Heavy Metals in some soils of Baquba city: determination Distribution and Controlling Factors

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Abstract

The objective of the present work was determining of some heavy metals levels (Cd, Co, Cr, Fe, Ni, Pb & Zn) in the soil of Baquba city, to actualizing this target, (20) soil samples were collected from different areas inside Baquba city, the averages values of (Cd, Co and Fe) were within the international limits in the soil while the other elements values (Cr, Ni, Pb and Zn) were over the international limits.

This study deals with the factors affecting the distribution of heavy metals in the soil (pH, organic matter (O.M), quality and the ratio of the clay minerals and iron ratio). The average of the ratio of pH for four selected soil samples (more and less four soil samples in the concentrations of heavy metals) (9.1) that's mean that soil of this area is basic and affecting the mobility of the heavy metals and make them precipitate, while the average of the (O.M) for the same samples was (0.76 %), mineralogical analysis for the soil samples was conducted to know the mineralogy of the soil and the quality of the clay minerals in the selected soil samples and types of clay minerals were (Palygorskite, Kaolinite, Montmorillonite) and the average of clay minerals was (17.4 %), the ratio of the iron in the same soil samples was (21532 ppm) this value less than its average in the international soils. We can conclude that these factors don't have an affecting on the distribution of the heavy metals and its increasing and decreasing in soil, because of low values for these factors. In general the increasing of the heavy metals in the soil due to the releasing of these metals from the by products of the combustion of the fuel in different automobiles and the type of the mother rocks that formed this soil which are rich with these heavy metals, using of fertilizers and discharge of industrial wastes adding some heavy metals to the soil.

Introduction

Modern civilization is completely dependent on a large range of metals for all aspects of daily life. Heavy metals are released into the environment by both natural and anthropogenic sources. With the exception of soils derived from the physical and chemical weathering of parent materials containing elevated levels of trace elements (e.g. black shales and basic igneous rocks), the presence of elevated metal concentrations in the environment is related to man's activities [(1)]. Heavy metal pollution not only affects the production and quality of crops, but also influences the quality of the atmosphere and water bodies, and threatens the health and life of animals and human beings. Several researchers have clearly identified the Influence of human activity as a major cause for metal contamination of the ecosystem, metals are considering among the most dangerous environmental pollutants, because they do not disintegrate with physical processes and therefore remain for longtime period. They affect biogeochemical cycles and accumulate within living organisms, eventually making their way to humans through the food chain, where they can cause perturbation to biological reactions, long lasting harm to vital organs or even death [(2)].

Contamination of soil by heavy metals occurs due to the industrial wastes (solid, liquid and gaseous), application of fertilizers, spill of hydrocarbons on the ground, effects of oil wells drilling and the by products of fuel combustion in the electrical power station and in the automobile emissions. Three main factors known to influence the levels in soil samples, which have been reported, are traffic, industry and weathered materials [(3)].

The main objective of the present work was assessment of some heavy metals content (Cd, Co, Cr, Fe, Ni, Pb and Zn) in the soil of Baquba city the center of Diyala Governorate (60 km to the north east of Baghdad).

Materials and Methods:

1- Sampling:

Diyala governorate located in the middle of Iraq (Fig.1) bordered with Wasit Governorate, Baghdad, Saladin governorate, Sulaimania city and the international border with Iran, its area about (17685 km^2) and represents (4.1 %) from the area of Iraq, consist of (19) administrative units, (6) urban areas including the Governorate center (Baquba city the area of study) (Fig. 2) [4]. after obtaining the map of the area of study, (20) Soil samples were collected with depth (5- 10 cm) using iron shovel (the quantity of each sample was 1 kg), isolation of foreign materials such as plant leaves, debris etc. were removed from the collected soil samples then all the samples were put in plastic bags to measure the concentration of heavy metals (Cd, Co, Cr, Fe, Ni, Pb and Zn).

2- Preparation of samples:

- Heavy metals:

After collecting soil samples from Baquba city then all the samples were taken to the laboratory to preparing these samples for analyzing by (AAS) equipments(Buck Scientific, Model 210 VGP, Atomic Absorption Spectrophotometer).

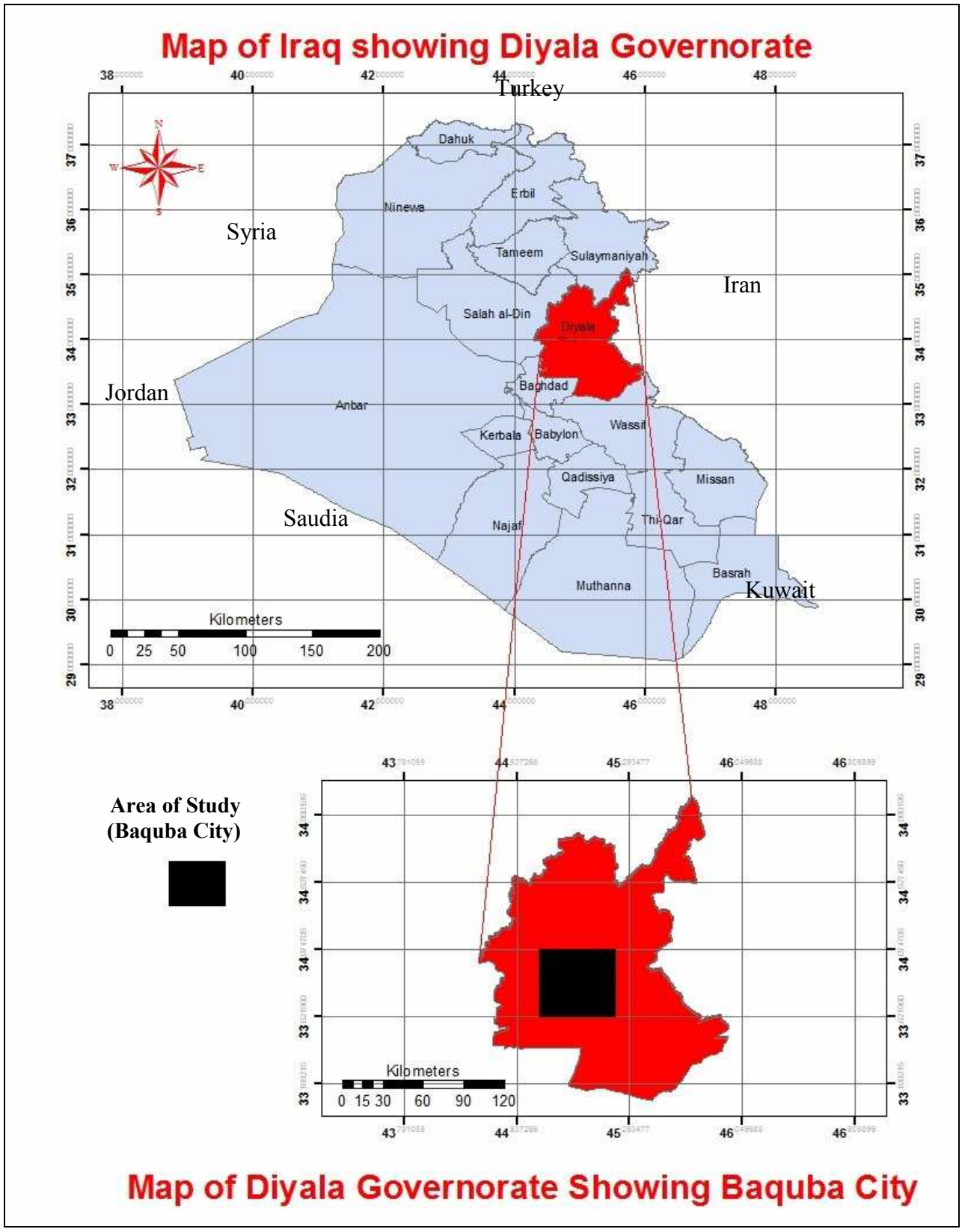

Fig. 1: Map of Iraq Showing Diyala Governorate

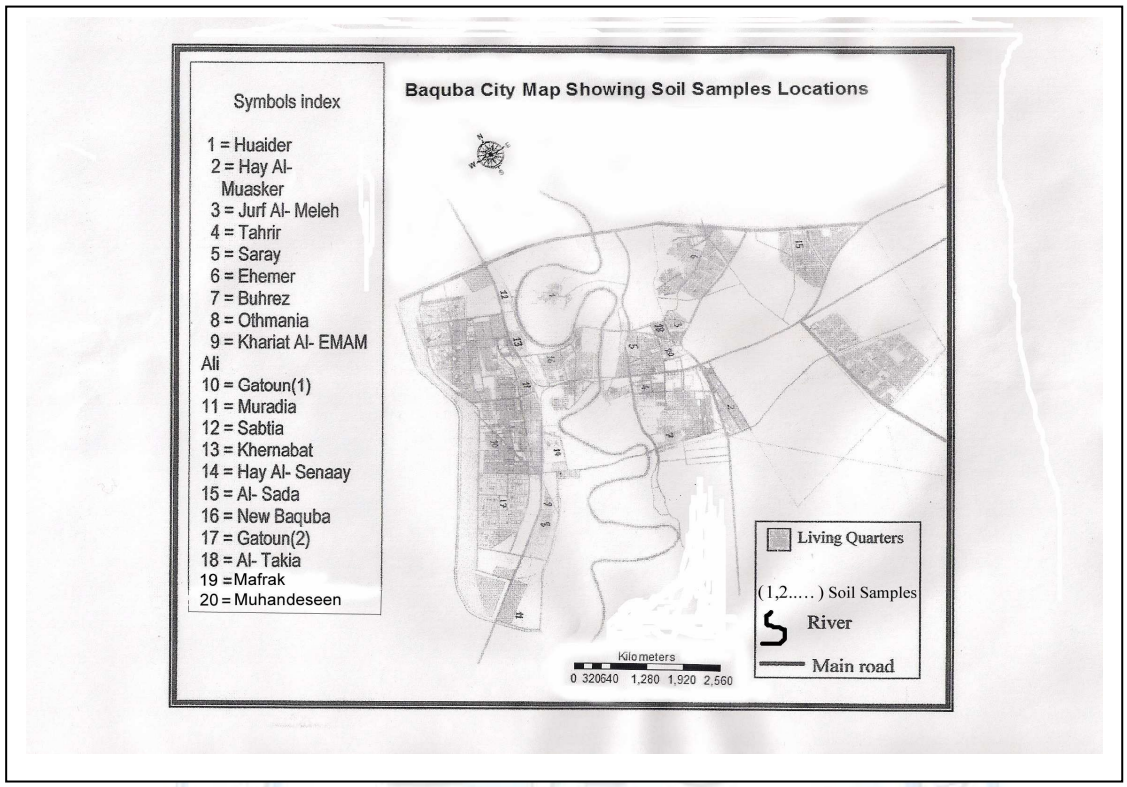

Fig. 2: Baquba city map (the area of study) showing soil samples locations

- Digestion method:

Preparations and digestion of samples in this study was conducted according to the work procedures in the state company for geological survey and mining [5]:

1- Spread the soil sample (1 kg) then a plus (+) symbol will make on the sample after crumbling all the soil then a few sample from each quarter will take then homogeneity will be done for all samples.

2- (5) gm of soil sample were taken, Crumbling to (75) μ and put it in oven till the dryness.

3- Crush them to small volumes by mill and after harmonizing these samples take (1) gm for analysis.

4- Add (5) ml of concentrated Hydrochloric acid (HCI) and (15) ml of Concentrated Nitric acid (HNO_3) to the sample after putting it in a Beaker (100) ml.

5- Put this mixture on the Hot plate till the disappearing of vapors and the drying of the sample.
6- Cooling the Beaker and adding (5) ml of Concentrating Hydrochloric acid and after this step, warming in hot plate till dryness.
7- Cooling the Beaker and adding (5) ml Concentrating Hydrochloric acid and (50) ml of hot Filtered water for washing the sides of the Beaker of the melted sample traces.
8- Warming the mixture to the boiling degree for few minutes.
9- Filtering the mixture by Filtering paper (No. 42) and put it in volumetric flask.
10- Washing unmelted sediments by Filtered water and adding the washing water to the filter and complete the Volume to and then sending the prepared samples to the analysis by atomic absorption spectrometry (AAS).

- XRD, Grain size, O.M and pH:

The analysis of soil samples for (XRD) using the equipment (SHIMADZU 7000, Japan, Cu Target, Ni Filter, λ = 1.54 Å), grain size (using hydrometer method), organic matters (O.M) and pH, was conducted according to the work procedures in the state company for Geological survey and mining (GEOSURV) Baghdad- IRAQ.

Results and discussion:

- HEAVY METALS:

1- Cadmium:

The concentration of Cadmium in the soil samples was ranging (1- 4.2ppm) with a mean (2.4 ppm), it was within the range in the soil (5 ppm) [6]. Highest value of Cadmium was in the sample of (Mafrak) (Table 1) (Fig. 3). Increasing of Cadmium due to the incineration of plastic materials that can cause an increasing of Cadmium concentration in the atmosphere then accumulates on the soil [7].

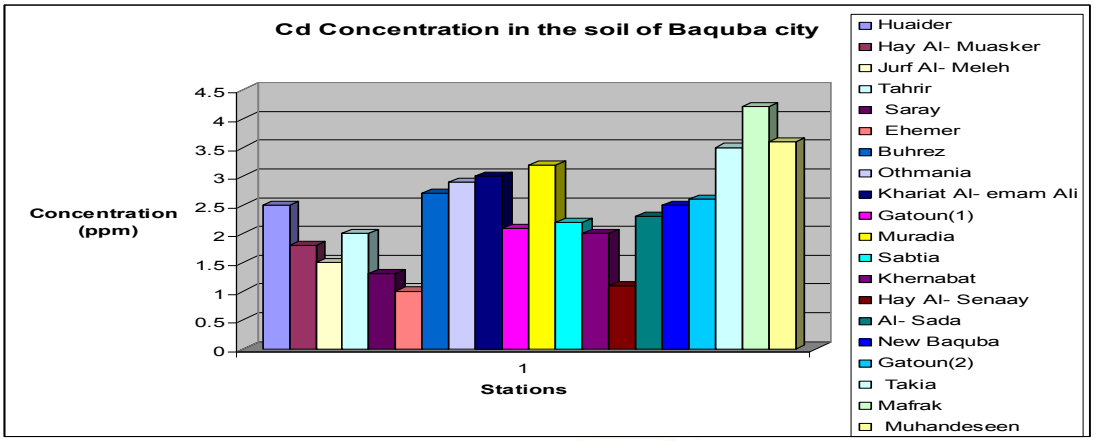

Fig. 3: Cd concentration in the soil of Baquba city

2- Cobalt:

The concentration of Cobalt in this study ranging (11- 17ppm) with mean (13.8ppm) the mean was within the range in the soil according to [8]. The highest values were in the samples of (Khariat Al- Emam Ali & Gatoun (1)) (Table 1) (Fig. 4). Increasing in the concentration of Cobalt in the soil affected by different factors: the origin and the formation of the soil, weathering processes, anthropogenic activities, in addition to sewage water [9].

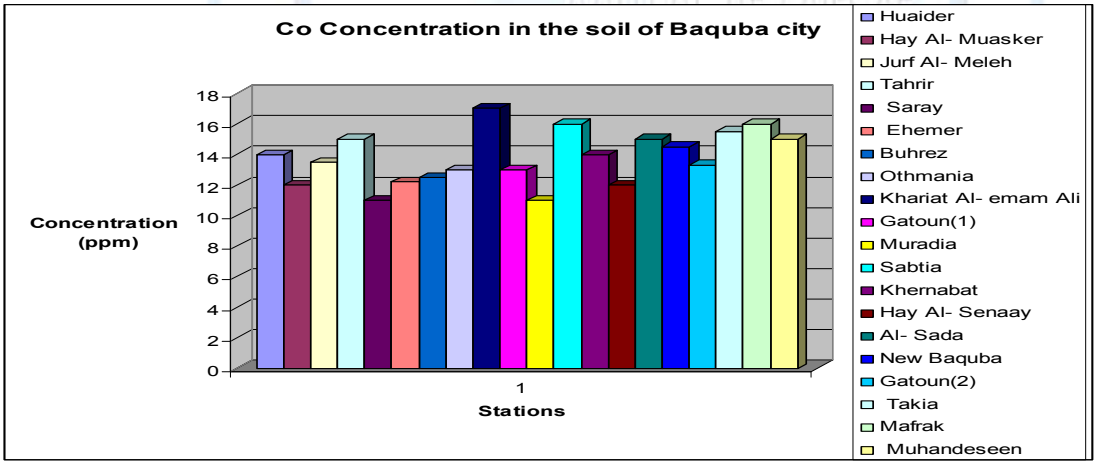

Fig. 4: Co concentration in the soil of Baquba city

3- Chromium:

The concentration of Chromium in the soil of Baquba city was ranging (96- 275 ppm) with a mean (133ppm). The lowest concentrations of Chromium in this study were in the samples (Hay Al- Senaay, Al- Sada & Mafrak) and the other samples were over the international limits in the soil (Table 1) (Fig. 5). The increasing of Chromium in the Iraqi soils due to the

transported clastics sediments which formed the stratigraphic column of Mesopotamian plain, these clastics sediments come from the north and north- east of Iraq as a result of weathering processes in these areas, weathering processes move with the Tigris River and its tributaries which are rich with Chromium metals and Serpentine metals and Olivine as Chromites (Cr_2O_4) [10].

5- Iron:

The concentration of Iron in the present work was ranging (15304ppmin the sample of (Khariat Al- Emam Ali) and (29885 ppm) in the sample of (Takia)) (Fig. 6). with a mean (21532 ppm), (Table 1). All the values in the soil samples in this study were under their limits in the soils. The increasing of the concentration of Iron in the soil or exist the Iron within the limits in the soil depends on their concentration in the mother rocks that forming this soil [11].

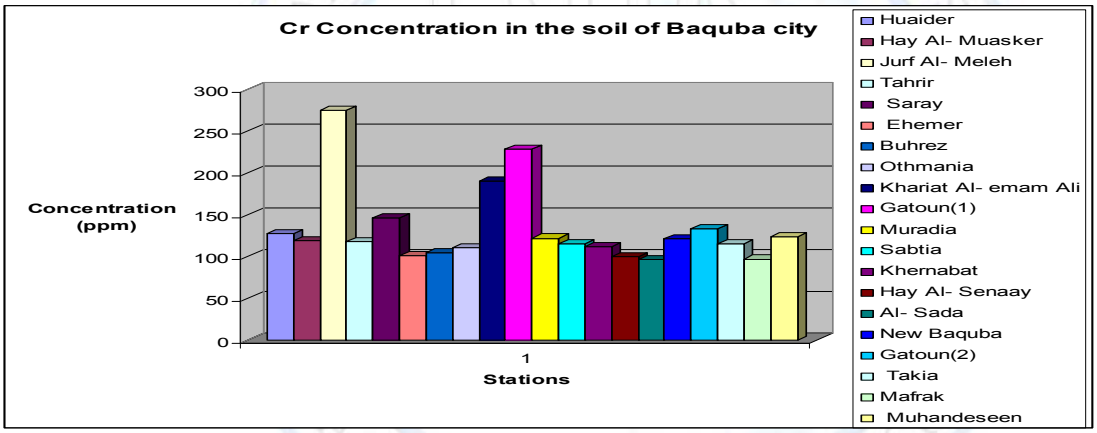

Fig. 5: Cr concentration in the soil of Baquba city

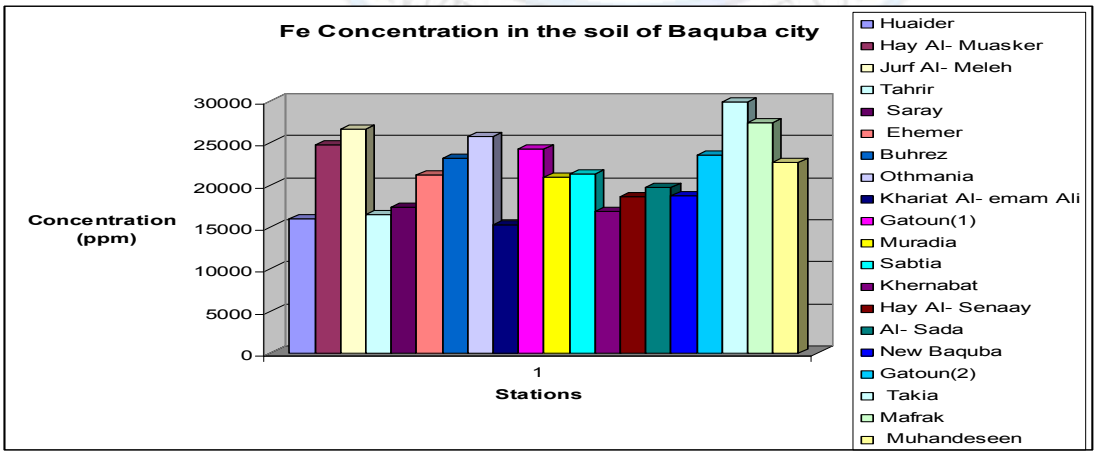

Fig. 6: Fe concentration in the soil of Baquba city

6- Lead:

The values of Lead in the soil samples ranging (15- 128ppm) with a mean (51ppm), (Table 1). Lead concentration in all soil samples was over the limits in the soil according to [12] (10ppm). Highest concentration was in the sample (Hay Al- Muasker) and the lowest concentration of Lead was in (Jurf Al- Meleh) (Fig. 7), the increasing of Lead concentration in soil due to different sources and the most probable source is fuel combustion in the automobiles which adding for the fuel of automobiles as tetraethyl lead [9]. Studies of heavy metals in ecosystem have indicated that many areas near urban complexes or major road systems contain enormous high concentrations of the elements. In particular, soils in such regions have been contaminated from wide range of sources with Lead, Cadmium and other heavy metals [13], [14], [15].

7- Nickel:

The mean of nickel in this study was (111ppm) ranging (58- 178ppm), the values of nickel in all soil samples were exceed the limits in soil (40ppm) according to [12] (Table 1). The highest value of nickel was in (Hay Al- Muasker) and the lowest value was in (Jurf Al- Meleh) (Fig. 8). It is known that untreated or not filtered emissions from most types of combustion and incineration will carry different trace metals [16].

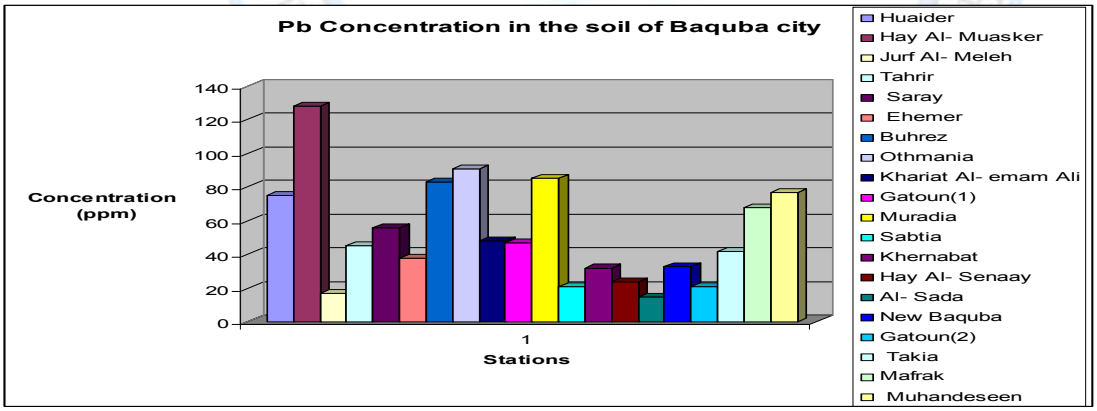

Fig. 7: Pb concentration in the soil of Baquba city

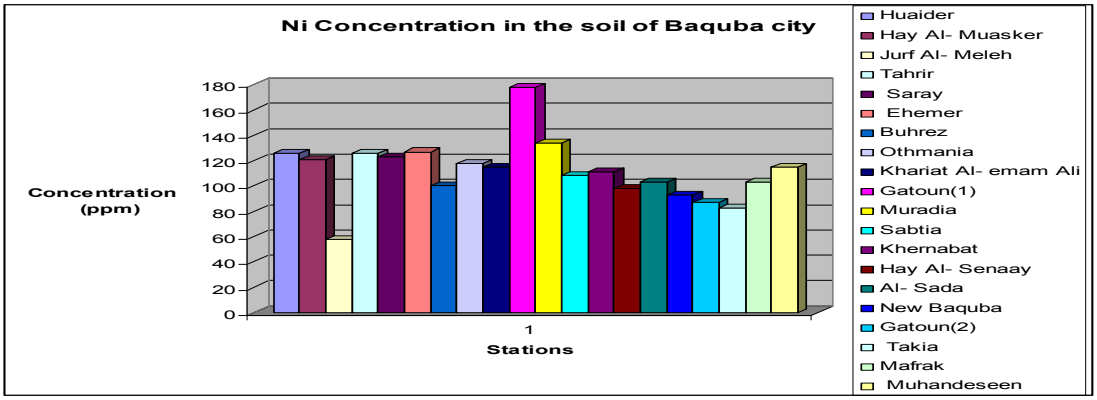

Fig. 8: Ni concentration in the soil of Baquba city

8- Zinc:

The mean of Zinc in the soil samples was (99ppm) ranging (80- 156ppm) (Table 1), all the values of Zinc were above limits in the soil (70ppm) according to [12].

The highest one was in (Buhrez) while the lowest value was in (Sabtia) (Fig. 9). Zinc connecting by a strong positive relation with (Cd, Cr, Cu, Ni, and Pb), organic matter and the ratio of clays, this strong relation with these elements due to their origin from basic and ultra basic igneous rocks and weathering of different sedimentary rocks and the influence of anthropogenic activities [17].

Table 1: The concentrations of the studied heavy metals in the soil of Baquba city

No.	Sample ID	Samples	Cd	Co	Cr	Fe	Ni	Pb	Zn
1	SS 1	Huaider	2.5	14	127	16040	126	75	111
2	SS 2	Hay Al- Muasker	1.8	12	119	24750	121	128	121
3	SS 3	Jurf Al- Meleh	1.5	13.5	275	26600	58	17	96
4	SS 4	Tahrir	2	15	118	16500	126	45	98
5	SS 5	Al- Saray	1.3	11	146	17330	123	56	82
6	SS 6	Al- Ehemer	1	12.2	101	21223	127	38	83
7	SS 7	Buhrez	2.7	12.5	105	23202	100	83	156
8	SS 8	Al- Othmania	2.9	13	111	25801	118	91	122
9	SS 9	Khariat Al- EMAM Ali	3	17	191	15304	115	48	104
10	SS 10	Gatoun(1)	2.1	13	229	24262	178	47	99
11	SS 11	Muradia	3.2	11	122	20998	134	85	86
12	SS 12	Sabtia	2.2	16	115	21325	108	21	80
13	SS 13	Khernabat	2	14	112	16878	111	32	91
14	SS 14	Hay Al- Senaay	1.1	12	100	18543	98	24	83
15	SS 15	Al- Sada	2.3	15	96	19664	103	15	94
16	SS 16	New Baquba	2.5	14.5	121	18774	93	33	97
17	SS 17	Gatoun(2)	2.6	13.3	133	23546	87	21	103
18	SS 18	Al- Takia	3.5	15.5	116	29885	83	42	90
19	SS 19	Mafrak	4.2	16	97	27353	103	68	88
20	SS 20	Al- Muhandeseen	3.6	15	124	22654	115	77	92
Average			2.4	13.8	133	21532	111	51	99
Ranges			1-4.2	11-17	96-275	15304-29885	58-178	15-128	80-156
Inter. mean in soil (Lindsay, 1979)			0.06	8	100	38000	40	10	70

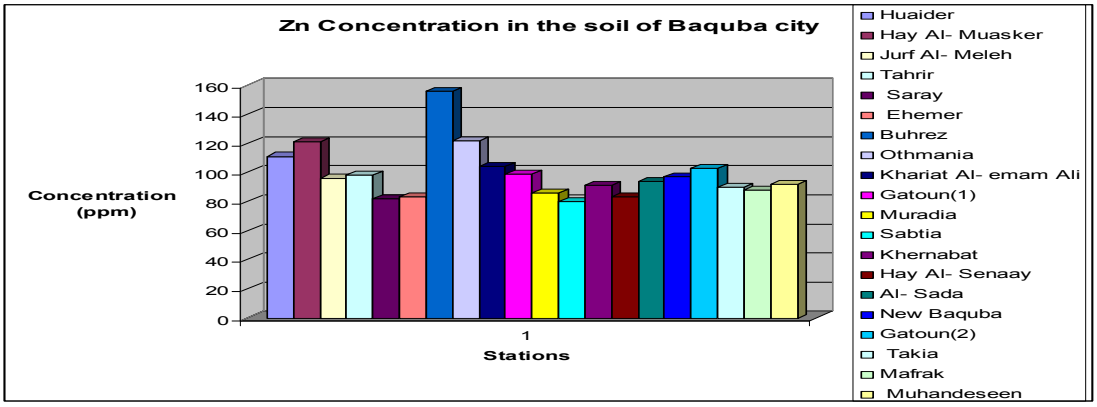

Fig. 9: Zn concentration in the soil of Baquba city

Factors Controlling the Distribution of Heavy Metals in the Soil:

Many factors and variables govern trace metal behavior in soils and sediments in complex ways [18]. These factors are: Organic matters (O.M.), Clay minerals, Iron oxides and pH [11]. Mineral and organic soils can bind metals to different extents. Organic matter, Fe oxides, and clay content are the most significant soil properties influencing sorption reaction [19], [20].

1- pH:

pH plays an important role in the mobility of heavy metals in the soil which controlled directly by the solution of metals hydroxides, in addition pH affects the solution of organic matters and the charge on the iron and aluminum oxides, increasing of pH for soil increase the ability of soil to catch the metals on the soil surface through absorption process [21]. High pH soils may have an inadequate availability of iron, manganese, copper, zinc, and especially of phosphorus and boron [22]. Trace elements in soils depends on contaminants concentration, chemical speciation, water movement & soil matrix properties such as mineralogy, pH & redox potential, the solubility of trace elements increases with decrease pH value of soil towards acidity [23].

The value of soil pH in this study ranging (9.0 - 9.2) with average (9.1) (Table 2). the values of pH in the soil samples were over (9.0) in the tow highest soil samples in the concentration of heavy metals and the tow lowest soil samples in the concentration of heavy metals. So it can not consider as an important factor that controlling the mobility of heavy metals in the soil of Baquba city.

2- Organic Matter (O.M.):

The organic matter in the soil can be described quantitatively by the organic level of carbon, Soil organic matter is quite effective in retaining metals, humus and other organic matter compounds can chelate metals and form stable complexes [24]. The percentage of organic matter in the selected soil samples ranging (0.67- 1.0 %) with average (0.76 %), highest value was in Al- Ehemer soil

Table 2: Values of (O.M % & pH) for the selected soil samples

Sample No.	Samples ID	O.M %	pH
2	**Hay Al- Muasker**	0.82	9.0
6	**Al- Ehemer**	1.0	9.1
10	**Gatoun(1)**	0.54	9.2
14	**Hay Al- Senaay**	0.67	9.1
The mean		0.76	9.1

sample which has low concentration of the studied heavy metals, while the lowest value of the organic matter was in Hay Al- Senaay which has low concentration of the studied heavy metals(Table 2), therefore, we can conclude that the organic matter in the soil samples is not the controlling factors on the distribution of heavy metals in the present work.

3-Iron:

Iron oxides play an important role in adsorption reactions, the most frequent and stable iron oxides in soils are goethite (FeOOH) and hematite (Fe_2O_3). Metals such as Cd, Cu, Pb and Zn can be imprisoned within iron oxide structure under specific conditions, either by forming a true solid solution as clusters with the oxides, or by segregating within the oxide or at the oxide surface [25], [24]. The concentration of iron in the samples which have high concentration of heavy metals was ranging (24750- 24262 ppm) while its concentration in the samples with low concentration ranging (21223- 18543 ppm) (Table 1). but it still under the international limits of iron in the soils (38000 ppm), So it can be conclude that iron have not high concentration that can catch metals in the soil of Baquba city.

4-Clay Minerals:

The clay minerals are hydrous aluminum, magnesium or iron silicates Clay particles are usually negatively charged. This is a very important factor influencing sorption properties of The soil. There are at least two major possibilities as to how these charges are formed, firstly the hydroxyl groups which exist on the edges and on the outer layers of minerals can dispose of hydrogen which is bonded with oxygen probably covalently, not very tight. This is a pH- dependent process and the ability to split the hydrogen atom decreases when pH decreases [26].

Table 3: The results of Grain size analysis and XRD for the selected soil samples

Sample No.	Samples ID	Clay %	Silt %	Sand %	XRD
2	**Hay Al- Muasker**	14.6	13.8	71.6	Quartz, Calcite, Feldspar, Dolomite, Halite, Gypsum, Trace Palygorskite, Trace Kaolinite.
6	**Al- Ehemer**	18	25.5	61.4	Quartz, Calcite, Feldspar, Dolomite, Halite, Kaolinite, Trace Palygorskite, Trace Montmorillonite.
10	**Gatoun(1)**	13.1	42.9	44	Calcite, Quartz, Feldspar, Dolomite, Gypsum, Kaolinite, Palygorskite, Montmorillonite.
14	**Hay Al- Senaay**	24	38.5	37.5	Calcite, Quartz, Feldspar, Gypsum, Kaolinite, Palygorskite, Montmorillonite.
Mean		17.4	30.2	53.6	

Grain size analysis was conducted to know the percentage of clay, sand and silt (Table 3). The soil texture of Baquba city is sandy loam according to [27], in [28] (Fig. 10). Soil texture plays an important and significant role in the ability to exchange and retain substances that are transported in the soil solution [28]. The clay minerals in these samples were (Trace Palygorskite, Trace Kaolinite and Trace Montmorillonite) (Table 3).

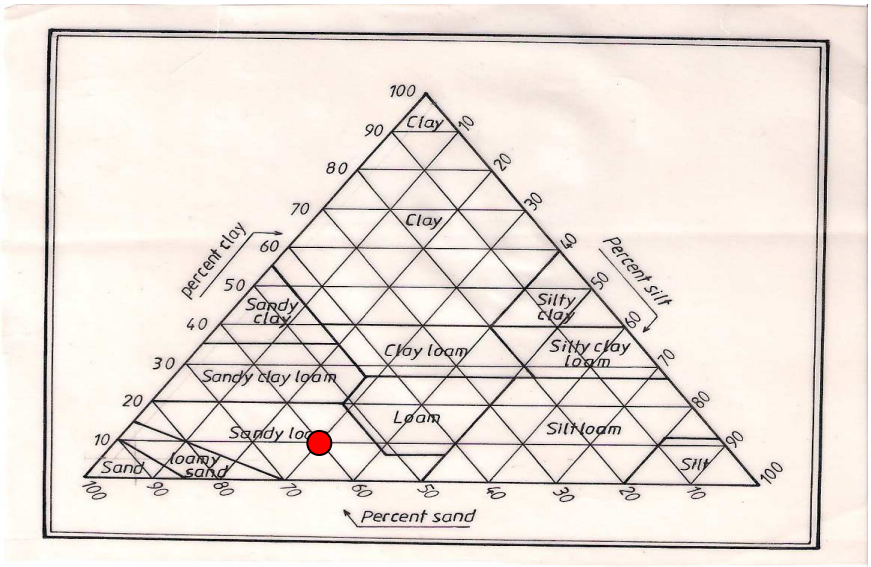

Fig. 10: Texture classes adopted by the US department of agricultural after (USDA, 1999, in Perk, 2007)

The percentage of clay minerals in the present work was (14.6- 13.1 %) in the soil samples with high concentration of heavy metals and it s less than the clay minerals percentage in the soil samples with low concentration of heavy metals (18- 24 %), therefore we can not consider the clay minerals as as a natural probable factor that contributed in controlling in the concentration of heavy metals in the soil of the area of study.

The increasing of some heavy metals concentration in soil samples couldn't due to the control of natural factors like pH, OM, Iron & clay minerals. That's indicated to the anthropogenic activities role in increasing of the concentration of some heavy metals, in addition the type of soil and parent rocks that forming this soil and its contents of heavy metals.

Conclusions:

The results which obtained from the present work show that soil of Baquba city were found to be significantly contaminated with metals like Cr, Ni, Pb and Zn at levels above the background concentration in the international soils, which may give rise to various health hazards, while the concentrations of Cd, Co and Fe were under the background concentration in soil. The study of factors (pH, OM, Iron & clay minerals) that controlling the distribution of heavy metals in soil showed that these factors didn't influence on the concentration of heavy metals in the soil samples which reveal the anthropogenic activities role in increasing of the concentration of some heavy metals in the soil of Baquba city, in addition the type of soil and parent rocks that forming this soil and its contents of heavy metals.

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