Journal of Soil Sciences and Agricultural Engineering

Journal homepage & Available online at: www.jssae.journals.ekb.eg

A Qualitative and Quantitative Study to Effect of El- Gharbia Main Drain Wastewater on The Surrounding Soils and Plant Life

Eman M. Abd El-Razik*; Omnia F. Amin; M. S. A. Ramadan and A. M. Abosena

Soil Water and Environment Research Institute (SWERI), Agricultural research center (ARC) Giza Egypt

ABSTRACT

El-Gharbia main drain poses a significant environmental threat, as it receives wastewater from three sources: sewage, agriculture, and industry. The objective of this study is to evaluate the impact of El-Gharbia main drain wastewater on the micronutrient and heavy metal content of surrounding soil and plant. Samples (soils and plants) were taken from fifteen sites along the drain in winter of 2020 and summer of 2021. Results showed that the content of soils and plants samples from micronutrients such as Fe, Mn, Zn, Cu and B and heavy metals such as Cd, Co, Cr, Ni and Pb) were differed from site to another, in some cases, the overall mean exceeded the permissible limit in both seasons, but the pollution degree was higher in the summer season. As for the bioaccumulation factor values (BCF) in plant samples were higher than 1. Application of risk assessment equations showed that the enrichment factor (EF) of micronutrients and heavy metals values were low level except for cadmium element values which varied from very significant to severe level and lead element values were moderate level in both seasons under study, contamination factor (CF) values were varied from low to moderate except for cadmium element were severe contamination level in both seasons, contamination degree (Cd) were varied from considerable to very high level in both seasons, pollution load index (PLI) values were high contamination level in both seasons except for site No. 1was low level at winter season.

Keywords: El-Gharbia drain water, heavy metals, risk assessment equations.

INTRODUCTION

Human activates participate the contamination of water bodies and organisms with probably toxic materials (Maanan, 2008). Abnormal level of land use change has led to a dangerous risk of heavy metal contamination in ecosystems. El-Gharbia main drain, also known as Kitchener drain, poses a severe threat to the residents of several villages in El-Gharbia and Dakahlia governorates, as well as some centers in Kafr El-Sheikh governorate. The drain stretches over 100 kilometers, starting from El-Mahalla El-Kubra in El-Gharbia governorate and ending in Burullus in Kafr El-Sheikh. Many factories in El-Mahalla and Kafr El-Zayat dispose of their industrial wastewater through subsidiary drains that connect to the El-Gharbia main drain. Additionally, the sewage system in Tanta passes through the borders of Kafr El-Sheikh governorate, adding to the pollution of the drain. Farmers in the area are compelled to use the contaminated water from the Kitchener drain to irrigate their fields, despite the presence of various industrial and health pollutants. This hazardous practice puts the health of Egyptians at risk and may explain the high incidence of hepatitis C virus in the villages of Hamoul, Bella, and Baltim centers, which the drain passes through. Heavy metals dissolve in water so easily absorbed and accumulate by aquatic organisms. Small levels of concentrations can be toxic because the metals bioaccumulation, which means that their concentration in an organism is higher than in water (Rajeshkumar and Li, 2018). On the other hand, using of sewage and industrial wastewater, municipal compost and pesticides lead to pollute agricultural soils with heavy metals (Alengebawy, 2021).

Heavy metals are found in wastewater, such as Cd, Cr, Pb, Cu, Zn, and Ni, the high content of wastewater of these metals above the permissible limits cause serious risks to human health, all living organisms and environmental balance, so plants were grown on polluted soil may be to accumulate toxic metals in their tissues, which leads to accumulate of these toxic metals in the livers and kidneys of humans, leading to disruption of biochemical processes, such as liver, kidney, cardiovascular, nervous and bone disorders (Tchounwou *et al.*, 2014).

Also, pollutants may be in solid or liquid forms consisting of organic and inorganic wastes, spent oil or lubricants, pesticides and fertilizers over-enrichment, which caused human health problems and adversely affect biological communities and resources (Chang *et al.*, 2012). Furthermore, depletion of dissolved oxygen caused by the aerobic decomposition of organic and inorganic compounds, thus being an environmental concern in water bodies throughout the world (Chang *et al.*, 2012). The decrease of dissolved oxygen concentration in these drains may be related to the domestic wastes discharged directly into the drains, which contain high amounts of biodegradable organic matter (Zaghloul and Elwan, 2011). The current study aims to assess degree of influence of El-Gharbia drain wastewater on soil and plant contamination with micronutrients and heavy metals.

MATERIALS AND METHODS

El-Gharbia main drain (Kitchener) is the longest existing drain in Egypt, extends more than 100km, and it connects three governorates "Gharbia, Dakahlia and Kafr El-Sheih", 46 km of which are within the Kafr El-Sheikh governorate, It ends up in the Mediterranean Sea and pollutes Burullus Lake, On its edges, there are 128 villages whose residents depend on the drain water to irrigate their agricultural soils and fish.

*** Corresponding author.**
E-mail address: eman66mohamed16@gmail.com
DOI: 10.21608/jssae.2023.196540.1151

Samples were taken from fifteen sites along El-Gharbia main drain in the winter of 2020 and the summer of 2021 seasons. The samples include soil and plants from each site, Table 1 show the sampling sites and its coordinates.

Table 1. Sampling sites along El-Gharbia main drain

Site No.	Site Name	Longitude (E)	Latitude (N)
1	Segaeya	31° 3' 42.373" E	30° 59' 16.062" N
2	Segaeya after uploading station	31° 4' 17.600" E	31° 1' 9.323" N
3	After Nemra Albasal	31° 4' 55.324" E	31° 3' 47.393" N
4	Before Dukhmays	31° 4' 23.211" E	31° 5' 49.515" N
5	Mansheya Nasrya	31° 4' 23.074" E	31° 9' 42.549" N
6	Ezbet George Dagher	31° 6' 57.130" E	31° 11' 5.214" N
7	Before Ezbet Neel El-Kbeir	31° 7' 27.539" E	31° 13' 47.324" N
8	Ezbet Mashrqi	31° 7' 16.078" E	31° 16' 4.776" N
9	After El-Hamoul	31° 9' 19.013" E	31° 19' 47.516" N
10	Qetaa Alzaweyah	31° 10' 15.726" E	31° 21' 7.117" N
11	Before Ezbet elbadarwa	31° 11' 4.500" E	31° 22' 16.883" N
12	Before Qaria 7	31° 11' 7.050" E	31° 23' 28.045" N
13	After Qaria 9	31° 10' 23.592" E	31° 26' 22.848" N
14	Before Qaria 13	31° 9' 45.446" E	31° 28' 3.322" N
15	After uploading station AlKhashaa	31° 8' 47.136" E	31° 29' 59.130" N

Soil samples preparation

Surface soil (0 – 30 cm) samples were collected from all sites and kept in polyethylene bags. Soil samples were air dried and sieved through a <0.2 mm and stored in the labeled polythene sampling bags (Lei *et al.*, 2008). One gram of each sample was digested according to Cottenie *et al.*, 1982 to determined total contents of micro nutrients and heavy metals, with three replicates.

Plant samples preparation

A parts of plants grown in the study area were taken such as; clover leaves (*Alfalfa*), turnip leaves (*Brassica rapa subsp. rapa*) and cabbage leaves (*Brassica oleracea var*) , cabbage leaves (*Brassica oleracea var.*),bean stalks and leaves (*Vicia faba*) and carrot leaves (*Daucus carota*) in winter season, cotton leaves (*Gossypium*), corn leaves (*Zea mays*), rice leaves (*Oryza sativa*) and pepper leaves (*Annuum Capsicum*) in summer season were collected from different sites in three replicates and stored in labeled polythene sampling bags and were brought to the laboratory directly after sampling. Plant parts were washed with distilled water, and then oven dried, ground and digested (Jamali *et al.*, 2009). Plant samples were digested according to Jackson, 1979.

Samples analysis

Available micro nutrients and heavy metals were extracted using NH4HCO3-DTPA (AB-DTPA) solution according to Lindsay and Novell (1978). The total and available micro nutrients and heavy metals contents of Cd, Co, Cu, Cr, Fe, Pb, Mn, Ni and Zn for all samples (soil and plant) were determined by using inductively coupled plasma (ICP-JY ULTIMA).

Risk assessment equations

Environmental pollution by heavy metals has been consideration as a dangerous problem because of their toxicity, persistence and bioaccumulation (Liu *et al.*, 2022). So it is necessary to investigate the distribution and pollution degree of heavy metal, in order to explain the mechanism of transportation and accumulation of pollutants (long *et al.*, 2006).

1- Enrichment factors

This factor is used to calculate the degree of environmental pollution from heavy metals as a result of human activity. Iron is used as a reference element depending on its stability in the soil (Table 2), which is characterized by the absence of vertical movement in the soil or its exposure to deterioration phenomena (Barbieri *et al.*, 2015).

Table 2. Distribution of the elements in the Earth's crust

Elements	Fe	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb
	(mgkg^{-1})									
Elements background	47000	850.0	95.0	45.0	100.0	0.30	19.0	90.0	68.0	23.9

$$EF = (C_x/Fe)\ sample\ /\ (C_x/Fe)\ background \quad (1)$$

where C_x concentration of metal x.

According to Faiz *et al.*, (2012) EF < 2 indicates that deficiency to low enrichment, 2 < EF > 5 moderate enrichment, 5< EF ≤ 20 significant enrichment; 20 < EF ≤ 40 very high enrichment; and EF > 40 extremely high enrichment factor.

2. Contamination Factor (CF)

$$CF = C/C_0 \quad (2)$$

where C is the concentration of the studied element in the sample, C_0 is the concentration of the studied element in the earth's crust.

The levels of sample contamination by CFs are characterized according to Sutherland *et al.* (2000) as follows: CF < 1 indicates a low contamination level, 1 ≤ CF < 3 moderate contamination level, 3 ≤ CF ≤ 6 high contamination and CF > 6 very high contamination level.

3. Contamination degree (Cd)

The Cd is aimed at providing a measure of the degree of overall contamination sampling site. The numeric sum of the k specific contamination factors expressed the overall of contamination degree.

$$Cd = \sum_{i=1}^{k} CF \quad (3)$$

where k is specific contamination factors expressed the overall of contamination degree and i is the element or pollutant and CF is contamination factor Hakanson (1980) proposed the classification of the contamination degree in samples as: Cd<1 low contamination level,1≤ Cd < 3 moderate contamination level, 3 ≤ Cd < 6 considerable contamination level, Cd ≥ 6 very high contamination level.

4. Modified contamination degree

$$Cd = \sum_{i=1}^{k} CF/n \quad (4)$$

where n is number of analyzed elements and i is ith element or pollutant and CF is contamination factor.

5. Pollution Load Index (PLI)

$$PLI = (CF1 \times CF2 \times CF3 \times .... \times CFn)^{1/n} \quad (5)$$

where PLI is the pollution load index, n is the number of studied metals and CF is the contamination factor.

The obtained results of PLIs are outlined according to Varol (2011) as follows: PLI < 1 indicates the absence of contamination, PLI = 1 low contamination level and PLI > 1 refers to high contamination level.

RESULTS AND DISCUSSION

Continuous reuse of wastewater in agricultural practices without treatment leads to accumulation of micronutrients (Fe, Mn, Zn, Cu and B) and heavy metals (Cd, Co, Cr, Ni and Pb) in the soil and plants to extent that endangers the life of living organisms

1- Effect of using low-quality irrigation water from El-Gharbia main drain on total micronutrients and heavy metals content in studied soils.

Tables 3 and 4 showed that the long-term use of water from El-Gharbia main drain to irrigate the surrounding agricultural soil led to accumulation of micronutrients and heavy metal content in two seasons under study, but less than the permissible limits according to the European Union (2006).

Table 3. Effect of using low-quality water from El-Gharbia main drain on total micronutrients and heavy metals content in studied soils at winter

Sites	%	mgkg^{-1}								
	Fe	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb
1	4.20	819.96	62.82	46.01	44.55	3.29	27.10	81.59	57.15	42.45
2	4.46	866.90	71.83	46.40	35.85	4.61	26.44	70.99	56.09	48.07
3	4.56	876.67	71.80	65.28	38.68	4.05	26.49	89.61	51.54	39.97
4	4.65	796.11	72.57	53.61	42.89	4.44	24.74	68.50	62.39	47.70
5	4.41	1151.44	84.74	59.20	54.20	4.11	28.84	90.55	79.65	60.17
6	4.54	946.30	66.69	51.82	45.49	3.94	24.29	89.98	64.41	49.67
7	4.52	792.03	63.56	53.50	46.00	4.51	22.74	156.78	74.74	62.00
8	4.49	858.85	70.31	65.89	49.45	2.95	21.34	164.83	92.34	62.48
9	4.80	1013.92	78.79	70.40	94.59	5.03	26.92	101.14	92.09	51.89
10	4.39	900.42	66.35	53.49	44.36	4.65	21.85	70.21	78.49	39.78
11	4.01	630.07	62.45	41.80	33.46	2.97	25.70	66.09	47.29	34.31
12	3.93	714.79	58.40	41.46	41.27	3.51	21.02	62.55	49.39	37.44
13	4.64	751.22	72.51	50.39	39.89	3.45	23.74	66.49	54.91	39.43
14	3.98	674.25	62.61	64.48	47.97	2.23	18.40	87.64	49.95	34.81
15	3.75	730.61	58.90	49.94	40.80	3.99	21.67	73.65	70.87	38.19
Mean	4.36	834.90	68.29	54.24	43.63	3.85	24.08	89.37	65.42	45.91
SD	0.31	135.20	7.35	9.01	5.52	0.77	2.88	31.18	15.16	9.72
Permissible limits	-	2000.0	300.0	100.0	-	3.0	50.0	100.0	100.0	100.0

SD: Standard deviation (statistically significant coefficients $p < .05$), Permissible limits according to European Union (2006)

Table 4. Effect of using low-quality water from El-Gharbia main drain on total micronutrients and heavy metals content in studied soils at summer

Sites	%	mgkg^{-1}								
	Fe	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb
1	3.90	135.10	89.90	51.10	44.78	24.20	10.14	94.74	62.76	49.15
2	4.11	297.32	58.20	20.90	26.48	12.14	11.90	63.21	79.27	50.23
3	4.22	189.00	28.90	40.10	33.71	12.40	14.62	35.24	76.30	36.47
4	4.90	126.90	27.70	20.00	43.19	14.70	9.04	83.54	61.50	49.52
5	4.25	105.10	55.10	25.10	41.34	13.21	20.50	77.02	89.50	54.86
6	4.60	215.80	52.90	14.90	41.98	13.38	11.90	83.41	71.30	38.26
7	4.62	183.50	64.10	18.80	42.57	12.86	0.00	45.09	46.90	36.47
8	4.55	124.90	29.60	16.90	38.74	26.24	0.00	29.35	40.39	60.12
9	4.37	123.10	58.90	31.70	29.37	23.49	20.20	66.47	75.00	28.36
10	4.16	186.50	77.90	18.50	28.72	24.39	0.00	63.21	71.65	29.31
11	4.26	153.40	82.50	17.20	26.48	23.62	13.20	85.45	77.24	41.24
12	4.35	131.90	73.50	34.70	32.45	27.63	15.80	66.25	80.60	30.87
13	4.13	914.35	66.9	23.80	38.54	27.64	18.50	45.64	83.60	31.88
14	4.08	756.51	72.70	15.70	40.78	27.80	15.50	52.34	74.24	41.67
15	4.75	485.91	71.10	22.70	39.58	22.53	8.15	71.54	55.12	45.54
Mean	4.35	818.82	60.66	24.81	36.58	20.42	15.38	64.17	69.69	41.60
SD	0.28	120.03	19.38	10.32	6.42	6.39	4.63	19.38	13.78	9.74
Permissible limits	-	2000.0	300.0	100.0	-	3.0	50.0	100.0	100.0	100.0

SD: Standard deviation (statistically significant coefficients $p < .05$), Permissible limits according to European Union (2006)

With regard to cadmium element, it exceeded the permissible limit (3 mg kg-1) in all sites except for sites No. 8, 11and 14 with values were 2.95, 2.97 and 2.23 mg kg-1, respectively, at the winter season (Fig. 1),

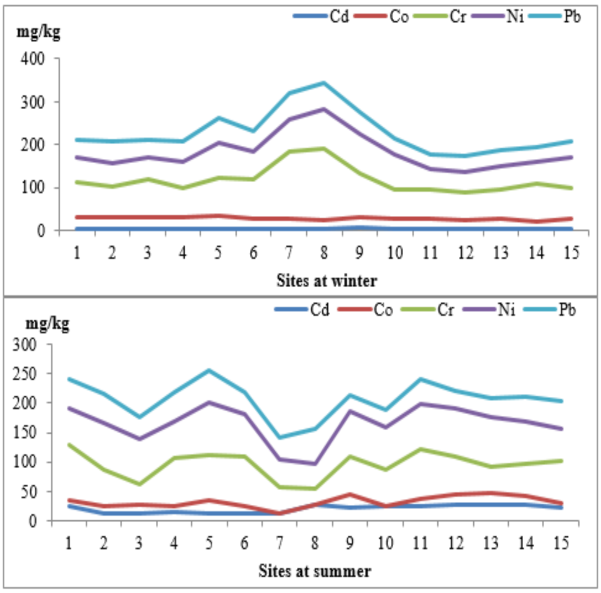

Fig. 1. Total heavy metals content in soil samples at winter and summer seasons

but in the summer season, the values of cadmium element in all sites exceeded the permissible limit with mean of 20.42 mgkg-1 to all sites under study (Fig. 1). On the other hand, chromium values were less than the permissible limit (100 mg kg-1) in both seasons under study, except for sites No. 7, 8 and 9, with values were 156.78, 164.83 and 101.14 mgkg-1, respectively. From the results, it is clear that the accumulation of heavy metals increases at summer season than winter season, and this may be due to increased consumption of detergents (Aonghusa and Gray, 2002). Also, many elements are entering to the water by human activities such as manufacturing construction and agriculture (Ghazi *et al.*, 2012). Furthermore, increasing micronutrient and heavy metals accumulation in agricultural soils due to using continuously of low-quality water irrigation at the long term (Mahmood and Malik, 2014).

2- Effect of using low-quality irrigation water from El-Gharbia main drain on available micronutrients and heavy metals content in studied soils.

The data in Tables 5 and 6 showed that the available soil contents of heavy metals did not exceed the permissible limits at two study seasons according to Kabata-Pendias and Pendias. (1992), ISI (1983) EUS (2002), except for Pb in tow sites at winter season were No. 7 and 8 with values of 1.1, 1.03 mg kg^{-1} (Fig. 4) and three sites at summer season were No. 7, 8 and 11 with values of 1.36, 1.17 and 1.11 mg kg^{-1} (Fig.2), respectively. Regard to the available soil contents of micronutrients in same previous Tables (5 and 6), it were found to exceed the permissible limits in both seasons under study, with exception of B element, suppose this due to the fertilizers addition which contains low amounts of heavy metals compared with micronutrients (Abdelhafez *et al.*, 2012). Also, addition of mineral fertilization and herbal and insect pesticides which contain considerable quantities of these micro-nutrients (Abdelhafez *et al.*, 2012).

Table 5. Effect of using low-quality water from El-Gharbia main drain on available micronutrients and heavy metals content in studied soils at winter

Sites	mgkg^{-1}									
	Fe	**Mn**	**Zn**	**Cu**	**B**	**Cd**	**Co**	**Cr**	**Ni**	**Pb**
1	16.47	6.99	4.73	2.85	1.42	0.07	0.17	0.05	0.45	0.45
2	21.91	8.34	4.92	2.95	0.55	0.12	0.28	0.38	0.51	0.49
3	20.69	11.75	5.97	3.57	0.49	0.10	0.04	0.39	0.47	0.48
4	15.19	8.48	4.444	2.61	0.53	0.07	0.17	0.35	0.69	0.45
5	23.40	10.28	8.22	3.23	0.89	0.15	0.26	0.10	0.78	0.74
6	23.79	15.25	8.46	3.10	1.68	0.13	0.08	0.38	0.72	0.74
7	18.79	11.35	9.99	4.29	1.99	0.12	0.03	0.12	1.11	1.10
8	25.20	11.72	9.08	3.66	1.00	0.15	0.07	0.11	1.00	1.03
9	16.57	11.80	6.69	2.67	1.05	0.16	0.24	0.51	0.51	0.56
10	11.10	8.54	6.94	5.03	0.76	0.08	0.33	0.91	0.54	0.54
11	15.44	7.70	4.60	3.58	0.27	0.03	0.03	0.41	0.41	0.37
12	13.25	8.39	5.61	2.85	0.27	0.04	0.03	0.03	0.65	0.72
13	19.22	8.12	6.24	3.45	1.68	0.17	0.07	0.02	0.46	0.41
14	22.14	11.01	7.98	3.38	0.58	0.03	0.0p2	0.04	0.73	0.78
15	16.13	8.03	6.78	3.17	0.31	0.12	0.16	0.02	0.55	0.57
Mean	18.63	9.85	6.71	3.36	0.90	0.10	0.13	0.27	0.64	0.64
SD	4.17	2.25	1.73	0.64	0.56	0.05	0.11	0.26	0.21	0.23
Permissible limits	0-5[a]	0-1[a]	0-1.5[a]	0.05[a]	0-5[a]	0-0.5[b]	-	8.0[b]	0-5[c]	0-1[c]

SD: Standard deviation (statistically significant coefficients p < .05), Permissible limits according to (a) Kabata-Pendias and Pendias. (1992), (b) ISI (1983), (c) EUS (2002)

Table 6. Effect of using low-quality water from El-Gharbia main drain on available micronutrients and heavy metals content in studied soils at summer

Sites	mgkg^{-1}									
	Fe	**Mn**	**Zn**	**Cu**	**B**	**Cd**	**Co**	**Cr**	**Ni**	**Pb**
1	16.33	7.03	4.63	2.94	0.38	0.05	0.31	0.06	0.52	0.54
2	23.19	8.66	5.27	3.31	0.32	0.11	0.47	0.40	0.50	0.48
3	15.70	12.65	7.05	2.66	0.20	0.17	0.04	0.05	0.55	0.56
4	14.43	8.71	4.31	2.62	0.48	0.09	0.26	0.12	0.65	0.66
5	32.84	8.77	5.79	3.26	0.98	0.24	0.48	0.09	0.58	0.59
6	27.24	23.03	10.34	3.13	2.38	0.10	0.13	0.02	0.87	0.92
7	19.07	13.70	12.07	3.38	1.02	0.06	0.04	0.02	1.30	1.36
8	23.18	13.95	10.47	3.42	0.40	0.18	0.10	0.07	1.11	1.17
9	17.17	15.36	7.15	2.75	0.94	0.22	0.14	0.19	0.72	0.71
10	11.39	9.49	6.77	4.09	0.80	0.03	0.36	0.07	0.62	0.63
11	15.34	11.35	5.66	0.04	1.12	0.03	0.02	0.30	0.76	1.11
12	18.47	10.58	8.47	0.02	0.98	0.05	0.68	0.54	0.54	0.36
13	13.48	11.27	15.48	0.05	0.71	0.05	0.21	0.21	1.83	0.87
14	16.58	15.89	10.54	0.04	0.78	0.15	0.73	0.03	0.39	0.54
15	17.88	7.58	11.57	0.04	1.45	0.28	0.53	0.11	0.29	0.99
Mean	18.82	11.87	8.37	2.12	0.86	0.12	0.30	0.15	0.75	0.77
SD	5.64	4.15	3.24	1.56	0.54	0.08	0.23	0.15	0.40	0.29
Permissible limits	0-5[a]	0-1[a]	0-1.5[a]	0.05[a]	0-5[a]	0-0.5b	-	8.0[b]	0-5[c]	0-1[c]

SD: Standard deviation (statistically significant coefficients p < .05), Permissible limits according to (a) Kabata-Pendias and Pendias. (1992), (b) ISI (1983), (c) EUS (2002)

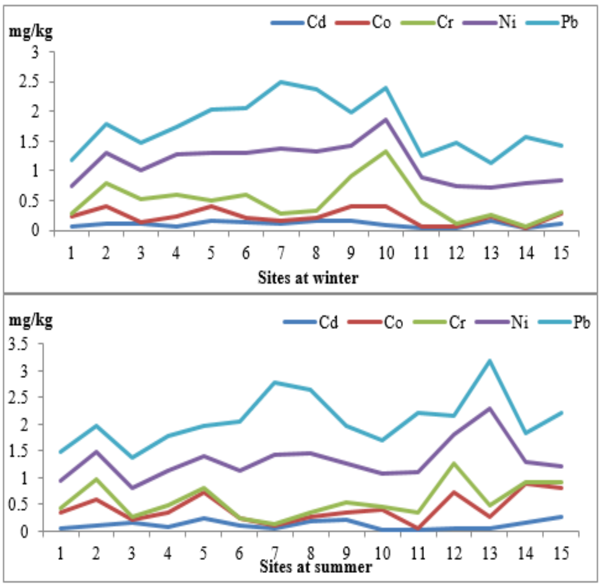

Fig. 2. Available heavy metals content in soil samples at winter and summer seasons.

3- Effect of using low-quality irrigation water from El-Gharbia main drain on micronutrients and heavy metals content in plants.

The data illustrated in Tables 7 and 8 showed the effect of the irrigation from El-Gharbia main drain on micro nutrient and heavy metals contents in plants grown in sites under study.

The data revealed that the content of some micronutrients such as Fe, Mn, Zn and Cu in some parts of plants were higher than the permissible limits according to FAO/WHO (1986) with values were 384.66 and 689.32, 51.83 and 30.43, 53.11 and 31.02 and 17.70 and 14.14 mg kg-1 as mean for all plants grown in winter and summer seasons at all sites under study, respectively. Also, B content in part of plants were higher than the permissible limits (20 mg kg-1) according to FAO/WHO (1986) except for cabbage and bean leaves with values were 8.01 and 15.93 mg kg-1 in sites No. 3 and 12 at winter season, while, at summer season the content of B in plants under study were less than the permissible limits(20 mg kg-1) according to FAO/WHO (1986) in sites No. 4, 9, 10, 11, 12, 13, 14 and 15.

On the other hand, it was found that the content of heavy metals such as Cd, Co, Cr, Ni and Pb in some plants under study were higher than the permissible limits with mean values were 0.97 and 0.28, 3.63 and 1.19, 5.72 and 1.64, 2.70 and 2.10 and 1.66 and 1.40 mg kg-1 in winter and summer seasons, respectively, according to FAO/WHO (1986), at all sites under study. Figure 3 showed that the heavy metals accumulate in plants which irrigated from El-Gharbia main drain wastewater.

Table 7. Effect of using low-quality water from El-Gharbia main drain on micronutrients and heavy metals content in plants at winter

Sites	Part of plants	mgkg^{-1}									
		Fe	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb
1	Clover leaves	272.32	24.36	54.41	20.88	68.35	0.95	5.92	2.51	2.51	2.37
2	Turnip leaves	685.15	47.84	67.35	16.13	45.94	0.93	3.92	7.25	3.13	1.42
3	Cabbage leaves	151.96	52.55	43.42	16.35	8.01	0.78	5.64	21.12	0.11	1.97
4	Bean stalks	151.95	29.47	57.35	14.86	45.12	0.88	1.48	2.49	3.45	2.31
5	Carrot leaves	185.73	67.78	45.94	8.64	24.15	0.77	1.35	2.60	2.53	1.14
6	Clover leaves	240.45	107.35	53.47	33.68	52.42	0.56	9.39	9.78	3.29	0.97
7	Turnip leaves	447.35	56.54	59.93	21.43	45.11	1.54	3.25	5.39	2.62	1.74
8	Carrot leaves	448.85	21.68	52.62	8.95	20.19	0.74	1.39	2.72	3.69	1.98
9	Turnip leaves	279.46	34.32	45.34	20.24	45.30	0.95	5.54	5.41	2.89	2.89
10	Turnip leaves	250.95	11.38	41.88	17.45	44.34	0.84	2.65	9.15	3.67	1.32
11	Clover leaves	222.46	53.34	64.79	24.36	61.16	1.24	4.17	3.36	3.59	3.20
12	Bean leaves	737.47	36.79	47.57	6.35	15.93	0.62	1.49	2.44	2.49	0.85
13	Carrot leaves	241.38	123.31	69.46	13.89	27.98	0.73	1.35	2.39	3.43	1.10
14	Turnip leaves	638.65	69.23	50.58	19.88	62.10	1.21	3.52	3.47	1.38	0.30
15	Turnip leaves	815.78	41.57	42.49	22.35	63.33	1.81	3.19	5.78	1.75	1.30
Mean		384.66	51.83	53.11	17.90	41.96	0.97	3.63	5.72	2.70	1.66
SD		228.39	30.74	9.08	6.92	18.72	0.34	2.26	4.93	0.99	0.80
Permissible limits		82.0	3.0	27.4	3.0	20	0.21	-	0.0	1.63	0.43

SD: Standard deviation (statistically significant coefficients p < .05), Permissible limits according to FAO/WHO, 1986.

Table 8. Effect of using low-quality water from El-Gharbia main drain on micronutrients and heavy metals content in plants at summer

Sites	Part of plants	mgkg^{-1}									
		Fe	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb
1	Cotton leaves	1451.3	56.87	46.00	40.80	32.20	0.30	4.70	3.50	3.60	3.60
2	Corn leaves	146.7	56.8	39.52	12.50	25.64	0.50	0.50	0.90	0.30	1.60
3	Rice leaves	684.6	45.78	36.00	20.80	29.20	0.10	1.70	2.10	1.70	2.00
4	Corn leaves	1171.5	63.89	23.40	22.00	12.90	0.10	2.90	4.40	1.21	1.19
5	Pepper leaves	218	10.20	55.20	10.80	25.49	0.80	0.30	2.40	0.90	0.70
6	Rice leaves	475.7	13.10	31.60	21.56	27.44	0.90	2.80	4.00	1.10	1.50
7	Pepper leaves	1109.2	41.50	25.90	10.60	35.40	0.10	3.80	4.20	3.40	4.70
8	Cotton leaves	1529.3	41.80	22.80	18.40	40.24	0.20	0.90	4.90	3.40	3.10
9	Rice leaves	342.8	9.90	52.00	22.40	5.10	0.30	1.10	2.60	1.20	2.30
10	Pepper leaves	253.7	14.00	59.89	12.90	5.60	0.60	1.50	2.20	1.10	1.10
11	Cotton leaves	403.77	26.80	13.40	2.45	1.90	0.37	1.95	5.80	8.50	0.35
12	Corn leaves	175.6	4.40	5.80	0.10	1.20	0.33	1.70	2.70	1.10	0.20
13	Rice leaves	486	6.10	7.30	0.10	1.90	0.53	2.36	3.00	1.10	0.10
14	Pepper leaves	559.48	29.50	19.85	5.55	1.70	0.75	1.79	7.40	0.40	0.35
15	Cotton leaves	1332.1	35.78	26.70	11.20	16.90	0.84	2.21	4.40	0.70	0.10
Mean		689.32	30.43	31.02	14.14	17.52	0.45	2.01	3.63	1.98	1.53
SD		491.63	20.20	16.87	10.69	13.99	0.28	1.19	1.64	2.10	1.40
Permissible limits		82.0	3.0	27.4	3.0	20.0	0.21	-	0.0	1.63	0.43

SD: Standard deviation (statistically significant coefficients p < .05), Permissible limits according to FAO/WHO, 1986.

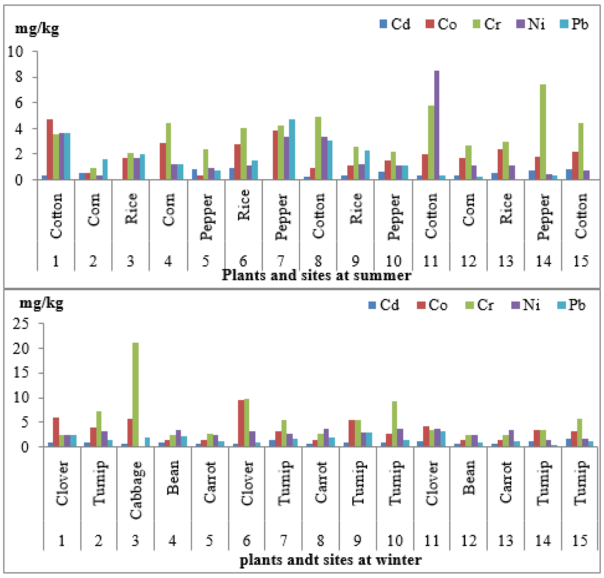

Fig. 3. Heavy metals content in plant samples at winter and summer seasons

This attributed with high contents of these elements in soil under study as noticed before. Plants irrigated from El-Gharbia main drain water showed the high content values of micro nutrients and heavy metals, this was attributed to the high content values of these metals in irrigation water as a result of many factories activities, sewage effluent and agricultural drainage (Simon *et al.*, 2016).

The heavy metals accumulation in plant leaves more than rest of plant parts, especially plants that growing in polluted soil or irrigated with wastewater, so leafy plants are considered more dangerous to human health, especially children (El-Tohamy, 2017). Using of wastewater to irrigate the vegetables caused accumulate higher concentration of heavy metals than those irrigate using ground water (Khan *et al.,* 2010). High Cd level in plant tissues might cause gastrointestinal problems and severe toxic effects on different body parts of human like kidney, liver, testis, ovaries, nervous system and cardiovascular system(Cooke and Johnson, 1996). While existing of Pb causes hematological effects, neurological effects, renal failure, gastrointestinal effects, physiological disorders and carcinogenic effects (ATSDR, 2007). On the other hand, Cr has epidemiological effects on the urogenital system, cardiovascular problems and carcinogenic effects (Costa and Klein, 2006).

4- Effect of using low-quality irrigation water from El-Gharbia main drain on plants bioconcentration factor (BCF).

A high level of micronutrients and heavy metals contents in agricultural soils when application the low-quality water to plants irrigation may be increase the uptake of elements in different plant parts (Liu *et al.*, 2015), and this is called bioconcentration factor (BCF). The bioconcentration factor (BCF) reveals to transfer and bioavailability of elements from soil to different plant parts (Lugwisha, 2016). BCF is relationship between element concentration in plant (C plant) to element concentration in soil (C soil) (Liu *et. al*, 2006)

BCF= C plant/ C soil

where: C plant and C soil represents the micro nutrients and heavy metals concentration in extracts of plants and soils on dry weight basis, respectively.

If the bio concentration factor is higher than one (> 1), this means that the elements concentration in plant is higher compared to the elements concentration in soil (Lugwisha, 2016), in this case, the plant has the ability to accumulate elements in its tissues.

The BCF for studied micro nutrient and heavy metals were as follows: Fe (7.35–55.66), Mn (1.33–15.19), Zn (5.59–14.09), Cu (2.23–10.87), B (16.35–226.52), Cd (4.29–48.4), Co (5.86–195.56), Cr (4.72–321.11), Ni (0.23–8.86) and Pb (0.39–8.65) to all sites at winter season (Table 9), the results showed that the BCF was less than one for Ni (0.23) at site No. 3 and Pb (0.39) at site No.14 which indicate that less elements concentration were in plant samples compared to concentration of the same elements in soils samples. while, the BCF for same elements to all sites at summer season as shown in Table 10 were as follows: Fe (6.30–88.90), Mn (0.40–8.10), Zn (0.50–9.90), Cu (2.0–280.0), B (1.20–146.0), Cd (0.60–17.60), Co (0.60–97.50), Cr (2.30–231.30), Ni (0.60–11.10) and Pb (0.10–6.70), the BCF less than one (< 1) in some sites and more than one (>1) in other sites, which indicate that elements concentration in some sites were low, but in the other sites the elements concentration were high and each plant has specified capability to accumulate element in its tissue (Sekhar *et al.*, 2004).

As shown in Fig. 4, the plant samples content of heavy metals in winter and summer seasons, respectively. It is noticeable from the figure the difference in the ability of different plants to accumulate heavy metals in its tissues.

From the data contained in Tables 9 and 10, it was found that there is pollution happened with micro nutrients and heavy metals in plants and soil samples in two seasons under study as a result of using the water from El-Gharbia main drain for irrigation, our results agree with Mng'ong'o *et al.*, 2021.

Table 9. Bio concentration factor (BCF) in some parts of plants grown in the agricultural soils around El-Gharbia drain at winter

Sites	Part of plant	Bio concentration factor (BCF)									
		Fe	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb
1	Clover leaves	16.53	3.49	11.50	7.33	48.13	13.97	35.24	50.10	5.62	5.27
2	Turnip leaves	31.27	5.73	13.69	5.46	83.53	7.62	13.92	19.08	6.15	2.90
3	Cabbage leaves	7.35	4.47	7.27	5.24	16.35	7.65	148.42	53.59	0.23	4.10
4	Bean stalks	10.00	3.48	12.93	5.70	85.13	12.57	8.97	4.72	5.02	5.13
5	Carrot leaves	7.94	6.60	5.59	2.68	27.13	5.24	5.86	26.80	3.26	1.54
6	Clover leaves	10.11	7.04	6.32	10.86	31.20	4.44	118.86	25.80	4.55	1.31
7	Turnip leaves	23.58	4.98	6.00	4.99	22.67	13.39	98.48	44.92	2.37	1.58
8	Carrot leaves	17.81	1.85	5.79	2.45	20.19	5.07	20.14	23.86	3.70	1.92
9	Turnip leaves	16.87	2.91	6.77	7.57	43.14	5.97	22.80	10.67	5.66	5.16
10	Turnip leaves	22.62	1.33	6.04	3.47	58.34	10.24	7.93	10.10	6.75	2.44
11	Clover leaves	14.41	6.92	14.07	6.80	226.52	44.29	145.80	8.14	8.86	8.65
12	Bean leaves	55.66	4.39	8.49	2.23	59.00	17.71	53.99	87.14	3.81	1.18
13	Carrot leaves	12.56	15.19	11.13	4.03	16.65	4.29	19.01	132.78	7.49	2.68
14	Turnip leaves	28..85	6.29	6.34	5.89	107.07	48.40	195.56	84.63	1.89	0.39
15	Turnip leaves	50.57	5.18	6.27	7.04	204.29	14.96	20.32	321.11	3.16	2.28

Table 10. Bio concentration factor (BCF) in some parts of plants grown in the agricultural soils around El-Gharbia drain at summer

Sites	Part of plant	Bio concentration factor (BCF)									
		Fe	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb
1	Cotton leaves	88.90	8.10	9.90	13.90	84.70	5.60	15.30	58.30	6.90	6.70
2	Corn leaves	6.30	6.60	7.50	3.80	80.10	4.70	1.10	2.30	0.60	3.30
3	Rice leaves	43.60	3.60	5.10	7.80	146.00	0.60	40.50	42.00	3.10	3.60
4	Corns leaves	81.20	7.30	5.40	8.40	26.90	1.10	11.20	36.70	1.90	1.80
5	Pepper leaves	6.60	1.20	9.50	3.30	26.00	3.40	0.60	26.70	1.60	1.20
6	Rice leaves	17.50	0.60	3.10	6.90	11.50	9.00	21.90	200.00	1.30	1.60
7	Pepper leaves	58.20	3.00	2.10	3.10	34.70	1.80	86.40	210.00	2.60	3.50
8	Cotton leaves	66.00	3.00	2.20	5.40	100.60	1.10	9.20	70.00	3.10	2.60
9	Rice leaves	20.00	0.60	7.30	8.10	5.40	1.40	8.10	13.70	1.70	3.20
10	Pepper leaves	22.30	1.50	8.80	3.20	7.00	17.60	4.20	31.40	1.80	1.70
11	Cotton leaves	26.30	2.40	2.40	64.50	1.70	11.60	97.50	19.30	11.10	0.30
12	Corn leaves	9.50	0.40	0.70	4.50	1.20	6.60	2.50	5.00	2.00	0.60
13	Rice leaves	36.10	0.50	0.50	2.00	2.70	11.30	11.10	14.30	0.60	0.10
14	Pepper leaves	33.70	1.90	1.90	146.10	2.20	4.90	2.50	231.30	1.00	0.60
15	Cotton leaves	74.50	4.70	2.30	280.00	11.70	3.00	4.20	40.00	2.40	0.10

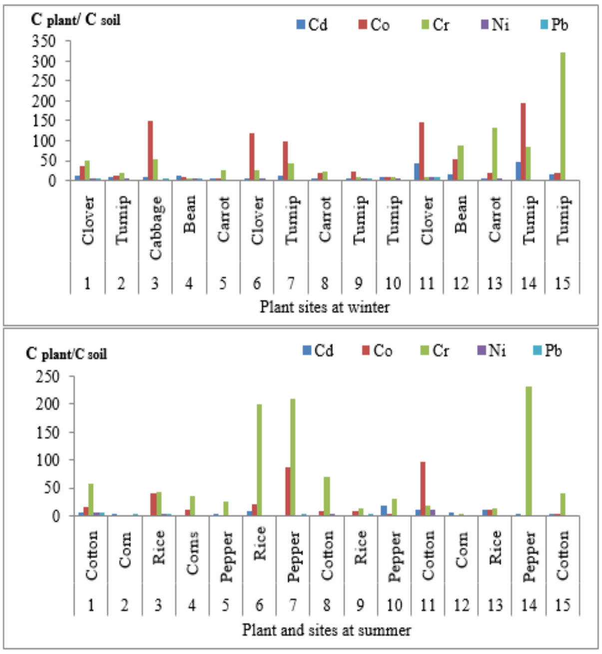

Fig. 4. Bio concentration factor of heavy metals content in plant samples at winter and summer seasons.

5- Chemical evaluation of agricultural soils pollution with micronutrients and heavy metals as a result of using wastewater from El-Gharbia main drain for irrigation.

Enrichment factor:

Enrichment factors were calculated for the studied micro nutrients and heavy metals in the collected agricultural soils samples, and the results were registered in Tables 11 and 12 for winter and summer seasons, respectively.

The lowest enriched values were recorded for all micro nutrients and some heavy metals under study such as Co, Cr, and Ni in winter and summer seasons, where their concentrations in soils were lower than 2 this is indicate that the predominant source of element is the earth's crust (Abdelhafez and Li, 2014).

The EF values of Cd varied from very significant enrichment to severe enrichment factor, which varied between 8.78 (site 14) to 16.67 (site 15) and 43.59 (site 7) to 106.79 (site 14) at winter and summer season, respectively, while the EF values of Pb were moderate enrichment in sites 2, 4, 5, 6, 7. 8, 9 and 15 at winter season, and sites 1, 2, 5, 8 and 14 at summer season, respectively (Abdelhafez and Li, 2014).

Table 11. Enrichment factor of some micronutrients and heavy metals in studied soils around El-Gharbia main drain at winter

Sites	Enrichment factor (EF)								
	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb
1	1.08	0.74	1.14	0.50	12.26	1.59	1.01	0.94	1.99
2	1.08	0.80	1.09	0.38	16.19	1.47	0.83	0.87	2.12
3	1.06	0.78	1.50	0.40	13.92	1.44	1.03	078	1.72
4	0.95	0.77	1.20	0.43	14.96	1.32	0.77	0.93	2.02
5	1.44	0.95	1.40	0.58	14.57	1.62	1.07	1.25	2.68
6	1.15	0.73	1.19	0.47	13.57	1.32	1.03	0.98	2.15
7	0.97	0.70	1.24	0.48	15.62	1.24	1.81	1.14	2.70
8	1.06	0.77	1.53	0.52	10.29	1.18	1.92	1.42	2.74
9	1.17	0.81	1.53	0.49	16.40	1.39	1.10	1.32	2.12
10	1.14	0.75	1.27	0.48	16.61	1.23	0.84	1.24	1.78
11	0.87	0.77	1.09	0.39	11.60	1.59	0.86	0.82	1.68
12	1.01	0.74	1.10	0.49	13.97	1.32	0.83	0.87	1.87
13	0.90	0.77	1.14	0.40	11.66	1.27	0.75	0.82	1.67
14	0.94	0.78	1.69	0.57	8.78	1.14	1.15	0.87	1.72
15	1.08	0.78	1.39	0.51	16.65	1.43	1.03	1.31	2.00

Table 12. Enrichment factor of some micro nutrients and heavy metals in studied soils around El-Gharbia drain at summer

Sites	Enrichment factor (EF)								
	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb
1	1.02	1.14	1.37	0.54	97.19	0.64	1.27	1.11	2.48
2	1.27	0.70	0.53	0.30	46.30	0.72	0.80	1.33	2.40
3	1.10	0.34	0.99	0.38	46.08	0.86	0.44	1.25	1.70
4	0.83	0.28	0.43	0.41	47.04	0.46	0.89	0.87	1.99
5	1.13	0.64	0.62	0.46	48.64	1.19	0.95	1.45	2.54
6	1.09	0.57	0.34	0.43	45.53	0.64	0.95	1.07	1.63
7	1.03	0.69	0.42	0.43	43.59	0.99	0.51	0.70	1.55
8	1.15	0.32	0.39	0.40	90.38	1.28	0.34	0.61	2.60
9	0.99	0.67	0.76	0.32	84.20	1.14	0.79	1.19	1.28
10	1.21	0.93	0.46	0.32	91.91	1.16	0.79	1.19	1.39
11	1.12	0.96	0.42	0.29	86.91	0.77	1.05	1.25	1.90
12	0.95	0.84	0.83	0.35	99.61	0.90	0.80	1.28	1.40
13	1.22	0.80	0.60	0.44	104.90	1.11	0.58	1.40	1.52
14	1.03	0.88	0.40	0.47	106.79	0.94	0.67	1.26	2.01
15	0.57	0.74	0.50	0.39	74.38	0.42	0.79	0.80	1.89

Contamination Factor (CF) Contamination degree (Cd), modified Contamination degree (mCd) and Pollution Load Index (PLI).

Tables 13 and 14 show the values of the calculated CF, Cd, mCd and PLI of the studied micro nutrients and heavy metals at winter and summers seasons. It is note that contamination factor (CF) ranged between low (CF < 1) to moderate (1 ≤ CF < 3) level of all the sites for micronutrients and heavy metals in both seasons under study, except for cadmium element, where the contamination level values (CF > 6) refer to the severe contamination level at winter and summer seasons of all sites under study.

In addition to, the contamination degree (Cd) values ranged between 15.71 to 28.39 (considerable contamination degree 16≤ Cd < 32) and 48.39 to 100.18 (very high contamination degree ≥ 32) at winter and summer seasons, respectively (Likuku *et al*., 2013).

Furthermore, the results showed that the modified contamination degree (mCd) was ranged between low (1.5 ≤ mCd < 2) to moderate (2 < mCd < 4) contamination degree at winter season, but at summer season, the mCd varied between high (4 ≤ mCd < 8) to very high (8 ≤ mCd <16) contamination degree (Sivakumar *et al*., 2016)

Pollution load index (PLI) was used to examine the contamination degree of the studied sites at winter and summer seasons along El-Gharbia main drain. The results refer that all sites were high contamination level (PLI > 1) at tow season except for site 1 (PLI < 1) in winter season (Sivakumar *et al*., 2016). These results are agreement with the results of CFs and EFs (Abdelhafez and Li, 2014).

The plan of wastewater reuse is the most appropriate solution to outdo the irrigation water lack (Elshemy, 2017). Now, wastewater was common used as a low-quality water resource for recompensing the irrigation water lack at all world (Tabatabaei *et al*., 2020). On the other hand, recycling wastewater without careful management leads to serious environmental degradation and severe decrease in crop yield (Tripathi *et al*., 2019). Therefore, the continued use of low-quality water to irrigate agricultural soils leads to real potential environmental risks.

El-Gharbia main drain receives drainage water from adjacent fields, industrial and sewage effluent, which are the main sources of pollution by micro-nutrients and heavy metals. The elements concentration increase in the environment at last decades is firstly due to anthropogenic activities and erosion, because metals are very persistent pollutants, it accumulate in the soil, water sediments and in the food chain (Čelechovská *et al*., 2008).

Table 13. Contamination factor (CF), contamination degree (Cd), modified contamination degree (mCd) and pollution load index (PLI) in studied soils around El-Gharbia main drain at winter

Sites	Contamination factor (CF)										Cd	mCd	PLI
	Fe	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb			
1	0.88	0.46	0.82	1.08	0.03	9.80	0.40	0.88	0.54	0.81	15.71	1.57	0.66
2	0.89	0.96	0.66	1.02	0.45	10.97	1.43	0.91	0.84	1.78	19.90	1.99	1.19
3	0.95	1.02	0.76	1.03	0.36	15.37	1.39	0.79	0.82	2.01	24.50	2.45	1.22
4	0.97	1.03	0.76	1.45	0.39	13.50	1.39	1.00	0.76	1.67	22.91	2.29	1.26
5	0.99	0.94	0.76	1.19	0.43	14.80	1.30	0.76	0.92	2.00	24.09	2.41	1.26
6	0.94	1.35	0.89	1.32	0.54	13.70	1.52	1.01	1.17	2.52	24.96	2.50	1.51
7	0.97	1.11	0.70	1.15	0.45	13.13	1.28	1.00	0.95	2.08	22.83	2.28	1.37
8	0.96	0.93	0.67	1.19	0.46	15.03	1.20	1.74	1.10	2.59	25.88	2.59	1.49
9	0.96	1.01	0.74	1.46	0.49	9.83	1.12	1.83	1.36	2.61	21.42	2.14	1.52
10	1.03	1.19	0.83	1.56	0.95	16.77	1.42	1.12	1.35	2.17	28.39	2.84	1.56
11	0.85	0.74	0.66	0.93	0.33	9.90	1.35	0.73	0.70	1.44	17.63	1.76	1.02
12	0.84	0.84	0.61	0.92	0.41	11.70	1.11	0.70	0.73	1.57	19.42	1.94	1.05
13	0.99	0.88	0.76	1.12	0.40	11.50	1.25	0.74	0.81	1.65	20.10	2.01	1.15
14	0.85	0.79	0.66	1.43	0.48	7.43	0.97	0.97	0.73	1.46	15.78	1.58	1.09
15	0.80	0.86	0.62	1.11	0.41	13.30	1.14	0.82	1.04	1.60	21.69	2.17	1.15

Table 14. Contamination factor (CF), contamination degree (Cd), modified contamination degree (mCd) and pollution load index (PLI) in studied soils around El-Gharbia main drain at summer

Sites	Contamination factor (CF)										Cd	mCd	PLI
	Fe	Mn	Zn	Cu	B	Cd	Co	Cr	Ni	Pb			
1	0.83	0.84	0.95	1.14	0.45	80.67	0.53	1.05	0.92	2.06	89.44	8.94	1.40
2	0.87	1.11	0.61	0.46	0.26	40.47	0.63	0.70	1.17	2.10	48.39	4.84	1.12
3	0.90	0.99	0.30	0.89	0.34	41.33	0.77	0.39	1.12	1.53	48.56	4.86	1.06
4	1.04	0.87	0.29	0.44	0.43	49.00	0.48	0.93	0.90	2.07	56.46	5.65	1.07
5	0.91	1.02	0.58	0.56	0.41	44.03	1.08	0.86	1.32	2.30	53.06	5.31	1.31
6	0.98	1.07	0.56	0.33	0.42	44.60	0.63	0.93	1.05	1.60	52.16	5.22	1.30
7	0.98	1.02	0.67	0.42	0.43	42.87	0.97	0.50	0.69	1.53	50.07	5.01	1.20
8	0.97	1.11	0.31	0.38	0.39	87.47	1.23	0.33	0.59	2.52	95.29	9.53	1.18
9	0.93	0.92	0.62	0.70	0.29	78.30	1.06	0.74	1.10	1.19	85.86	8.59	1.40
10	0.88	1.07	0.82	0.41	0.29	81.30	1.02	0.70	1.05	1.23	88.78	8.88	1.37
11	0.91	1.02	0.87	0.38	0.26	78.73	0.69	0.95	1.14	1.73	86.68	8.67	1.23
12	0.92	0.88	0.77	0.77	0.32	92.10	0.83	0.74	1.19	1.29	99.82	9.98	1.30
13	0.88	1.08	0.70	0.53	0.39	92.13	0.97	0.51	1.23	1.33	99.75	9.97	1.26
14	0.87	0.89	0.77	0.35	0.41	92.67	0.82	0.58	1.09	1.74	100.18	10.02	1.22
15	1.01	0.57	0.75	0.50	0.40	75.10	0.43	0.79	0.81	1.91	82.27	8.23	1.13

CONCLUSION

It can be inferred that the ongoing discharge of sewage, agricultural, and industrial wastewater into the El-Gharbia main drain will elevate the pollution levels of micronutrients and heavy metals in the surrounding soil and plant life. Based on this, the following recommendations are suggested:

-Regularly monitor the environmental impacts of the various pollution levels

-Cultivate crops that are suitable for the given level of pollution, as well as tolerant to pollution.

-Use a crop rotation system with both human and animal consumption crops along with crops that can be used in industries to reduce the pollution levels.

REFERENCES

Abdelhafez A. A. and Li, J. 2014. Geochemical and statistical evaluation of heavy metal status in the region around Jinxi River, China. Soil and Sediment Contamination, 23:850-868.

Abdelhafez, A. A., Abbas, H. H., Abd-El-Aal, R. S., Kandil, N. F., Li, J. and Mahmoud, W. 2012. Environmental and health impacts of successive mineral fertilization in Egypt. *Clean*. 40(4): 356–363.

Alengebawy, A., Sara, T. A., Sundas R. Q. and Wang, M. 2021. Heavy Metals and Pesticides Toxicity in Agricultural Soil and Plants: Ecological Risks and Human Health Implications Toxics, (9), 42: 1-33.

Aonghusa, C. N and Nick F. Gray, N. F. 2002. Laundry detergents as a source of heavy metals in Irish domestic wastewater. J. Environ. Sci. Health, A37(1), 1–6.

ATSDR .2007. Toxicological proûle for lead. http://www.atsdr.cdc.gov/csem/lead/pb lead.

Barbieri, M., Nigro, A. and Sappa, G. 2015. Soil contamination evaluation by Enrichment Factor (EF) and Geoaccumulation Index (Igeo). Senses Sci., 2 (3):94-97.

Čelechovská, O., Malota, L. and Zima, S. 2008. Entry of heavy metals into food chains: a 20-year comparison study in northern Moravia (Czech Republic). Acta Vet Brno 77: 645–652.

Chang, W. K., Ryu, J., Yi, Y., Lee, W. C., Lee, C. W., Kang, D., Lee, C. H., Hong, S., Nam, J. and Khim, J. S. 2012. Improved water quality in response to pollution control measures at Masan Bay, Korea. Mar. Pollut. Bull. 64: 427–435.

Cooke, J. A. and Johnson, M. S. 1996. Cadmium in mammals. In: Beyer, W.N., Heinz, G., Redmon-Norwood, A.W. (Eds.). Environmental Contaminants in Wildlife. SETAC special publication series, Boca Raton, FL, Lewis, 377–388.

Costa, M. and Klein, C. B. 2006. Toxicity and carcinogenicity of chromium compounds in humans. Crit. Rev. Toxicol. 36: 155–163.

Cottenie, A., Verloo, M., Kikens, L., Velghe, G. and Camerlynck, R. 1982. Analytical Problems and Method in Chemical Plant and Soil Analysis. Hand book Ed. Gent, Belgium.

Elshemy, M. 2017. Review of technologies and practices for improving agricultural drainage water quality in Egypt. In Unconventional water resources and agriculture in Egypt (pp. 163–188). Springer, Cham.

El-Tohamy, S. A. 2017. Environmental effects of drainage water reuse from El-Gharbia drain. J. Biol. Chem. Environ. Sci., 12(3): 49-69.

European Union, (2006). Commission regulation (EC) No. 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. Official Journal of European Union L364/5.

EUS (2002) Heavy metals in wastes, European commission on environment. European Union Standards (EUS)

Faiz, Y., Siddique, N. and Tufail, M. 2012. Pollution level and health risk assessment of road dust from an expressway. J of Environ. Sci. Health, A. 47: 818–829.

FAO/WHO .1986. Toxicological evaluation of certain food additives and contaminants, WHO Food Additives Series 21, Rome.

Ghazi, Dina A. M., Ragab, M. M., El-Ghamry, A. M. and EL-Tantawy, I. M. 2012. Impact of reusing drainage water for irrigation on agro-ecosystem. J. Soil Sci. and Agric. Eng., Mansoura Univ., 3 (2): 313 – 325.

Hakanson, L., 1980. Ecological risk index for aquatic pollution control, a sedimentological approach. Water Res. 14 (8), 975–1001.

ISI. 1983. Specifications for drinking and irrigation waters. IS: 10500. Indian Standard Institution (ISI) New Delhi, India.

Jackson, M. L. (1979). Soil chemical analysis. Prentice-Hall, Inc. N. J. USA.

Jamali, M. K., Kazi, T. G., Arain, M. B., Afridi, H. I. Jalbani, N., Kandhro, G. A., Shah, A. Q. and Baig, J. A. 2009. Heavy metal accumulation in different varieties of wheat (Triticumaestivum L.) grown in soil amended with domestic sewage sludge. J. Hazard. Mater., 164: 1386–1391.

Kabata-Pendias, A. and Pendias, H. 1992. Trace elements in soil and plants-CRC Press.inc., Boca Raton, Florida

Khan, S., Rehman, S., Khan, A. Z., Khan, M. A. and Shah, T. 2010. Soil and vegetables enrichment with heavy metals from geological sources in Gilgit, northern Pakistan. Ecotoxicol. Environ. Safety 73: 1820–1827.

Lei, M.; Liao,B.; Zeng, Q.; Qin, P.; Khan, S., 2008. Fraction distribution of lead, cadmium, copper, and zinc in metal contaminated soil before and after extraction with Disodiumethylene diamine tetraacetic acid. Commun. Soil Sci. Plant Anal. 39: 1963–1978.

Likuku, A. S., Mmolawa, K. B. and Gaboutloeloe, G. K. 2013. Assessment of heavy metal enrichment and degree of contamination around the copper-nickel mine in the Selebi Phikwe Region, Eastern Botswana. Environment and Ecology Research, 1(2): 32-40.

Lindsay, W. L., Norvell, W. A. 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Science Society of America Journal 42: 421-428.

Liu, Y. G., Chena, S. L., Lia, J. and Lib., B. F. 2006. Genetic diversity in three Japanese flounder (Paralichthys olivaceus) populations revealed by ISSR markers. Aquaculture, 255(1-4): 565-572

Liu, Y., Cao, X., Hu, Y. and Cheng, H. 2022. Pollution, risk and transfer of heavy metals in soil and rice: a case study in a typical industrialized Region in South China. Sustainability, 14: 1- 16.

Liu, Z., Zhang, Q., Han, T., Ding, Y., Sun, J., Wang, F. and Zhu, C. 2015. Heavy metal pollution in a soil-rice system in the Yangtze river region of China. Int. J. Environ. Res. Public Health 13.

Long, E. R, Ingersoll C. G and MacDonald D. D. 2006. Calculation and uses of mean sediment quality guideline quotients: a critical review. Environ Sci Tech 40: 1726-1736.

Lugwisha, E.H., 2016. Heavy metal levels in soil, tomatoes and selected vegetables from Morogoro region, Tanzania. Int. J. Environ. Monit. Anal. 4, 82.

Maanan, M. 2008. Heavy metal concentrations in marine mollusks from the Moroccan coastal region. Environ. Poll 153: 176-183.

Mahmood, A. and Malik, R. N. 2014. Human health risk assessment of heavy metals via consumption of contaminated vegetables collected from deferent irrigation sources in Lahore, Pakistan. Arab J of Chem., 7: 91–99.

Mng'ong'o, M., Munishi, L. K., Ndakidemi, P. A., Blake, W., Sean Comber, S., Thomas H. Hutchinson, T. H. 2021. Accumulation and bio concentration of heavy metals in two phases from agricultural soil to plants in Usangu agroecosystem-Tanzania. Heliyon, 7: 1-9.

Rajeshkumar, S. and Li, x. 2018. Bioaccumulation of heavy metals in fish species from the Meiliang Bay, Taihu Lake, China. toxicology-reports, 5:288-295.

Sekhar, K. C., Kamala, C. T., Chary, N. S., Sastry, A. R. K., Nageswara, R. and Vairamani, M. 2004. Removal of lead from aqueous solutions using an immobilized biomaterial derived from a plan biomass. J. Hazard. Mater. B. 108:111-117.

Simon, F., Mtei, K.M. and Kimanya, M., 2016. Heavy metals contamination in agricultural soil and rice in Tanzania: a review. Int. J. Environ. Prot. Policy 4, 16.

Sivakumar, S., Chandrasekaran, A., Balaji, G. and Ravisankar, R. 2016. Assessment of heavy metal enrichment and the degree of contamination in coastal sediment from south east coast of Tamilnadu, India. Journal of Heavy Metal Toxicity and Diseases, 1(2):1- 8.

Tabatabaei, S. H., Nourmahnad, N., Kermani, S. G., Tabatabaei, S.-A., Najafi, P., & Heidarpour, M. 2020. Urban wastewater reuse in agriculture for irrigation in arid and semi-arid regions-A review. International Journal of Recycling of Organic Waste in Agriculture, 9(2): 193–220.

Tchounwou, P. B., Yedjou,C. G., Patlolla, A. K. and Sutton, D. J. 2014. Heavy Metals Toxicity and the Environment. NIH Public Access, 101:133-164

Tripathi, M. P., Bisen, Y., & Tiwari, P. (2019). Reuse of wastewater in agriculture. In Water Conservation,Recycling and Reuse: Issues and Challenges (pp. 231– 258). Singapore: Springer.

Varol, M. 2011. Assessment of heavy metal contamination in sediments of the Tigris River (Turkey) using pollution indices and multivariate statistical techniques. Journal of Hazardous Materials 195 : 355–364.

Zaghloul, S. S. and Elwan, H. 2011. Water quality deterioration of middle Nile delta due to urbanizations expansion, Egypt. Fifteenth International Water Technology Conference, IWTC-15.

دراسة نوعية وكمية لتأثير مياه مصرف الغربية الرئيسى على التربة والحياة النباتية المحيطة

ايمان محمد عبد الرازق ، أمنية فاروق أمين، محمد سعد عبد الستار رمضان و أحمد محمد أمين أبو سنة

معهد بحوث الاراضي والمياه والبيئة – مركز البحوث الزراعية (الجيزة – مصر)

الملخص

يعتبر المصرف الرئيسى بالغربية (كتشنر) من المخاطر الجسيمة التى تواجه سكان قرى محافظات الغربية والدقهلية وعدد من مراكز محافظة كفر الشيخ. حيث يستقبل ثلاثة مصادر لمياه الصرف وهي الصرف الصحي والزراعي والصناعي والتي تستخدم في الممارسات الزراعية والصيد. تهدف الدراسة الحالية إلى تقييم درجة تأثير المياه العادمة لمصرف الغربية الرئيسى على محتوى التربة والنبات من المغذيات الدقيقة والمعادن الثقيلة. تم أخذ عينات (تربة ونباتات) من خمسة عشر موقعاً بمحاذاة المصرف الرئيسي بالغربية (أكثر من 100 كم) في شتاء 2020 وصيف 2021. أظهرت النتائج أن محتوى عينات التربة والنباتات من المغذيات الدقيقة (Fe, Mn, Zn, Cu and B) والمعادن الثقيلة (Cd, Cr, Co, Ni and Pb) اختلفت من موقع إلى آخر ، في بعض الحالات تجاوز المتوسط العام للعناصر محل الدراسة الحد المسموح به في كلا الموسمين قيد الدراسة ولكن درجة التلوث كانت أعلى في فصل الصيف. أما بالنسبة لقيم عامل التراكم الحيوى (BCF) في عينات النباتات كان أعلى من واحد صحيح، وهذا يعكس قدرة النباتات على تراكم المغذيات الدقيقة والمعادن الثقيلة في أنسجتها. أظهر تطبيق معادلات تقييم المخاطر أن قيم معامل التخصيب (EF) للمغذيات الدقيقة والمعادن الثقيلة كان منخفض المستوى باستثناء قيم عنصر الكادميوم التي اختلفت من مستوى معنوي إلى شديد وكانت قيم عنصر الرصاص في مستوى معتدل في كلا الموسمين قيد الدراسة ،قيم عامل التلوث (CF) اختلفت من منخفضة المستوى إلى متوسطة باستثناء عنصر الكادميوم حيث كان مستوى التلوث شديدًا في كلا الموسمين قيد الدراسة ، وتفاوتت درجة التلوث (Cd) من مستوى كبير إلى مرتفع جدًا في كلا الموسمين قيد الدراسة ، وكانت قيم مؤشر دليل حمل التلوث (PLI) مرتفعة المستوى في كلا الموسمين قيد الدراسة فيما عدا الموقع رقم 1 كان منخفض المستوى في فصل الشتاء.