*2021 International Nuclear Atlantic Conference – INAC 2021*
*Virtual meeting, Brazil, November 29 – December 2, 2021*

ISBN: 978-65-594-1256-3

# Analysis of Geochemical Process Simulation Data Related to Mineralogical Control on Mobility of Oligoelements in Uranium Mine

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## 1. Introduction

Oligoelements, trace elements, are mineral substances that occur in minimal amounts in living organisms. These components produce divergent effects depending on their concentration in the body, being essential for healthy growth and development, but also potentially toxic, both when deficient and in excess in the body. Mercury, nickel, cadmium, lead, aluminum and arsenic can exert immunotoxic effects through epigenetic mechanisms. Certain trace elements can even be interrelated with the risk of autoimmune diseases, such as type 1 diabetes and multiple sclerosis [1].

The world health organization has classified trace elements into three groups based on possible nutritional roles, namely: potentially toxic elements (eg, lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), aluminum (Al)), elements of likely physiological importance (eg nickel (Ni), boron (B), vanadium (V)), essential elements (eg copper (Cu), selenium (Se), molybdenum (Mo) [2].

The amount absorbed and accumulation of the trace element control whether the effects to the body will be toxic or beneficial, and studying the concentration and availability of these elements in food and water is important to understand how they are disposed in the environment and can affect life, and in particular human health.

Metals, metalloids and radionuclides are trace elements that occur naturally in the earth's crust. Many human activities also contribute to the increased concentration of these minerals in the environment, such as the exploitation of metals for industrial and economic purposes [3]. Thus, these activities can intensify exposure

to trace elements, as is the case in regions of uranium exploration mines. Thus, the study of the disposition of these elements in mining regions in order to analyze the possible subsequent environmental impact is relevant.

In this work, the concentration of 5 elements was analyzed: arsenic, selenium, aluminum, uranium and molybdenum, seeking to correlate them with the experimental planning variables developed in partnership with the Universities of Salamanca and Extremadura, which sought to simulate environmental conditions to which the soil of the studied region could be submitted – rainfall volume (degree of saturation and time of water-to-soil contact), soil water suction force by plant roots and soil particle size.

## 2. Methodology

The concentrations of 5 elements were analyzed - arsenic, selenium, aluminum, uranium and molybdenum - obtained based on experiments previously carried out [4] in partnership with a Spanish research group from soil collected near the uranium mine region explored in the decade of 1960.

Soil samples were obtained from the municipality of Villar de la Yegua, located in the province of Salamanca, with the coordinates of the collection point: 40°43’28.86’’N; 6°42’59.96’’W.

The soil was worked in a laboratory with particle size separation to represent different textures: coarse sand (0.5-2mm), fine sand (0.067-0.5mm) and silt and clay (<0.067mm). Afterwards, the samples were moistened with different amounts of deionized water to study the influence of the volume of rainfall (50, 75 and 100% of humidity level), kept at a certain degree of saturation for a certain period of time: 1, 7 and 30 days. The extracts of the soil solution were then obtained by centrifugation in a method adapted to the experiment and a direct relationship between the centrifugation speed and the soil suction was assumed. The values used were 2200, 5000 and 12000 rpm, which correspond to the suction ranges 32-41KPa, 153-193kPa and 760-938kPa, respectively, which are related to the source of water in the soil.

In this work, the objective was to study selected trace elements from the database obtained from this experimental design, observing the influence of the experiment factors in the concentration of the elements and in the possible relationship between them.

## 3. Results and Discussion

In order to evidence the relationships between the planning factors (size, humidity, incubation, pressure) and the respective concentration results obtained for the elements studied in the collected water sample, the ANOVA test of variance analysis [5] was applied. There was a significant difference (5% significance level) for elements As, U and Al in relation to the size factor; for the moisture factor, As and U were significantly different; for incubation there was no significant difference for the elements; considering the pressure factor, only As presents a significant difference.

In Figure 1, boxplot graphs can be seen for the standardized concentrations of the elements As, Se, Al, U and Mo, depicting the set of experimental data obtained for each one of them. As can be seen, the elements As, Al, U and Mo exhibited outliers, while the Se did not, with arsenic being the one with the largest number of outliers in relation to the distribution center.

Considering that extreme values were not registered in all elements, values above the third quartile were studied. In relative values, the result of the distribution of the analyzed samples belonging to this group in relation to the levels of the worked factors can be seen in Table I.

Figure 1: Boxplot of standardized concentrations of analyzed elements.

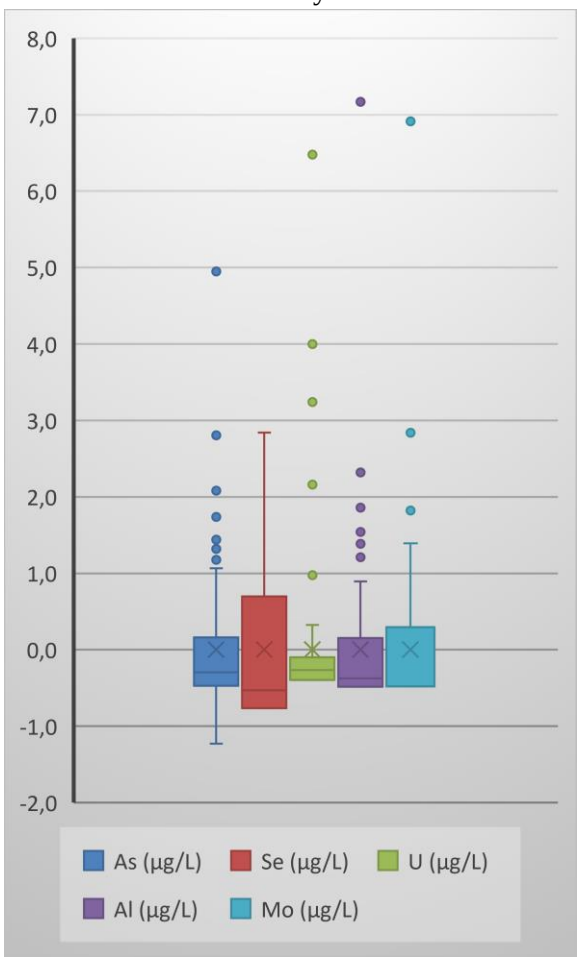


Table I: Number of observations of samples above the third quartile for each factor (in relative values).

| FACTORS | LEVELS | As (µg/L) | Se (µg/L) | U (µg/L) | Mo (µg/L) | Al (µg/L) |
|---|---|---|---|---|---|---|
| PARTICLE SIZE (mm) | <0,067 | **0,50** | **0,50** | 0,20 | 0,33 | 0,37 |
| | 0,067-0,5 | 0,40 | 0,33 | **0,65** | **0,43** | 0,11 |
| | 0,5 – 2 | 0,10 | 0,17 | 0,15 | 0,23 | **0,53** |
| MOISTURE (%) | 50 | 0,15 | **0,33** | 0,25 | **0,40** | 0,26 |
| | 75 | **0,35** | **0,33** | 0,15 | 0,30 | 0,26 |
| | 100 | 0,50 | **0,33** | **0,60** | 0,30 | **0,47** |
| INCUBATION (days) | 1 | **0,40** | **0,50** | 0,20 | 0,33 | 0,37 |
| | 7 | 0,25 | 0,33 | **0,65** | **0,43** | 0,11 |
| | 30 | 0,35 | 0,17 | 0,15 | 0,23 | **0,53** |
| SUCTION PRESSURE (kPa) | 32-41 | **0,60** | **0,42** | 0,35 | 0,40 | 0,26 |
| | 153-193 | 0,35 | 0,33 | **0,40** | 0,20 | 0,32 |
| | 760-938 | 0,05 | 0,25 | 0,25 | **0,40** | **0,42** |
| | **Total samples in quartile** | **20** | **12** | **20** | **30** | **19** |

## 4. Conclusions

The experimental data made it possible to compare relevant information regarding the impact of factors that seek to simulate environmental conditions to which the soil in the vicinity of an already explored uranium mine may be subject. Factors such as rainfall volume directly impact the mobility of trace elements in the water, which may be accessible and captured by plants in the region.

ANOVA analysis showed that the factors size, moisture and pressure were significantly different for arsenic; for uranium, size and moisture; for aluminum, the size factor. The incubation factor was not significantly different for any of the studied elements.

In the data set, there was a dispersion of values with the presence of outliers. Thus, another exploration was carried out, considering the highest concentration values of the selected elements - arsenic, selenium, aluminum, uranium and molybdenum. The level distribution of factors - saturation condition, incubation, suction pressure or soil particle size - for these samples was characterized in terms of relative values, in order to allow for comparison.

## Acknowledgements

We thank CAPES for the services provided, CNPq and FAPEMIG for financial support. We also thank to Universities of Salamanca and Extremadura for experimental data provided to be used in this work.

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