Heavy metals characteristics of settled particles of streets dust from Diwaniyah City- Qadisiyah Governorate - Southern Iraq

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Abstract. Road-side dust samples were collected from selected areas of Diwaniyah city- Qadisiyah Governorate - Southern Iraq. The heavy metals (Fe, Co, Ni, Cu, Zn and Pb) in these streets dust samples were studied and used as indicator for pollution by using three of main indices (I-geo, CF, and PLI). Determination of heavy metal in the roadside dust is with XRD and XRF methods. I-geo for Co, Zn, Pb, and Ni in the studied sites shows relative values of class 1, which indicated the slightly polluted, while I-geo for Fe and Cu shows relative values of class 0, which indicated no pollution. The contamination factor for Co, Zn, Pb, and Ni classified as class 2, which indicate moderately contamination, while the contamination factor for Fe and Cu classified as class 1, which indicate low contamination. PLI values in the all of studied sites classified as class 2 (Deterioration on site quality) indicating local pollution, as well as denote perfection with (class 0) of no pollution. The distribution pattern of metals percentages was affected by gases emitted from transportation vehicles as well as the prevailing wind direction.
1. INTRODUCTION

Dust storms are significant phenomena in Iraq and especially in Diwaniyah City which represent a serious natural hazard where the number of day in which dust storms occur is considerable, such phenomenon have a wind speed at least 25 mile/hour, playing an active role in transporting and deposition of material of different sizes led to change in earth surface. These storms are most prevalent in spring and summer when a prevailing north westerly wind known locally as the “Shamal” kicks up the fine desert sand and silt along the Tigris and Euphrates rivers basins towards south part of Iraq (Al-Dabbas et al., 2011, and 2012). Moreover, Al-Dabbas et al., (2011) estimated that the texture of dust fall out ranged from sandy clayey silt and clayey sandy silt, whereas the quartz, feldspar, and calcite were most of light minerals, and chlorite, illite, montmorillonite, palygorskite and kaolinite were most of clay minerals in the dust fallout. Soil receives pollutants from different sources including exhaust gases from vehicles, factory chimneys, dust storm etc. Banerjee, 2003, concluded that the composition and quantity of chemical matrix of road dust are indicators of environmental pollution (Khuwaidem, 2007; Awadh, 2013). Street dust is typically derived from anthropogenic sources via the interaction of natural solid, liquid or gaseous materials with pollutant (Al-Khashman, 2004 and 2007; Aydin, et al., 2012). The effects of heavy metals in road dust on human health include respiratory system disorders, nervous system interruptions and the risk of cancer in later life (Ferreira- Baptista and Miguel, 2005; Ahmed and Ishiga, 2006). The rapid growth in population and urbanization in Diwaniyah City (of semi-arid to arid climate) exert a pressure on its urban environment. The source of heavy elements can be from the quaternary unconsolidated sediment of the Mesopotamian plain and from river sediments (sand, silt and clay) as natural sources as well as the artificial sources that include industrial sources that supply the heavy metals to the air and causing contamination of the atmosphere (Al-Dabbas et al., 2011). Urbanization and industrial processes development and increase extraction of oil and the subsequent burning of associated gas especially during the past years in Diwaniyah city, these exerts formed a heavy pressure on its urban environment. For these reasons it is necessary to know the main of heavy metals in the dust storm in order to understand their behavior and impact. This work was carried out on roadside dust in twelve selected sites of Diwaniyah City- Qadisiyah Governorate - Southern Iraq 'Figure 1'.

The objective of this study is to elucidate the concentrations and distribution of heavy metals (Fe, Zn, Cu, Co, Pb, and Ni) and assessment of heavy metals pollution in the streets dust particles of Diwaniyah city by using the geo-accumulation (I-geo), contamination factor (CF), and Pollution load index (PLI) as first attempt to evaluate the heavy metals pollution in the streets dust samples particles in Diwaniyah city - southern Iraq.
Figure 1: Locations of the collected streets dust samples within Diwaniyah city.
2. METHEdology
The study area is Diwaniyah city that divided by Shatt Al-Diwaniyah (The extension of Shatt Al-Hillah which is an eastern part of Euphrates River). Total of twelve road dust samples were collected (Based on traffic load, major roadways near the fuel stations old military camps) during 2016; five from the western district (the west part of Diwaniyah) and seven from the eastern district (the east part of Diwaniyah) locations were recorded with GPS (Figure 1, Table1). These samples were analyzed in the laboratory of geochemistry in the Geology Department, University of Baghdad by XRD and XRF Methods. Ten grams of samples were powdered to detect the Fe, Co, Zn, Cu, Ni, and Pb elements by XRF and XRD Methods. The results are tabulated in (Table 1).

Table 1: Values of heavy metals for the streets dust samples within Diwaniyah city.

| Sample No. | Fe₂O₃ % | Co ppm | Zn ppm | Cu ppm | Ni ppm | Pb ppm |
|------------|---------|--------|--------|--------|--------|--------|
| 1          | 2.26    | 4      | 130    | 25     | 77     | 45     |
| 2          | 2.86    | 4      | 80     | 25     | 100    | 32     |
| 3          | 2.5     | 4      | 100    | 30     | 100    | 20     |
| 4          | 2.16    | 4      | 80     | 22     | 70     | 22     |
| 5          | 5.26    | 18     | 160    | 45     | 200    | 27     |
| 6          | 2.6     | 4      | 90     | 23     | 86     | 35     |
| 7          | 4.86    | 16     | 88     | 25     | 164    | 17     |
| 8          | 2.73    | 4      | 120    | 37     | 94     | 40     |
| 9          | 2.98    | 4      | 114    | 38     | 100    | 70     |
| 10         | 3.42    | 4      | 190    | 80     | 100    | 110    |
| 11         | 2.82    | 4      | 97     | 30     | 90     | 60     |
| 12         | 3.63    | 4      | 130    | 160    | 130    | 40     |
| Mean of This study | 3.17 | 6 | 115 | 45 | 109 | 43 |
| Mean of Al-Jaberi ,2014, results | 0.23 | 29 | 123 | 27 | 119 | 48 |
Table 2: CF, I-geo and PLI index for the streets dust samples within Diwaniyah city.

| S.No | Fe2O3 % | Co ppm | Zn ppm | Cu ppm | Ni ppm | Pb ppm | CF   | I-geo | CF   | I-geo | CF   | I-geo | CF   | I-geo | CF   | I-geo | PLI |
|-----|---------|--------|--------|--------|--------|--------|------|-------|------|-------|------|-------|------|-------|------|-------|-----|
| 1   | 0.7     | 0.1    | 1.8    | 0.4    | 1.0    | 3.6    | 0.5  | 0.8  | 1.2  | 0.8  |
| 2   | 0.9     | 0.1    | 1.1    | 0.4    | 1.3    | 2.5    | 0.7  | 0.8  | 1.6  | 0.7  |
| 3   | 0.8     | 0.1    | 1.4    | 0.5    | 1.3    | 1.6    | 0.0  | 0.7  | 1.8  | 0.8  |
| 4   | 0.7     | 0.1    | 1.1    | 0.4    | 1.0    | 1.7    | 0.2  | 0.6  | 2.1  | 1.5  |
| 5   | 1.7     | 0.1    | 2.2    | 0.8    | 2.6    | 2.1    | 0.5  | 1.5  | 1.3  | 1.0  |
| 6   | 0.8     | 0.1    | 1.2    | 0.4    | 1.1    | 2.8    | 0.9  | 0.7  | 1.3  | 0.9  |
| 7   | 1.6     | 0.1    | 1.2    | 0.4    | 2.1    | 1.3    | 0.1  | 1.1  | 3.2  | 0.4  |
| 8   | 0.9     | 0.1    | 1.7    | 0.6    | 1.2    | 3.2    | 1.0  | 0.9  | 1.9  | 1.0  |
| 9   | 0.9     | 0.1    | 1.6    | 0.6    | 1.3    | 5.6    | 1.9  | 1.0  | 1.4  | 1.4  |
| 10  | 1.1     | 0.1    | 2.7    | 0.6    | 1.4    | 5.9    | 1.9  | 1.4  | 1.6  | 1.4  |
| 11  | 0.9     | 0.1    | 1.3    | 0.5    | 1.2    | 4.8    | 1.6  | 0.9  | 1.3  | 1.0  |
| 12  | 1.2     | 0.1    | 1.8    | 0.8    | 1.4    | 3.4    | 0.9  | 1.0  | 1.3  | 1.2  |
| Mean| 1.0     | 0.2    | 1.6    | 0.8    | 1.4    | 3.4    | 0.9  | 1.0  | 1.3  | 1.2  |
Table 3: Classified grades of I-geo, CF and PLI indices, (after Thomilson et al (1980) and Al-Jaberi and Al-Dabbas, 2014).

| I-geo                  | CF contamination factor          | PLI                      |
|-----------------------|---------------------------------|--------------------------|
| ≤ 0 (class 0), Practically un polluted | <1 Low contamination (class 1). | <1 Perfection (class 0) |
| 0 < to ≤ 1 (class 1), slightly polluted | 1<CF< 3 Moderate contamination (class 2). | =1 Baseline Level (class 1). |
| 1< to ≤ 2 (class 2), Moderately polluted | 3≤ CF≤6 Considerable Contamination (class 3). | >1 Deterioration on site quality (class 2) |
| 2< to ≤ 3 (class 3), moderately severely polluted | >6 Very high Contamination (class 4). | |
| 3< to ≤ 4 (class 4), Severely polluted |                                  |                          |
| 4< to ≤ 5 (class 5), Severely extremely polluted |                                  |                          |
| > 5 (class 6), Extremely polluted |                                  |                          |

3. RESULT AND DISCUSSION

A-Heavy metals
Metals, a major category of globally-distributed pollutants, are natural elements that have been extracted from the earth and harnessed for human industry and products for millennia. Metals are notable for their wide environmental dispersion from such activity; their tendency to accumulate in select tissues of the human body; and their overall potential to be toxic even at relatively minor levels of exposure. Some metals, such as copper and iron, are essential to life and play irreplaceable roles in, for example, the functioning of critical enzyme systems. Other metals are xenobiotics, i.e., they have no useful role in human physiology (and most other living organisms) and, even worse, as in the case of lead and mercury, may be toxic even at trace levels of exposure. Even those metals that are essential, however, have the potential to turn harmful at very high levels of exposure, a reflection of a very basic tenet of toxicology—“the dose makes the poison. Exposure to metals can occur through a variety of routes. Metals may be inhaled as dust or fume (tiny particulate matter, such as the lead oxide particles produced by the combustion of leaded gasoline). Metals may also be ingested involuntarily through food and drink (Howard Hu, 2002). Six common heavy metals are discussed in this brief: iron, cobalt, zinc, copper, lead, and nickel in the dust particles of the studied area (Table1). Discussion of these heavy metals is as follows:

1-Lead
As a result of human activities, such as fossil fuel burning, mining, and manufacturing, lead and lead compounds can be found in all parts of our environment (includes air, soil, and water). Lead can affect every organ and system in the body. Exposure to lead can damage the brain and kidneys and ultimately cause death (CHSR, 2009). The human body may take the lead through air which ranges between less than (4 Mg /day) and more than (200 Mg/day) according to area where he lives. The averages concentrations of Pb in dust particles of in Diwaniyah city selected sites ranging from 22 ppm in site No. 7 to 110 ppm in site No. 10 with mean value of 43 ppm.
2- **Copper**
Copper toxicity is contributor to health problems such as anorexia, depression, anxiety, liver and kidney damage, headaches, and allergies \( \text{(CHSR, 2009)} \). The averages concentrations of Cu in dust particles of in Diwaniyah city selected sites ranging from 17 ppm in site No. 4 to 160 ppm in site No. 12 with mean value of 45 ppm.

3- **Iron**
The corrosive nature of Iron seems to further increase the absorption. Target organs are the liver, cardiovascular system, and kidneys. Iron exposure in utero, in infancy and childhood may result in low birth rate, anemia, neurological impairment, IQ deficits and growth retardation \( \text{(CHSR, 2009)} \). The averages concentrations of Fe in dust particles of in Diwaniyah city selected sites ranging from 2.16 % in site No. 4 to 5.26 % in site No. 5 with mean value of 3.17%.

4- **Zinc**
The excess amount of Zinc can cause system dysfunctions that result in impairment of growth and reproduction \( \text{(McCluggage, 1991; Nolan, 2003)} \). The clinical signs of zinc toxicities have been reported as vomiting, diarrhea, bloody urine, liver failure, kidney failure and anemia \( \text{(Kabata-Pendias and Mukherjee, 2007)} \). The averages concentrations of Zn in dust particles of in Diwaniyah city selected sites ranging from 80 ppm in site No. 4 and No.2 to 190 ppm in site No. 10 with mean value of 115 ppm.

5- **Nickel**
The high Nickel concentrations are carcinogenic to human and animals which result in respiratory system rapid damage and cause health affection, vertigo, bronchitis and Asthma \( \text{(CHSR, 2009)} \). The averages concentrations of Ni in dust particles of in Diwaniyah city selected sites ranging from 70 ppm in site No. 4 to 200 ppm in site No. 5 with mean value of 109 ppm.

6- **Cobalt**
The cobalt increase rats will cause disturbances in some important organism \( \text{(CHSR, 2009)} \). The averages concentrations of Cobalt (Co) in dust particles of in Diwaniyah city selected sites ranging from 4 ppm in 10 sites to 18 ppm in site No. 5 with mean value of 6 ppm.

Observed from the concentrations of heavy metals in the dust particles of studied sites \( \text{(Table 1)} \) that significantly increase of these metals in site No. 5 and No. 10, this increase may be due to urbanization and industrial processes problems, represented by manufacturing, waste flaring associated gas from oil drilling sites, and from vehicle emission.

Comparing the above results with that of Al-Jaberi, 2014, reflect that they are lower for Co, Zn, Ni and Pb except for Fe and Cu values which are higher.

**B- Contamination evaluation:**

Three indices were selected to evaluate the contamination level of Fe, Co, Zn, Cu, Ni, and Pb in the dust particles. These are contamination factor \( \text{(CF)} \), Geo accumulation index \( \text{(I- geo)} \), and Pollution Load Index \( \text{(PLI)} \) \( \text{(Tables 2 and 3)} \).
1- Geo- accumulation index (I- geo):

The Geo accumulation (I-geo) index means the assessment of contamination by comparing the levels of heavy metal obtained to a background level (Muller, 1969; Gowd et al., 2010). Geo-accumulation index (I- geo) was determined by the following equation according to Muller (1969).

\[ I_{\text{geo}} = \log_2 \left( \frac{C_n}{1.5 \cdot B_n} \right) \]

Where:

\( C_n \) = the heavy metals concentration in the sediments and

\( B_n \) = the geochemical background concentration of the heavy metals (crustal average) (Muller, 1969; Taylor and McLennan, 1985; Lu et al, 2009). This index range from subzero to more than 5 having 7 grades (Table 3). The highest grade (6) reflects a 100-fold enrichment and (0) reflects the background concentration. The Fe\(_2\)O\(_3\) was found negative in most of the sites, ranging from -1.06 to -0.31 (Table 2). These results are of (class 0) which indicated that the concentrations of Fe\(_2\)O\(_3\) in the dust particles of studied sites are unpolluted and lower than the background (Table 3). While, the samples from sites No. 5 and No.7 show I-Geo of 0.23 and 0.11 respectively, which reflect (class 1) of slightly polluted sites.

The Co was found negative in all the sites, ranging from -1.06 to -3.23 (Table 2). These results are of (class 0) which indicated that the concentrations of Co in the dust particles of studied sites are unpolluted and lower than the background (Table 3).

The Zn was found negative in the sites (No. 2, 3, 4, 6, 7 and 11), ranging from -0.07 to -0.39 (Table 2). These results are of (class 0) which indicated that the concentrations of Zn in the dust particles of studied sites are unpolluted and lower than the background (Table 3). While in the sites (No. 1, 5, 8, 9, 10 and 12), are with positive values I-Geo values ranging from of 0.12 to 0.61 which reflect (class 1) of slightly polluted sites (Table 2).

The Cu was found negative in all the sites, ranging from -0.04 to -1.91 except site No. 12 that has positive value of 0.96 (Table 2). These results are of (class 0) which indicates that the concentrations of Cu in the dust particles of studies sites are unpolluted and lower than the background, except site No.12 which reflect (class 1) of slightly polluted sites (Table 2).

The Ni was found negative in most of the sites, ranging from -0.17 to -0.69 (Table 2). These results are of (class 0) which indicated that the concentrations of Ni in the dust particles of studied sites are unpolluted and lower than the background (Table 3). While site No. 5, No.7 and No.12 are with positive I-Geo of 0.83, 0.54 and 0.21 respectively, which reflect (class 1) of slightly polluted sites (Table 2).

The Pb had positive values in the all of studied sites, some ranging from 0.09 to 0.94 (Table 3); these results are of (class 1) which indicated that the concentrations of Pb in the dust particles of these sites are slightly polluted (Table 2). While, the other sites ranging from 1.09 to 1.99 of (class 2) which indicated moderately polluted.
2- Contamination factor (CF):

Contamination factor (CF) was determined following equation according to Thomilson et al (1980). The level of contamination by metals was established by applying the CF that can be calculated as follows:

\[ \text{CF} = \frac{C_{m\text{ Sample}}}{C_{m\text{ Background}}} \]

The contamination factor (CF) for Fe, Co, Zn, Cu, Ni, and Pb was calculated in Table 2. Lead (Pb) classified as class 2 representing moderate contamination ranging from 1.36 to 2.80 for some samples. While other samples classified as class 3 representing Considerable contamination in six samples (No. 1, 8, 9, 10, 11, 12) ranging from 3.20 to 5.98. The CF for Ni classified as class 2 which indicate moderately contamination in all the studied sites, ranging from 1.00 to 2.67. It is believed that considerable part of Lead and nickel find their way into the environment as a result of the burning of diesel oil and oil spilling that caused to increase both of nickel in the sediments. The CF for Cu classified as class 1 which indicate Low contamination ranging from 0.40 to 0.82, except two sites (No. 10 and 12) have 1.46 and 2.91 respectively, classified as class 2 representing moderate contamination. It is believed that considerable part of copper finds its way into the environment as a result of the burning of diesel oil and may be due to the disposal of copper-containing wastewater. Zinc (Zn) classified as class 2 representing moderate contamination ranging from 1.14 to 2.71. Zn is come from toxic waste from industrial sources (Thorpe and Harrison, 2008). Cobalt (Co) classified as class 1 representing a low contamination ranging from 0.16 to 0.72. The CF for Fe classified as class 1 which indicate low contamination, ranging from 0.72 to 0.99 except four sites (No. 5, 7, 10, 12) classified as class 2 which indicate Moderate contamination, ranging from 1.14 to 1.75. It is believed that considerable part of iron finds its way into the environment as a result of the burning of diesel oil and may be due to the disposal of iron-containing wastewater.

3- Pollution load index (PLI):

The PLI provides a simple but comparative means for assessing a site quality. Pollution load index (PLI) was determined following equation according to Thomilson et al (1980), where (PLI) is expressed as follows:

\[ \text{PLI} = n^{\frac{1}{n}} \text{CF1} \times \text{CF2} \times \text{CF3} \times \ldots \times \text{CFn} \]

Where:

\( n \) = the number of studied metals in each site.

The Pollution Load Index (PLI) for Fe, Co, Zn, Cu, Ni, and Pb was calculated and classified as class 0 with perfection of no pollution, while five sites were classified as class 2 (Deterioration on site quality) indicating local pollution, ranging from 1.05 to 1.55.

4. CONCLUSION

The heavy metals (Fe, Co, Ni, Cu, Zn and Pb) in these streets dust samples were studied and used as indicator for pollution by using three of main indices (I-geo, CF, and PLI). In the roadside dust, the heavy metal contents were determined using XRD and XRF Methods. Comparing the above results
with that of Al-Jaberi, 2014, reflect that they are lower for Co, Zn, Ni and Pb except for Fe and Cu values which are higher. I-geo for Co, Zn, Pb, and Ni in the studied sites shows relative values of class 1, which indicated the slightly polluted, while I-geo for Fe and Cu shows relative values of class 0, which indicated no pollution. The contamination factor for Co, Zn, Pb, and Ni classified as class 2, which indicate moderately contamination, while the contamination factor for Fe and Cu classified as class 1, which indicate low contamination. PLI values in the all of studied sites classified as class 2 (Deterioration on site quality) indicating local pollution, as well as denote perfection with (class 0) of no pollution. The distribution pattern of metals percentages was affected by gases emitted from transportation vehicles as well as the prevailing wind direction.

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