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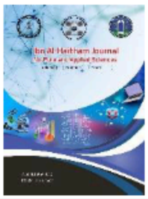

Evaluation of Heavy Metals Concentration in Street, Storm and Suspended Dust in Al-Zafaraniya Area, Baghdad- Iraq

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Abstract

The current study was applied in Al-Zafaraniya area southeast of the capital Baghdad from October 2021 to April 2022. This is to evaluate some heavy elements (Cd, Co, Cu, Fe, Pb, and Mn) in the street, storm, and suspended dust. Four sampling sites were selected, and codes A, B, C, and D were given to represent the industrial activity sites, service workshops, business activity, and residential areas.

The results showed that the concentration rates of elements (Cd, Co, Cu, Fe, Pb, Mn) in street dust samples were (1.15, 6.6, 60.15, 26770, 44.4, 6, 489.8). In storm dust (2, 10, 49.3, 54760, 24.3, 827.2) ppm, respectively, the results of suspended dust revealed that the general rates of element concentrations were (0.707, 3.546, 3.727, 83.204, 1.076, 8.706) µg/m3, respectively. The results also showed the frequency of the appearance of the same elements and different concentrations in the three types of dust. They also indicate that each other interacted in increasing and continuing to expose the city atmosphere to the air loaded with hazardous metals to the health of human society and the components of the city's ecosystem.

It can also be concluded from the values and variations of the elements that there are several environmental factors, such as temperature, humidity, air currents, local and regional storm surges, and irregular distribution of vegetation, can be attributed to the main reason in the deference values of heavy elements and their presence in the street, storm and suspended dust.

Keywords*: Air pollution, Heavy metals, Street dust, Storm dust, Suspended dust.*

1.Introduction

The environment and its problems are important as it imposes itself at various international, regional, or local levels. Environmental pollution and the risks caused by it are not limited to the borders of the state driving it. Still, the effect on the rest of the other countries, and one of the most critical problems facing human beings in most countries of the world is environmental pollution, where the seriousness of this problem lies in the transmission of pollutants by water and wind, and for long distances. Air pollution, which is most dangerous to human health through its direct effect on the vital breathing process of various organisms [1- 2] and environmental pollution, represents an undesirable change in physical, chemical, and biological phenomena of air, water, and soil and may adversely damage or affect organisms and facilities [3]. Although heavy elements are found in an environmental medium in small and harmless proportions of their living and non-living components, their increased concentration in the environment in recent years, mainly as a result of the diversity of pollutants and their sources of access to these communities due to the growth of densities, human activities, industrial progress and the entry of technology into all processes of public life and their agricultural, industrial and service applications, has led to the growth of waste, chemical compounds, pesticides, toxins [4].

Increasing the content of some heavy elements in cultivated land and water as a result of fertilization, control, and sterilization of various chemicals and fertilizers leads to loading these elements. They reach humans through plant and animal food sources, by eating water directly, or by the participation of soil components due to drifts or atmospheric erosion, etc., and part of them reach the air components of factors, causing several serious diseases [5-6].

Therefore, contemporary humans should be aware of the importance of maintaining the quality of the surrounding air and the rest of the components of the environment when it understands the negative effects and risks generated by the change in the essential components of its environment, especially the air, both inside and outside the work, and the emergence and accumulation of new components and elements in it to levels that make the problem of air pollution one of the most critical problems that threaten life and threaten the progress, movement, growth and development of human societies, the low productivity of ecosystems and the difficulty of living in many cities and human communities in different regions of the world are at the forefront of these risks, the growing levels of dust and particles of all kinds, oxides, toxic gases and their content of environmentally harmful elements and their living and non-living components, which requires the synergy of all efforts to find appropriate solutions between state institutions and the citizen both according to its responsibility and effect [7- 8].

Street dust is a mixture of organic and inorganic materials, car exhausts, and solid residues scattered on the sides of the roads, which is the main source of particles in the air and is a dangerous environmental pollutant [9].

While suspended dust is atoms suspended in the air, dust is produced when dust storms occur, and dust rises, where micro-particles remain stuck in the air after storms and winds remain for an estimated period of hours and days [11- 12]. Dust storms are small granules with diameters of only 100 µm and arise with strong winds (8 m/s and above), and they are loaded with dust transported from disassembled topsoil in dry areas [10]. The particles of suspended dust from mud and light green atoms, ranging in diameter from 0.1 to 10 µm, and the sources of these particles are different. They may result from soil volatilization caused by dust storms or combustion, or these particles are caused by dust storm surges, a complex combination of different chemical compositions [13].

Therefore, the study aims to reveal the presence of dangerous heavy elements in the components and types of dust, to alert the community and government agencies about the dangers of leaving these pollutants in the city environment, and work to combat and limit their spread.

The study area

The study area is located southeast of the capital Baghdad, in Al-Zafaraniya area, which occupies an area of about 30 km2; four sites were chosen to study street dust located within the area, the site of factories, which is characterized by many big factories, the site of building materials store, which contains several places to sell building materials, the commercial site that includes several markets and the residential site near the General Park of Al-Zafaraniya, which is surrounded by many residential houses (**Figure** 1 shows the map of the study area) [14; 15].

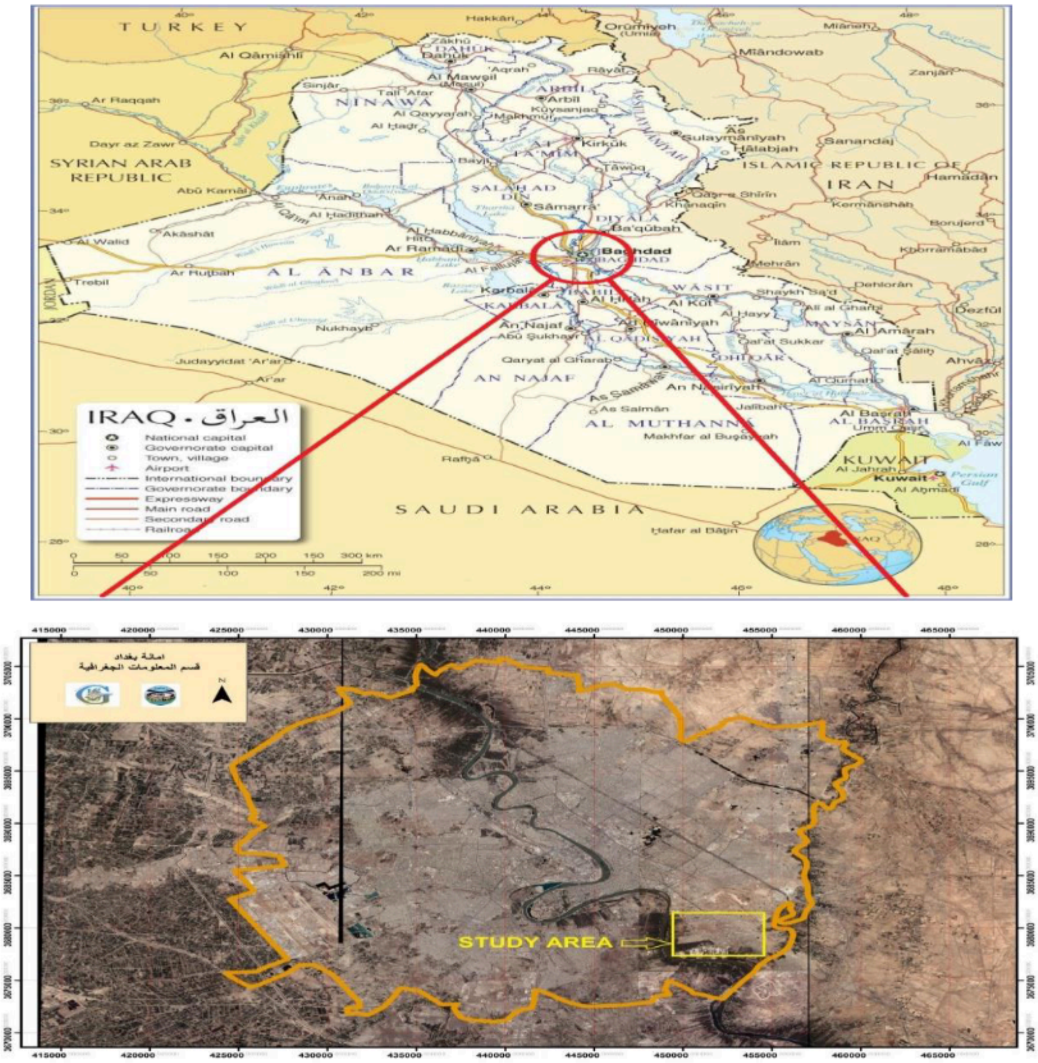

Figure 1. Map of Iraq showing the location of Baghdad city and study sites within the city GIS-2022

2.Materials and Methods:

Street dust and suspended dust samples were collected from October/2021 to April/2022 from four different sites (**Figure** 1) and coded (A) for the industrial area, (B)for the Building materials store area, (C) for the commercial area and (D) for the residential area during October 2021.

The study part included the implementation of experiments in two methods. The first was fieldwork, where wooden shovels collected street dust samples, 12 samples, and three samples per street. The samples were carefully collected and preserved using paper bags and transported to the laboratory for examination. Still, Sniffer's advice was used for suspended dust to collect suspended particle samples and heavy elements for six consecutive months (October 2021 to April 2022), samples collected twice a month. Street dust and suspended dust samples were collected from October/2021 to April/2022 from four different sites (**Figure** 1) and coded (A) for the industrial area, (B)for the Building materials store area, (C) for the commercial area and (D) for the residential area during October 2021. The dust samples collected during morning and afternoon peak times take the mean rate of each site and three points. Then, the laboratory work was done. It included the analysis of (37) selected samples from the study area of heavy elements using the XRF device, where (12) samples of street dust and (24) samples of suspended dust filters, and one sample representing dust in Iraq were taken during the study period.

To measure the heavy metals (Cd, Co, Cu, Fe, Pb, and Mn) within the dust samples (street dust, storm dust, and suspended dust),(5) g of powder were taken from each sample of the study sites. They were analyzed by the XRF device to identify the oxides associated with the heavy elements of dust particles and to analyze their components by dropping the scans on the sample if the device receives samples in powder. The powder is compressed and converted into a disc to obtain high analysis accuracy. The work is done using a special piston with a pressure of 5 tons. As for the samples of suspended dust, the dust-collecting filters were taken and inserted into the XRF device. The samples and experiments were analyzed in the Iraqi-German laboratory/Department of Geology at the College of Sciences/ University of Baghdad. The following formula was used to convert measurements of heavy elements from ppm to μg/m^3.

$$\mathbf{Metal\ Conc.}\ (\mathbf{\mu g/m3}) = \frac{\mathbf{C\ (ppm) * WT}}{\mathbf{TVA}}$$

Whereas,

WT =W2-W1$*10^6$

TVA= the volume of air flowing per cubic meter.

3.Results and Discussion:

Table (1) shows the values of concentrations of the target elements (Cd, Co, Cu, Fe, Pb, and Mn in samples of street dust in selected study sites (A, B, C, and D) as well as the average values of storm dust samples that was exposed to the study area.

Table 1. Concentration of elements (Cd, Co, Cu, Fe, Pb and Mn) in street and storm dust with ppm.

Dust sample	Site	Collection points	Cd	Co	Cu	Fe	Pb	Mn
Street dust	**Industrial site A**	A1	2	3.9	48.9	33700	42.4	623.5
		A2	1.3	9.3	41.5	31420	29.1	569.8
		A3	2	3.9	37.7	30060	31.9	556.2
	Building materials store site B	B1	2	3.9	44.3	20220	28.4	356.1
		B2	0.3	3.9	41.7	19840	19.9	382.3
		B3	2	3.9	82.6	21730	21.4	426.4
	Commercial site C	C1	2	3.9	39.8	22300	31.5	366.6
		C2	2	3.9	48.8	22740	69.3	398.9
		C3	2	3.9	62	24860	35.3	368.5
	Residential site D	D1	2	3.9	46.4	30030	39.5	543.9
		D2	2	3.9	80.6	24520	38.8	434.5
		D3	2	3.9	47.9	26830	36.3	472.3
Range		------	2-0.3	9.3-3.9	-37.7 82.6	-19840 33700	-19.9 69.3	-356.1 623.5
Mean		------	1.15	6.6	60.15	26770	44.6	489.8
Strom dust		S	2	10	49.3	54790	24.3	827.2

When comparing the distribution of the concentrations of each element in the four study sites in **Tables (1 and 2)**, there is an evident variation in their values in both street, storm, and suspended dust. This is probably due to different human activities and sources of pollution by following each element independently as follows:

3. ***Cadmium* (Cd):** The results of the analysis of street dust samples, as shown in **Table** (1), showed that the presence of cadmium in a range (of 0.3-2) ppm and at a mean of (1.15 ppm), but

in storm dust was mean of (2 ppm) and we note that the ratios were close to street dust samples in all areas of the study. This shows that dust particles associated with cadmium move between the three dust levels, and the element has different sources. It is released into the atmosphere through car exhausts in addition to friction, combustion, mechanical corrosion, the mashing of solid municipal waste, and the dust of storms, and this conclusion is consistent with what the researchers stated [16-17-18].

The results of the statistical analysis showed a negative correlation with cobalt. At the same time, it positively correlated with copper, iron, lead, and manganese. There were non-significant differences $p>0.05$ **Figure (2)**. In the suspended dust, **Table (2)** showed the lowest rate of Cd recorded at site D (0.255 µg/m^3) during the winter, while the highest rate was at, A site (1,155 µg/m^3) during the spring. It exceeded the global limit of 0.05 µg/m^3 due to human activities represented by factories. This is consistent with the study's results [19-20]. Also, the statistical analysis showed a significant difference between the study sites and the months, a strong positive correlation with Co, Cu, Fe, Pb, Mn, and temperatures. There was a significant difference under the level of $p\leq0.05$. There was a strong negative correlation with humidity and a weak negative with the wind (**Figure 3**).

1.Cobalt (Co): Table (1) showed that the presence of cobalt range between (3.9-9.3) ppm and a mean of (6.6 ppm), while its ratio in storm dust (10 ppm), where it recorded the highest percentage at A- site at (9.3 ppm) in the rest of the regions recorded the same values (3.9 ppm) and the increase in the proportion in the factory site is due to the traffic momentum and the combustion of fuel emitted by cars and generators, in line with the researcher's findings [21]. Statistical analysis showed that Co was negatively correlated with Cu and Pb while was positively correlated with Fe and Mn, as well as the presence of non-significant differences $p>0.05$ (**Figure** 4). The results of the suspended dust also showed that the lowest rate of Co was recorded at the C- site (2.28 µg/m3) during the winter. The highest rate was at the B- site (6.44 µg/m3) during the spring, as shown in **Table** (2). It was due to traffic momentum in the area and the presence of the Al-Zafaraniyah gas factory, in addition to an unauthorized random waste incineration square where waste is burned almost daily. This is consistent with the study conducted by the researchers [22-23]. Also, the statistical analysis showed a moderate negative correlation with humidity, a strong positive with Cu, Fe, leads, and Mn, a moderate positive with temperatures, and a weak positive with the wind (**Figure** 5).

2.Copper (Cu): The results showed that the ratio of Cu ranged from (37.7-82.6) ppm to a mean of (60.15 ppm) in street dust. **Table 1**, with the highest ratio (82.15 ppm) recorded in B- site, followed by the residential site (80.6 ppm), while a close ratio was recorded between the A-site and C- site, where it was (48.9 ppm) and (48.8 ppm) respectively. It was recorded in storm dust (49.3 ppm), and it was found that there was a key role for traffic in increasing concentration, in line with the study conducted by the researchers [24] and [25]. The statistical analysis results showed a negative correlation with Fe, Pb, and Mn and showed non-significant differences $p>0.05$ (**Figure 6**). The suspended dust (**Table 2**) showed that the lowest Cu rate was recorded at D-site (2.98 µg/m3) during the winter. In contrast, the highest rate was recorded at the C- site (4.59 µg/m3) during the spring due to traffic momentum at this site, in line with the results of the study conducted by the researchers [26-27]. The statistical analysis results showed that the lead element negatively correlated with humidity and wind. In contrast, its strong positive correlation with Fe, Pb, Mn, and temperatures was a significant correlation $p\leq0.05$ (**Figure** 7).

3.Iron (Fe): in **Table** (1), it was found that the presence of the Fe element ranged from (19840-33700) ppm in street dust and at a mean of (26770 ppm), with the highest percentage recorded at A- site (33700 ppm), followed by D- site (30030 ppm), followed by C- site (24860 ppm), finally recorded at B- site (21730 ppm), while recorded in dust storm (54790 ppm). It is believed that the main source of Fe comes from workshops and industrial district construction processes where it is released to the soil and atmosphere, as well as metal cans that are thrown as waste left on the ground and exposed for crushing and grinding. This is consistent with the researcher's study [28]. The results of the statistical analysis showed that it was a positive correlation between Pb and Mn, and there was a non-significant difference of $p>0.05$ with Pb. In contrast, a significant difference with Mn appeared at the probability level of $p\leq0.01$ (**Figure 8**).

While in the suspended dust (**Table 2**), the highest Fe rate was recorded at the B site (140.37 $\mu g/m^3$) during t spring. The lowest was at the A- site (57.01 5 $\mu g/m^3$) during winter. This was due to the effect of this element on weather factors such as wind speed, temperature, rain, and humidity, in addition to the spread of random workshops for blacksmithing, cold, and maintenance of cars as well due to the work of stacking, transporting and loading iron rods (rebar ash used in construction work), building materials and scaffolding continuously in that area, and this is consistent with the results of the study reached by the researchers [29- 30]. The statistical analysis results showed that the correlation between Fe, Pb, Mn, and temperatures was strongly positive, while it was negatively correlated with humidity and wind. These correlations had significant differences $p\leq0.05$ (**Figure 9**).

4.Lead (Pb): The results in **Table** (**1**), it was found that the lead rate in the street dust ranged from (19.9-69.3) ppm to a mean of (44.6 ppm), with the highest rate (69.6 ppm) on C- site, followed by A- site (42.4 ppm) and A site (39.5 ppm), finally recorded at B- site, (19.9 ppm), while in storm dust it was (24.3 ppm). The reason for the high percentage of Pb was due to its use with gasoline in transportation in addition to generator exhausts and the accumulation of waste and burning by the people, as well as the entry of lead in many industries such as welding, painting, plastic and glass and these pollutants moved with the wind and negatively affected the atmosphere of the study areas. This was in line with the findings of the researcher [31]. Statistical analysis showed that Pb positively correlated with Mn and a non-significant difference of $p>0.05$ (Figure 10). The suspended dust results (Table 2) showed that the highest lead rate was recorded at the A- site (2,405 $\mu g/m^3$) during spring. The lowest rate at the D- site (0.44 $\mu g/m^3$) during winter when comparing lead concentrations with the proposed Iraqi determinants (2 µg/ µg/m3), we note that they have exceeded the allowable limit and far exceeded the global determinants [32] of (0.5 $\mu g/m^3$). The reason for its rise in the location of the industrial site was due to a large number of factories, including plastic and paint, in addition to a large number of vehicles and cars, which still use gasoline with tetraethyl lead, as each liter of gasoline contains (0.8 g) of tetraethyl lead [33]. This is consistent with the findings of the researcher [34]. The statistical analysis noted that the correlation between Pb, Mn, and temperatures was strongly positive, while it was negative with humidity and wind, and these correlations had significant differences $p\leq0.05$ (11).

5.Manganese (Mn): Table -1 showed that Mn present in street dust ranged from (356.1-623.5) ppm to a mean of (489.8 ppm) while in storm dust, it was (827.2 ppm). People may be exposed through the modern distillation of crude oil, or by adding it to gasoline to improve its quality, in addition to the high traffic density, which is a source of increased Mn in the environment, in as well as the presence of fuel filling stations generators in the study areas. This is consistent with the researcher's findings [35] and [36]. The statistical analysis showed that there were non-significant differences below the probability level of $p>0.05$ (**Figure** 12).

While in the suspended dust **(Table 2)**, the results showed that the lowest Mn rate was recorded at the D- site(3,405 µg/m^3) during the winter, while the highest rate at the squall site (14.14 µg/m^3) during spring. The statistical analysis showed that the relationship of Mn to temperatures was positive while negative with humidity and wind, and these correlations had significant differences $p \leq 0.05$ (**Figure 13).** This was due to the indiscriminate spread of workshops, increased transportation, inefficient engines, and the burning of waste by residents. This was due to the lack of municipal services for the study area. The results were in line with the study conducted by the researchers [37-38].

When examining the contents of the samples of suspended dust from heavy elements targeted in the study, as shown in **Table (2),** the results showed the presence of elements in all areas of the research and during the winter and spring as follows:

Table 2. Concentrations heavy elements (Cd, Co,Cu, Fe, Pb and Mn) in the suspended dust to the study area for winter and spring in µg/m^3 unit.

	Month	Code of Sample	Element sample					
			Cd	Co	Cu	Fe	Pb	Mn
Winter months	November	*A1	1.03	3.74	4.25	99.30	1.87	11.87
	December	A2	0.82	3.93	3.17	90.76	1.92	8.54
	January	A3	0.54	2.94	3.05	62.24	1.85	8.57
	Range		-0.54 1.03	-2.94 3.93	-3.05 4.25	99.30-62.24	-1.85 1.92	11.87-8.54
	Mean		0.785	3.435	3.65	80.77	1.885	10.205
	November	*B1	0.93	4.22	4.03	105.97	1.22	15.34
	December	B2	0.97	4.15	4.22	73.30	1.05	12.32
	January	B3	0.61	3.79	3.12	77.05	0.43	12.45
	Range		-0.61 0.97	-3.79 4.22	-3.12 4.22	150.97-73.30	-0.43 1.22	15.34-12.32
	Mean		0.79	4.005	3.67	89.635	0.825	13.83
	November	*C1	0.77	2.55	4.70	83.70	1.06	7.32
	December	C2	0.62	2.51	3.51	81.31	0.38	7.54
	January	C3	0.60	2.01	3.35	72.12	0.20	5.20
	Range		-0.60 0.77	-2.01 2.55	-3.35 4.70	83.70-72.12	-0.20 1.06	7.54-5.20
	Mean		0.685	2.28	4.025	77.91	0.63	6.37
	November	*D1	0.31	2.42	3.91	63.38	0.79	4.22
	December	D2	0.20	2.56	2.05	55.43	0.61	2.59
	January	D3	0.23	2.16	2.17	50.65	0.09	2.70
	Range		-0.20 0.31	-2.16 2.56	-2.05 3.91	63.38-50.65	-0.09 0.79	4.22-2.59
	Mean		0.255	2.36	2.98	57.015	0.44	3.405
Spring months	February	A4	0.59	3.33	2.27	65.01	1.90	8.32
	March	A5	1.62	4.53	4.03	78.34	2.44	10.35
	April	A6	1.72	4.92	4.97	96.30	2.91	13.70
	Range		-0.59 1.72	-3.33 4.92	-2.27 4.97	96.30-65.01	-1.90 2.91	13.70-8.32
	Mean		1.155	4.125	3.62	80.655	2.405	11.01
	February	B4	0.42	4.57	2.66	105.30	0.39	12.05
	March	B5	1.33	5.99	3.97	133.37	1.66	15.73
	April	B6	1.34	8.31	5.23	175.44	1.13	16.23
	Range		-0.42 1.34	-4.57 8.31	-2.66 5.23	-105.30 175.44	-0.39 1.66	16.23-12.05
	Mean		0.88	6.44	3.945	140.37	1.025	14.14
	February	C4	0.54	2.37	3.95	66.27	0.35	5.34
	March	C5	0.93	3.40	4.17	79.34	1.06	8.93
	April	C6	1.07	3.39	5.23	91.20	1.43	8.42

	Range		-0.54 1.07	-2.37 3.40	-3.95 5.23	91.20-66.27	-0.35 1.43	8.93-5.34
	Mean		0.805	2.885	4.59	78.735	0.89	7.135
	February	D4	0.27	2.55	2.78	49.14	0.08	2.15
	March	D5	0.30	3.14	3.77	59.03	0.94	4.23
	April	D6	0.34	3.09	3.90	71.95	0.88	4.97
	Range		-0.27 0.34	-2.55 3.14	-2.78 3.90	71.95-49.14	-0.08 0.94	4.97-2.15
	Mean		0.305	2.845	3.34	60.545	0.51	3.56

* A: industrial site, B: Building materials store, C: commercial site, D: residential site.

Table 3. General rates of heavy metals (μg/m^3) in the suspended particles of current study area and compared with local studies and determinants of WHO and Iraqi Ministry of Environment.

Previous studies	**Province**	**Cd**	**Co**	**Cu**	**Fe**	**Pb**	**Mn**
Current study 2022	Baghdad	0.707	3.546	3.727	83.204	1.076	8.706
Fayad et al., 2012	Baghdad	0.03	……..	0.53	……..	1.96	……..
Al-Duhaidahawi, 2015	Najaf	3.13	6.57	5.53	……..	1.50	……..
Al-Hesnawi, 2015	Karbala	1.567	12.318	3.153	531.433	1.071	10.191
Al-Hesnawi, 2018	Karbala	1.088	……..	……..	……..	4.537	……
Al-Kasser and AlKam, 2018	Diwania	0.06	……..	5.25	……..	3.19	……..
Mutlag *et al*., 2020	Najaf	1.29	……..	……..	……..	0.56	……..
Al- Hashmi, and Al-Shammari, 2020	Wasit	0.86	……..	4.16	67.64	4.46	……..
WHO, 2000		0.005	……..	…….	……..	0.5	0.150
ministry of Environment,2008		……..	……..	……..	……..	2	……..

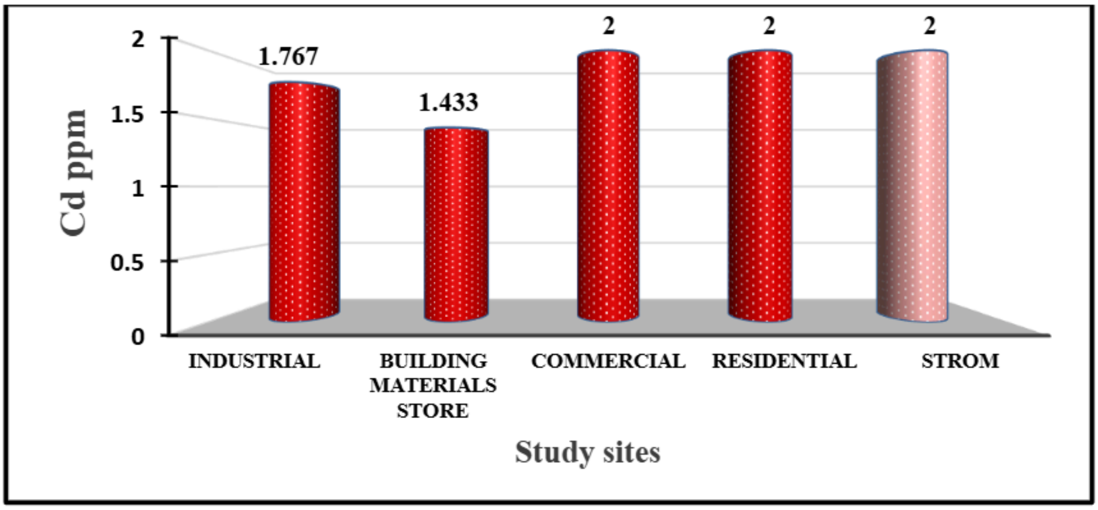

Figure 2. Cadmium concentration/ppm in street dust and storm dust.

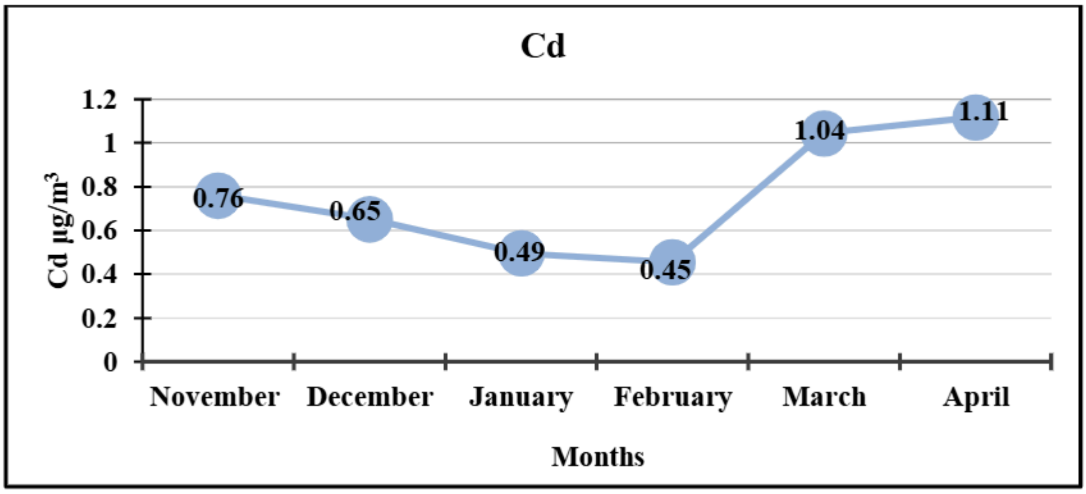

Figure 3. Monthly changes in cadmium concentration in suspended particles (µg/m³)

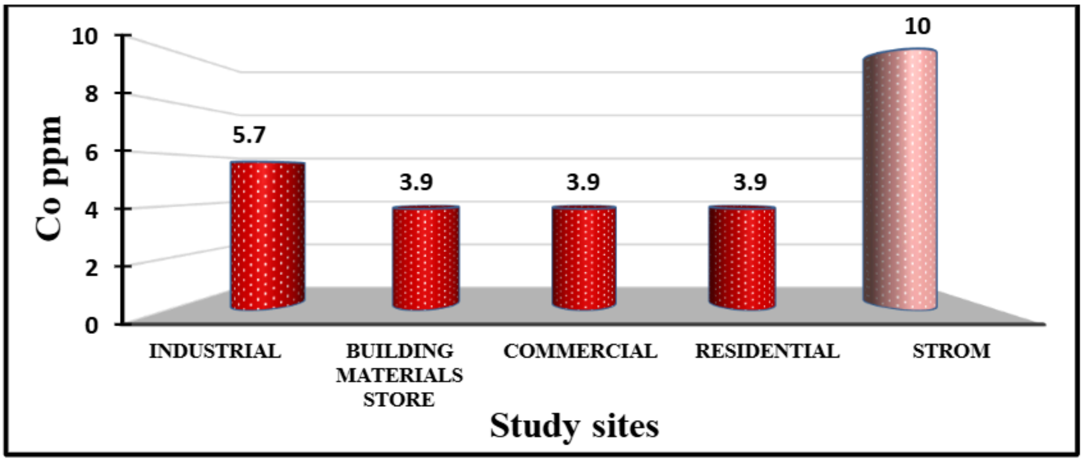

Figure 4. Cobalt concentration/ppm in street dust and storm dust

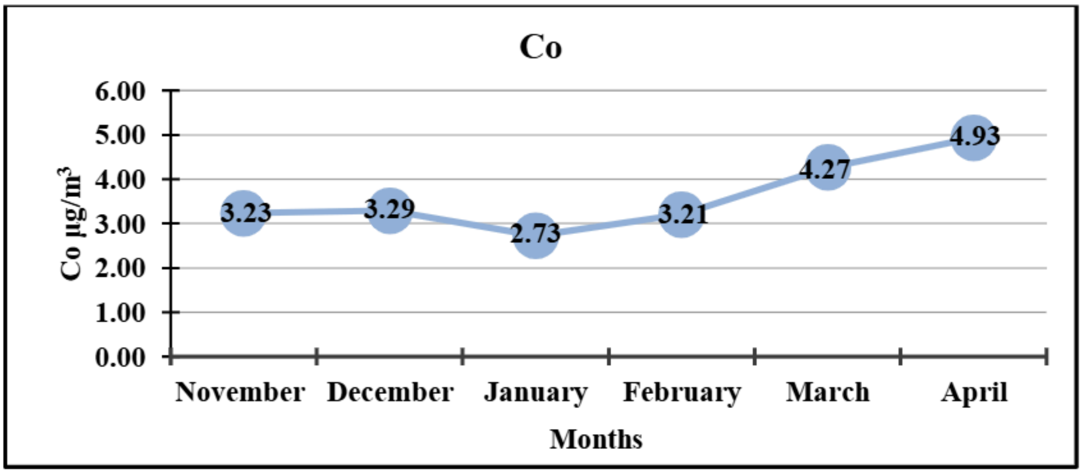

Figure 5. Monthly changes of cobalt concentration in suspended particles (µg/m³)

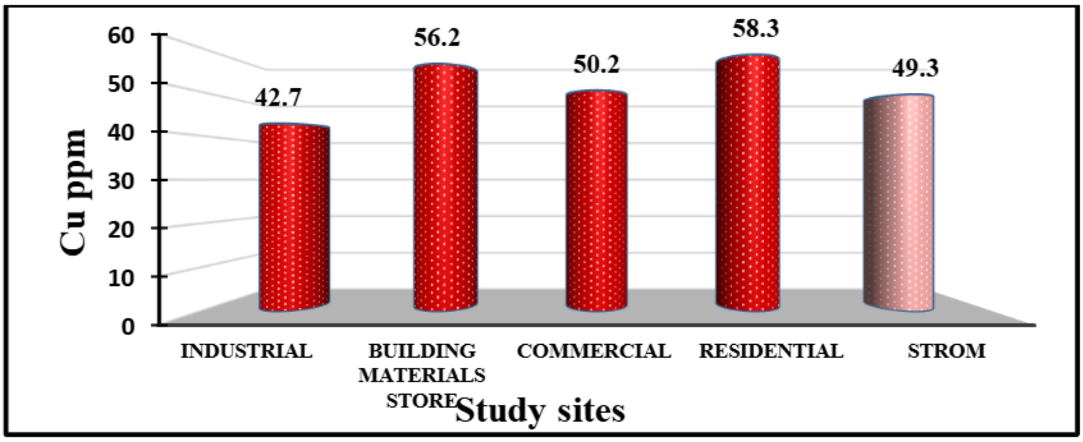

Figure 6. Copper concentration/ppm in street dust and storm dust.

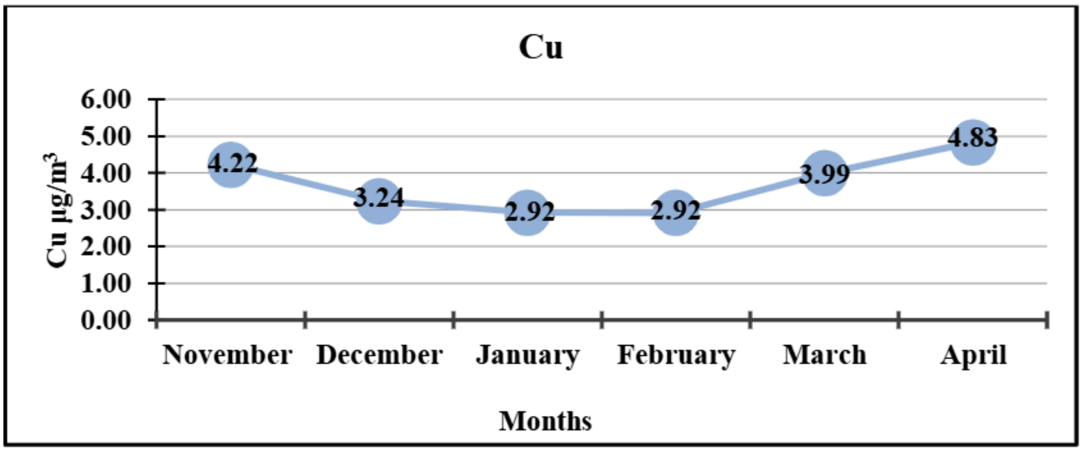

Figure 7. Monthly changes of copper concentration in suspended particles (µg/m^3).

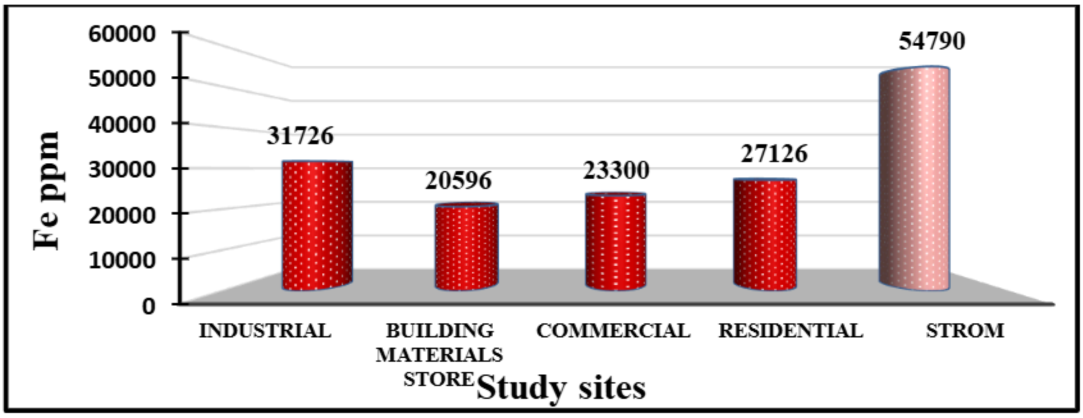

Figure 8. Iron concentration/ppm in street dust and storm dust.

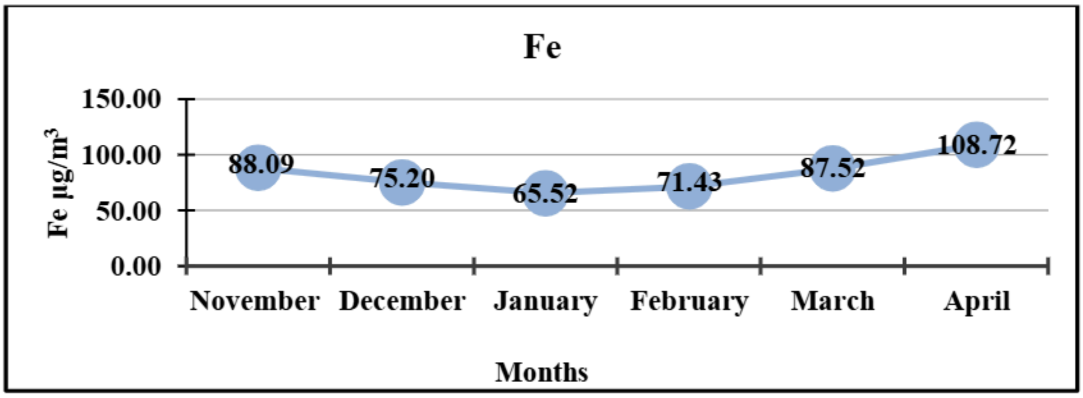

Figure 9. Monthly changes of iron concentration in suspended particles (µg/m^3).

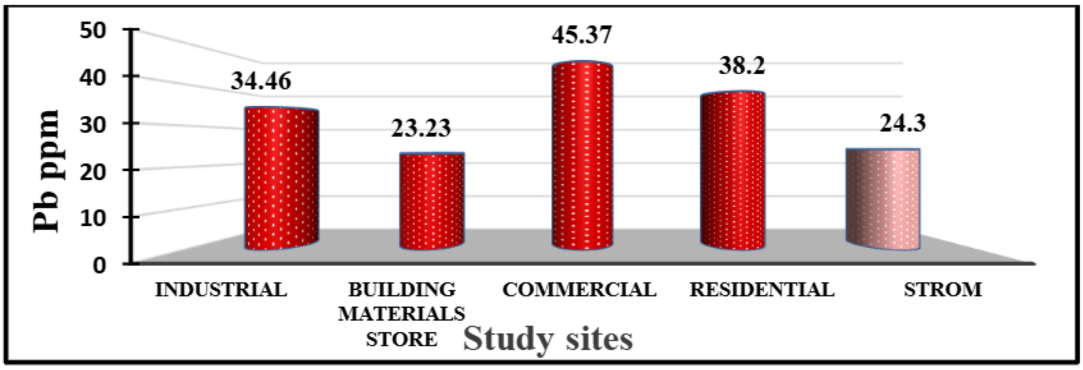

Figure 10. Lead concentration in street dust and storm dust.

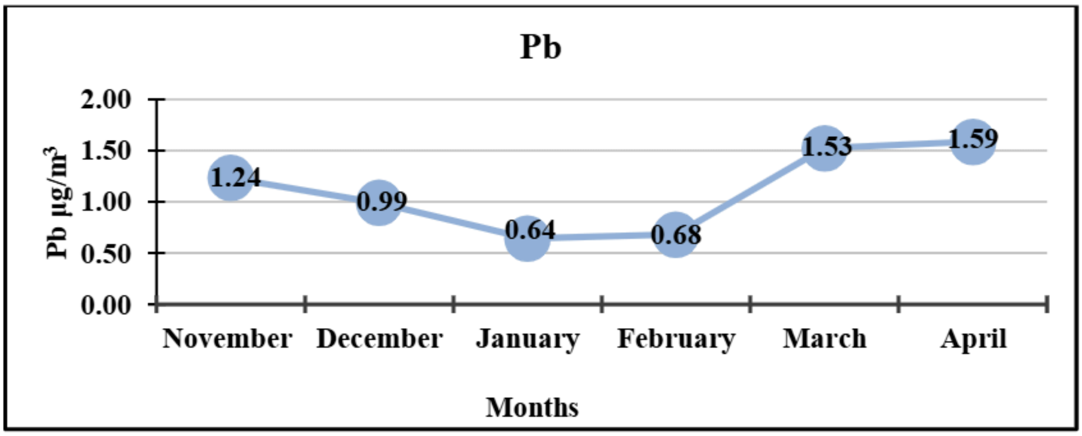

Figure 11. Monthly changes of lead concentration in suspended particles (µg/m^3).

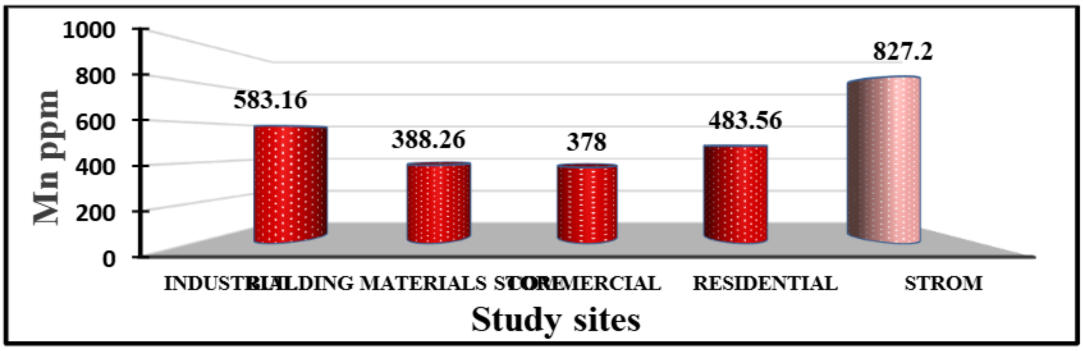

Figure 12. Manganese concentration in street dust and storm dust.

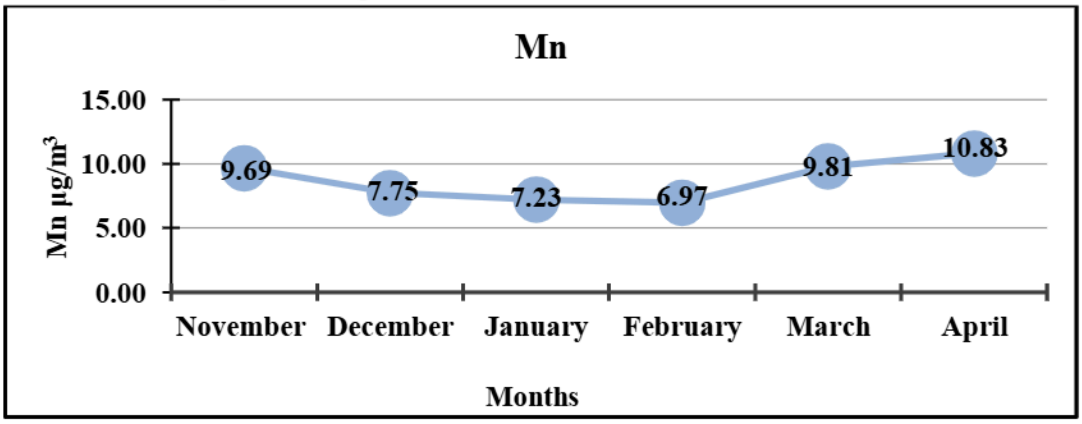

Figure 13. Monthly changes of manganese concentration in suspended particles (µg/m^3).

4.Conclusions

By following up on the results of the current study, it can be concluded:

-The atmosphere of Baghdad is exposed to dangerous levels of pollution of all kinds of dust (street, storm, and suspended), which contain Cd, Co, Cu, Fe, Pb, and Mn elements.

-All the concentrations of these elements have been considered high as measured by the environmental allowable if the values recorded (1.15, 6.6, 60.15, 26770, 44.4 6, 489.8) and (2, 10, 49.3, 54760, 24.3, 827.2) ppm in street and storm dust respectively, whereas in the suspended dust, were (0.707, 3.546, 3.727, 83.204, 1.076, 8.706) µg/ m^3.

-The presence of interaction and change between the components and particles of dust in the three types of streets, storm, and suspended dust revealed elements of the particle scans and their content of the target element of the study.

-There is an apparent failure in the process of waste management and the application of environmental sanitation rules by government agencies, civil society organizations, and scientific institutions.

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