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Monitoring accumulation of Mn, Pb and Zn in surface soils after long-term irrigation with low-quality water: A case study of southeast and middle Nile Delta, Egypt

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Abstract

This work aimed at investigating the effect of prolonged irrigation using low-quality water on the accumulation of Mn, Pb, and Zn in surface soils (0 – 30 cm). Two locations were selected; the first was inside El-Gabal El-Asfar farm (GAF), southeast the Nile Delta, where nine irrigation water and adjacent soil samples were collected. The second was in the middle Nile Delta (MND) region, where three water samples from Kitchener drain (mixed wastewater), Tirah drain (agricultural drainage water) and Bahr Tirah (Nile freshwater), and adjacent soil samples were collected. The total and DTPA-extractable Mn, Pb, and Zn in soils were analyzed. The soils showed total Mn below the average natural content (ANC) of the Earth's crust (900 mg kg^{-1}). The total Pb in four sites within GAF and all soils in MND were above the ANC (15 mg kg^{-1}) but below the maximum allowable concentration (MAC) of 200 mg kg^{-1}. Soils of GAF had total Zn contents above the ANC (70 mg kg^{-1}), but below the MAC (300 mg kg^{-1}). Mixed wastewater and agricultural drainage water-irrigated soils showed total Zn contents above the MAC. Soils of GAF showed DTPA-extractable Mn and Zn above the MAC (5 and 1.25 mg kg^{-1}, respectively), while Pb contents surpassed the MAC (2.0 mg kg^{-1}) in seven sites. The DTPA-extractable Mn and Zn in the MND soils exceeded the MAL. Soils irrigated with Kitchener drain showed available Pb double the MAC. Proper water treatments and remediation strategies are recommended to alleviate metal accumulation in the food chain.

Keywords: Metal; Low-quality water; Irrigation; Total; DTPA

Introduction

Soil chemical pollution has become a common phenomenon and attracted global attention in both developed and developing countries. It has negative effects on food production in terms of quantity and quality **(Elbana et al., 2019)**. The presence of toxic pollutants in soil induces adverse effects on all living beings, including micro-organisms, fauna, and higher plants, which in turn reduce biomass production. These toxicants may also accumulate in the food chain and result in human health risks **(Kabata-Pendias, 2011)**. Also, polluted soils in turn become a source of groundwater pollution through leaching of pollutants **(Abuzaid and Jahin, 2021; Abuzaid et al., 2021)**

Among various soils pollutants, potentially toxic metals (PTMs) are ubiquitous inorganic pollutants in soil and water ecosystems. They can enter the ecosystems through various natural and anthropic pathways **(Abuzaid and Jahin, 2019; Elbana et al., 2019)**. Recently, accumulation of PTMs in agro-ecosystems has attracted world-wide attention due to their toxicity and severity **(Abuzaid et al., 2019; Alloway, 2013)**. Unlike organic pollutants, PTMs are the most potent toxicants because they do not undergo any microbial or chemical degradation, and thus they can persist for long periods after their introduction into the ecosystem **(Bolan et al., 2014)**.

In fact, PTMs are not hazardous per se but only when exceeding a certain threshold of internal concentrations. Some elements such as Fe, Mn, Zn, Cu, Ni, and Mo have been known as essential micro-nutrients for all plant species **(Abuzaid and Bassouny, 2020; Appenroth, 2010)**. Other elements have been mentioned as beneficial elements, which have specific functions for certain species. For instance, Co is essential for symbiotic N_2 fixation and the formation of vitamin B_{12}. On the other hand, Cd and Pb are not essential for living organisms **(Kabata-Pendias, 2011)**. However, very low concentrations of Cd and Pb have some stimulating effects on barely seedlings and detached leaves, respectively **(Appenroth, 2010)**.

Due to freshwater scarcity in Egypt, a significant use of low-quality waters in the agricultural sector has been increasingly practiced **(Abbas et al., 2020; Abuzaid, 2016; Jahin et al., 2020)**. The low-quality waters include wastewater from urban and peri-urban areas, saline agricultural drainage water, and brackish groundwater **(Zidan and Daoud, 2013)**. Since 1911, Egypt has an experience in using raw and partially treated wastewater in El-Gabal El-Asfar farm in southeastern the Nile Delta **(Abuzaid and Fadl, 2018; Elbana et al., 2019)**. Agricultural drainage water mixed with the Nile freshwater is a common irrigation source in north and middle delta **(Abuzaid, 2018; Salem et al., 2012)**. Wastewaters of main drains have been also used for irrigation such as Kitchener drain **(Aitta et al., 2019; Eid et al., 2020)**. Normally, low-quality waters contain high amounts of PTMs, which may accumulate in irrigated soils and the growing plants, causing environmental and human health risks.

Accordingly, the current work aimed at screening the accumulation of three PTMs, i.e. Mn, Pb and Zn in surface soils as affected by long-term irrigation with low-quality waters in the two locations of the Nile Delta region, i.e. southeast and middle parts.

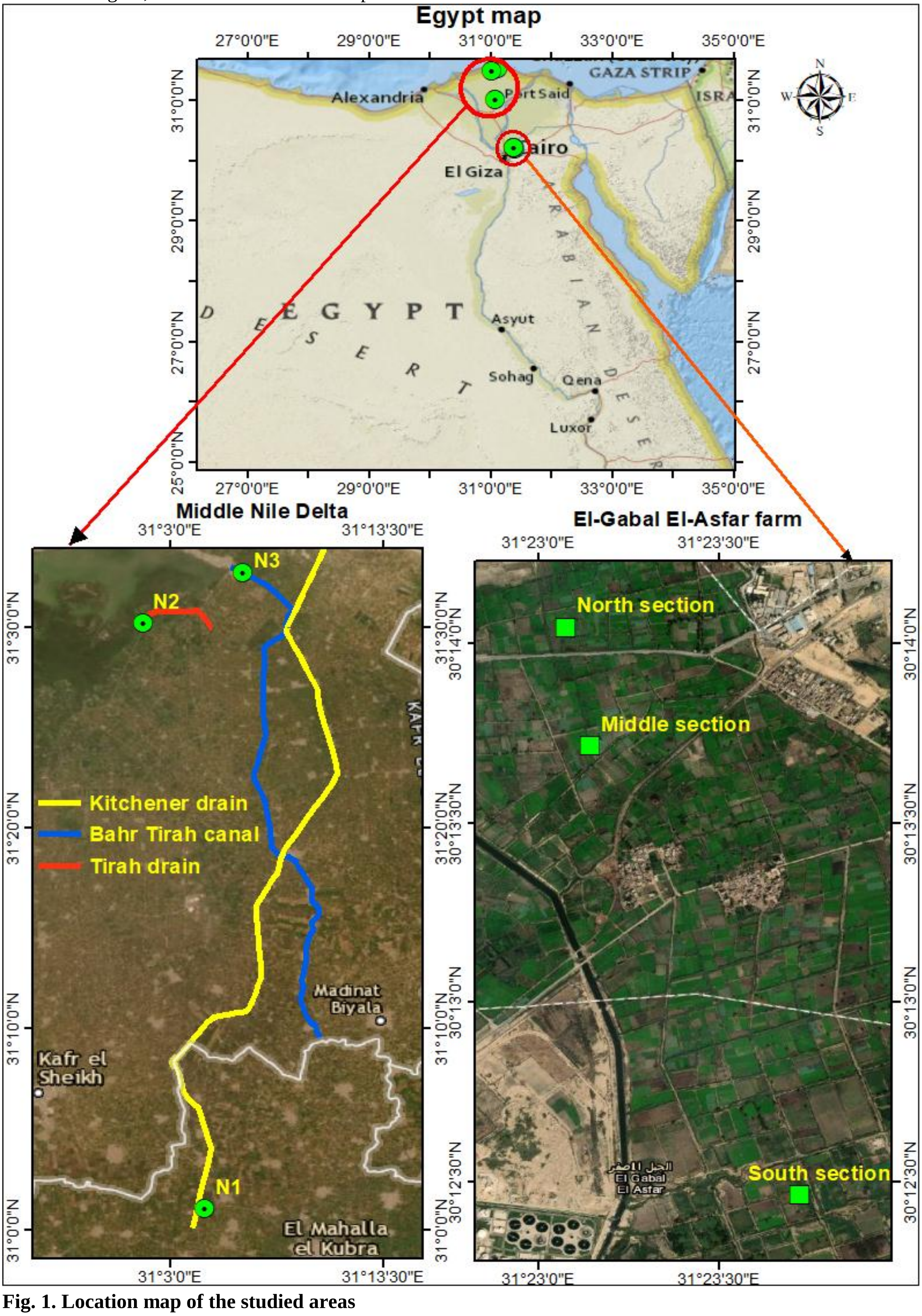


Fig. 1. Location map of the studied areas

2. Materials and methods

2.1. Study areas

In the current work, two locations subjected to long-term irrigation with low-quality waters have been chosen. The first location is situated southeastern the Nile Delta of Egypt inside El-Gabal El-Asfar farm in El-Khanka District, Qualibiya Governorate. This area has undergone wastewater irrigation for more than 110 years through a network of open drains covering the whole area. Within the farm, three sections have been selected, including south, middle and north sections as shown in Fig. 1. The second location is situated in the middle Nile Delta region in El-Gharbia and Kafr El-Sheikh Governorates. In this location, three sites have been selected (Fig. 1). Table 1 summarizes locations and irrigation water sources in the studied areas.

Table 1. Locations of water and soil samples collected from the studied areas

Location	Site	Code	Irrigation water
El-Gabal El-Asfar	South section / Plot 5	G1	Treated domestic wastewater
	South section / Plot 8	G2	Raw domestic wastewater
	South section / Plot 2	G3	Raw domestic wastewater
	Middle section / Plot 5	G4	Raw domestic wastewater
	Middle section / Plot 2	G5	Treated domestic wastewater
	Middle section / Plot 8	G6	Well water
	North section / Plot 5	G7	Raw domestic wastewater
	North section / Plot 2	G8	Raw industrial wastewater
	North section / Plot 8	G9	Well water
Middle Nile Delta	El-Gharbia (El-Mahala El-Kobra)	N1	Kitchener drain (mixed wastewater)
	Kafr El-Sheikh (El-Hamoul)	N2	Tirah drain (Mixed agricultural + Nile water
	Kafr El-Sheikh (Baltim)	N3	Bahr Tirah (Nile freshwater)

2.2. Sampling

At each sampling site, the pH and electrical conductivity (EC) for irrigation waters were measured instantaneously *in-situ* using a HACH instrument (HQ 40d, multi, USA). Water samples were collected in acid-washed highly-density polypropylene vials (1 L). Moreover, samples to be analyzed for PTMs were collected in another set of 0.5 L polypropylene vials previously washed with 50% HNO_3 and double deionized water, and acidified with 5 mL HNO_3. The collected samples were transported in iceboxes to the laboratory within 24 h of collection time and kept in the refrigerator at 4 °C until analysis. Surface soil samples (0 – 30 cm) were collected from agricultural fields adjacent to irrigation water sources using a stainless steel auger and then packed in polyethylene bags and kept for laboratory analyses.

2.3. Laboratory analyses

All water analyses were perfumed according to standard methods of the **APHA (2017)** and the results are presented in Table 2. Soils samples were air-dried, grounded, and passed through a 2-mm sieve. The soil physicochemical properties (pH, EC, organic matter, calcium carbonate, and particle size distribution) were analyzed according to methods outlined by **Estefan et al. (2013)**. The results are tabulated in Table 3.

Table 2. Chemical properties of the investigated irrigation water in the studied areas

Site	pH	EC dS m^{-1}	Soluble ions, $mmol_c$ L^{-1}							
			Na^+	Ca^{2+}	Mg^{2+}	K^+	Cl^-	HCO_3^-	CO_3^{2-}	SO_4^{2-}
G1	7.89	1.34	7.40	2.91	2.11	0.74	10.24	0.71	0.00	2.21
G2	7.81	1.56	7.90	3.92	2.80	0.80	11.90	0.74	0.00	2.78
G3	7.83	0.95	3.20	3.23	1.90	0.70	6.93	0.50	0.00	1.60
G4	7.42	0.94	3.90	2.91	1.80	0.40	6.90	0.41	0.00	1.70
G5	7.86	1.60	8.91	3.96	2.77	0.35	12.62	0.78	0.00	2.59
G6	7.78	1.74	9.20	4.24	2.90	0.70	13.98	0.97	0.00	2.09
G7	7.88	0.70	3.30	2.12	1.30	0.20	5.50	0.20	0.00	1.22
G8	7.80	2.85	20.40	4.63	1.43	1.90	23.38	1.82	0.00	3.16
G9	7.92	0.84	2.47	2.91	2.11	0.80	5.59	0.50	0.00	2.20
N1	7.14	1.89	10.76	4.18	3.35	0.54	10.09	6.10	0.00	2.64
N2	6.65	2.07	12.46	0.79	4.28	2.97	10.91	5.22	0.00	4.37
N3	7.80	0.84	3.95	2.39	1.40	0.48	3.70	2.50	0.00	2.02

See sample codes in Table 1

Table 3. Physicochemical properties of the investigated soils in the studied areas

Site	pH*	EC**, dS m^{-1}	$CaCO_3$, g kg^{-1}	OM g kg^{-1}	Particle size distribution, %			Textural class
					Sand	Silt	Clay	
G1	7.84	1.41	13.40	34.12	83.60	10.40	6.00	Loamy sand
G2	7.83	1.12	15.60	42.26	84.30	9.80	5.90	Loamy sand
G3	7.83	1.61	9.50	36.15	86.50	10.20	3.30	Loamy sand
G4	7.12	1.49	9.40	36.11	86.10	8.17	5.73	Loamy sand
G5	7.82	1.51	16.00	28.42	87.39	2.50	10.11	Loamy sand
G6	7.85	1.44	17.40	30.63	86.80	5.20	8.00	Loamy sand
G7	7.83	1.22	7.01	23.44	91.30	1.22	7.48	Sand
G8	7.81	1.98	28.50	20.15	89.20	2.30	8.50	Loamy sand
G9	7.85	1.43	8.40	28.33	88.70	3.50	7.80	Loamy sand
N1	7.35	1.64	34.10	56.15	71.00	17.50	11.50	Sandy loam
N2	7.28	1.90	0.80	28.50	90.20	6.20	3.60	Sand
N3	7.11	0.85	0.30	1.20	84.30	9.90	5.80	Loamy sand

See sample codes in Table 1
* 1:2.5 soil:water suspension, **Soil paste extract, EC, electrical conductivity; OM, organic matter

The acidified water samples were digested using APHA Method 3030 I. Nitric acid-perchloric acid-hydrofluoric acid digestion. The total metal contents in soils were extracted according to **USEPA (1995)**; method 3052: microwave-assisted acid digestion by concentrated HNO_3, HF, and HCl. The available contents were extracted using diethylene triamine pentacetate acid (DTPA) at pH 7.3 according to **Lindsay and Norvell (1978)**. The concentrations of Mn, Pb, and Zn were measured using atomic absorption spectrometry (AAS) (novaAA 350 Analytik Jena GmbH, Germany) using appropriate lamb for each metal.

3. Results and discussion

3.1. Metal concentrations in irrigation waters

3.1.1. El-Gabal El-Asfar farm

As shown in Fig. 2, the concentrations of Mn ranged from 240.11 to 413.13 µg L^{-1}. This indicates that Mn concentrations in all water samples were above the maximum recommended limit of 200 µg L^{-1} set by FAO 29 guidelines **(Ayers and Westcot, 1994)** and Egyptian standards 501/2015 **(ECP, 2015)**. High Mn concentrations (> 200 µg L^{-1}) is a common phenomenon in waters of El-Gabal El-Asfar, which has been indicated by previous works **(Abdel-Shafy and Abdel-Sabour, 2006; El-Nennah et al., 1982; Gemail, 2012)**.

The concentrations of Pb ranged from 3.20 to 42.67 µg L^{-1}. This indicates that Pb concentrations in all water samples were below the safe limit of 5000 µg L^{-1} as set by FAO 29 guidelines **(Ayers and Westcot, 1994)** and Egyptian standards 501/2015 **(ECP, 2015)**. These findings are similar to those obtained by **Elbana et al. (2013)** and **Abd-Elwahed (2018)** who reported that Pb concentrations in wastewater collected from the south, middle and north sections did not exceed the safe limit (5000 µg L^{-1}).

The concentrations of Zn ranged from 131.62 to 275.21 µg L^{-1}. This indicates that Zn in all water samples did not surpass the safe limit of 5000 µg L^{-1} as recommended by FAO 29 guidelines **(Ayers and Westcot, 1994)** and Egyptian standards 501/2015 **(ECP, 2015)** This result is in harmony with those reported by earlier studies **(Abdel-Shafy and Abdel-Sabour, 2006; Abdel El Lateef et al., 2006; El-Nennah et al., 1982; Elhassanin et al., 1993)** who indicated that Zn concentrations in either raw or partially treated sewage effluents of El-Gabal El-Asfar did not exceed the permissible limit.

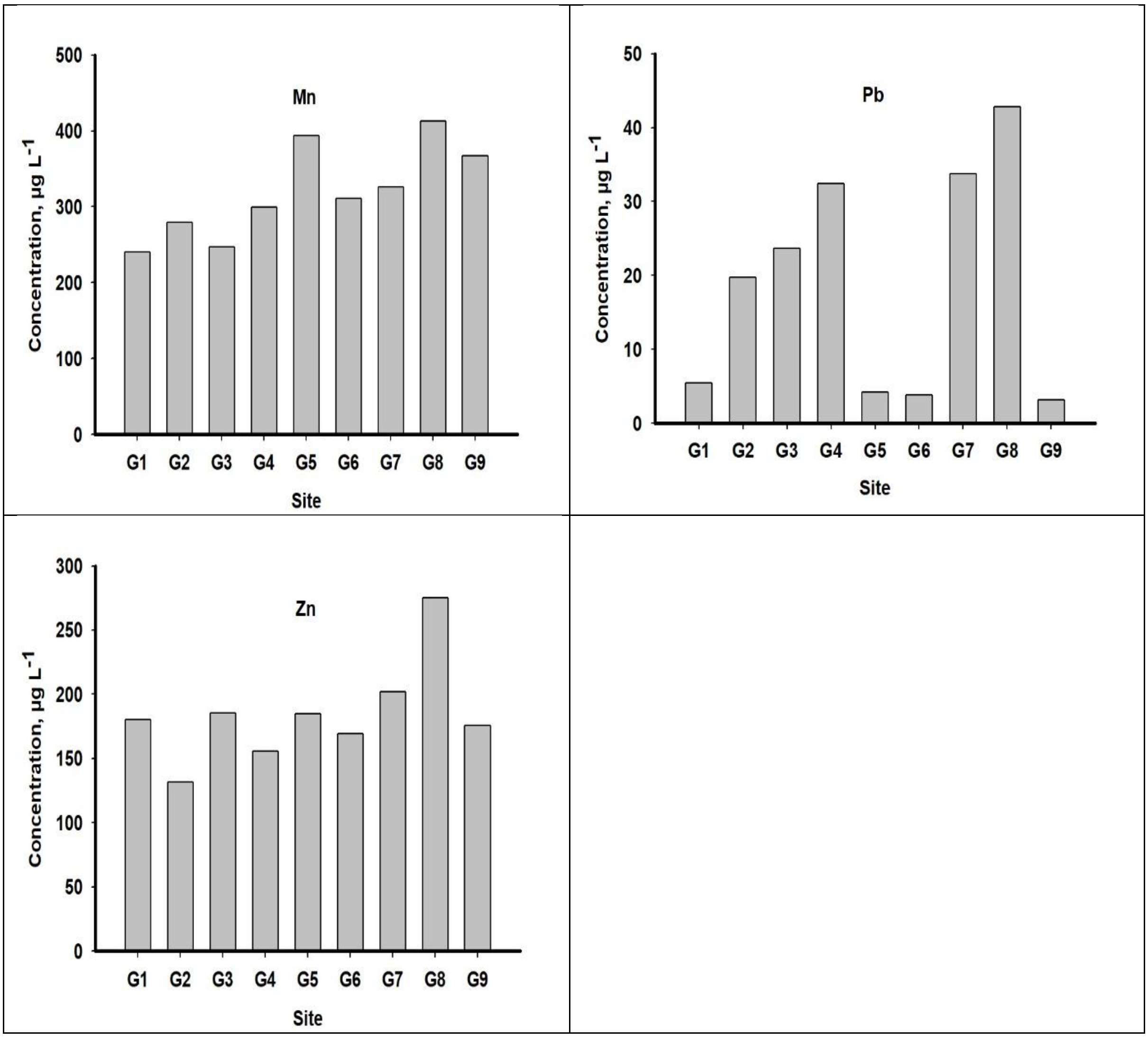


Fig. 2. Concentrations of Mn, Pb and Zn in the investigated irrigation water samples from El-Gabal El-Asfar farm

3.1.2. Middle Nile Delta region

As shown in Fig. 3, the concentrations of Mn, Pb, and Zn in the three sites ranged from 5.11 to 377.50, 7.22 to 62.67, and 4.31 to 235.51 µg L^{-1}, respectively. The concentrations of Mn in site N3 were < the safe limit (200 µg L^{-1}), while the corresponding ones in sites N1 and N2 were 1.88 and 1.83-folds the safe limit. The concentrations of Pb and Zn were below the safe limits (5000 µg L^{-1}) in the three sampling sites. In the middle Nile Delta region, **Salem et al. (2012)** reported that the average concentration of Mn in water samples collected from Kitchener drain was 210 µg L^{-1}, while that of samples collected from Tala drain (agricultural drainage water) was 150 µg L^{-1}.

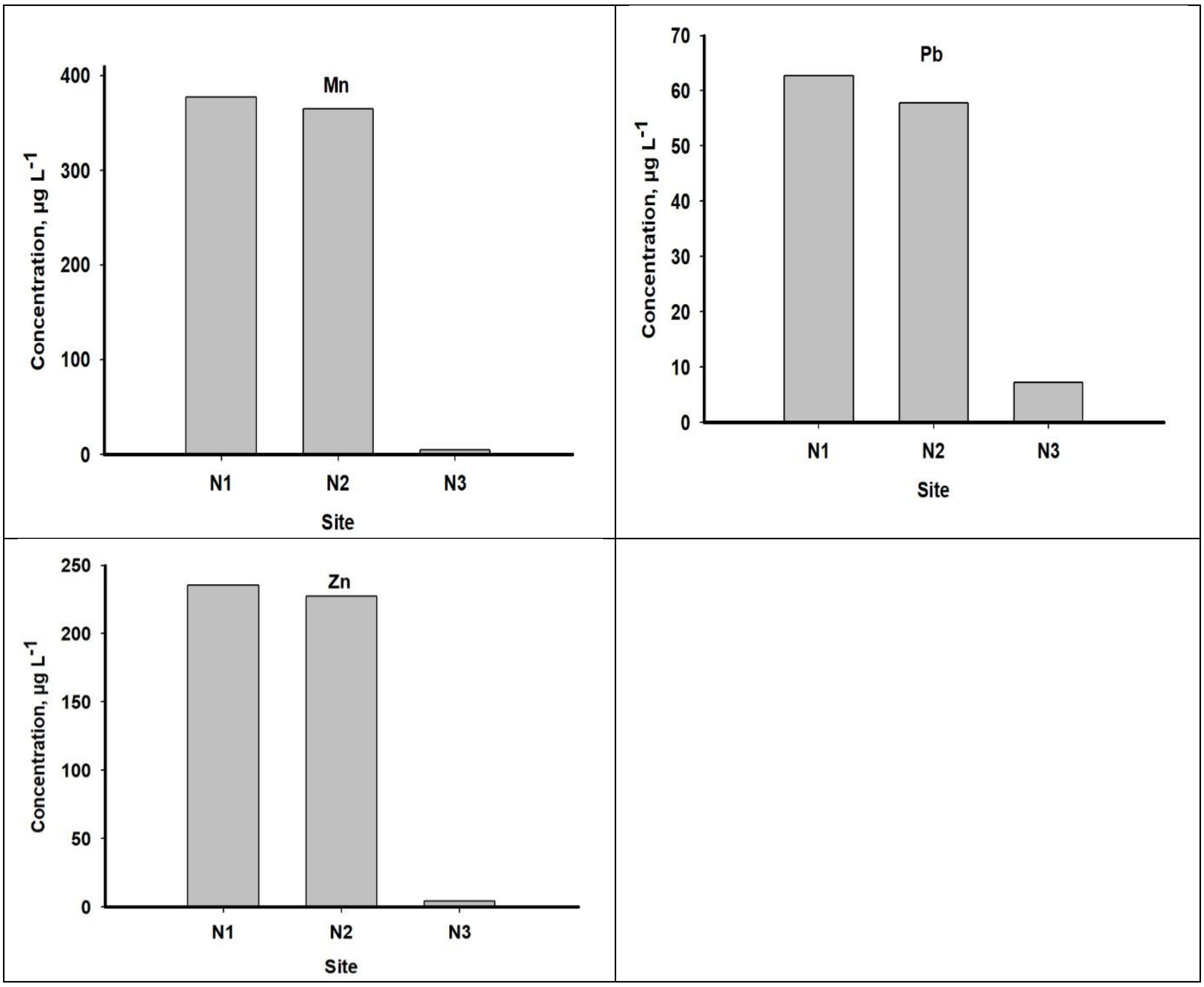
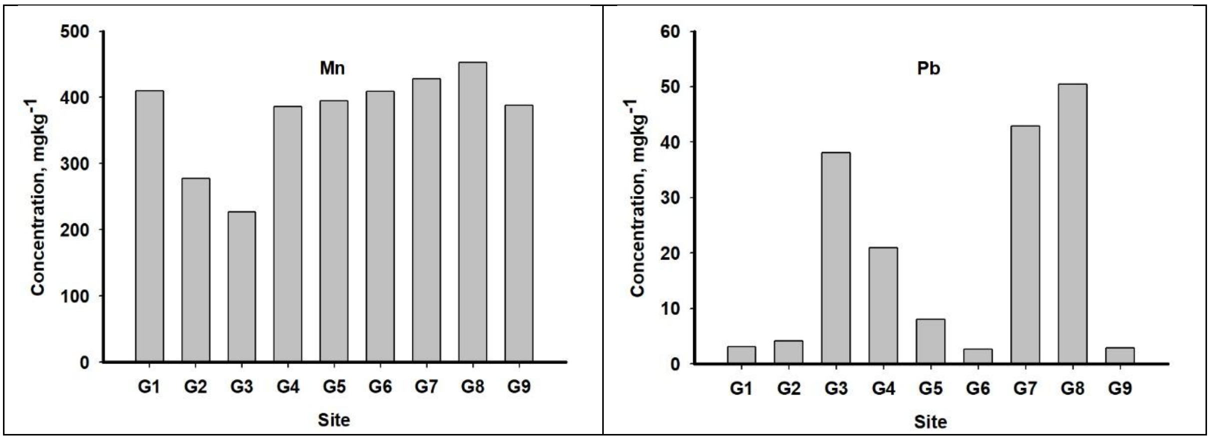


Fig. 3. Concentrations of Mn, Pb and Zn in the investigated irrigation water samples from the middle Nile Delta

3.2. Total metal content in the investigated soils

3.2.1. El-Gabal El-Asfar farm

Results in Fig. 4 show that the total Mn concentrations ranged from 226.90 to 452.72 mg kg^{-1}. This range demonstrates that Mn concentrations in the studied soils did not yet reach warning concentrations. The Mn concentrations in all soil samples were below the average natural content (ANC) in the Earth's crust (i.e. 900 mg kg^{-1}; **Kabata-Pendias, 2011**) or the maximum allowable concentrations (MAC) of 4 g kg^{-1}; **(Allaway, 1968)**. These findings are in harmony with **Abdel El Lateef et al. (2006)** who reported a maximum total Mn concentration of 141.0 mg kg^{-1} in surface soils samples collected from El-Gabal El-Asfar farm.



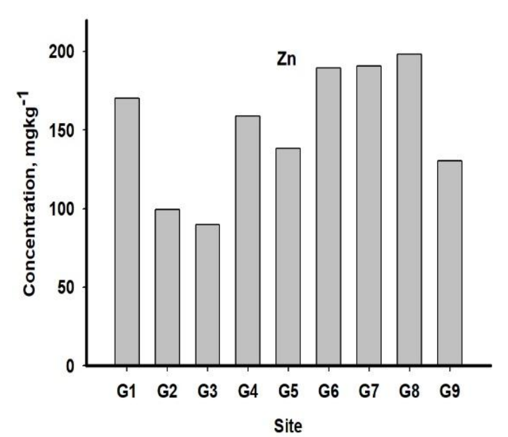


Fig. 4. Total concentrations of Mn, Pb and Zn in soils of El-Gabal El-Asfar farm

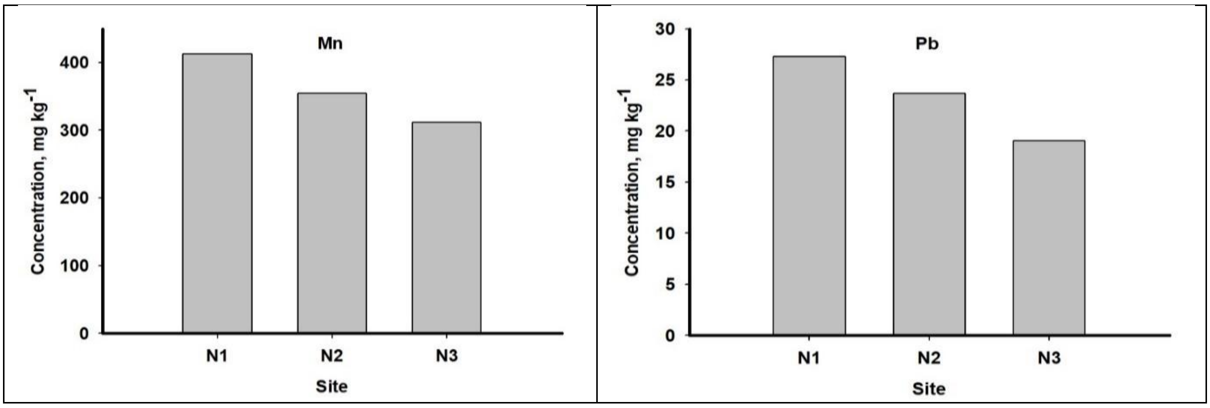
The concentrations of total Pb varied from 2.72 to 50.43 mg kg^{-1}. These ranges show that Pb concentrations exceeded the ANC of 15 mg kg^{-1} **(Kabata-Pendias, 2011)** in four sites; G3, G4, G7, and G8, causing potential environmental risks. However, they did not surpass the MAC of 200 mg kg^{-1} **(Allaway, 1968)**. These findings are rather similar to previous studies that reported maximum Pb concentrations of 117.60 mg kg^{-1} **(Elhassanin et al., 1993)** and 196.00 mg kg^{-1} **(Abdel El Lateef et al., 2006)** in surface soils samples of El-Gabal El-Asfar farm. However, **Elbana et al. (2013)** reported that the total Mn content of surface soils collected from the south, middle and north sections of El-Gabal El-Asfar farm varied from 7.0 to 237.0 mg kg^{-1}.

The concentrations of total Zn ranged from 89.73 to 198.40 mg kg^{-1}. These ranges demonstrate that total Zn contents in all soil samples were above the ANC of 70 mg kg^{-1} **(Kabata-Pendias, 2011)**, rendering potential hazards. However, they remained below the MAC of 300 mg kg^{-1} **(Kabata-Pendias, 2011)**. These findings are in line with those obtained by **Abdel El Lateef et al. (2006)** who reported a range of 69.7 to 166.0 mg kg^{-1} for total Zn in surface soils of El-Gabal El-Asfar farm. On the other hand, higher concentrations of total Zn content in surface soils than 300 mg kg^{-1} were reported in previous works **(El-Nennah et al., 1982; Elhassanin et al., 1993)**.

3.2.2. The middle Nile Delta region

As shown in Fig. 5, the total concentrations of studied metals in the three sampling sites were 311.24 to 412.80 mg kg^{-1} for Mn, 19.06 to 27.30 mg kg^{-1} for Pb, and 61.11 to 408.12 mg kg^{-1} for Zn. These values in turn show that the total Mn content in the three sampling sites remained within the safe limits since they did not exceed neither the ANC of the Earth's crust (900 mg kg^{-1}) nor MAC (4 g kg^{-1}). These values indicate that total Pb concentrations in all sampling sites were above the ANC (15 mg kg^{-1}), which may result in potential hazards. However, they remained below the MAC (200 mg kg^{-1}). The concentrations of Zn in sites N1 and N2 surpassed either ANC (70 mg kg^{-1}) or MAC (300 mg kg^{-1}), while Zn in site N3 did not exceed those ranges.

These findings are similar to those obtained by **Mansour et al. (2020)** who indicated that total concentrations of Mn, Pb, and Zn in Kafr El-Sheikh soils irrigated with Kitchener drain were 498.26, 31.30, and 80.13 mg kg^{-1}, respectively. On the other hand, **Aitta et al. (2019)** reported that total concentrations of the same metal in soils irrigated with Kitchener drain in Kafr El-Shikh Governorate ranged from 605.00 to 1032.50, 9.05 to 94.60, and 17.25 to 198.75 mg kg^{-1} for Zn, Pb, and Zn, respectively.



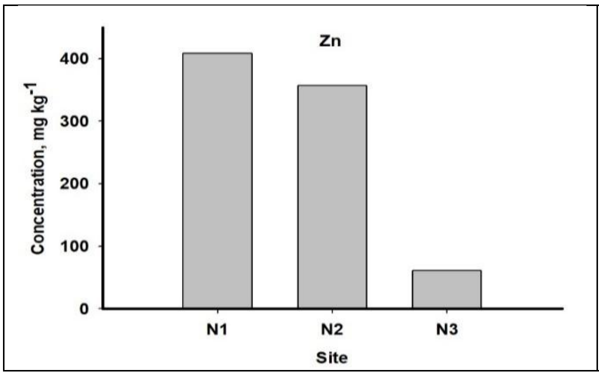


Fig. 5. Total concentrations of Mn, Pb and Zn in soils of middle Nile Delta region

3.3. The DTPA-extractable metal content in the investigated soils

3.3.1. El-Gabal El-Asfar farm

The concentrations of DTPA-extractable Mn ranged from 49.46 to 91.47 mg kg^{-1} (Fig. 6). These values indicate that Mn concentration in all sites would pose potential risks since they were above the safe limit of 5.0 mg kg^{-1} **(Gatta et al., 2021)**. These findings are rather similar to those reported by **Abdel-Shafy and Abdel-Sabour (2006)** who reported a value of 35.61 mg kg^{-1} for the DTPA-extractable Mn in surface soils of El-Gabal El-Asfar.

The concentrations of DTPA-extractable Pb varied from 0.91 to 4.87 mg kg^{-1}. With exception of sites G1 and G9, Pb concentrations in all sampling sites would result in potential hazards as they were beyond the safe limit of 2.0 mg kg^{-1} **(Gatta et al., 2021)**. These findings are in rather similar to those obtained by **Elhassanin et al. (1993)** who reported that the DTPA-extractable Pb in surface soils of El-Gabal El-Asfar farm was 4.8 mg kg^{-1}. Moreover, in surface soils of south, middle and north sections of El-Gabal El-Asfar farm, **Elbana et al. (2013)** and **Abd-Elwahed (2018)** reported that the AB-DTPA- extractable Pb ranged from 0.34 to 35.0 and 0.26 to 37.4 mg kg^{-1}, respectively.

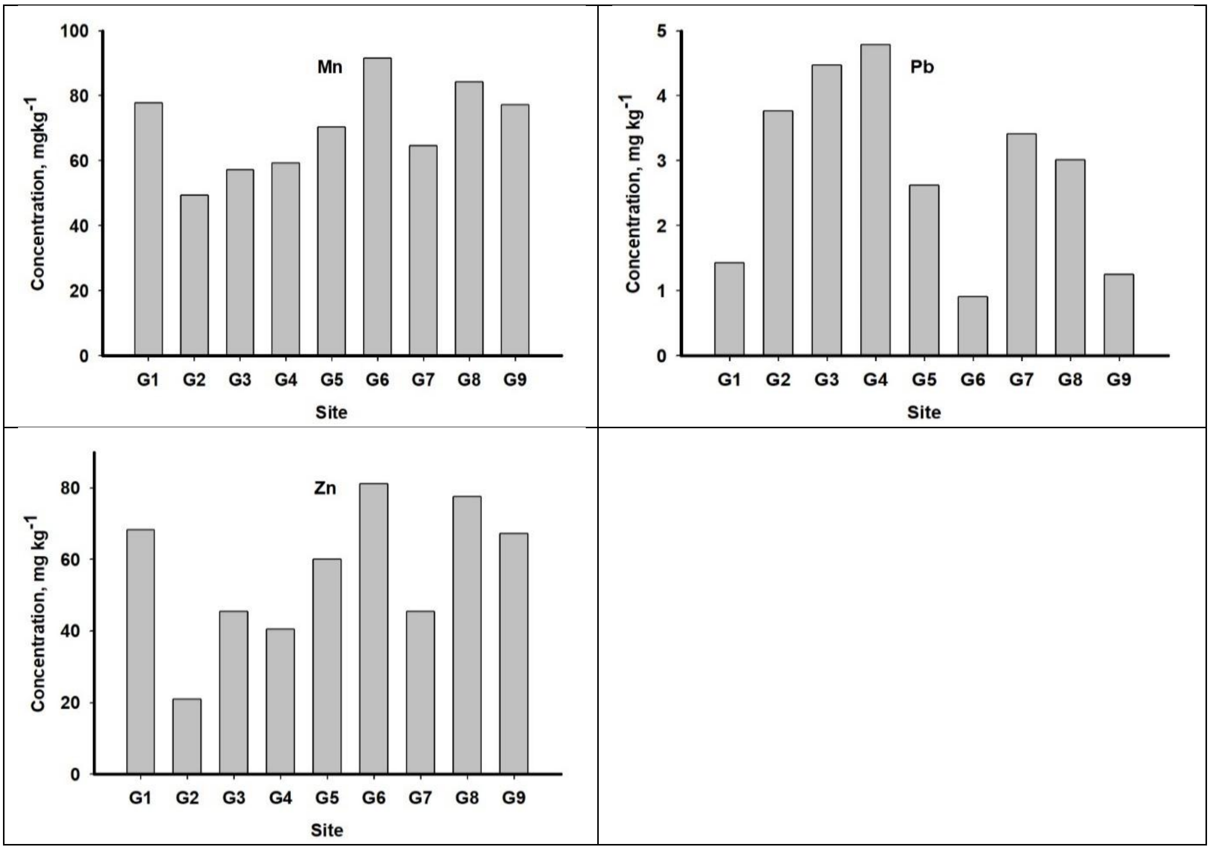


Fig. 6. DTPA-extractable contents of Mn, Pb and Zn in soils of El-Gabal El-Asfar farm

The concentrations of DTPA-extractable Zn varied from 21.05 to 81.23 mg kg^{-1}. These values in turn illustrate that Zn concentrations in all sampling sites would pose potential risks since they were far away from the safe limit of 1.25 mg kg^{-1}**(Gatta et al., 2021)**. These findings are in harmony with those obtained by **Abdel-Shafy and Abdel-Sabour (2006)** who reported that the content of the DTPA-extractable Zn in surface soils of El-Gabal El-Asfar farm was 43.78 mg kg^{-1}. However, a higher value of 140.3 mg kg^{-1} was also reported by **Elhassanin et al. (1993)**.

3.3.2. The middle Nile Delta region

As shown in Fig. 7, the DTPA-extractable metal contents in the sampling sites were 5.13 to 11.44 mg kg^{-1} for Mn, 0.50 to 4.03 mg kg^{-1} for Pb, and 2.11 to 6.36 mg kg^{-1} for Zn. These ranges indicate that concentrations of available Mn and Zn in the three sampling sites were beyond the safe limits of 5 and 1.25 mg kg^{-1}, respectively **(Gatta et al., 2021)**. On the other hand, Pb content in site N1 was about double the safe limit (2.0 mg kg^{-1}), while below that limit in the two other sites.

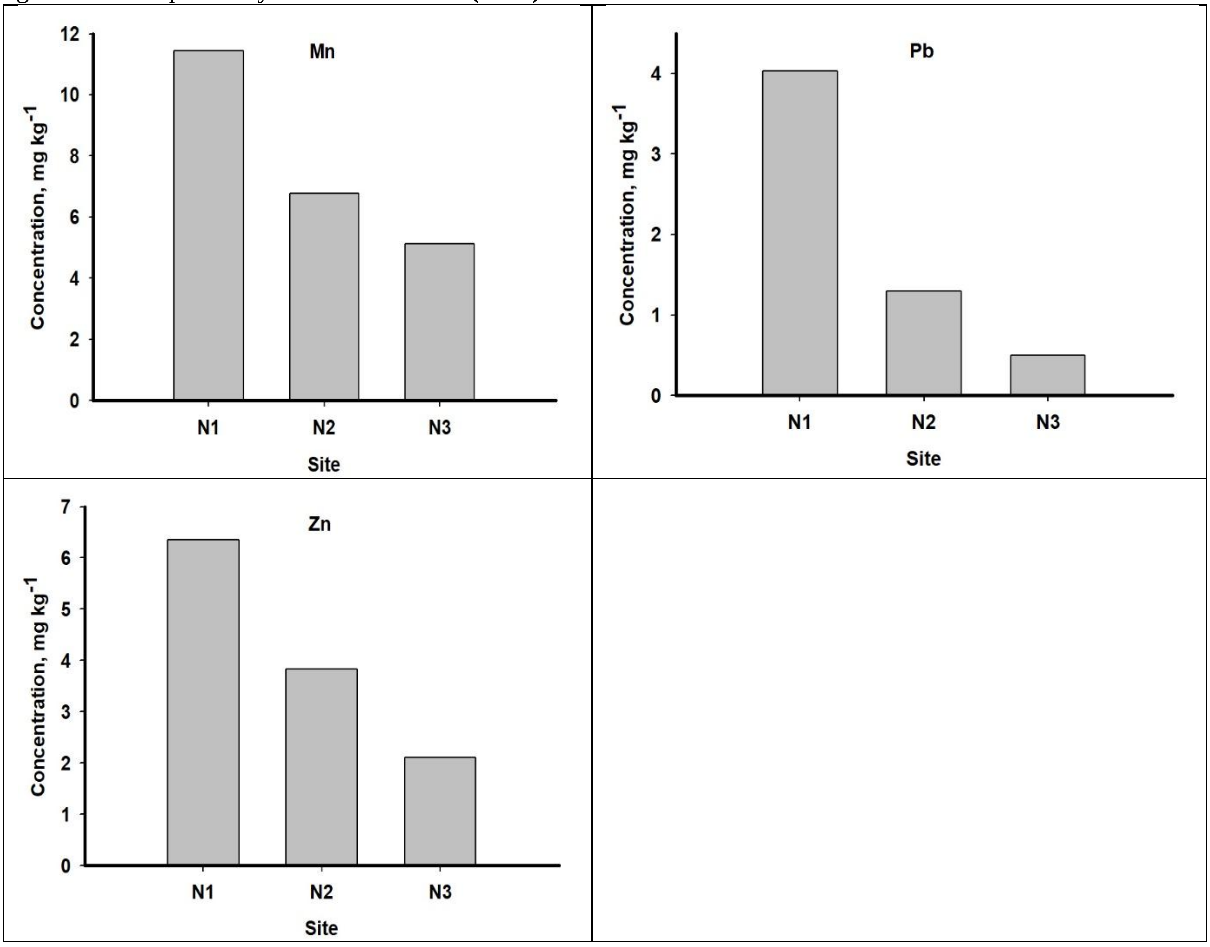


Fig. 7. DTPA-extractable contents of Mn, Pb and Zn in soils of middle Delta region

These findings are rather similar to those obtained by **El-Alfy et al. (2017)** who reported that the DTPA-extractable Pb in surface soils irrigated with Kitchener drain ranged from 1.88 to 2.81 mg kg^{-1}. Furthermore, **Aitta et al. (2019)** reported that the AB-DTPA extractable contents of Mn, Pb, and Zn in Kafr El-Sheikh soils subjected to long term irrigation with Kitchener drain ranged from 1.46 to 8.87, bdl to 2.56, and 0.55 to 5.01 mg kg^{-1}, respectively.

4. Conclusion

In this work, total and DTPA-extractable contents of Mn, Pb, and Zn in surface soils in the southeast (El-Gabal El-Asfar farm) and middle Nile Delta regions after long-term irrigation using low-quality waters were investigated. The concentrations of Mn in irrigation waters in El-Gabal El-Asfar farm and Kitchener drain (middle Nile Delta) were above the permissible limit for irrigation, while Pb and Zn were below that limit in all collected samples. The soils showed total Mn lower than the ANC. The total Pb content in four sites within El-Gabal El-Asfar farm and all sites in the middle Nile Delta region surpassed the ANC, but did not exceed the MAC. Soils of El-Gabal El-Asfar farm showed total Zn contents higher than the ANC, but below the MAC. Mixed wastewater and agricultural drainage water-irrigated soils in the middle Nile Delta showed total Zn contents higher than the MAC. Soils of El-Gabal El-Asfar farm showed DTPA-extractable contents of Mn and Zn above the safe limits, while the corresponding Pb concentrations were beyond the safe limit, except for two sites only. The DTPA-extractable Mn and Zn in the middle Nile Delta soils were beyond the safe limits. Furthermore, soils irrigated with Kitchener drain showed available Pb content about double the safe limit. Adequate wastewater treatments in addition to adopting proper remediation strategy are recommended to alleviate metal accumulation in the food chain.

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رصد تراكم المنجنيز والرصاص والزنك في التربة السطحية بعد الري طويل الأمد بالمياه منخفضة النوعية : دراسة حالة لجنوب شرق ووسط دلتا النيل – مصر

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يهدف هذا البحث إلى رصد المنجنيز والرصاص والزنك في التربة السطحية المتأثرة بالري طويل الأمد بإستخدام مياه منخفضة النوعية. تم إختيار منطقتين للدراسة وهما مزرعة الجبل الأصفر جنوب شرق دلتا النيل التي تروى بمياه الصرف الصحي والمياه الجوفية وتم تجميع 9 عينات من مياه الري ومن التربة السطحية (0 – 30 سم). اما المنطقة الثانية في وسط الدلتا ومنها تم تجميع 3 عينات مياه من مصادر ري مختلفة وهي مصرف كتشنر(صرف مختلط)، مصرف تيره (صرف زراعي مع مياه النيل)، وترعة بحر تيره (مياه النيل)، كما تم تجميع 3 عينات من التربة التي تروى بهذه المصادر الثلاث. تم تقدير المحتوى الكلي والميسر (DTPA) من هذه العناصر في التربة. أكدت النتائج أن المحتوى الكلي من المنجنيز في التربة لم يتعدى الموجود في القشرة الأرضية (900 ملجم/كجم). ظهر المحتوى الكلي للرصاص في 4 مواقع بالجبل الأصفر وجميع مواقع وسط الدلتا بتركيزات أعلى من الموجودة بالقشرة الأرضية (15 ملجم/كجم)، ولكنها لم تتعدى الحد الأقصى المسموح به في التربة (200 ملجم/كجم). أظهرت أراضي الجبل الأصفر تركيزات من الزنك الكلي أعلى من الموجودة في القشرة الأرضية (70 ملجم/كجم)، ولكنها لم تتعدى الحد الأقصى المسموح به في التربة (300 ملجم/كجم). أظهرت الأراضي المروية بمياه الصرف المختلط أو الصرف الزراعي في وسط الدلتا تركيزات من الزنك الكلي أعلى من الحد الأقصى المسوح به في التربة. وجد المحتوى الميسر من المنجنيز والرصاص بأراضي الجبل الأصفر أعلى من الحدود المسموح بها في التربة (5 و 1.25 ملجم/كجم في التوالي)، بينما تعدت تركيزات الرصاص الحد الآمن (2 ملجم/كجم) في 7 مواقع بالمزرعة. زاد المحتوى الميسر من المنجنيز والزنك الحدود الآمنة في جميع أراضي وسط الدلتا، بينما زاد تركيز الرصاص الميسر في الأراضي المروية بمياه مصرف كتشنر عن الحد الآمن.