Sand and Dust Storms (SDS): Types, Characteristics, and Indications

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Abstract. Sand and dust storms (SDS) is a common weather phenomenon in the Middle East. Topography and the northern or northwesterly wind are the main control factors for types of SDS trajectories. The main SDS corridors in the Middle East were classified and spotted from March 2000 to March 2017. The SDS can be classified in the region in accordance to shape and magnitude into three main types namely; Small with 3 subtypes (Arrow shape-straight, Arrow shape-curved and Needle like), Intermediate with 3 subtypes (Curved, Hook and Straight), and Extensive with 6 subtypes (Spiral, Agglomerated-Dense, Agglomerated-Dispersed, Wavy, Hook-Single head, and Hook-multiple heads). Most of the trajectories are located within the northeastern parts of the Middle East. Dust properties led us to sort SDS and their indications. Dust deposits in the eastern Mediterranean Sea and the Red Sea and are initiated from Northern Desert of Africa (NDA). On the other hand, dust deposits in the Middle East originate from NDA, Western Desert of Iraq (WD), Mesopotamian Flood Plain (MFP), Ahwaz (HZ), Ahwar (HR) and Baluchistan Desert (BSH). The deposited dust in coastal areas is categorized as trimodal particle size distribution, finer mean size fractions with higher values of particles surface area and contains more carbonates and less quartz percentages compared to fallen dust in inland regions which is dominantly initiated from Western Desert of Iraq (WD), Nafud Desert (NFD) and Empty Quarter (EQ)..

1 Introduction

Sand and dust storms (SDS) are a common phenomena in the Middle East region [1, 2]. The Middle East region is surrounded by a desert ecosystem characterized by active aeolian conditions [3-5]. The SDS has a huge socioeconomic effect mainly on the marine environment [6,7], human health [8], aviation and oil industry [9, 10]. The SDS passing over the region are considered to be major sources of sediments [11-14]. Al-Dousari [1] found evidence of local, regional and global sources contribution to dust throw in higher percentages of sand particles within dust contents. Globally, there is a need to put proper classification for SDS trajectories, and it is indications. Therefore, this study aims to pass through the relation between climate and dust within the Middle East region.

2 Materials and methods

SDS was monitored using images of from MODIS (The moderate-resolution imaging spectroradiometer) within the period from 2002 to 2017 taking in consideration the meteorological data in the region. Deposited dust was also collected from smooth surfaces on buildings with 5m at least above ground level roofs in Cairo-Egypt, Manama-Bahrain, Riyadh and Walamen-south Arabia, south Ahwar-Iraq, and Dubai and Ain-UAE. The collected samples were analyzed by scanning electron microscope (SEM), and the Brunauer, Emmett, and Teller (BET) particles surface area, Centrifugal Particle Analyzer (using Friedman and Blott methods [16]) and X-ray diffraction (XRD).

3 Results and discussion

The SDS was categorized into three major forms in accordance to their size: Small (SDS width less than 100 km), Intermediate (width 100-300 km) and Extensive (width more than 300 km).

Among the three major types, there are 12 subtypes of SDS trajectories (Fig. 1). The wide SDS dominantly originated at the northern part of the Arabian Peninsula and normally originated from Nafud Desert (NFD), East Syria and south Turkey, the Mesopotamian Flood Plain (MFP), Western Desert of Iraq (WD) and the Ahwaz (HZ) or by the combination between multiple sources and each path has it is own fingerprint in the dust properties (Fig. 2). The wide SDS dominantly originated at the southern part is majorly from the Empty Quarter desert (EQ).

The very fine and fine sand particles represent 58% of the average dust fallout percentages in desert areas, while they represents only 11% within the coastal area of the Middle East. The dust fallout particles are fining towards the coastal regions within the Middle East and getting coarser towards the desert areas (Table 1). Quartz and carbonates are the major components of dust in the

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region, feldspars are found with certain percentages, but it was observed that quartz increases and carbonates decrease in the desert area dust. Evaporites (anhydrite, gypsum, and Bassanite) and heavy minerals are present with minor percentages in the dust (Fig. 3, Table 2). The coastal dust shows much more BET-surface area for partcles compared to the desert dust in Kuwait and in the globe (Fig. 4).

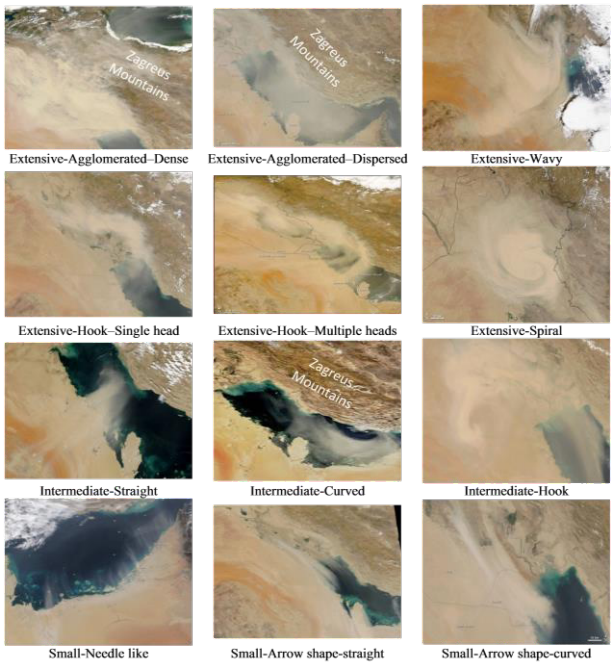

Fig. 1. Sorting index of sand and dust storms (SDS) observed by MODIS images (3 major types and 12 sub types) [3].

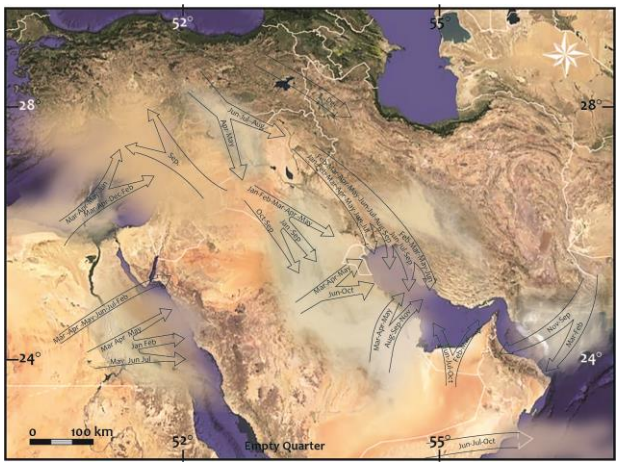

Fig. 2. Temporal and spatial dispersal for numerous dominant SDS main trajectories (2000–2017) overlaid images in the Middle East.

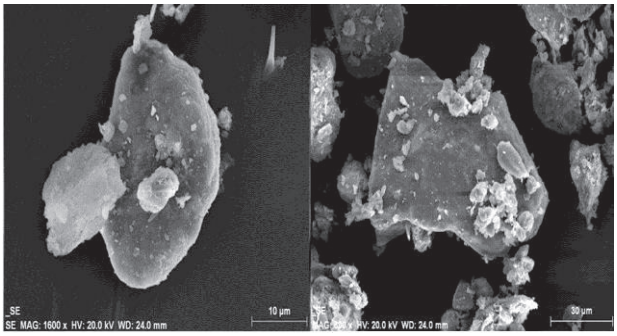

Fig. 3. Quartz subangular dust particle from the Empty Quarter carrying tiny particles of carbonates and feldspars (left), carbonates and evaporites as adhering particles on the surface of quartz from Buibiyan Island in Kuwait (right).

Table 1. Particle size percentages of dust fallout within world major dust storm trajectories [17].

Location	Particle size percentages						
	A	C	C	D	E	F	G
Kuwait	37	22	18	14	7	2	0
Walamen-Saudi	40	8	21	15	11	2	4
Ain	97	0	1	1	1	1	0
Dubai	17	3	14	24	23	10	8
Amman-Jordan	30	11	30	17	8	2	2
Um Qasir-Iraq	3	12	20	25	15	5	20
Manamah-Bahrain	12	10	20	11	13	5	28
Tripoli-Libya	20	12	17	19	17	8	8
Biougra-Morocco	12	28	22	16	8	8	6
Cartagena-Colombia	10	4	18	22	18	12	16
Arizona-USA	9	26	30	13	8	4	10
Tripoli-Libya	20	12	17	19	17	8	8
Cairo-Egypt	10	15	37	21	10	4	3
Taklimakan-China	70	24	2	1	2	1	0
Ejin-China	35	18	10	8	5	2	22
Siberia-Russia	11	31	28	11	7	4	8
Bald Hill-Australia	9	3	5	5	4	3	70
Average	26	14	18	14	10	5	13
Max	97	31	37	25	23	12	70
Min	3	0	1	1	1	1	0

Where A: sand, B: Very coarse silt, C: coarse silt, D: medium silt, E: fine silt, F: very fine silt, and G: clay.

4 Summary and conclusions

The Middle East SDS trajectories (2000-2017) were detected and categorized using satellite images and weather data. The coastal dust regions in the Arabian Gulf, Red Sea, and Mediterranian Sea contain more carbonates and finner in size fraction. The finning of

dust towards the coastal region can be attributed to the presence of the water bodies as they act as a dust trap mainly for larger particles. Knowledge about properties of dust in the region is so valuable in socioeconomically, mainly for future urbanization, solar energy units, and health aspects.

Table 2. Depositional rates of dust fallout within major dust storm trajectories in the world [17].

Location	A	B	C	D	E	F	G
Kuwait	38	38	7	45	10	2	5
Um Qasir-Iraq	13	78	3	80	8	0	0
Riyadh-Saudi	68	32	0	32	0	0	0
Walamen-Saudi	62	13	0	13	24	1	0
Ain-UAE	26	34	19	52	20	1	0
Dubai-UAE	21	25	21	45	6	0	27
Amman-Jordan	21	52	16	68	4	0	7
Manama-Bahrain	32	25	16	41	10	3	15
Tropoli-Libya	64	27	0	27	5	4	0
Sosmasa-Morocco	46	46	0	46	8	1	0
Bawku-Ghana	87	0	0	0	9	2	2
Cartagena-Colombia	66	0	0	0	33	0	1
Cairo-Egypt	51	20	14	34	15	0	0
Negev-Palestine	41	21	2	23	18	17	0
Shapotou-China	38	28	0	28	21	7	5
Beijing-China	24	9	0	9	13	51	3
Andong-S Korea	28	8	0	8	19	45	0
Bald Hill-Australia	57	0	0	0	21	14	7
Average	44	24	5	29	13	10	4
Maximum	87	78	21	80	33	51	27
Minimum	13	0	0	0	0	0	0

Where A: quartz, B: calcite, C: dolomite, D: carbonates, E: clay, and F: other minerals.

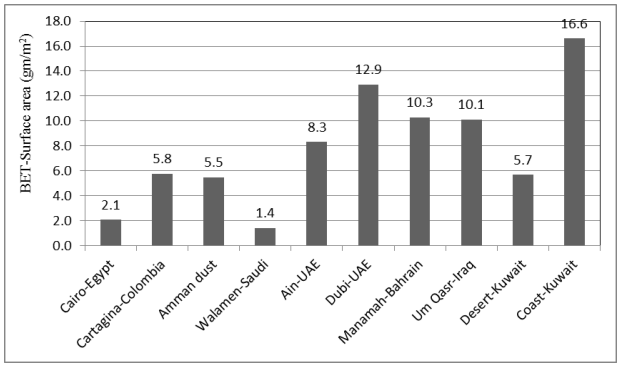

Fig. 4. The BET surface area of dust samples in comparison to surface sediments and other aeolian samples in the world.

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