Paper

# The Concentration of Uranium-238 in Soil Samples from the Central Maysan Governorate Determined Using ICP-MS

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*Abstract*—**In this particular investigation, 30 surface soil samples taken from various locations across the Middle Omara governorate in southeastern Iraq were analyzed using ICP-MS (inductively coupled plasma mass spectrometry), and several of these, as far as the researchers know, had never been analyzed previously. The results are presented and compared with those from a different study. The studied soil samples had <100 ppm of uranium, which shows they are composed of overloads and garbage rather than mineable stocks. This article describes and assesses the uranium content in the Middle Omara Governorates. Additionally, all 30 exposed earth samples had uranium below the detection threshold. The results show that the samples of surface soils under investigation have uranium concentrations below the permissible maximum (11.7 ppm) established by UNSCEAR in 1993.**
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**Key words: $^{238}$U; education, health physics; exposure, radiation; soil**

## INTRODUCTION

Uranium is found in the earth's crust and can also be found in different concentrations in sand, soil, and rocks in various regions of the planet. Uranium (U) is a heavy metal with a density of 18.95 g cm$^{-3}$ (1.7 times more than lead's density of 11.35 g cm$^{-3}$). Uranium is both a radioactive element and a chemical. The melting and points of metallic uranium are both quite high (1,132 °C and 4,131 °C), are chemically extremely reactive, and have a strength that is comparable with most steels (Algrifi and Salman 2023). There are three isotopes of uranium in nature. The percentages of $^{238}$U, $^{235}$U, and $^{234}$U in bulk are 99.276%, 0.718%, and 0.0056%, respectively (Salman and Fleifil 2015; Algrifi and Salman 2023). The earth's crust contains between 0.1 to 20 mg kg$^{-1}$ of the organic metal uranium, which occurs significantly more frequently than silver or gold, and human health may be harmed as a consequence. The greatest threat to health is not radiation exposure but rather uranium's chemical toxicity (Raji et al. 2023). The substance's toxicity can be contrasted with that of lead. Numerous earth science disciplines have made extensive use of chemical and isotopic uranium abundances to investigate both physical and biogeochemical processes (Algrifi and Salman 2023.). Low U concentrations and the predominance of $^{238}$U in most natural samples, however, limit many uses due to measuring difficulties. For measuring uranium radionuclides, alpha specimen techniques have been employed for five decades, but enormous sample needs and the introduction of equipment with noticeably improved performance and precision have rendered alpha counting methodologies outdated. To measure the concentration of uranium, inductively coupled plasma atomic emission spectrometry (ICP-AES) is widely used. However, several samples and extended testing times frequently produce trustworthy findings since uranium is extremely sensitive to these methods.

Furthermore, because of alpha spectrometry's accuracy, uranium levels can only be roughly calculated. Mass spectrometry's exceptional sensitivity and accuracy make it one of the best alternatives to earlier methods (Kaddhim and Ahmed 2014; Salman and Fleifil 2015). Examining all of the numerous connections, transactions, and dangers associated with soil samples is its main objective. The Middle Omara Governorate in Iraq is home to the research area (see Fig. 1).

## MATERIALS AND METHODS

### Collecting soil samples

Thirty samples of soil were distributed at a depth of 5–15 cm in Omara Governorate, a study location in the Middle Omara, as follows: Awash 1, Awash 2, Awash 3, Awash 4, Awash 5, Hay alhussain alkadeem 1, Hay alhussain alkadeem 2, Hay alhussain alkadeem 3, Police station 1, Police station 2, Police station 3, Police station 4, Police station 5, Maysan games city, Alrafidain water project 1, Alrafidain water project 2, Alrafidain water project 3, Al omarat Al kadeema 1, Al omarat Al kadeema 2, Al omarat Al kadeema 3, Al omarat

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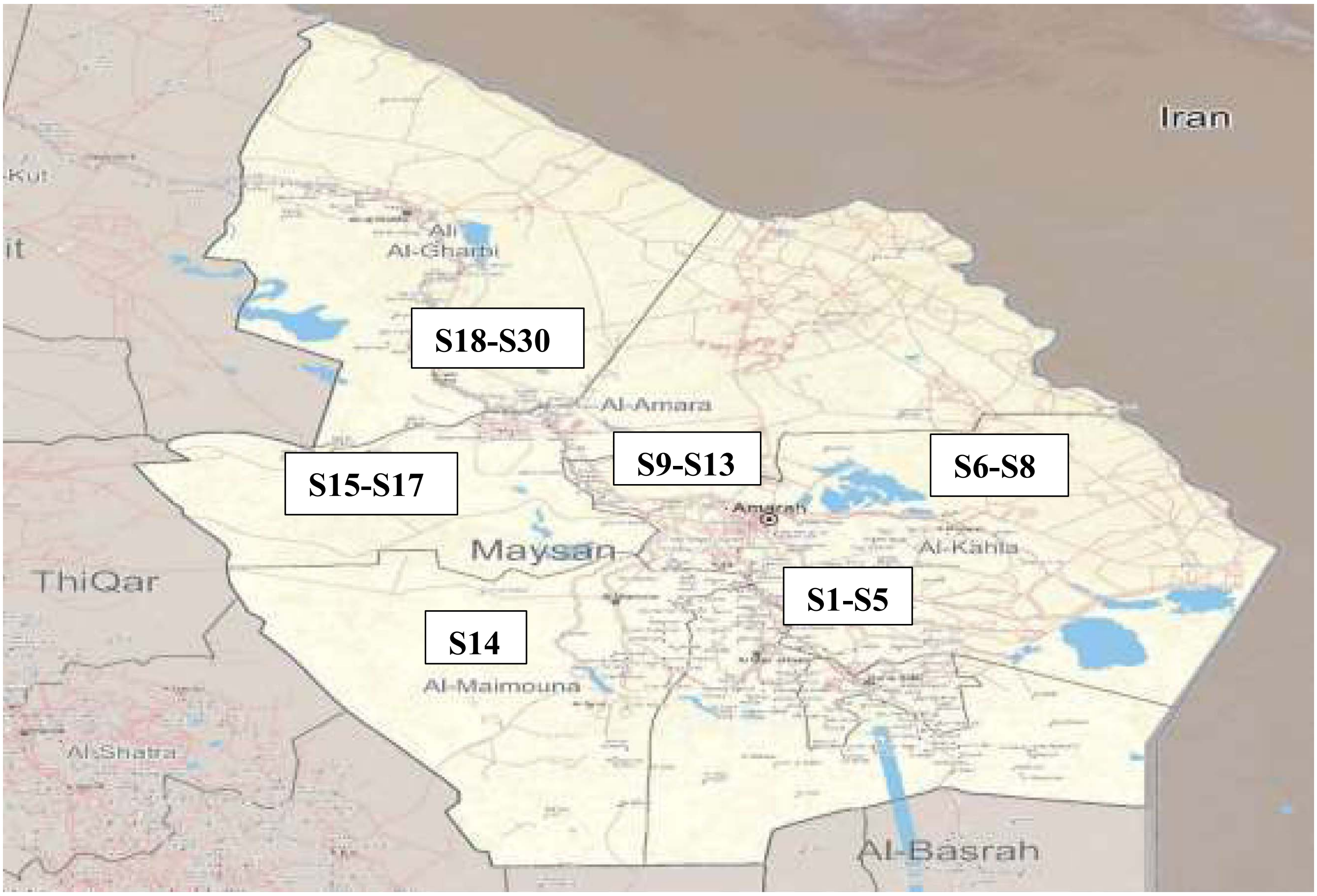


**Fig. 1.** Locations where samples were obtained in the Middle Omara Governorate.



Al kadeema 4, Al omarat Al kadeema 5, Al omarat Al kadeema 6, Al omarat Al kadeema 7, Al omarat Al kadeema 8, Al omarat Al kadeema 9, Al omarat Al kadeema 10, Al omarat Al kadeema 11, Al omarat Al kadeema 12, and Al omarat Al kadeema 13. The materials were subsequently ground into a powder, filtered using a mesh with a particle size of 75 m (Algrifi and Salman 2023), and dried for 7 h in a furnace set to 70 °C.

**Plasma-source MS**

The ICP-MS (inductively coupled plasma mass spectrometry) approach combines two technologies: high-sensitivity ion sensor technology (MS) and ion source technology (ICP). Ionizing source input systems and ICP are the same for ICP-OES and ICP-MS. In the case of ICP-MS, plasma-generated ions are transported to a high vacuum MS zone via a sampler and a skimmer cone. An ion optic system is used to concentrate the ions in the MS and measure the mass-to-charge ratios of the ion(s) of interest. A traditional quadrupole mass spectrometer (MS) can only pass ions with a specified mass-to-charge ratio via its mass filter. Ions passing through the MS are moved to an ion detector, which turns the ionic power into a power source and enables the measurement of the examined quantity. During multi-element study, the settings may be modified to make space for new ions with varying mass-to-charge ratios to flow through the detector. A single-element sequential analysis is used in ICP-MS multi-functional analysis. The ICP-MS offers benefits over other approaches in terms of sensitivity, detection, and simultaneous U-concentration and U-isotope ratios. The most exact ICP-MS measurement is considered to be U, which employs a method known as the analytical isotopes diluting approach. Several studies have employed the FI (flow injection) technique for U preconcentration and determination by the isotope dilution method to increase sensitivity, accuracy, and detection capabilities (Algrifi and Salman 2023, UNSCEAR 2000).

## RESULTS AND DISCUSSION

The findings for the uranium content in soil samples taken for this inquiry from numerous sites in the middle Omara Governorate, South Iraq, are shown in Table 1. Table 1 and Fig. 2 reveal that the uranium levels in these soil samples were lower than those reported by the U.S. Environmental Protection Agency (EPA). In Fig. 2 and Table 1, the findings for these 30 samples were classified into 30 categories ranging from S1 to S30. The city of Awasha 2 had the

**Table 1.** Uranium content in soil samples from Middle Omara Governorate locations as determined by ICP-MS.

| Sites numbers | Sites | Uranium concentration in ppm |
|---|---|---|
| **S1** | **Awash 1** | **0.52** |
| **S2** | **Awash 2** | **6.26** |
| **S3** | **Awash 3** | **1.09** |
| **S4** | **Awash 4** | **1.30** |
| **S5** | **Awash 5** | **0.66** |
| **S6** | **Hay alhussain alkadeem 1** | **0.93** |
| **S7** | **Hay alhussain alkadeem 2** | **0.72** |
| **S8** | **Hay alhussain alkadeem 3** | **0.70** |
| **S9** | **Police station 1** | **1.06** |
| **S10** | **Police station 2** | **0.86** |
| **S11** | **Police station 3** | **1.01** |
| **S12** | **Police station 4** | **0.55** |
| **S13** | **Police station 5** | **0.67** |
| **S14** | **Maysan games city** | **1.22** |
| **S15** | **Alrafidain water project 1** | **1.87** |
| **S16** | **Alrafidain water project2** | **0.60** |
| **S17** | **Alrafidain water project 3** | **1.10** |
| **S18** | **Al omarat Al kadeema 1** | **0.60** |
| **S19** | **Al omarat Al kadeema 2** | **3.96** |
| **S20** | **Al omarat Al kadeema 3** | **0.61** |
| **S21** | **Al omarat Al kadeema 4** | **0.76** |
| **S22** | **Al omarat Al kadeema 5** | **0.66** |
| **S23** | **Al omarat Al kadeema 6** | **1.00** |
| **S24** | **Al omarat Al kadeema 7** | **0.63** |
| **S25** | **Al omarat Al kadeema 8** | **0.83** |
| **S26** | **Al omarat Al kadeema 9** | **0.80** |
| **S27** | **Al omarat Al kadeema 10** | **0.73** |
| **S28** | **Al omarat Al kadeema 11** | **0.65** |
| **S29** | **Al omarat Al kadeema 12** | **0.73** |
| **S30** | **Al omarat Al kadeema 13** | **0.65** |

greatest uranium level (6.26 ppm), whereas beyond 10 m, (Awasha 1) had the lowest (0.52 ppm). The EPA determined the maximum contamination limit (MCL) for uranium, which is roughly 30 g $L^{-1}$. Environmental samples must be tested for uranium levels on a regular basis. Uranium content is commonly determined using plasma atomic emission spectrometry (ICP-AES) and inductively linked alpha spectrometry. However, due to how sensitive these technologies are to uranium, it typically requires a significant number of objects and measurements to provide accurate findings. Furthermore, only an approximate assessment of the uranium quantity is possible due to the alpha spectrometric accuracy. Specific mass spectrometry is one of the finest alternatives to these techniques, having good sensitivity and precision (Yousuf and Abullah 2011; Salman and Algrifi 2022). Hashim and Najam conducted a research study in which they compared the results of the investigation. Testing was done on the uranium, radium, and radon content of construction materials from Iraq. Uranium levels in these samples ranged from 0.52 to 6.26 ppm, with a mean of 1.124 ppm. It is vital to determine the uranium ratio based on a variety of various factors, since nuclear weapons are still present in certain locations bordering the Middle Omara Governorate as a result of the ongoing conflict (UNSCEAR 2000; Algrifi and Salman 2023).

## CONCLUSION

The Middle Omara region of Iraq has never had soil sources with amounts of uranium before, according to this study. Oftentimes, soil specimens from the investigating area are heavily mineralized. The test conducted here reveals a strong positive association between uranium and certain chemical components in soil samples. Healthy people depend on safe soil, which is a serious public health concern. By safeguarding the supply of raw soil samples and purifying

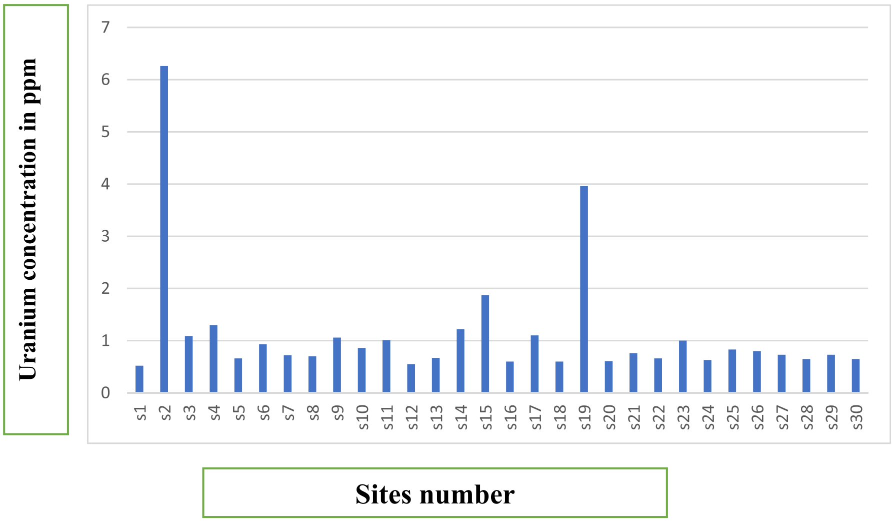


**Fig. 2.** Uranium concentrations in soil samples collected from several sites in middle Omara as determined by ICP-MS analysis.

soil water, high-quality soil samples might be preserved. The availability of unprocessed soil samples can be safeguarded by effective watershed management approaches and pollution control measures that limit the introduction of unwanted materials into soil samples. The sample with the highest concentration of uranium, S 30, contained less than the maximum allowed in soil samples (6.26 ppm), or 0.52 ppm. Awasha 1 region, in contrast to other areas, has the greatest prevalence of uranium contamination, making nearby local residents there more susceptible to uranium exposure. Due to its higher contamination ratio compared to other areas, residents of this region (Awasha 2) are more exposed to uranium from other locations.

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