Effect of interaction for phosphate fertilization and the quality of irrigation water on the accumulation of some heavy elements in the soil

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ABSTRACT

The field experiment was conducted in the project of developing the cultivation of Tomato by the modern technologies belonging to the Directorate of Agriculture in Basra, Khor Al-Zubair, Basra province, which is about 31 km from the center of province during the autumn agricultural season (2017-2018) in order to study the effect of adding Types of phosphate fertilizers are: The concentrated Super Phosphate (CSP), NPK fertilizer and Diammonium Phosphate (DAP) fertilizer to sandy loam soil that irrigated with two types of water: well water and tap water on soil contamination with heavy elements (cadmium (Cd) and lead (Pb), nickel (Ni) and cobalt (Co)) at the end of growth season. Samples were taken from the field soil at the depth of (0 - 30 cm) and analyzed to estimate the availability from the heavy elements (Co, Ni, Pb, Cd) at the end of the growing season. The results of the study showed the soil that fertilized with phosphate fertilizers, whether CSP or NPK or DAP, which is a source to provide the phosphorus element for the plant in soil that is not contaminated with heavy elements (Co, Ni, Pb, Cd) when compared with natural limits as identified by [20] and with the critical elements of the total quantity as described in [17] and their percentage is insensible even though these fertilizers contain high concentrations of some heavy elements. The studied elements took the following order in terms of their available quantity in the soil after the end of the growth season (Co <Cd <Ni <Pb).

تأثير التداخل للتسميد الفوسفاتي ونوعية مياه الري في تراكم بعض العناصر الثقيلة في التربة

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المستخلص:

أجريت التجربة الحقلية في مشروع تطوير زراعة الطماطة بالتقانات الحديثة التابع لمديرية زراعة البصرة في خور الزبير- محافظة البصرة خلال الموسم الزراعي الخريفي 2017 - 2018 لدراسة تأثير أضافة أنواع من الأسمدة الفوسفاتية وهي السوبر فوسفات المركز (Concentrated Super Phosphate CSP) وسماد المركب NPK وسماد الداب (Diammonium Phosohate DAP) الى تربة رملية مزيجه المروية بنوعين من المياه هي مياه الآبار ومياه الأسالة في تلوث التربة بالعناصر الثقيلة الكادميوم (Cd) والرصاص (Pb) والنيكل (Ni) والكوبلت (Co) نهاية موسم النمو ، أخذت نماذج من تربة الحقل وعلى العمق (30 – 0) وحللت لتقدير الجاهز من العناصر الثقيلة (Co,Ni, Pb,Cd) نهاية موسم النمو ، وأظهرت نتائج الدراسة أن التربة المسمدة بالأسمدة الفوسفاتية سواء السوبر فوسفات المركز CSP او NPK أو DAP التي هي مصدر لتوفير عنصر الفسفور للنبات هي تربة غير ملوثة بالعناصر الثقيلة (Co,Ni, Pb,Cd) عند مقارنتها مع الحدود الطبيعية كما حددها [20] ومع الحدود الحرجة للكمية الكلية كما ورد في [17] وتكاد تكون نسبتها غير محسوسة رغم أحتواء تلك الأسمدة على تراكيز عالية من بعض العناصر الثقيلة ، وأتخذت العناصر المدروسة الترتيب التالي من حيث كميتها الجاهزة في التربة بعد نهاية موسم النمو Co < Cd < Ni < Pb.

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1. INTRODUCTION

Phosphorus is considered one of the basic and important elements needed by the plant to complete its life cycle, it must be readily available in the soil to be absorbed by the plant. the importance of phosphorus stands out for its role in various bioactivities within the plant such as photosynthesis, cell division, seed formation, regulation of cellular processes and transmission of genetic traits [6]. Phosphorus is one of the essential elements which should be available for the plant, so Phosphate fertilizers such as the concentrated superphosphate fertilizer, Diammonium phosphate (DAP) fertilizer, and NPK compound fertilizer are added as a source to supply the plant with phosphorus. Several studies have confirmed that phosphate fertilizers contain heavy elements (Cr, Ni, Cd, Pb, Co), It is considered more polluted than nitrogen fertilizers. The concentration of Cd in the concentrated superphosphate fertilizer amounted to (27 - 48 $mg.kg^{-1}$)[28]. The increase of cadmium in the growth environment is due to the increase of phosphate fertilizers and that the fastest parts of the plant absorption of heavy elements are roots and leaves, causing rapid damage [22]. The Concentrated superphosphate (CSP) contains the highest concentration of cadmium, chromium, and nickel and it is considered contaminated with nickel and cadmium as compared to other phosphate fertilizers [7]. The soil content of cadmium, nickel, lead, and chromium increases with the use of phosphate fertilizers [14]. The gravity of the heavy elements on the environment through the impossibility of biological collapse and the transition through the food chain [19]. World Health Organization (WHO) has confessed that some heavy elements have the potential to accumulate in different human organs with highly toxic quantities, especially Cd, Hg, Pb [22]. Water has become the main challenge for the 21st century. The integrated water resources management is an essential prerequisite for the planning process for sustainable development and relying on one source of water is a threat to development projects, especially in rivers shared by more than two countries, as in the Tigris and Euphrates rivers in Iraq. And other sources of water, as well as to rationalize and optimize the use of water and not to waste it [10]. The regions of the Tigris and Euphrates have witnessed a marked decrease in the overall rainfall from 510 mm to 385.8 mm, causing a decrease in the water level of the Tigris and Euphrates Rivers [4]. The decline of each billion cubic meters of Euphrates water equivalent to the loss of approximately 26 thousand acres of agricultural land and 40% of arable land due to reducing water levels and rise it salt [11]. The water of the central and southern regions of Iraq suffers from contamination due to the water of agricultural drainage and industrial wastewater, which is a danger to sustainable development projects in Iraq. Groundwater in Iraq is considered the third source, a renewable water source, with a renewable reserve estimated at 6.2 billion cubic meters, of which 930 million cubic meters in the desert areas [13]. The difference in the concentration of heavy metals in groundwater (As, Ni, Co, Zn, Cr, Fe) depends on the number of contaminants leaking from fertilizers and pesticides to groundwater and the nature of the geological region [8]. Groundwater content with high concentrations of certain heavy elements (Cd, Ni, Hg) is associated with the proximity of groundwater from areas of industrial activity, as well as to medical facilities and hospitals [26]. Therefore, this study was conducted to evaluate the soil contamination treated with phosphate fertilizers in the studied heavy elements (Ni, Cd, Co, Pb) after cultivating.

2. MATERIALS AND METHODS

The field experiment was conducted in the project of developing the cultivation of Tomato by the modern technologies belonging to the Directorate of Agriculture in Basra, Khor Al-Zubair, Basra province, which is about 31 km from the center of province during the autumn

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agricultural season (2017-2018) in order to study the effect of different types of phosphate fertilizers and the quality of irrigation water in the accumulation of some heavy elements in the soil of the study. Soil samples were randomly taken from the study location from several regions for the soil before cultivating at depth (0-30) cm. It then mixed homogeneous, and dried in the air, milled and sieved with a 2 mm diameter sieve. The analyses were conducted in the laboratories belonging to the Department of Soil Science and Water Resources, College of Agriculture, University of Basra. The following traits were measured: pH, electrical conductivity EC as described in [15], total solid carbonates [16] and cation exchange capacity (CEC), total nitrogen, organic carbon, organic matter, C: N ratio, phosphorus availability, the dissolved ions as described in [15] (Ca^{+2}, Mg^{+2}, Na^{+1}, K^{+1}, HCO_3^{-1}, CO_3^{-2}, Cl^{-1}, SO_4^{-2}), the available content from heavy elements (Co, Ni, Pb, Cd) as described in [27] and the volumetric distribution for soil separates according to [15] as shown in Table (1). Some of the physical and chemical properties for the used irrigation water in the study (tap water, well water) as described in [27] and as shown in Table (2).

Table 1: Some chemical and physical properties for the soil before cultivating.

Soil characteristics	Units	Value
pH	—	7.55
Electrical conductivity (EC)	$dS.m^{-1}$	7.18
Total solid carbonates	$g.kg^{-1}$	100.00
Cation Exchange Capacity (CEC)	$cmol^{(+)}.kg^{-1}$	8.40
Total nitrogen	$g.kg^{-1}$	0.37
Organic Carbon	$g.kg^{-1}$	3.20
Organic matter	$g.kg^{-1}$	5.38
C: N ratio	—	9.39
Phosphorus availability	$mg.kg^{-1}$	10.40
Ca^{+2}	Dissolved ions $Mmol.L^{-1}$	20.00
Mg^{+2}		7.5
Na^{+1}		13.68
K^{+1}		1.39
HCO_3^{-1}		2.8
CO_3^{-2}		0
Cl^{-1}		35
SO_4^{-2}		14.10
Cadmium availability	$mg.kg^{-1}$	*nd
Lead availability		0.020
Nickel availability		0.001
Cobalt availability		*nd
Sand	$g.kg^{-1}$	830
Silt		36
Clay		134
Texture	Sandy loam	

* nd: not detected

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Table 2: shows the physical and chemical properties for the irrigation water used in the experiment (Tap water, the water of artesian well).

Type of analysis	Tap water	Units	Well water	Units
Ph	7.70	----	7.11	----
Ec	5.45	$dS.m^{-1}$	11.68	$dS.m^{-1}$
T.H	2100.0		2250.0	
Ca	180.0		570.0	
Mg	2056.0	$mg.L^{-1}$	409.9	
Na	699.3		870.9	ppm
K	32.4		40.5	
Cl	88.6		177.2	
NO_3	0.350	ppm	8.0	
SO_4	234.0		795.0	
Cd	0.0201		0.0214	
Pb	0.0460	ppm	0.0153	ppm
Ni	0.023		0.0441	
Co	0.0086		0.0116	

Treatments:

The treatments of the experiment included irrigation water with two types: well water and tap water, the fertilizer treatments:

1- The concentrated Superphosphate fertilizer CSP added to the soil.
2- NPK Fertilizer 12:12:17 added to the soil.
3- DAP fertilizer 18:48 added to the soil.

Field preparation and agricultural service operations

The land was plowed deeply in the perpendicular method for two times and divided into lines (48 lines), with a length of 12.5 m and a width of 0.5 m and a distance of one meter between each line. Each line represents one experimental unit, the fertilized animal fertilizer was then added at the rate of (8 $tons.dunam^{-1}$) a month before the date of cultivation and Phosphate chemical fertilizers were added with three types according to the recommendation of the fertilizer for the plant [12]. The urea fertilizer was added to the lines that treated with fertilizers (DAP 18:48 and CSP), it was then covered with a light layer of soil with a thickness about (15 cm). The subsurface drip irrigation system (T-Tape) from French origin was used to irrigate the plants. Two qualities of irrigation water (well water, liquefied water) were used in irrigating (24) experimental unit for each quality of irrigation water.

Experimental Design

The Randomized Complete Block Design (RCBD) was used for the split-split-Plot factorial experiment where the seeds of two cultivars of the potato plant (Arizona and Burren) were planted in the main plots. Two types of irrigation water (tap water and well water) are used in sub-plots, which are fertilized with three types of phosphate fertilizers: CSP, NPK 12:12:17 and DAP 18:48 which represent the Sub-Sub-Plots. Thus, the number of treatment is 12 factorial treatments, with three replicates to be the number of experimental units are 36 units per unit area as well as 12 experimental units for the control treatments. Results were statistically analyzed using the genstat program, and the least significant difference test (L.S.D.) was used to compare the averages at the probability level of 0.05 [3].

3. RESULTS AND DISCUSSION

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The studied heavy elements (Co, Ni, Pb, Cd) in the soil at the end of growth season:

1- Cadmium availability (Cd):

Table (3) shows significant differences between the types of used fertilizers in increasing the average of cadmium availability in the soil. where the fertilization with the concentrated superphosphate led to a significant increase in the average of cadmium availability amounted to (0.065 $mg.kg^{-1}$ soil) followed by dap fertilizer which recorded an average of cadmium availability amounted to (0.038 $mg.kg^{-1}$ soil), as for NPK fertilizer recorded an average amounted to (0.023 $mg.kg^{-1}$ soil) compared to the control treatment, which recorded an average amounted to (0.001 $mg.kg^{-1}$ soil). It is noted from the table that there is no significant effect of the quality of irrigation water on the concentration of cadmium availability in the soil at the end of the growing season. As for the bi-interaction between the quality of irrigation water and the type of fertilizer, it is noticed that the interaction was significant at the level of (0.05). The irrigated treatment with well water and treated with the superphosphate fertilizer recorded the highest cadmium availability amounted to (0.069 $mg.kg^{-1}$ soil) compared to the control treatment that irrigated with well water, Which recorded an average of cadmium availability amounted to (0.001 $mg.kg^{-1}$ soil). It was noticed that cadmium availability values for the current study the lower than the critical limits for total cadmium in sandy soils and with an average amounted to (0.37 $mg.kg^{-1}$ soil) as indicated by [17]. While the highest value for cadmium availability in the current study, which amounted to (0.069 mg kg^{-1} soil), forms a percentage of (17.6%) from the total cadmium for critical limits and this is a very low percentage. This result agrees with [14] who showed that the reason for the reduction of Cadmium availability in the soil of his study away from the sources of contamination and the association of cadmium with mineral soil colloids that represented by oxides and carbonates [21]. The [21] showed that cadmium is more closely correlated with solid carbonate surfaces due to the convergence of the cadmium radius with the calcium radius. It can be noted that the highest value for cadmium in the current study which amounted to (0.069 $mg.kg^{-1}$ soil) is within the common range in the soils which amounted to (0.01- 0.07 $mg.kg^{-1}$ Soil) as identified by [20].

Table 3: Effect of the quality of irrigation water and phosphate fertilizer in the average concentration of cadmium availability in soil ($mg.kg^{-1}$ soil).

The quality of irrigation water	Type of phosphate fertilizer				Average of well water
	Control	**CSP**	**NPK**	**DAP**	
Well water	0.001	0.069	0.025	0.043	0.035
Tap water	0.000	0.062	0.021	0.033	0.029
Average type of phosphate fertilizer	0.001	0.065	0.023	0.038	
L.S.D = 0.05					
Irrigation water		Type of fertilizer		Irrigation water × Type of fertilizer	
NS		**0.006**		**0.009**	

NS: No significant differences

Lead availability (Pb):

Table (4) shows the differential effect of fertilizers on Lead availability in the soil at the end of the growing season. Superphosphate fertilizer was characterized by recording it the highest Lead availability and with significant difference at a potential level of (0.05) which

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amounted to (0.091 mg.kg^{-1} soil) and it did not significantly differ from Dap fertilizer Which recorded a value amounted to (0.086 mg.kg^{-1} soil) and the lowest value recorded by NPK fertilizer which amounted to (0.047 mg.kg^{-1} soil) compared to the control treatment which recorded a value amounted to (0.025 mg.kg^{-1} soil). The quality of irrigation water had no effect on lead availability in the soil after the end of the growing season, It is noted from the results of the table that the well water and fertilization with the superphosphate fertilizer recorded a value amounted to (0.095 mg.kg^{-1} soil) and the lowest value recorded by the well water treatment that fertilized with NPK fertilizers amounted to (0.046 mg.kg^{-1} soil) compared to the control treatment that irrigated with tap water which amounted to (0.020 mg.kg^{-1} soil) compared to the highest lead availability recorded in this study, which amounted to (0.097 mg kg^{-1} soil) with the critical limit for the total amount from lead in the sandy soil, which was an average of (22 mg kg^{-1} soil) as stated in [17] we note that the lead availability in this study amounted to (0.4%) from the critical limit of total lead in sandy soils and less than this critical limit with amount 244 times. [11] found that the concentration of lead availability amounted to (0.18 mg.kg^{-1} soil) and form the percentage amounted to 0.19% from the total lead and showed that This percentage is low relative to the total concentration and indicates that more than 99.5% from the lead in the soil is not available for the plant and It may be in the form of oxides, hydroxides or lead carbonates. Many factors control the concentration of lead in soil, including soil texture, organic matter, industrial and agricultural pollution, etc. It also [1] concluded that the values of lead availability ranged between (1.29 - 82.16 mg.kg -1 soil), with a general average amounted to (4.25 mg-1 soil) and a percentage amounted to (0.53%) from the total lead and all these studies recorded values higher than the values recorded in the current study and this means the possibility of using these types of fertilizers in these soils and irrigating it with well water that used in the study region safely and without any risk. [23] confirmed that lead is considered one of the least heavy elements movement in the soil.

Table 4: Effect of the quality of irrigation water and phosphate fertilizer in the average concentration of Lead availability in soil (mg.kg^{-1} soil).

The quality of irrigation water	Type of phosphate fertilizer				Average of well water
	Control	**CSP**	**NPK**	**DAP**	
Well water	0.030	0.095	0.046	0.090	0.065
Tap water	0.020	0.087	0.047	0.082	0.059
Average type of phosphate fertilizer	0.025	0.091	0.047	0.086	
L.S.D = 0.05					
Irrigation water		Type of fertilizer		Irrigation water × Type of fertilizer	
NS		0.012		0.018	

NS: No significant differences

Nickel availability (Pb):

Table (5) shows that the quality of the used irrigation water in the experiment has a significant effect at the level of (0.05) on the nickel availability and amounted for the well water (0.059 mg.kg^{-1}) compared to the tap water treatment which amounted to (0.052 mg.kg^{-1}). This may be due to increasing the concentration of nickel in well water compared to tap water as shown in Table (2). It is noted from the results of the table that there is a significant effect of the used fertilizer in the experiment on the concentration of nickel availability in the soil.

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where DAP fertilizer was characterized by recording it the highest concentration for nickel availability amounted to (0.085 mg.kg^{-1}), excelling on the rest of the fertilizers, which recorded (0.077 and 0.051 mg.kg^{-1}) for the superphosphate fertilizer and NPK fertilizer, respectively compared to the control treatment which recorded the lowest nickel value at the end of the Growth season amounted to (0.012 mg.kg^{-1}). The interaction between the quality of irrigation water and the type of phosphate fertilizer was significant at the level of (0.05), where the well water with the DAP fertilizer recorded the highest amount of nickel availability which amounted to (0.086 mg.kg^{-1}) compared to the tap water treatment with the DAP fertilizer which amounted to (0.083 mg.kg^{-1}). This result agrees with [9] who showed that the manufactured fertilizers in Iraq contain nickel. However, the nickel values in this study are much lower than the natural limits in the soils identified by [20] which amounted to (5 - 500 mg.kg^{-1}), As well as below the critical limits of the total amount for the sandy soils as described in [17] which amounted to (13.0 mg kg^{-1}), although the highest content of nickel availability in this study amounted to (0.087 mg.kg^{-1}), which constitutes 0.65%. This means that it is less than 135 times from this limit and this indicates that the quantity of availability is very low. The values obtained in this study are considered less than what was obtained by [14]. when estimating of nickel availability in the silty loam soil, which amounted to (0.22 mg.kg^{-1} soil) and forms a percentage amounted to (0.27%) from total nickel, which amounted to (81.43 mg.kg^{-1}). The results of the study were close to the results of the study [2] when studying some industrial regions that are far from contamination and amounted to (0.077, 0.038 mg.kg^{-1} soil) on the distance of (100, 200, 300 m) from the source of contamination in industrial regions. [11] conformed that the amount of nickel availability obtained (0.22 mg.kg^{-1}) is low due to raising the pH, low soil content of organic matter and high content of solid carbonate that may contribute to nickel deposition or adsorption.

Table 5: Effect of the quality of irrigation water and phosphate fertilizer in the average concentration of nickel availability in soil (mg.kg^{-1} soil).

The quality of irrigation water	Type of phosphate fertilizer				Average of well water
	Control	**CSP**	**NPK**	**DAP**	
Well water	0.020	0.080	0.052	0.086	0.059
Tap water	0.000	0.073	0.050	0.083	0.052
Average type of phosphate fertilizer	0.010	0.077	0.051	0.085	
L.S.D = 0.05					
Irrigation water		Type of fertilizer		Irrigation water × Type of fertilizer	
0.004		0.005		0.007	

NS: No significant differences

Cobalt availability (Co):

Table (6) shows that there are no significant quantities of this element in most of the treatments in the study soil at the end of the growing season for the agricultural experiment. The statistical analysis showed no significant effect at the level of (0.05).

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Table 6: Effect of the quality of irrigation water and phosphate fertilizer in the average concentration of Cobalt availability in soil (mg.kg^{-1} soil).

The quality of irrigation water	Type of phosphate fertilizer				Average of well water
	Control	**CSP**	**NPK**	**DAP**	
Well water	0.000	0.012	0.035	0.005	0.013
Tap water	0.000	0.008	0.017	0.082	0.027
Average type of phosphate fertilizer	0.000	0.010	0.026	0.043	

L.S.D = 0.05		
Irrigation water	Type of fertilizer	Irrigation water × Type of fertilizer
NS	NS	NS

NS: No significant differences

We conclude from this that the fertilized study soil with the phosphate fertilizer (NPK, DAP, CSP) is not contaminated with heavy elements (C0, Ni, Pb, Cd). Despite the fact that these fertilizers contain high concentrations of some heavy elements that cause contamination and the concentrations of all these elements are few and almost inconceivable in the soil compared to the limits of natural and critical globally defined. It is noted that these elements have taken the following order in terms of their available quantity in soils Co <Cd <Ni <Pb.

REFERENCES

[1] Al-Hilfi, Allawi Hassan (2010). Evaluation of lead contamination and behavior in some Basra soils and their effect on yellow corn growth (Zea mays L.) at different levels of phosphate and organic fertilizer. Master Thesis, College of Agriculture, University of Basra.

[2] Al-Hamdani, Sabih Abdul Wahab and Mohammed Salman Mohammed. (2014). Effect of salinity of irrigation water and spraying with amino acids (propylene and arginine) in potato growth and yield (Solanum tuberosum L.). Diyala Journal of Agricultural Sciences, 6 (2): 154-163.

[3] Al-Rawi, Khasha Mahmood and Abdul Aziz Mohammed Khalaf Allah. (1980). Design and analysis of agricultural experiments. Dar Al Kutb for Printing and Publishing, University of Mosul / Iraq: 488 p.

[4] Early Production and Evaluation Division. (2010). United Nations Environment Program Environment Outlook for the Arab Region for the Development and Welfare of Humanity.

[5] Al-Shammari, Imad Mutair Khalaf and Kadhim, Nihad. (2012). Environment and Pollution Study of Pollution in Iraq, University of Baghdad: 219 pages.

[6] Awad, Kadhim Mashhout. (1987). Fertilization and fertility. Dar Al Kuttab for Printing and Publishing, University of Mosul.

[7] Al-Eid, Mohammed bin Abdul Rahman, Mohammad Mohammed al-Jarwani and Ali Fathi Hamail. (2008). Studying the Effect of Fertilization with Phosphate Fertilizers on the accumulation of cadmium in soil and Some vegetative Parts of Some Vegetable Crops. Agricultural and Veterinary Research and Training Station, funded by Deanship of Scientific Research, King Faisal University.

[8] Qasim, Abdul Rahman and Ahmed Sarhal. (2011). Studying the transfer of trace elements from groundwater and soil to plants in the Syrian coastal region using the technique of neutron activation. Final Report, Scientific Research, Atomic Energy Commission, Syrian Arab Republic.

ISSN 2072-3875

[9] Al-Qarghuli, Nahida. (1987). The nutrient content of the plant is produced in the fertilizer. Zanko. Volume 5. Issue 20.

[10] Kadhim, Duha Jawad and Jadwa, Amir Hadi. (2016). Available water possibilities for Iraq (the study of the Iraq geographic). Journal of Basic Education for Educational and Human Sciences, University of Babylon, 30 (1): 672 - 683.

[11] National Water Research Center. (2010). United Nations Development Program for Water Management for the Arab States. Training manual on environmental aspects of integrated water resource management in the Arab region.

[12] Matlub, Adnan Nasser. (1979). Practical vegetables. Dar Al Kutb for Printing and Publishing - University of Mosul: 242 p.

[13] Mutouf, Safia Shaker. (2015). Hydrochemical changes for the Marshlands of southern Iraq and their environmental impacts. Journal of Basrah Studies, No. 15: 226-232.

[14] Al-Mayahi, Riyadh Shaker Beedeh. (2012). The content of phosphate fertilizers and organic waste of some heavy elements and their impact on soil contamination and wheat plant (Triticum aestivum L.).

[15] Black, C.A. (1965). Methods of Soil Analysis. Am. Soc. Agron. Inc. Publisher, Madison, Wis., USA.

[16] Jackson, P. C. and Hagen, C. F. (1960). Products of orthophosphate absorption by barly roots. Plant physoil. 35: 326 – 332.

[17] Kabata – Pendias, A . and Pendias, H . (2001). Trace Elements in Soil and Plants. 3 rd ed. CRC Press Boca Raton FL, p.114.

[18] Loganathan, P.and M.J.Hedley. (1997). Downward Movement of Cadmium and Phosphorus from Phosphatic Fertilizer in a Pasture Soil in New Zealand. Environmental Pollution ,Vol.95,No.3,Pp.319-324.

[19] Lone, I. M . ; He, Z . ; Stoffella, J . P . and Yang, X. (2008) . Phytorem edition of heavy metal polluted soil and wetter: Progress and Perspectives. J . Zhejiang Univ. Sci. , 9(3) : 210 – 220 .

[20] Lindsay, W. L. (1979). Chemical equity briar in soils. John Wiley and sous. Inc., New York.

[21] McBride, M. B. (1980). Chemisorption of Cd on calcite surfaces. Soil Sci. Soc. Am. J. 44: 26-28.

[22] Moral, R.; Palacios, G . ; Gomez, I . ; Navarro-Pederno, J . and Mataix, J . (1994). Distribution and accumulation of heavy metals (Cd, Ni, and Cr) in the tomato plant. Fresenius Environmental Bulletin., 3 (7): 395 – 399.

[23] Musilova, J.; Bystericka, J.; Vollmannova, A. and Melichacova, S. (2011). Contamination of potato tubers by heavy metals and their influence on the formation of phenolic substances. J. Central Eur. Agr. , 12(3) : 433-444 .

[24] Page, A.I. (Ed). (1982). Methods of Soil Analysis Part 2. Chemical and microbiological properties 2nd edition, Amer. Soc. of Agron. Inc. Soil Sci. Soc. Am. Inc. Madison. Wis. the U.S.A.

[25] Rahimil, M . ; Farhadi, R . and Balashahri, S. M. (2012). Effect of heavy metals on the medicinal plant. J . Inter. Agronomy and Plant Prod. , 3(4) : 154 – 158 .

[26] Seddique, A. A . ; Ahmed, K. M.; Shamsudduha, M.; Aziz, Z, and Hoque, M. A., (2004). Heavy Metal Pollution in Groundwater in and around Narayanganj Town, Bangladesh. Bangladesh Journal of Geology, 23: 1 – 12.

[27] Standard Methods for the examination of water and wastewaters, American water Public Health Assoc., American water works Assoc., New York. AWPHA (2005).

[28] Williams, C.H . and David, D. J . (1973). The effect of superphosphate on the cadmium content of soil and plant. Australian J . of Soil Research, 11: 43 – 56.

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