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Assessment of Radionuclide Activity (238U, 232Th, 40K) in Airborne Dust from Dust Storms in Wasit and Al-Qadissiya, Iraq

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Abstract

General Background Dust storms in arid regions transport fine particulate matter containing natural radioactive materials that pose potential ecological and respiratory risks. **Specific Background** In Iraq, airborne dust events frequently carry radionuclides across various governorates. **Knowledge Gap** However, spatial variations in radionuclide activity across specific regions like Wasit and Al-Qadissiya remain insufficiently characterized. **Aims** This study quantifies uranium-238, thorium-232, and potassium-40 activity levels in airborne dust using microwave digestion and inductively coupled plasma optical emission spectrometry. **Results** Measurements revealed significant geographical heterogeneity, with potassium-40 reaching 3546.9 Bq/kg and uranium-238 peaking at 113.5 Bq/kg in Al-Qadissiya**. Novelty** This work establishes regional baseline radiometric profiles for dust storm events across specific Iraqi sites. **Implications** The findings emphasize the necessity of continuous environmental monitoring and public health safeguards during severe dust events.

Keywords : Dust Storms, Iraq, Natural Radionuclides, Radiological Health, Spectrometry Analysis

Key Findings Highlights

Radionuclide activity in airborne dust exhibits significant geographic variation across Iraqi governorates.

Dust samples from Al-Qadissiya showed peak concentrations of uranium-238 and potassium-40.

Measured radionuclide levels remain below international radiation safety limits.

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1. Introduction

Dust In dry and semi-arid regions of the world, one of the most vital environmental phenomena is dust storms, which conveyance massive amounts of fine particles over excessive distances and have detrimental effects on ecosystems, human health, air quality, and temperature [1], [2]. Due to the country's location, deserts, and lack of vegetation cover, dust storms are common in Iraq, particularly during the spring and summer [3]. Minerals, heavy metals, and naturally occurring radioactive materials (NORMs) including uranium, thorium, and potassium isotopes are frequently found in the airborne dust linked to these storms [4][5]. These radionuclides could be produced by geological developments or anthropogenic processes such as industries, military activities, and prior nuclear testing [6]. Numerous studies have established the airborne fine particulate matter related with dust storms (less than 50 µm) can penetrate the respiratory system and when augmented with radioactive elements can lead to respiratory diseases, cardiovascular problems, and increased risk of cancer [7], [8]. Alpha Radionuclides such as uranium-238 (238U) and thorium-232 (232Th) become entrapped in the lung tissues after inhalation that cumulative the internal radiation dosage [9]. An additional radioisotope like potassium-40 (40K), naturally augmented in clay minerals, significantly upsurges background radiation to an alike extent [10]. The Prior Middle Eastern Radiometric analyses have published mutable amounts of radioactive activity of the airborne of the dust. Some of the Notable radiological contributions of 40K have been documented in seasonal dust incidences in Jordan [12]. Simultaneously studies conducted in Baghdad and Ramadi that noted augmented 238U and 40K activity during sandstorms [11]. Equally important while typically in line with global safety guidelines, a recent study carried out in Hilla City, Iraq, described detectable concentrations of 238U, 232Th, and 40K in dust storm samples [13]. This research discloses the importance of tailored valuations since radionuclide concentrations can vary considerably between soil types, the storm intensities, and source sites [14]. The Preparation for the environment and public health necessitates an awareness of the radioactive gratified of dust storms, which are flattering more frequent and severe in Iraq. So, this study's objectives are to measure the amounts of ^{238}U, ^{232}Th, and ^{40}K in airborne dust samples taken during dust storm events from the governorates of Wasit and Al-Qadissiya, evaluate any possible health risks, and compare the findings with published research and international standards [15].

2. Materials and Methods

2.1 Study Area and Sample Collection

Five sites in Wasit Governorate (Sheikh Saad, Al-Hay, Al-Muwafaqiyah, Kut city center, and Al-Zahraa) and one site in Al-Qadissiya Governorate were used to gather dust samples. In order to prevent contamination, samples were collected during active dust storm occurrences using sterile plastic containers. After being gathered, the material was brought to the lab for processing and examination.**2.2 Sample Preparation**

Dust samples were oven-dried for 48 hours at 150°C to remove moisture. Following drying, one gram of each sample was weighed and digested using one milliliter of 35% hydrogen peroxide and nine milliliters of 65% nitric acid. A high-pressure microwave digestion system (Milestone Ethos UP, Italy) was used to process the samples. In just 15 minutes, the temperature was raised from 25°C to 200°C and the pressure was increased from 10 to 100 bar. Thirty minutes later, digestion was finished. After filtering, the digestate was diluted with 50 milliliters of deionized water.

2.3 Analytical Techniques (ICP-OES)

Trace elements in liquid samples can be found quantitatively using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). It can be used to analyze metals, ceramics, polymers, ambient water, and plating solutions because of its excellent sensitivity, dependability, and broad dynamic range [16]. The technique uses photons released by excited atoms and ions in an RF discharge. Solid samples frequently need extraction or acid digestion, but liquid and gas samples can be injected straight [17]. ICP-OES uses a high-temperature plasma to dry, evaporate, and excite the sample mist. After that, the atomic emission is gathered and sent to a device that selects wavelengths [18]. A sampler, pump, nebulizer, spray chamber, ICP torch, monochromator's/polychromatic, and detector are among the primary parts [19]. ICP-OES reduces detector overload and maintenance requirements by efficiently handling complex matrices with up to 5% dissolved solids. As a result, it is a trustworthy instrument for screening for trace elements and metals [20]. A spectrometer, detector, data processor, plasma generator, and sample introduction unit make up the system, which can be modified for a number of uses [16].

3. Results

The measured radionuclide concentrations in airborne dust samples are presented in Table 1.

Table 1. Activity concentrations of radionuclides in airborne dust samples

Sample Code	238U (Bq/kg)	232Th (Bq/kg)	40K (Bq/kg)
A001	12.103	0.1218	1125.978
B002	19.6365	0	1283.602
C003	54.34	0	1581.085
D004	36.9265	1.218	1894.072
E005	113.4965	1.5834	3546.863

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F006	31.2455	0.812	1881.798

Table 1.

Figure 1concentration of ^{238}U in the dust flaying samples

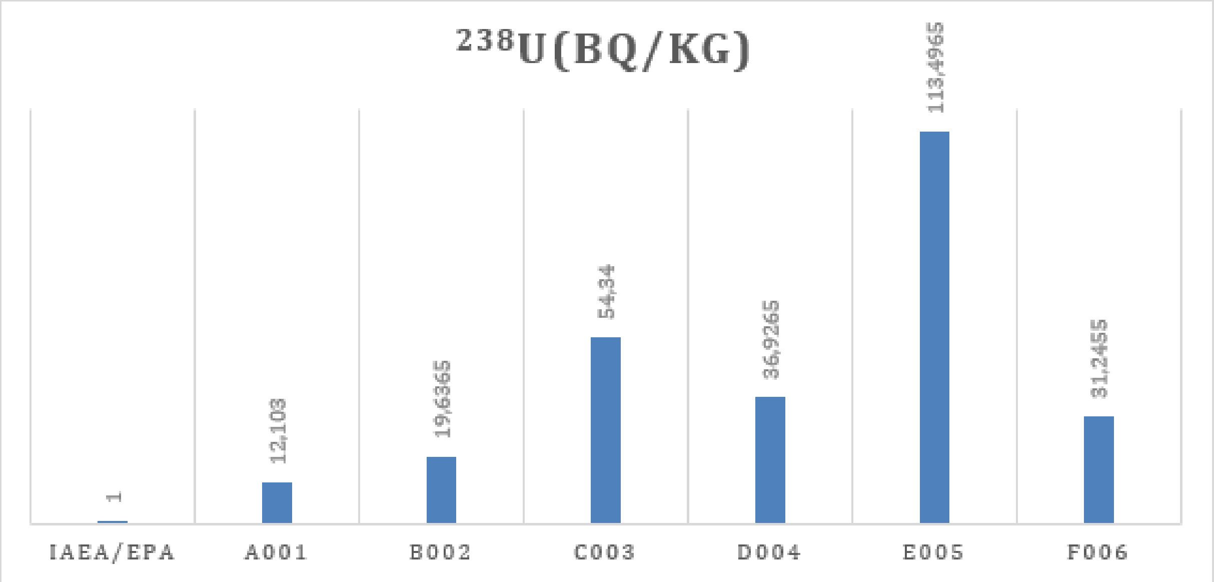

Figure 1.

Figure 2 concentration of ^{232}Th in the dust flaying samples

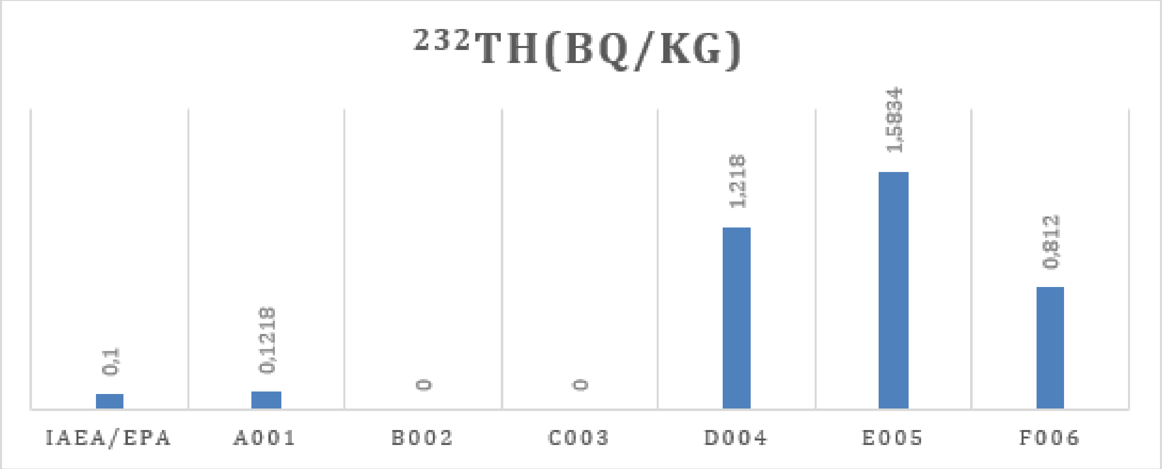

Figure 2.

Figure 3 concentration of ^{40}K in the dust flaying samples

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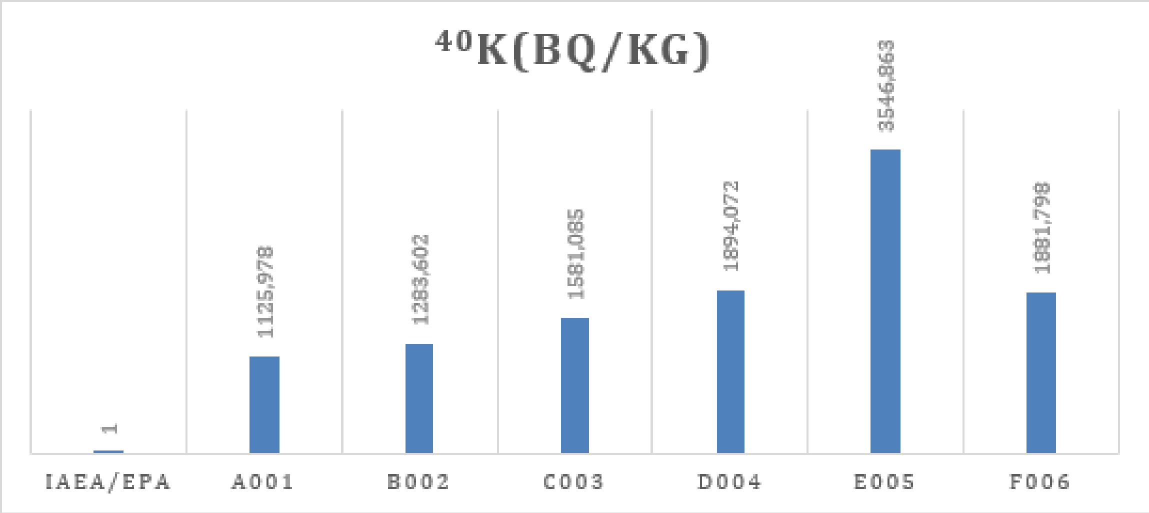

Figure 3.

4. Discussion

There were significant variances in ^{238}U, ^{232}Th, and ^{40}K contents amongst the sampling locations. In the Al-Qadissiya (Sample E005) has the maximum activity of ^{238}U (113.5 Bq/kg) and ^{40}K (3546.9 Bq/kg), they representing the potential geological or human influences. On the other hand, radioactive concentrations were lesser in samples from Kut and Al-Hay. Some samples (B002 and C003) do not comprise ^{232}Th, which could be a result of regional differences in soil composition. Potassium content in all the locations are similar to typical values found in silicate rocks and some clay minerals. This is consistent with prior research conducted using samples from Baghdad and Ramadi, which indicated higher concentrations of specific radioactive materials resulting from historical air pollution and natural weathering. On the contrary, results of this site are not homogeneous which is unexpected, bearing in mind that global research including studies from Jordan and Hilla have demonstrated that levels of these materials seemed to be at expected level range for Middle East. Of course breathing in the radioactive dust is dangerous – especially with alpha-emitting isotopes such as 232Th and 238U that can bioaccumulate in lung tissue and may increase cancer risk over a prolonged range of time. The implications of these data regarding long-term monitoring and public health measures, especially in the context of dust storms in Iraq are clearly significant. In fact, in some cases dust storms can worsen it and hence constant monitoring and measures should be taken to keep health of people at bay.

5. Conclusion

The present study demonstrated a heterogeneity in the distribution of radionuclide among airborne dust collected during duststorm events in Iraq. Radiative hazards on unprotected populations from 238U and 40K are suspected, due to elevated concentrations of the isotopes (especially in Al-Qadissiya) [11]. Although these feedbacks are still beneath international limits for safety, it is strongly advised to continuous monitoring, evaluate health hazards and adopt mitigation techniques like afforestation soil stabilization and public education programs.

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