Flügge, S. (Ed.), Handbuch der Physik, XLVI/2. Springer-Verlag, NewYork, pp. 551-612.

[10] OECD Nuclear Energy Agency 2002, Chernobyl: Assessment of Radiological and Health Impacts: 2002 update of Chernobyl: Ten years on, report, NEA Comm. Radiat. Protect. and Public Health, Paris, France.

[11] Papastefanou, C., Manolopoulou, M., 1989, The Radioactivity of Colored Rain in Thessaloniki, Greece. Sci. Total Environ., 80 (2-3), 225-227.

[12] Papastefanou, C., Manolopoulou, M., Stoulos, S., Ioannidou, A., Gerasopoulos, E., 2001, Colored Rain Dust from Sahara Desert is Still Radioactive. J. Environ. Radioact, 55 (1), 109-112.

[13] UNSCEAR, 2000, Sources and Effects of Ionnizing Radiation. Report to General Assembly, United Nations, New York.