HEAVY METALS POLLUTION OF WHEAT FIELDS (SOIL AND LEAVES) SAMPLED FROM BASRAH AND MAYSAN PROVINCES

PERIÓDICO TCHÊ QUÍMICA
ARTIGO ORIGINAL

POLUIÇÃO POR METAIS PESADOS EM CAMPOS DE TRIGO (SOLO E FOLHAS) AMOSTRADOS NAS PROVÍNCIAS DE BASRAH E MAYSAN

HEAVY METALS POLLUTION OF WHEAT FIELDS (SOIL AND LEAVES) SAMPLED FROM BASRAH AND MAYSAN PROVINCES

التلوث بالمعادن الثقيلة في حقول الحنطة (عينات تربة و اوراق) في محافظتي البصرة وميسان

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RESUMO

Este estudo foi realizado para estimar o nível de alguns metais pesados, principalmente chumbo (Pb), cádmio (Cd), cromo (Cr) e cobalto (Co) no solo e nas folhas de trigo de algumas lavouras de trigo na província de Basra e Maysan; as áreas de amostragem foram Al-Qurna, Al-Madinah, Al-Amara, Kumit, Ali Al-Sharqi e Ali Al-Gharbi. A análise foi realizada utilizando um espectrofotômetro atômico de chama. Os resultados indicaram um aumento nas concentrações dos metais pesados mencionados acima em todas as áreas examinadas; Verificou-se que os níveis em solos agrícolas excediam os limites internacionalmente permitidos, de acordo com as normas da UE-2000; os níveis mais altos de poluição foram observados no local de Al-Qurna, com diferenças significativas em relação a outros locais, para as concentrações disponíveis e totais de metais pesados no solo. Indicando a disponibilidade dos metais, de acordo com as concentrações disponíveis no solo analisado, foi o seguinte: chumbo (21,32) > cobalto (14,63) > cromo (11,06) > cádmio (1,15) em mg/kg de solo. Além disso, os resultados mostraram que o maior teor de chumbo nas folhas de trigo foi examinado nos campos de Qurna (0,175 mg/kg), seguido por Amara com uma concentração de 0,136 mg/kg. A menor concentração de chumbo foi observada nas folhas de trigo nos campos de Kumit (0,007 mg/kg). Em relação à concentração de Cd nas folhas de trigo, o nível mais alto foi observado em Al-Qurna, com diferença significativa em relação aos demais campos, atingindo 0,009 mg/kg. A menor concentração Cd registrada em Ali Al-Gharbi, que atingiu 0,002 mg/kg. Os resultados da correlação entre a concentração disponível de elementos de metais pesados e as características do solo revelaram uma correlação significativa entre o pH do solo e as concentrações disponíveis de chumbo, cádmio e cromo, enquanto não foi observada correlação com o cobalto e uma correlação significativa entre a CE do solo e o chumbo, e uma correlação negativa altamente significativa com o cobalto. Os resultados provaram os altos níveis de poluição em todas as áreas examinadas nas províncias de Basra e Maysan.

Palavras-chave: *Metais pesados, poluição, Iraque, textura do solo, planta de trigo.*

ABSTRACT

This study was conducted to estimate the level of some heavy metals, mainly Lead (Pb), cadmium (Cd), chromium (Cr) and cobalt (Co) in the soil and wheat leaves of some wheat fields in Basra and Maysan province; the sampling areas were Al-Qurna, Al-Madinah, Al-Amara, Kumit, Ali Al-Sharqi, and Ali Al-Gharbi. It was performed the analysis using the Flame Atomic Spectrophotometer. The results indicated an increase in the concentrations of above mentioned these heavy metals in all examined areas; the levels in agricultural soils were found to be exceeding the internationally permissible limits according to EU-2000 standards, the highest levels of pollution were observed at Al- Qurna site with significant differences than other sites for both available and total HMs concentrations in soils. Indicating that the arrangement of the metals according to their available concentrations in the analyzed soil was as follows: lead (21.32)> cobalt (14.63) > chromium (11.06) > cadmium (1.15) as mg/Kg of soil. Additionally, results showed that the highest lead content in the wheat leaves was examined in the Qurna fields (0.175 mg/kg), followed by Amara with a concentration of 0.136 *mg/kg*. The lowest concentration of lead was observed in wheat leaves in the Kumit fields (0.007 mg/kg). In terms of Cd concentration in wheat leaves, the highest level was observed in Al-Qurna, with a significant difference from other fields, reaching 0.009 *mg/kg*. The lowest concentration of this HM was recorded in Ali Al-Gharbi, which reached 0.002 mg/kg. The results of the correlation between the available concentration of heavy metals elements and soil characteristics revealed a significant correlation between the soil pH and lead, cadmium, and chromium available concentrations, whereas no correlation with cobalt and a significant correlation between soil EC and lead was observed and a highly significant negative correlation with the cobalt. Results proved the high levels of pollution in all examined areas in Basra and Maysan provinces.

Keywords: *Heavy metals, pollution, Iraq, soil texture, wheat plant.*

الملخص

أجريت هذه الدراسة لتقدير مستوى بعض المعادن الثقيلة وهي الرصاص، الكادميوم، الكروم والكوبلت في تربة وأوراق بعض حقول الحنطة في محافظتي البصرة و ميسان. وكانت مناطق أخذ العينات هي القرنة والمدينة والعمارة وكميت وعلي الشرقي وعلي الغربي. تم إجراء التحليل باستخدام جهاز مطياف الامتصاص الذري.أظهرت النتائج زيادة في تراكيز هذه المعادن الثقيلة في جميع المناطق التي تم فحصها. تبين أن مستويات التربة الزراعية تجاوزت الحدود المسموح بها دوليًا وفقًا لمعايير الاتحاد الأوروبي لعام 2000 ، وقد لوحظت أعلى مستويات التلوث في موقع القرنة مع وجود فروقات معنوية عن المواقع الأخرى لكل من تراكيز المعادن الثقيلة الكلية في التربة والتراكيز الجاهزة وكذلك محتوى اوراق الحنطة من المعادن الثقيلة .أوضحت النتائج أن ترتيب المعادن حسب التراكيز الجاهزة في التربة هو كالتالي: الرصاص (21.32) > كوبالت (14.63) > كروم (11.06) > كادميوم (1.15). بالإضافة إلى ذلك ، أظهرت النتائج أنه تم فحص أعلى محتوى من الرصاص في أوراق القمح في حقول القرنة (0.175 ملغم / كغم) تليها العمارة بتركيز (0.136 ملغم / كغم). ولوحظ أقل تركيز للرصاص في أوراق الحنطة في حقول كميت (0.007 ملغم / كغم) . اما تركيز Cd في أوراق الحنطة فقد لوحظ أعلى مستوى في القرنة مع وجود فرق معنوي عن الحقول الاخرى حيث بلغ 0.009 ملغم / كغم. وسجل أقل تركيز لهذا المركب في علي الغربي والذي بلغ (0.002 ملغم / كغم). أظهرت نتائج الارتباط بين التركيز الجاهز للعناصر الثقيلة وخصائص التربة وجود علاقة معنوية بين الرقم الهيدروجيني للتربة والرصاص والكادميوم والكروم الجاهز في حين لم يلاحظ أي ارتباط بالكوبلت ، ووجد ارتباط بين ملوحة التربة والرصاص وارتباط سالب مع الكوبلت .أثبتت النتائج ارتفاع مستويات التلوث في جميع المناطق التي تم فحصها في محافظتي البصرة وميسان.

الكلمات المفتاحية: *المعادن الثقيلة، التلوث، العراق، نسجة التربة، نبات الحنطة.*

1. INTRODUCTION

Wheat is one of the main staple foods for feeding human populations throughout the world. Wheat crop *Triticum aestivum* L. is considered as one of the most important and economic crops in the world; and has a substantial role in food reserve all over the world, including Iraq. Their nutritious significance as a source of carbohydrates is remarkably increased during the last decades, and about 4.5 billion people of the third world are consuming wheat on a daily bases (Pathak and Shrivastova 2015; Verma and Khah, 2016). Nowadays, this crop is cultivated in more than seventy different countries worldwide, with approximately 920,096 acres of cultivated areas with around 3,052,939 million tons of harvested grains (FAO, 2017). Iraq, among these countries with wheat production 2974 thousand tons, as well as an area of 4,215,906 acres (Central Agency for Statistics and Information Technology, 2017).

Wheat plant is hugely influenced by several biotic and abiotic factors, causing a significant reduction in their production; among these abiotic factors; environmental pollution is raised as one of the most problematic stressors, and the direct impact of environmental pollution on human health has generated an increase of global concern. Heavy metals are among the most dangerous pollutants, and the seriousness of these pollutants is due to their toxicity and tends to accumulate in the soil and tissues of living organisms as well as their degradable behavior (Dalman *et al.,* 2006; Akbarzade, 2015; Baghvand *et al.*, 2010).Heavy metals are defined as metals or semi-metals whose density is more than (5 g/cm^3) (Sussiu *et al.*,2008). Heavy metals occur naturally, but they also enter into the ecosystem throughout at different concentrations of the anthropogenic activity (You *et al.*, 2015). Heavy metals, among them, are necessary for living organisms but at low concentrations and are toxic at high concentrations such as iron, zinc, chromium, and copper, while lead, cadmium, and mercury are considered as unnecessary elements that have no vital role yet and are toxic at any concentration (McGrath *et al.*, 2001)

Soil is the main storehouse of heavy metals that are emitted to the environment, and that soil pollution, especially agricultural ones, has raised the interest of specialists in this field, not only because of the accumulation of these minerals in the soil but because of the transfer of these toxic metals to crops that grow in polluted soils leading to their entry into the food leading to a significant effect on human health; in addition to plant growth and development (Huand *et al.*, 2007). Soil heavy metals are transported and accumulated in plant tissues that are consumed by humans, leading a severe accumulation in fatty tissue and cause nerve damage and influence on the endocrine system, immunity, and natural cellular metabolism and other processes (Waisberg *et al.*, 2003; Wang, 2013).

Plants are one of the most sensitive types of organisms that capable of concentrating high levels of heavy metals because they are immobile and their ability to accumulate minerals by absorbing them from the soil or through precipitation into the atmosphere (Zurayk *et al.*, 2001). Plant responses to heavy metals are varied according to the plant species, heavy metals, and their concentrations or forms, the responses appear on plants through their morphology to the biochemical level, such as increasing or decreasing the level of some compounds and molecules in cells or in physiological and biological processes and anatomical composition of the plant, and their effect may reach the level of genetic stability (Shahid *et al.*, 2014). The heavy metals toxicity to plants may be attributed to the enzyme inhibition by binding their sulfhydryl groups (Choudhry and Panda, 2004), it reduces the relative content of water and transpiration by affecting the water balance (Krantev *et al.*, 2006), and increasing the permeability of the plasma membrane. Inhibition of photosynthesis pigments such as chlorophyll-a, b, and carotenoids, and increases reactive oxygen species (ROS) are other plant responses to heavy metals accumulation (Abass *et al.*, 2016); lipid peroxidation is one of the most common responses to heavy metals accumulation on plant cell level (Zouri *et al.*, 2016).

Among the toxic heavy metals, the most dangerous ones are lead, cadmium, chromium, and cobalt, many local studies have indicated the high levels of pollution of heavy metals in Iraqi soil and their transcendence to the internationally accepted limits (Abass *et al.,* 2015; Al-Jabary *et al.,* 2016*).* The internationally permitted rate according to the standard indicators of lead in agricultural soils is 100 mg/kg of soil and cadmium 3 mg/kg soil. It was found that the rate of accumulation of lead in the different soils of Basra exceeded the international limits, some of which reached 270 mg/kg, and cadmium at a rate of 9 mg/kg of soil (Abass *et al.*, 2015; Abass *et al.*, 2017), indicated that there is a variation in the accumulation rate of lead, cadmium, chromium and nickel elements in different regions of Maysan Governorate, some of which are across the internationally permissible level (Tawfiq and Ghazi, 2017). The aims of the present work were to determine the heavy metals pollution in different wheat fields soil and plant parts in Basra and Maysan governorates.

2. MATERIALS AND METHODS

The study was conducted at the laboratory of the Plant Protection Department/ from the College of Agriculture of the Basra University of Basrah.

2.1 Description of sampling sites

Maysan province is located in the southeastern part of Iraq, and it is confined between two latitudes (15-31° - 45-32) in the north and between longitude (30 - 46 ° - 30 - 47 °) in the east, and it is bordered in the south by Basra province, while it is bordered in the east and northeast by Iran.

Basrah Governorate is located in southern Iraq and is bordered by Iran, Kuwait, and Saudi Arabia. It is located at 30.53 degrees north latitude, 47.79 degrees east longitude, and 3 meters above sea level. Maysan Governorate is located along with the Basrah Governorate to the north**.** Six different regions in Basra and Maysan were selected to collect soil samples and leaves of wheat plants. The study sites were: Al-Qurna and Al-Madinah in Basrah province, Al-Amara, Ali Gharbi, Ali Al-Sharqi, and Kumait in Maysan province**.**

2.2 Samples collection

Five fields were selected from each site, marked in Figure 1, and compound soil samples were taken at a depth of 30 cm from each site. Samples of wheat were collected at the age of two months and brought to the laboratory.

2.3 Samples preparation

The soil samples were air-dried, mixed, and homogenized well, then passed through a plastic sieve with a diameter of 2 mm, after that the following characteristics were estimated:

2.3.1 Soil texture

The Pipette method was used in Miller and Miller (1987), after extracting the proportions of the three soil segments of sand, silt, and clay - the soil texture triangle is used to determine the soil texture*.*

2.3.2 Organic matter

It was weighed 1 gram of soil in a glass beaker of 500 ml capacity and add 10 ml of potassium dichromate solution N1, add concentrated sulfuric acid, move the beaker well to mix the suspension, leave for 30 minutes, add 200 ml of distilled water, add 10 ml of concentrated phosphorous acid Leave the mixture to cool, add 10 drops of Di-phenyl amine guide, add a magnetic bar and put the beaker on a magnetic stirring device, titrate the ferrous sulfate solution and ammonium sulfate 0.5 m until the color changes from blue to purple to green, bring two blanks containing all the solutions except the soil. The proportion of organic matter is calculated according to the formulas mentioned in (Schulte, 1995).

2.3.3 Cation exchange capacity (CEC)

Weigh 4 g anaerobically dry soil in a 40 mL centrifuge tube, add 1 mL of sodium acetate solution (ternate water molecules) N1, shake the tube for five minutes, remove the plug from the tube and place the tube in the centrifuge 3,000 r / min until it becomes Floating liquid is clear, the clear liquid is completely filtered and then cast. Repeat the process four times with 33 mL of sodium acetate solution (triple water molecules) N1. Each time the floating liquid is filtered, then add 33 mL of 95% ethyl alcohol, clog the tube and shake for 5 minutes, lift the plug and place the tube in the centrifuge until The floating liquid becomes clear. Wash the sample with ethyl alcohol (95%) three times, each time the floating liquid is filtered so that the clear conductivity of the clear liquid after the third wash is less than 400 m / cm. Replace the chopped sodium from the sample by adding 33 mL of ammonium acetate solution N1 three times each time shaking for 5 minutes. We measure the soil extract and spectrum readings by flame spectroscopy at a wavelength of 767 nm. Calculate the sodium (Na) concentration according to the calibration curve. (Polemio and Rhoades, 1977).

2.3.4 Soil Ph

From dry soils it weighed 50 g in a 100 mL glass Baker, then add 50 mL of distilled water, then mix the suspension and leave it for 3 minutes and move the suspension every 10 minutes, after an hour we move the suspension and then place the combined electrode (German model PH 7110) in the suspension with a depth of about 3 cm. The reading was taken after 30 seconds (McLean 1982).

2.3.5 Soil salinity

Prepare a suspension (1: 1) (soil: water), then filter the suspension using a vacuum filtration system, put filter paper type Whatman No.42 and in a Buchner funnel, then transfer the filtrate to a 5 mL beaker, then record electrical conductivity using (Italian-made Milwaukee-SM302) (Richards, 1954).

2.3.6 Percentage of major nutrients N.P.K

Ion (NH_4) was estimated by extracting with potassium chloride solution (2N) and using MgO, and measuring it using the microceldal device. The nitrate ion was estimated by reducing it via the Devarda alloy, then by using the microceldal device according to a method according to the Brenner (1965) method described in Black (1965). Phosphorous was extracted using $NaHCO_3$, then with ammonium molybdate and ascorbic acid. It was estimated by the spectrophotometer at a wavelength of 882 nm Page *et al*. (1982). Potassium was extracted with ammonium acetate solution(1N) and then measured with Flame- photometer (Black,1965).

2.4 Determination of heavy metals in soil samples and wheat leaves

Determination of the total and available concentrations of lead metal (Pb), cadmium (Cd), chromium (Cr) and cobalt (Co) in the soil was performed using the Flame Atomic Spectrophotometer (Perkin Elmer AAS analysis 300, *USA) according to the following extraction methods:*

2.4.1 Extraction of the total concentrations of heavy metals in the soil

Extraction was done according to the method described in Davidson (2013) by acid digestion procedure,1 g of dried soil was crushed in a Teflon Beaker heat-resistant plastic baker and moisten with water, then 10 ml of HNO_3 was added, the mixture was then heated at 75°C, and left to evaporate until the volume remains 2 ml, then add a mixture of HNO_3 (25 mL) and 5 mL $HClO_4$ (70%) and 1 ml of Hydrofluoric acid (HF) gradually and carefully and heated the mixture (without boiling) until the appearance of brown fume, then add 1 mL of hydrofluoric acid (1:1) (volume:volume), Half an hour after the appearance of brown fume, then heated for a period of 10 minutes, then diluted with distilled water to 100 ml.

2.4.2 Extraction of the available concentrations of heavy metals in the soil

Extraction solution consisting of:(0.005mol/L of DTPA, diethylenetriaminepentaacetic acid, 0.01 mol/L of calcium chloride $CaCl_2$ and 0.1 mol/L of TEA Triethanolamine), was used to extract the available concentrations of heavy metals in soils; 30 ml of the extraction solution was added to 15 g of dry soil in a glass jar, then shacked well for two hours with a mechanical shaker, then filtered through Whatman. No.4 filter paper, and diluted to 100 ml with distilled water.

2.4.3 Extraction of heavy metals in the wheat leaves

Heavy minerals were extracted from the wheat plant leaves using the method of wet acid digesting according to the protocol described in Jones (1984). Briefly, by adding 5 ml of nitric acid (70%) and 1.5 ml of hydrochloric acid (60%) to 0.5 g of a sampled leaves, then heated until brown fume disappeared, 5 ml of dilute hydrochloric acid (1:1) was added, and the mixture was diluted to 25 ml with distilled water.

2.5 Permissible limits for heavy metals

The permissible standard limits for the total soil concentration of heavy metals were adopted from the European Union (2006) to compare the results, and the permissible levels are Lead (Pb) 100 mg/kg, Cadmium (Cd) 3 mg/kg, Chromium (Cr) 100 mg/kg and Cobalt (Co) 50 mg/kg.

2.6 Statistical analysis

The experiment was designed using Complete Randomization Design (C.R.D), and the Least Significant Difference (L.S.D) test was used to compare the averages at the 0.05 probability level. The Statistical Package for Social Science (SPSS) version (21) was applied data analysis, and the results represented an average of three replicates per treatment.

3. RESULTS AND DISCUSSION:

3.1 Soil properties:

The results of Table (1) showed the soil properties for the study sites that were chosen to assess the levels of pollution of heavy metals in some fields of Basra and Maysan provinces. The results showed that the pH values were close between the study sites, and their values ranged between 7.2 and 8.1. Al-Qurnah fields recorded the highest electrical conductivity value of 16.76 dS/m and the lowest value in Ali Al-Gharbi fields, which was 7.50 ds /m. The results of the organic matter percentage for the study sites showed that the Al-Qurna site recorded the highest percentage by 1.80% and with a significant difference from other examined sites. As for the Cation exchange capacity ions, Al-Madinah recorded the highest value, which was 34.71 Ctmol/kg, and the lowest value was in a Kumit site of 13.49 cm/kg, and the results showed that the highest value of nitrogen content element was seen in Ali Al- Sharqi fields by 113.17%, and there are no statistically significant differences between the values of phosphorous for all examined sites. As for the potassium component, Ali Al- Sharqi fields recorded the highest percentage, 121.2%, significant differences than other sites.

Table (2) showed the results of soil texture of the study sites, it was found that the Al-Qurna, Medina, and Al-Amara fields were silt soils, while the soil textures of Ali Al-Sharqia was clay soils, and Ali Al- Gharbi fields were clay sand soils.

3.2 The total concentration of heavy metals in the soil

The results of Table (3) showed the total concentrations of lead, cadmium, chromium, and cobalt minerals in the soil of several fields in Basra and Maysan provinces, the highest concentrations of these metals were examined in the soil of Al-Qurna fields, and reached 319.93, 10.79, 130.29 and 50.56 mg/kg, respectively, while the lowest concentrations of lead appeared in the soil of Ali Al-Gharbi fields, as it reached 159.98 mg/kg without a significant difference from the fields of Ali Al-Sharqi and Kumit, and a significant difference from the soil of the fields of the rest of the sites.

The lowest concentration of cadmium was reported in the soil of Ali Al-Sharqi fields, as it reached 3.03 mg/kg and without a significant difference from the areas of Kumit and Ali Al-Gharbi. While the chromium, the soil fields of Kumit and Ali Al-Gharbi recorded the lowest concentration 10, 88, 90 and 89 mg/kg respectively, and cobalt element was found to be the lowest total concentration in the soil of Kumait fields, as it reached 25.39 mg/kg, without significant differences were recorded between Ali Al-Gharbi and Ali Al-Sharqi.

To assess the level of pollution of heavy metals in the soil of some fields in Basra and Maysan governorates, the total concentrations of the examined metals were compared with the permissible limits for the total concentration of heavy metals in the soil according to the European Union standard 2006, it was noted that the concentration of lead, cadmium and chromium metals exceeded the permissible limit which was 100 mg/kg for lead, 3 mg/kg for cadmium and 100 mg/kg for chromium and that cobalt concentrations were within the permissible limit of 50 mg/kg with an exception for the soil of Al-Qurna fields, as it reached 50.56 mg/kg.

3.3 Available concentrations of heavy metals in the soil

The results of Table (4) showed the available concentrations of heavy metals lead, cadmium, chromium, and cobalt in the soils of some wheat fields of Basra and Maysan provinces, and the results indicated that the highest concentration of lead was examined in the soil of the Al-Qurna fields as it reached 37.32 mg/kg with a significant difference from the rest of the fields, while the lowest concentration was examined in the soil of Ali Al-Gharbi field (13.58 mg/kg). The highest available concentration of cadmium was found in Al-Qurna fields, and reached 1.89 mg/kg, while the lowest concentration was reported in the fields of Kumit, as it reached 0.83 mg/kg with a significant difference than those observed in other fields. The results indicated that the soil of Al-Qurna fields had the highest concentration of Cr with an average of 22.50 mg/kg, while the soil of Ali Al-Sharqi fields had the lowest concentration, as it reached 6.16 mg/kg. The cobalt was found to be high in the fields of the Al-Amarah fields 18.37 mg/kg and without a significant difference from the soil of the fields of Ali Al -Sharqi region that recorded a concentration of 16.52 mg/Kg.

The concentration of HMs, according to their availability, was as follows: Lead (21.32) > Cobalt (14.63) > Chromium (11.06) > Cadmium (1.15). As for the arrangement of the regions according to their pollution with heavy elements, they were as follows:

Lead: Al-Qurna > Al-Amara > Al-Madinah > Ali Al-Sharqi > Kumit > Ali Al-Gharbi, cadmium: Al-Qurna > Al-Amara > Al-Madinah > Ali Al-Sharqi > Ali Al-Gharbi > Kumit

Cobalt: Al- Amara < Ali Al-Sharqi > Kumit > Ali Al-Gharbi > Al-Qurna > Al-Madinah

Chromium: Al-Qurna > Ali Al- Gharbi > Al-Amara > Kumit > Al -Madinah > Ali Al-Sharqi.

Abass *et al.* (2015) showed that the concentrations of heavy elements, Lead, Cadmium, Cobalt, and Chromium exceeded the internationally permitted limits, as the concentrations of these elements were 115.00, 2.80,10.25 and 60.50 mg/kg respectively. Al-Jabary *et al.* (2016) stated that the concentrations of lead, cadmium, cobalt, and chromium increased and exceeded the internationally permitted limits and were recorded 196.73,6.27,35.9 and 107.93 mg/kg, respectively. Khan *et al.* (2016) indicated that the cadmium and chromium exceeded the internationally permissible limits as it reached 0.58 mg/ kg and 50 mg/ kg, respectively. A study conducted by Al-Moussawi and Mustafa (2016) on the soil of Al-Qurna and Al-Madinah revealed the variation in the level of cadmium and led concentrations in the soil of the study sites, which exceeded the internationally allowed limit.

3.4 Heavy metals content in wheat leaves

The results of Table (5) showed the content of heavy metals in the wheat leaves in some areas of Basra and Maysan governorates. The highest lead concentration was 0.175 *mg/kg*, which examined in the Qurna fields, followed by Amara with a concentration of 0.136 *mg/kg*. The lowest concentration of lead was observed in wheat leaves in the Kumit fields (0.007 mg/kg). The highest concentration of Cd was recorded in wheat leaves in Al-Qurna, with a significant difference from other fields, reaching 0.009 *mg/kg*. The lowest concentration of this HM was recorded in Ali Al Gharbi, which reached 0.002 mg/kg.

Kearallah *et al*. (2016), indicated that the average heavy metals of lead for the dry and rainy seasons ranges between 33.4 -35.42 mg/kg, and cadmium ranges between 3.23 -3.60 mg/kg. In a study conducted by Abu –Shanab *et al.,* (2007) on sixty-one plant species in soils contaminated with heavy elements, the content of plants from heavy elements varies, as the concentration of lead was found between 1- 508 mg/kg and cadmium 0.2-6 mg/kg.

3.5 Correlation between the total concentration of heavy metals and soil properties

The results of Table (6) showed the correlation coefficient analysis between the soil characteristics and total concentration of heavy metals, a highly significant negative correlation was seen between HMs content and soil pH, as well as a significant correlation between lead and cadmium with EC. There was no significant association between heavy metals and other soil characteristics.

The results of Table (7) analyzing the correlation between the available concentration of heavy elements and soil characteristics, a significant correlation between the soil pH and lead, cadmium, and chromium available concentrations, whereas no correlation with cobalt and a significant correlation between soil EC and lead was observed and a highly significant negative correlation with the cobalt. No correlation was observed between OM and CEC with available concentrations of heavy metals, with an exception for the cobalt, which recorded a highly significant negative correlation, and no association was observed between heavy metals and major nutrients NPK.

Several studies showed the importance of soil properties and HMs availability. Vishun *et al.* (2007) concluded that the cadmium extracted from clay, sand, and calcareous soils was 8.92, 5.13, and 7.17 mg/kg soil, respectively, and that the amount of cadmium ready increased as the soil content of clay increased.

Zueng (2009) mentioned that the amount of cadmium extracted from the soil is determined by the value of the soil pH as it increases with the increase in the value of soil pH. CEPA(1994) found that high levels of organic matter encouraged the formation of cadmium complexes with organic matter in the soil. The behavior of chromium compounds in the soil is determined by the degree of soil interaction, the soil content of clay, organic matter, oxidation, and reduction effort (Kabata - Pendias and Pendias, 1992). Monday and Michael (2004) concluded that the amount of lead extracted was 98, 198, and 127 mg/kg soil in Spain with pH 7.3, 7.4, and 7.3, respectively, and different content of sand, silt, clay, and organic matter. Additionally; El khatib *et al.* (1990) found that the amount of availability of lead was determined by the quantity and quality of clay minerals, as the amount of lead in clay soil was greater than sandy soils, and this was due to the positive ion exchange capacity of the clay.

4. CONCLUSIONS:

Results revealed that the concentrations of lead, cadmium, cobalt, and chromium elements had been exceeded the internationally permitted limits, and the high concentration of lead and cadmium elements in wheat leaves indicated the soil pollution with these two elements. A difference was observed in the association between heavy elements and chemical soil properties, indicating the effect of some of these properties on the readiness of heavy elements and some traits that do not affect the readiness of heavy elements in the soil.

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Figure 1. Sampling map in different regions at Basra and Maysan provinces.

Table 1. *Soil properties of investigated sites.*

Sites	EC	PH	CEC	OM	N%	P%	K%
Al-Qurna	16.76	7.2667	24.4867	1. 8033	74.0000	0.0437	89.4667
Al-Madinah	14.52	7.5333	34.7167	1.7500	63.3333	0.0720	72.9133
Al-Amarah	12.53	7.6667	18.2167	0.9167	113.1700	0.0883	99.4767
Kumit	9.60	8.1333	13.4900	0.6733	58.8000	0.0943	71.4200
Al-Al Sharqi	8.4	7.7000	24.5533	0.8367	57.3933	0.1057	121.1967
AliAl Gharbi	7.50	7.5000	29.1700	0.7733	108.1000	0.0947	70.8333
L.S.D	0.856	0.30	0.122	0.086	5.189	0.128	9.678

Table 2. Particle size distribution of studied soils.

Sites	Soil texture	Sand %	Clay %	Silt %
Al-Qurna	silt	3	32	65
Al-Madinah	silt	6	24	70
Al-Amarah	silt	7	32	61
Kumit	silt	13	25	61
Ali Al Sharqi	clay	1	58	41
Ali Al Gharbi	Clay sand	25	-	24

Table 3. the total concentrations of heavy metals (*mg/kg*) in the soils of the study sites.

Sites	lead	Cadmium	Cobalt	Chromium
Al-Qurna	319.93	10.79	50.56	130.29
Al-Madinah	219.99	5.29	33.13	85.27
Al-Amarah	259.05	5.88	42.26	119.32
Kumit	153.74	3.15	25.39	89.90
Ali Al Sharqi	162.20	3.03	35.82	88.10
Ali Al Gharbi	159.98	3.16	35.97	96.53
L.S.D	11.60	0.20	5.83	10.27

Table 4. The available concentration of heavy metals (mg/kg) in the soils of the study sites.

Sites	lead	Cadmium	Cobalt	Chromium
Al-Qurna	37.32	1.89	13.14	22.50
Al-Madinah	20.23	1.04	8.69	8.29
Al-Amarah	24.13	1.31	18.37	9.53b
Kumit	15.95	0.83	15.54	8.58
Ali Al Sharqi	16.72	1.01	16.52	6.16
Ali Al Gharbi	13.58	0.85	15.48	11.31
L.S.D	2.38	0.17	3.24	6.31

Table 5. heavy metals content (mg/kg) in wheat leaves in the study sites.

sites	Lead	Cadmium
Al-Qurna	0.175	0.009
Al-Madinah	0.118	0.007
Al-Amarah	0.136	0.007
Kumit	0.007	0.006
Ali Al Sharqi	0.017	0.002
Ali Al Gharbi	0.021	0.002
L.S.D	0.06	0.001

Table 6. Analysis of correlation between the total concentration of heavy metals and soil characteristics of study sites.

Metal	PH	EC	OM	CEC	N	P	K
Pb	0.633**-	0.573*	0.380	0.071	0.198	0.372-	0.114
Cd	0.644**-	0.580*	0.336	0.084	0.061	0.328-	0.038
Cr	-0.6.33**	0.094	0.110-	0.237-	0.449	0.155-	0.159
Co	0.785**-	0.277	0.155	0.148	0.361	0.104-	0.334

* significant ** high significant

Table7. Analysis of correlation between the available concentration of heavy metals and soil characteristics of study sites.

Metal	PH	EC	OM	CEC	N	P	K
Pb	0.563*-	0.503*	0.267	0.019-	0.011	0.291-	0.159
Cd	0.587*-	0.431	0.199	0.003-	0.075	0.230-	0.251
Cr	0.527*-	0.306	0.044	0.037	0.122	0.275-	0.123-
Co	0.354	0.811**-	0.777**-	0.637**-	0.386	0.212	0.430

* significant ** high significant