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Application and Evaluation of Some Pollution Indices in Heavy Metal Contaminated Soil

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ABSTRACT

Egypt may soon suffer from water problems due to many factors, including the intransigence of upstream countries in addition to climate change and various pollution factors. Under these circumstances, many farmers are forced to use sewage water for irrigation, which may eventually lead to deterioration of soil and environmental quality. Therefore, the present investigation aims to assess the implication associated with using sewage effluent water in irrigation for long period on some soil properties and to assess soil contamination using some pollution indices Results revealed that the sewage effluent water had elevated contents of TN (25.9ppm), P (2.75ppm) and K (1.65ppm) confirming that it may be considered as low- price fertilizer. Also, the physicochemical parameters of the water, such as water acidity (pH 7.7) water salinity and EC1.175dS/m, NH_4 1.19 ppm, Fe 0.648ppm, Pb 0.45ppm), Zn (0.425ppm) Co(0.46ppm) and Cu (0. 0.33 ppm) were within the permissible limits reported by FAO (1976). Meanwhile Mn (0.42ppm) >Ni (0.31ppm)> Cd (0.083ppm) contents were above. In sewage amended soils the present data revealed that prolonged use of sewage water irrigation over 100-yerars led to detectable increases in all the tested soil parameters, except for $CaCO_3$ content (Table,2). On mean basis, clay content, EC, and pH increased by (8.15, 2, and 1.04 times) over the control soil, referring to high influence of sewage water irrigation on soil texture as well as soil salinization.

Keywords: sewage water effluent, soil irrigation, soil heavy metals, soil pollution indices.

1. Introduction

In the most arid and semi-arid regions of the world, water security is a major problem, due to water restrictions and increased water consumption. The use of low-quality water (effluent sewage) to irrigate the soil has addressed the problem and has become an accepted practice in the world. Many regions of the world are considered a solution to the problem of agricultural irrigation, which constitutes the largest global consumption of water for soil irrigation (Zarei *et al.,* 2020).

Several studies confirmed that application of sewage sludge to agricultural soils may be sustainable and economical due to nutrient cycling, it may be considered as low price fertilizer. Also, sewage effluent water contains detectable level of organic matter in addition to fine particles and debris which in turn influence on chemical, physical and biological properties of soils (Alnaimy *et al.,* 2021).

Unfortunately, sewage effluent water has elevated level of toxic heavy metals, which might accumulate in the soil and be absorbed by crops and, consequently, posing risks to human beings. The biggest problem with heavy metals pollution is the fact that they are persistent, and it is very difficult to eliminate and considered non- biodegradable therefore threatens the ecological system According to Landrigan *et al*. (2019) environmental pollution is responsible for 940,000deaths within the children worldwide in 2016 (two thirds aged under 5 yr). Moreover, it is important to assess heavy metal pollution both quantitatively and descriptively to minimize its hazards, these waters which are

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Thus, monitoring the levels considered periodically while evaluating the suitability of water for irrigation to insure its safe use in crop production (Farid *et al.,* 2020).

There is an array of indices used for the assessment of soil heavy metal contamination based on physical, chemical, or biological parameters. Among the most used are:

1: Single-element indices such as; Geoaccumulation Index (Igeo) proposed by Muller (1969); Pollution Index (PI) Wu *et al.*, 2015; Threshold Pollution Index (PIT), Lu *et al*., (2009), and Contamination Factor (CF) Hakanson (1980).

2: Mult-element or integrated indices as; Pollution Load Index (PLI) Liu *et al.* (2005). Nemerow Pollution Index (PINemerow) (Cheng *et al*., 2008). Degree of Contamination (Cdeg) Hakanson (1980); Modified Contamination Factor (MCdeg) Abrahim and Parker (2008); Potential Ecological Risk Index (PERI) (Kowalska *et al*., 2016).

Therefore, the present investigation was initiated to study the influence of continual use of sewage effluent water for long period on some soil properties, and also to assess soil contamination using some soil contamination indices. Therefore, this study examined the effects of irrigation with contaminated groundwater and sewage effluents over an extended period of time on metal accumulations in Typic Torripsamment soils and edible portions of food crop according to Abuzaid *et al.* (2022)

2. Material and Methods

The Egyptian Wastewater Treatment Plant namely Gabal El-Asfar (GAWWTP) in Cairo is one of the largest W plant TPs in the world. It is located (Egypt) in the eastern desert in the southeastern edge of Al Qaliobia governorate. This plant received sewage effluent from Great Cairo since 1911. The soils of this plant where selected for the present study to represent long-term use of sewage effluent water in irrigation.

2.1. Sampling

Sewage effluent water sample (4 separately liters) was collected from the outlet of irrigation water source in that location. This sample was mixed carefully and stored at less than 4°C until the following analysis carried four soil profiles were dug to 120 cm depth. Three profiles collected from Gabal El-Asfar (GAWWTP) farm to represent sewage effluent irrigated soil and symbolized as (100-SS, 70-SS, 48-SS), while the other soil profile collected from irrigated site, at the same location to represent control soil and symbolized as (CS). The tested profiles were sampled at 30 cm increments. At each depth, three disturbed sub-soil samples were collected to make a composite soil sample and kept for analysis.

2.2. Water analysis

Water acidity (pH), electrical conductivity (EC) and soluble ions were determined according to Page *et al*. (1982), available nitrogen (AN), NH_4, NO_3, and P were determiner in the collected water sample as vailable described by Page *et al.* (1982). Also, the contents of Zn, Cu, Fe, Mn and Ni were determined according to Brar *et al.* (2000) methodology, using ICP (Perkin Elemer model 4300 DV) and the results are listed in Table (1).

2.3. Soil analysis

Soil acidity (pH) and soil salinity (EC) were measured in the saturated soil extract (Jackson, 1984). Calcium carbonate, organic matter content, total Nitrogen (TN), total phosphorus (TP) and total potassium (TK) of the soil determined according to Page *et al.* (1982). Soil heavy metals content was determined according to Tessier *et al.* (1979).

2.4. Assessment Heavy Metal Contamination in the sewage effluent irrigated soil.

Four pollution Indices were applied to the data; three of them belong to single pollution indices The Contamination Factor (CF), Ecological Risk Factor(Er), geo-accumulation (Igeo) and one of the integrated pollution indices (Pollution load index, PLI) to evaluate the soil pollution status.

2.4.1. Contamination Indices

The contamination factor is calculated as described by Hakanson, (1980) as follows;

$CF = C_m / C_b$……………………………………………………………………………………….(1)

Where C_m is the metal concentration in soil sample and C_b = background value of the metal.

The data of the background content of the tested metal were taken from Wedepohl, (1995). In accordance with Hakanson, (1980) the soil classified to: CF ≤ 1 designates low pollution; 1 < CF ≤ 3 is moderate pollution; 3 < Cf ≤ 6 is considerable pollution; and CF> 6 is very high pollution.

2.4.2. Ecological risk factor (Er)

An ecological risk factor is used to quantitatively suggested Hakanson, (1980) to express the potential ecological risk of a given contaminant. It is calculated as follows;

$Ei = CF \times Tr$……………………………………………………………………………………….(2)

Where; CF is the contamination factor, and Tr is toxic response factor of a given metal Ti= Toxic response factors for Cd, Cr, Cu, Mn, Ni, Pb, Co and Zn are 30, 2, 5, 1, 5, 5, 2 and 1,respectively. The following terminologies are used to describe the risk factor: Er<40, low potential ecological risk; 40≤Er<80, moderate potential ecological risk; 80≤Er<160, considerable potential ecological risk; 160≤Er<320, high potential ecological risk; and Er≥320, very high ecological risk.

2.4.3. Index of geo-accumulation

Index of geo-accumulation (Igeo) was originally defined by Muller *et al.* (1969) in order to determinethe levels of metal contamination in soil and sediments as follows;

$Igeo = \log_2 (C_m/1.5C_b)$………………………………………………………………………..…(3)

Muller *et al.* (1969) distinguished seven classes for the Igeo: Igeo ≤0: uncontaminated; 0 < Igeo ≤ 1: slightly contaminated; 1 < Igeo ≤ 2: moderately contaminated; 2 < Igeo ≤ 3: moderately to heavily contaminated; 3 < Igeo ≤ 4: heavily contaminated; 4 < Igeo ≤ 5: heavily to extremely contaminated; and Igeo > 5: extremely contaminated.

3.4.4. Threshold pollution index (PI_T)

PIT proposed by Qingjie *et al.* (2008) as follows**:**

$PI_T = C_i / C_{TL}$……………………………………………………………………………………….(4)

Where; C_{TL} is the toxic level of metal
PI_T< 1 Unpolluted, 1 ≤ PI_T ≤ 2 Low polluted,2 ≤ PI_T ≤ 3 Moderate polluted, 3 ≤ PI_T ≤ 5 Strong polluted, 5 ≤ PI_T Very strong pollute.

3.4.5: Pollution load index (PLI) Tomlinson *et al.* (1980).

The PLI is calculated according to the equation:

$PLI = [CF1 \times CF2 \times CF3 \times CF4 \times ::::: \times CFn]^{1/n}$…………………………………………………………(5)

Where n = the number of metals; CFn = the contamination factor of metal n. the (PLI) classes are; < 1 (unpolluted), 0 (Perfection), and > 1 (polluted).

3. Results and Discussion

3.1. Evaluation of the sewage effluent water used

The quantity and quality of wastewater produced from households is influenced by the behavior, lifestyle and standard of living of the inhabitants as well as the technical and juridical framework by which people are surrounded by Hejabi *et al.* (2021) in water samples collected from El-Gabal El-Asfer sewage station relieved that the pH values for the tested sewage water (Ww) were 7.7) which were slightly basic.,data reported in Table (1) indicate that EC of the Ww by (1.175dsm^{-1}), indicating that this effluent was saline in nature and was lower than the PML which suggested as (FAO, 1976).

Nitrogen (N), phosphorus (P) and potassium (K) are essential nutrient for all kind of biological organisms and plants but at elevated levels it can as hazard the nitrogen total (N_t) concentration in Ww as shown from the Table (1) was (25.9). This may be due to enrichment of sewage water with dissolved organic matter, which considered the main source of nitrogen. Moreover, it appears from Table (1) that amounts of nitrate concentration in Ww reached to (24.01ppm), which was higher than the safe level (15ppm), reported by FAO (1976), furthermore the data in Table (1) reveal that P and K values 2.75, 1.65 respectively, these results confirmed that sewage water effluent may be considered as low price fertilizer.

3.2. Heavy of metals in Sewage water effluent

Many of heavy metals are necessary for the growth of biological life but only in trace concentrations, but if they concentrations are exceeded they become toxic and deterioration the environment (Kabata and Pedias, 1993). The results in Table (1) show that values of heavy metals in Ww (in ppm) were follow the sequence; Fe (0.648) >Co(0.46) >Pb(0.45) >Zn (0.425) >Mn(0.42) > Cu (0.33) >Ni(0.31)> Cd (0.083).Generally, the previous arrangement was agreed by the studies of Gatta *et al.* (2021); Abuzaid *et al.* (2022).

Table 1: Some of chemical characters of sewage water of El-Gabal Al-Asfer

Sewage Sample(Ww)							
pH	**EC ds/m**	**TSS**	**NO_3 (ppm)**	**NH_4 (ppm)**	**N_t (ppm)**	**P_t (ppm)**	**K_t (ppm)**
7.7	1.175	752	24.01	1.19	25.9	2.75	1.65
Heavy metals contents (ppm)							
Cd	**Cu**	**Fe**	**Mn**	**Zn**	**Ni**	**Co**	**Pb**
0.083	0.33	0.648	0.42	0.425	0.31	0.46	0.45

3.3. Impacts of continual use of sewage effluent irrigation on some soil properties

Table (2) shows that the texture of the sewage irrigated soils(SS)was characterized as sandy loam in the surface soil layer while in the underlying soil layers, the percentage of coarse fraction increased, thereby the texture grade became sandy in the last soil layer. Meanwhile, soil texture in CS soil was sandy in all the tested soil layers. So, the present results confirmed that the continual use of sewage effluent water in irrigation has a favorable effect on soil texture. That is probably due to fine particles, debris, and organic residues existed in sewage effluent water which enhanced physical, chemical and biological processes of soil Mean while the results of Ozdemir (2021); Ibrahim *et al.* (2010) indicated that soil texture not change appreciably by wastewater disposal and dependent on period of application and wastewater characters.

3.4. Organic Matter Content (OM)

As shown from Table (2) that the highest OM content was recorded in the top layer of (CS) soil and decreased with increasing soil depth. It increased from (0.34%) in the control soil to (2.81%) in the sewage soils 100-(SS) mainly due to disposal of sewage effluent water as well as agronomic practices. Similar observation was also reported by Ali *et al.* (2012) and Evangelou *et al.* (2017).

3.5. $CaCO_3$ content of Soils

As shown from Table (2) that $CaCO_3$ content decrease with using sewage water in irrigation, especially in the tope soil layer. On mean basis, $CaCO_3$ content decreased from (3.19%) in CS soil to (1.95%) in 100-SS soil, The present results were confirmed with the results of Ali *et al.* (2012) who concluded that the reduction in $CaCO_3$ content of sewage irrigated soil may be attributed to production of organic acids via anaerobic decomposition process of OM, which led to more solubility of $CaCO_3$.The present results confirmed that the continual use of sewage effluent water in irrigation has a favorable effect on soil texture, irrigated soil was characterized as clay loam in the surface soil layer while in the underlying soil layers, the percentage of coarse fraction increased, and thereby the texture grade became sandy in the last soil layer.

Table 2: Some of chemical analysis of the investigated soil sample

Samples (Years)	Depth	pH	EC ds/m	Clay %	OM %	$CaCO_3$ %	T N mg /kg	T P mg /kg	T K mg /kg
	0-30	7.26	0.57	0.90	0.42	0.47	31.37	10.27	56.60
	30-60	7.29	0.58	0.89	0.35	0.79	30.97	3.87	35.12
CS	60-90	7.34	0.66	0.78	0.30	0.36	30.44	3.67	28.10
	90-120	7.49	0.64	0.66	0.27	0.21	24.12	3.60	19.80
	Mean	**7.34**	**0.61**	**0.81**	**0.34**	**0.54**	**29.22**	**5.35**	**34.91**
	0-30	7.27	0.77	8.87	1.68	3.18	41.10	104.77	92.00
	30-60	7.47	0.78	5.85	2.18	2.95	32.90	122.50	68.45
48-SS	60-90	7.35	0.94	3.90	2.49	3.54	27.30	85.15	73.10
	90-120	7.79	1.18	2.42	2.29	3.11	26.30	94.50	61.37
	Mean	**7.47**	**0.92**	**5.26**	**2.16**	**3.19**	**31.90**	**94.50**	**84.52**
	0-30	7.65	2.00	12.08	2.55	2.49	130.80	239.00	307.12
	30-60	7.76	1.39	10.58	2.44	2.17	126.59	101.61	275.13
70-SS	60-90	7.44	1.32	3.47	2.00	1.80	121.50	127.49	289.45
	90-120	7.49	1.06	5.48	2.37	2.89	118.38	127.78	280.82
	Mean	**7.58**	**1.44**	**7.90**	**2.34**	**2.34**	**124.32**	**115.41**	**288.13**
	0-30	7.65	1.96	15.96	2.32	2.00	148.85	293.75	655.94
	30-60	7.57	1.82	8.26	2.84	1.44	140.55	311.43	641.11
100-SS	60-90	7.60	1.89	5.13	2.98	2.00	140.39	174.37	470.15
	90-120	7.67	1.66	3.44	3.12	2.37	132.36	125.45	377.20
	Mean	**7.62**	**1.83**	**8.19**	**2.81**	**1.95**	**140.54**	**226.25**	**536.10**

3.6. Soil pH

Data presented in Table (2) show that the pH values of (CS) soil samples ranged from neutral to slightly alkaline in nature with an average pH value (7.34). While with prolonged using of sewage effluent water, soil pH of (SS) soil, increased to 7.47, 7.58 to 7.62in the 48-SS, 70-SS and 100-SS soils respectively. This may be attributed to the high content of basic cations viz. Na^{+}, $Ca^{2+}$and Mg^{2+} in that water. These results are agreed with the findings of Alnaimy *et al.* (2021).

3.7. Soil Salinity and sodicity

As shown from Table (2) that EC values of the tested soils increased with the continual use of sewage effluent water in irrigation. On mean basis, in the control soil, EC increased from (0.61dSm^{-1}), to (1.83dSm^{-1}) in the sewage water effluent soils. This means that, this water plays an important role in the salinization of that soils (Mtshali *et al.,* 2014). Also, These results are consistent with (Evangelou *et al.,* 2017) who attributed the increase in EC values to the high soluble salts content in applied sludge as well as, due to elevated concentration of soil NO_3-N.

3.8. Soil Macronutrient concentrations in the tested soils

Total-N (TN) of the tested soil profiles are listed in Table (2). The data showed that TN in the studied soils ranged between (24.12 to 31.37, x= 29.22mg/Kg) in the control soil and from 26.30 to 41.10 56, x=31.90 mg/Kg), **(**118.38 to 130.80, x= 124.32 mg/Kg) and (132.36 to 148.85, x= 140.54 mg/Kg) in the sewage effluent treated soils. It is cleared that soil total nitrogen increases with using sewage effluent water in irrigation. These results are in consistent with Ahmed and El-Hedek (2017) added that the different values of total N depend on many factors, such as soil O.M. content, quantity of soluble N added from sewage water irrigation, as well as years of sewage effluent application.

With regard to available N in sewage irrigated soils, data in Table (2) show that the surface soil depth of both soils had the highest amount of total content nitrogen for 48-SS, 70-SS and 100-SS, respectively. Furthermore, the present data refer that with increasing soil depth, the concentrations of TN decreased, confirming that the continual use of sewage effluent is fraught with environmental hazards.

Data of Total-P (TP) are presented in Table (2). in CS in throughout soil profile is low. It ranges between (3.6 and 10.27mg/Kg), in top soil and deepest soil depth, respectively. While in sewage irrigated soils, the highest value is recorded for top depth of 100-SS (293.75mg/Kg), followed by the top soil depth of 70-SS (239 mg/Kg) and (104.77 mg/Kg) by the top soil depth of 48-SS Also the data revel that the highest values of TP was observed in the surface layers and declined with soil depth. The variation of TP in the soils depends on many factors such as soil texture, organic matter, $CaCO_3$ and fertilization with P fertilizers.

Data of Total- K (TK) in the tested soils are presented in Table (2).in CS, k concentrations in the (0-30,-60,-90.-120 cm) soil depth were (56.60, 35.12, 28.10 and 19.80 mg'Kg), respectively, while in 48-SS, 70-SS and 100-SS, the values were (92.00, 68.45, 73.10 and 61.37), (307.12, 275.13, 289.45 and 280.82) and (655.94, 641.11, 470.15 and 377.20) respectively. It is clearly shown that sewage irrigated soils exhibit the highest values of TK, especially in the surface soil depth. These results are consistent with Ahmed and El-Hedek (2017).

3.9. Metals content in the Soils

Total contents of Fe, Mn, Zn, Cu, Ni, Cd, Pb,Co in the investigated soil profiles are shown in Table (3). On mean basis, the results indicated that the continual use of sewage effluent in irrigation had resulted in significant build–up of Fe (11212.6,11264.10 and 21770.23), Mn by (178.05, 201 and 882.05), Cu by (30.46,48.96 and 79.74), Zn by (71.09, 87.09 and167.22), Ni by (80.39, 90.14 and 213.56), Cd by (2.11, 3.61 and 12.53), Pb by (102.09, 115.59 and 360.90), and Co by (36.33, 53.83 and 79.74) over their corresponding values in the control soil.

Table 3: Total contents of some heavy metals in the investigated soil samples.

Samples	Depth (cm)	Total (mg/kg)							
		Cd	Ni	Fe	Mn	Zn	Cu	Pb	Co
CS	0-30	0.089	16.11	914.98	71.45	52.15	8.67	8.4	6.54
	30-60	0.023	16.64	865.02	65.87	41.63	7.93	6.88	6.98
	60-90	0.02	15.11	810.45	61.34	30.51	6.23	5.57	5.46
	90-120	0.016	15.3	782.23	59.02	11.57	4.9	2.74	5.98
	Mean	**0.04**	**15.79**	**843.17**	**64.42**	**33.97**	**6.93**	**5.9**	**6.24**
48-SS	0-30	3.2	98.76	13143.8	424.36	87.3	39.59	117.94	46.27
	30-60	2.3	96.45	11930.8	110.09	77.9	34.4	105.4	42.28
	60-90	2.14	67.32	10167.4	96.97	69.43	28.34	92.59	30.28
	90-120	0.8	59.02	9608.4	80.77	49.71	19.52	92.41	26.48
	Mean	**2.11**	**80.39**	**11212.6**	**178.05**	**71.09**	**30.46**	**102.09**	**36.33**
70-SS	0-30	4.7	110.76	13195.3	447.36	103.3	58.09	131.44	63.77
	30-60	3.8	108.45	11982.3	133.09	93.9	52.9	118.9	59.78
	60-90	3.64	79.32	10218.9	119.97	85.43	46.84	106.09	47.78
	90-120	2.3	62.02	9659.9	103.77	65.71	38.02	105.91	43.98
	Mean	**3.61**	**90.14**	**11264.10**	**201.05**	**87.09**	**48.96**	**115.59**	**53.83**
100-SS	0-30	17.01	303.9	30017.5	1192.75	197.15	119.56	546.57	87.54
	30-60	13.7	218.8	21971.9	934.52	186.63	111.38	493.74	82.98
	60-90	10.82	170.76	18223.8	803.11	148.51	90.17	218.4	75.46
	90-120	8.57	160.79	16867.7	597.8	136.57	82.89	184.88	72.98
	Mean	**12.53**	**213.56**	**21770.23**	**882.05**	**167.22**	**101.00**	**360.90**	**79.74**

Also, the present results showed that the surface soil layers (0-30cm) of the sewage effluent irrigated soil had the highest contents of the tested metals compared with the underlying layers. So, there is a consensus that the continuous use of sewage effluent water in irrigation must be abiding by the regulatory limits and these results agree with (Kalsom *et al.*, 2020).

3.10. Evaluate soil metal concentration using contamination indices

Analyzing the results of soil metal contents of the surface layer (0-30cm) of the sewage effluent irrigated soil using the aforementioned pollution indices are listed in Table (4). Comparing the total contents of the heavy metal by background concentration (BG) of metals reported and maximum permissible limits (PML) reported by Kabata-Pendias, (1993) it shown that Fe, Zn, Mn, Cu, Pb, Cd, Ni and Co values were less than their values in both of BG and PML values in control soil but after irrigated the values of metals, were exceeded than values of BG except Fe value in 48-SS, 70-SS and 100-SS respectively, beside we found that (Fe, Zn, Mn, Cu, Pb, Cd, Ni and Co) exceed with PML values in 100-SS Furthermore, the total metals exceeded in either BG concentration or PML after irrigation. With long term of sewage water, so it can be concluded that the soil tested its contaminated.

Table 4: The calculated pollution indices of the tested heavy metals.

Heavy metals	Cd	Ni	Fe	Mn	Zn	Cu	Pb	Co
Total concentration in CS	0.089	16.11	914.98	71.45	42.15	8.67	8.4	6.54
Total concentration in 48-SS	3.2	98.76	13143.8	534.36	87.3	39.59	117.94	46.27
E_f in 48-SS	620.59	21.61	0.36	0.39	1.37	10.65	30.03	6.26
Total concentration in 70-SS	4.7	110.76	13195.3	547.36	103.3	58.09	131.44	63.77
E_f in 70-SS	1061.8	24.2	0.4	0.4	1.7	17.1	34.0	9.3
Total concentration in 100-SS	17.01	303.9	30017.5	1192.75	197.15	119.56	546.57	87.54
E_f in 100-SS	3683.8	57.4	0.7	1.7	3.2	35.3	106.1	13.7
BG of Welepole (1995)	0.102	18.6	30890	527	52	14.3	17	11.6
PML Katbata-Pendias, (1993)	3	50	5000	2000	300	100	100	50
Toxicity factor	30	5	1	1	1	5	5	2
PLI in CS				0.65				
PLI in 48-SS				3.04				
PLI in 70-SS				3.69				
PLI in 100-SS				9.08				

Geo-accumulation (Igeo) values revealed in Fig. (1) that the tested soil was uncontaminated with Fe and Mn were slightly contaminated while Cu, and Zn, were moderately to heavily contaminate by and heavily contaminate byCd, Ni, Co, and Pb. Therefore, Igeo values of the tested metals could be arranged ascending as follows:

Fe (-1.1, -2.1 and 2.1) < Mn (-2.4, -2.2 and 0.1) < Zn (-0.2, 0.1 and 1.1) < Cu(0.5, 1.2 and 2.2) < Ni(1.5, 1.7 and 2.9)< Co (1,1.6 and 2.2) < Pb (2, 2.2 and 3.7) < Cd (3.6, 4.5 and 6.3) after irrigated with 48-SS, 70-SS and 100-SS,respectively. Also, we found the values of Geo-accumulation (Igeo) decreased with depth soil while the high contaminated in the surface layers (0-30cm) based on values of contamination factor (CF) index in Fig. (2), the tested soil was low polluted with Fe, while it was moderately polluted by Mn, Zn. Meanwhile, it was very high polluted by Cu, Ni., Cd, Pb and Co.

Therefore the soil could be ranked based on CF values as follows Fe(0.4, 0.4 and 0.7), Mn(0.4,0.4 and1.7), Zn (1.4, 1.7 and 3.2), Cu(2.1, 3.4 and 7.1), Ni(4.3, 4.8 and 11.5), Pb (6, 6.8 and 21.2), Co (3.1, 4.6 and 6.9) and Cd (20.7, 35.4 and 122.8) in 48-SS, 70-SS and 100-SS respectively in the surface layer.

Ecological risk factor (Er) index values in (table 4) revealed that the soil was considerable low potential ecological risk by Zn, Cu, and Mn, Fe, Ni, Pb, Co while were classified as moderate potential ecological risk of Ni, Pb at 70-SS, regarding to Er of Cd was classified as high potential, the

Er cleared that in spite the difference between Er values of the tested metal could be wide, it may be in the same class, consequently the reliability and sensitivity of the results could be affected.

The values of threshold pollution indices (PI_T) As shown at Fig (3). relived that the tested soil with Cu, Fe, Mn, Zn, Co, Pb, Ni and Cd it was range between low polluted to strong polluted after irrigated with long term of sewage and the sequence of the threshold pollution index (PI_T) showed a study of all metals tested.

Pollution load index (PLI) was also evaluated and the results listed in Table (4). This type of index can reflect the degree of soil pollution caused by various pollutants (heavy metals). The PLI value indicated that the tested soil considered polluted by the tested metals which ranged between (3.04, 3.69 and 9.08) compare with control soil

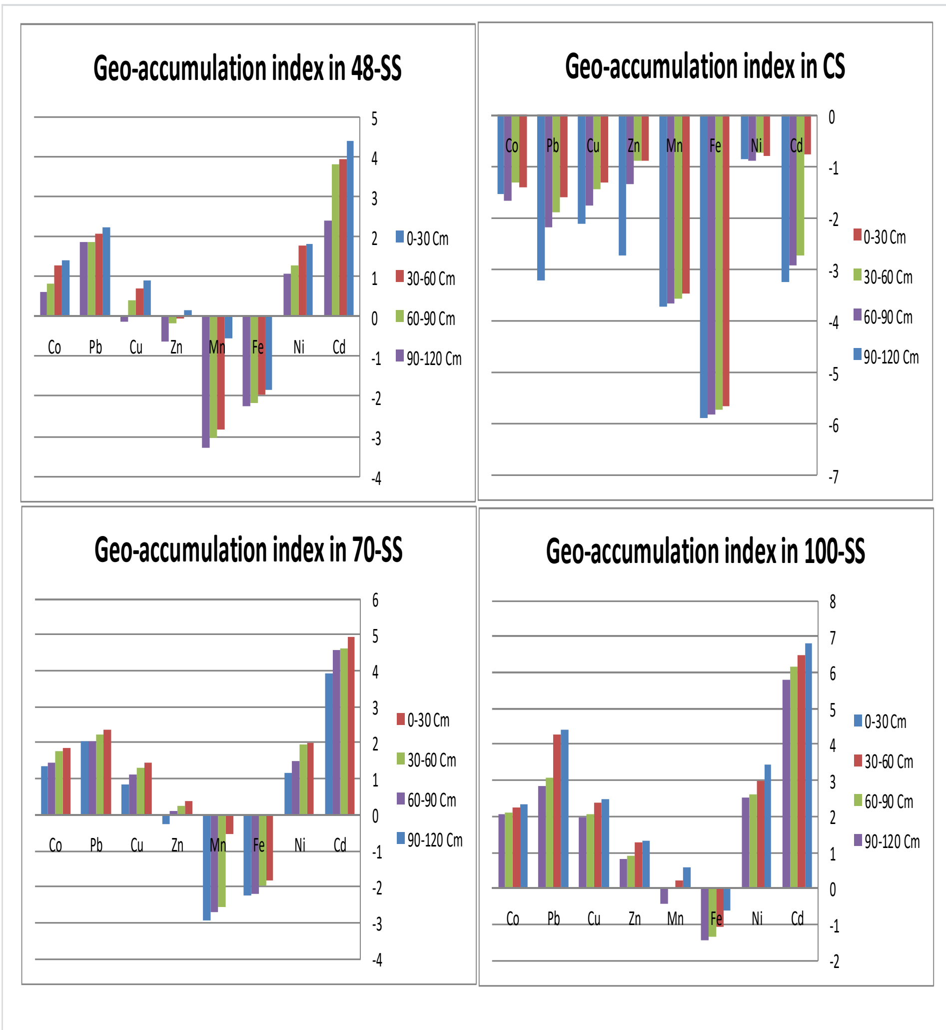

Fig. 1: Geo -accumulation index (Igeo).

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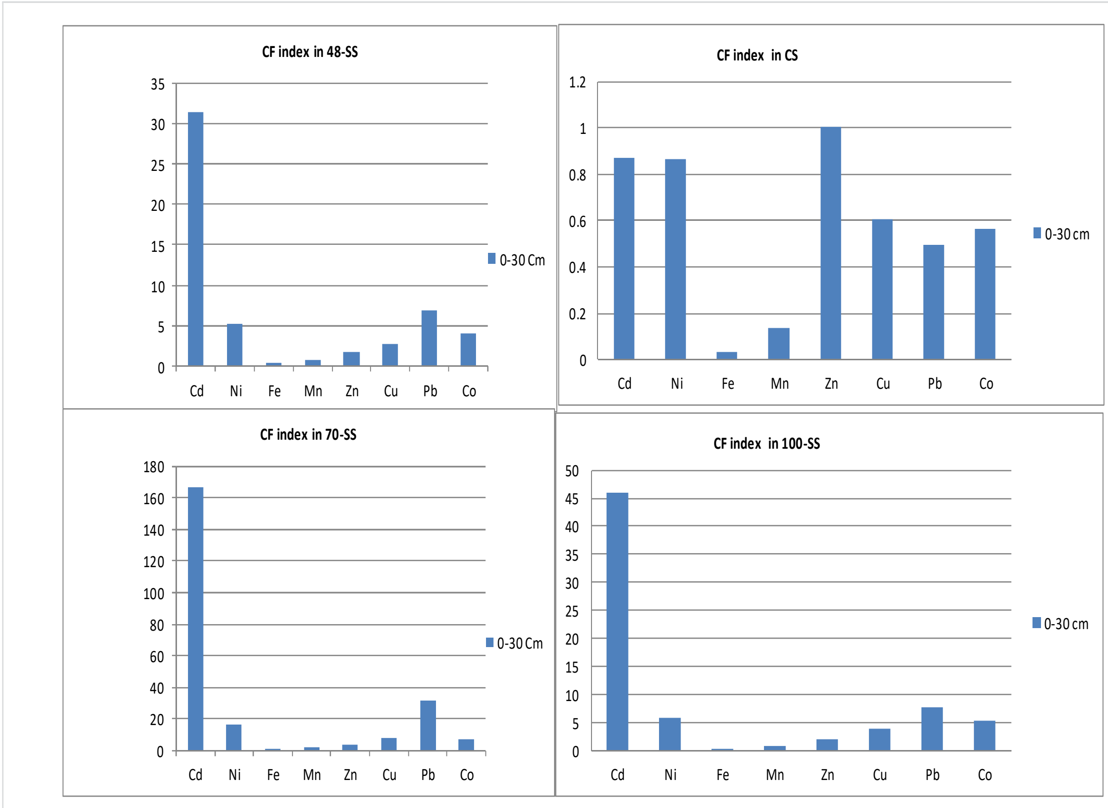

Fig. 2: Contamination factor (CF) index

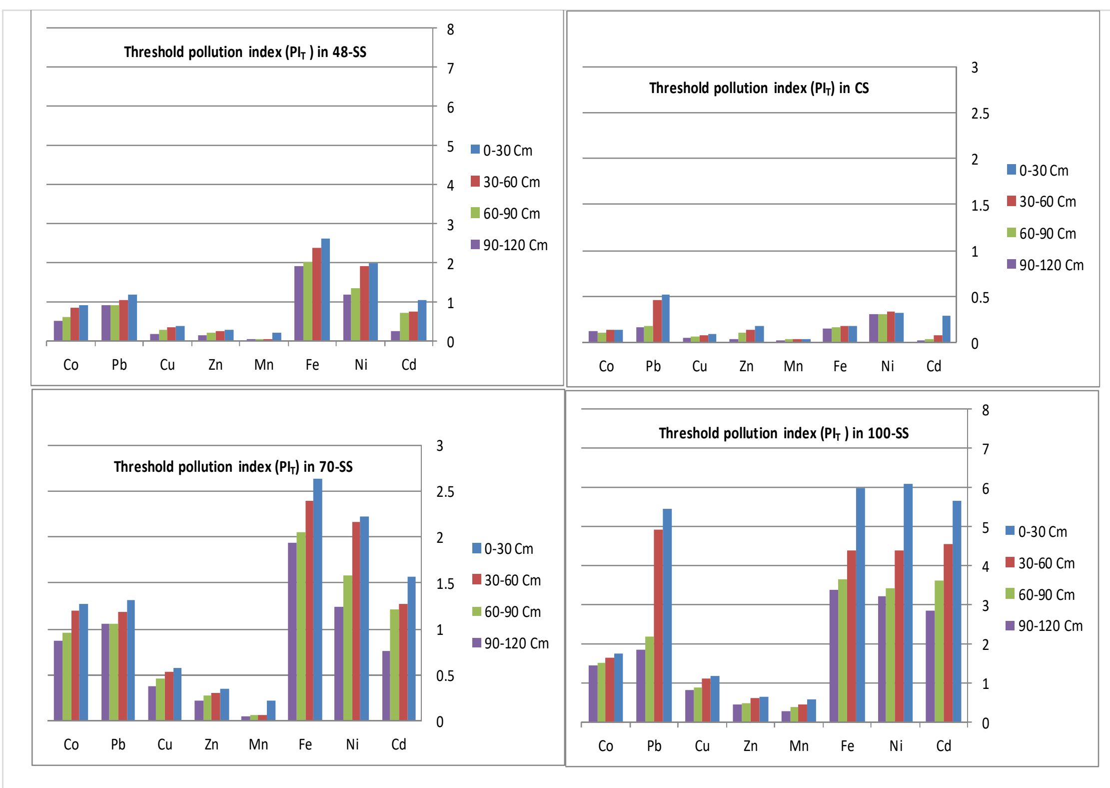

Fig. 3: Threshold pollution indices (PI_t)

Conclusion

From the previous results it can be concluded that the indexes values were inconsistent with other data that may be in their calculated form and which include specific parameters for response to heavy metal toxicity that may be reliable and suitable for sewage soils. In the same communications, pollution threshold indices (PI_T) were calculated based on offsetting the heavy metal present with its corresponding PML value; however it is difficult to find PML values that are compatible with all soil conditions

In general, it can be said that these pollution indices can be used separately and results reported separately, but if a choice should be made, the Geo accumulation Index (Igeo), Pollution Factor, Pollution Load Index (PLI) can be used. They were chosen because they are more sensitive, reliable, have a more stringent classification, and are consistent with background results and maximum permissible limits for heavy metals.

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