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Charactrization and Chemical Analysis of Dust Storms using SEM/EDX Technique

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Abstract:

This study was conducted to determine the shape, size and chemical composition of dust particles resulting from dust storms as they are among the most important characteristics that affect the transmission, distribution and health impact of dust particles. Samples of deposited dust particles was collected from dust storms that hit Al- Diwaniyah Governorate during the June and July 2022.

The results showed that the dust particles were in the form of irregular sphericals containing many protrusions and rough surfaces, their diameter ranged between 0.752-19.25 µm, while their chemical composition was greatly variable and included the following elements: Si, Fe, Cd, Ru, Pb, Hg, Ni, Mn, Sb, C, Ca, Al, Mg, Au, N, Ge, and Cl. This variation is due to many factors, including the origin of these storms, the distance they travel, and their interaction with pollutants in the atmosphere.

Keywords: Dust storms, Dust heavy metals, EDS/EDX, Scanning Electron Microscope.

1. Introduction:

The Middle East is one of the most exposed regions in the world to dust storms [1]. Iraq is one of these countries that is exposed to repeated waves of dust storms throughout the year, which may be local or from outside the borders from a neighboring countries [2]. This is due to many reasons, including Iraq's geographical location, effects of global warming, droughting, absence of green cover, increase in desertified areas, loosening of the soil surface, and increase in urbanization and construction [3].

Dust storms are one of the dust phenomena that occur as a result of fast winds blowing on dry and loose soil, which leads to the wind carrying dust particles to other areas [4].

Dust storms cause many direct and indirect effects on human health, such as eye diseases and difficulty breathing especially for those with asthma, in addition to

respiratory diseases, lung cancer, and cardiovascular diseases [2]. It also has many other effects on the clarity of vision, transportation systems, the intensity of solar and terrestrial radiation, humidity and temperature, It also affects soil fertility, harms agricultural crops and affects buildings and archaeological landmarks [5].

Dust storms are one of the important sources of heavy metals transfer, either by adsorption of metals from the atmospheric pollutants on the surface of dust particles or by blowing the surface of soil polluted with heavy metals by wind and then transporting them with the air inside the storm in addition to the metals that make up the dust particles themselves [6].

The electron microscope with EDX spectroscopy is one of the important tools used to determine the properties of individual particles such as shape, size, chemistry, crystal structure and metals identification [7]. The electron microscope can display important information about the chemical composition, atmospheric transformations in addition to the size distribution and sources of suspended dust particles [8]. EDS/EDX is a chemical microscopic technique in which a small areas of the sample are analyzed using a focused beam of electrons, The composition of the element is determined by determining the spectrum of X-rays emitted by that element [9]. When electrons strike the atoms of the elements, these atoms will ionized and move to a higher energy level, and when they back to its ground state, they will emit a distinctive X-ray and a photon energy resulting from the difference between the two orbitals involved in the transition, which is a distinctive property of the element [10].

2. Methods

2.1.Samples collection:

Samples were collected from three dust storms during their blowing over the city of Diwaniyah, 180 km south of the capital, Baghdad, during June and July 2022. A 1 m^2 plastic sheet was placed on top of buildings at a height ranging between 3-4 m, After that, the settled dust was collected using a plastic brush and the samples were placed in polyethylene containers, then transferred to the laboratory and air-dried, sieved using a sieve with a hole diameter of 0.5 mm, then stored until measurement [11].

2.2.Characterization the shape and size of dust particles:

The dust particles shape and size were characterized using SEM type Thermal Fisher model Quanta FEG 250 at the College of Science, Al-Qadisiyah University, Fig. (1), by placing a thin layer of dust particles on a piece of plastic and conducting the examination using an acceleration voltage of 30 KV and a working area of 8.7 mm and a magnification ranging between 1000-200000.

2.3.Chemical analysis of dust particles:

The chemical composition of dust particles was analyzed using SEM model Thermal Fisher Quanta FEG 250 with EDX/EDS using an accelerating voltage of 20 kV and a counting rate of > 15-20 kcps to determine the chemical elements present in the samples.

Fig. (1) Scanning Electron Microscope

3. Results and Discussion

3.1. Size and shape of dust particles

Using SEM is one of the most widely used methods to determine the complex shape of dust particles, Although the resulting images are two-dimensional, deviations and protrusions from the center of the particle can be observed, and thus a general description of the shape can be given based on the assumption that there are a relationship between a particle area and the expected height [12]. The size of the particles can also be described based on the diameter, while for particles with irregular shaped, the equivalent particle diameter can be used, which is the diameter of a spherical particle that has the same physical properties as the measured particle [13]. The equivalent diameter of particles is related to many properties including inertia, sedimentation, dispersion, transfer of particles, interaction with gases, pollutants, water vapor in the atmosphere, light scattering, radioactivity, cross-sectional area, and volume-to-surface ratio [14][15].

The results Figure (2 B, D, F) showed that the diameter of particles in the studied samples ranged between 0.752-19.25 µm, and Figure (2 A, C, E) shows that the studied dust particles were in the form of irregular spherical particles containing many protrusions and rough surfaces. It was noted from the results that there is a large

variety in the size and shape of the storm dust particles, this is due to many factors, including geochemistry, mineral content, and the traveling distance [14]. Also, the shape of the terrain, the abundance of salts, wind speed, and frictional force are factors that affect the shape and size of dust particles [16].

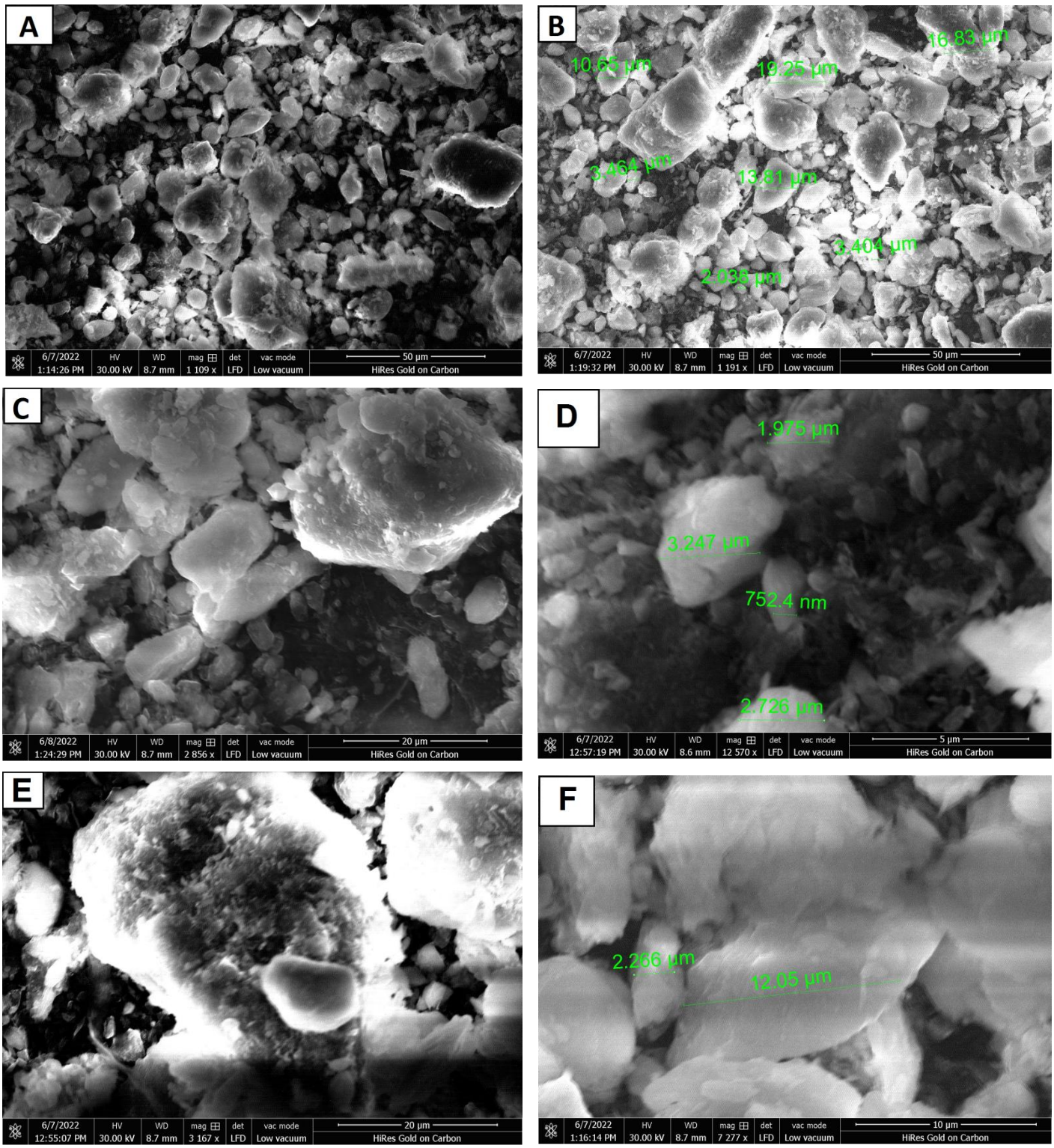


Fig. (2) Scanning Electron Microscope imge of studied samples

3.1.Chemical analysis of dust particles

Tables (1,2,3) and Figures (3,4,5) show chemical composition of dust particles in the studied samples, The first sample Table (1) Figure (3) contained a number of elements that appeared in the following proportions: Si 62.68%, Fe 13.37%, Cd 12.99%, Ru 6.57%, Pb 2.01%, Hg 1.79%, Ni 0.36%, Mn 0.24% of the sample weight. The elements in the sample showed the following sequence: Si>Fe>Cd>Ru>Pb>Hg>Ni>Mn.

The second sample, Table (2) Figure (4), contained the following elements proportion: Sb 20.35%, C 11.87%, Ca 10.87%, Si 8.38%, Al 4.83%, Mg 2.65% of the sample weight, and the elements showed the following sequence Sb>C>Ca>Si>Al>Mg.

The proportions of the elements in the third sample, Table (3), Figure (5), were as follows: C 28.65%, Si 15.51, Au 2.63%, N 2.05%, Ge 0.27%, Cl 0.1% of the sample weight, and the elements showed the following sequence C>Si>Au>N>Ge>Cl.

The variation observed in the chemical composition of dust particles and the elements they contain depends on many factors, the most important of which is the source of these dust storms, When winds blow over polluted soil, they carry these pollutants [3]. Pollutants in the atmosphere can interact with suspended dust particles or be adsorbed on their surface and thus be transported with these particles [14]. When these storms pass through cities and industrial areas, they will carry with them many pollutants and heavy metals resulting from fossil fuel burning, energy production, and various industrial and construction processes [17].

Table (1) EDX analysis of sample 1.

No.	Element	norm. C [wt.%]	Atom. C [wt.%]
1	Lead	2.01	0.36
2	Cadmium	12.99	4.31
3	Copper	0.00	0.00
4	Arsenic	0.00	0.00
5	Nickel	0.36	0.23
6	Mercury	1.79	0.33
7	Silicon	62.68	83.25
8	Palladium	0.00	0.00
9	Zirconium	0.00	0.00
10	Selenium	0.00	0.00
11	Ruthenium	6.57	2.42
12	Iron	13.37	8.93
13	Manganese	0.24	0.16
Total		100	100

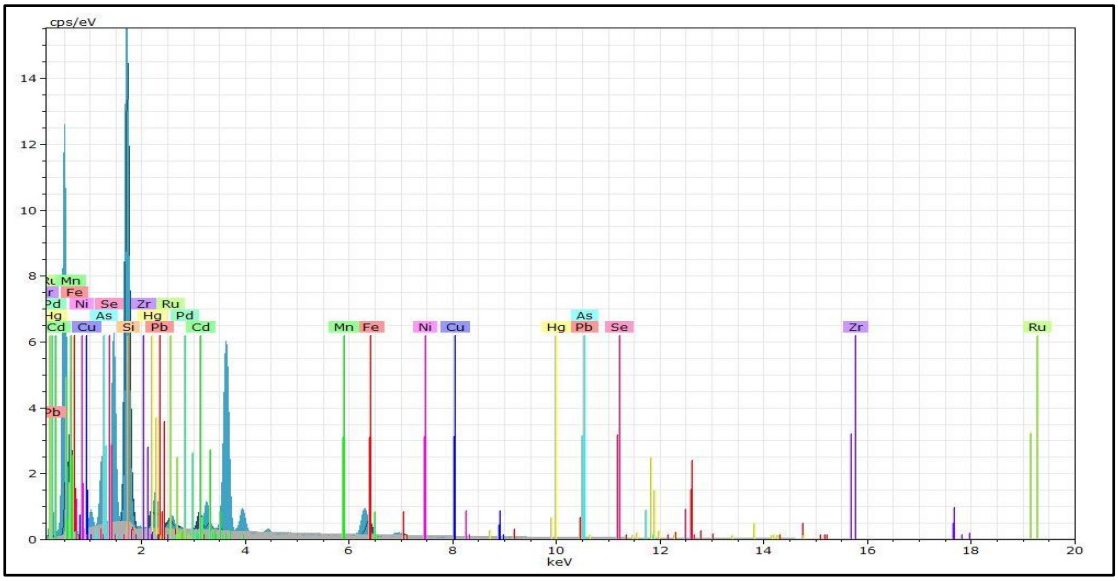
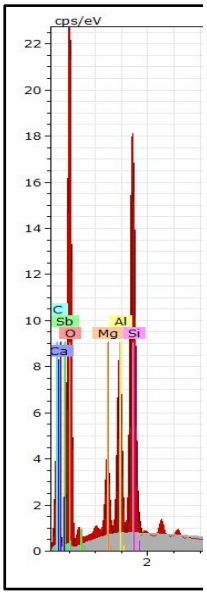


Fig. (3) EDX analysis of sample 1.

Table (2) EDX analysis of sample 2.

No.	Element	norm. C [wt.%]	Atom. C [wt.%]
1	Oxygen	41.06	56.04
2	Antimony	20.35	3.65
3	Calcium	10.87	5.92
4	Carbon	11.87	21.58
5	Silicon	8.38	6.51
6	Aluminium	4.83	3.91
7	Magnesium	2.65	2.38
Total		100	100



No.	Element	norm. C [wt.%]	Atom. C [wt.%]
1	Clorine	0.01	0.05
2	Phosphorus	0.00	0.00
3	Nitrogen	2.05	2.33
4	Oxygen	50.79	50.57
5	Silicon	15.51	8.80
6	Carbon	28.65	37.99
7	Germanium	0.27	0.06
8	Gold	2.63	0.21
Total		100	100

Fig. (4) EDX analysis of sample 2.

Table (3) EDX analysis of sample 3.

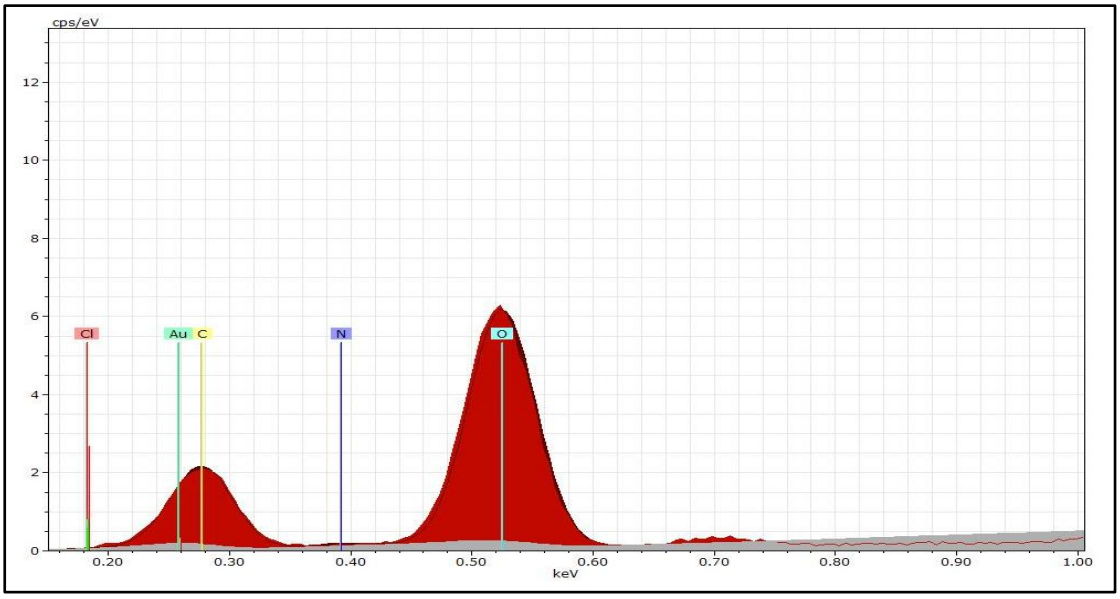


Fig. (5) EDX analysis of sample 3.

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