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MINERALOGICAL COMPOSITION OF KHAMASIN WIND DUST AT ASSIUT, EGYPT

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ABSTRACT:

The present study investigated the mineralogical composition of the deposited dust from Khamasin wind on the agricultural soils at Assiut city through April 2008 and 2009. Five sites were chosen between the fringes of eastern and western deserts throughout the Nile valley. Wood boxes (dimensions of 1x1m) were put in the selected sites and precipitated dust was collected from each box after the finish of Khamasin storms in the two years. The quantity, pH and EC were determined for the collected Khamasin dust. The mineral particles of these dusts were examined by the scanning electron microscope (SEM) and the X-ray analysis.

The obtained results revealed some variation in the dust quantity of Khamasin wind in the year of 2008 and 2009. The quantity of the collected bulk samples of the Khamasin dust varied from site to another in both 2008 and 2009 years. The highest amounts in both years are recorded in the sites of the eastern side of the Nile valley that faraway from the western desert, where the Khamasin wind come. The mean values of dust EC and pH were low and similar in both years of 2008 and 2009.

The Scanning electron microscope photomicrographs showed that the grain sizes of Khamasin dust in the sites located in the interference zone of Nile valley with the eastern desert were finer than those in site located in the western side of the Nile river. Generally, relatively large angular to subangular grains, larger amount of very fine grains with more oblate particle and spherical particles with differences in size as well as particles with irregular shapes in Khamasin dust of 2008 and 2009 years.

Semi-quantitative measurements of the identified minerals in the Khamasin dust of 2008 year have shown the order of quartz>k-feldspar>calcite>magnetite>epidote>anhydrite>garnet> augite> tourmaline >zircon>ilmenite>plagioclase>goethite>actinolite>hematite. However, the minerals in the Khamasin dust of 2009 year could be ordered as quartz>k-feldspar>calcite>epidote>magnetite> tourmaline >anhydrite >augite>plagioclase >ilmenite>rutile>hematite>garnet>actinolite. There was no general trend for distribution of these minerals throughout the studied sites. From a qualitative point of view, most of the sites have the same mineralogical composition. Comparison of the mineralogical compositions of mineral dusts at the five sites, revealed certain quantitative differences.

INTRODUCTION:

The recognition and characterization of aeolian dust in soil contribute to a better understanding of landscape and ecosystem

dynamics of drylands (Reynolds *et al*., 2006). Soil dust is recognized as an important factor on climate forcing (Duce, 1995; Li *et al*., 1996; Arimoto, 2001; Arimoto *et al*., 2006). Aeolian dust influences surficial and ecological processes in desert regions, where large amounts of dust are both sequestered and emitted over long periods of time (Goudie, 1978). In these settings, eolian dust plays important roles in soil formation, soil hydrology, development of surfaces, distribution of biologic soil crusts and nutrient status (Chadwick and Davis, 1990; McDonald *et al*., 1996; Belnap and Gillette, 1998; McFadden *et al*., 1998; Shachak and Lovett, 1998; Reynolds *et al*., 2001).

Mineralogy of aerosols has been used to assess the sources of eolian sediments (Leinen *et al*., 1994; Merrill *et al*., 1994; Biscaye *et al*., 1997; Drab *et al*., 2002; Bory *et al*., 2002). Mineralogy may be more diagnostically significant for identifying aerosol source areas than elemental ratios (Schutz & Sebert, 1987 and Molinaroli *et al*., 1993). Clay mineral ratios, such as I/K ratio (I: illite, K: kaolinite) can also be used as relevant tracers of the origin of soil-derived aerosols within Saharan source regions (Caquineau *et al*., 1998). The main mineralogical difference in dust composition is its carbonate (especially calcite) and feldspar contents. On the other hand, the clay mineralogy of the dust displays little variation within the source regions with high illite and low kaolinite+chlorite contents. The mineralogical composition of dust collected in the deposition area of the Chinese Loess Plateau (Changwu) was enriched by clay minerals (Shen *et al*., 2009).

Khamasin winds of Egypt and North Africa, which coming from the south-east and south, carry the Libyan dust over the Mediterranean. With deep depressions of the western desert of Egypt, Khamasin winds blow with great violence. In sweeping the desert to the south, they have a double action. Being hot and dry, with relative humidities of 30, 20, even 10 percent., the mantle of dust is fully dried out so that the grains lose all coherence, and in this desiccated state are raised freely into the air and carried along as ust-clouds. In its southerly phase the Khamasin brings temperatures approaching 40°C. (104°F.), but when it veers to the north-west there is rapid cooling and within fifteen minutes the temperature reading may drop to 27°C. (80.6°F.). These hot winds characterize the later months (April-May): earlier in the year a Khamasin may be relatively cold. But even after the wind has veered north-west the dust-storm will continue till the velocity abates. The visibility at times being restricted to only a few metres, whilst in exposed desert places it was reported as nil and the velocity of the wind reached 53 miles per hour in some places (Oliver, 1945).

The highest average values of dust deposit, all over the greater Cairo city, were found in the spring, which is characterized by the passage of the hot Khamasin storms that are loaded with dust and sand (Hgazy, 1961). Deposited dust resulting from such storms varied in the mean from 15.6 to 23.1 ton/mile^2/storm (Salam, and

Sowelim, 1967). However, the average rate of dust deposit in the industrial center at Helwan, about 20 km south of Cairo, for the month of April, when Khamasin dust storms were more frequent, was found to be 117.6 ton/mile^2 in 1967 (Salam, 1967). The silt-plus-clay fraction (fines) of the recently deposited aeolian dust on the isolated surfaces is closely alike in magnetic-mineral composition, in contrast to greatly dissimilar magnetic compositions of rock surfaces of vastly different lithologies, on which the fines have accumulated. The fines, thus, are predominantly deposited dust. The compositional similarity of the dust on these surfaces is interpreted to result from mixing of fines in the atmosphere as well as in fluvial, alluvial, and lacustrine depositional settings prior to dust emission (Reynolds *et al*., 2006).

No research on the particulate air dust of Khamasin wind around Assiut has been documented. Therefore, the present study was carried out to investigate the quantity, some chemical properties and mineralogical composition of the deposited dust from Khamasin wind on the agricultural soils at Assiut city.

MATERIALS AND METHODS:

Khamasin is a Middle Eastern term for the dry, hot wind that blows in from the desert. It can refer to the wind that blows from the desert across Egypt in the spring, typically from March through May, that brings very large amounts of sand and even dust from the Arabian Desert to cities and the agricultural soils. Khamasin blows from the south to the northwest, in opposition to the prevailing winds. Egypt is mostly desert, with the exception of the Nile River delta and basin. As a result, the country is hot and dry most of the year-round. Egypt experiences very mild winters. In the spring, the country is subject to a hot, driving windstorm called the Khamasin. The Khamasin causes major drifting of sand. Due to its desert terrain, Egypt is also prone to dust and sandstorms, along with periodic droughts. Sand storms are very dangerous for residents because they can continue for days, making life extremely difficult for citizens to live. Illness can occur from sand storms as a result of days of brutal winds and even damage to homes, infrastructures and crops can leave local Egyptians with a sense of unease and sadness.

In Assiut, Khamasin usually arrives in April every year carrying great quantities of dust and sand from the deserts, which shrouded the city in a thick yellowish haze. Khamasin wind dust in Assiut increase in particulate air matter considered as environmental contaminants. Metrological data reveal that the prevailing climate is corresponding to hot desert; the maximum temperature varies from 21°C in January to 41°C in July and the minimum temperature varies from 4.5°C in January to 22°C in July. The average value of high relative humidity is about 78.92% while the low one is about 18.17%. Pan evaporation is about 1910.2 mm per year. Precipitation is practically nil, except some light showers of rain that rarely fall during winter and some unrecorded flush floods

that come from the Eastern Desert (Faragallah, 1995; Ainer and Eid, 2003).

To study the annual additions and the mineralogical composition of the Khamasin dust, five sites were chosen between the fringes of eastern and western deserts throughout the Nile valley as shown in Figure (1). Wood boxes with dimensions of 1x1m were put in the soil surface of these sites in the 1st of April 2008 and 2009. The precipitated dust was collected from each box after the finish of Khamasin storms in the two years. The quantity of each sample was weighted to calculate the average of annual addition of Khamasin dust to the agricultural soils at Assiut City. The electrical conductivity (EC) of the collected dust was measured in 1:2.5 soil to water extract by using a conductivity meter. The pH was measured in 1:2.5 soil: water suspension using a glass electrode as reported by Mclean (1982).

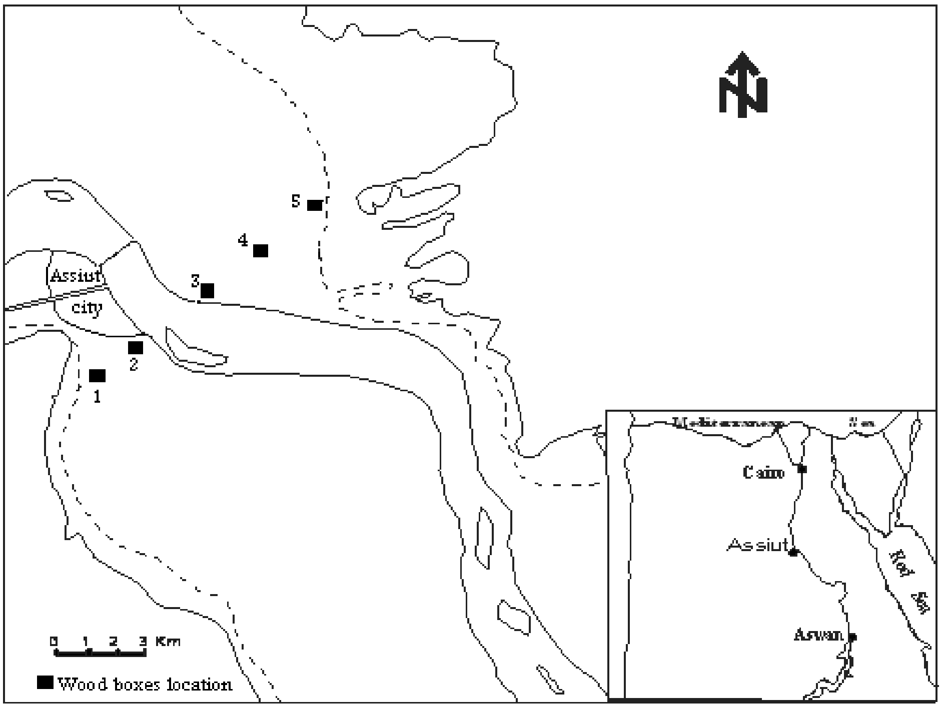

Figure 1: Locations of the wood boxes for collection the deposited Khamasin dust

The bulk samples of the collected Khamasin dust were treated to remove the soluble salts and organic matter for investigation by X-ray Diffractometer (XRD) and the scanning electron microscope (SEM). The sizes and shapes of the grain particles were examined by using Scanning Electron Microscope (SEM). The samples were prepared by mounting onto aluminum stubs and then coating with gold for best resolution using JEOL-JSM-5400 LV SEM. The dust samples were ground for examination by X-ray Diffractometer (XRD). The mineral phases identified by X-ray powder diffraction technique. The powder samples were

investigated using PHILLIPS X-ray diffractometer with CuKα radiation, 45 KV and 35 mA and scanning between 2θ of 2 and 60. The mineral constituents of the studied samples were identified and their relative proportions were determined using the semi-quantitative peak area technique according to Schultz (1964), Jackson (1964), Whitting (1965), Mac Ewan (1968) and Carroll (1970).

RESULTS AND DISCUSSION:

1-The quantity and some chemical properties:

The obtained data in Table (1) reveal that the quantity of the collected bulk samples of the Khamasin dust varied from site to another in both 2008 and 2009 years. Deposited dust resulting from Khamasin storm in 2008 ranged from 0.5106 to 4.8798 g/m^2. However, the quantity of deposited Khamasin dust in 2009 varied between 1.0129 and 5.4678 g/m^2. The highest amounts in both years are recorded in the sites of the eastern side of the Nile valley that faraway from the western desert, from where the Khamasin wind come. This may be due to the decrease of Khamasin wind velocity then loses most their carriage. The mean quantity of the bulk samples of the deposited Khamasin dust varied from year to another, since the mean quantity is higher in the 2009 (2.4304 g/m^2) than 2008 (2.3004 g/m^2). This may be attributed to the difference of velocity and the carriage of dust from year to another.

The electrical conductivity (EC) of the collected Khamasin dust in 2008 and 2009 years was extremely low and ranged from 13.51 to 14.08 µSm^{-1} and 13.46 to 13.87 µSm^{-1}, respectively. The similarity of EC values in both 2008 and 2009 years may be due to the same source of dust. Also, the mean values of dust pH were similar in year of 2008 and 2009 (6.20 and 6.19, respectively).

Table 1: The quantity, EC and pH of the Khamasin dust in the studied sites

Site No.	the quantity (g/m^2)		EC (µSm^{-1}) (1:2.5)		pH (1:2.5)	
	2008	2009	2008	2009	2008	2009
1	0.9208	1.0129	13.60	13.71	6.14	6.13
2	0.5106	1.0186	13.51	13.46	6.13	6.13
3	4.8798	5.4678	13.62	13.72	6.13	6.13
4	4.3954	4.9349	14.08	13.85	6.13	6.33
5	2.3004	2.4304	13.74	13.87	6.45	6.24
Mean	2.6014	2.9729	13.71	13.72	6.20	6.19

2-Dust mineralogy:

A-The sizes and shapes of the mineral grains:

The sizes and shapes of the grain particles of Khamasin dust samples were examined by using Scanning Electron Microscope (SEM) as shown in Figures 2 and 3. SEM observations

provide more information about the finest dust particle. The Scanning electron microscope photomicrographs show that the grain sizes of Khamasin dust in site 4 were finer than those in site 2, where site 4 locate in the interference zone of Nile valley with the eastern desert while site 2 in the western side of the Nile river. Generally, relatively large angular to subangular grains in Khamasin dust of 2008 and 2009 years, particularly, the finest fraction, often with elongated shape. A larger amount of very fine grains with more oblate particle shapes are observed. Spherical particles with differences in size as well as particles with irregular shapes are present.

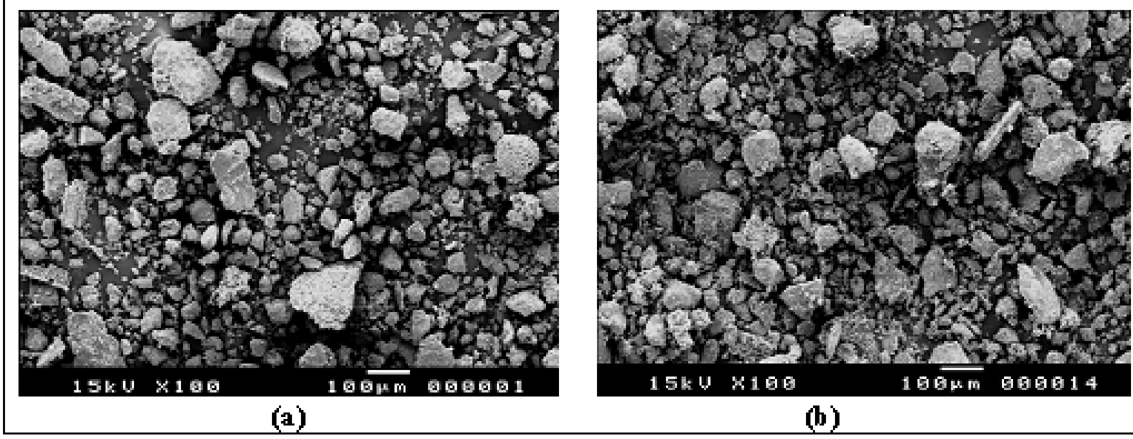

Figure 2: Scanning electron microscope photomicrograph showing the grain sizes and shapes of the Khamasin dust in site 2, (a) 2008 year and (b) 2009 year

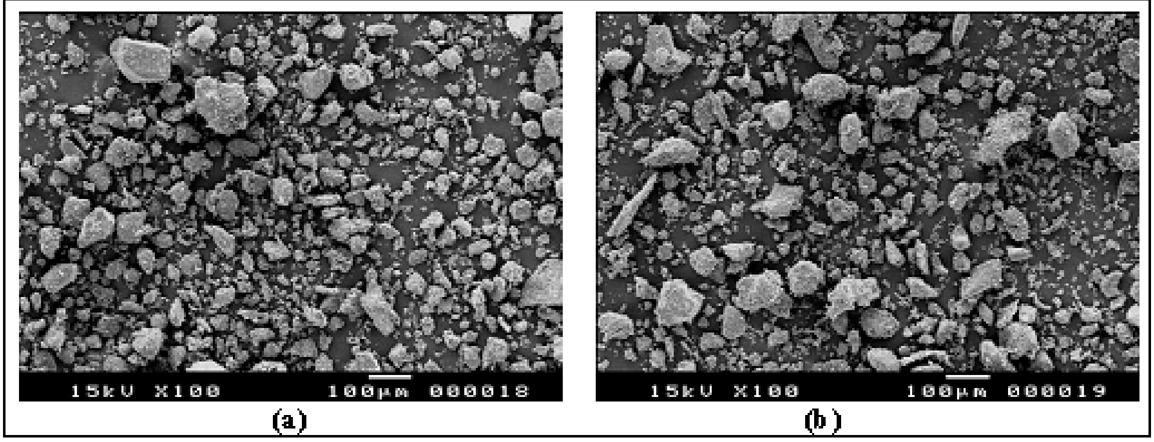

Figure 3: Scanning electron microscope photomicrograph showing the grain sizes and shapes of the Khamasin dust in site 4, (a) 2008 year and (b) 2009 year

B-The type and amount of minerals:

X-ray powder diffractograms of the collected Khamasin dust from the studied sites

are shown in figures 4 and 5. Semi-quantitative measurements of the identified minerals in the Khamasin dust of 2008 and 2009 years are given in Tables 2 and 3, respectively. They have shown that the order of quartz>k-feldspar> calcite> magnetite>epidote> anhydrite> garnet> augite>tourmaline> zircon>ilmenite>plagioclase > goethite>actinolite> hematite in the Khamasin dust of 2008 year. However, the minerals in the Khamasin dust of 2009 year could be ordered as quartz >k-feldspar>calcite>epidote> magnetite> tourmaline> anhydrite> augite> plagioclase> ilmenite>rutile> hematite> garnet> actinolite.

Quartz was the main constituent in the minerals of Khamasin dust samples with rang of 30.45-74.83% and 32.37-52.20% in years of 2008 and 2009, respectively (Tables 2&3). The highest amounts of quartz (74.83 and 52.20%) for years of 2008 and 2009, respectively, are found in the site 5 that located in the fringe of the eastern desert. Irregular pattern for the distribution of quartz content was observed in both years (Figures 6&7).

K-feldspar occurred as the second abundant Khamasin dust mineral in both 2008 and 2009 years, with amounts ranged from 11.56 to 23.36% and 9.49 to 23.10%, respectively. Calcite present as the third abundant Khamasin dust mineral in both 2008 and 2009 years, with amounts varied between 4.44 to 19.23% and 4.76 to 25.18%, respectively (Tables 2&3).

Magnetite, epidote, anhydrite and garnet were common minerals in Khamasin dust of 2008 year with the range reached up to 11.22, 6.31, 4.78 and 4.59%, respectively. However, epidote, magnetite, tourmaline and anhydrite were common minerals in Khamasin dust of 2009 year with the range reached up to 9.35, 8.24, 4.43 and 5.06%, respectively (Tables 2&3). All of these minerals have not clear tend of distribution with sites in both years (Figures 6&7).

The rest identified minerals i.e., augite, tourmaline, zircon, ilmenite, plagioclase, goethite, actinolite and hematite in the Khamasin dust of 2008 year only occurred in few sites. Also, augite, plagioclase, ilmenite, rutile, hematite, garnet and actinolite were only found in few Khamasin dust samples of 2009 year.

From a qualitative point of view, most the sites have the same mineralogical composition. Comparison of the mineralogical compositions of mineral dusts at five sites, reveal certain quantitative differences as shown in Tables 2&3 and Figures 6&7. The carbonate content in Khamasin dust increased from west to east in both two years. Similar to calcite, feldspar content increased from west to east up to site 4 then decreased.

Table 2: Semi-quantitative measurements of the identified minerals in the Khamasin dust of 2008 year

Site No.	Quartz	K-feldspar	Calcite	Magnetite	Epidote	Anhydrite	Garnet	Augite	Tourmaline	Zircon	Ilmenite	Plagioclase	Goethite	Actinolite	Hematite
1	31.74	17.59	5.35	5.74	6.31	4.78	4.59	10.71	0.00	5.16	4.40	0.00	3.63	0.00	0.00
2	49.38	19.75	4.44	4.20	4.20	4.20	0.00	6.17	3.46	0.00	0.00	4.20	0.00	0.00	0.00
3	32.87	23.36	17.99	10.38	4.67	3.98	4.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.42
4	30.45	22.12	19.23	11.22	4.01	3.37	3.21	0.00	3.85	0.00	0.00	0.00	0.00	2.56	0.00
5	74.83	11.56	13.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 3: Semi-quantitative measurements of the identified minerals in the Khamasin dust of 2009 year

Site No.	Quartz	K-feldspar	Calcite	Epidote	Magnetite	Tourmaline	Anhydrite	Augite	Plagioclase	Ilmenite	Rutile	Hematite	Garnet	Actinolite
1	36.50	9.49	5.49	5.27	4.85	4.43	5.06	9.70	4.22	3.59	8.02	3.38	0.00	0.00
2	47.06	17.37	4.76	4.20	4.76	3.92	4.20	6.44	4.20	0.00	0.00	0.00	3.08	0.00
3	32.37	19.78	25.18	9.35	3.96	3.06	3.96	0.00	0.00	2.34	0.00	0.00	0.00	0.00
4	34.48	23.10	24.83	5.86	4.83	3.62	3.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	52.20	13.46	17.58	3.02	8.24	3.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.47

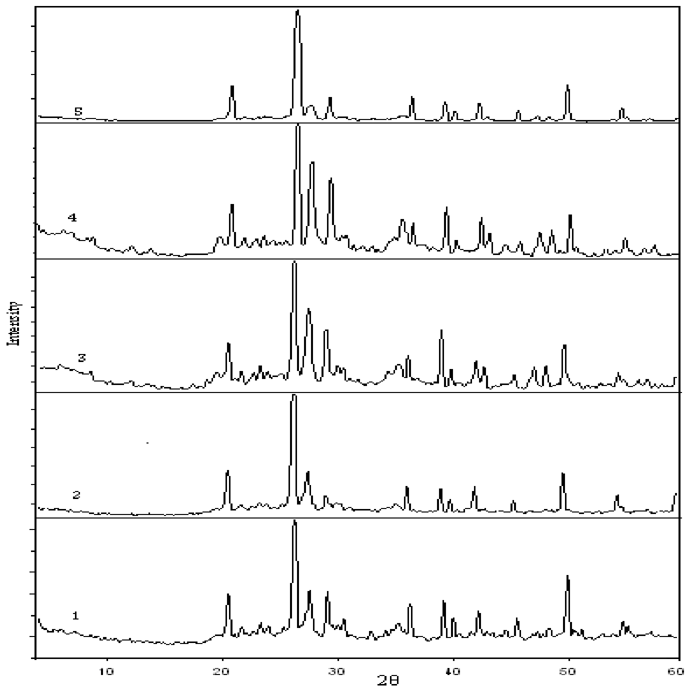

Figure 4: X-ray diffractograms of the Khamasin dust of different sites in 2008 year

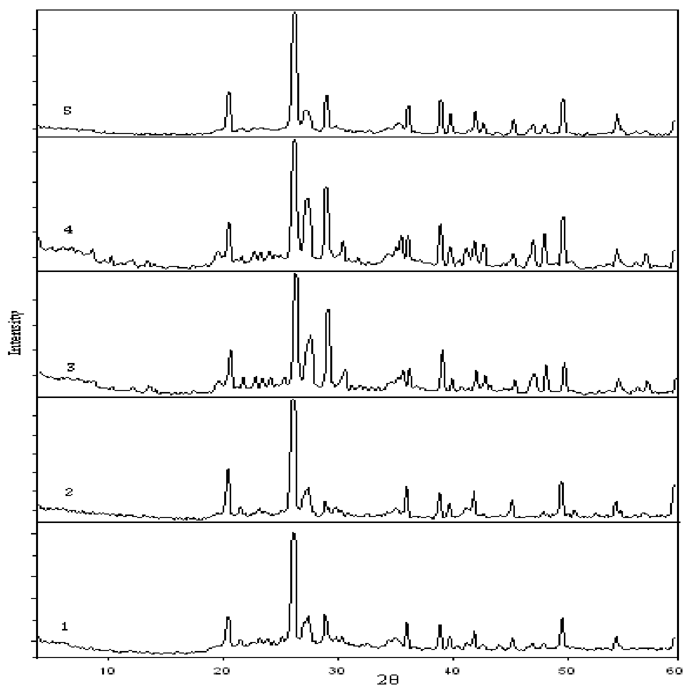

Figure 5: X-ray diffractograms of the Khamasin dust of different sites in 2009 year

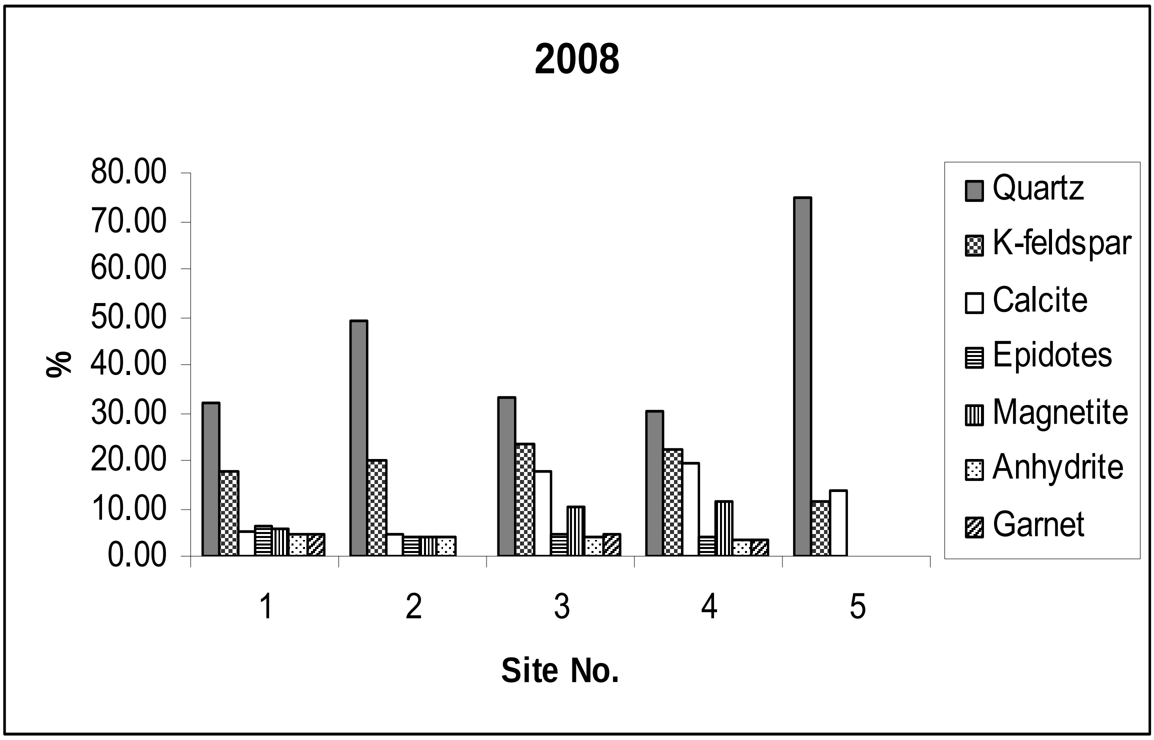

Figure 6: Distribution of common minerals in the sites of Khamasin dust samples in 2008 year

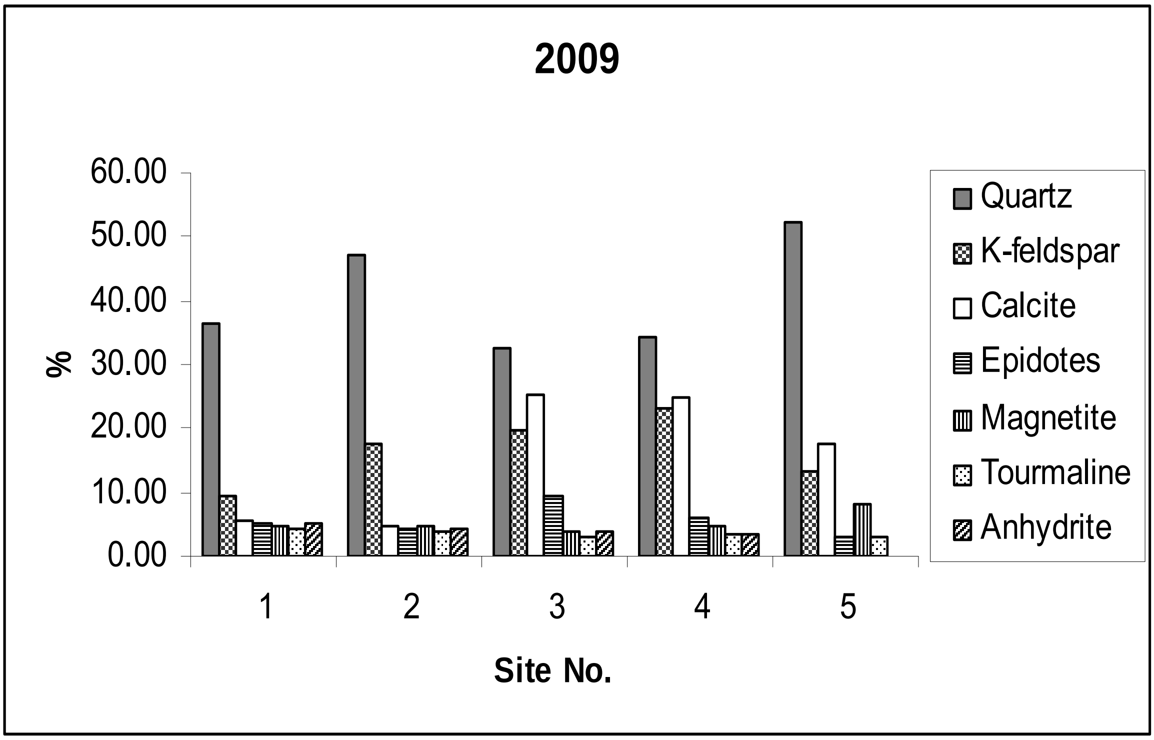

Figure 7: Distribution of common minerals in the sites of Khamasin dust samples in 2009 year

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التركيب المعدنى لرواسب رياح الخماسين فى أسيوط- مصر

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**** قسم الجيولوجيا – كلية العلوم - جامعة أسيوط**

تهدف هذه الدراسة لمعرفة كمية الغبار المترسب من رياح الخماسين على الأراضى الزراعية بأسيوط وتركيبه المعدنى خلال شهر أبريل لعامى ٢٠٠٨ و ٢٠٠٩، لذلك تم اختيار خمس مواقع بين حافة الصحراء الغربية إلى حافة الصحراء الشرقية، وتم وضع صناديق خشبية مساحتها ١م^{٢} فى هذه الأماكن من أول شهر أبريل حتى آخره.

أظهرت النتائج المتحصل عليها بعض الاختلافات فى كمية الغبار المترسب من رياح الخماسين من عام ٢٠٠٨ لعام ٢٠٠٩. كما اختلفت كمية رواسب رياح الخماسين من موقع لآخر لنفس العام الواحد. وسجلت الكميات الأعلى من هذه الرواسب في مواقعِ الجانب الشرقيِ لوادي النيل البعيدة من الصحراءِ الغربيةِ. والقيم المتوسطة لـ EC و pH الرواسب من رياح الخماسين كانت منخفضة ومتشابهة فى كلا عامى الدراسة.

أوضح فحص العينات بالميكروسكوب الالكترونى الماسح أن حجم المعادن المترسبة من رياح الخماسين تناقص كلما اتجهنا نحو الشرق بعيداً عن الصحراءِ الغربية حيث كانت أدق فى المواقع الشرقية عنها فى المواقع الغربية لرواسب خماسين ٢٠٠٨ و ٢٠٠٩. وبوجه عام توجد كميات كبيرة من الحبيبات زاوية وتحت زاوية الشكل بأحجام مختلفة، وتوجد حبيبات ناعمة كثيرة مفلطحة الشكل، وكذلك توجد بعض الحبيبات كروية الشكل باحجام متنوعة، كما لوحظت حبيبات غير منتظمة الشكل فى عينات رواسب رياح الخماسين لعامى ٢٠٠٨ و ٢٠٠٩.

أظهرت نتائج الفحص المعدنى باستخدام حيود الأشعة السينية لرواسب رياح الخماسين لعام ٢٠٠٨ أن معدن الكوارتز هو أكثرالمعادن شيوعاً تليه معادن الفلسبارات البوتاسية والكالسيت والابيدوت والماجنتيت والأنهيدريت والجارنت مرتبة ترتيباً تنازلياً، ثم معادن الأوجيت والتورمالين والزركون والالمنيت والبلاجيوكليز والجيوثيت والأكتينوليت والهيماتيت موجودة فقط فى بعض المواقع. كما وجد أيضاً أن معدن الكوارتز هو الأكثر شيوعاً فى رواسب رياح الخماسين لعام ٢٠٠٩ تليه معادن الفلسبارات البوتاسية والكالسيت والابيدوت والماجنتيت والتورمالين والأنهيدريت مرتبة ترتيباً تنازلياً فى كل المواقع، بينما سجلت معادن الأوجيت والبلاجيوكليز والالمنيت والروتيل والهيماتيت والجارنت والأكتينوليت فى بعض المواقع فقط. ولا يوجد هناك إتجاه عام لتوزيعِ هذه المعادنِ بين المواقع المدروسة. ومن وجهة نظر نوعية فإن معظم المواقعِ لَها نفس التركيب المعدنى فى كل من عامى الدراسة. وبمقارنة التركيب المعدنى لرواسب رياح الخماسين في الخمسة مواقع المدروسة اتضح وجود بعض الإختلافات الكمّية بينها.

وإن مثل هذه الدراسة تفيد فى معرفة كمية الرواسب التى تضاف من رياح الخماسين سنوياً وبعض خواصها الكيميائية مثل ملوحتها وأنواع المعادن المكونة لها مما يؤثر على الخواص المختلفة للأراضى الزراعية التى ترسبت عليها، كما أنها مفيدة فى الدراسات التى تهتم بأصل التربة حيث أن هذا التنوع فى المعادن المترسبة من رياح الخماسين والمضافة للأراضى الزراعية فى وادى النيل يدل على تعدد مواد الأصل للرواسب التى تكونت منها هذه الأراضى.