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Study the heavy metal in domestic wastewater used to irrigate agricultural fields

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Abstract
The current study of the evaluation of heavy metals was conducted Pollution in Domestic Wastewater Used in Agricultural Irrigation Crops in central Najaf, Iraq. Water samples were collected Three editions from October to December 2024 of three Fields located in the same area. The study focused on measurement Concentration of four heavy metals in water samples: Lead (pb) cadmium (CD), copper (Cu), chromium.leadparticular the result showed , the highest averge161.17mg/l in s2, and lowest averge 14.08 mg/l in s1. As a dissolved the result showed of highest averge 5.05 mg/l in S2 and lowest averge 2.75 in s1. cadmium particulate the result showed highest averge 59.3 mg/l in s2 and lowest averge 9.33 mg/l in S1. As a dissolved the result showed of highest averge 2.89 mg/l in S2 and lowest averge 1.6 in s1. copper particulate the result showed, the highest averge 154.77 mg/l in s2, and lowest averge 14.83 mg/l in s1. As a dissolved the result showed of highest averge 6.5 mg/l in S2 and lowest averge 1.5 in s1. chromium particulatethe result showed, the highest averge 54.6 mg/l in s2, and lowest averge 10 mg/l in s1. As a dissolved the result showed of highest averge 15.2 mg/l in S2 and lowest averge 5.2 in s1. Results of the current study suggests that the levels of heavy metals in domestic wastewater exceeded the permissible l imits for irrigation purposes.

Keywords: agricultural fields, domestic wastewater, dissolved, heavy metal, particulate.

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1.Introduction

Water is a vital component in the development of both agriculture and industry. Domestic wastewater has become one of the important alternative water resources, especially with the growing need for water due to population increase, scarcity of surface water, and the high individual demand for this essential resource (Bin Hamza & Bin Salem, 2018). Domestic wastewater refers to water resulting from various household activities, such as those in kitchens and toilets. It may also include rainwater runoff, water used for street cleaning, and effluents from small urban factories. This type of can pose significant environmental threats because it contains varying levels of sediments, excess nutrients, and both organic and inorganic substances (Al-Anbari,2010**).** especially when present in elevated concentrations. These contaminants tend to accumulate in the soil and may enter the food chain through plants and animals, potentially leading to the emergence of serious human diseases. Moreover, such practices cause noticeable alteration in the physical and chemical properties of the soil (Alzobi et al., 2014). The presence of minerals in natural water, as well as in industrial and domestic wastewater, is a growing concern due to the toxic characteristics of certain elements. Given human interaction with numerous mineral elements and their compounds in daily life, these substances can easily find their way into the environment, particularly into water sources (Abawi & Suleiman, 1990)**.**

2. materials and methods

2.1 study area

The study area is located in Najaf Governorate in southwestern Iraq, situated to the southwest of Baghdad. According to 2024 statistics, the population of Najaf Governorate represents the population of 1,672,312 people. of the total provincial population. Three agricultural fields located in the Al-Houli area were selected for this study.

- **Field 1**

This filed has an area of 3 dunams (7,500 m²). The irrigation source is the Shatt Al-Kufa River. This field was considered as the reference site for comparison with the other field. The geographic coordinates of the study area are approximately 31.989533 N latitude, and 44. 300186 E longitude Both winter and summer crops of leafy vegetables are cultivated, including cress, basil, radish, eggplant, tomatoes and others.

- **Field 2**

This field has an area of 2 dunams (5,000 m²) and is located approximately 4 kilometers from the first field. It is irrigated exclusively with domestic wastewater, which has been in the area for more than 20 years. The geographic coordinates of the study area are approximately 31.977508 N latitude, and 44.320977 "E longitude". Like the first field, it is cultivated with winter and summer leafy vegetables such as cress, basil, Eggplant, and tomatoes.

- **Field 3**

This field covers 1.5 dunams (3,750 m²) and is located around 2 kilometers from the first field. It is irrigated using a combination of well water and domestic wastewater. The geographic coordinates of the study area are approximately 31.962667 N latitude, and 44. 37154 3"E longitude. The field is also planted with winter and summer crops of leafy vegetables including cress, basil, radish, eggplant, and tomatoes.

2.2 collection Sample

Water samples were collected between October and December 2024 to analyze heavy metal concentrations. Triplicate samples were taken from each site at a depth of 30 cm below the water surface. The sample were collected in 3-liter polyethylene containers that had been pre-washed with diluted hydrochloric acid, followed by rinsing with distilled water and finally with re-distilled water.

2.3 Working methods

2.3.1Dissolved heavy metals

Dissolved heavy metals in water sample were extracted following the method described by (Nollet, 2007) .The water sample were filtered through a 0.45 µm membrane filter, and the concentrations of heavy metals were determined using a flam atomic absorption spectrophotometer (FAAS). The results were expressed in (mg/L).

2.3.2Particulate heavy metals

The method described by (APHA, 2003) was used to extract particulate heavy metals from the water sample. The sample were stored in polyethylene bottles until analysis. The concentrations of heavy metals were determined using a flam atomic absorption spectrophotometer (FAAS). The results were expressed in (mg/L).

3. Results and discussion

3.1Lead

The results showed that the highest average concentration of particulate lead in irrigation water was 161.17 mg/L at S2, and the lowest average was 14.08 mg/L at S1. The results of the analysis showed that the highest average concentration of lead dissolved in irrigation water was 5.05 mg/l at S2, and the lowest average was 2.75 mg/L at S1. Table (1.1) and Figure (1)

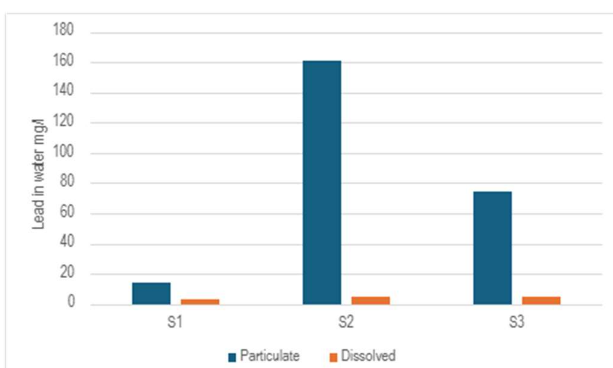

Figure (1) concentration lead values in water

High lead values in the S2 particulate matter indicate severe contamination resulting from the use of untreated domestic wastewater. The high concentration of lead particles in S2 is due to the contaminated nature of this water, which often contains residues of cleaning agents and household chemical products containing heavy metals, as well as leaks from old pipes or deteriorating sewer systems. Also, suspended particles are not adequately treated before being used for irrigation (Elnazer *et al*., 2023).
As for S1, its dependence on river water explains the decrease in lead particles, as river water is more mobile and flowing, which contributes to the natural dilution of particles (Othman *et al*., 2021) The high level of dissolved lead in S2 indicates that there is a continuous source of lead contamination, and that the chemical conditions of the water, especially the pH, promote its survival in its dissolved form rather than sedimentation. This poses a direct risk to human health and the aquatic organisms that consume or live in this water, and facilitates its transmission through the food (Malassa *et al,* 2014) .
The low concentration of dissolved lead at S1 mg/L reflects the relative purity of the water source. High water flow and regeneration, which prevents the accumulation of dissolved pollutants. The absence of strong solvent agents for metals such as chemical compounds contained in domestic drainage (Ali *et al* ., 2019)

3.2 Cadmium

The results showed that the highest average concentration of particulate cadmium in irrigation water was 59.3 mg/L in S2, and the lowest average was 19.33 mg/L in S1. The results of the analysis showed that the highest average concentration of cadmium dissolved in irrigation water was 2.897 mg/l in S2, and the lowest average was 1.67 mg/L in S1.table(1.1) figure (2).

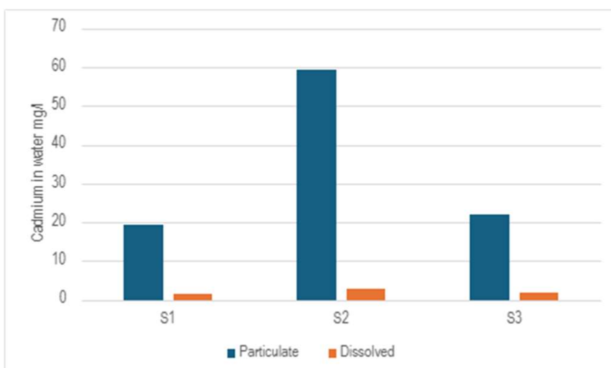

Figure (2) concentration cadmium values in water

The high average concentration of cadmium particulates in irrigation water at site S2 indicates the impact of water source quality, as domestic wastewater contains metal contaminants such as cadmium from domestic waste or old pipes, which increases the concentration of heavy metals. S1 is less polluted because it relies on river water that undergoes natural purification processes, which explains the low concentration of cadmium in it. This is in line with studies that have confirmed that wastewater use increases levels of heavy metals in water (Manzoor *et al.,* 2018).
The high concentration of cadmium dissolved at site S2 due to the use of domestic wastewater, which contains larger amounts of heavy metals such as cadmium, indicates the water system, Unlike S1, which is less polluting, due to the fact that wastewater contains household and chemical waste that may increase cadmium solubility (Alghobar and Suresha, 2016 & Jamali *et al*., 2007).

3.3 copper

The results showed the highest average concentration of particulate copper in irrigation water was 154.77 mg/L in S2, and the lowest average was 14.83 mg/L in S1. the results showed the highest average concentration of copper dissolved in irrigation water was 6.54 mg/l in S2, and the lowest average was 1.53 mg/L in S1. Table (1.1)figuer(3).

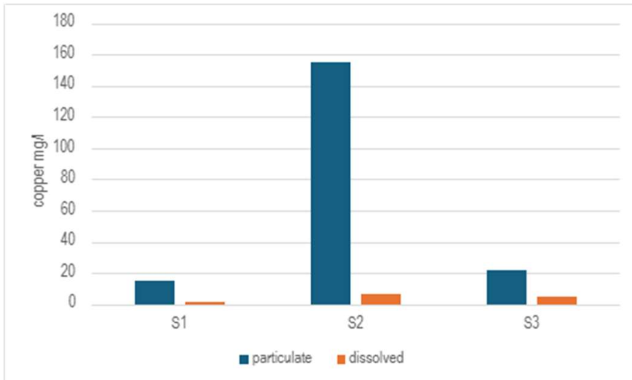

Figure (3) concentration copper values in water

High levels of copper particulates in irrigation water at site S2 indicate the presence of external sources rich in copper such as domestic wastewater or leaks from older copper-containing piping systems. Particles suspended in wastewater often carry heavy metals either in the form of insoluble compounds or bonded to micro-organic matter, which explains the high values recorded. On the other hand, the low concentration of particulates in S1 reflects a more stable and less human-affected river flow, reducing the accumulation of copper in its particulate form (Li et al ., 2009).

For copper in its dissolved form, the highest concentration recorded in S2 indicates the corrosion of copper plumbing pipes and the use of copper-containing domestic and industrial products. The chemical conditions of water, such as pH which may promote solubility, and the presence of organic matter forming stable complexes with copper ions, contribute to its survival in its dissolved form rather than precipitation. This melted presence of copper makes it more mobile and bioavailable, which increases its environmental impact. These results show that the shift between the particulate and dissolved copper form in irrigation water is not only dependent on the source, but is directly influenced by the physical and chemical properties of the water, and the environmental conditions associated with each site(Li et al.,2017 & Yuan et al., 2020) .

3.4 chromium

The results showed the highest average concentration of particulate chromium in irrigation water was 54.67 mg/L in S2, and the lowest average was 10.0 mg/L in S1. The results showed the highest average concentration of chromium dissolved in irrigation water was 15.27 mg/l in S2, and the lowest average was 5.25 mg/L in S1.table (1.1)figure(4).

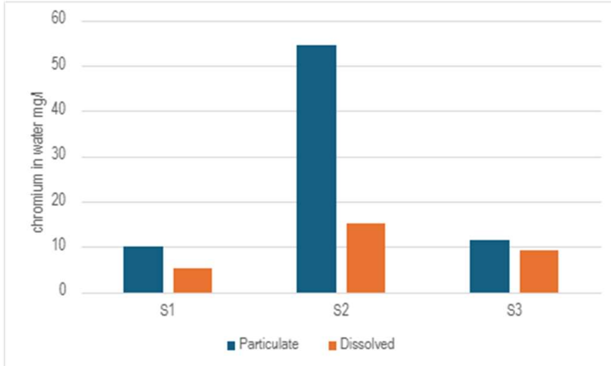

Figure (4) concentration chromium values in water

For particulate chromium, the high chromium in S2 is explained by the presence of multiple sources of chromium in products and daily uses such as cosmetics and some small businesses, while its low in S1 explains the significant dilution and natural processes such as sedimentation and adsorption that remove chromium from water.

The high concentration of dissolved lead in S2 indicates multiple sources inside homes, such as old water pipes, corrosion of paints, or improper disposal of chromium-containing products such as electronic compounds and batteries, where contaminants accumulate in a limited volume of water. The significant decrease in S1 is mainly due to the dramatic dilution due to the large volume of river water, as well as sedimentation and adsorption processes that remove cadmium from the water column and fix it in sediments, and the contribution of natural and biological water treatment, but it should be noted that 5.25 mg/L remains a very high and dangerous concentration of lead in rivers, which requires serious treatment of sources of pollution (Azeez *et al.*,2021).

Table [1.1] concentrations of heavy metals in water

		S1	S2	S3	LSD
Lead	Particle	16.1-19.4 14.08 ± 6.72	152.9-167.8 161.17 ± 7.75	26.8-122.1 74.72 ± 51.96	20.9
	Dissolved	1.20-4.230 2.75 ± 1.52	2.981-7.12 5.05 ± 2.07	3.204-6.987 4.59 ± 1.56	1.68
cadmium	Particle	32.11-10 11.4±9.33	65.2-52.8 620±59.3	48.48.0-9.1 19.45±22.08	6.61
	Dissolved	0.557-2.198 1.67 ± 1.12	1.000-4.28 2.897 ± 1.91	0.931-3.843 2 ± 1.46	1.36
copper	Particle	10- 19.4 14.83±4.71	134-166.5 154.77±11.75	9.1-48.0 22.08 ± 19.45	20.9
	Dissolved	2.809-0.542 1.16±1.53	2.981-7.109 6.54 ± 3.31	1.236-10.653 4.79 ± 1.12	1.36
Chromium	Particulate	7.4-13.3 10.0±3.01	48.4-60.1 54.67 ±5.90	6.2-16.3 11.42± 3.91	5.38
	Dissolved	2.42-7.21 5.25±2.51	12.791-17.391 15.27±2.30	6.836-11.55 9.109± 2.37	2.23

Conclusion

1.Heavy metal concentrations in domestic wastewater exceeded irrigation limits.
2. S2 showed the highest levels of Pb, Cd, Cu, and Cr.
3.S1 showed the lowest concentrations.
4.Using untreated wastewater poses serious risks to agriculture and health.

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دراسة المعادن الثقيلة في مياه الصرف الصحي المنزلية المستخدمة في ري الحقول الزراعية

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المستخلص

هدفت الدراسة الحالية إلى تقييم تلوث المعادن الثقيلة في مياه الصرف الصحي المنزلية المستخدمة في ري المحاصيل الزراعية في منطقة وسط النجف، العراق. جُمعت عينات المياه خلال ثلاث مرات اذ تم أخذ العينات من تشرين الأول/أكتوبر إلى كانون الأول/ديسمبر 2024 من ثلاثة حقول زراعية تقع ضمن المنطقة نفسها. ركزت الدراسة على قياس تراكيز أربعة معادن ثقيلة في عينات المياه، وهي: الرصاص(Pb) ، والكادميوم(Cd) ، والنحاس(Cu) ، والكروم.(Cr) أظهرت النتائج أن أعلى متوسط لتركيز الرصاص العالق (Particulate Lead)بلغ 161.17 ملغم/لتر في الموقعS2 ، في حين سُجل أدنى متوسط وقدره 14.08 ملغم/لتر في الموقع .S1 أما الرصاص الذائب فقد بلغ أعلى متوسط لتركيزه 5.05 ملغم/لتر في الموقعS2 ، بينما بلغ أدنى متوسط 2.75 ملغم/لتر في الموقع.S1 وفيما يتعلق بالكادميوم، فقد بلغ أعلى متوسط لتركيز الكادميوم العالق 59.3 ملغم/لتر في الموقعS2 ، بينما سُجل أدنى متوسط وقدره 9.33 ملغم/لتر في الموقع .S1 أما الكادميوم الذائب فقد تراوحت تراكيزه بين أعلى متوسط بلغ 2.89 ملغم/لتر في الموقع S2 وأدنى متوسط بلغ 1.6 ملغم/لتر في الموقع.S1 أما بالنسبة للنحاس، فقد أظهرت النتائج أن أعلى متوسط لتركيز النحاس العالق بلغ 154.77 ملغم/لتر في الموقعS2 ، في حين بلغ أدنى متوسط 14.83 ملغم/لتر في الموقع .S1 وسجل النحاس الذائب أعلى متوسط تركيز قدره 6.5 ملغم/لتر في الموقع S2 وأدنى متوسط بلغ 1.5 ملغم/لتر في الموقع.S1 وبالنسبة للكروم، فقد بلغ أعلى متوسط لتركيز الكروم العالق 54.6 ملغم/لتر في الموقعS2 ، بينما سُجل أدنى متوسط وقدره 10 ملغم/لتر في الموقع .S1 أما الكروم الذائب فقد سجل أعلى متوسط تركيز بلغ 15.2 ملغم/لتر في الموقعS2 ، وأدنى متوسط بلغ 5.2 ملغم/لتر في الموقع.S1 تشير نتائج الدراسة الحالية إلى أن تراكيز المعادن الثقيلة في مياه الصرف الصحي المنزلية تجاوزت الحدود المسموح بها لأغراض الري الزراعي، مما يشير إلى وجود مخاطر بيئية وزراعية محتملة ناجمة عن استخدام هذه المياه في ري المحاصيل الزراعية.

الكلمات المفتاحية: حقول زراعية، مياه الصرف الصحي المنزلي، مُذاب، معدن ثقيل، جسيمات.