The Effect of North Refineries Company on Soil pollution of Baiji City-Iraq

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Abstract

The average concentrations of heavy metals (Pb, Co, Ni, Cr, Cd and Zn) in soil of North Refineries Company (NRC) at Baiji and around were determined in 29 selected locations using GPS. The pickings up of samples were carried out in three periods in 2012 in January, March and July. The concentration levels of determined heavy metals shows values within or lower than many researchers.

The model of cumulative effect of the heavy metals, which was determined by GIS for the triple sampling periods show distribution of concentration towards wind directions and away from the site of NRC e.g. SE direction. This indicates the meteorological conditions represented by the wind direction and the rainfall, which plays an important role in distribution and deposition of pollutant metals via water drainage of the area.

Key words: Soil Pollution, Heavy Metals, Baiji, Iraq**.**

تاثير شركة مصافي الشمال على تلوث تربة مدينة بيجي – العراق

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الخلاصة:

ان معدلات الفلزات الثقيلة (الكوبلت و النيكل و الر صاص والخارصين و الكروم والكادميوم) الكلية في نماذج التربة الماخوذة من مصفى بيجي والمناطق المحيطة بة قد تم تعينها بواسطة جهاز G P S لثلاث فترات هي كانون ثاني و نيسان و تموز 2012. ان مقارنة معدلات الفلزات الثقيلة (الكوبلت و النيكل و الرصاص والخارصين و الكروم والكادميوم) في نماذج التربة المدروسة مع نتائج العديد من الباحثين اوضحت بان النتائج كانت ضمن المعدلات او اقل منها وللفترات الثلاثة.تم تحديد الموديل التراكمي لتاثير الفلزات الثقيلة باستخدام GIS للفترات الثلاثة لجمع النماذج وظهر وجود زيادة التراكيز باتجاة الرياح مبتعدة عن مصفى النفط (باتجاة الجنوب الشرقي). ان نتائج تراكيز الفلزات الثقيلة كانت تمثل تاثيرات العوامل المناخية كالرياح والامطار على انتشار وترسيب الفلزات الملوثة من خلال المجاري المائية في المنطقة المدروسة.

Introduction

Heavy metals are naturally present in soil; contamination may come from local sources: mostly chemical industries, irrigation with polluted waters, sewage sludge, fertilizer waste incineration, combustion of fossil fuels and road traffics…etc. All these activities can provide the environment with different concentrations of heavy metals, which are effect directly on our life [1].

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Theoretically, every 1000 kg of "normal" soil contains 200 gm of Chromium, 80 gm Nickel, 16 gm Lead, 0.5 gm Mercury and 0.2 gm Cadmium. Therefore, it is not always easy to assign a definite cause for the increment of heavy metal content. Those metals are described as "heavy metals", in their standard state. Normally, heavy metals have a specific gravity (density) exceeding 5 g/cm^3, (e.g. Ni, Cr and Fe).

The presence of some concentration of heavy metals is essential for the survival of all forms of life. These are described as essential trace elements [1].

Heavy metals are considered as important pollutants in the soil. They are non-biodegradable; hence these are not readily detoxified and removed by metabolic activities once they are available in the environment. This may subsequently lead to their gradual build up to toxic levels or bioaccumulation in the ecosystem [2, 3].

It is expected that the heavy metals concentration varied considerably with the polluted, industrial, and contaminated areas, depending on the wind speed and directions. The trace elements (Co, Ni, Pb, Zn, Cr, and Cd) are designated as priority pollutants by many researchers [3, 4].

Several researchers had been carried out studies on environmental soil pollution, [5, 6] .but there are very limited studies particularly of the soil pollution from oil industrial activities in Iraq.

The climatic parameters such as rainfall, speed and direction of wind have an important effect on the concentration of pollutants in the soil in which lead is a key role in controlling the spread of various soil pollutants [7] .Rain works to purify the air from many solid and gaseous pollutants. Also, a large part of the particles attached to the outstanding during the rain drops fall like dust particles. The wind direction plays an important role in the distribution of the pollutants in air, which is moving it according to the pollutants with the general direction of the prevailing winds.

As thousands of people in Baiji Governorates live near North Refineries Company (NRC) at Baiji and it concerns that concentrations of the hazardous pollutants increase near the Baiji refinery, determination of heavy metal contamination levels in soil, as one class of hazardous pollutants is a very vital subject. The objective of this study was to evaluate the concentration of these contaminants in the soil samples collected from the vicinity of Baiji city.

This study aims to measure the concentration of heavy metals (Co, Ni, Pb, Zn, Cr, and Cd) in soil as well as the assessment of environmental impacts of the North Refineries Company (NRC) at Baiji and around.

Materials and Methods

The heavy metals in soil at depths of 0-10 cm were analyzed. Twenty nine different sampling sites inside and outside the North Refineries Company (NRC) have been selected between latitudes (34° 56" – 35° 34") and longitude (43° 30" – 43° 34") figure-1.

The site selection of the soil sampling in the North Refineries Company (NRC) takes into consideration the prevailing wind direction that is an important factor in pollutants distribution, as well as the nearby populated sectors within Baiji city figure-2. The concentrations of the heavy metals (Co, Ni, Pb, Zn, Cr, and Cd) were analyzed using Atomic Absorption Spectrometry equipment.

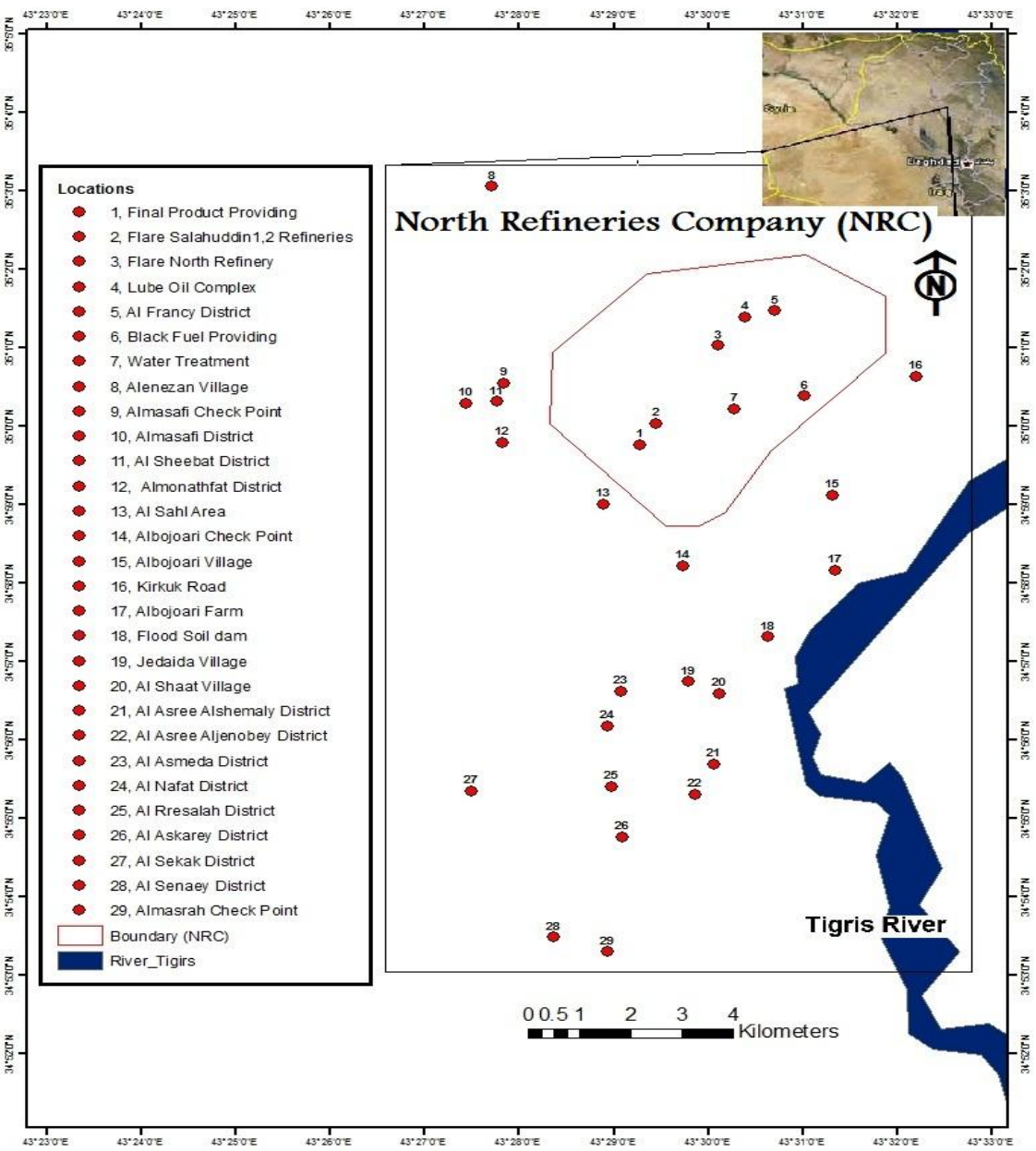

Figure 1- Sketch map shows the location of North Refineries Company (NRC) at Baiji and the sampling sites [8].

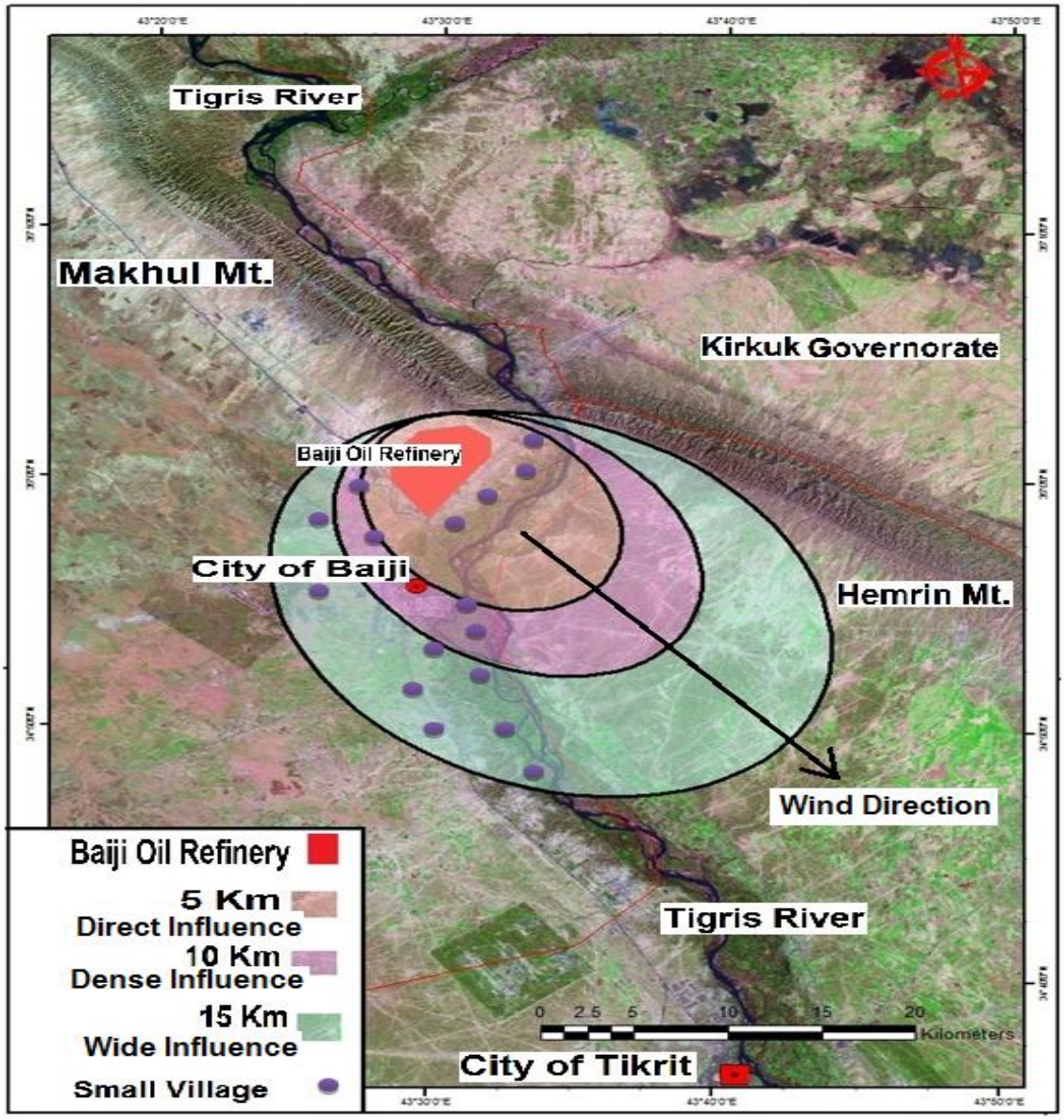

Figure 2- satellite photo shows the levels of influence of North Refineries Company (NRC) at Baiji according to the wind direction, [9].

Results and Discussion

The range of the measured heavy metals concentrations (Co, Ni, Pb, Zn, Cr, and Cd) in soil at depths 0-10cm of the studied area in January, April and July 2012 shown in table-1.

Obviously, the results reflect that the worst polluted sites lies within the area inside the North Refineries Company (NRC) .While the maximum polluted area is the site No.6 (the Black Fuel Dep.) which shows high concentrations of the measured heavy metals, table-1. The heavy metals (Co, Ni, Pb, Zn, Cr, and Cd) in the site (No.6) have the concentration range of (37.1-45.7 ppm) (195.4-227.4 ppm) (167.2-182.3 ppm) (67.2-75.7 ppm) (121.7-144.7 ppm) and (5.15-5.7 ppm) respectively. While, the lowest concentration are present in site No.27 (Al-Sekak District) which is lying outside the influence of the pollution effects of the North Refineries Company, figure-1. In this site, all the heavy metals show the lowest concentration in the soil of the studied sites, table-1. The heavy metals (Co, Ni, Pb, Zn, Cr, and Cd) in the site (No.27) have the concentration range of (1.6-6.4 ppm) (5.6-15.6 ppm) (4.2-9.0 ppm) (3.2-12.8 ppm) (7.3-18.6 ppm) and (0.2-0.9 ppm) ppm respectively, table-1.

Comparison of the mean concentration values of the studied heavy metals in the studied sites with the results of other studies indicate that the results of this study lies within the range or less than the others table-2, [6, 10-15].

Lead (Pb): The mean concentration of Lead (Pb) found in the soils recorded was 48.8 ppm.

Cobalt (Co): The mean concentration of Cobalt(Co) found in the soils recorded was 16.1ppm, table-2. Almost all the clay soils contain 0.020 – 0.030 ppm of this element. The cobalt is present in deferent soils in amount of 1 – 15 ppm. The amount relates to the parent rocks containing this element.
Nickel (Ni): The mean concentration of Nickel (Ni) found in the soils recorded was 55.9 ppm.
Zinc (Zn): The mean concentration of Zinc (Zn) found in the soils recorded was 26.6 ppm. The Zinc (Zn) forms around 0.02 % of earth crust and it present widely in the nature. It is noted in low amount in the soils, water streams, lakes, oceans and in every living organism [16].Zinc is not available in sufficient quantities in the soil. The Zn concentration in argillaceous sediments and shale is enhanced, ranging from 80 to 120 ppm; while in sandstones and carboniferous rocks, concentrations of this metal range from 10 to 30 ppm. Mean total Zn contents in surface soils ranged from 17 to 125 ppm.
Chromium (Cr) : The mean concentration of Chromium (Cr) found in the soils recorded was 48.2 ppm.
Cadmium (Cd): The mean concentration of Cadmium (Cd) found in the soils recorded was 2.4 ppm. There is growing environmental concern about Cd as being one of the most ecotoxic metals that exhibit highly adverse effects on soil biological activity, plant metabolism, and the health of humans and the animal kingdom. One of the most important symptoms of exposure to cadmium (Cd) anemia resistant to treatment and osteomalacia and urinary tract problems and inefficient kidney and prostate and lung cancer and the loss of sense of smell [17].

The abundance of Cd in magmatic and sedimentary rocks does not exceed around 0.3 ppm, and this metal is likely to be concentrated in argillaceous and shale deposits. Cd is strongly associated with Zn in its geochemistry, and also exhibits a higher mobility than Zn^{+2}, Co^{+2}, Ni^{+2} in acid environments. However Cadmium in the earth crust is around 0.2 ppm [16].

Table 1- Heavy metals concentrations (Co, Ni, Pb, Zn, Cr, and Cd) in soil of the studied area in January, April and July 2012.

No	Sample Location	Co(ppm) Range	Ni(ppm) Range	Pb(ppm) Range	Zn(ppm) Range	Cr(ppm) Range	Cd(ppm) Range
1	Final Product Dep.	18.4-34.2	71.7-90.1	164.8-172.2	20.8-35.5	73.1-88.6	2.2-4.5
2	Flare Salahu ddin 1.2 Ref.	19.8-27.3	32.7-38.3	20.8-28.7	19.9-25.4	31.9-42.1	1.8-3.3
3	Flare North Refinery	22.9-28.3	36.8-49.1	26.3-36.4	25.3-34.6	34.7-50.2	2.7-6.1
4	Lube Oil complex	28.8-43.4	165.7-196.3	155.8-178.5	51.6-71.9	113.4-140.5	3.2-5.3
5	Al Francy District	21.9-37.3	170.8-187.7	156.3-167.3	45.5-75.5	120.3-135.3	3.2-5.1
6	Black Fuel Dep.	37.1-45.7	195.4-227.4	167.2-182.3	67.2-75.7	121.7-144.7	5.2-5.7
7	Water Treatment	25.4-34.3	70.3-90.2	75.2-96.7	38.3-56.7	73.6-97.9	3.1-5.1
8	Al enezan Village	6.5-12.3	30.7-45.5	9.4-18.1	12.8-22.4	12.4-28.5	1.3-1.9
9	Almasafi Check Point	16.4-21.2	50.8-70.4	29.3-39.7	18.4-29.3	40.7-70.8	1.3-3.1
10	Almasafi District	3.8-10.2	20.2-31.2	10.9-16.2	11.3-19.4	12.8-44.1	0.5-0.9
11	Al Sheebat District	2.3-13.4	9.4-43.3	6.4-9.2	12.8-17.2	13.5-31.7	0.5-0.9
12	Almonathfat District	4.6-7.3	15.3-33.3	7.8-9.2	12.3-16.4	17.4-27.5	0.5-1.1
13	Al sahl Area	3.8-12.1	7.2-40.1	5.3-9.7	10.1-18.1	20.7-31.2	0.4-1.2
14	AlboJoari Check point	20.4-28.3	57.7-76.8	50.4-58.8	27.6-38.1	41.7-97.2	1.9-5.5
15	AlboJoari Village	21.3-31.4	71.4-83.9	67.3-86.3	31.5-45.6	67.9-83.3	2.4-4.8
16	Kirkuk Road	21.2-39.7	78.9-94.4	126.7-143.4	34.7-47.9	67.8-97.3	3.2-5.3
17	AlboJoari Farm	13.9-22.4	39.8-56.6	38.7-57.5	20.0-36.7	36.4-49.8	1.9-3.3
18	Flood soil dam	10.2-16.8	27.6-35.2	24.1-30.4	16.1-23.3	23.3-30.3	1.4-1.8
19	Jedaida Village	5.3-7.2	14.2-21.8	9.1-12.2	10.4-16.8	13.3-21.7	0.9-1.1
20	Al Shaat Village	3.2-6.8	9.7-19.3	8.4-9.8	7.6-24.5	8.9-29.2	0.7-0.9
21	Al Asree Alshemaly	9.7-13.9	27.4-39.8	11.4-15.4	17.4-29.6	23.8-38.4	1.7-3.5
22	Al Asree Aljenobey	8.6-11.3	25.4-38.8	10.8-13.8	15.6-26.9	20.4-34.5	1.4-2.9
23	Al Asmeda District	3.4-10.7	11.3-32.2	12.6-29.3	9.4-28.4	9.2-25.3	0.4-2.2
24	Al nafat District	1.2-10.5	10.3-34.2	6.8-28.8	4.5-21.1	9.2-37.7	0.7-2.2
25	Al Resalah District	6.8-15.7	17.3-39.8	21.3-42.7	17.6-31.1	15.4-47.4	0.6-2.9
26	Al Askarey District	3.2-8.8	12.3-36.8	7.1-38.1	9.8-24.3	21.5-37.9	0.6-2.1
27	Al Sekak District	1.6-6.4	5.6-15.6	4.2-9.0	3.2-12.8	7.3-18.6	0.2-0.9
28	Al Senaey District	2.3-12.2	11.8-34.5	5.9-18.1	6.7-20.4	15.6-37.3	0.5-2.1
29	Almasrah Check Point	3.1-26.5	12.5-70.8	5.0-45.1	13.2-36.7	12.5-57.4	0.6-3.1
Mean		16.12	55.9	48.77	26.6	48.2	2.4

Table 2- Mean concentrations (ppm) of heavy metals in the soil samples in January, April and July in 2012 with comparison the average concentrations of the analyzed heavy metals(ppm) in different other areas of other researchers in Iraq.

Heavy Metals Conc.	Sample No.	Pb ppm	Co ppm	Ni ppm	Cr ppm	Cd ppm	Zn ppm
The results of this study	Mean	48.7	16.1	55.9	48.2	2.4	26.6
Salman, [10]	Mean	39.4		20.9	161.9	5.5	
Al-Bassam and Yousif, [11]	Mean	6.8		99.0	232.0	--------	56
Deabreu, et al, [12]	Mean	50.0		30.0	100.0	3.0	
Al- Maliki [6]	Mean	153.7	27.5	111.4	----	5.3	133.3
Khuawdim [14]	Mean	39.4	18.8	20.9	161.9	5.5	
Ali [13]	Mean	10.0		38.2	61.3	10.0	
Makino,et al, [15]	Mean	29	9	39	64	0.45	99

In this study, the program (Arc GIS 10) of modeling for measurements of heavy metals pollution in soil was applied for the studied area. The (Arc GIS 10) was applied for measurements of pollution in January, April and July periods in 2012.

The cumulative soil model of total heavy metal (Co, Ni, Pb, Zn, Cr, and Cd) concentration in soil of each period was shown in figures- (3, 4 and 5). The concentrations of these pollutants distribute away from the refinery toward the south east part of the studied area, in which the results show that the North Refineries Company (NRC) at Baiji emissions are the only contamination source, [9].

The meteorological condition plays an important role in the heavy metals distribution in air and consequently effect the soil in the same wind direction. Therefore the effects of seasonal changes are obviously noticed on the model measurement as it is shown in the figures- (3, 4 ,5 and 6).

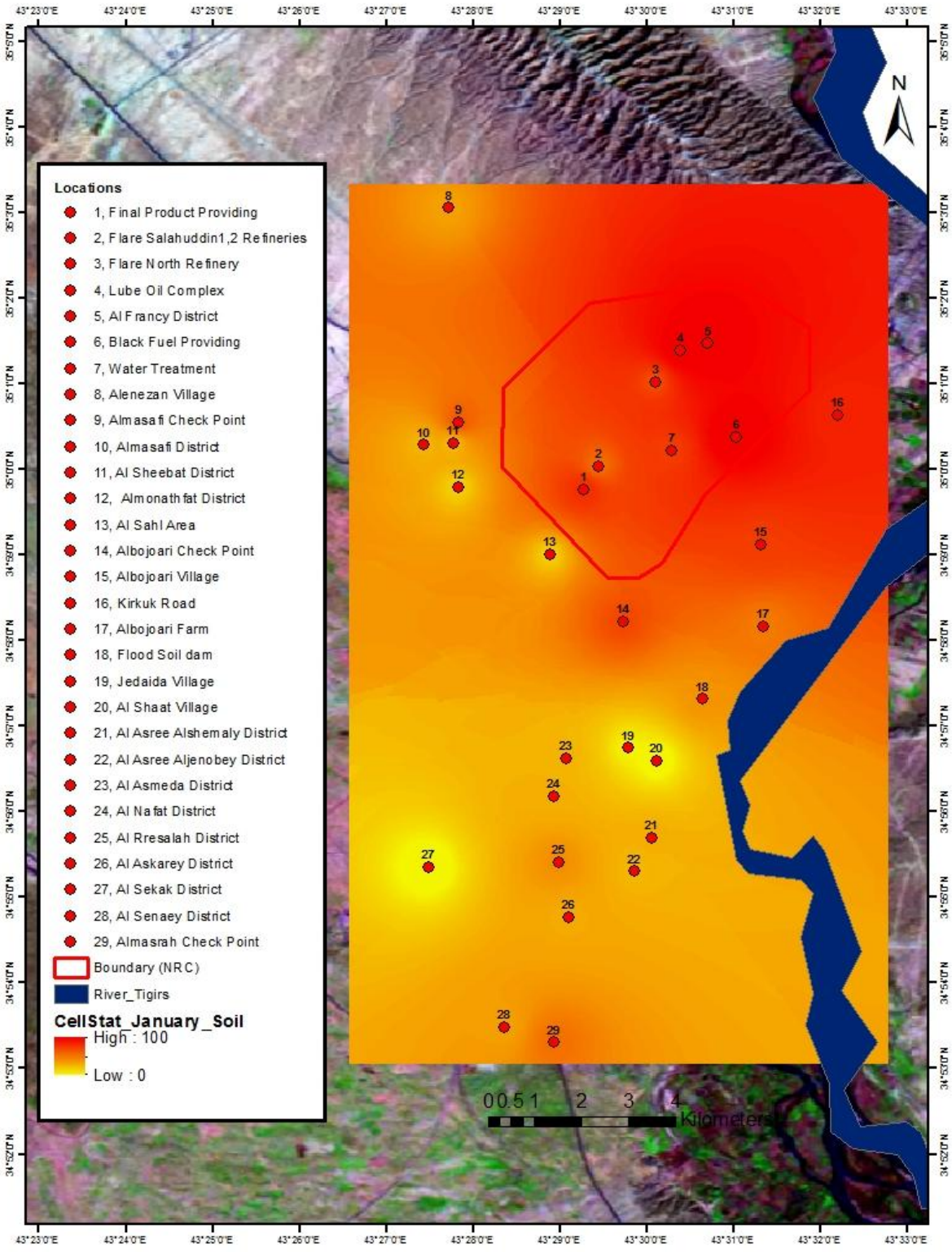

Figure 3- Show the Arc GIS model for total heavy metals (Co, Ni, Pb, Zn, Cr, and Cd) distributions in soil (ppm) at the studied area for January 2012.

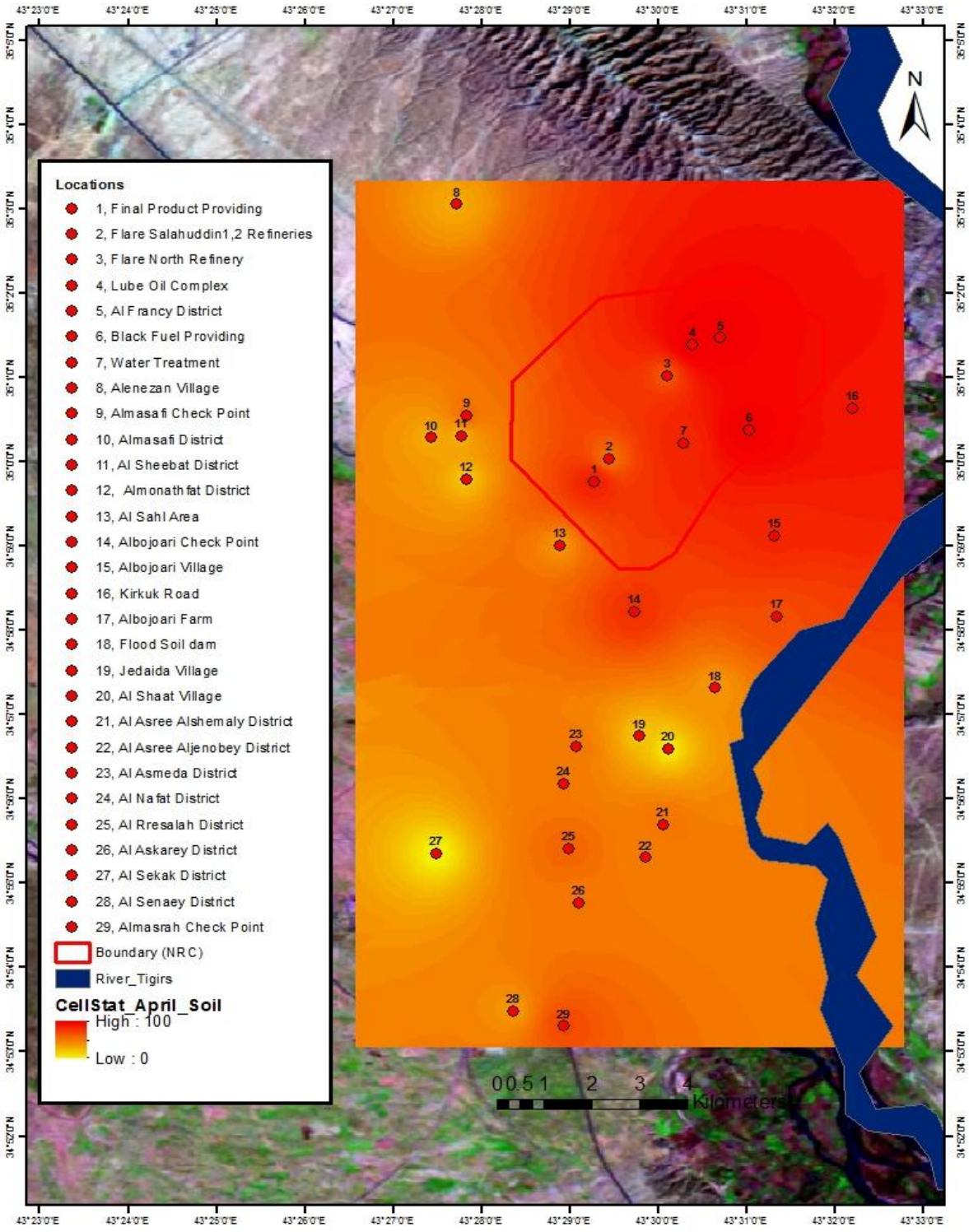

Figure 4- Show the Arc GIS model for total heavy metals (Co, Ni, Pb, Zn, Cr, and Cd) distributions in Soil (ppm) at the studied area for April 2012.

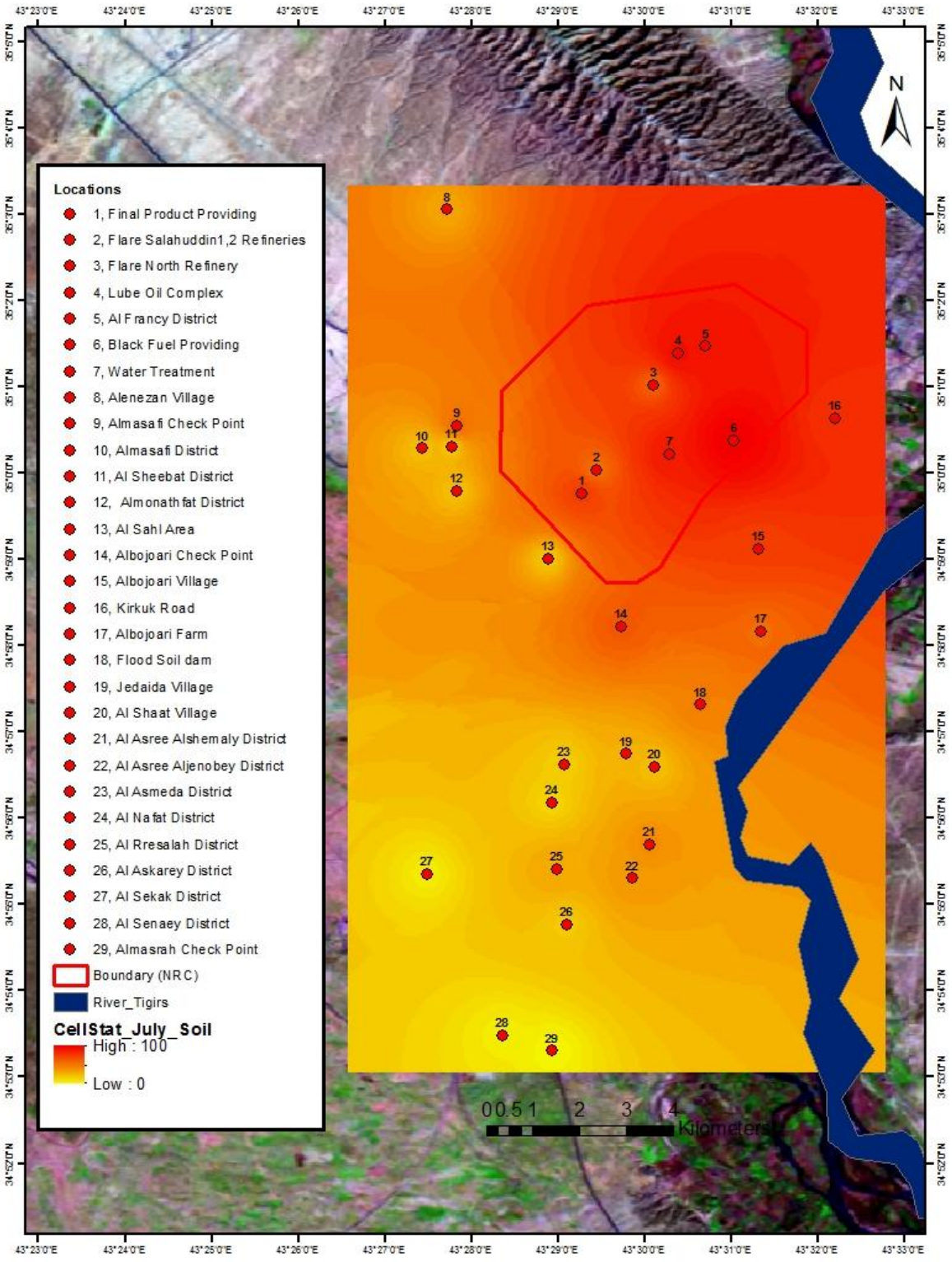

Figure 5- Show the Arc GIS model for total heavy metals (Co, Ni, Pb, Zn, Cr, and Cd) distributions in Soil (ppm) at the studied area for July 2012.

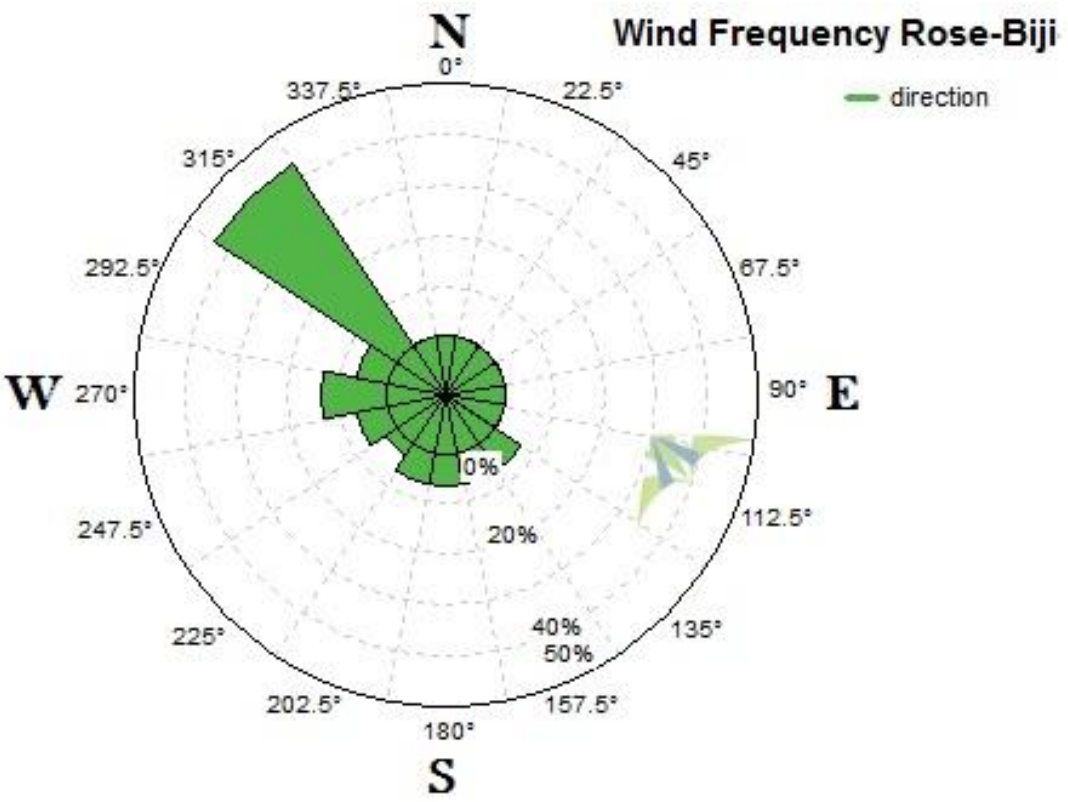

Figure 6- The annual wind direction frequency Rose diagrams for Baiji meteorological station for the period from 1981-2010.

Conclusions

The range of heavy metals concentrations (Co, Ni, Pb, Zn, Cr, and Cd) in soil samples in the studied area in the periods of January, April and July 2012 reflect that the worst polluted sites are lying within the area inside the North Refineries Company (NRC), where the maximum contaminated soil site is site No.6 (the Black Fuel Dep.). While ,the lowest concentration of these heavy metals Co, Ni, Pb, Zn, Cr, and Cd are represented in site No.27 (Al-Sekak District) which lies outside the influence of the influence effects of the North Refineries Company.

Comparison of the mean heavy metals concentration values of Co, Ni, Pb, Zn, Cr, and Cd in the sampling sites with other studies indicate that the results of this study lies within the range or less than the other studies findings. The cumulative effects map of the heavy metals concentrations in the soil by using GIS for the sampling periods shows that the concentrations of these pollutants distributed away from the North Refineries Company toward the south east according to the wind direction in which the meteorological condition plays an important role to the heavy metals distribution.

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