Journal of Engineering and Applied Sciences 14 (Special Issue 6): 9340-9344, 2019
ISSN: 1816-949X

Some Physical and Chemical Characteristic of Dust Falling on Kerbela City, Iraq

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Abstract: The study was conducted during the period from March 2017 to February 2018 at three locations rural, urban and industrial to monitoring deposition of dust on monthly basis in Kerbala, Iraq. The results of this study revealed that the rate of dust falling ranged 9.66-96.04 g/m^2 with average 36.47 g/m^2 in the rural and areas industrial, respectively. The morphological analysis of dust using the scanning electron microscope showed that the dust particles are not homogeneous, particularly the urban area, most of which are of different and irregular shapes and the sizes of dust particles ranged from 13.22-30.80 μm. The 16 elements in dust were found using energy dispersive x-ray analysis five of them were heavy metals (Cu, Cr, Ni, Cd and Pb). X-ray diffraction analysis showed that calcite (42.6%) and quartz (26.1%) were the dominant minerals in the dust. It appears from the collection and analysis of the results that the sites of study have a significant effect on the concentration, shapes, sizes and contents of dust particles.

Key words: Dust fall, minerals, particulate morphology, heavy metals, urban area, scanning electrons

INTRODUCTION

Air pollution is a major challenge to the urban environment which is steadily increasing due to urban expansion and the decline of green areas. Particulate Matters (PM) are a major air pollutants, according to the Environmental Protection Agency (EPA), an important indicator of ambient air quality and its concentration in the air depends on sources of emission and metrological conditions (Qari and Hassan, 2017). Dust is the particulate matter that range in size from 1~75 μm. Recently, researches have been focused on large particles because of their physical and chemical properties. These particles contain many heavy metals, Polycyclic Aromatic Hydrocarbons (PAHs) and pesticides because of their ability to adsorb these pollutants on their surfaces. By this way, many pollutants are transported to remote areas (Al-Dabbas *et al*., 2011; Al-Awadhi and AlShuaibi, 2013). Dust has many effects on geochemical cycles, ecosystems and the environment as well as negatively affects public health (Harrison *et al*., 1997; Jickells *et al*., 2005; Lawrence and Neff, 2009). Many epidemiological studies have shown an increase in deaths, respiratory and cardiovascular diseases as well as allergies. High dust concentrations in the air or dust storms have been associated with the number of patients entering hospitals (Katsouyanni *et al*., 2001; Fuzzi *et al*., 2015). Iraq is one of the most affected countries in the Middle East by dust and dust storms due to increased desertification as a result of drought and erosion (Sissakian *et al*., 2013). Among the most affected provinces is Kerbala which is exposed to dusty events throughout the year due to its proximity to Western Plateau as well as the increase in industrial activities, traffic and urban expansion (Alhesnawi *et al*., 2018). Despite, the environmental importance of knowledge of the properties and contents of deposition dust, only limited and inadequate studies were conducted. Therefore, this study was designed to estimate the amount of dust falling and to know some of its chemical and physical properties.

MATERIALS AND METHODS

Study area: The province of Kerbala is located in the Middle Euphrates region of Iraq on the edge of the desert of the Western Desert. The province is located at a latitude of 44° and 40 min and at a latitude of 33° and 31 min (Fig. 1). The area of the province is (5034 km^2) representing 1.14% of the area of Iraq (438317 km^2).

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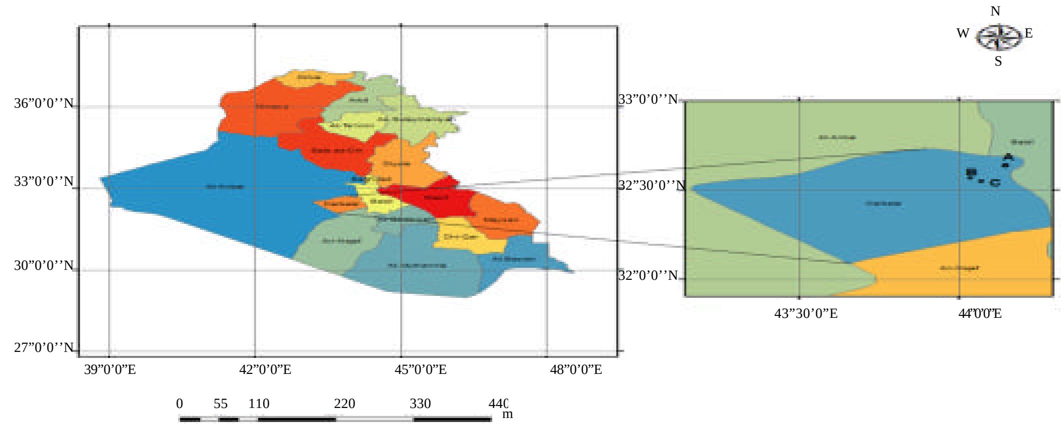

Fig. 1: Rural, urban and industrial study areas

Climate: Temperatures range from 5°C in January to 45°C in July and average was 25°C. The governorate is within the 100 mm rain line within the dry region. The prevailing wind is the Northwest wind, followed by the Western wind.

Samples collection: A sample of dust fall was collected from three sites selected in Kerbala Governorate the first was rural area (N 32°39'33.25", E 44°8'54.59"), the second was urban area (N 32°36'48.09", E 44°1'56.26") and last site was in industrial area (N 32°34'34.37", E 44°2'51.82"). The samples were collected monthly by three replicates from each site from March, 2017 to February, 2018.

Dust fall concentration measurement: To estimate the amount of deposited dust, the described method was followed by Al-Awadhi and AlShuaibi (2013) and the data were expressed as g/m^2 for month (Zhao *et al*., 2010). Climate data were obtained from Kerbala meteorological station.

SEM and EDS analysis: Scanning Electron Microscope (SEM)/Energy Dispersive X-ray Analysis (EDS) determined the particle morphology and chemical composition. Dust particle sizes were measured using Image-J Software based electron microscope images (n = 500).

X-Ray Diffraction (XRD): Minerals have been identified using X-ray diffraction technique (Bruker D2 Phaser) with Cu-Ka radiation at the Faculty of Science, University of Baghdad.

RESULTS AND DISCUSSION

Dust fall concentration: The highest rate of dust was found in the industrial area followed by urban and rural areas, respectively. Palm trees in the rural area play an important role in reducing the amount of dust falling as well as the rise of buildings in urban areas. The results showed that the highest rate of dust in the industrial site was 96.04 g/m^2 in March while the lowest rate in the rural site was 9.66 g/m^2 during February with average deposition rate of 36.47 g/m^2 (Fig. 2). The increase in dust concentrations during the Spring months is due to the high impact of dust storms that coincide annually with these months. The results showed an increase in concentrations of dust falling in the Summer months compared to Winter. This is due to the role of climatic factors in increasing or decreasing dust (Biglari *et al*., 2017; Malakootian *et al*., 2013). The role of climatic factors are confirmed by the analysis of the coefficient of correlation between dust and climatic factors. A positive correlation was found between the falling dust and the temperature. In other words, the increase in these factors increases the amount of dust falling. In contrast, a negative correlation was found with relative humidity (Table 1).

Table 1: Correlation coefficient analysis between dust fall concentration and metrological factors

Parameters	r	p-values
Temperature (C)	0.259	0.007
Humidity (%)	-0.265	0.006
Rain (mm)	-0.184	0.057
Wind Speed (m^{-1} sec)	0.456	0.000

Sizes of falling dust: The results showed a difference in dust particles. The highest rate was 30.80 μm in the industrial area during the autumn season while the lowest rate was 13.22 μm at the urban site during the Winter with average was 19.94 μm (Fig. 3). The difference in the size of the dust particles is due to the impact of the site and climatic factors, the most important of which is the wind speed. The analysis of dust sizes shows that the Kerbala

Table 2: Weight percentage of elements in the dust falling within the study sites

Elements	Rural Mean	Rural SD	Rural Min.	Rural Max.	Urban Mean	Urban SD	Urban Min.	Urban Max.	Industrial Mean	Industrial SD	Industrial Min.	Industrial Max.
C	23.35	7.47	12.10	40.49	24.95	18.37	8.37	67.77	30.55	16.32	13.72	68.28
O	39.10	9.81	15.56	51.20	42.06	7.68	23.25	50.20	39.12	8.86	21.25	49.06
Na	0.80	0.38	0.23	1.30	0.76	0.53	0.36	2.25	0.63	0.77	0.00	2.61
Mg	1.84	0.73	0.89	2.69	1.48	0.80	0.28	3.03	1.46	0.68	0.25	2.54
Al	3.27	0.89	1.51	4.07	2.57	1.33	0.54	5.12	2.38	1.04	0.45	3.97
Si	9.77	3.41	4.89	18.77	8.84	3.72	1.78	13.65	8.22	3.80	1.56	14.41
S	1.68	0.95	0.64	3.60	1.76	0.88	0.41	3.57	2.34	1.81	0.20	6.89
Cl	1.16	0.59	0.52	2.56	1.51	2.46	0.12	8.23	1.22	1.09	0.00	4.00
K	1.63	0.68	0.80	3.43	0.89	0.50	0.24	2.18	0.79	0.53	0.00	1.58
Ca	10.82	3.48	8.02	20.39	9.63	5.01	3.23	20.55	8.95	3.56	2.74	13.89
Cr	0.14	0.17	0.00	0.51	0.21	0.11	0.05	0.41	0.36	0.67	0.00	2.37
Ti	0.24	0.15	0.00	0.46	0.06	0.06	0.00	0.20	0.10	0.14	0.00	0.42
Fe	4.81	0.72	3.64	6.06	3.84	1.80	1.00	7.49	3.86	1.46	1.20	5.94
Ni	0.38	0.58	0.00	2.05	0.79	0.73	0.08	2.62	0.46	0.41	0.00	1.20
Pb	0.39	0.50	0.00	1.35	0.32	0.25	0.00	0.90	0.53	0.44	0.02	1.55
Cd	0.60	0.78	0.00	2.49	0.12	0.13	0.00	0.34	0.26	0.32	0.00	0.95

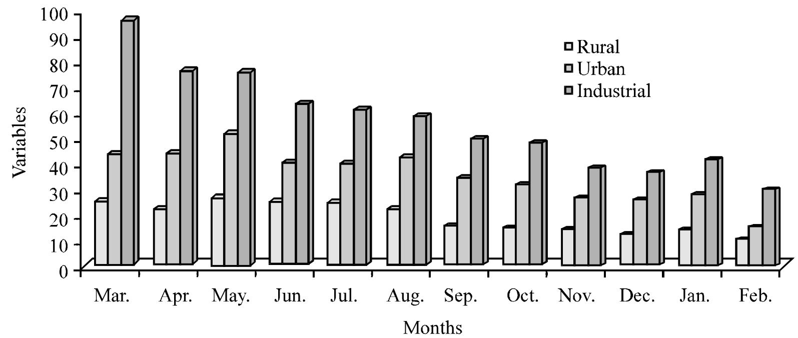

Fig. 2: Monthly variations of dust falling on the province of Kerbala within the study areas: total dustfall g/m^2

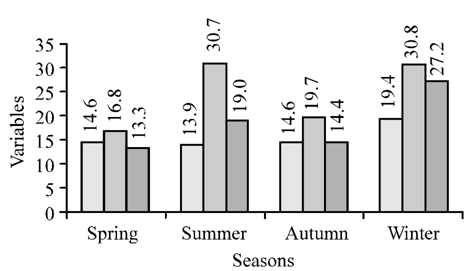

Fig. 3: Average of dust fall particle sizes during seasons and locations: dust fall size (μm)

is significantly affected by local activities and soil erosion much more than the effect of the mobile sand dunes coming from Western Sahara. Some studies have suggested that dust particles of <50 microns are sourced from local sites and sedimentation processes of suspended air particles rather than mobile sand dunes while particle sources larger than 100 microns are sand dunes (Mori *et al*., 2002; Wang *et al*., 2005). More importantly that the dust in the respirable size range is harmful to human health (Bian and Zender, 2003; Guthrie and Mossman, 1993).

Morphology of dust fall: The results of the analysis by the electron microscope showed significant changes in the shapes and sizes of the dust particles in the study sites during the Spring and Autumn (Fig. 4). These changes can be due to the impact of the site because the particles of falling dust are large and often settle close to their sources. Attribute the dust particles falling in the urban site were very different and heterogeneous compared to other sites and the various activities in the city, traffic, the increase of vehicles, building construction and workshops. The morphology of particles produced from natural sources are have solid and irregular shapes while that particles from anthropogenic sources are liquid or solid with variable morphology. The spherical shape of particles as result to the secondary reactions and transportation in atmosphere (Buseck *et al*., 2000; Li and Shao, 2009).

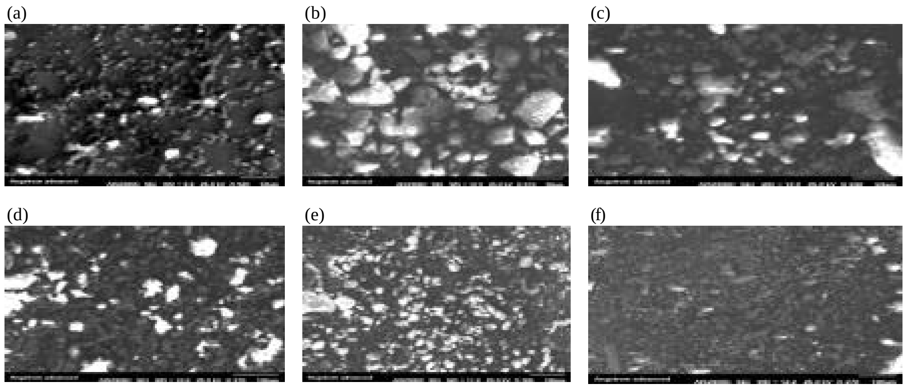

Fig. 4: SEM analysis for dust particles shown different changes in size and shapes: a) Rural/Autumn; b) Urban/Autumn; c) Industrial/Autumn; d) Rural/Spring; e) Urban/Spring and f) Industrial/Spring

Table 3: The mineral composition of the falling dust in the study sites

	Sites						
Minerals	Rural	Urban	Industrial	Mean	SD	Min.	Max.
Calcite	40.8	49.4	37.7	42.6	6.1	37.7	49.4
Quartz	23.0	17.6	37.8	26.1	10.5	17.6	37.8
Albite	8.4	0.0	9.9	6.1	5.3	0.0	9.9
Illite	6.9	0.8	4.3	4.0	3.1	0.8	6.9
Gypsum	5.9	19.2	2.8	9.3	8.7	2.8	19.2
Dolomite	4.2	0.0	3.0	2.4	2.2	0.0	4.2
Palygorskite	4.1	6.2	2.3	4.2	2.0	2.3	6.2
Kaolinite	6.6	4.7	2.2	4.5	2.2	2.2	6.6
Halite	0.0	2.1	0.0	0.7	1.2	0.0	2.1

Chemical composition of dust fall by EDS analysis: As shown in Table 2, 16 elements were found in the falling dust particles in which the oxygen element was dominant and follows the trend as C>Ca>Si>Fe>Al>S>K>Mg>Cl>Cd>Na>Pb>Ni>Ti. From these elements were found five heavy metals (Cu, Cr, Ni, Cd and Pb) that have hazardous toxicity to health and the ecosystem (Tchounwou *et al*., 2012; Suvarapu and Baek, 2016). The presence of changes in the weight percentage of the elements within the sites may be due to the geochemical processes of each site in addition to the local activities that contribute to the increase of a certain element at another expense (Hindy *et al*., 2018). The presence of elements Si, Al, Fe, Ca, K and Mg can be attributed to the abundance of clay minerals carbonates (Miler, 2014). While the presence of heavy metals is due to industrial activities, vehicle exhausts and other different human activities (Ram *et al*., 2014).

X-ray diffraction analysis of dust fall: The mineral composition of the falling dust was identified as shown in Table 3. The highest percentage of minerals was calcite followed by quartz, gypsum, albite, kaolinite, palygorskite, illite, dolomite and halite. The difference in the ratio of minerals between sites it may be due to impact of the activities variation of each site. The abundance of calcite in the urban area is associated with pollution from cement dust or clay-rich soils. The results show presence of clay minerals for the different sites were illite, kaolinite and palygorskite. The presence of kaolinite and palygorskite among the clay minerals reflects the semi-arid and arid climatic conditions (Al-Dabbas *et al*., 2011). The results were in agreement with (Al-Dabbas *et al*., 2011; Al-Awadhi and AlShuaibi, 2013; Hindy *et al*., 2018; Ram *et al*., 2014).

CONCLUSION

The study of the physical and chemical properties of dust revealed that most of its sources were local sources directly affected by on-site activities. The rise of dust concentrations and its containment of clay minerals clearly reflect the state of drought in the country.

The particles of falling dust are very dangerous particles to human health because of their small sizes that can reach the upper parts of the respiratory system and contain heavy metals carcinogenic.

REFERENCES

Al-Awadhi, J.M. and A.A. AlShuaibi, 2013. Dust fallout in Kuwait city: Deposition and characterization. Sci. Total Environ., 461: 139-148.

Al-Dabbas, M., M.A. Abbas and R. Al-Khafaji, 2011. The mineralogical and micro-organisms effects of regional dust storms over Middle. Intl. J. Water Resou. Arid Env., 1: 129-141.

Alhesnawi, A.S.M., I.M. Alsalman and N.A. Najem, 2018. Evaluation of air pollution tolerance index of some plants species in Kerbala city, Iraq. J. Pharm. Sci. Res., 10: 1386-1390.

Bian, H. and C.S. Zender, 2003. Mineral dust and global tropospheric chemistry: Relative roles of photolysis and heterogeneous uptake. J. Geophys. Res. Atmos., 108: 1-14.

Biglari, H., S. Geravandi, M.J. Mohammadi, E.J. Porazmey and R.Z. Chuturkova *et al*., 2017. Relationship between air particulate matter and meteorological parameters. Fresenius Environ. Bull., 26: 4047-4056.

Buseck, P.R., D.J. Jacob, M. Posfai, J. Li and J.R. Anderson, 2000. Minerals in the air: An environmental perspective. Intl. Geol. Rev., 42: 577-593.

Fuzzi, S., U. Baltensperger, K. Carslaw, S. Decesari and H.D. van der Gon *et al*., 2015. Particulate matter, air quality and climate: Lessons learned and future needs. Atmos. Chem. Phys., 15: 8217-8299.

Guthrie Jr., G.D. and B.T. Mossman, 1993. Merging the geological and biological sciences: An integrated approach to the study of mineral-induced pulmonary diseases. Proceedings of the International Conference on Health Effects of Mineral Dusts (CONF-9310406- Vol. 28), October 22-24, 1993, Mineralogical Society of America, Washington, DC., USA., pp: 1-584.

Harrison, R.M., D.J.T. Smith, C.A. Piou and L.M. Castro, 1997. Comparative receptor modelling study of airborne particulate pollutants in Birmingham (United Kingdom), Coimbra (Portugal) and Lahore (Pakistan). Atmos. Environ., 31: 3309-3321.

Hindy, K.T., A.R. Baghdady, M.F. Howari and A.S. Abdelmaksoud, 2018. A qualitative study of airborne minerals and associated organic compounds in southeast of Cairo, Egypt. Intl. J. Environ. Res. Publ. Health, 15: 1-16.

Jickells, T.D., Z.S. An, K.K. Andersen, A.R. Baker and G. Bergametti *et al*., 2005. Global iron connections between desert dust, ocean biogeochemistry and climate. Sci., 308: 67-71.

Katsouyanni, K., G. Touloumi, E. Samoli, A. Gryparis and A. Le Tertre *et al*., 2001. Confounding and effect modification in the short-term effects of ambient particles on total mortality: Results from 29 European cities within the APHEA2 project. Epidemiology, 12: 521-531.

Lawrence, C.R. and J.C. Neff, 2009. The contemporary physical and chemical flux of aeolian dust: A synthesis of direct measurements of dust deposition. Chem. Geol., 267: 46-63.

Li, W.J. and L.Y. Shao, 2009. Observation of nitrate coatings on atmospheric mineral dust particles. Atmospheric Chem. Phys., 9: 1863-1871.

Malakootian, M., M. Ghiasseddin, H. Akbari and N.A.J.H. Fard, 2013. Urban dust fall concentration and its properties in Kerman City, Iran. Health Scope, 1: 192-198.

Miler, M., 2014. SEM/EDS characterisation of dusty deposits in precipitation and assessment of their origin. Geologija, 57: 5-14.

Mori, I., M. Nishikawa, H. Quan and M. Morita, 2002. Estimation of the concentration and chemical composition of kosa aerosols at their origin. Atmos. Environ., 36: 4569-4575.

Qari, H.A. and I.A. Hassan, 2017. Bioaccumulation of PAHs in Padina boryana Alga Collected from a Contaminated Site on the Red Sea, Saudi Arabia. Pol. J. Environ. Stud., 26: 435-439.

Ram, S.S., R.V. Kumar, P. Chaudhuri, S. Chanda and S.C. Santra *et al*., 2014. Physico-chemical characterization of street dust and re-suspended dust on plant canopies: An approach for finger printing the urban environment. Ecol. Indic., 36: 334-338.

Sissakian, V., N. Al-Ansari and S. Knutsson, 2013. Sand and dust storm events in Iraq. J. Nat. Sci., 5: 1084-1094.

Suvarapu, L.N. and S.O. Baek, 2016. Determination of heavy metals in the ambient atmosphere: A review. Toxicol. Ind. Health, 33: 79-96.

Tchounwou, P.B., C.G. Yedjou, A.K. Patlolla and D.J. Sutton, 2012. Heavy Metal Toxicity and the Environment. In: Molecular, Clinical and Environmental Toxicology, Volume 3: Environmental Toxicology, Luch, A. (Ed.). Springer, Basel, Switzerland, ISBN-13: 978-3-7643-8340-4, pp: 133-164.

Wang, X., Z. Dong, P. Yan, Z. Yang and Z. Hu, 2005. Surface sample collection and dust source analysis in northwestern China. Catena, 59: 35-53.

Zhao, J., P.A. Peng, J. Song, S. Ma and G. Sheng *et al*., 2010. Research on flux of dry atmospheric falling dust and its characterization in a subtropical city, Guangzhou, South China. Air Qual. Atmos. Health, 3: 139-147.