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Research Article
Chemical Composition of Dust Storms in Agricultural Areas of Arid Land in KSA

Abdulaziz B. Alharbi

Department of Plant Production and Protection, Agriculture College and Veterinary Medicine,
Qassim University, Buraydah, Kingdom of Saudi Arabia

Abstract

Background and Objective: The elemental concentrations of deposited dust are often used to assess the level of contamination and for monitoring air pollution. Therefore, this study determined the chemical composition of dust storms in agricultural areas of arid land. **Materials and Methods:** Samples were collected from 18 positions in the Qassim region. The concentrations of As, Cd, Co, Cr, Cu, Pb, Ni, Ba and Zn were determined in the deposited dust. **Results:** The means of As, Co, Cr, Cu, Pb, Ni and Zn concentrations in dust were 9.72, 14.4, 109, 31.6, 14.o, 59.3, 437 and 75.5, respectively. The concentrations of the previous elements in dust samples were not in the toxicity values range. Also, data indicated that positions D_1, D_2, D_3, D_{12} and D_{14} were higher in silicon but lower in aluminum, iron, Ca and Mg. Conversely, the other positions were lower in silicon but higher in aluminum, iron, calcium and magnesium. However, all positions recorded almost the same amount of the alkali elements, potassium and sodium. **Conclusion:** The analyses showed that dust has increased nutrient value and great agricultural value. The dust content of heavy metals was less than the maximum allowable concentrations.

Key words: Dust storms, arid, chemical composition, agricultural area, heavy metals, minerals

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Corresponding Author: Abdulaziz B. Alharbi, Department of Plant Production and Protection, Agriculture College and Veterinary Medicine, Qassim University, Buraydah, Kingdom of Saudi Arabia

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

A dust (sand) storm is a meteorological phenomenon common in arid and semi-arid regions. Dust storms arise when a gust front or other strong wind blows loose sand and dust from a dry surface. Particles are transported by saltation and suspension, causing soil erosion in one place and deposition in another. The Sahara and dry lands around the Arabian Peninsula are the main terrestrial sources of airborne dust, with some contributions from Iran, Pakistan and India into the Arabian Sea. It has recently been argued that poor management of the Earth's dry lands, such as neglecting the fallow system, is increasing dust storms from desert margins, changing both the local and global climate and impacting local economies[1].

Another study[2] Reported that the quantities of dust carried by individual pulses, from small to massive storms, extend from a few thousand to ISO million metric tons. The dust could add significant quantities of nutrient elements; for example, the south of the Sahara came into the picture even later. The beneficial effects of airborne dust to many soils have posed an interesting question. Is the dust more or less useful in its new location compared to its source area? An adequate answer to that question would provide an improved basis for assessing the effects of wind erosion.

Sand and dust storms are natural hazards that can affect large areas of continents and produce impacts across continents. As shown by several other papers from this workshop, there are impacts on human health and the economies of countries. Several climatic factors are involved in land degradation such as rainfall, floods, droughts, solar radiation, temperature, evaporation and wind[3]. Whereas the degradation arising from water erosion is ubiquitous, wind erosion is most common in semiarid and arid environments. Africa harbors the largest area affected by wind erosion. In the world's drylands, wind and water erosion constitute 42 and 45% respectively, of the total soil degradation[4]. In North Africa, dust contained in red rains (here named red dust) recorded a variable mineralogical composition depending strongly on the soil types of the dust source regions[5-7]. The elemental composition of these dust is similar to the global crustal composition[8], but for some elements, the dust composition reflects that of the different soils at the desert source areas, rather than the general crustal composition.

It was[9] demonstrated that cement dust contains high amounts of Zn, Cd, Cu and Pb and the magnetic susceptibility of dust was also higher in cement dust compared to other samples. Moreover, the cement industry produced additional pollutants, including heavy metals deposited in dust[10].

The mineralogical composition of dust is variable and depends strongly on the soil types of the dust source regions. Generally, the most abundant minerals in the Earth's continental crust are feldspars, which constitute about 41% of the crust by weight, followed by quartz at 12% and pyroxenes at 11%[11]. This paper provides an overview of the chemical composition of sand and dust storms in the agricultural area for arid land. Also, this study compared the concentration of elements in the dust with the Maximum Allowable Concentrations (MAC) in agriculture.

MATERIALS AND METHODS

Study area: The Qassim region is located in the center of Saudi Arabia. It has an area of 65,000 km^2. The climate in Qassim region is mild during summer, but it gets hot during the day, temperatures cool down at sunset and the night breeze is refreshing. During winter, the weather is cold and accompanied by rain and precipitation. In summer, the mean monthly air temperature is 34°C and during winter, it is 15°C. Dust storm can occur any time of the year but it is most frequent during March, April and May.

Samples collection and preparation: Dust samples were collected to determine the chemical composition of sand and dust storms in the agricultural area. The Global Positioning System (GPS) was used to record the absolute positions of collected samples (Map 1). A total of 18 dust samples were collected from different locations in the Qassim area (see Map 1) between September, 2017 to July, 2018, by using dry stainless steel dust fall collectors (l.2×1.2 square meter) at 1.5 m altitude above ground level. The locations of these samples are stated in Fig. 1. The collectors were situated in some cities in Qassim province and to get enough materials for analysis, samples were collected at the end of the study period (approximately one year, from September, 2017 to July, 2018).

A total of 18 samples of dust were collected from the Qassim region in Saudi Arabia for investigation by instrumental neutron activation analysis. The powdered samples were homogenized using an electric shaker. The samples were then irradiated by thermal neutrons at *Act labs* in Canada. The 4E-Research-INAA, total digestion-ICP, lithium metaborate/tetraborate fusion-ICP were used. A 30 g aliquot was encapsulated in a polyethylene via land irradiated with flux wires using a thermal neutron flux of 7×10^{12} n cm^{-2} sec^{-1}. After a 7 days decay of Na-24, the samples were counted on a high purity Ge detector with a resolution better than 1.7 keV for the 1332 keV Co-60 photopeak. Using the flux wires, the

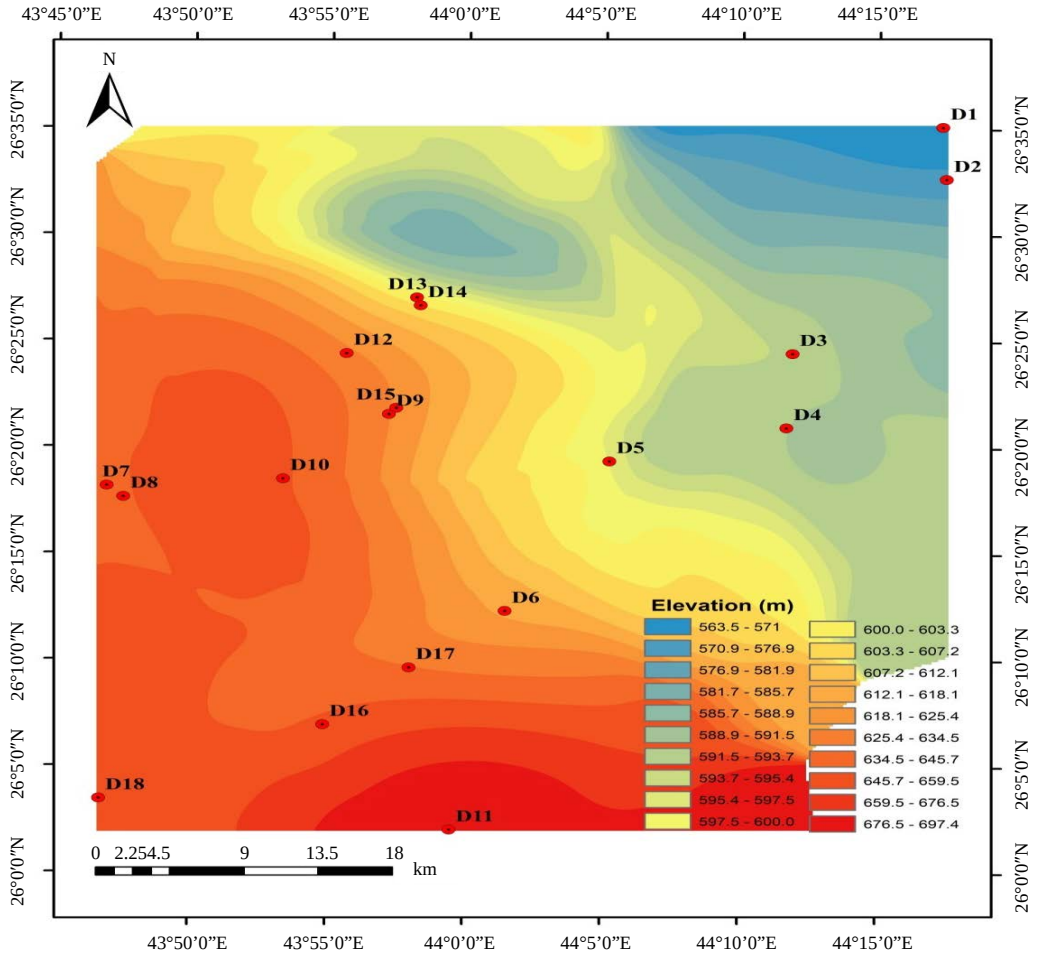

Fig. 1: Elevation and distribution of positions of collected samples in the Qassim area, D: Location

decay-corrected activities were compared to a calibration developed from multiple certified international reference materials. Researcher[12] gave the technical details of INAA such as the radioisotopes used to calculate the concentration of the analyzed elements as well as their nuclear data.

For measuring the elements undetected by INAA like: Si, Al, Fe, Mn, Mg, Ca, Na, K, Cd, Cu, Pb, Ni, Ba, Zn,Ti, P,a 0.2 g sample was mixed with a mixture of lithium metaborate/ lithium tetra borate and fused in a graphite crucible. The molten mixture was poured into a 5% nitric acid solution and shaken until dissolved (~30 min).

The samples were run for selected traces on a Varian Vista ICP.A 0.25 g sample was digested with four acids beginning with hydrofluoric, followed by a mixture of nitric and per chloric acids, heated using a precise programmer controlled heating in several ramping and holding cycles, which takes the samples to dryness. After attaining dryness, samples were brought back into solution using hydrochloric acid. With this digestion, certain phases were only partially solubilized.

Data analysis: The fused sample was diluted and analyzed by Perkin Elmer Sciex ELAN 6000, 6100 or 9000 ICP/MS. Data analysis was conducted using SPSS 18.0 and Microsoft Office Excel and a final map was prepared using the Arc GIS 9.3 software.

RESULTS AND DISCUSSION

The results and discussion were based on the fact that dust has a variable minerals composition depending heavily on the soil types of the dust source regions. Therefore, the minerals concentration in the dust samples was compared with levels of elements concentration for the different sources of dust, such as the Earth's crust, as well as igneous and sedimentary rocks, to identify sources of dust in the region. Moreover, the concentration of elements in the dust was also compared to the limits allowed by agriculture to determine the usefulness or danger of dust on the agricultural sector in the Qassim region.

Table 1: Concentration of elements in dust samples in different locations of Qassim region

	Concentration of minerals (mg kg^{-1})								
Region	Cd	As	Co	Cr	Cu	Ni	Pb	Zn	Ba
D_1	>0.5	9	8.1	134	90	33	41	48	497
D_2	>0.5	9	10.0	81.5	19	36	14	40	509
D_3	>0.5	7	10.3	130	18	42	18	51	491
D_4	>0.5	12	20.3	108	34	79	12	80	374
D_5	>0.5	11	22.1	114	36	83	12	85	347
D_6	>0.5	8	13.7	86.8	18	39	12	51	494
D_7	>0.5	7	11.4	128	22	47	17	64	612
D_8	>0.5	5	7.6	57.0	17	26	12	33	475
D_9	>0.5	8	10.9	119	36	46	16	226	427
D_{10}	>0.5	9	15.6	104	33	76	12	83	431
D_{11}	>0.5	12	17.0	113	30	74	13	80	381
D_{12}	>0.5	5	5.8	59.1	14	26	10	33	487
D_{13}	>0.5	9	13.5	136	22	53	14	67	500
D_{14}	>0.5	8	8.3	83.8	17	37	12	51	550
D_{15}	>0.5	15	23.0	121	41	94	11	95	335
D_{16}	>0.5	14	24.8	119	50	104	10	101	320
D_{17}	>0.5	12	17.8	131	34	82	6	82	271
D_{18}	>0.5	15	20.6	140	39	91	11	89	370
[3]Mini.		5.0	5.8	57	14	26	6.0	33.0	271
[4]Max.		15.0	24.8	140	90.0	104	41.0	226	612
[5]M-SD		3.08-9.72	5.89-14.4	25.5-109	17.8-31.6	25.6-59.3	7.26-14.0	43.2-75.5	90.0-437

[1]D: Location, [2]mg kg^{-1}: Milligram/kilogram, [3]Mini: Minimum, [4]Maxi: Maximum, [5]M-SD: Mean standard deviation

Table 2: Minerals composition of dust as oxides for different positions of the Qassim region

P	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (T) (%)	MnO (%)	MgO (%)	CaO (%)	Na_2O (%)	K_2O (%)	TiO_2 (%)	P_2O_5 (%)
D_1	72.41	7.37	3.56	0.056	1.68	4.27	0.89	2.06	0.798	0.08
D_2	72.99	7.58	3.85	0.059	1.76	3.55	0.88	2.09	0.807	0.1
D_3	70.79	8.2	3.82	0.063	2.29	3.43	0.79	2.25	0.653	0.33
D_4	51.83	12.73	6.02	0.104	5.21	6.76	0.76	2.42	0.656	0.24
D_5	46.26	13.3	6.32	0.112	5.24	7.93	1.36	2.33	0.646	0.26
D_6	67.32	8.53	4.07	0.071	2.35	5.26	0.95	2.18	0.741	0.12
D_7	63.35	9.74	4.28	0.068	2.53	6.44	1.24	2.43	0.777	0.16
D_8	74.45	5.93	2.80	0.044	1.4	5.57	0.78	1.83	0.432	0.09
D_9	49.28	8.73	4.43	0.068	3.38	14.76	1.22	1.77	0.733	0.18
D_{10}	52.10	12.68	5.99	0.102	5.93	5.87	1.13	2.47	0.72	0.26
D_{11}	48.94	12.30	5.87	0.104	4.66	7.61	2.84	2.29	0.697	0.25
D_{12}	77.69	7.29	3.11	0.047	1.16	2.39	1.24	2.09	0.575	0.05
D_{13}	62.52	11.48	5.35	0.089	2.86	4.98	1.8	2.48	0.944	0.14
D_{14}	68.86	10.05	4.55	0.074	1.85	3.71	1.74	2.43	0.934	0.1
D_{15}	44.48	14.89	7.22	0.126	5.14	7.17	0.81	2.28	0.712	0.28
D_{16}	41.64	15.17	7.31	0.147	5.38	7.86	0.86	2.24	0.762	0.3
D_{17}	38.99	12.43	6.17	0.11	5.42	10.22	2.2	2.02	0.661	0.26
D_{18}	44.13	14.28	7.01	0.126	4.62	9.72	1.27	2.16	0.875	0.26
[3]Mini.	38.99	5.93	2.80	0.044	1.16	2.39	0.76	1.77	0.432	0.05
[4]Max.	77.69	15.17	7.31	0.147	5.93	14.76	2.84	2.48	0.944	0.33
[5]M-SD	58.2-13.0	10.7-2.89	5.1-1.44	0.08-0.03	3.49-1.67	6.52-2.98	1.26-0.56	2.12-0.21	0.73-0.12	0.19-0.08

[1]D: Location, [2]%: Percentage, [3]Mini: Minimum, [4]Maxi: Maximum, [5]M-SD: Mean standard deviation

Dust deposition may precipitate amounts of macro and micro element inputs every year in the Qassim region. Table 1 and 2 present the chemical composition of dust samples.

Zinc: Data in Table 1 show that zinc concentrations in dust samples ranged between 33-226 mg kg^{-1}. The D_6 sample exhibited the highest concentration (226 mg kg^{-1}), while the lowest concentration was in both D_8 and D_{12}. The concentrations of zinc in dust samples were in line with world data. Researcher[13] reported that zinc is unevenly distributed in soils and its concentration ranges between 10-300 mg kg^{-1}, with a mean of about 50 mg kg^{-1}.

The Maximum Allowable Concentrations (MAC) for trace metals, differ greatly between countries. The MAC for zinc was between (100-300 mg kg^{-1})[14,15]. Consequently, the Zn concentrations in dust samples were not in the toxicity values range.

Cadmium: Cadmium is regarded as one of the most ecotoxic metals adversely affecting all biological processes of humans, animals and plants. This metal has revealed its great adverse potential to affect the environment and the quality of food.

Table 1 shows the concentration of Cd in the dust sediment. In all samples, the Cadmium concentration was less than 0.5 mg kg^{-1}.

In fact, the global average soil Cd concentration has been estimated to range between 0.06 and 1.1 mg kg^{-1}, with an average of 0.5 mg kg^{-1}. In uncontaminated soils, its contents are highly governed by soil texture and averages ranging from 0.22-0.51 mg kg^{-1} in light sandy and heavy-loamy soils, respectively[16].

The dust samples were uncontaminated, where the MAC for Cadmium was between (1-5 mg kg^{-1})[14,15]. The Cd concentration in all dust samples was less than 0.5 mg kg^{-1}.

Arsenic: Data in Table 1 shows that as concentrations in dust ranged between 5-15 mg kg^{-1}. These results were almost similar to those in the Earth's crust. The concentrations of arsenic in Canadian sediments range from 6-100 mg kg^{-1}. Naturally, 4.8-13.6 mg kg^{-1} of arsenic was found in agricultural soils in Canada. Arsenic in soil concentrations was estimated to be 7.5 mg kg^{-1} in the US[17].

Conversely, the concentration of As in dust samples was not up to the toxic level, where the Maximum Allowable Concentrations (MAC) for as were between (10-20 mg kg^{-1})[14,15].

Cobalt: Cobalt concentrations in dust samples ranged between 5.8-24.8 mg kg^{-1} (Table 1). The concentration of Cobalt in dust samples was not up to the toxic level, where the Maximum Allowable Concentrations (MAC) for Co were between (20-50 mg kg^{-1})[14,15].

The values of Co coincided with the world mean values in surface soils. The range of the world mean values of Co in surface soils is between 4.5 and 12 mg kg^{-1}, being the highest for heavy loamy soils and the lowest for light sandy soils and organic soils[18]. The range of Co in reference samples of the USA is from 5.5-29.9 mg kg^{-1} and in Chinese soil, the range is from (5.5-97 mg kg^{-1})[19].

Chromium: Chromium concentrations in dust samples ranged between 57.0-140 mg kg^{-1} (Table 1). The concentration of chromium in dust samples was not up to the toxic level, where the Maximum Allowable Concentrations (MAC) for Cr ranged from (50-200 mg kg^{-1})[14,15].

These results were in agreement with the mean values of Cr in the differentsoil types of the world. Sandy and light loamy soils contain Cr within the range 2-350 mg kg^{-1}, whereas in heavy loamy and clay soils Cr ranges from (30-100 mg kg^{-1})[16]. Cr ranges from 3-50 mg kg^{-1} in Swedish arable soils, at an average value of (22 mg kg^{-1})[20]. The median Cr contents in agricultural soils of Japan vary from 56-70 mg kg^{-1} in Andosols and Acrisols, respectively[18].

Copper: Table 1 shows that Cu in dust samples ranged between 14-90 mg kg^{-1}. The highest and lowest concentrations were found in D_1 and D_{12}, respectively. Similar results were obtained in other regions of the world. The general values for the average total Cu contents in the different soil types of the world have been reported to range between (20 and 30 mg kg^{-1})[21]. However, values below 10 mg kg^{-1} are very often cited and thus, the global range for mean Cu concentration is cited to be from 8 mg kg^{-1} in acid sandy soils to 80 mg kg^{-1} in heavy loamy soils[16].

On the other hand, the Maximum Allowable Concentrations (MAC) for Cu were between (60-150 mg kg^{-1})[14,15]. Consequently, the Cu concentrations in dust samples were not in the toxicity values range.

Nickel: Nickel concentrations in dust samples ranged between 26.0-104 mg kg^{-1} (Table 1). These results are higher than the mean values of Ni in the different soil types of the world.

The common background range of mean Ni contents varies between 19 and 22 mg kg^{-1}, but various values ranging from 20-40, have been cited[22]. The Ni contents in soils for the agricultural zones in Odo-Oba, southwestern Nigeria ranged between is (7.9-31.9 mg kg^{-1})[23]. The sandy soils of Poland contain, on average, 8 mg Ni kg^{-1} and loamy soils (18 mg Ni kg^{-1})[16]. The geometric means of Ni concentrations in the soils of two background-sites in the State of Idaho, USA, are (11.8 and 23.4 mg kg^{-1})[24]. The median Ni contents in Japanese soils range from 25-31 mg kg^{-1}, with the lowest value for Acrisols and the highest for Andosols[18].

The increasing Ni concentration in most dust samples may be due to the soil texture of dust. A close relationship between Ni in the surface soils of Alabama as well as CEC and clay content was reported previously[25]. The lowest Ni level (7.6 mg kg^{-1}) was in the soilwith 0.9% clay content and the highest (53.8 mg kg^{-1}) was in the soil with 4.6% clay content.

The data presented by another researcher[26], 88 mg Ni kg^{-1} in calcareous loam and 27 mg Ni kg^{-1} in light sandy soil, also revealed the impact of soil texture on the soil Ni status. The Maximum Allowable Concentrations (MAC) for Ni were between (20-60 mg kg^{-1})[14,15]. Consequently, the Ni concentrations in most dust samples (D_4-D_5-D_{10}-D_{11}-D_{15}-C1-C2-C3) were more than the Maximum Allowable Concentrations.

Lead: Lead concentrations in dust samples ranged between 6.0-18 mg kg^{-1}, except the D_1 sample which recorded 41 mg kg^{-1} (Table 1).

The overall mean value of Pb for different soils has been calculated to be, in the average, at (25 mg kg^{-1})[16]. Unpolluted soil Pb concentration as being less than 85 mg kg^{-1} was observed[27]. In Greenland soils, Pb contents were found to vary between <12 and 13.8 mg kg^{-1}. Thus, at the end of the 1990s, the Pb contents of arctic soils were at values below the stringent guideline value of 25 mg kg^{-1}. Contents of Pb in soils show a positive correlation with contents of fine granulometric fractions. Its lowest amounts, up to 40 mg kg^{-1}, are in light sandy soils and the highest, up to 90 mg kg^{-1}, in heavy loam soils. Some increased Pb contents have also been reported for calcareous and organic soils[28]. Depending on the previous discussion, most dust samples consist oflight sandy soils.

On the other hand, the Maximum Allowable Concentrations (MAC) for Pb were between (20-300 mg kg^{-1})[14,15]. Consequently, the Pb concentrations in all dust samples were in a safe range.

Barium: Barium concentrations in dust samples ranged between 271-612 mg kg^{-1}, with an average value of 437 mg kg^{-1} (Table 1). The average range of Barium for soils on the world scale is from 84-960 mg kg^{-1}, with the lowest being in organic soils and the highest in loamy and clay soils[28]. Another study[19] reported the Ba content in reference soils from China to range between 18-1210 mg kg^{-1} and in soils of the USA, from 290-240 mg kg^{-1}.

Trigger Action Value (TAV) for trace metals in agricultural soils for Ba were between (400-600 mg kg^{-1})[14,15]. Consequently, the Ba concentrations in almost all dust samples were in a safe range.

Table 2 showed the content of minerals composition in dust storms as oxides for different positions in the Qassim region. The SiO_2 concentrations in all position were the highest compared to other elements. In addition, data indicated that positions D_1, D_2, D_3, D_{12}, D_{13} and D_{14} were higher in SiO_2 compared with other positions. The descending order of concentrations of the elements in the dust was as follow: SiO_2>Al_2O_3>CaO>Fe_2O_3>MgO>K_2O>Na_2O>TiO_2>P_2O_3>MnO.

However, all positions almost contain similar amounts of the alkali elements as KO_2 and NaO_2. The data showed that there are interferences between silicon and some other elements. This finding was reported by other researcher[16] who stated the existence of several interferences between Silicon and other ions occurring in soil that modify its behavior.

In fact, Silicon a major constituent of nearly all rocks[29]. The most common source of Silicon in the Earth's crust is plagioclase feldspar ($NaAlSi_3O_8$-$CaAl_2Si_2O_8$)[30].

The Silicon concentrations in dust for all positions were ranged between 18-36% (39.9-77.6% as SiO_2) with mean was about 27.1% (58.2% as SiO_2). The highest and lowest concentration of Silicon were in positions D_{12} and D_{17}, respectively. According to other study[16], the concentration of Silicon in the Earth s crust ranged between 26-29%, in igneous rocks it ranged between 20-34%, in sedimentary rocks as sandstones and calcareous sediments, it ranged between 25-28 and 30-40%, respectively.

Regarding of aluminum, the concentrations in dust for all positions were ranged between 3.13-8.02% (5.93-15.17% as Al_2O_3) with mean 5.66% (10.7% as Al_2O_3). The positions of D_{16} and D_8 recorded the highest and lowest concentration of Al, respectively. The concentration of Al in the Earth s crust was about 8.2%, in igneous rocks it ranged between 6-8.8%, also in sedimentary rocks as Argillaceousmaterials, sandstones and calcareous rocks,it ranged between 7-10, 2.5-4.3 and 0.4-1.3%, respectively[16].

Respect of Iron, the concentration in dust for all positions was ranged between 1.96-5.13% (2.8-7.31% as Fe_2O_3), with mean was about 3.56% (5.1% as Fe_2O_3). The positions of D_{16} and D_8 recorded the highest and lowest concentration of Iron, respectively. According to previous study[16], the concentration of Iron in the Earth s crust was about 5.0%, in igneous rocks it ranged between 1.4-8.7%, in sedimentary rocks as argillaceous materials, sandstones and calcareous rocks it ranged between 3.3-4.7, 1.0-3.0 and 0.4-1.0%, respectively.

The concentration of Manganese in dust for all positions was ranged between0.034- 0.113% (0.044-0.147 as MnO) with mean was about 0.061% (0.08% as MnO). The position of D_{16} and D_8 recorded the highest and lowest concentration of Manganese, respectively. According to other study[17], the concentration of Manganeseinthe Earth's crust ranged between 716-1400 mg kg^{-1}, in igneous rocks it ranged between 350-2000 mg kg^{-1}, in sedimentary rocks as argillaceous materials, sandstones and calcareous srocks, itranged between 400-850, 100-500 and 200-1000 mg kg^{-1}, respectively.

The concentration of Magnesium in dust for all positions was ranged between 0.669- 3.55% (1.16- 5.93% as MgO) with mean was about 2.094% (3.49% as MgO). The positions of D_{10} and D_{12} recorded the highest and lowest concentration of Magnesium, respectively.

Regarding Calcium, D_9 recorded a higher concentration of Calcium, 10.5% (14.76% as CaO). The lowest concentration of Calcium was found in D_{12}, 1.64% (2.39% as CaO). The mean of Calcium concentration in storm dust was 4.65% (6.52% as CaO).

The concentration of Sodium in dust for all positions was ranged between 0.56-2.1% (0.76-2.84% as NaO_2) with mean was about 0.743% (1.26% as NaO_2). The positions of D_{11} and D_3 recorded the highest and lowest concentration of Sodium, respectively.

The concentration of Potassium in dust for all positions was ranged between 1.46-2.05% (1.77-2.48% as K_2O) with mean was about 1.75% (2.12% as K_2O). The positions of D_{13} and D_9 recorded the highest and lowest concentration of Potassium, respectively.

Total content of alkali metals, Magnesium, Calcium, Sodium and Potassium, in the Serbia soils was 0.61, 2.22, 0.85 and 1.77%, respectively[31].

The concentration of Titanium in dust for all positions was ranged between 0.258- 0.56% (0.43-0.94% as TiO_2) with mean was about 0.43% (0.73% as TiO_2). The positions of D_{13} and D_8 recorded the highest and lowest concentration of Titanium, respectively. Titanium shows the strong lithophilic characteristic and is a common constituent of rocks, in the range of 0.03-1.4%. Its average abundance in the Earth's crust is given as 0.4-0.6%[32].

Also, the concentration of Phosphorous in dust for all positions was ranged between 0.021-0.143% (0.05-0.33% as P_2O_5) with mean was about 0.082% (0.19% as P_2O_5). The positions of D_3 and D_{12} recorded the highest and lowest concentration of Phosphorous, respectively.

The earth's crust contains Phosphorous about 1,200 mg kg^{-1}, making it the 11th most abundant element. Common concentrations for total Phosphorous in soils are between 200 and 800 mg kg^{-1}, with older soils containing lower amounts of Phosphorous and younger soils containing higher amounts of Phosphorous[33].

CONCLUSION

The deposition of dust may be a source of macro and micro elements in agricultural soils of the Qassim region, on a yearly basis. The analyses showed that dust has increased nutrient value and great agricultural value. However, the dust content of heavy metals was less than the Maximum Allowable Concentrations (MAC) in all locations. These results proof that dust has more than one source, but the main source is the Earth's crust.

SIGNIFICANCE STATEMENT

This study discovered the chemical composition of sand and dust storms by high precision technic using instrumental neutron activation analysis which includes a large number of chemical elements and most of the minerals composition of dust as oxides that can be beneficial for the agricultural area in arid land. This study will help the researchers to uncover the critical areas of environmental change in the agricultural area especially in arid land that many researchers were not able to explore.

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