DISTRIBUTION OF SOME HEAVY METALS IN THE RECENT SEDIMENTS OF AL-NASIRIYA AREA, MESOPOTAMIA PLAIN, SOUTH IRAQ

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ABSTRACT

During the period 15 March to 15 May 2011, 436 surface soil samples have been collected systematically based on the grid net in Al-Nasiriya Quadrangle (sheet NH-38-3, scale 1: 250 000), Mesopotamia Plain, and analyzed for Cr, Ni, Pb, Zn, Co, Cu and U, to re-evaluate the environmental conditions and concentration of the analyzed elements in the soil to detect any pollution, and to determine background levels and distribution of heavy metals in the studied area. The mineralogical analysis shows that for non clay minerals, quartz is the most abundant mineral, followed by calcite, feldspar, halite, and gypsum. For clay minerals; the most abundant mineral is montmorillonite, followed by palygorskite, illite, and kaolinite. The geochemical results show that the distribution and concentration of the heavy metals in the studied soils is within the average concentration given for the reported world soils of arid and semi arid regions, and the soil of the studied area is still free from pollution, except Pb in some local areas, which shows higher concentrations than those reported for world soils. In general, the concentrations of Cr, Ni, and Co are high, which is mainly due to the influence of igneous and sedimentary complexes in Turkey and Syria, derived by the Euphrates River and Injana and Dibdibba formations inside Iraq, as well as the clastics derived from northeast Iraq by the Tigris River and its tributaries, which show their influence in the Mesopotamia part of the river basin.

توزيع بعض العناصر الثقيلة في الترسبات الحديثة في منطقة الناصرية، السهل الرسوبي، جنوب العراق

ثائر جرجيس بني

المستخلص

خلال الفترة الممتده من 15 نيسان ولغاية 15 أيار 2011، تم جمع 436 نموذج تربة سطحي اعتمادا على شبكة نظامية اعتمدت لهذا الغرض في منطقة لوحة الناصرية ضمن السهل الرسوبي. حللت هذه النماذج الى العناصر Cr، Ni، Pb، Zn، Co، Cu و U لغرض تحديد وإعادة تقييم نسب التلوث وكذلك لتحديد المستويات الخلفية الجيوكيميائية لهذه العناصر وتوزيعها في ترب منطقة الدراسة. أظهرت نتائج التحليلات المعدنية أن معدن الكوارتز هو المعدن الغالب في عينات التربة التي حللت بشكل كامل، تليه معادن الكالسايت والفلدسبار والهلايت والجبسم، أما النماذج التي عوملت مختبريا لتحديد نسب المعادن الطينية، فقد أظهرت أن معدن المونتموريلونايت هو المعدن الغالب، يليه معادن الباليغورسكايت الإلايت ثم الكاؤلينايت. تبين النتائج الجيوكيميائية التي تم الحصول عليها من هذا العمل أن توزيع وتركيز العناصر المذكورة هي ضمن معدلاتها الطبيعية مقارنة مع نسب معدلاتها العالمية في المناطق الجافة وشبه الجافة في العالم وإن تربة منطقة الدراسة مازالت خالية من آثار التلوث بهذه العناصر، ماعدا عنصر الرصاص الذي يظهر بعض التراكيز العالية في مناطق معينة مقارنة مع تلك المثبتة عالميا. على العموم، ظهرت هنالك تراكيز عالية لكل من العناصر Ni، Cr و Co وهذا ناتج من تأثير منطقة المصدر على ترسبات منطقة الدراسة، حيث إن منطقة المصدر والتجهيز لهذه الرسوبيات هي صخور نارية ومتحولة تتواجد في كل من تركيا وسوريا وينقل كل من نهري الفرات ودجلة مع روافدهما الرسوبيات عالية التركيز بهذه العناصر لكي تترسب لاحقا في منطقة السهل الرسوبي جنوب العراق.

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INTRODUCTION

Regional geochemical reconnaissance survey using soil sampling media was conducted in Al-Nasiriya Quadrangle (Pilot area sheet No. NH-38-3, scale 1: 250 000) during spring and summer seasons of 2011 as a part of geochemical and environmental program for Mesopotamia Basin Project; aimed to delineate the background (normal) levels and distribution of some heavy metals in the study area, and to outline anomalous concentrations in some places where natural or industrial contamination may have taken place. Information from this study can also be used for geochemical and environmental differentiation that can be compared with previous studies achieved within the studied area and for a sustainable development and management of the Mesopotamia Basin.

The project area is located within Al-Nasiriya Governorate; south of Iraq (Fig.1). Two main cities are located within the project area, Al-Nasiriya and Samawa, both of them represent governorate center, beside many small towns and villages. The Euphrates River drains the project area between Samawa and Al-Nasiriya cities, with NW – SE direction. Shatt Al-Diwaniya and Shatt Al-Atshan are the main distributaries of the Euphrates River within the project area. Although the Tigris River is not within the project area, but its distributaries, Al-Gharraf River and Shatt Al-Shattra (to the south) cross the map area from eastern side with N – S direction. The area between Shatt Al-Gharaf and the Euphrates River and Shatt Al-Diwaniya represents an abandoned area having desert feature due to lack of surface water. The project area is limited, by the following coordinates:

Longitude	45° 00'	46° 30'	E
Latitude	31° 00'	32° 00'	N

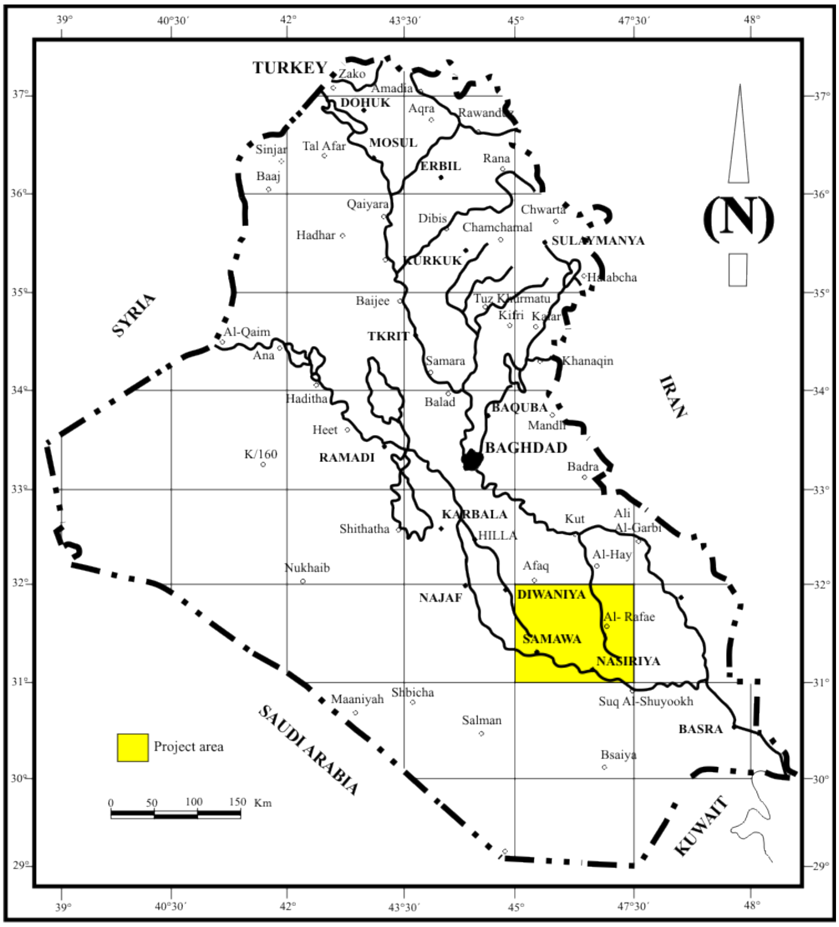


Fig.1: Location map of the project area

- **Aim**

The main aims of this project are:

- To cover Al-Nasiriya Quadrangle, at scale of 1: 250 000 by geochemical reconnaissance survey.
- To re-evaluate and determine background levels of heavy metals and distribution of trace elements in the project area by geochemical analysis of soil samples.
- To monitor and re-evaluate the environmental conditions of the area covered by Al-Nasiriya Quadrangle.

PREVIOUS WORKS

Many works were carried out in the Mesopotamia Plain concerning the geological survey, geomorphological, mineralogical and geoenvironmental studies. These works started in the fifties of the last century; one of these interesting interpretation was presented by:

– Less and Falcon (1952), based primarily on the modern geomorphological and geological evidences. They contended that the recent history of the Mesopotamia Plain should be understood, as the dominant motive is subsidence. It is not just that static depression is being filled by river sediments; it is the long continued subsidence, which allows the sedimentation to continue.

From other point of view, the Mesopotamia Plain was included in many regional studies, such as the hydrogeological study by:

– Parsons (1957); the soil and soil condition in Iraq by Buringh (1960). The later gave some information on Iraqi soils; particularly the fluvial system of the Tigris and Euphrates Rivers.
– Philip (1966) studied the recent sediments content of heavy minerals in the Euphrates and Tigris Rivers.
– Ali (1972) determined heavy mineral provinces of recent sediments in Euphrates and Tigris Basin.
– Al-Rawi *et al*. (1976) reported about the mechanical, chemical and mineralogical characters of some soil and alluvial sediments in the lower Mesopotamia Plain.

A comprehensive geological study on the deposits of the lower Mesopotamia Plain was carried out by:

– The joint research group of the Geological Survey of Iraq and University of Paris (Yacoub *et al*., 1980). They recognized during the field reconnaissance and laboratory study, six modern sedimentary environments (alluvial cone, delta fans, fluviatile channel, lake, marsh, sabkha and estuarine).
– There are many reports prepared for the Mesopotamia Plain project that have provided valuable information on the geology of the plain, these reports are: Hamza and Yacoub (1982) and Domas (1983).
– The final report of geological survey of Mesopotamia Plain was implemented by geological survey group (Yacoub *et al*., 1985). They divided the Mesopotamia Plain into several sedimentary units depending on their genesis.
– Hanna and Al-Bassam (1983) reported and surveyed Pb pollution in Baghdad by analyzing samples of soil.
– Al-Bassam *et al*. (1985) gave concentration, ranges and averages for some heavy metals in Iraqi soils, their results have shown that Pb contents were within the reported average for soil, except where pollution occurs either from natural or industrial sources.
– The distribution of some chemical elements in the sediments of Mesopotamia Plain have been studied by Hanna and Al-Hilali (1983) by collecting 720 samples, analyzed for Cr, Ni, Zn, Pb, Cu, and V, in addition to nitrogen to determines background levels for each element

and to follow any pollution in the future. Their results showed that the distribution of the heavy metals in the studied soils indicates that the Mesopotamia Plain at that time was still free from pollution, except Pb in some local areas.

- Deikran and Mahdi (1993) reported about the geology of Al-Nasiriya Quadrangle, sheet NH-38-3, at scale of 1: 250 000, and described the geology, structure, hydrogeology and economic geology of the map area.
- Al-Bassam and Al-Mukhtar (2007) studied the heavy minerals in the + 63 µm fraction of the Euphrates River sediments, distribution pattern in the various river sectors and their contribution to the enrichment of some heavy metals in the river sediments.

SAMPLING

According to a predetermined plan, a prior location map; scale 1: 250 000 was prepared using GIS program to locate 436 surface pits. In order to obtain as uniform samples distribution as possible on the map area in the region as a whole. Sampling sites were selected on 6 × 6 Km grid system, and attention was paid to the accessibility of the sampling sites (Fig.2).

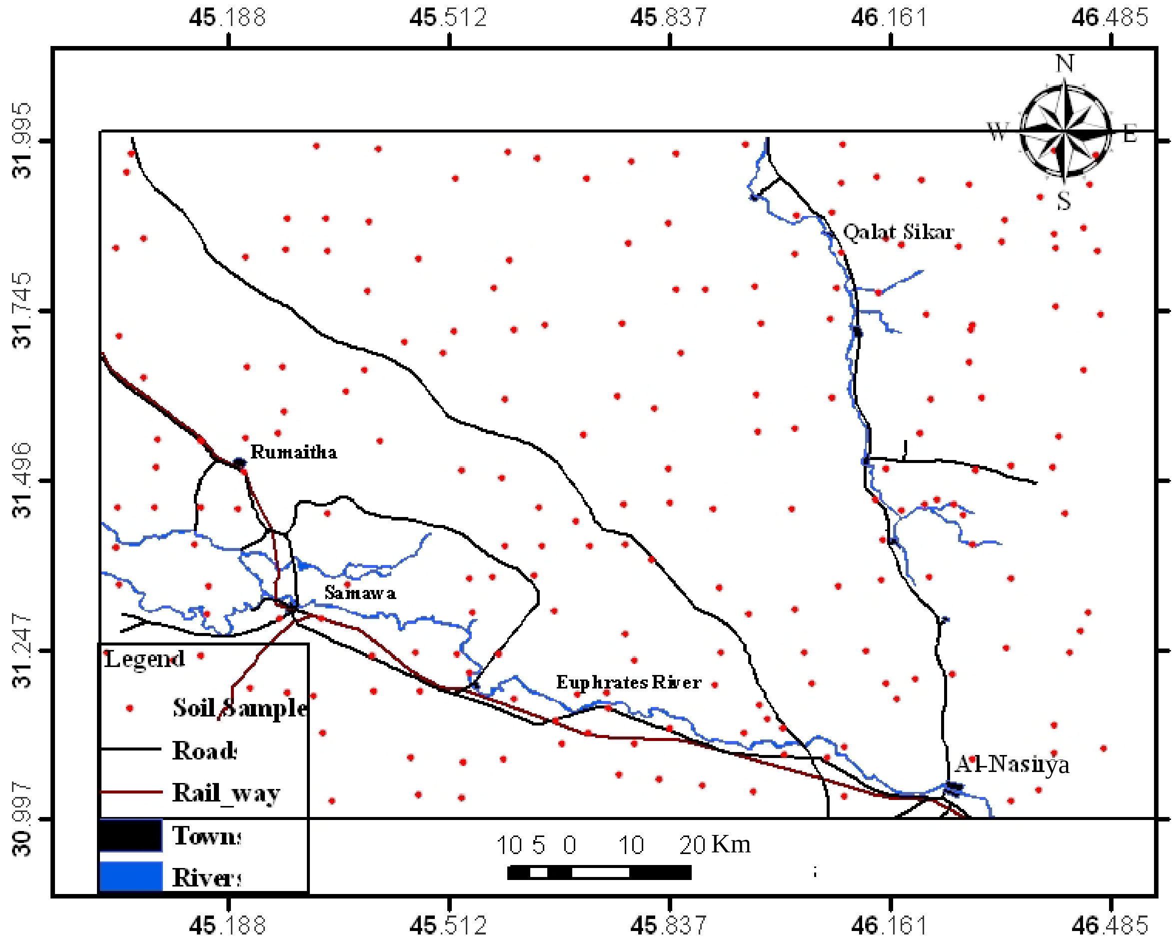


Fig.2: Location map of surface soil samples in Al-Nasiriya area

The location of all surface soil samples was determined through Global Positioning System (GPS). The points were downloaded into Excel Office software, then added and integrated to the GIS program; so that the data could be analyzed with respect to relative geographic position.

The soil samples were collected by field geologist in two different campaigns carried out in 2011. The first campaign was accomplished in March 2011. Soil surface samples were collected from 30 cm deep pits in the whole area. The second campaign was performed in May 2011. The type and numbers of the collected soil samples are illustrated in Table (1).

Table1: Type of analysis and number of soil samples in Al-Nasiriya area

Surface Soil Samples (pit samples)			
Chemical Analyses (Trace Elements) ppm	**No. of samples**	**Mineralogical Analysis (XRD)**	**No. of samples**
Pb, Zn, Cr, Ni, Cu	436	Bulk and clay minerals	24
Co	411		
U	42		

CHEMICAL ANALYSES

All dry samples were preserved in polyethylene bags, while wet samples were preserved after sun drying. All sampling operation was executed according to Geochemical Survey Procedure, Part 13 defined by GEOSURV (Benni, 2011). The type and numbers of the collected soil samples is illustrated in Table (1). The prepared samples were analyzed for Pb, Zn, Cr, Ni, Cu, and Co, using Atomic Absorption Analysis, while U was analyzed by Fluorometry following the methods described by Chemical Laboratories Procedure, Part 21 defined by GEOSURV (Al-Janabi *et al*., 1993). The analysis was carried out at the chemical laboratories of Iraq Geological Survey. Analytical accuracy was controlled by analyzing several standards, and by comparison with synthetically prepared soil standards.

STATISTICAL ANALYSIS

The statistical analysis of elemental contents in soil samples included (Table 2):

- Calculation of the descriptive statistics and nonparametrive; Mean, Median, Minimum, Maximum, Geometric Mean, Standard Deviation, Median Absolute Deviation (MAD), 25-persentile, and 75-percentile.
- Determining the law of distribution of elements.
- Establishing the values of background and threshold of elements to satisfy the main objective of the survey; defining geochemical anomalies.

The statistical study was performed with the program STATISTICA 99 Edition. The contour maps of the elements concentration was performed with the program SURFER Version 8.01.

DATA PRESENTATION

There are different methods to present geochemical data. The distribution of elemental concentration is presented as histograms, and the regional distribution of elements is presented on 1: 250 000 scale maps; as contouring of regional soil data. In these maps, the location point of samples site was plotted using the decimal coordinate as X and Y values and concentration as Z values. The region was classified to background and anomalous depending on the statistical parameters of the individual element.

RESULTS AND DISCUSSION

▪ Mineralogical Analysis

To determine the mineral composition of soil in the study area by X-ray diffraction analysis, 24 soil samples were selected to represent different soil samples (Table 1). The results show that the soil is mainly composed of common natural phases, among which are XRD spectra indicate that for non clay minerals were, quartz is the most abundant mineral, and followed, by calcite, feldspar, halite, and gypsum.

For clay minerals, the most abundant mineral is montmorillonite; followed by palygorskite, illite, and kaolinite. The sources for these natural phases in the soil sediments, include alteration products of igneous and sedimentary complexes in Turkey and Syria, Injana and Dibdibba formations inside Iraq, as well as the clastics derived from northeast Iraq by the Tigris River and its tributaries, which show their influence in the Mesopotamia part of the river basin (Al-Bassam and Al-Mukhtar, 2007). Low grade metamorphic rocks and sedimentary rocks contain to a large extent phyllosilicate material, excluding carbonate minerals and quartz, which is very close in mineral character to that of clay minerals (Velde and Meunier, 2008). Basically, there are three types of rocks, which contain large quantities of silicate minerals: acid igneous rocks, basic igneous rocks (those dominated by ferromagnesian) and their metamorphic equivalents. Carbonate and sandstones do not produce much clay mineral. The clays formed in granite or gabbro by alteration are greatly different from the clays formed from the alteration of sedimentary rocks. The difference is considered to be due to different "alterability" degree of the primary minerals (Velde and Meunier, 2008).

▪ Chemical Analyses

─ Zinc: The concentration range of Zn in soil surface samples is (15 – 310) ppm with mean of 57.3 ppm. The background is 57 ppm and the threshold is 71 ppm (Table 2). Zinc concentration exhibits a normal and unimodal distribution (Fig.3). The mean value of zinc in surface soils of the study area is within the reported values of different parts of Iraqi soils (Table 3). The mean concentration of Zn in surface soil of the area is close to the mean total of Zn content in surface soils of different countries. In the U.S.A., the range is from (17 – 125) ppm, while the grand mean of Zn for worldwide soils is 64 ppm (Pendias and Pendias, 2001). In arid regions, Aubert and Pinta (1977) reported that the range of Zn between (50 – 100) ppm zinc content is close to that for agricultural soils of the U.S.A., where the geometric mean of Zn is 42.9 ppm and median Zn content is 50 ppm (White *et al*., 1997).

The geographic distribution of Zn indicates that zinc anomalies are located near the main cities in the region (Fig.3); however, Zinc does not migrate very far in arid climate and alkaline media (Aubert and Pinta, 1977).

The most dangerous elements in scale and size of release are Cd, Pb and Zn among the elements of the first class of danger, and Ni, Co and Cu are among the second class. Currently, (70 – 95) % of all heavy metals is transferred to soil from anthropogenic sources; the rest are from natural source (Sanzharova *et al*., 2005). The anthropogenic sources of Zn are related, first of all, to the nonferric metal industry and then to agricultural practice. As mentioned above, the average content of zinc in soils of Al-Nasiriya area is within the reported values of the worldwide soils and the reported values of different parts of Iraqi soils. The slightly high values, which have been obtained in some areas, especially near some towns (Fig.3) could be due to domestic and agricultural inputs, because the addition of these materials to soils modifies the natural distribution pattern of Zn (Dudka and Chlopecka, 1990).

Table 2: Descriptive statistics of trace elements concentration in Al-Nasiriya area

Variable	Valid N	Mean (ppm)	Geometric Mean (ppm)	Median (ppm)	Median Abs. Deviation	Median + 2 MAD (Th.)	Min. (ppm)	Max. (ppm)	Std. Dev.	25% – tile	75% – tile	Type of Distribution	Mode of Distribution
Zn	436	57.3	55.2	57.0	7	71.0	15.0	310	19.1	50	64	Normal	Unimodal
Ni	436	147.1	142.7	150.0	16	182.0	27.0	494.0	35.6	131	164	Normal	Unimodal
Cu	436	27.3	26.0	27.0	3	33.0	6.0	144.0	11.8	23	30	Normal	Unimodal
Cr	436	116.3	112.9	117.0	13	143.0	44	418.0	29.8	101	128.5	Normal	Unimodal
Pb	436	16.84	14.4	14.13	4.64	23.41	2.0	54	9.13	10.23	26.0	Normal	Bimodal
Co	411	27.5	27.3	27.0	2	31.0	11	39	3.8	26	30	Normal	Unimodal
U	42	0.9	0.6	0.85	0.35	1.55	0.02	2.66	0.57	0.6	1.2	Normal	Unimodal

Table 3: Comparison between mean values results of Al-Nasiriya area with other soils of Iraq

Element (ppm)	Present Work (Mean)	Mosul Tel Affar (Al-Bassam, 1977)	Nehaidin (Al-Bassam, 1979)	East of Erbil (Al-Aasam& Salaiman, 1979)	Western part of Western Desert. (Buday and Hack, 1980)	Hit – Nasiriyah (Al-Bassam, 1981)	Sersink – Ain Sifni (Abdul Aal, 1982)	W. and S. Desert (Shehata and Mahmoud,1983)	Mesopotamia Plain (Hana and Al-Hilali, 1986)	Sediments of the Euphrates River (Al-Bassam and Al-Mukhtar, 2007)
Cr	116.3	458	90	450	120	240	371	110	497	119.4
Ni	147.1	221	80	180	66	103	170	74	238	182.9
Zn	57.3	–	57	60	57	70	27	64	54	91.2
Pb	16.84	14	5	25	13	7	6	–	9	19.5
Cu	27.3	4	26	35	23	17	16	25	26	35.8
Co	27.5	–	–	41	–	8	–	–	21	48.7
U	0.9	–	0.28	–	–	–	–	0.60	–	–

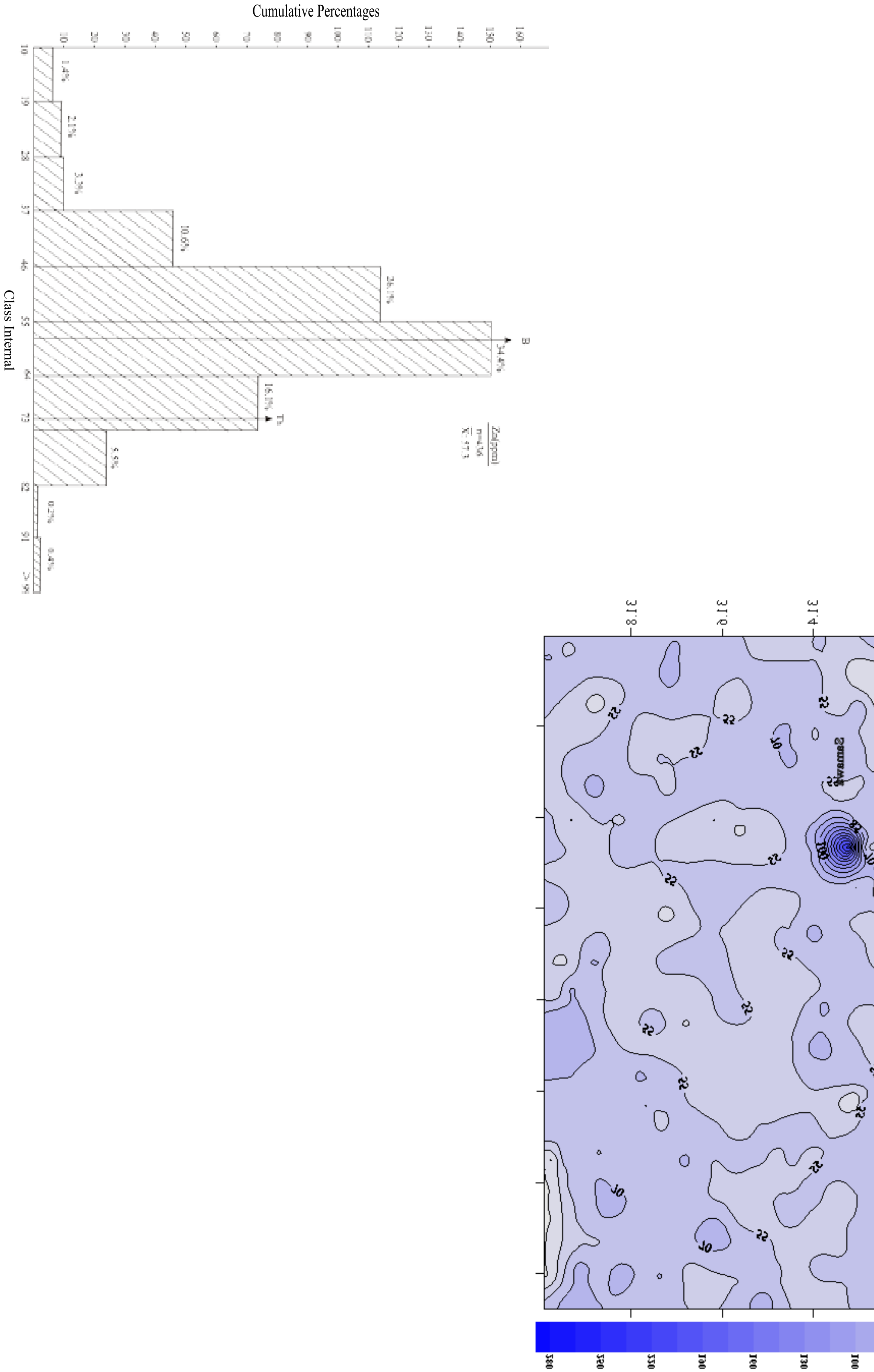


Fig.3: Histogram and regional geochemical distribution map of Zinc (ppm) in Al-Nasiriya area

─ **Chromium:** The range of chromium content in the analyzed soil is (44 – 418) ppm with a mean of 116.3 ppm (Table 2). Chromium distribution is normal and unimodal (Fig.4), with a background of 117 ppm and threshold of 143 (Table 2). The mean value of chromium in surface soils of the study area is close to the reported values of other Iraqi soils (Table 3). The grand mean Cr content is calculated to be 54 ppm for worldwide surface soils (Pendias and Pendias, 2001). In arid regions, Aubert and Pinta (1977) reported the range of Cr between (100 – 300) ppm.

The terrestrial abundance of Cr indicates that it is associated mainly with ultramaphic and mafic rocks (Pendias and Pendias, 2001). While, Ginzburg (1960) indicated that argillites and, to a lesser extent, sandstone are enriched in Cr. The mobility of Cr is low; only a minimal amount of Cr remains in solution during weathering (Thalmann *et al*., 1989). The soil Cr is inherited from parent rocks and therefore, its higher concentration in some soil samples in the area is mainly due to the influence of the mafic and volcanic rocks located in the north and northeastern Iraq, which was transported as detrital chromite grains by the Euphrates River and precipitated in the flood plain of the Mesopotamia. The geographic distribution of Cr indicates that chromium anomalies are located in the north and east – southeast parts of the area (Fig.4). The high content of this metal in the soil in these areas was probably due to the enrichment of this metal in the flood plain sediments, and secondly to the anthropogenic sources. The Cr content of surface soil is known to increase due to pollution from various sources, of which the main ones are several industrial wastes (e.g., electroplating sludge, Cr pigment and tannery wastes, leather manufacturing wastes), and municipal sewage sludge. The added Cr to soils is usually accumulated at the thin top layer, (Beckett *et al*., 1979 and Uminska, 1988). The average Cr content in the soil samples is very high; compared with the reported averages for soil in the worldwide surface soils, as mentioned above. This enrichment corresponds to the influence of ultrabasic igneous complexes of Turkey and Syria and NE Iraq brought to the south by the Euphrates and Tigris rivers.

─ **Lead:** The concentration range of Pb in surface soil samples is (2 – 54) ppm with a mean of 16.8 ppm. The background is 14.1 ppm and the threshold is 23.4 ppm (Table 2). Lead concentration exhibits a normal and bimodal distribution (Fig.5). The mean value of lead in surface soils of the study area is slightly within the reported values of different parts of Iraqi soils (Table 3). The average abundance of Pb in the Earth's crust is estimated at 15 ppm. In the terrestrial environment, two kinds of Pb are known: primary and secondary. **Primary** Pb is of geogenic origin and was incorporated into minerals at the time of their formation, and **Secondary** Pb is of a radiogenic origin from the decay of U and Th. The ratio of Pb of various origins is used for dating the host materials. The natural Pb content of soil is inherited from parent rocks. However, due to widespread Pb pollution, most soils are likely to be enriched in this metal, especially in the top horizon. The natural Pb occurrence in top horizons of different soils from various countries show that it ranges from (3 – 189) ppm, while mean values for soil; various types range from (10 – 67) ppm and average 32 ppm (Pendias and Pendias, 2001). Farrah and Pickering (1977) discussed several possible mechanisms of adsorption of hydroxyl species and suggested that Pb sorption with montmorillonite can be interpreted as simply cation exchange processes, while kaolinite and illite; Pb is rather competitively adsorbed. Lead distribution in the studied soils exhibits an extensive dispersion pattern (Fig.5) with several, well developed anomalies. Some of these anomalies probably indicate that there are various pollution sources at some towns, villages and near the main roads in the whole area. The accumulation of Pb in the surface soil is exposed to various pollution sources. The Pb levels in soils that are toxic to plants are not easy to evaluate; however, several authors

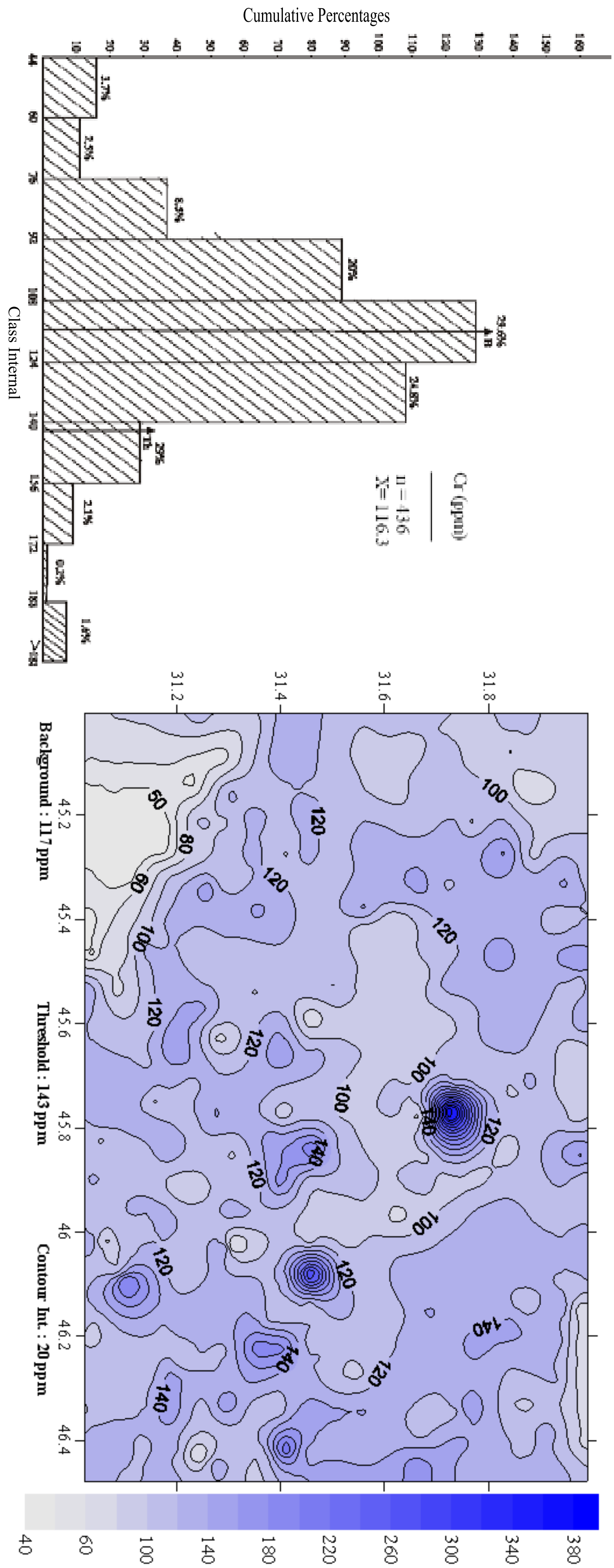


Fig.4: Histogram and regional geochemical distribution map of chromium (ppm) in Al-Nasiriya area

have given quite similar concentrations, ranging from (100 – 500) ppm, (Pendias and Pendias, 2001). The accumulation of Pb in surface soils is of great ecological significance, because this metal is known to greatly affect the biological activity of soils (Andersson, 1976).The lead concentration and content in the study area do not show or indicate pollution in the area. However, the slight enrichment in some parts (Fig.5) may be due to the effect of automobile exhaust, and duo to industrial processes.

─ **Nickel:** The range of nickel content in the studied surface soil is (27 – 494) ppm with a mean 147.1 ppm (Table 2). Nickel distribution is normal and unimodal (Fig.6), with a background of 150 ppm and threshold of 182 (Table 2). The nickel content in surface soils of the study area is higher (4 folds) than the reported concentrations of the world records. Geometric mean of the Ni content in surface soil from major agricultural production areas of U.S.A. is 16.5 ppm, ranging from (0.7 – 269) ppm (Holmgren *et al*., 1988). The grand mean for world soils is calculated to be 22 ppm, and 19 ppm was reported for U.S.A. soils. Soils throughout the world contain Ni within broad range from (0.2 – 450) ppm, while the range for soils of U.S.A. is from (< 5 – 150) ppm (Pendias and Pendias, 2001). In arid regions, Aubert and Pinta (1977) reported that the average concentration of Ni is 50 ppm. The geographic distribution of Ni indicates that nickel anomalies are located in the central and southern parts of the area especially near Al-Nasiriya town (Fig.6). The high content of this metal in the soil in these areas probably is due to the enrichment of this metal in the flood plain sediments from the source area, and secondly to the anthropogenic sources. The nickel status in soils is highly dependent on the Ni content of parent rocks. However, the concentration of Ni in surface soils also reflects soil-forming processes and pollution. Its higher mobility in ionic form increases its toxicity effects; compared with Cr and Pb, which are usually present in less mobile forms in soil. The higher content of this metal in the studied area could be explained by the close proximity of the area to the source rocks of ultrabasic composition in Turkey and Syria driven by the Euphrates River, as well as the clastics derived from northeast Iraq by the Tigris River and Its tributaries, which show their influence in the Mesopotamian part of the rivers basin (Al-Bassam and Al-Mukhtar, 2007).

─ **Copper:** The concentration range of Cu in surface soil samples is (6 – 144) ppm with a mean of 27.3 ppm. The background is 27 ppm and the threshold is 33 ppm (Table 2). Copper concentration exhibits a normal and bimodal distribution (Fig.7). The mean value of copper in surface soils of the study area is within the reported values of different parts of Iraqi soils (Table 3).

Copper in the Earth’s crust is most abundant in mafic and intermediate rocks and has a tendency to be excluded from carbonate rocks. Cu forms several minerals of which the common primary minerals are simple and complex sulfides. These minerals are quite easily soluble in weathering processes and release Cu ions, especially in acid environments (Pendias and Pendias, 2001).

Total Cu distribution in surface soils in the study area is within the reported average of the world. Hawaks and Webb (1962); Rosler and Lang (1972) and Aubert and Pinta (1977) reported that the concentration of Cu in surface soil is 20 ppm. Quite similar Cu background values were calculated for the surface soils of U.S.A. from data given by Shacklette and Boerngen (1984). The common characteristic of Cu distribution in soil profiles is its accumulation in the top horizons. This phenomenon is an effect of various factors, but above all, Cu concentration in surface soils reflects the bioaccumulation of the metal and also recent anthropogenic sources of the element (Pendias and Pendias, 2001).

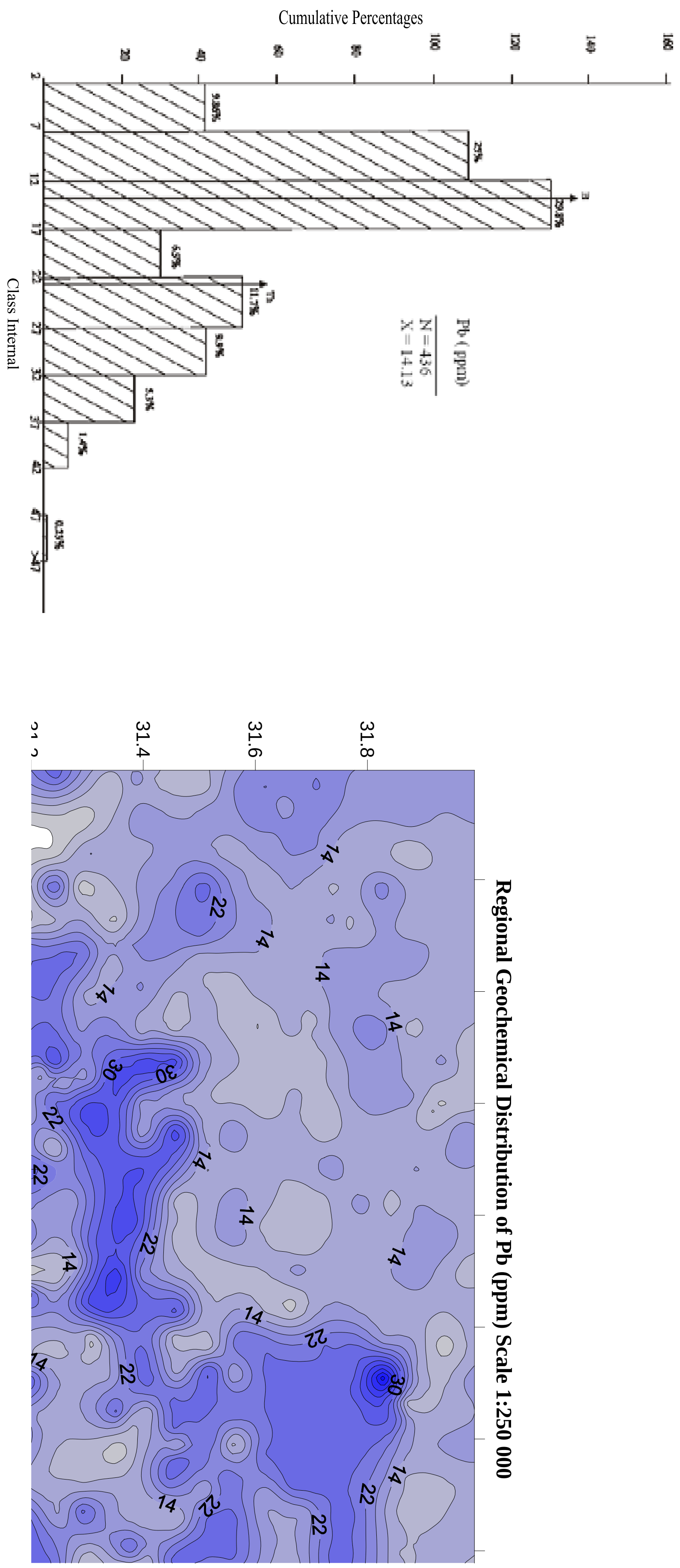


Fig.5: Histogram and regional geochemical distribution map of lead (ppm) in Al-Nasiriya area

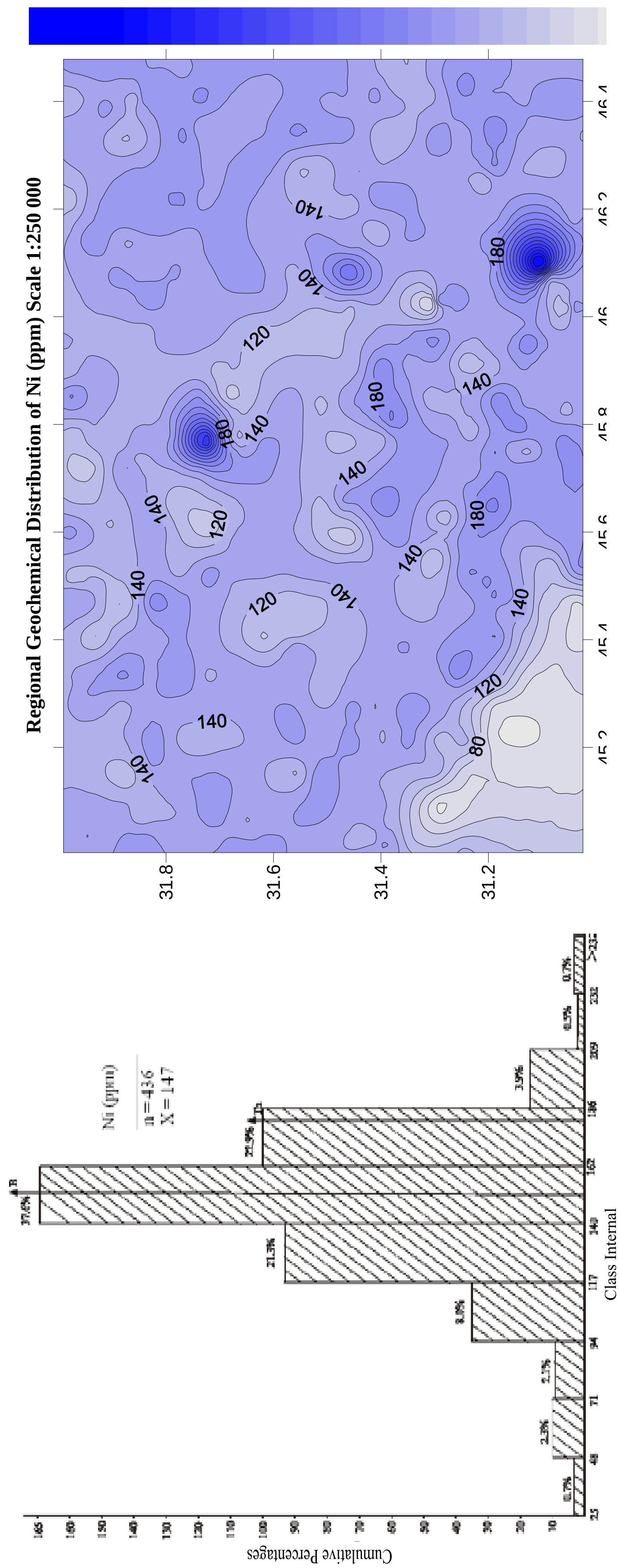


Fig.6: Histogram and regional geochemical distribution map of nickel (ppm) in Al-Nasiriya area

The geographic distribution of Cu indicates that Copper anomalies are located in the northwestern parts of the area, especially north of Qalat Sikar town (Fig.7). The Cu balance in surface soils of different ecosystems shows clearly that the atmospheric input of this metal may partly replace the removal of Cu by biomass production and in some cases may even exceed the total output of the metal from soils. Contemporarily observed soil contamination with Cu can lead to an extremely high Cu accumulation in top soils (Pendias and Pendias, 2001).

Contamination of soil by Cu compounds results from utilization of Cu-containing material such as fertilizers, sprays, and agricultural or municipal wastes as well as from industrial emissions. Some local or incidental Cu input to soils may arise from corrosion of Cu alloy construction materials (e.g., electric wires, pipes). As mentioned above, copper content in the studied area is within the reported average values of different parts of Iraqi soils and the world, except some samples in the top northeastern part of the studied area (Fig.7), which show a relative enrichment in copper content that could be due to environmental contamination.

─ **Cobalt:** The concentration range of Co in the studied surface soil samples is (11 – 39) ppm with a mean of 27.3 ppm. The background is 27 ppm and the threshold is 31 ppm (Table 2). Al-Bassam and Al-Mukhtar (2007) in studying heavy minerals in the sediments of the Euphrates River in Iraq, reported that the mean concentration of Co is 48.7 ppm. Cobalt concentration exhibits a normal and unimodal distribution (Fig.8).

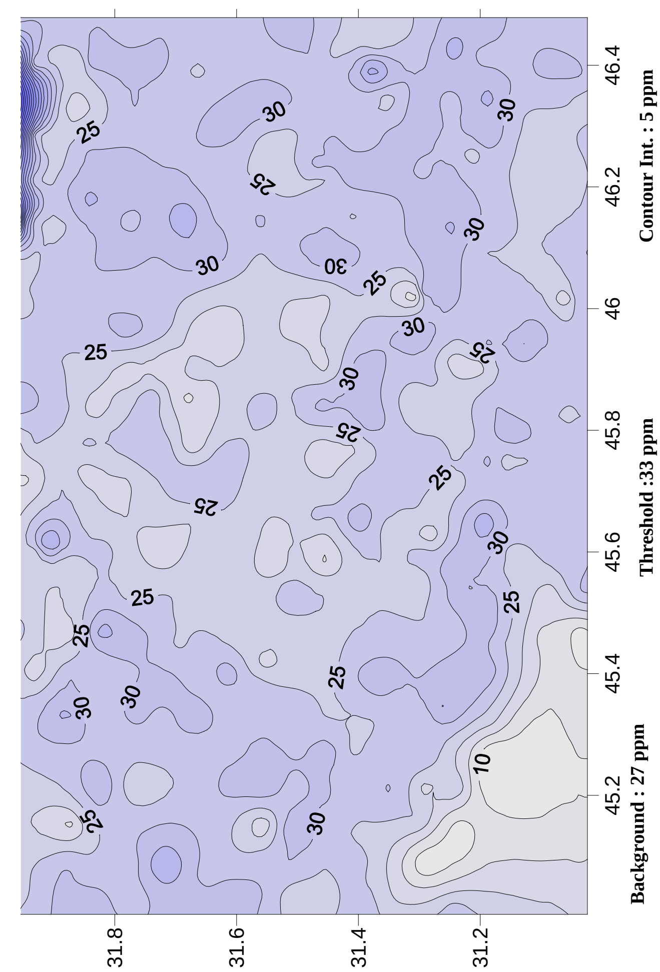
In the Earth’s crust, Co has a high concentration in ultramaphic rocks (100 – 220) ppm, when compared to its content in acidic rocks (1 – 15) ppm. The Co abundance in sedimentary rocks ranges from (0.1 – 20) ppm and seems to be associated with clay minerals or organic matter. The crust of the Earth as a whole contains, on average, 25 ppm Co (Pendias and Pendias, 2001).

In soils, the weathering, transforming, and adsorption mechanisms of Co compounds and forms are extremely complicated, due to variable oxidation stages of Co and due to microbial activity (Zachara and Westall, 1999). Adequate amounts of Co in soil are essential to its biological activity since Co, as a component of vitamin B12, is involved in methylation processes in soil.

Soil organic matter and clay content are also important factors that govern Co distribution and behavior. The roles of montmorillonitic and illitic clays, especially, have been cited by numerous investigators as being of significant, because of their great sorption capacity and their relatively easy release of Co (Pendias and Pendias, 2001).

The range of Co in the reference soil samples of U.S.A. is from (5.5 – 29.9) ppm (mean, 10 ppm), and in the soil samples of China is from (5.5 – 97) ppm (mean, 11.6 ppm) Govindaraju (1994). The mean value of cobalt in surface soils of the study area is within the reported values of different parts of world soils. The geographic distribution of Co indicates that cobalt anomalies are located in the southwestern parts of the area especially north of Al-Nasiriya city and near roads (Fig.8).

Cobalt is an important element for living organisms even though it is present at lower trace level, for example, animals need cobalt for the formation of hemoglobin. Bovine and ovine can suffer from anemia as a result of cobalt deficiency in soils and consequently in forage plants.



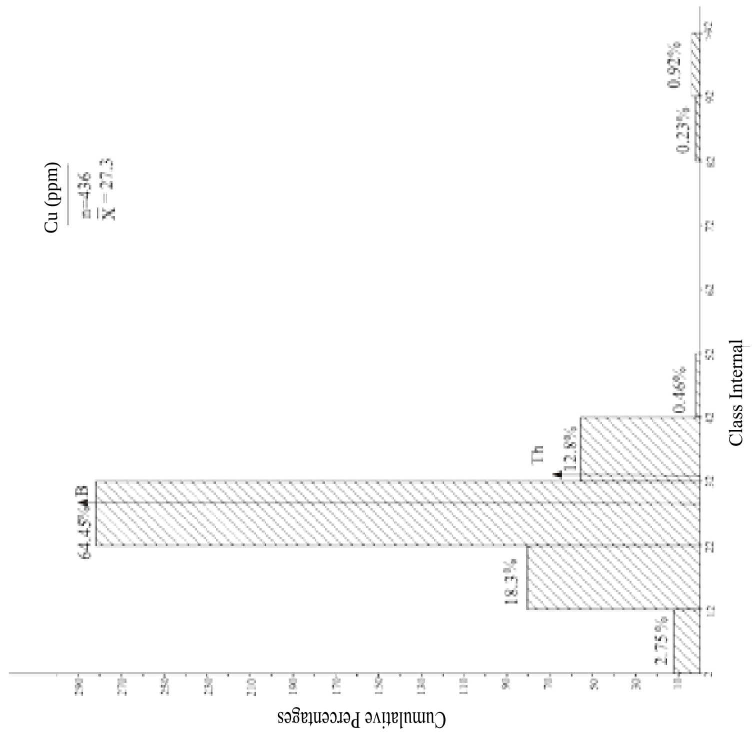


Fig.7: Regional geochemical distribution of copper (ppm) in Al-Nasiriya area

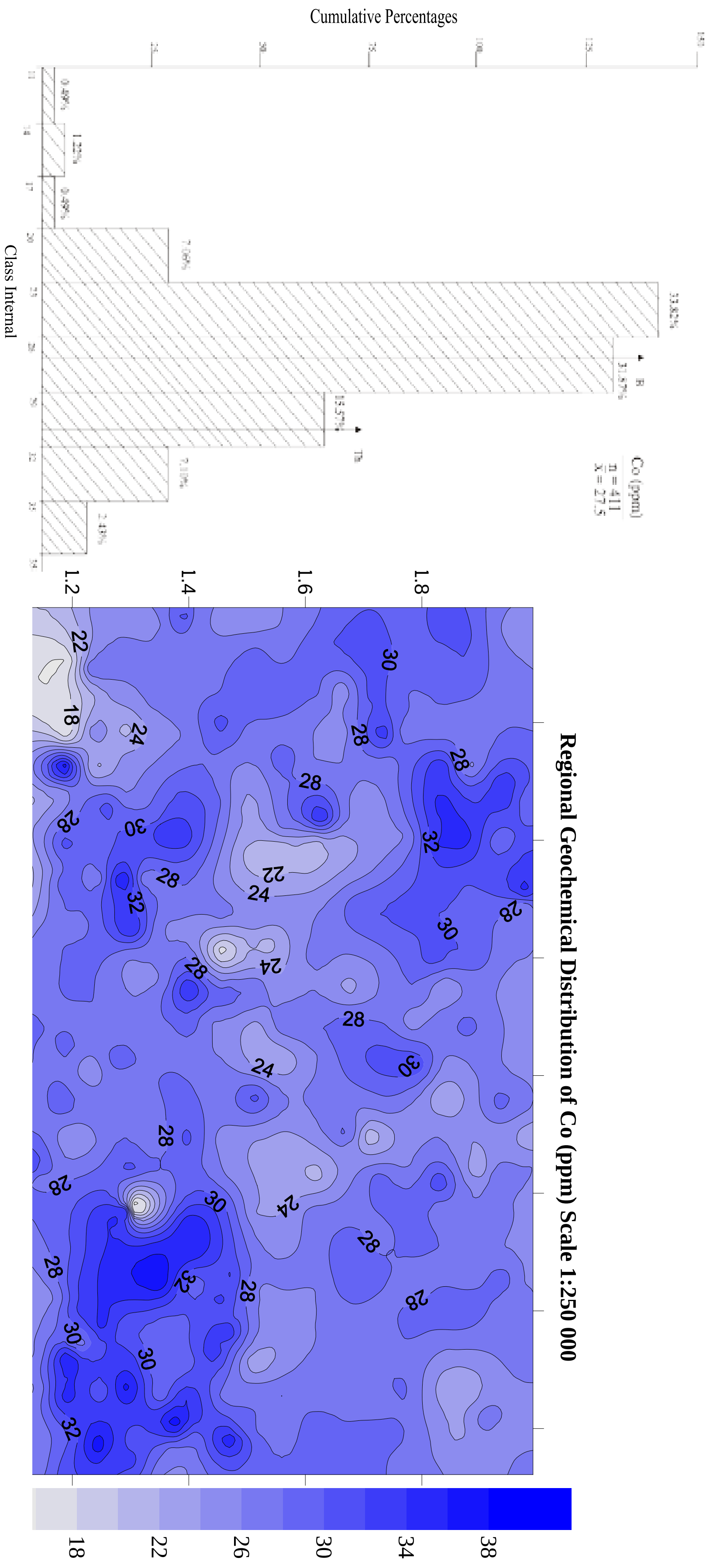


Fig.8: Regional geochemical distribution map of cobalt (ppm) in Al-Nasiriya area

The analytical result of cobalt in the soil of the study area indicate that there is no pollution of this elements and the high concentration of this metal, in general is mainly due to the influence of the basic and ultrabasic igneous rocks located in the northeast Iraq.

– **Uranium:** Only 42 soil samples have been selected to be analyzed for uranium in the whole area. The concentration range of U in surface soil samples is (0.02 – 2.66) ppm with a mean of 0.9 ppm. The background is 0.85 ppm and the threshold is 1.55 ppm (Table 2). Uranium concentration exhibits a normal and unimodal distribution (Fig.9).

Uranium occurs as a natural constituent in soil, originating from rocks in the earth's mantle. Worldwide uranium concentrations in soils have been reported to range from (0.3 – 11.7) mg/kg (UNSCEAR, 1993). The average background concentration of uranium in soil is about 2 mg/kg (NCRP, 1984). The mean value of uranium in surface soils of the study area is less than or within the reported values of different parts of world soils.

The biological half-life (the average time it takes for the human body to eliminate half the amount in the body) for uranium is about 15 days (Georgia State University, Biological Half Lives). Normal functioning of the kidney, brain, liver, heart, and numerous other systems can be affected by uranium exposure, because uranium is a toxic metal (Craft *et al*., 2004). Background concentrations and environmental fate of metals strongly depends on geological and biological characteristics and therefore, any assessment of potential risks should take into consideration regional differences in metal content in the natural environment (Chapman and Wang, 2000).

No pollution of this element can be outlined in the study area. The average concentration of uranium element is the study area is less than the reported values of different parts of the world soils, and the anomalies values that are shown in Fig. (9) are statistically not related to pollution.

CONCLUSIONS

- Background levels for trace elements Cr, Ni, Pb, Zn, Co, and U have been determined for the soils of Al-Nasiriya area (sheet NH-38-3). The results of this work have shown that the distribution and concentration of the heavy metals (Cr, Ni, Pb, Zn, Co, Cu and U) in the studied soils is within the average concentration given for the world reported soils of arid and semi arid regions.
- The soil of the studied area is still free from pollution, except Pb in some local areas, which shows higher concentrations than those reported for world soils.
- In general, the concentrations of Cr, Ni, and Co are high in Iraqi soils, and highly dependent on their content of parent rocks, which is mainly due to the influence of igneous and sedimentary complexes in the Turkey and Syria, derived by Euphrates River and Injana and Dibdibba formations inside Iraq, as well as the clastics derived from northeast Iraq by the Tigris River and its tributaries, which show their influence in the Mesopotamia part of the river basin.
- The area in general contains no major mineralization, although a distinct trace metal anomaly was found in local soils e.g. the Pb concentration in the main cities in the area. Lead is used in the automobile industry, in the production of batteries as the anti-knock gasoline additives tetraethyl lead. Gasoline combustion primarily causes an air pollution problem.
- The mineralogical results of 24 soil samples showed that for non clay minerals, quartz is the most abundant mineral, followed by calcite, feldspar, halite, and gypsum. For clay minerals; the most abundant mineral is montmorillonite followed by palygorskite, illite, and kaolinite.

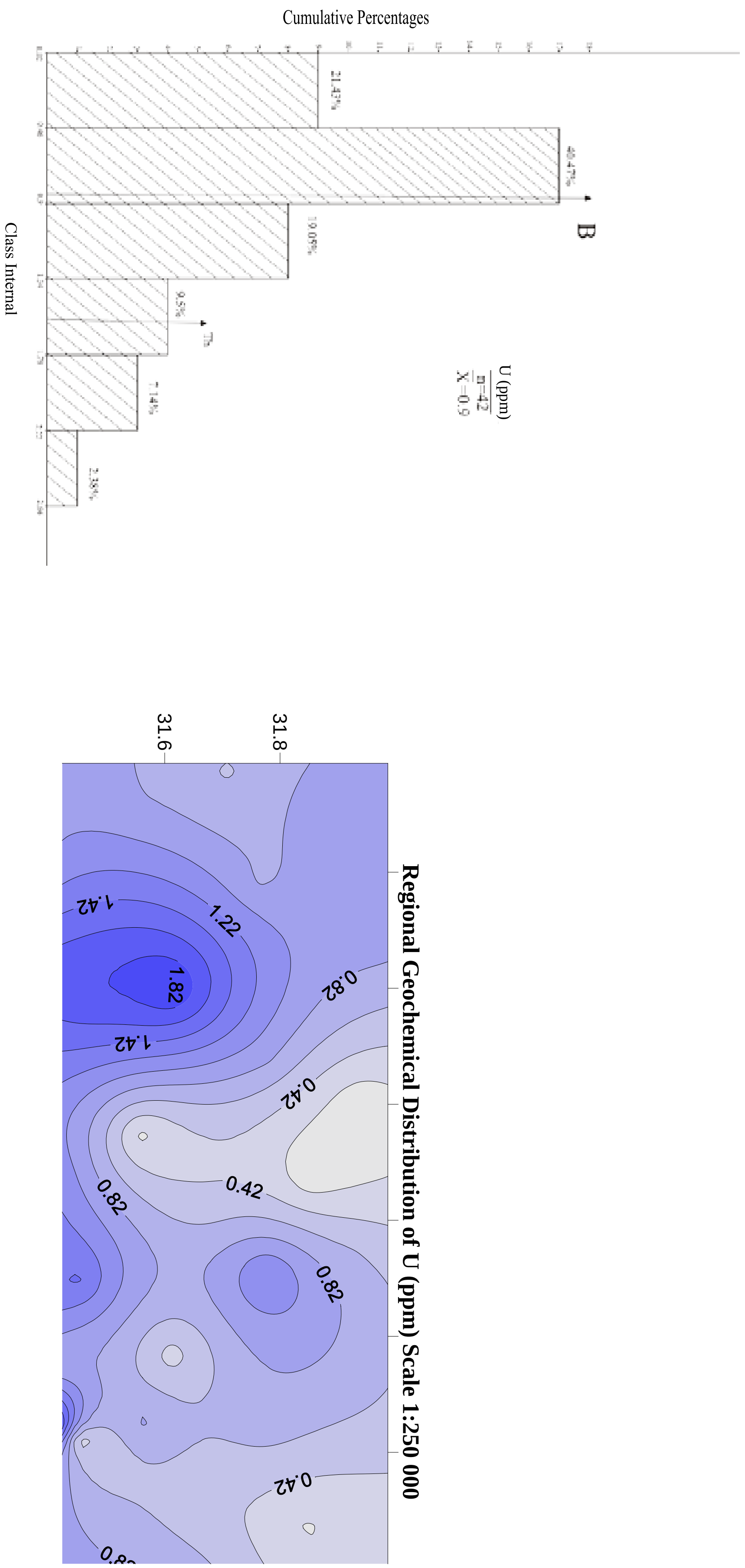


Fig.9: Regional geochemical distribution map of uranium (ppm) in Al-Nasiriya area

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