Physio-chemical Properties of Airborne Particles Collected from some locations in QassimRegion

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Abstract: Qassime Region, is one of the thirteen administrative provinces of Saudi Arabia. It is located in the center of Saudi Arabia, and receives annually a considerable amount of dust. Dust deposit samples were collected, from eighteen different locations in Qassime during the period from September 2012 to July 2013. Samples were analyzed for particle size distribution as well as physio-chemical analysis. The dust fractions lie between loamy sand and clay, having an average composition of 44.5% sand, 27.4% silt and 28.19% clay. Organic matter %, CaCO3 %, EC and pH were rather high and averaged 0.83%, 15.65%, 1.5dSm^{-1} and 8.57, respectively. Results showed that dust samples contained considerable levels of some essential elements. Mean values of the detected elements (in µg g^{-1}were P 17.73; TN, 388.9; and K, 26.6. Also, the results explained that dust samples contained considerable levels of some trace elements. Mean values of the detected elements (in µg g^{-1} were Pb13.44; Zn, 198;Mn, 136.85; and Cu, 23.39.The concentration of Pb ranged between 1.25 µg.g^{-1} and 25 µg.g^{-1}. The Integrated pollution index (IPI) for all dust deposit samples equal to or less than 1 for that the pollution levels is low. In addition to natural sources, these higher values may be related to other traditional sources such as motor vehicle emissions. Finally the dust deposit may be more, or less, useful in its new location than it was in its source area. dust have a variety of effects in soil and can contribute supplies of nutrient elements for plants, provides the bulk of the material for sandy surface horizons in many soils.

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1. Introduction

A Dust or sand storm is one of the most important natural phenomena in arid regions. The deserts and semi-arid are major sources of the dust in the world. Large quantities of dust are known to be carried out of the Sahara every year. Quantities of dust carried by individual pulses, from the small ones to the massive storms, extend from a few thousand to hundred million metric tons **(Simonson,1995)**. Desert dust can be transported over long distances from the source regions, with the larger particles to be deposited near the source, while the smaller ones to be suspended in the air for a few days or weeks, thus traveling over large distances **(Prospero et al.,2002).** The residence time of dust particles depends on the meteorological conditions, wind speed and precipitation. Increasing dust storms from desert can changing both the local and global climate **(Satheesh and Krishna Moorthy, 2005).** Dust storms cause soil loss from the dry lands**,** and worse, they preferentially remove organic matter and the nutrient-rich lightest particles, thereby reducing agricultural productivity. Dust can also have beneficial effects where it deposits: Central and South American rain forests get most of their mineral nutrients from the Sahara; iron-poor ocean regions get iron; and dust in Hawaii increases plantain growth. In northern China as well as the mid-western U.S., ancient dust storm deposits known as loess are highly fertile soils, but they are also a significant source of contemporary dust storms when soil-securing vegetation is disturbed **(http://www.eosnap.com/image-2012)**. Also the abrasive effect of the storm damages young crop plants. Other effects that may impact the economy are: reduced visibility affecting aircraft and road transportation; reduced sunlight reaching the surface; increased cloud formation increasing the heat blanket effect **(Levin and Ganor, 1996)**; high level dust sometimes obscures the sun over cities; effects on human health of breathing dust **(Rodriguez et al., 2001).** Dust emissions from arid areas of the world are, influencing chemical constituents of the atmosphere **(Hwang and Ro, 2006; Wang *et al*., 2007)**, modifying cloud formation **(Kaufman *et al*., 2005)** and affecting the energy balance of the Earth **(Satheesh and Krishna Moorthy, 2005; Alpert et al., 2004)**.The dust samples collected during dust storm events on the saline land contain abundant Na, Mg, Al, K, Ca, Fe and Ti, as well as toxic elements such as Cu, V, Zn and Ba. Individual particle analysis reveals that fine saline particles (< 10 µm in diameter) on the saline land, consisting largely of carbonate, halite and sulfate together with lithogenic minerals such as SiO_2 and aluminosilicate, are eventually uplifted during the interval from spring to autumn**(Chen, 2008).** The aims of this research are: 1) Study some physical properties of dust particle including texture, packing bulk density, total porosity, $CaCO_3$%, organic matter %. 2) Study the chemical properties of Collected dust samples (pH, EC, soluble cations and anions). 3) Determining the major nutrients content in dust samples(N, P, and K) and total amount of micronutrients (Zn, Mn and Cu) in the dust samples.

2. Materials and Methods

Study area

Al Qassim Region is one of the thirteen administrative provinces of Saudi Arabia. It is located in the center of Saudi Arabia approximately 400 km northwest of Riyadh the capital. its area is about 65,000 km^2. Qassim Region has an arid climate, with very hot summers, low rainfall winter, low humidity and frequent dust storms. Statistical summary of meteorological data for the period of 1985–2010 **(Prince Naïf bin Abdul-Aziz International Airport, Qassim, Saudi Arabia-meteorological Airport-Station number 40405)** indicates that the climate in Qassim Region has a mean monthly rainfall of 11.4mm. Rain may also occur in the spring and its rainfall is very rare, and normally non-existent. Mean monthly air temperature 25.1°C, but Winters are much cooler than summer. Mean monthly air temperature is 34 °C and 15 °C, in summer and winter seasons, respectively. During summer the wind blows dominantly. The average wind speed is 6 kts/month. Dust storms can occur anytime of the year but they are mostly frequent during (March, April, May**) (http://www. jrcc.sa)** and less frequently during a rest of year. Statistical analysis of dust phenomena data in Qassim Region shows that blowing dust, dust/sand storm, haze occur during 34.40%, 6.44% and 59.15% of the total dusty days, respectively. According to data **(http://www. jrcc.sa)**the blowing dust, dust/sand storms, and rising/suspended dust) is continuously present 29.78% throughout the year in Qassim Region**. Also,** statistical analysis shows that the annual average number of dusty days in Qassim Region is 108.7 days.

Sampling

through the period from September 2012 to July 2013, 18dust samples (total suspended particles) were collected at1.5 m above ground level, from different Cities of Qassim Region, using dry stainless steel dust fall collectors (squared with length 1.2 m), modeled on the ASTM standard (ASTM, D1739-70, 1979).The collectors were situated in some cities in Qassim Region and to get enough materials for analysis the samples collected at the end of study period (approximately one year).Samples were sieved using 0.125 mm sieve to avoid ash.The location of these samples were stated in Table 1.

Table 1: Location of Airborne Dust collected Samples.

No.S	Site(city)	location		
		N	E	elevation
1	Shmaceah	26/35/126	44/17/307	582 m
2	Bandareh	26/32/673	44/17/445	585m
3	Robeeah	26/24/460	44/11/867	616 m
4	Shmaceah East	26/20/969	44/11/662	619 m
5	Bureydah Southeast	26/19/377	44/05/222	616 m
6	Bureydah South	26/12/325	44/01/455	632 m
7	Muleeda South	26/18/153	43/46/898	647 m
8	Muleeda North	26/17/627	43/47/513	644 m
9	Bureydah Center	26/21/555	43/57/164	607 m
10	Bureydah west	26/18/504	43/53/325	661 m
11	Bureydah East	26/02/032	43/59/498	598 m
12	Bureydah North	26/24/409	43/55/590	633 m
13	Bureydah Northeast	26/27/039	43/58/138	608 m
14	Bureydah Northeast(2)	26/26/670	43/58/278	604 m
15	Bureydah North(2)	26/21/848	43/57/427	618 m
16	Unezah Southeast	26/09/651	43/57/980	651 m
17	Unezah East	26/06/958	43/54/866	727 m
18	Unezah North	26/07/981	43/52/180	727 m

Method of analysis:

Eighteen samples were dried at 105 °C and prepared for study the physical properties of dust samples (texture, packing bulk density, water retention, and total porosity).Dust texture determined by hydrometer method using calgon as dispersing agent according to **(Day,1965)**, packing bulk density determined using cylinder method according to **(Black, C.A. 1965)**, and water retention andtotal porosity were determined using pressure membrane method according to**(Klute,1986)**.

Eighteen samples were extracted(1:5) for study the chemical properties of dust samples (EC,pH,, Soluble cations and anions Na^+, K^+,Ca^{++},Mg^{++}, Cl,

CO_3^{--}, $HCO3^-$, and SO_4^{--}). Electrical conductivity EC (dSm^{-1}) determined in 1: 5 (soil: water) extract, using EC meter, as described by **(Jackson,1973).** Soil pH assayed in 1:5 (soil: water) suspension using glass electrode pH meter according to **(Jackson,1973)**, Na, and K were determined by flam photometer, Ca, Mg, Cl,HCO_3,SO_4 by titration, CaCO3% by back titration according to (FAO,1980),and total organic matter determined according Walkely and Black method using α- phenol phythaline as indicator **(Black,C.A. 1965)**. Total nitrogen was determined by steam distillation procedure using Mg devarda alloy according to **Black et al., 1965**, Available phosphorus was extracted according to **Olsen et al., 1954**using 0.5 M NaHCO3 solution for extraction. Phosphorus was measured calorimetrically using ammonium molybdate procedure by spectrophotometer according to **(Chapman and Pratt, 1961)**.

Eighteen dust samples were completely dissolved in a mixture of concentrated nitric acid, and concentrated hydrofluoric acid. The total amount of (Mn, Cu and Zn) as micronutrients,and Pb as pollutant were determined with atomic emission spectrometer (Shimadz, 7000) according to (**Culicov et al., 2002; AOAC,1990).** The integrated pollution index **IPI** was calculated using the following formulation **(Wei and Yang.,2009;Chen et al.,2005)**:

$PI_n = C_n / B_n$

Where, Cn is the metal concentration in the dust fall particles and B_n is the back ground concentration of corresponding metal. (back ground concentration in soils):

Pb= 25 $\mu g.g^{-1}$(**Kabata-Pendias and Pendias 2001**), and the classification of IPI as following:

IPI	pollution level
IPI < 1	low
1< IPI <2	Moderate
2< IPI <5	High
IPI > 5	Extreme

3. Result and discussion:

Physical properties of airborne particles

Table 2 shows some physical properties of the dust samples falling on some cities in Qassim Region. The dust particles represented by six texture class, clay and sandy clay loam as dominant class,followed by sandy loam, silt loam,and clay loam, loamy sand. The texture class of dust particles had random distribution through the samples locations. The results indicated that sand fraction (<0.125mm)was the dominants in almost all of dust samples and ranged between 10-87%,followed by clay fraction which ranged between 5-75%, and silt fraction which ranged between 8-60%.The results also revealed that, on average, the percent of the dust fractions was 44.50% sand, 28.19% clay, and 27.40% silt. The abundance of clay and silt fraction in dust sample, and deposition of dust on soil surface layer might have beneficial effects like improve its productivity of sandy soil on a long time.

The results indicated that all of dust samples had a high percent of $CaCO_3$, ranged between 5-33.5% with an average of 15.65%. The high value of $CaCO_3$are believed to have originated from soils rich in lime stone which spread in Saudi Arabia, as the rain fall is not enough to leach out the carbonates **(Ashraf,1991).** The results indicated that all of dust samples had a low percent of organic matter, ranged between 0.1-1.87 % with an average of 0.83 %. Its believed that arid soils in Saudi Arabia poor in organic matter due to sparse vegetation cover**(Girgirah et.al.,1975).**

Table (2): Mechanical analysis, Organic matter%, and CaCO3% of Airborne Dust samples(<0.125mm).

NO.S	OM%	CaCO3%	Sand%	Silt%	Clay%	texture
1	0.51	11.10	70	10	20	Sandy Clay loam
2	0.10	10.00	75	10	15	Sandy loam
3	1.20	11.20	60	10	30	Sandy Clay loam
4	0.49	18.50	15	30	55	clay
5	0.53	18.70	15	20	65	clay
6	0.17	12.50	60	20	20	Sandy Clay loam
7	0.68	16.20	65	15	20	Sandy Clay loam
8	1.05	16.10	30	40	30	Clay Loam
9	1.50	30.00	32	58	10	Silt loam
10	0.81	12.99	10	75	15	Silt loam
11	0.78	13.50	60	27.5	12.5	Sandy loam
12	1.87	17.00	60	25	15	Sandy loam
13	0.91	12.50	82	8	10	Loamy sand
14	0.65	16.00	15	60	25	Silt loam
15	1.00	9.50	87	8	5	Loamy sand
16	1.91	17.50	40	25	35	Clay Loam
17	0.49	5.00	10	15	75	Clay
18	0.28	33.50	15	35	50	Clay
average	0.83%	15.65%	44.50%	27.40%	28.19%	

The results in Table3explained that total porosity% (volumetric moisture content at saturation), moisture contents at field capacity(- 0.33bar), wilting point(-15 bar), and available water of dust particles ranged between 27.44-116.44, 10.86-57.99, 2.68-23.4,and8.18-47.31, with an average 57.17%, 33.65%, 8.98%, and 24.64 respectively. The presence of silt and clay fraction increased all of previous parameters which improve soil productivity. The results also revealed that the packing bulk density (g/cm^3) of dust samples ranged between 1.05 for sample 10,which has silt loam texture class, to 1.70 for sample 13 which has loamy sand texture class. The average of bulk density for all dust samples was 1.43 (g/cm^3). The abundance of high percent of clay and silt fraction in dust sample controlled the water infiltration rate of soil surface causing water runoff and forming surface water bonds which encourage water evaporation. Otherwise, deposition of dust on soil surface layer of sandy soil might have beneficial effects like improve water holding capacity of sandy soil.The dust deposit may be more, or less, useful in its new location than it was in its source area.

Table(3): Total porosity, Field capacity, wilting point, available water,and Bulk density for airborne dust samples (< 0.125mm).

NO.S	T.P%	F.C% (-0.33 bar)	W.P%(-15 bar)	A.W%	ᵽb g/cm3
1	38.45	22.92	4.05	18.87	1.54
2	37.53	23.20	4.12	19.08	1.58
3	49.12	27.81	8.15	19.66	1.43
4	67.75	41.80	15.11	26.69	1.33
5	75.73	45.47	19.14	26.33	1.34
6	43.20	29.33	5.81	23.52	1.45
7	45.19	31.05	5.81	25.24	1.46
8	61.28	28.23	5.19	23.04	1.53
9	50.65	31.23	5.23	26.00	1.64
10	116.44	57.99	10.68	47.31	1.05
11	52.51	24.00	3.58	20.42	1.46
12	53.37	38.49	6.40	32.09	1.25
13	27.44	10.86	2.68	8.18	1.70
14	62.54	43.59	14.48	29.11	1.46
15	34.38	13.58	2.68	10.90	1.47
16	62.93	43.76	12.94	30.82	1.31
17	88.67	51.84	23.40	28.44	1.33
18	62.03	40.64	12.36	28.28	1.57
average	57.17	33.65	8.98	24.64	1.43

Chemical properties of airborne particles:

Data in Table 4 explained that most samples had alkaline reaction,with pH numbers ranged from 7.96 to 9.14,with average 8.57;these behavior could be due to presence of high percent of CaCO3 and Na^+, Mg^{++} cations in dust deposit. The soluble salts in dust deposit were high(electrical conductivity of 1:5 extracted ranged between 0.14-6.25 dsm^{-1}). Presence of high amounts of soluble salts in dust deposit, which originated from Sabkhas or saline soil, may attributes to forms of saline soil.

The results revealed that the dominant soluble cations (meq/l) in dust deposit followed this category Ca^{2+},Na^+,Mg^{2+},and K^+,with average 11.63, 3.99, 2.79, and 0.71 respectively. The high concentration of Ca in dust deposit due to high content of calcite and dolomite carbonate in calcareous soils of Saudi Arabia.these results are in accordance with that reported by **(Bashour et.al.,1983)**.Otherwise, the dominant soluble anions (meq/l) followed this category Cl^-, SO_4^{--},and HCO_3^-,with average 8.81, 5.95, 4.37 respectively. These results explained that CaCl,NaCl,$CaSO_4$,and Na_2SO_4 salts can be formed in soils received deposits.

Nutrients:

Macronutrients

Amounts of total N (µg.g^{-1}), and available P and K (µg.g^{-1}) illustrated in Figure (1a,b,c) the data revealed that there are a significant difference between the values of total N, available P and K for the dust deposit samples due to properties of source area, low organic matter in the arid soils in Saudi Arabia as a results of sparse vegetation cover. The data shows that values of these nutrients extremely low, ranged between 100-900, 9.30-35.80,and 6.79-105.69, (µg.g^{-1}), with average values 338.8, 17.73,and 26.60 (µg.g^{-1}) respectively. The highest values of total N,P, and K were for sample 12,16,and 10.Wheares the lowest values were for sample (2,7,16,18),2,and 1 respectively. The values of N,P, and K were in agreements with results obtained by **(Al-Tayeb and jarrar.,1993).**

Table(4): ECe, pH, and soluble cations and anions for airborne dust samples (< 0.125mm).

NO.S	*ECe 1:5*	*pH*	*Soluble cations& anions (meq/L)*						
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}
1	0.20	8.74	2.50	1.70	0.40	0.17	0.1	4.0	0.67
2	0.14	8.78	3.40	0.20	0.34	0.22	2.1	2.0	0.06
3	0.30	8.80	2.60	0.90	1.20	0.52	2.5	1.9	0.82
4	0.44	8.58	2.90	3.20	1.66	0.29	2.5	4.4	1.15
5	6.25	8.38	27.6	8.10	21.6	0.58	36.5	3.5	17.88
6	0.47	8.58	4.00	1.20	0.52	0.22	3.0	1.9	1.04
7	0.84	8.49	9.00	1.40	1.90	0.47	6.0	6.7	0.07
8	1.01	8.52	10.2	3.20	2.03	0.36	6.0	5.8	3.99
9	0.38	8.86	5.50	2.60	1.81	0.49	4.0	6.2	0.20
10	4.52	8.44	32.4	7.00	6.50	2.71	15.0	4.9	28.71
11	1.10	8.56	11.9	0.80	3.80	2.02	6.5	4.1	7.92
12	1.71	8.54	15.1	0.20	6.00	1.01	6.2	5.4	10.71
13	0.74	8.72	9.8	3.60	0.34	1.01	4.5	3.5	6.75
14	1.50	7.96	12.5	2.00	4.10	0.82	5.5	3.7	10.22
15	1.70	9.14	13.3	1.20	5.80	0.82	10.0	4.8	6.32
16	3.74	8.26	25.7	8.20	5.09	0.27	28.3	4.5	6.46
17	0.54	8.50	7.40	1.00	1.44	0.27	4.2	5.1	0.81
18	1.93	8.48	13.7	3.80	7.33	0.45	15.7	6.2	3.38
average	1.50	8.57	11.63	2.79	3.99	0.71	8.81	4.37	5.95

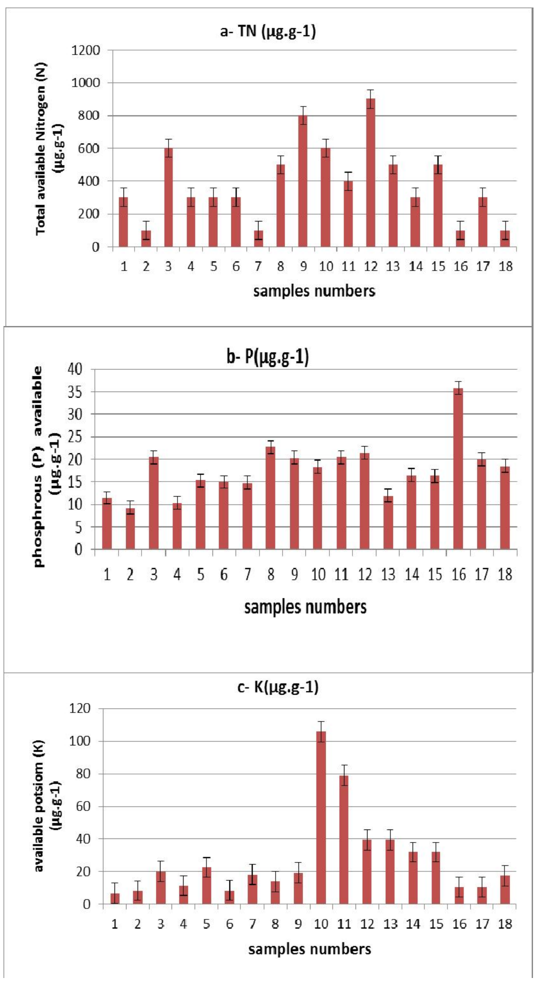


Figure (1a,b,c): Total N,available P, and K (µg.g^{-1}) for airborne dust samples (< 0.125mm).

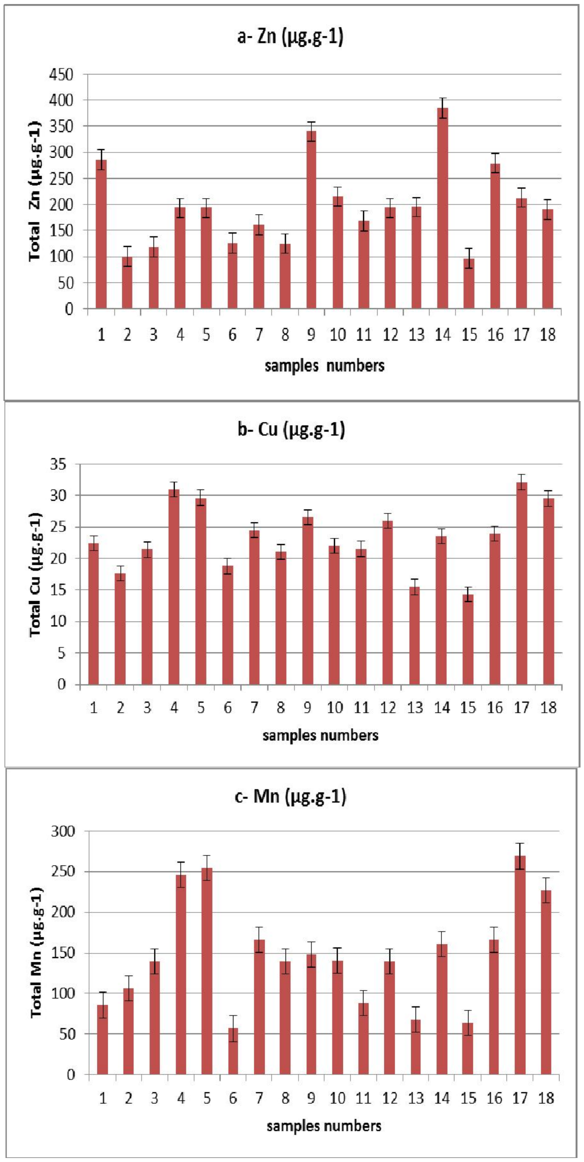
Heavy Metals:

Micronutrients levels

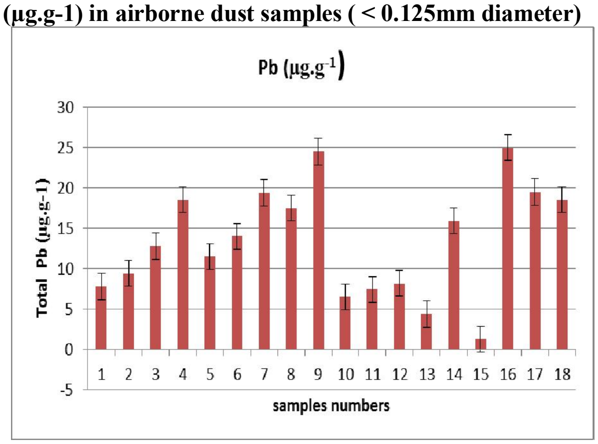
Figure (2a,b,c) illustrated the total concentrations of micronutrients in the dust sample. Zn which had the highest levels of elements in all sites with average 198 (µg.g^{-1}) followed by Mn, Cu with average 136.85, and 23,39 (µg.g^{-1}) respectively. Sample 9 which collected from inside Buraydah city showed extremely higher concentrations of Zn 340 (µg.g^{-1}), whereas the lowest concentration 97(µg.g^{-1}) recorded in sample 15 (North of Buraydah 2). Other side the higher concentration of Cu, Mn recorded in samples 17,whereas the lowest values recorded in samples 15,and 6 respectively. The results of the present study are particularly interesting when compared with results obtained several years before by **Modaihsh(1997)** in Riyadh city, the present study noted lower concentration of Mn and Cu, whereas higher concentration for Zn than those reported for Riyadh city (Figure 2).

Pollutant:

Figure (3) illustrated the total concentration of Pb as pollutant in the dust deposit samples. Pb concentration ranged between 1.25 µg.g^{-1} for sample 15(North Buraydah 2) and 25 µg.g^{-1} for sample 16 and 9 (Unaiza 1, and inside Buraydah city) which had the highest levels of elements due to traffic intensity. Integrated pollution index (IPI) for all dust deposit samples equal to or less than 1 for that the pollution levels is low.



Figure(2a,b,c): Total Heavy metals (micronutrients) (µg.g-1) in airborne dust samples (< 0.125mm diameter)



Figure(3):Total Pb (pollutant) (µg.g-1) in airborne dust samples (< 0.125mm diameter)

4. Conclusion:

The results of this study explained the following:

- Sand fraction (<0.125mm) was the dominants in almost all of dust samples. The results also revealed that, on average, the percent of the dust fractions was 44.50% sand, 28.19% clay, and 27.40% silt. The abundance of clay and silt fraction in dust sample, and deposition of dust on soil surface layer might have beneficial effects like improve its productivity of sandy soil on a long time.
- Dust samples had a high percent of $CaCO_3$,ranged between 5-33.5% with an average of 15.65%. High active $CaCO_3$ % can reduce plant nutrition by some elements like phosphorous and iron.
- Dust samples had a low percent of organic matter, ranged between 0.1-1.87 % with an average of 0.83 %.
- Total porosity% (volumetric moisture content at saturation), moisture contents at field capacity(-0.33bar), wilting point(-15 bar), and available water of dust particles had an average 57.17%, 33.65%, 8.98%, and 24.64 respectively. The presence of silt and clay fraction increased all of previous parameters which improve soil productivity, and reduce the water irrigation requirements for a long time.
- The abundance of high percent of clay and silt fraction in dust sample controlled the water infiltration rate of soil surface causing water runoff and forming surface water bonds which encourage water evaporation.
- The electrical conductivity for dust deposit ranged between 0.14-6.25 dsm^{-1}). Presence of high amounts of soluble salts in dust deposit may attributes to forms of saline soil. The results revealed that the dominant soluble cations (meq/l) in dust deposit followed this category Ca^{2+}, Na^{+}, Mg^{2+}, and K^{+}. Otherwise, the dominant soluble anions (meq/l) followed this category Cl^{-}, SO_4^{--}, and HCO_3^{-}. These results explained that CaCl, NaCl, $CaSO_4$,and Na_2SO_4 salts can be formed in soils received deposits .
- The macronutrients (NPK) extremely low, had an average values 338.8, 17.73,and 26.60 ($\mu g.g^{-1}$) respectively. But the dust deposit can supply the plant with a considerable amount of these elements.
- The total concentrations of micronutrients in the dust sample explained that Zn had the highest levels of elements in all sites with average 198 ($\mu g.g^{-1}$) followed by Mn, Cu with average 136.85, and 23,39 ($\mu g.g^{-1}$) respectively.
- Pb concentration ranged between 1.25 $\mu g.g^{-1}$ and 25 $\mu g.g^{-1}$.The Integrated pollution index (IPI) for all dust deposit samples equal to or less than 1 for that the pollution levels is low.

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