Spatial and Seasonal Variation of Atmospheric Particulate Matter Heavy Metals in Al-Diwaniyah City, Iraq.

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RESEARCH ARTICLE

Spatial and Seasonal Variation of Atmospheric Particulate Matter Heavy Metals in Al-Diwaniyah City, Iraq.

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ABSTRACT

The current study was conducted to estimate heavy metals pollution in the atmospheric total suspended particles (TSP) in Al- Diwaniyah city. To achieve this, seven sites were identified in different directions within the city center. The results showed that the seasonal mean of Pb, Cr, Cd, Cu and Zn concentrations ranged between 0.1-3.19, 0.07-0.33, 0.018-0.059, 0.73-5.25 and 0.74-2.34 $\mu g.m^{-3}$ respectively. The findings showed that the annual mean of the lead and cadmium at all sites exceeded the WHO guideline criteria of air pollutants. The results also showed local variation depending on the differences of human activities and seasonal variation according to the metrological variables.

Keyword: Total suspended particles, heavy metals, air pollution, toxic.

INTRODUCTION

Air is an important environment that plays a major role in the transmission of many pollutants whether in gas or particles state, which contributes to their spread and distribution among different environments (Saghatelyan *et al*., 2013). The air pollutants have a very wide effect. In humans, absorption and sedimentation within the lung have direct effects on the health and life of the human, while indirect effect on public health is through the deposition of these pollutants into the environment and taking by animals and plants through the food chain or drinking water, resulting in additional sources of human exposure to these pollutants. (WHO, 2000). The air pollutants have a wide impact on the plants in the forests or agricultural crops, causing great losses and also affect the wild and domestic animals directly or indirectly through the food chain causing the death in large numbers (Vallero, 2008).

Heavy metals are one of the most important environmental pollutants and their emission into the atmosphere represent the greatest threat to the environment and finely to human health, due to their large quantities and widespread, resulting in many ways of exposure to these toxic pollutants (Dinis and Fiuza, 2011). The heavy metals among the various chemical compounds, whether essential or non-essential to organisms, are particularly important in environmental toxicology because they are highly stable, bioaccumulative, carcinogenic, mutagenic, teratogenic and all of which have the potential to be toxic to organisms (Storeli *et al*., 2005; Agrawal, 2012).

Heavy metals are released into the atmosphere from natural and anthropogenic sources; natural sources include volcanic eruptions, rock weathering, soil processes, forest fires and ocean evaporation (Cyranlak and Bolzan, 2014). The anthropogenic sources include combustion of fossil fuels and coal for power generation, industry, transportation and various household purposes; various mining and smelting processes; industrial activities such as cement, glass and tile industry; burning of municipal solid waste and organic matter burning processes (Wood and residues of agricultural processes) and cars tires and brakes wear (Tian *et al*., 2015). Re-suspension of Earth's surface dust contributes significantly to increased concentration of heavy metals in the atmosphere (Yang *et al*., 2015).

Heavy metals are the most important components of airborne particles and thus play a major role in exacerbating the problem of air pollution, especially in cities, causing toxic and carcinogenic effects of humans (Hassan *et al*., 2013). It is well known that suspended particles contain high concentration of many toxic metals such as cadmium, chromium, copper, iron, manganese, nickel, lead, zinc (Radulescu *et al*., 2015), and heavy metals attached to the particles suspended in the air can be enter to the human body through direct inhalation or by ingestion, especially in children or through absorption through the skin, which leads to health damage to humans (Wan *et al*., 2016). After entering the body, heavy metals may causes various effects such as neurological, renal, hepatic, and immunological toxicity; and congenital malformations; and may directly affect human behavior, especially children; and may cause brain and nervous system dysfunction and leads to attention deficit syndrome (Saghatelyan *et al*., 2013).

MATERIALS AND METHODS

Study area

The current study was achieved in Al- Diwaniyah city south of Iraq. Seven sites were identified in the different directions of the city center for samples collection, as shown in Table (1) and Figure (1).

Sampling

Total suspended particles TSP were collected from September 2016 to August 2017 by air sampler model HI-Q (D-AFC-50), in the elevation of 1.5 meters above ground, using Knowing weight cellulose filters 0.45μm, then placed in clean polyethylene containers and stored until heavy metals are extracted (Gioda *et al*., 2007).

Analysis

The heavy metals are extracted using the hot acid extraction method. By add10 ml of 1:3 nitric and hydrochloric acid mixture to the filters containing the suspended particles in a 100 ml volume beaker with ensuring that the entire filter is covered with acid, heating to 80 °C for 30 minutes after covering the beaker, then diluted to 25 ml with deionized distill water (USEPA, 1999d).

The samples were measured using the Flame Atomic Absorption Spectrophotometer (Shimadzo AA-6300), after a series of standard solutions for Pb, Cr, Cd, Cu and Zn were prepared. The concentration of elements in the air samples was calculated in micrograms per cubic meter (USEPA, 1999b).

RESULTS AND DISCUSSION

The table (2) showed that the highest values of Pb and Zn concentrations appeared in the sixth site during the summer, while the lowest values were recorded in the third site in the fall, this is due to the power plant emission (diesel plant of East Diwaniyah) in this site, it works by heavy oil which is a source of the atmospheric heavy metals (Wang *et al*., 2010). Also the site is located near the highway linking Al-Diwaniyah city from the east, which adds another source of heavy metals pollution, that the transportation are a major source of heavy metals to be released into the atmosphere from exhaust or from corrosion in different parts such as tires, brakes and asphalt surfaces (Vianna *et al*., 2010).

Increasing concentrations during summer and fall are due to the increase in fuel combustion by the power generators of houses and residential districts because electricity cut off during the summer (Al-Duhaidahawi, 2015), the results showed a positive correlation r = 0.624 between Pb and temperature. While the observed increase in wind speed during the summer table (3) may lead to an increase in the re-suspension of lead-adsorbed surface dust especially in both sides of the roads to the atmosphere again (Krzeminska-Flowers *et al*., 2006), and the results showed a positive correlation r = 0.273 and r = 0.063 between the wind speed and Pb and Zn respectively. The observed decrease in concentrations during the fall may be attributed to the low energy consumption because of low temperature as well as the increased sedimentation of the suspended particles due to the increase in relative humidity. The results showed an inverse correlation r = -0.176 between TSP and relative humidity.

The results in table (2) showed that the chromium, cadmium and copper concentration recorded highest value in site four during autumn. The high concentrations of these elements are due to exhaust emissions, also the construction and demolition activates contribute the increase in the concentrations of heavy metals in the particles suspended in the air (Eneji *et al*., 2015), and the increased in fuel combustion use in domestic heating (Vaio *et al*., 2018), the results recorded an inverse correlation r = -0.512 , r = -0.491 and r = -0.558 between the temperature and chromium, cadmium and copper respectively. Also the decrease in wind speed recorded during the winter contributes to reducing the dispersion of contaminants (Li *et al*., 2015), especially in residential areas and areas containing high buildings as the lack of surface homogeneity reduces the horizontal mixing and this leads to a concentration of pollutants in surface air layer (Owoade *et al*., 2012). The results showed an inverse correlation r = -0.197, r = -0.103 and r = -0.195 between wind speed and concentrations of chromium, cadmium and copper respectively.

CONCLUSION

The study showed an increase in heavy metals concentration as a result to the human activities primarily transportation, energy production, construction and demolition processes and heating activities. The concentration of heavy metals various according to the site and season due to the type of activity and metrological factors. The annual mean of Pb and Cd were exceeded the WHO guide line (Pb=0.5, Cd=0.005 $\mu g.m^{-3}$) (WHO, 2000).

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Table 1. Shows the locations, specifications and activity of study sites.

Site	location	Activity	East	North
First	Al-Mawakeb street	Traffic and commercial	55° 44' 37.69"	59° 31' 11.89"
Second	Doctors street	Traffic and industrial	55° 44' 07.62"	58° 31' 54.41"
Third	Al-Wahdah district	Residential	56° 44' 19.23"	59° 31' 24.79"
Fourth	Al-Jamieh district	Residential	52° 44' 36.91"	59° 31'43.24"
Fifth	North Al-Diwaniyah power plant	Energy production and Residential	54 ° 44'03.75 "	01 ° 45'47.45"
Sixth	East Al-Diwaniyah power plant	Energy production and traffic	58° 44' 24.15"	59° 31' 39.91"
Seventh	Reference site	Agricultural	51° 44' 16.11"	58° 31' 38.16"

Table 2. Heavy metals concentration (μg.m^{-3}) (mean±SD).

Site No.	season	Pb	Cr	Cd	Cu	Zn
1	Fall	0.47±0.57	0.13±0.094	0.031±0.009	1.65±1.11	1.09±0.76
	Autumn	0.28±0.20	0.15±0.049	0.037±0.001	3.07±0.37	1.83±0.90
	Spring	0.87±0.14	0.12±0.007	0.034±0.004	2.12±2.37	1.31±0.23
	Summer	2.44±0.68	0.10±0.015	0.038±0.006	0.89±0.64	1.98±0.69
	Annual mean	1.014	0.128	0.035	1.930	1.552
2	Fall	0.42±0.37	0.07±0.048	0.027±0.020	1.31±1.18	1.09±0.76
	Autumn	0.59±0.22	0.32±0.129	0.047±0.006	4.23±1.51	1.83±0.90
	Spring	1.14±0.25	0.15±0.030	0.037±0.007	1.06±0.35	1.31±0.23
	Summer	2.69±0.90	0.10±0.011	0.035±0.009	1.27±0.94	1.98±0.69
	Annual mean	1.209	0.158	0.037	1.969	1.552
3	Fall	0.10±0.05	0.07±0.045	0.018±0.003	1.29±1.30	0.74±0.47
	Autumn	0.42±0.22	0.23±0.114	0.046±0.023	4.38±2.41	1.91±0.74
	Spring	1.08±0.41	0.14±0.020	0.036±0.003	2.98±1.01	1.78±0.36
	Summer	2.67±0.45	0.10±0.011	0.036±0.003	2.17±0.39	1.98±0.42
	Annual mean	1.068	0.135	0.034	2.705	1.604
4	Fall	0.42±0.30	0.08±0.071	0.027±0.012	1.24±0.90	0.94±1.10
	Autumn	0.80±0.45	0.33±0.191	0.059±0.023	5.25±2.45	1.98±0.82
	Spring	0.95±0.48	0.13±0.008	0.035±0.006	4.92±0.61	1.11±0.12
	Summer	3.02±0.72	0.12±0.001	0.041±0.004	3.36±0.25	2.23±0.72
	Annual mean	1.294	0.164	0.040	3.692	1.566
5	Fall	0.28±0.27	0.09±0.068	0.031±0.017	1.69±1.14	1.87±0.90
	Autumn	0.63±0.46	0.15±0.072	0.036±0.004	3.42±0.06	1.30±0.09

	Spring	1.09±0.56	0.13±0.025	0.031±0.003	1.29±1.36	1.63±0.26
	Summer	2.86±0.56	0.13±0.008	0.033±0.008	1.59±0.79	2.21±0.60
	Annual mean	1.216	0.125	0.033	1.996	1.751
6	Fall	0.42±0.51	0.08±0.069	0.030±0.015	1.97±1.52	1.09±0.75
	Autumn	0.73±0.28	0.15±0.022	0.038±0.009	3.61±1.29	1.71±0.23
	Spring	1.29±0.48	0.13±0.003	0.034±0.006	1.46±0.96	2.27±0.88
	Summer	3.19±0.75	0.13±0.005	0.038±0.009	2.74±0.54	2.34±0.39
	Annual mean	1.408	0.122	0.035	2.447	1.852
7	Fall	0.28±0.24	0.09±0.059	0.038±0.026	2.31±1.92	0.76±0.63
	Autumn	0.47±0.17	0.18±0.030	0.046±0.003	4.72±1.10	1.83±0.57
	Spring	1.16±0.38	0.14±0.033	0.031±0.003	0.73±0.86	1.23±0.18
	Summer	2.33±0.55	0.10±0.014	0.027±0.004	1.22±0.40	1.65±0.38
	Annual mean	1.061	0.125	0.036	2.245	1.367

Table 3. Metrological parameters during the study time.

Season	Tem. °c	R.H. %	L.I. lux	W.S. m/s
Fall	27.3	22.6	61464.0	1.4
Autumn	15.5	45.9	45566.7	1.1
Spring	32.7	23.2	58498.1	1.7
Summer	42.2	12.1	91849.6	2.2
Annual mean	29.4	25.9	64344.6	1.6

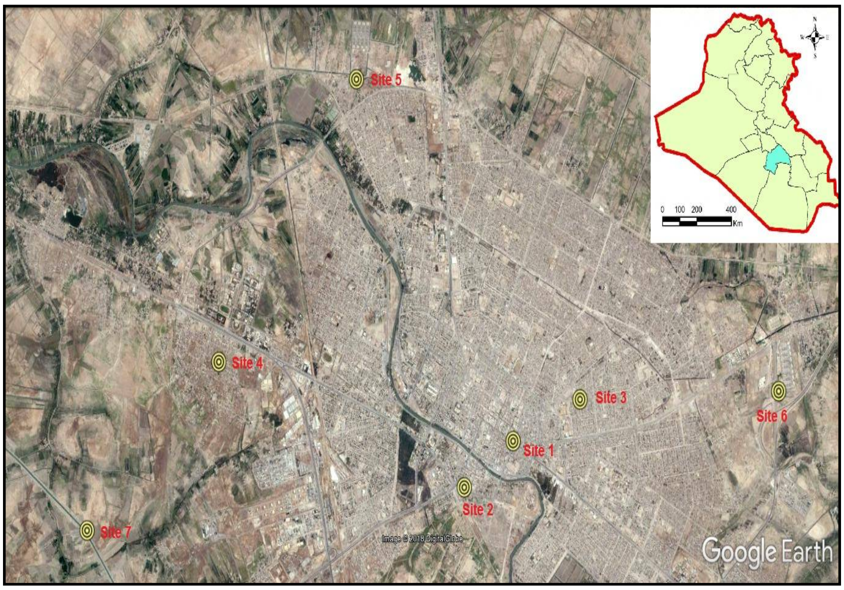

Figure 1. Study Area

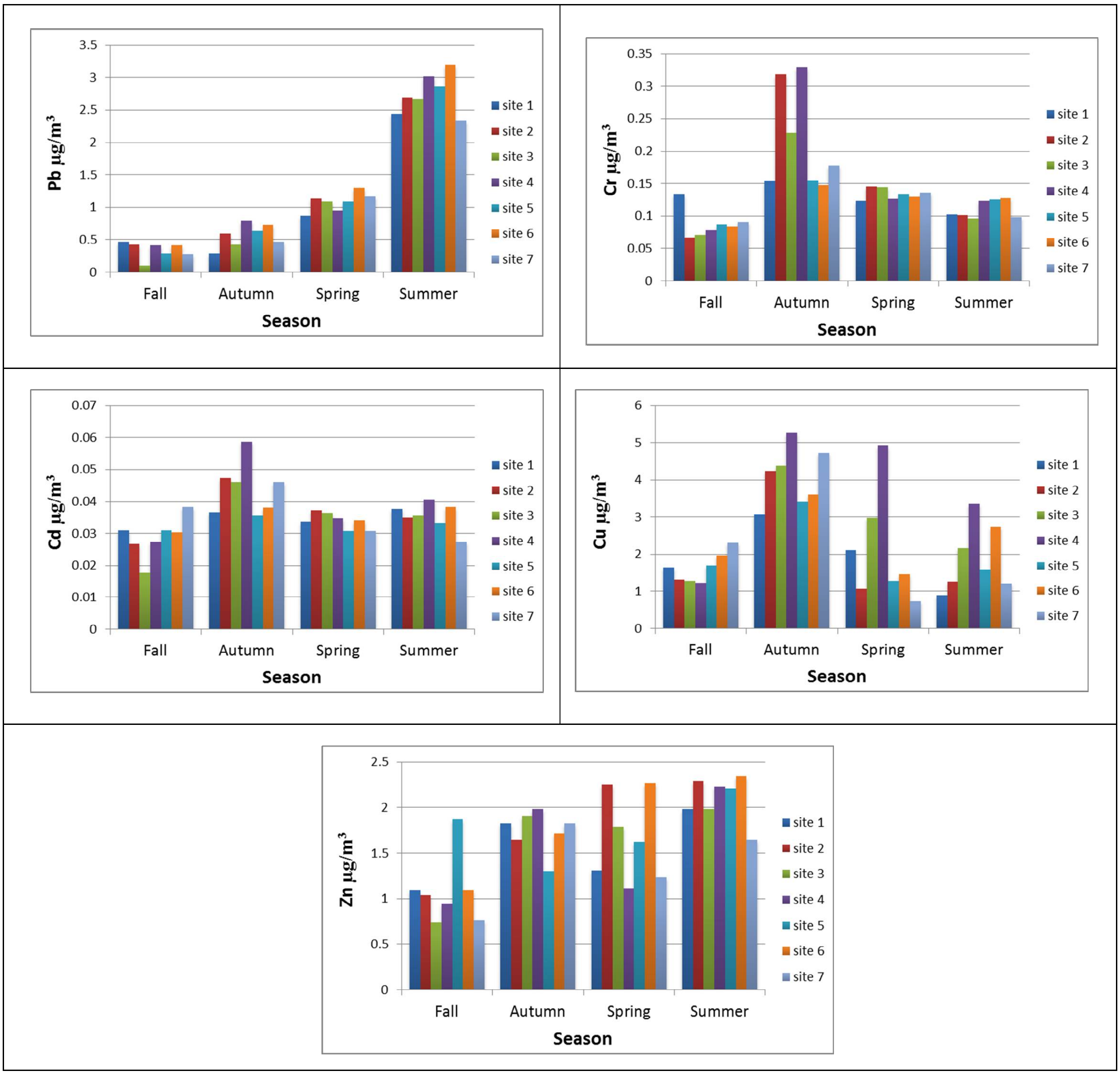

Figure 2. Heavy Metals Concentrations