**Experimental and Theoretical NANOTECHNOLOGY**
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# Evaluation of uranium concentration in soil samples of Al-Diwaniya governorates using ICP-mass techniques

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The present work is concerned with the measurements of uranium concentrations in fourty nine surface soils samples from selected locations (some of them were measured for the first time as far as authors know) in Al-Diwaniyah governorate by using ICP-Mass (inductively coupled plasma mass spectrometry) was found to be ranging from 2.78 ppm in (Al-shamr 2) to 7.99 ppm in(Al-shawfa) in soils. The results are presented and compared with other studies. The measurements of uranium concentration of soils samples measured had a uranium content of less than 100 ppm, a concentration that characterizes overburden and tailings quality, rather than minable reserves. This paper presents and evaluates the concentration of uranium in Al-Diwaniya Governorates. The study further reveals that 49 surface soil samples have uranium below detection limit. The present results have shown that the uranium concentrations in the studied surface soils samples were less than the allowed value (11.7 ppm) recommended by UNSCEAR, 1993.

**Keywords:** Uranium, Soil samples, ICP-Mass, Al-Diwaniya Governorates.

## 1. INTRODUCTION

Uranium is a very widely distributed element in the earth's crust, is presented naturally everywhere in soil, sand and rock in various concentration from one place to another. Uranium is a radioactive and chemical element, represents by (U) symbol, and it is a heavy metal with a very high density (18.95 g /cm$^3$, 1.7 times higher than lead's density of 11.35 g /cm$^3$). Metallic uranium has a high melting point (1132 $^o$C) and boiling point (4131 $^0$C), has a tensile strength

similar to most steels and it is chemically very reactive [1]. Natural uranium consists of three isotopes. Their concentrations by mass are $^{238}$U 99.276%, $^{235}$U 0.718% and $^{234}$U 0.0056% [2-4]. Uranium is a naturally occurring element with an average abundance in the earth crust of about 2 mg per kg (range 0.1 to 20 mg per kg). It is more abundant than silver or gold. It has adverse effects on the human health. The major health effect of uranium is its chemical toxicity, rather than its radiological hazard [5-8]. The chemical toxicity was thought to be similar to lead. The elemental and isotopic abundances of uranium have been extensively used to explore biogeochemical and physical processes in diverse fields of the Earth sciences [9]. Low uranium concentrations ([U]) and low abundances of $^{234}$U in most natural samples, however, constrain many applications due to measurement limitations. Alpha spectrometry methods have been used to quantify uranium radionuclides for five decades [10,11] but large sample size requirements and the advent of techniques with vastly improved throughput and analytical precision have pushed alpha-counting techniques toward obsolescence. Monitoring uranium content in environmental samples is typically performed using alpha spectrometry and inductively coupled plasma atomic emission spectrometry (ICP-AES). However, due to the relatively low sensitivity of these techniques for uranium, a large number of samples and long measurement times are generally required to obtain reliable results. Moreover, the accuracy of alpha spectrometry allows only a rough estimation of uranium levels. Mass spectrometry, which boasts both high sensitivity and accuracy, is considered one of the best alternatives to the aforementioned methods [12,13]. The general aim is to investigate the complex interactions and exchanges with soil samples, and to estimate how much hazards brought with soils. In fact, the study area is located inside Al-Diwaniya Governorate which is located in the extreme southern part of Iraq, see Figure 1.

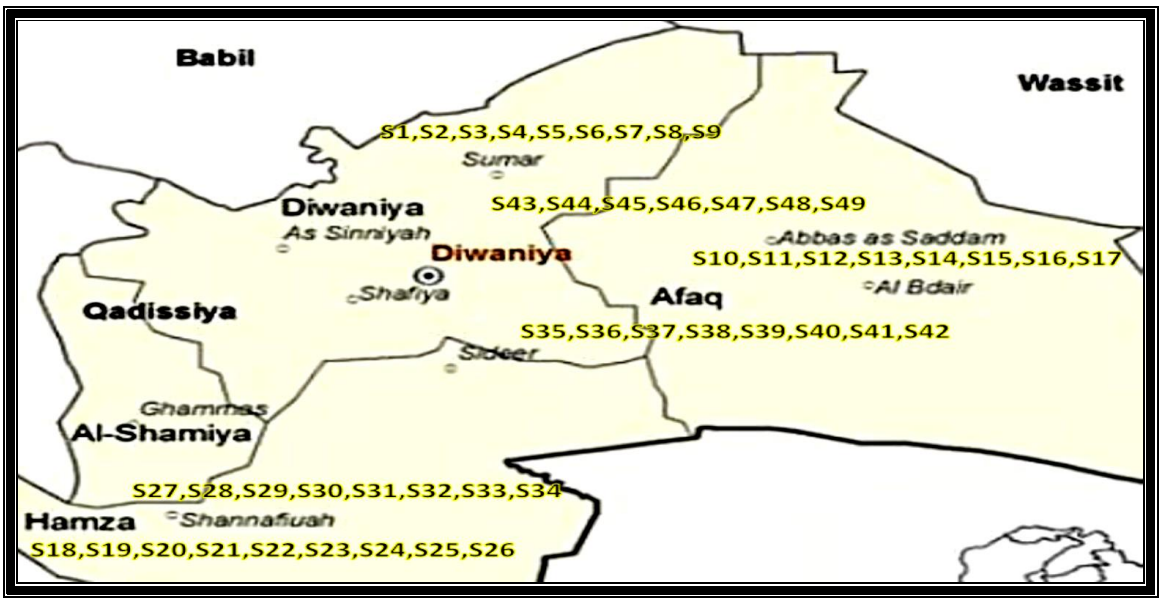


**Figure 1** Al-Diwaniya Governorate, dots represent the places where samples taken from, numbering in station number (S).

## 2-MATERIAL AND METHODS

*2.1 Collection of soil sample*

Fourty nine samples of soils distributed in Al- Diwaniya center, Al-ghanam, Al-shamr, Al-barakat, Al-aqarae, Al-khazraj, Alamisar Al-farahina, Al-thawra, Alsabahi, Albu-shrifa, Alsinidal, Alhuriya, Aljumhuriu, Al-sdeer, Al-shawfa, Al-ttabu, Al-askari, Al-karama, Aldawr Alshanaafia, Almuealimin, Alkhasf, Alsaray, Al-fawar, Al-daraeia, Afak Center, Aleayn,

fadalallah, Alkarama, alsaray and Al- dighara districts in Al- Diwaniya governorate were taken from location of study, from depth (5-15) cm than the sample s were cleaned. . dried in oven at 70 C° for few hours finally they were powdered and sifted by using special sieve (75) µm in diameter [7]

*2.2 Plasma-source MS*

The ICP–MS is the result of coupling an extremely efficient ion source (ICP) with an extremely sensitive ion detection technique (MS). Both ICP–OES and ICP–MS share ICP as the ionization source and both have the same systems for introduction. In the case of ICP–MS, ions generated in the plasma (at atmospheric pressure) pass through an assembly of a sampler and a skimmer cone to a highly evacuated MS area. An ion optic system focuses ions to the MS which measures mass-to-charge ratios of the ion(s) of interest. The commonly used quadruple MS acts as a mass filter that allows only a given mass-to-charge ratio of ions to pass to the detector. The ions passing through the MS are deflected to an ion detector that converts the ionic energy to electric energy which forms the basis for the measurement of the analytic concentration. For multielement analyses, the parameters are sequentially changed to allow the passage of other ions of differing mass-to-charge ratios to the detector. Thus, multielement analysis by ICP–MS is, in fact, sequential single element analysis. The advantages of ICP–MS over other methods are higher sensitivity, lower detection limits and simultaneous measurement of U concentrations and U isotope ratios. The ICP–MS can carry out U determination by the isotope dilution method which is considered the most precise for quantitative analysis. Some researchers have used FI technique for separation/ preconcentration of U and determination by the isotope dilution method to improve sensitivity and precision and detection capabilities [14, 15].

## 3. RESULTS AND DISCUSSION

The results for Uranium concentration in Soil samples determined in the present study are presented in Table 1 which are collected from some areas in Al-Diwaniya Governorate, southern Iraq. For the measurement of Uranium concentration level soils, table 1 and Fig. 2, reflect the fact that, there was some less than level of Uranium concentration in this soil samples less than from the U.S Environmental Protection Agency (EPA) . The results for these 49 samples categorized into 49 locations, from S1 to S49, shown in Fig. 2. Uranium content found maximum (7.99ppm) in Al-shawfa belt and minimum (2.78ppm) was recorded in Al-shamr2belt. Out of the 49 soil samples 4 samples recorded higher which are beginning from 7.12ppm to 7.99 ppm while the 16 soil samples are beginning from 6.04 ppm to 6.95 ppm but 24 soil samples which are beginning from 4.01 ppm to 5.97 ppm and 5 soils samples are beginning from 2.78 ppm to 3.97 ppm than the prescribed EPA limit (30 ppm). The maximum contaminant level (MCL) of uranium was determined to be about 30 µg/L by U.S Environmental Protection Agency (EPA)[16].it is important to reliably monitor uranium concentrations in environmental samples. Monitoring uranium content in environmental samples is typically performed using alpha spectrometry and inductively coupled plasma atomic emission spectrometry (ICP-AES). However, due to the relatively low sensitivity of these techniques for uranium, a large number of samples and long measurement times are generally required to obtain reliable results. Moreover, the accuracy of alpha spectrometry allows only a rough estimation of uranium levels. Mass spectrometry, which boasts both high sensitivity and accuracy, is considered one of the best alternatives to the aforementioned methods [12,13]. The results of this study were compared with a study of researchers Abd alsattar K. Hashim and Laith A. NajamMeasurement of Uranium Concentrations, Radium

Content and Radon Exhalation Rate in Iraqian Building Materials Samples, Uranium content in these samples has been found, it is varying from 0.074 to 5.055 ppm with a mean value of 0.755ppm The selection of these regions to measure the ratio of uranium, depending on several factors, the most important are The increase in uranium concentrations in some areas around the Diwaniyah center, due to the recent war in those areas and the remnants of nuclear weapons [11].

**Table 1** Measurements of Uranium concentration in soil samples from different areas of Al-Diwaniya Governorate by using ICP-Mass

| No of site | **Location of sample** | **Concentration of Uranum by ICP-mass (ppm)** |
|---|---|---|
| S1 | Al-ghanam 1 | **5.01** |
| S2 | Al-shamr 1 | **4.11** |
| S3 | Al-barakat 1 | **4.07** |
| S4 | Al-aqarae | **6.34** |
| S5 | Al-khazraj | **6.22** |
| S6 | Alamisar | **3.11** |
| S7 | Al-ghanam 2 | **7.12** |
| S8 | Al-shamr 2 | **2.78** |
| S9 | Al-barakat 2 | **4.84** |
| S10 | Al-farahina | **6.93** |
| S11 | Al-thawra | **6.69** |
| S12 | Alsabahi | **5.66** |
| S13 | Albu-shrifa | **4.7** |
| S14 | Alsinidal | **5.89** |
| S15 | Al-shuhada' | **4.17** |
| S16 | Alhuriya | **4.37** |
| S17 | Aljumhuriu | **5.92** |
| S18 | Al-sdeer | **7.98** |
| S19 | Al-shawfa | **7.99** |
| S20 | Al-ttabu | **5.77** |
| S21 | Al-askari | **6.04** |
| S22 | Al-karama | **6.78** |
| S23 | Alzuhur | **6.88** |
| S24 | Al-sdeer 2 | **6.95** |
| S25 | Al-askari 2 | **4.68** |
| S26 | Al-karama | **6.41** |
| S27 | Aldawr1 | **4.05** |
| S28 | Alshanaafia | **6.88** |
| S29 | Almuealimin | **6.31** |
| S30 | Alkhasf | **4.01** |

| No of site | **Location of sample** | **Concentration of Uranum by ICP-mass (ppm)** |
|---|---|---|
| S31 | Alsaray | **4.56** |
| S32 | Aldawr 2 | **4.27** |
| S33 | Alkhasf 2 | **3.97** |
| S34 | Alshanaafia 2 | **6.21** |
| S35 | Al-fawar | **6.24** |

| | | |
|---|---|---|
| S36 | Al-daraeia | **6.49** |
| S37 | Afak Center | **5.77** |
| S38 | Aleayn | **6.09** |
| S39 | fadalallah | **6.85** |
| S40 | Alkarama | **4.27** |
| S41 | alsaray | **3.25** |
| S42 | Almuealimin | **3.45** |
| S43 | aldighara 1 | **4.34** |
| S44 | aldighara 2 | **5.82** |
| S45 | aldighara 3 | **5.84** |
| S46 | aldighara 4 | **4.89** |
| S47 | aldighara 5 | **5.97** |
| S48 | aldighara 6 | **4.88** |
| S49 | aldighara 7 | **7.32** |

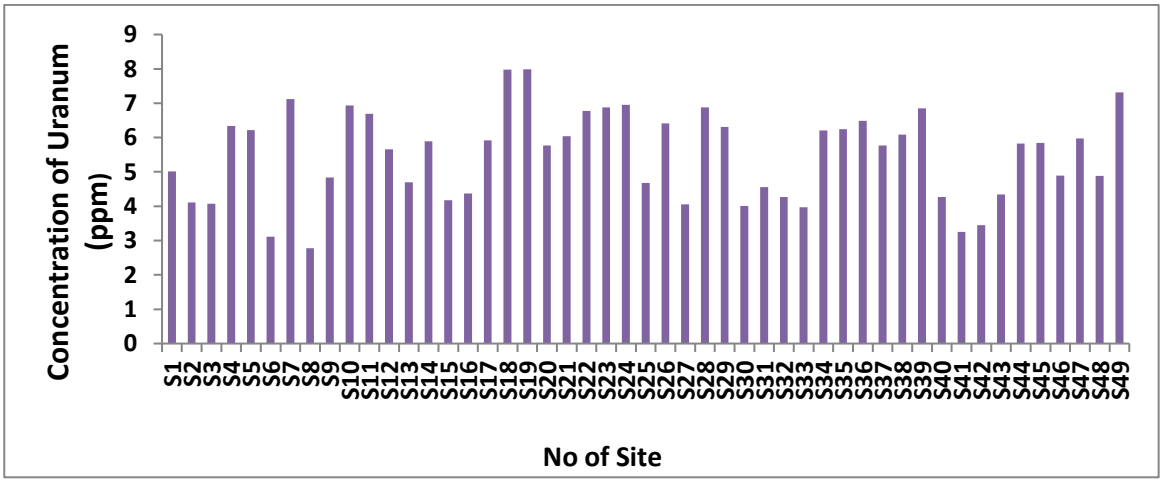


**Figure 2** Uranium Concentration in soil samples from different areas of Al-Diwaniya Governorate analysis by ICP- Mass.

## 4. CONCLUSION

This study is the first Uranium concentration measurement in soil sources that is performed in the area of Al-Diwaniya Governorate (Iraq). In general, well soil samples within the investigated area are highly mineralized. The correlation analysis revealed the strong positive association between uranium and some chemical compounds in soil samples. Access to safe soil samples is essential to human well-being and is a key public health issue. The maintenance of good quality of soil samples were achieved both by protecting the raw soil samples supply and soil water treatment. It is possible to protect the raw soil samples supply by means of pollution control measures that prevent undesirable constituents from entering the soil samples and by good watershed management practices. The highest concentration of uranium in the soil samples was in the sample (S 19) which is equal to (7.99 ppm), this value is less than the allowed limit, which is equal to (11.7 ppm). The pollution ratio in the region (Al-shawfa ) with uranium is the highest in the comparison with other regions, and this means that the people of this region are the most vulnerable to uranium from the other regions. The uranium

contamination ratio in (Al-sdeer) and the region (Near a Al-sdeer) despite being within allowed limit, but it is the ratio cannot be underestimated, the uranium ratio is relatively high, so it is advisable to processed with all means to ensure the safety of the population from continuous exposure to uranium, while the rest of the proportions of the other regions are reasonable proportions.

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