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كلية العلوم

The Analysis of Metallic Elements in a Soil Sample from Al Muzahimiyah Governorate

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Abstract:

This research paper focuses on analyzing metallic elements in soil samples from Al Muzahimiyah Governorate, aiming to identify and quantify their presence for a detailed geochemical profile. This study is significant for understanding environmental and geological characteristics of the region, impacting land management and assessing environmental risks. It tests the hypothesis that the soil, primarily sand, has a complex composition with silicon as a major constituent. Methods include Energy Dispersive Spectroscopy and Scanning Electron Microscopy. Key findings reveal the presence of various metallic elements like magnesium, aluminum, silicon, and iron, contradicting the hypothesis about silicon's predominance. The research contributes to understanding soil composition, providing a basis for environmental management and sustainable agricultural practices.

Introduction:

This research project aims to conduct a comprehensive analysis of metallic elements in soil samples collected from Al Muzahimiyah Governorate. The primary objective is to identify and quantify the presence of various metallic elements, thereby providing a detailed geochemical profile of the soil in this region. This study is significant as it contributes to the broader understanding of soil composition in Al Muzahimiyah, highlighting both natural and anthropogenic influences on soil quality.

The importance of this research is twofold. First, it enhances the understanding of the environmental and geological characteristics of the region, which is essential for effective land management and conservation strategies. Second, it aids in assessing potential environmental risks, such as soil contamination, which can have implications for public health and agriculture.

The hypothesis of this research centers on the premise that the soil in Al Muzahimiyah Governorate, primarily composed of sand, exhibits a complex and varied composition and that silicon (Si) would be the major constituent in the sample. Sand, inherently a compound material, consists of multiple crystalline substances, both organic and inorganic, each possessing distinct physical properties. Among these, the most prevalent is silicon (Si), a fundamental constituent of most sand types.

The motivation for this study stems from the need to develop a comprehensive understanding of soil composition in the region. This knowledge is crucial for informed decision-making in environmental management and policy formulation, aimed at promoting sustainable land use and protecting the health of the ecosystem.

Metallic Elements:

Metallic elements, characterized by their lustrous appearance, malleability, high thermal and electrical conductivities, and ability to transmit electricity through electron transfer, form a significant part of the periodic table. These properties distinguish them sharply from non-metals. The stark difference in electrical conductivities between metals like copper and silver, and non-metals like sulfur, highlights this distinction.[1] Metallic elements, with their unique properties and diverse alloys, are indispensable in various applications, from electrical engineering to industrial manufacturing.

Copper, for instance, is renowned for its superb electrical and thermal conductivity, making it a staple in industries requiring high conductivity. Copper alloys like cadmium copper, chromium copper, and silver copper, each with specific properties, cater to varied industrial needs from electric railways to high-temperature electrical machines. Similarly, aluminum and its alloys serve as effective conductors, combining strength with acceptable conductivity.[2]

Historically, theories like those of Goldhammer and Herzfeld have been pivotal in explaining the metal to non-metal transition. Herzfeld's theory, based on the classical (Lorentz) oscillator model, proposes that an element becomes metallic when the frequency of the oscillator in a dense dielectric medium approach zero, releasing the valence electron and imparting the element with metallic properties .[1]

The analysis of these metallic elements often employs techniques like Energy Dispersive Spectroscopy (EDS) in conjunction with Scanning Electron Microscopy (SEM). The advancement in those analytical techniques has significantly enhanced our understanding and characterization of these elements, especially in micro- and nanomaterials, and in assessing the morphology and chemical nature of materials like microplastics, an emerging environmental concern.[3]

Literature Review:

The study made by Abdullah Albabtain [4], aimed to assess the presence and concentration of heavy and trace metals in farm soils, groundwater, and date palm leaves from six farms in the Al Muzahimiyah area near Riyadh, Saudi Arabia. This review focuses specifically on the findings related to farm soil samples, excluding groundwater and date palm leaves.

The primary objectives of this study were to detect and quantify the trace metals in farm soil samples and to understand their correlation with the irrigation water and the environment where date palm trees are grown. The research methodology of this study involved analyzing six soil samples for heavy and trace metals, including iron (Fe), manganese (Mn), zinc (Zn), chromium (Cr), nickel (Ni), cadmium (Cd), cobalt (Co), copper (Co), and cesium (Ce), after appropriate preparation and acidification, and then using Optical Emission Spectroscopy (ICP-OES).[4]

The results indicated that the farm soils in Almuzahmiya contained high levels of iron, which is expected in agricultural soil. The concentration of iron ranged from a minimum of 3403 mg/kg to a maximum of 21780 mg/kg. Interestingly, the study also observed an inverse correlation between the iron content in the farm soil and that in the date palm leaves grown in the farm, suggesting a complex interaction between the soil and the plant system.[4]

Research Methodology:

For this research we used Energy-dispersive X-ray spectroscopy (EDX, EDS, or XEDS), sometimes-called energy dispersive X-ray analysis (EDXA) or energy dispersive X-ray microanalysis (EDXMA) together with A scanning electron microscope (SEM), as shown in figure (1). In its process a sample stable in a vacuum is bombarded with high-energy electrons, leading to the emission of characteristic X-rays from the sample. These X-rays are then detected and analyzed to identify and quantify the elements present[5]. EDX-EDS is particularly effective due to its interaction with the sample, where the electron beam undergoes inelastic and elastic scattering, producing secondary effects such as emitted secondary electrons and characteristic X-rays used in EDS for chemical analysis.[3]

Morphological characterization using EDX-EDS, as illustrated in the study of mineral content, highlights its importance in determining both the structure and composition of samples. This combination of techniques provides a comprehensive view of the sample, linking its physical structure to its chemical makeup.[6] Additionally, the analytical capabilities of EDS are further demonstrated in the context of chemistry and nanoscience. Here, the technique is crucial in identifying and quantifying elements at the nanoscale, underscoring its role in advancing research in these fields.[7]

We have also utilized the program "Image J", to analyze the microstructural image produced by the EDX/SEM.

Figure (1)

Procedure steps:

1- Obtaining the sample:

We obtained our sample by taking different soil samples from inside the town of Al Muzahimiyah and then mixing it together in one sample.

Drying:

This step involves drying the sample to eliminate moisture.

2- Sieving:

Once dry, the sample was sieved to remove large particles and debris, achieving a uniform particle size suitable for detailed analysis.:

3- Mounting on Holders:

The sample is mounted on an appropriate holder based on its size using adhesive carbon tape.

4- Sputtering (coating):

This is the process of covering the samples with particles of a conductive material that aids in the imaging process.

5- Sample Examination:

This is where we insert the sample in the device and examine it.

Specifications:

The specifications of the device that was used, for our analysis of the soil sample, are illustrated in table (1).

RESOLUTION	3.0 NM (30KV, WD8MM, SEI)
ACCELERATING VOLTAGE	0.3 TO 30 KV (55 STEPS)
MAGNIFICATION	X 18 TO 300,000 (136 STEPS)
FILAMENT	PRE-CENTERED W HAIRPIN FILAMENT
OBJECTIVE LENS	SUPER CONICAL LENS
OBJECTIVE LENS APERTURES	CLICK-STOP TYPE (3-STEP VARIABLE) FINE POSITION CONTROLLABLE IN X/Y DIRECTIONS
MAXIMUM SPECIMEN SIZE	8-INCH (203.2MM) DIA. SPECIMEN CAN BE MOUNTED
SPECIMEN STAGE	5 AXIS COMPUTER CONTROLLED EUCENTRIC GONIOMETER X=125MM, Y=100MM, Z=5 TO 48MM T= -10 TO 90°, R=360° (ENDLESS
DISPLAY CRT	18.1INCH, HIGH RESOLUTION FPD

Table (1)

Results And Discussions:

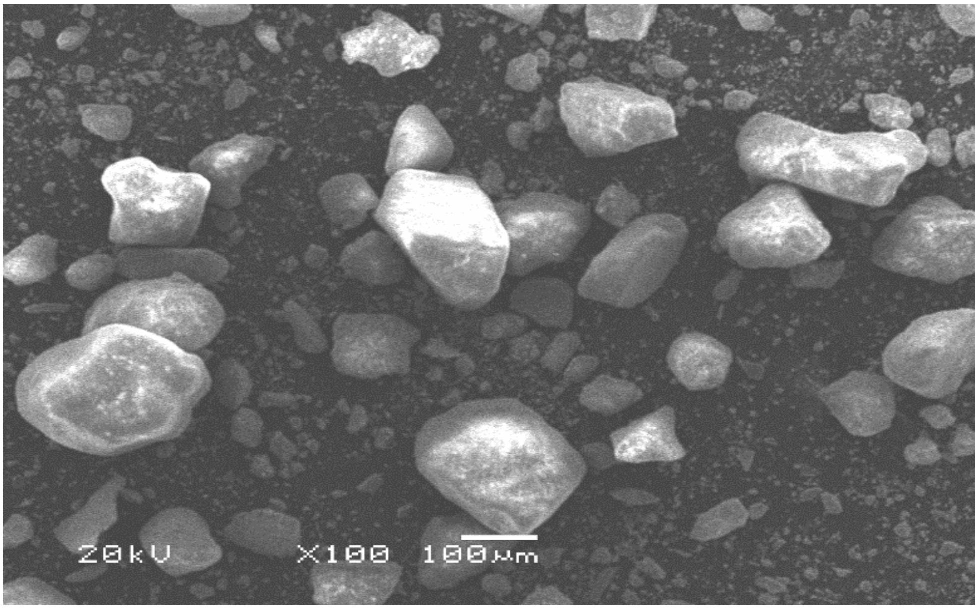

Figure (2)

Figure (2) presents a Microstructural Image of the soil sample that we analyzed, which allows for the observation of individual grains and their surface textures. Utilizing the program "Image J" for analysis, we determined that these grains have an average length of 183.4007 µm, with a standard deviation of 37.43161 µm. Additionally, the average size of these grains is measured to be 3.888 µm².

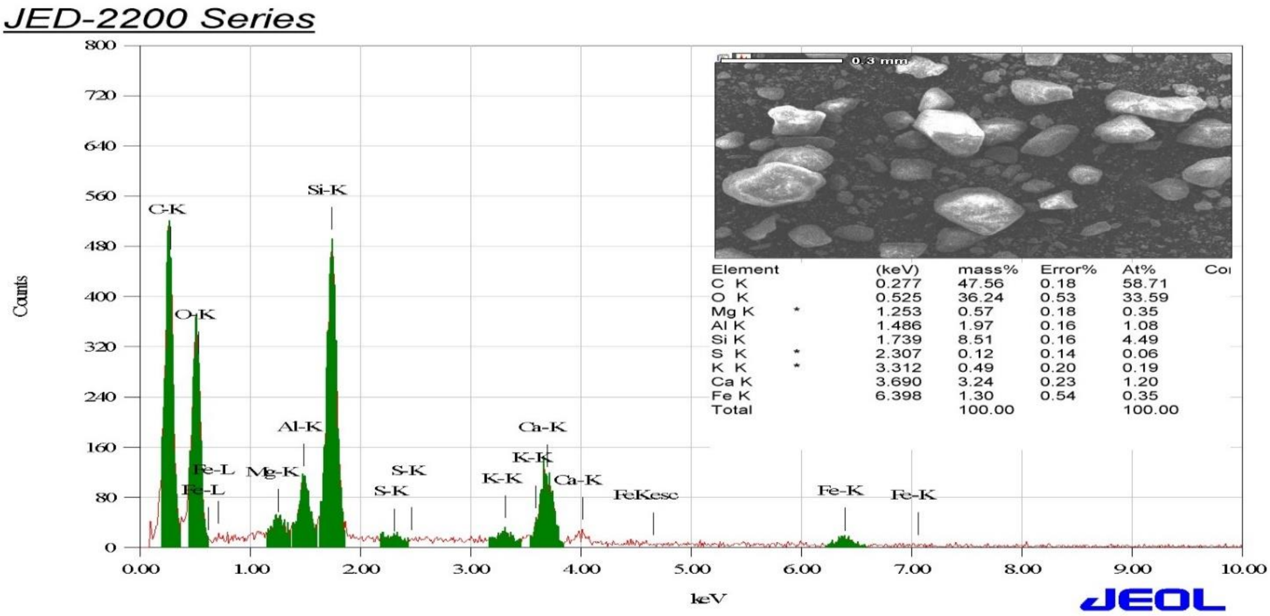

Figure (3)

Figure (3) showcases the elemental analysis of our soil sample, as determined by Energy-Dispersive X-ray Spectroscopy (EDX). The EDX/EDS spectrum reveals peaks corresponding to elements detected within the sample, including carbon (C) at 47.56 mass%, oxygen (O) at 36.24 mass%, magnesium (Mg) at 0.57 mass%, aluminum (Al) at 1.97 mass%, silicon (Si) at 8.51 mass%, sulfur (S) at 0.12 mass%, potassium (K) at 0.49 mass%, calcium (Ca) at 3.24 mass%, and iron (Fe) at

1.30 mass%. These peaks are quantified in the accompanying table, which provides their respective mass and atomic percentages, along with measurement errors.

The major constituents identified were carbon (C), and oxygen (O). all of which are non-metallic and align with the common compositions found in the literature for similar geological samples. Notably, the high carbon content could indicate organic material presence or contamination, which is consistent with soil samples rich in decomposed biological matter.

The substantial presence of aluminum (Al) and silicon (Si), which are both metallic, is consistent with the expectation of silicate minerals, which are ubiquitous in soils. Aluminum's presence at 1.97 mass% is typical for aluminosilicate clays, which are a significant component of the earth's crust. Silicon's presence in the sample, though its considerable, yet it's not the major constituent in the sample as we hypothesized.

Magnesium, Sulfur, potassium, and calcium, which are all metallic, are vital for soil fertility and plant nutrition, even though they are present in lower concentrations (0.57 mass%, 0.12 mass%, 0.49 mass%, and 3.24 mass%, respectively). The occurrence of calcium at higher levels than other trace elements could be indicative of calcareous soil conditions, which impacts soil pH and nutrient availability.

Iron, which is a metallic element, detected at 1.30 mass%, is commonly found in soils and is a significant component of many minerals like hematite and magnetite. The mass percentage of iron, although lower, is significant due to its higher atomic weight and its potential impact on soil properties. However, this clearly disagrees with the literature [4] ,which suggests that there are high levels of iron. We think that the disagreement is due to the differences in the location of the samples taken, we have taken ours from soils inside Almuzahimiya province, where Albabtain [4] collected his from farm soils in the same province.

The precision of our measurements is reflected in the low error percentages, demonstrating the reliability of our analysis.

Conclusion:

In conclusion, the research aimed to determine the presence of metallic elements in the soil, and the results confirmed the existence of several metallic elements, including magnesium, aluminum, silicon, potassium, calcium, and iron. These elements play significant roles in various natural and industrial processes.

The results we obtained aligned with part of the hypothesis, which is that the soil sample exhibits a complex and varied composition, and it disagrees with the part that silicon (Si) would be the major constituent in the sample. For future studies, we recommend further investigation into the bioavailability of these metals, the longitudinal effects of their presence on soil quality, and potential remediation measures to address any adverse environmental impacts. Additionally, studies should explore the interaction between these elements and organic soil compounds to inform sustainable agricultural practices.

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