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

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Abstract. In dry areas like Iraq, dust storms are a common occurrence that can have serious health effects on people. The radioactivity of dust particles gathered in the air during recent dust storms in the Wasit and Al-Qadissiya Governorates is assessed in this study. The levels of uranium-238 (^{238}U), thorium-232 (^{232}Th), and potassium-40 (^{40}K) were measured using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). The results showed significant geographical variation, with ^{40}K ranging from 1125.9 to 3546.9 Bq/kg, ^{232}Th from non-detectable levels to 1.58 Bq/kg, and ^{238}U concentrations from 12.1 to 113.5 Bq/kg. The highest ^{238}U and ^{40}K concentrations were found in Al-Qadissiya. These results emphasize the possible risks of dust inhalation for radiological health issues and the significance of ongoing environmental monitoring and public health readiness.

Highlights:

1. Highest uranium (^{238}U) and potassium (^{40}K) levels found in Al-Qadissiya indicate possible geological or human sources
2. All measured radionuclide values remain within international safety limits
3. Continuous environmental monitoring is vital to address long-term radiological health risks

Keywords: Dust Storms, Iraq, Radionuclides, ^{238}U, ^{232}Th, ^{40}K, ICP-OES, Radiological Health Risks.

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Introduction

Dust One of the most important environmental phenomena in arid and semi-arid regions of the world is dust storms, which carry massive amounts of fine particles over great 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) like uranium, thorium, and potassium isotopes are frequently found in the airborne dust linked to these storms [4][5]. Geological formations or human activity like industrial processes, military actions, and previous nuclear testing could be the source of these radionuclides [6]. Numerous investigations have shown that dust storm-borne fine particulate matter (less than 50 μm) can enter the respiratory system deeply and, when enriched with radioactive elements, can cause respiratory illnesses, cardiovascular issues, and an elevated risk of cancer [7], [8]. For example, alpha emitters such as uranium-238 (^{238}U) and thorium-232 (^{232}Th) can lodge in lung tissues after inhalation, increasing the internal radiation dosage [9]. In a similar vein, background radiation exposure is greatly increased by potassium-40 (^{40}K), an isotope that is naturally rich in clay minerals [10]. Variable amounts of radioactive activity in airborne dust have been recorded in earlier Middle Eastern investigations. Research conducted in Jordan revealed notable radiological contributions of ^{40}K in seasonal dust occurrences [12], whereas studies conducted in Baghdad and Ramadi noted increased ^{238}U and ^{40}K activity during sandstorms [11]. Furthermore, although often falling within international safety standards, recent research conducted in Hilla City, Iraq, found detectable activity concentrations of ^{238}U, ^{232}Th, and ^{40}K in dust storm samples [13]. Given that radionuclide concentrations might vary significantly based on soil type, storm severity, and source regions, these findings highlight the necessity of targeted assessments [14]. Planning for the environment and public health requires an awareness of the radioactive content of dust storms, which are becoming more frequent and severe in Iraq. Therefore, 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

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and Al-Qadissiya, assess any possible health risks, and compare the findings with published research and international standards [15].

Materials and Methods

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.

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.

Analytical Techniques

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-

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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].

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
F006	31.2455	0.812	1881.798

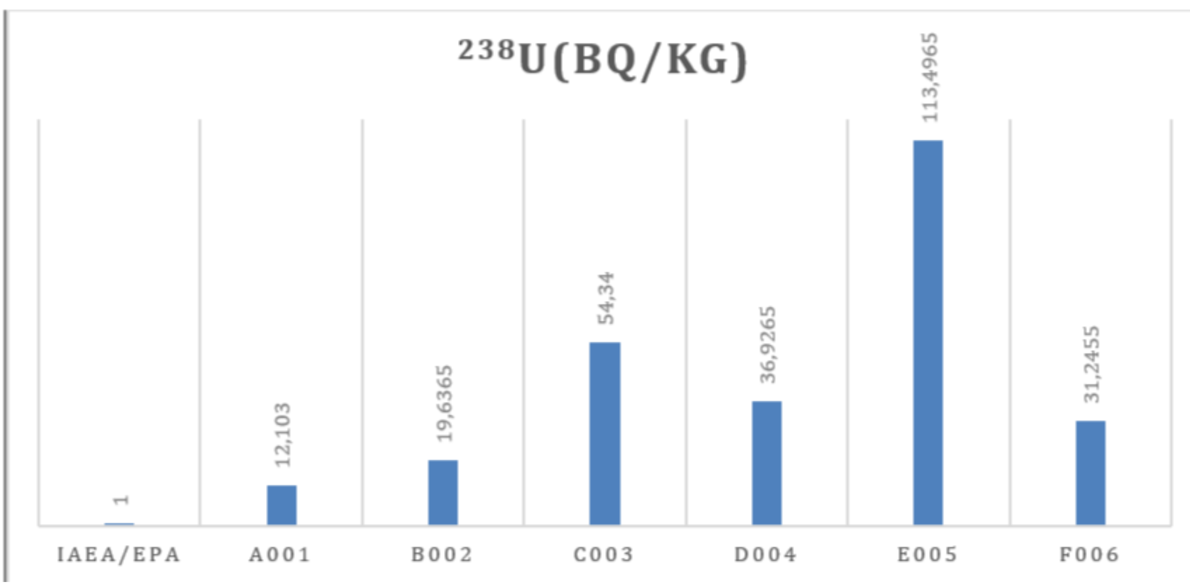

Figure 1. Concentration of ^{238} U in the dust flaying samples

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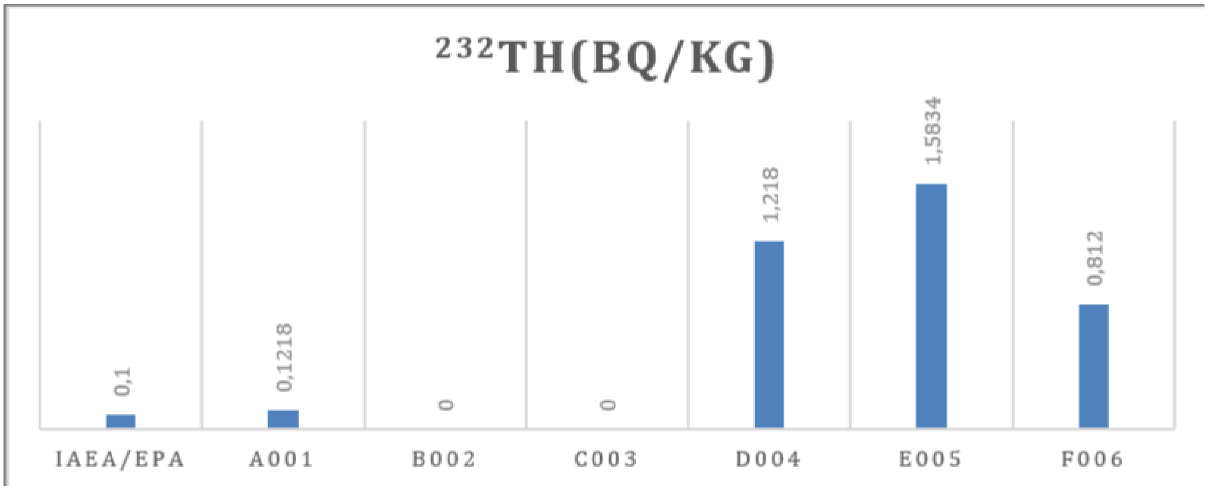

Figure 2. Concentration of ^{232} Th in the dust flaying samples

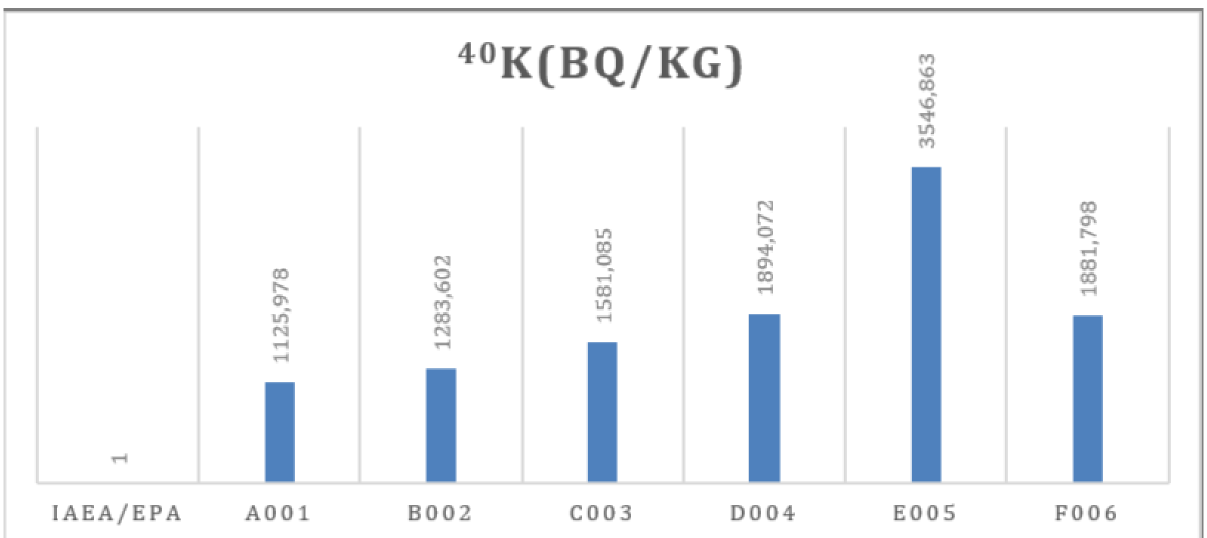

Figure 3. Concentration of ^{40} K in the dust flaying samples

Discussion

There were significant differences in 238U, 232Th, and 40K contents among the sampling locations. Al-Qadissiya (Sample E005) has the highest activity of 238U (113.5 Bq/kg) and 40K (3546.9 Bq/kg), indicating potential geological or human impacts. On the other hand, radioactive concentrations were lower in samples from Kut and Al-Hay. Some samples (B002 and C003) do not contain 232Th, which could be a result of regional variations in soil composition.

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The high potassium concentrations at all locations are in line with potassium's common presence in silicate rocks and clay minerals. These findings are consistent with research from Baghdad and Ramadi that found increased 238U and 40K activity as a result of previous air fallout and natural erosion. Although site-specific variability is highlighted, comparisons with worldwide research, including those carried out in Jordan and Hilla, show that the measured values fall within expected ranges for the Middle East. It is dangerous to breathe in radioactive dust, particularly alpha-emitting isotopes like 232Th and 238U, which can build up in lung tissues and raise the chance of developing cancer in the long run. Thus, during dust storm events in Iraq, the statistics emphasize the significance of long-term surveillance and public health actions.

Conclusion

The radionuclide distribution in airborne dust collected during dust storm events in Iraq is shown to be diverse in this study. Increased 238U and 40K concentrations, especially in Al-Qadissiya, raise the possibility of radioactive hazards for those who are exposed. Even if the recorded values are still within international safety limits, it is highly advised to conduct ongoing monitoring, evaluate health risks, and implement mitigation techniques such afforestation, soil stabilization, and public awareness programs.

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