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Short communication

The radioactivity of seasonal dust storms in the Middle East: the May 2012 case study in Jordan

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ABSTRACT

Dust storms in the Middle East are common during spring. Some of these storms are massive and carry a large amount of dust from faraway regions, which pose health and pollution risks. The huge dust storm event occurred in early May, 2012 was investigated for its radioactive content using gamma ray spectroscopy. Dust samples were collected from Northern Jordan and it was found that the storm carried a large amount of both artificial and natural radioactivity. The average activity concentration of fallout ^{137}Cs was 17.0 Bq/kg which is larger than that found in soil (2.3 Bq/kg), and this enrichment is attributed to particle size effects. ^{7}Be which is of atmospheric origin and has a relatively short half-life, was detected in dust with relatively large activity concentrations, as it would be expected, with an average of 2860 Bq/kg, but it was not detected in soil. Despite the large activity concentration of ^{7}Be, dose assessment showed that it does not contribute significantly to the effective dose through inhalation. The concentrations of the primodial nuclides ^{40}K, ^{232}Th and ^{238}U were 547, 30.0 and 49.3 Bq/kg, respectively. With the exception of ^{40}K, these were comparable to what was found in soil.

1. Introduction

In general, the main source of external radiation to humans is from cosmic rays and terrestrial radiation. The terrestrial radioisotopes are mainly coming from uranium and thorium series as well as the potassium radioisotope ^{40}K. These radioisotopes enter the human body by consumption of food and accumulate in specific organs, e.g. uranium in the lungs and urinary organ, thorium in liver and skeleton, and potassium in the muscles (Khan, 2003). Cosmogenic beryllium-7 (^{7}Be) is a relatively short lived radionuclide (half-life = 53.3 day) and is produced in the upper troposphere and lower stratosphere by spallation reactions of light atmospheric nuclei of nitrogen and oxygen with high energy cosmic ray particles (Lal et al., 1958).

In addition to the natural radionuclides, humans are exposed to artificial radionuclides such as ^{90}Sr, ^{137}Cs and ^{239}Pu. These radionuclides are produced from various sources such as medical waste and waste from the nuclear industry, nuclear weapon tests and nuclear accidents such as Chernobyl and Fukushima. However, the largest single source of the artificial radionuclides was the fallout from atmospheric nuclear weapons testing in the 1950s and 1960s, which dispersed and deposited ^{137}Cs world-wide (UNSCEAR, 2000).

^{137}Cs is an artificial radionuclide that attracts the most interest by many researchers worldwide. Because of the chemical nature of cesium, it moves easily through the environment, which makes it difficult to clean up. Additionally, the chemical behavior of cesium is similar to that of potassium and rubidium. The ^{137}Cs normally is ingested with food, but associated with dust it can be directly inhaled, which might elevate the dosage in the body (Okumura, 2003).

Each year during spring, the Eastern Mediterranean, including Jordan, is influenced by dust storms (Kutiel and Furman, 2003; Abed et al., 2009). Locally, such storms are called Khamaseen which refers to the fact that such storms typically occur during a period of around fifty days beginning late March and ending early

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May (Abed et al., 2009). This kind of dust storm is usually precipitated with rain to produce colored rain (Kutiel and Furman, 2003). Dust and sand storms are a persistent problem delivering significant amounts of particulates via inhalation into the lungs (Griffin and Kellogg, 2004). The radiological health risks due to the inhalation of this dust are not well studied nor effectively characterized (Akbari, 2011). Thus monitoring the radionuclides from sandstorm events is important to assess the radiation dose to humans.

The investigation of radioactivity in dust storms has recently received greater attention from many researchers in various regions of the world (Akata et al., 2007; Fujiwara et al., 2007; Fukuyama and Fujiwara, 2008; Kondratiev and Skalyga, 2011; Menut et al., 2009; Papastefanou et al., 2001; Papastefanou and Manolopoulou, 1989; Prezerakos et al., 2010). In Jordan, several studies have been performed to measure the level of radioactivity in soil samples and its associated health hazard to population (Ababneh et al., 2012, 2009; Al Hamarneh et al., 2003; Al-Jundi, 2002; Alzoubi et al., 2013; Kullab, 2005). However, no attempt has been made yet to assess the radioactivity associated with dust storms in Jordan.

The aim of the present work is to estimate the level of natural and artificial radionuclides in samples from an exceptionally large dust storm collected from Northern Jordan. In addition, soil samples from the same region were analyzed for comparison purposes. Of particular interest is the potential enrichment of radionuclides in dust particles compared to soil particles.

2. Materials and methods

2.1. Sampling area and sample collection

On May 11 2012, a huge dust storm blew over the Middle East, particularly east of Damascus. The storm covered most of Syria, and extended into Iraq, Jordan, and Saudi Arabia (Fig. 1). The dust was thickest in the west, especially over Jordan and northern Saudi Arabia, and thinning toward the east (Fig. 1). Backward trajectory analysis was made using the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT-4) model developed by National Oceanic and Atmospheric Administration (Draxle, 2003). The analysis identified northwest of Iraq as the source of the dust particles. The source area features a large sand bed which provided plentiful material for dust plumes. Moreover, the source area is close to the Tigris and Euphrates floodplains which can feed the storm with fine sediments (http://earthobservatory.nasa.gov/IOTD/view.php?id=77914).

Dust samples were collected from a Northern Jordan town called Aqraba (32°43′N–35°48′E) which lies 370 m above sea level. The town was covered by a thin layer of dust. Seven samples of dust were collected from different smooth flat surfaces on the top of selected buildings in the town, labeled D1–D7. The flat surfaces were cleaned in early May (few days before the storm occurred) and samples were collected from all layers of dust. Sampling locations were within a radius of about 2 km from the center of the town. In addition to dust samples, seven soil samples from the

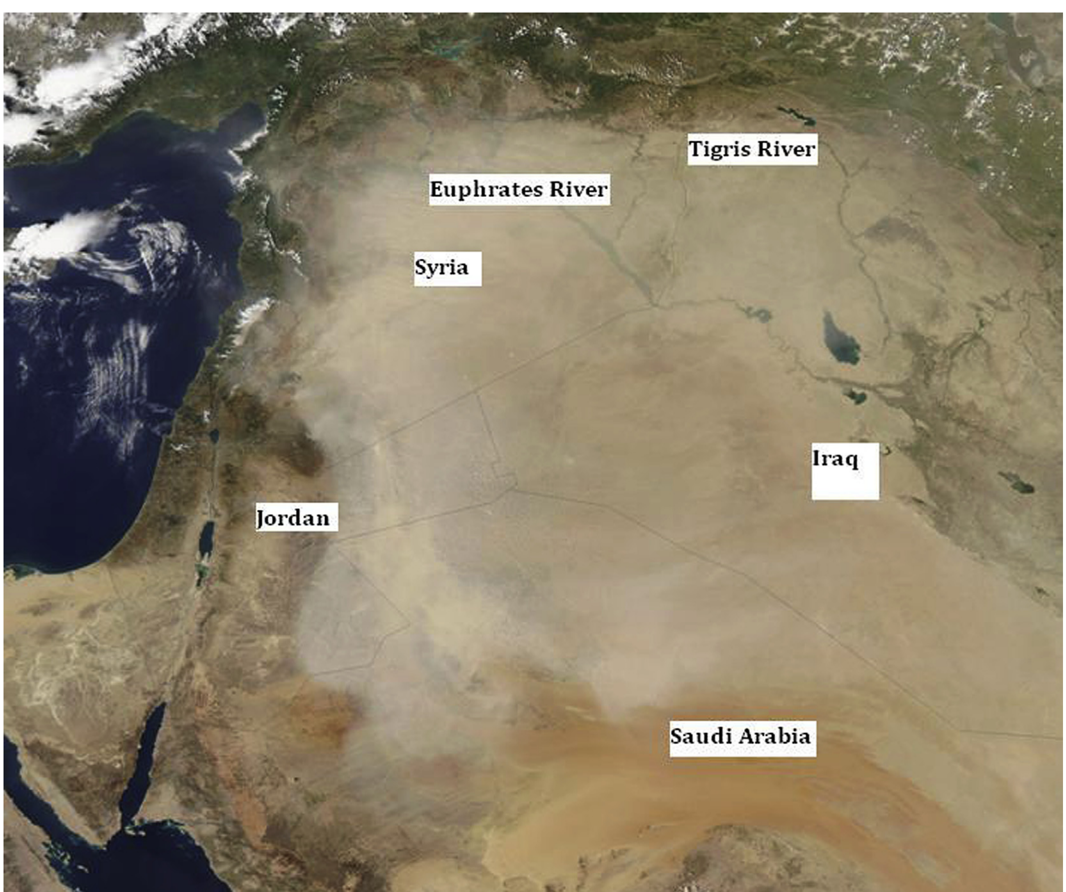

Fig. 1. A Massive dust storm sweeping across the Middle East on May 11, 2012. The storm covered most of Syria, and extended into Iraq, Jordan, and Saudi Arabia. True color MODIS/AQUA image from EOSDIS (NASA's Earth Observing System Data and Information System) URL: http://earthobservatory.nasa.gov/IOTD/view.php?id=77914). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)