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Assessment of the Toxic Elements Resulting from the Manufacture of Bricks on Air and Soil at Abu Smeache Area - Southwest Babylon governorate - Iraq

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Abstract

Brick factories distributed within the study area use fuel oil to complete the burning of the bricks, were high amounts of gases and suspended particles with different concentrations of heavy elements are produced and cause air and soil pollution. It is noted that the workers suffer from respiratory diseases and other health problems. This study is an attempt to detect the sources and concentrations of pollutants and to propose modalities for their treatment and reduction. Air and soil samples were collected from different sites in Abu Smeache brick factory in Al-Kifl area to the south of Babel city, Iraq, during two seasons (summer and winter). The process also included collecting and modelling of dust and soil samples from two depth, surface and sub-surface, to detect pollution and the mobility of heavy elements across the different depths. Heavy elements (Pb, Ni, Co), along with gases (CO, CO₂, NO₂, SO₂) and total suspended particles (TSP) in the air, were analyzed by atomic absorption spectroscopy. The air results showed high pollution with all the studied heavy elements, while the levels of TSP and SO₂ were higher than global and Iraqi limits in most of the studied stations, especially in the winter. The results also showed significant pollution in the soil with lead along with slight contamination with nickel and cobalt. Soil contamination was evaluated using several contamination indices; the values of contamination factors (CF) for the lead were very high, while CF values for nickel and copper indicated low to moderate pollution. Also, the high values of PLI >1 in the soil indicated high pollution with heavy elements, which provides clear evidence of the impact of industrial human activities on the environment of the region. In addition, low values of i-geo indicated a moderate contamination with lead and an unpolluted status for both nickel and copper. These results indicate a great need to develop strategies to prevent and reduce pollution by heavy metals in the areas under rapid industrial and urban development.

Keywords: Heavy elements, TSP, contamination factors, Brick factory, Al- Kifl - Babylon.

تقييم العناصر السامة الناتجة عن صناعة الطابوق على الهواء والتربة في منطقة أبو سميح - جنوب
غرب بابل / العراق

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الخلاصة

تستخدم مصانع الطابوق في منطقة الدراسة النفط الاسود لاستكمال عملية الحرق ، حيث تنتج كميات كبيرة من الغازات والجسيمات العالقة الكلية و العناصر الثقيلة التي تسبب تلوث الهواء والتربة. ويلاحظ أن العمال يعانون من أمراض الجهاز التنفسي ومشاكل صحية أخرى. ان هذه الدراسة هي محاولة لمعرفة كثافة ومصادر التلوث ، واقتراح طرائق للعلاج والحد من التلوث. تم جمع عينات من الهواء والتربة من مواقع مختلفة في معامل طابوق أبو سميح في منطقة الكفل جنوب مدينة بابل ، العراق. جمعت عينات الهواء من منطقة الدراسة خلال موسمين (الصيف والشتاء) ، كما رافق عملية نمذجة الغبار جمع عينات التربة من عميق ، عينات سطحية وتحت سطحية للكشف عن تلوث التربة وحركة العناصر الثقيلة عبر أعماق مختلفة . حللت العناصر الثقيلة (الرصاص ، النيكل ، الكوبلت) في كل من الوسائط المدروسة باستخدام تقنية التحليل الطيفي للامتصاص الذري ، كما تم قياس الغازات اول اوكسيد الكربون ، ثنائي اوكسيد الكربون ، ثنائي اوكسيد النروجين ، ثنائي اوكسيد الكبريت والجسيمات العالقة الكلية (TSP) في الهواء. أظهرت نتائج الهواء ارتفاع نسبة التلوث في جميع العناصر الثقيلة التي تمت دراستها ومستويات الجسيمات العالقة الكلية وثنائي اوكسيد الكبريت كما كانت أعلى من الحدود العالمية والعراقية في معظم المحطات التي شملتها الدراسة ، وخاصة في فصل الشتاء ، في حين أظهرت نتائج الدراسة تلوثاً كبيراً في التربة بعنصر الرصاص وتلوث قليل بعنصري النيكل والكوبالت. وقد تم تقييم تلوث التربة باستخدام مؤشرات بيئية ، وكانت قيم عوامل التلوث (CF) للرصاص تشير الى وجود تلوث عالية جدا ، في حين أن نتائج (CF) للنيكل والنحاس تراوحت بين منخفضه الى معتدلة التلوث ، كما تشير القيم العالية لـ $PLI > 1$ إلى ارتفاع التلوث في التربة بالعناصر الثقيلة ، مما يعطي دليلاً واضحاً على تأثير الأنشطة البشرية الصناعية على بيئة المنطقة ، في حين تشير القيم المنخفضة لمستوى i-geo إلى التلوث المعتدل بواسطة عنصر الرصاص وغير ملوث من قبل كل من عناصر النيكل والنحاس. تشير هذه النتائج إلى الحاجة الماسة إلى وضع استراتيجيات لمنع وتقليل التلوث بالمعادن الثقيلة في المناطق التي تشهد تطوراً صناعياً وحضرياً سريعاً.

1- Introduction

Traditional industries, such as brick factories, have an adverse effect on the environment because of the pollution caused by gases emission, evaporation, dust as well as solid materials and hydrocarbons that goes through sewage outlets to the rivers adjacent to industrial projects. The brick industry is one of the oldest traditional industries that showed only slight advances in the development of means of production. These industries have an environmental impact on the areas in which these brick factories are located. They continue to produce solid, liquid and gaseous wastes [1]

In Babylon Governorate (province of Al- Kifl) many of the brick factories have potential negative impact on the environmental situation of the area, especially that the area is located close to the residential neighbourhoods. Crude oil is used as fuel in the kiln of the brick industry, which is an essential cause of pollution with gaseous waste, one of the most dangerous wastes made of the residues of gases, dust and volatile atoms, containing heavy elements that have toxic effects on the human, animals and plants. These factories can be more harmful than other technical factories as they have a low-rise coefficient that does not exceed the height of 3 m, which leads to soil pollution in the factories and the areas surrounding them. Soil is considered one of the crucial components in any environment, whether rural or urban, and is subjected to pollutants coming from different anthropogenic sources, including combustion of fuels in brick kilns and solid wastes. The heavy elements and gases emitted, such as SO_2 , NO_2 , CO_2 and CO , are one of the results of these polluted sources. Previous studies showed that heavy metals have deleterious impacts on the environment due to their mobility nature; some of the heavy metals are mobile in nature, moving from soil to plants and underground water and circulating through the entire food chain. leading to indirect effects on the health of human [2].

Many countries have taken measures to judge the extent to which soil is contaminated with heavy metals. These scales vary according to the environment of the country issuing those standards. States whose territories are acidic are more stringent of those that fall under dry and semi-dry conditions, where there are alkaline soils. This difference is due to the fact that the heavy elements are less soluble

and can move in alkaline soils [3]. Monitoring of environmental quality around brick factories should be of a main importance. Regular monitoring can help to evaluate the extent or trend of pollution and can also suggest some controlling measures as well as possible remediation [4].

Urbanization is one of the main impact factors in the development of countries. In developing countries, especially Iraq, as the population accelerates, the rate of urbanization is also increasing. Demand for the construction of brick kilns is also increasing in major urban areas.

The production rate of the Abu Smeache block in the area of AL-Kifl is about 12 million blocks per year, while the amount of fuel consumed ranges from 150 to 170 thousand liters during the annual production period. Also, the design of the incinerator, the characteristics of the fuel and its incomplete combustion at the beginning of the burning period, as well as the non-control of emissions, contribute to the release of different pollutants. The availability of clay, water, and labor are the main features that have led to the establishment of a large number of block factories in this region.

Studies on factories' effects as a major source of environmental pollution in AL-Kifl are not very common. Few studies were carried out in order to assess the effects of brick kilns on soil and plants in other areas in Iraq. One of these studies (Shanshal, 2004) found high concentrations of heavy metals (Cd, Ni, Pb, Cr) in the soil of Nahrawan area, along with high concentrations of high heavy elements in the tissues of Schanginia plant in the same area, and attributed the increase to the presence of tanning plants and brick factories. Another study (Al- Kawaz, 2017) on the effects of factories smoke on the plant species *Dodonaea viscosa* and *Conocarpus lancifolius* showed high concentrations of lead and cadmium in plants, soil, dust and water used in irrigation at the affected site compared with the unaffected site[5]. However, no studies are available that evaluate the situation through conducting an environmental assessment and evaluating the extent of pollutants within the factories and their transfer to residential areas and the groundwater nearby. This is especially critical due to the presence of a religious shrine up to 4 km from the region, which led to its development as a residential area. The current investigation reveals the results collected in one year, with a purpose of understanding the impact of heavy metal pollution on the soil and air in the factories, as well as the extent of its spread to nearby lands.

1-1 Geological Setting:

According to the Buday's division, Al-Kifl area lies in the unstable shelf within the Mesopotamian zone and in the Euphrates subzone. It represents the boundary between stable and unstable shelves [6]. The study area is bound by Desert of Najaf from the west, Euphrates river from the east, Karbala city from the north, and Khan AL-Rahha from the south. The gradational deposits of the Euphrates river which originate the delta plain represent the limits of the east part [7], as shown in Figure-1

The geology and tectonic evolution of Iraq was greatly influenced by the opening and closing of the Palaeotethys and Neotethys oceans. The Neotethys was opened during the Upper Carboniferous Permian along the rifting axis that runs parallel to Zagros. The Mesopotamian intercontinental basin was developed inside the Arabian plate and to the west of Zagros thrust depth [8]. Consequently, AL-Kifl area was affected by this evolution and was located on the west flank of the Mesopotamian basin. The transversal faults played their rules in the depositional basin environment and later on in the developing of the main tectonic structures. It seems that these faults have been active since the Permian times [8]

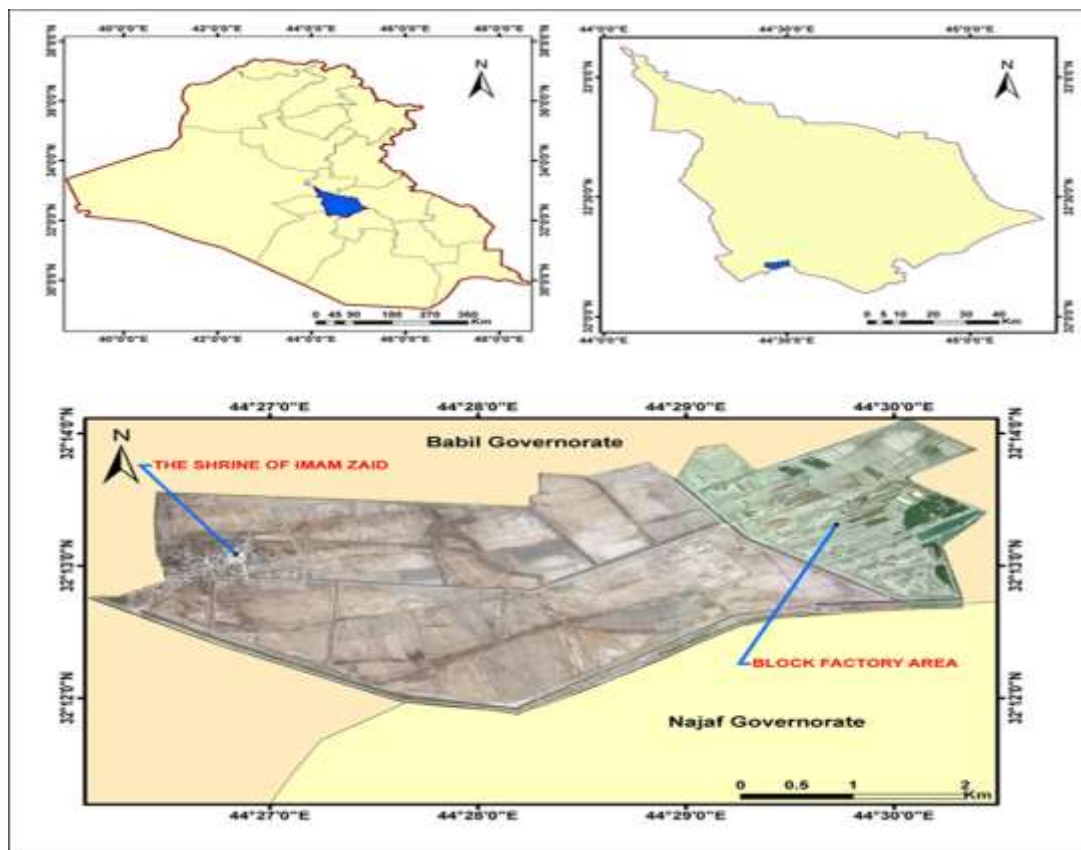


Figure 1- Location Map of study area

2-Materials and methods

2-1 Study area

The industrial Abu Smeache is located east of Al-Kifl district, affiliated to the city of Hilla (16 km south of Hilla). The present study area covers (15.59937) km². Al-Kifl district represents the road between Hilla and Najaf cities and characterized by the existence of agricultural areas, which depend on the Euphrates river and various branches and drainage channels. The area occupied by the factories is 3.375 km², located at the latitude 32°15'52.9 and the longitude 44°49'02.3", with a large number of brick factories, each of which occupying an area of 50-70. An increasing number of these factories has been observed to be established on this specific area .

2-2 Field and Sampling Works

Samples of air were taken from 8 stations (inside and outside the brick factories) distributed in different areas within the Abu Smeache. The stations were selected for the purpose of measuring the concentrations of total suspended particles (TSP) and gases (CO, CO₂, NO₂, SO₂). The study was designed to include stations that cover most of the area during two periods, winter 2017 and summer 2018, as shown in Figure-2 and Table-1. A sniffer measuring device was used in the modeling process, where the device was installed and operated for one hour and at a height not less than one meter

The soil sampling process was carried out by identifying 10 sampling sites inside and around the factories, for soils exposed, undisturbed or exposed to other human activities (such as sewage) as shown in Figure-2 and Table-2. A hand Auger device was used to collect soil samples. Two samples of each site were taken, representing surface (depth 0-10 cm) and sub-surface (depth 10-20 cm) samples. Each samples was placed in a plastic bag and sent to the laboratory for the necessary analysis.

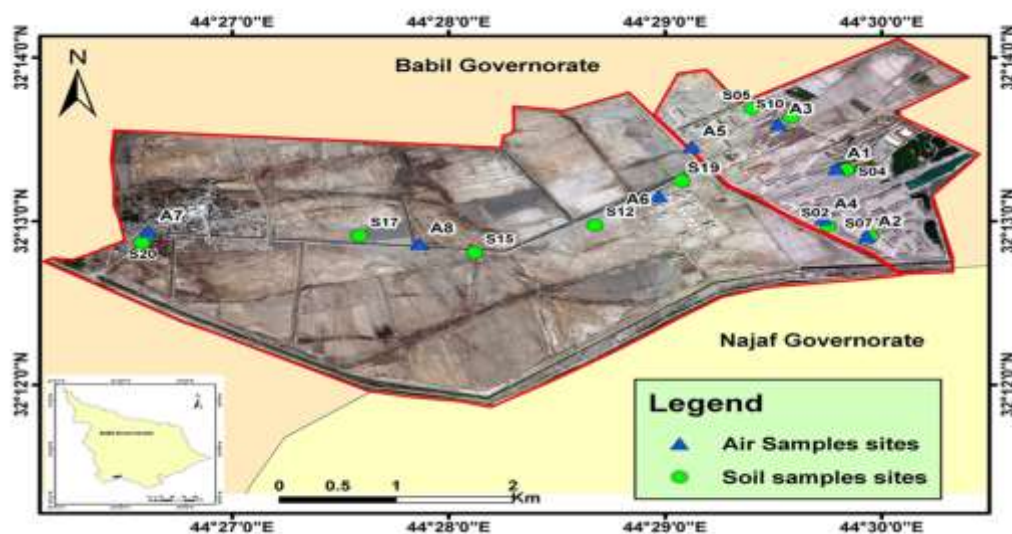


Figure 2-Air and Soil samples location of the study area

Table 1-Geographic coordination of Air samples location

Num.	Code sample	Station	E	N
1	A1	Inside Bricks factory	44.4965	32.2220
2	A2	Inside Bricks factory	44.4989	32.2151
3	A3	Inside Bricks factory	44.4920	32.2266
4	A4	Inside Bricks factory	44.4955	32.2169
5	A5	Outside the factories	44.4854	32.2243
6	A6	Outside the factories	44.4829	32.2192
7	A7	Outside the factories	44.4436	32.2157
8	A8	Outside the factories	44.4644	32.2144

Table 2-Geographic coordination of Soil samples location

Num.	Code sample	Station	E	N
1	A02	Inside Bricks factory	44.4958	32.2161
2	A04	Inside Bricks factory	44.4973	32.2219
3	A05	Inside Bricks factory	44.4900	32.2281
4	A07	Inside Bricks factory	44.4991	32.2150
5	A10	Inside Bricks factory	44.4930	32.2272
6	A12	Outside the factories	44.4779	32.2162
7	A15	Outside the factories	44.4686	32.2134
8	A17	Outside the factories	44.4598	32.2151
9	A19	Outside the factories	44.4841	32.2207
10	A20	Outside the factories	44.4430	32.2144

2-3 Laboratory Works

A digestion process of soil samples for heavy metals determination was conducted according to the procedure described by Sharidah [9] by using nitric acid and perchloric acid. Air and soil samples were examined by Atomic absorption spectroscopy (A.A.S) for trace elements in the lab of the Iraq

Ministry of Science and Technology, Baghdad. The following factors were applied to assess the level of soil pollution in the study area:

1- Contamination factor (CF) and Pollution Load Index (PLI)

The PLI was derived from the calculated value of the CF, which was used to classify the level of contamination with metals in the soil and river sediment samples. The quotient was obtained by dividing the concentration of each metal on background value of that metal. The PLI of each site was calculated by obtaining the n-root for the n- CFs that was obtained for all the metals [10]. The PLI was calculated according to Tomlinson et al [11], as follows:

$$CF = C_{\text{metal}} / C_{\text{background value}} \tag{1}$$

$$PLI = \sqrt[n]{CF_1 \times CF_2 \times CF_3 \dots \times CF_n} \tag{2}$$

Where:

CF = Contamination factor, n = Number of metals.

C metal = Metal concentration in polluted sediments.

C Background value = Background value of that metal.

The Contamination Factor was classified according to [12] into:

CF Value	Pollution
CF < 1	Low
1 ≤ CF < 3	Moderate
3 ≤ CF < 6	Considerable
CF > 6	Very high

The PLI value was classified according to [13] into:

PLI Value	Pollution
0	Perfection
<1	Baseline Level
>1	Polluted

2- Geo-accumulation index (I-geo)

Enrichment of metal concentrations above baseline levels was calculated using a previously proposed method [14], termed the geo accumulation index (Igeo). Geo-accumulation index was determined by the following an equation based on previous reports [15, 16]

$$I\text{-geo} = \ln (C_n / 1.5 B_n) \tag{3}$$

Where: Cn = Measured concentration of heavy metal in the soil.

Bn = Geochemical background value according to [17] of element n. The factor 1.5 is used for the possible variations of the background data due to lithological variations.

I-geo was classified into seven grades, according to [18]:

I _{geo}	I _{geo} grade	Pollution
< 0-0	0	Unpolluted
0-1	1	Unpolluted to Moderate
1-2	2	Moderate Polluted
2-3	3	Moderate to high Polluted
3-4	4	High Polluted
4-5	5	High to Extremely Polluted
5-6	>5	Extremely Polluted

3-Results and discussion

3-1 Air

The results of air pollutant concentrations in Abu Smeache area are shown in Tables- 3 and 4. The mean concentrations of total suspended particulate (TSP) in both seasons (summer and winter) were high, exceeding the limits allowed globally and nationally, whereas the mean concentrations of SO₂ increased during the winter, but in the summer they were within the global and national limits. Sulfur-derived gases act in the atmosphere as a layer preventing the entry of sun radiation and the exit of earth radiation [1]. There was also a small increase in the ratio of NO₂ inside the factories area during summer and winter periods, whereas the concentration of this gas outside was within the limits allowed. It was also found that most of the concentrations of the other gases (CO₂, CO) did not exceed the limits allowed. The examination of heavy elements in the air showed a large increase in the concentrations of lead in the atmosphere, while those of cobalt and nickel were lower but generally higher than the limits allowed Figures-(3 and 4).

Table 3-Concentrations of gases, TSP , heavy elements in the air of study area comparing with local and world limits. (for summer Season)

Station	TSP ($\mu\text{g}/\text{m}^3$)	CO PPM	CO2 PPM	NO2 PPM	SO2 PPM	Pb ($\mu\text{g}/\text{m}^3$)	Ni ($\mu\text{g}/\text{m}^3$)	Co ($\mu\text{g}/\text{m}^3$)
A1	229.691	10.42	79.5	1.7	0	5.536	1.045	0.578
A2	196.078	10.7	79	1.5	0	5.714	1.251	0.345
A3	561.660	1.4	64.3	0.25	0	4.468	1.794	1.001
A4	654.456	1.33	50.3	0.25	0	9.523	1.538	0.659
A5	751.322	8.42	78.875	0.15	0.1	2.264	2.095	0.772
A6	554.334	0	68	0	0	10.512	2.100	0.561
A7	757.020	0	45	0	0	11.233	2.478	1.111
A8	296.296	9.2	45	0.15	0	8.148	2.084	0.264
Mean	500.107	5.18	63.74	0.5	0.0125	7.175	1.798	0.661
Range	196.078 - 757.020	0 - 10.42	45- 79.5	0-1.7	0-0.1	2.264-11.233	1.045-2.478	0.264- 1.111
WHO, 1996	150	9	250	0.11	0.01	0.5		
EPA, 2005		35		0.53		0.15		
Iraqi standard, 2008	350	35	250	0.25	0.14	3	0.2	

Table 4-Concentrations of gases ,TSP , heavy elements in the air of study area comparing with local and world limits. (for winter Season)

Station	TSP ($\mu\text{g}/\text{m}^3$)	CO PPM	CO2 PPM	NO2 PPM	SO2 PPM	Pb ($\mu\text{g}/\text{m}^3$)	Ni ($\mu\text{g}/\text{m}^3$)	Co ($\mu\text{g}/\text{m}^3$)
A1	1532.275	2.3	25	0.3	0.45	3.153	1.481	0.825
A2	814.192	5	50	0.2	0.4	2.539	1.419	0.887
A3	1756.613	2.5	38	0.3	0.5	2.627	1.507	0.987
A4	984.126	1.8	50	0.2	0.4	8.219	1.269	2.210
A5	213.868	2.1	35	0.15	0.25	4.436	1.629	1.779
A6	452.798	2.4	54	0.1	0.2	3.458	0.877	1.746
A7	2267.573	2.5	94	0.1	0.2	6.757	2.505	3.072
A8	321.195	2.4	122	0.2	0.3	5.686	1.932	1.858
Mean	1042.830	2.625	58.5	0.193	0.337	4.609	1.577	1.670
Range	213.868 – 2267.573	1.8 - 5	25- 122	0.1-0.3	0.2- 0.45	2.539- 8.219	0.877-2.505	0.825-3.072
WHO, 1996	150	9	250	0.11	0.01	0.5		
EPA, 2005		35		0.53		0.15		
Iraqi standard, 2008	350	35	250	0.25	0.14	3	0.2	

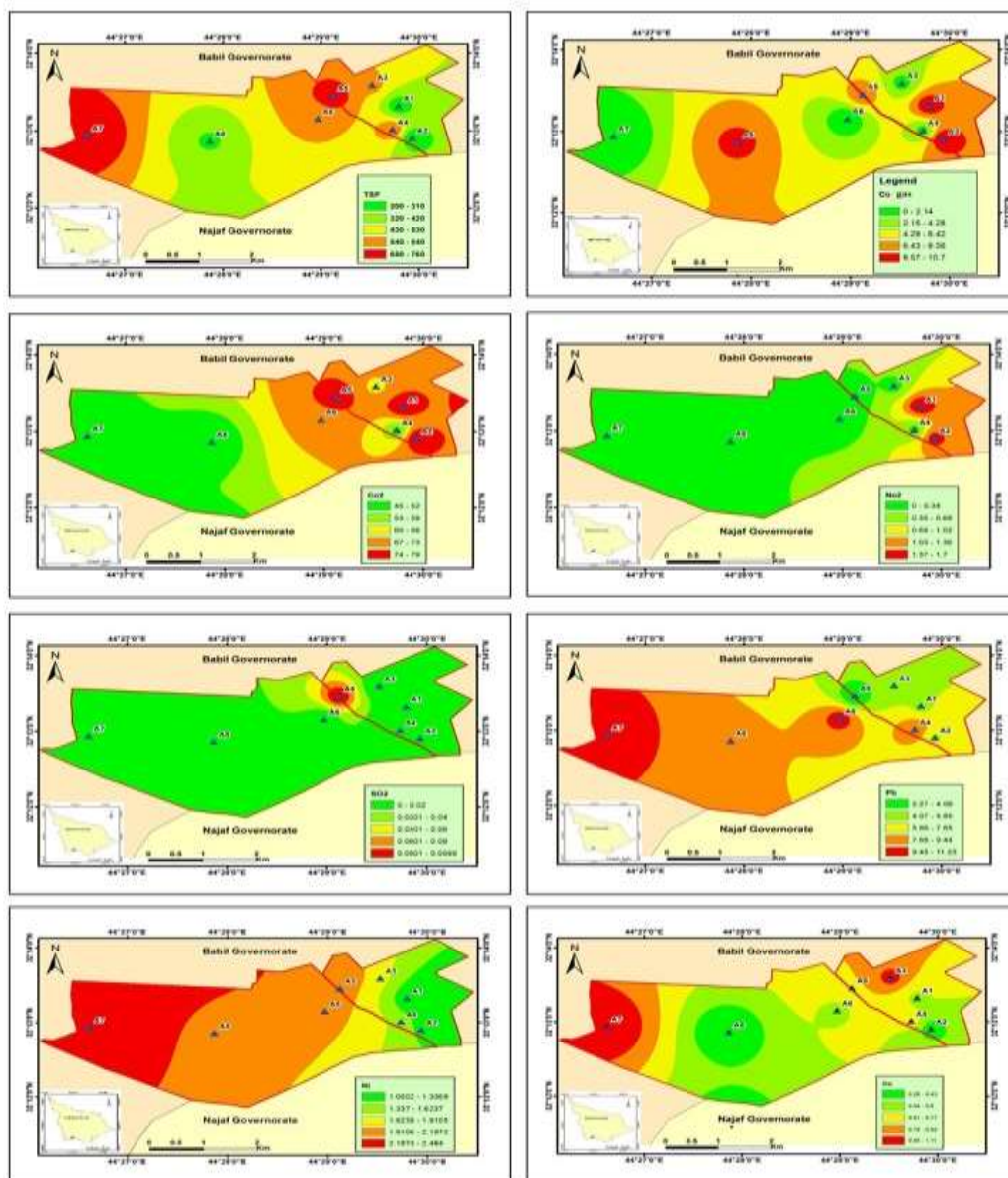


Figure 3: Map Concentrations of TSP , gases, heavy elements in the air of study area for summer Season

3-2 Soil samples

The accumulation of heavy metals in surface soils is affected by many environmental variables, including parent materials and soil properties, as well as human activities such as industrial production, traffic, farming, and irrigation. Large areas can be contaminated by heavy metals released from smelters, waste incinerators, industrial wastewater, and from the application of sludge or municipal compost, pesticides, and fertilizers. Irrespective of their sources in the soil, accumulation of heavy metals can degrade soil quality, reduce crop yield and the quality of agricultural products, and thus negatively impact the health of human, animals, and the ecosystem [19]. The diagram in Figure-5 shows a comparison of heavy metal concentrations in the soil in depth A and B (A = 0-10 cm , B =10-20 cm). Table- 5 compares total concentrations of each heavy metal in the tested soil samples, which were found to following order: Pb> Ni > Co.

The heavy metals are present in considerable amounts in the soil. This may be due to the wide use of chemicals containing heavy metals being discharged into the environment as a result of the use of crude oil in industrial activities [20]. Soil contamination with heavy elements is a measure of environmental pollution. Increasing the soil content of some rare elements leads to diseases due to soil containment of high levels of lead [21]. Studies indicated that heterogeneity in the content of rocks forming the earth's crust, which leads to changes in the levels of soil constituents, is due to the geochemical factors that dominate soil formation. Therefore, increasing the concentration of elements,

especially trace elements, results in soil contamination [22]. The distribution of heavy metals in sediments depends on the nature of the element (ion or composition), its physical and chemical properties, the presence of clay minerals (adsorbents and filters), the organic matter (which helps to attract the elements), and soil pH. The stability of the metal in the soil depends on the pH of the soil and the nature of the clay. Also, the low-rainfall areas with dry climates have a low movement of heavy elements compared to areas with heavy rain where the movement of solutions is greater [22].

The mean concentration of lead in the topsoil (0-10 cm) was about 187.067 ppm, while its mean concentration in sub-surface soil (10-20 cm) was about 162.294 ppm (Table-5), Figures-(6 and 7). These concentrations were higher than that in the shale rocks (20 ppm) reported by Krauskopf in 1967 [23], and higher than the determinants recorded by Kabata-Pendias and Mukherjee in 2007, which had a value of 25ppm [24]. It was also observed that lead concentrations in the surface soils were higher than those in the sub-surface soils. The reason for this difference is that lead is adsorbed on the surfaces of clay minerals and may be captured within the potash feldspar [25]. It is also adsorbed by the surfaces of iron oxides and manganese, while the lack of rainfall in the region leads to the persistence of its concentrations high in the surface layer, and in general, lead is found in the soil more than in the rocks [26]. The increase of lead concentrations in the soil of the study area might also be due to its increase in the air of the region as a result of its presence in the smoke of the factories which falls on the soil [22].

The mean concentration of nickel in the surface soil of the region was 19.59 ppm while in sub-surface soil was 17.95ppm (Table -5, Figures-(6 and 7), both of which were significantly lower than those in the shale (95 ppm), as reported by Krauskopf in 1967 [23]. However, these concentrations exceeded the global determinants of soil (18 ppm), described by Kabata-Pendias and Mukherjee [24], especially in the surface layer (Figure-4). Nickel generally shows different concentrations in different soils, where arid and semi-arid soil contains higher concentrations than tropical and temperate cold areas. The soil content of nickel is mainly related to the source rocks, with a secondary relationship with each of the following factors: soil quality, degree of development, fine fraction, moisture content and organic matter. The reason for the increase in nickel concentration in the soil of the study area might be the adsorption of clay minerals, especially montmorillonite, which is a clay ore prevalent in the soil of arid and semi-arid regions of the country [22]. Montmorillonites are stable and non-ionic exchangeable materials that act as a filter for the heavy elements that they absorb, and they have the ability to enter the crystal structure.

he mean concentration of cobalt 6.20 ppm in the surface soil and 8.15 ppm in the sub-surface soil (Table-5, Figures-(6 and 7). The average of its presence in the lithosphere was reported to be about 30 ppm and its content in the soil was 0.05-300 ppm [22]. Its concentrations in the subsurface soils in the present study record (18 ppm) that exceeded the global determinants by Kabata-Pendias and Mukherjee [24] which record (6.9 ppm), while the concentration of the cobalt in surface soils was below these limits. Soil content of cobalt depends on the source rocks, their degree of absorption, the type of soil, and the climate of the region or geographical range. Its presence in the soil also depends on the presence of the organic matter (humus), which is very adsorbent; this may increase its concentration in depth(B) as commonly occurs in Podzol soils. Studies indicated that the oxidation and reduction processes have an effect of increasing cobalt concentrations, with basal soils are rich in cobalt relative to acid soils due to increased transition.[22]

Table 5- shows the results of total concentration of heavy metals in the tested soil samples in the surface A(0-10cm) and under the surface B(10-20cm) comparison to the other studies

Num.	Cod	Pb ppm		Ni ppm		Co ppm	
		depth A	depth B	depth A	depth B	depth A	depth B
1	A02	203.265	177.85	22.47	22.82	1.32	10.02
2	A04	195.325	165.15	19.55	16.47	5.97	8.55
3	A05	182.62	193.73	24.87	13.57	5.85	6.10
4	A07	169.91	166.74	21.82	13.17	3.52	5.37
5	A10	217.55	211.20	18.27	16.72	5.85	4.87
6	A12	168.32	198.50	22.80	22.17	10.37	7.20
7	A15	177.85	204.85	13.37	24.87	4.025	7.07
8	A17	204.85	157.21	20.22	19.52	8.30	4.02

9	A19	160.38	125.45	11.22	10.20	4.40	4.15
10	A20	190.56	22.23	21.32	19.95	12.40	24.2
Mean		187.06	162.29	19.59	17.94	6.20	8.15
Range		160.38-217.55	22.23-211.2	11.22-24.87	10.20-28.87	1.32-12.40	4.02-24.2
Kabata-Pendias and Mukherjee, 2007		25		18		6.9	
WHO,2006		50-300		30-75		—	
Al_ Sultany, 2006		62.3		174.6		12.6	
Al-Maliky,2005		153.7		111.4		—	
Shanshal ,2004		41		111		—	

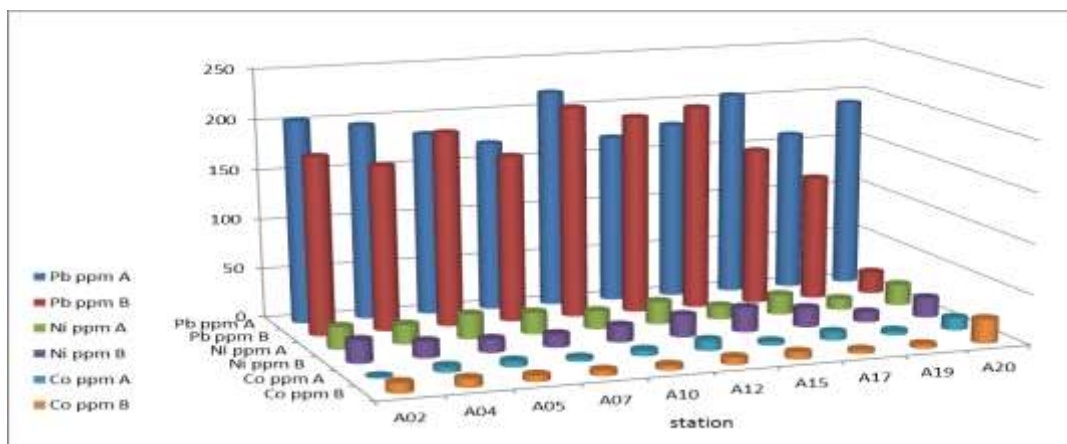


Figure 5-diagram shape for the heavy metals in the soil of study area for comparison between concentration in depth A and B (A = 0-10 cm , B =10-20 cm).

3-3 Contamination Index for Soil

1- Contamination Factor and Pollution Load Index

Pollution severity and its variation along the sites were determined with the use of pollution load index. This index is a quick tool in order to compare the pollution status of different places [27]. Table- 6 and Figures-(6 and 7) show that the values of contamination factor for lead indicated very high pollution in all sites, except for the sub-surface layer in stations A19 and A20 of zone B (5.0181 and 0.8893, respectively) which are classified as a considerably polluted and low polluted, respectively. CF values for Ni and Co ranged between low to moderate contamination, except for site A20 (zone B) which showed considerable pollution. Abundance of these elements in sediments depends on many factors such as the function of clay fraction, soil organic matter (O.M), as well as other physico-chemical conditions such as Eh and pH. Therefore, argillaceous sediments contain more heavy elements (e.g., Pb) than sands, sandstones and limestones [28]. Many stations can be classified as pollution areas; stations with PLI values >1 confirm their considerable contamination, while the few others have PLI values < 1 .Variation of PLI of sampling stations is shown in Table- 6 and Figure- 5. These results may be due to the presence of many pollutants in the area. PLI value close to 1 indicates heavy metal loads near the background level, while values above 1 indicate soil pollution. As modified and generalized form of Hakanson (1980), the equation for the calculation of the overall degree of contamination was defined as the sum of all contamination factors (CF) for a given set of pollutants divided by the number of analyzed pollutants [29].

Table 6-CF values and PLI Value of Heavy metals in the Study area

Num .	Cod	depth	CF						PLI	Decision
			Pb	Decision	Ni	Decision	Co	Decision		
1	A02	A	8.1306	Very high	1.2487	Moderate	0.1920	low	1.2492	polluted
		B	7.1143	Very high	1.2680	Moderate	1.4532	Moderate	2.3579	polluted
2	A04	A	7.813	Very high	1.0862	Moderate	0.8659	low	1.7237	polluted

		B	6.6061	Very high	0.9152	low	1.2391	Moderate	1.9808	polluted
3	A05	A	7.3048	Very high	1.3820	Moderate	0.8748	low	1.9442	polluted
		B	7.7495	Very high	0.7541	low	0.8840	low	1.9567	polluted
4	A07	A	6.7967	Very high	1.2125	Moderate	0.5108	low	2.0455	polluted
		B	6.6696	Very high	0.7319	low	0.7789	low	1.7287	polluted
5	A10	A	8.7023	Very high	1.0152	Moderate	0.8478	low	1.4886	polluted
		B	8.4482	Very high	0.9291	low	0.7065	low	1.9685	polluted
6	A12	A	6.7331	Very high	1.2666	Moderate	1.5036	Moderate	1.6147	polluted
		B	7.94	Very high	1.2319	Moderate	1.0434	Moderate	1.5608	polluted
7	A15	A	7.1143	Very high	0.7430	low	0.5833	low	1.2205	polluted
		B	8.1941	Very high	1.3819	Moderate	1.0253	Moderate	1.6639	polluted
8	A17	A	8.1941	Very high	1.1236	Moderate	1.2028	Moderate	1.4908	polluted
		B	6.2884	Very high	1.0847	Moderate	0.5833	low	2.0668	polluted
9	A19	A	6.4155	Very high	0.6236	low	0.6376	low	1.9566	polluted
		B	5.0181	considerable	0.5666	low	0.6014	low	1.7700	polluted
10	A20	A	7.6224	Very high	1.1847	Moderate	1.7971	Moderate	0.8112	Baseline level
		B	0.8893	low	1.1083	Moderate	3.5072	considerable	0.5900	Baseline level

2- Geo-accumulation index (I-Geo)

Using the I-geo to measure the enrichment of metals above baseline concentrations, sediments were classified as a moderately polluted with Pb, except for the sub-surface layer in station A20 of zone B, which reached a value of- 0.5227 that classifies it as unpolluted. Sediments were unpolluted with Ni and Co, except sites A12 (zone A) and A 20 (zones A, B) which were classified as unpolluted to moderate (Table-7 and Figures-(6 and 7).

Table 7-I-Geo values of Heavy metals in the Study area

Num.	Cod	depth	I-Geo					
			Pb	Decision	Ni	Decision	Co	Decision
1	A02	A	1.6901	Moderate Polluted	- 0.1833	unpolluted	- 2.0555	unpolluted
		B	1.5566	Moderate Polluted	- 0.1679	unpolluted	- 0.0316	unpolluted
2	A04	A	1.6503	Moderate Polluted	- 0.3227	unpolluted	- 0.5494	unpolluted
		B	1.4825	Moderate Polluted	- 0.4939	unpolluted	- 0.1910	unpolluted
3	A05	A	1.5830	Moderate Polluted	- 0.0818	unpolluted	- 0.5705	unpolluted
		B	1.6421	Moderate Polluted	- 0.6876	unpolluted	- 0.5286	unpolluted
4	A07	A	1.5109	Moderate Polluted	- 0.2127	unpolluted	- 1.0771	unpolluted
		B	1.4920	Moderate Polluted	- 0.7175	unpolluted	- 0.6552	unpolluted
5	A10	A	1.7581	Moderate Polluted	- 0.3903	unpolluted	- 0.5705	unpolluted
		B	1.7284	Moderate Polluted	- 0.4789	unpolluted	- 0.7528	unpolluted
6	A12	A	1.5015	Moderate Polluted	- 0.1690	unpolluted	0.0024	Unpolluted to Moderate
		B	1.6664	Moderate Polluted	- 0.1968	unpolluted	- 0.3629	unpolluted
7	A15	A	1.5566	Moderate Polluted	- 0.7024	unpolluted	- 0.9444	unpolluted
		B	1.6979	Moderate Polluted	- 0.0819	unpolluted	- 0.3804	unpolluted

8	A1 7	A	1.6979	Moderate Polluted	- 0.2889	unpolluted	- 0.2207	unpolluted
		B	1.4332	Moderate Polluted	- 0.3241	unpolluted	- 0.9444	unpolluted
9	A1 9	A	1.4532	Moderate Polluted	- 0.8776	unpolluted	- 0.8553	unpolluted
		B	1.2075	Moderate Polluted	- 0.9734	unpolluted	- 0.9138	unpolluted
10	A2 0	A	1.6256	Moderate Polluted	- 0.2359	unpolluted	0.1807	Unpolluted to Moderate
		B	-0.5227	unpolluted	- 0.3026	unpolluted	0.8493	Unpolluted to Moderate

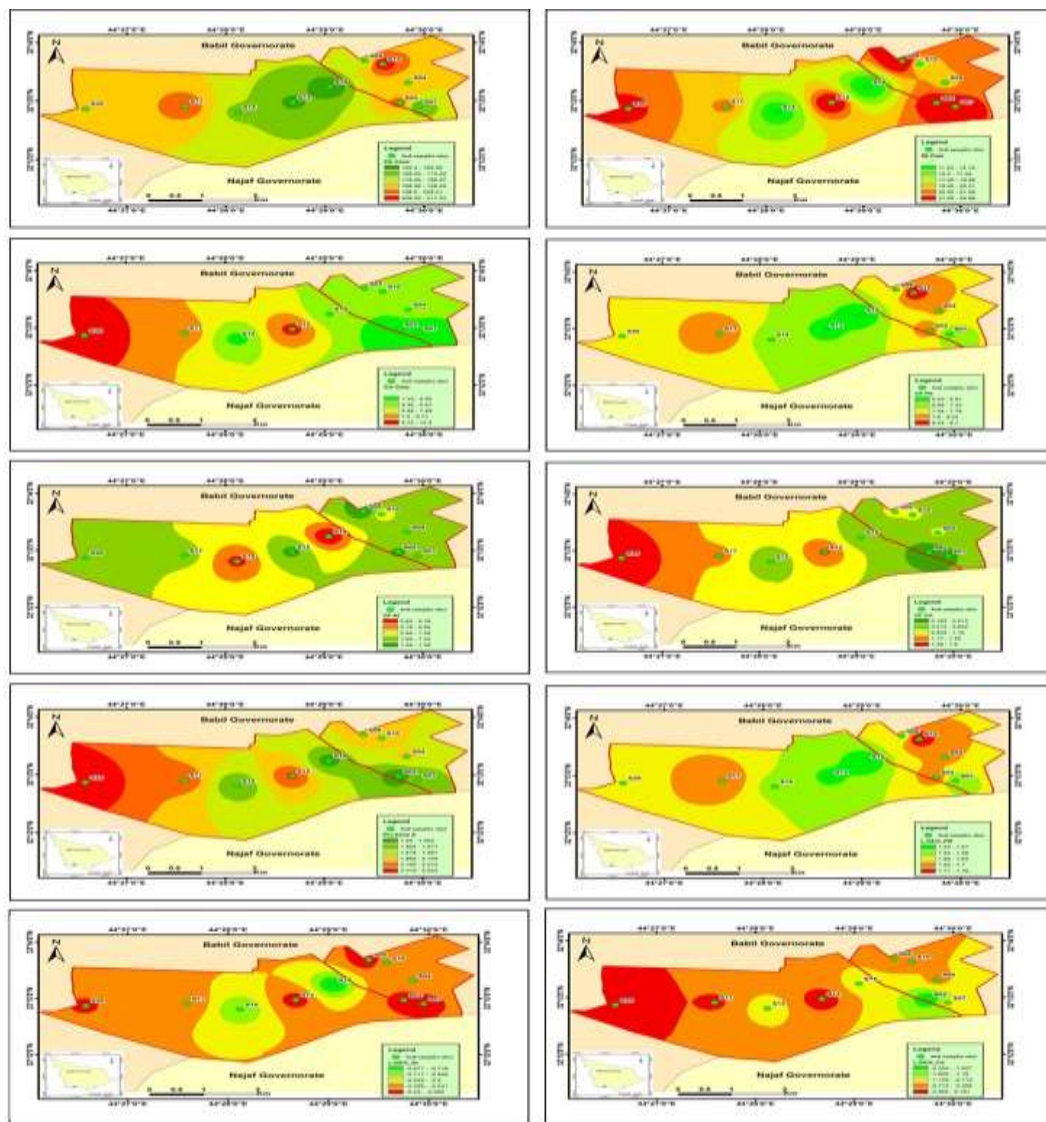


Figure 6: Map Concentrations of heavy elements ,CF,PLI,I-GEO in the soil of study area for surface layer

Conclusions

The current study showed that the air of the research area contained high concentration of total suspended particles (TSP), especially in the winter Season, which exceeded the global and national determinants. As a result of the continuous industrial processes in the region, with brick factories being probably the main reason, the concentrations of most heavy elements in the air of the region exceeded the limits allowed globally and nationally. The analysis of the cellulose filters revealed that the air of the region contained high concentrations of Pb, Ni, and Co. The high increase in these elements is due to the industrial processes of the brick, where the fuel used in the combustion process

contains high concentrations of elements that are transferred into the atmosphere with black smoke out of the chimneys. The volatilization of dust by air movement may lead to increased concentration of elements in the air; It should also be taken into account that the soil of the region is fragmented by industrial processes, especially the movement of vehicles that contribute to enrich the air of the region with some elements, and the exhaust of these compounds may contain different concentrations of elements. We also observed a noteworthy increase in concentrations of both gases of NO₂ and SO₂, especially in the winter, which is due to the fact that the levels of all the heavy elements, gases and total suspended particles are increased in the air with increasing moisture of the atmosphere. Low temperatures and high humidity work on capturing heavy elements for longer periods in the atmosphere before moving to areas far from the source of pollution or falling and depositing on the soil.

Soil analysis showed that the soil of the region contained high concentrations of trace elements (Pb, Ni, Co). This increase can be attributed to the fall of the precursors of the brick factories on the soil of the region. Clay minerals and soil organic matter could have adsorbed and accumulated these elements to high concentrations, which were then transferred to different layers of the soil. Consequently, these elements might reach the groundwater and surface water, where their presence is not a problem in itself if the concentrations are low, but increasing their concentration and their mobility through the mediums (Air, soil, water, plant) is one of the most important problems to cause environmental pollution. The evidence from contamination indices (CF and I-geo) showed unpolluted to moderate states for all studied elements except lead, which caused a highly polluted rank to the studied area. As for PLI, pollution was observed in all the studied areas inside and outside the brick factories. Generally, the high levels of pollution are due to industrial activities, the absence of vegetation cover surrounding the factories, insufficiently high chimneys, and the use of crude oil in the process of production. Such pollution causes danger to the lives of workers and the population living near the area.

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