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Impacts of Treated Wastewater on Soil and Yield of Sunflower

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Abstract: The bioavailability of trace elements, their biological uptake and ecotoxiccological effect on soil biota can be better understood in terms of their chemical fractionation. The current study examined the mobility and availability of Fe, Mn, Zn Cu Pb Ni and Cd in sewage water-irrigated soils using sequential extraction technique as a basis for predicting element uptake by sunflower plants. The residual fraction has the most abundant pool for all the investigated elements examined. The present study aimed to evaluate the agronomic performance of sunflower crop irrigated with treated domestic wastewater compared to normal water (well water). The experiment was conducted in complete randomized block design, consisting of five treatments.(T1): soil irrigated with 100% well water +100 % of recommended (RR) of fertilizers. (T2): soil irrigated with 75% well water + SW 25% +75 % of recommended (RR) of fertilizers. (T3): soil irrigated with 50% well water + SW 50% +50 % of recommended (RR) of fertilizers.(T4): soil irrigated with 25% well water + SW 75% +25 % of recommended (RR) of fertilizers. and T5: soil irrigated with 0% well water + SW 100% +0 % of recommended (RR) of fertilizersusing the Giza-102 sunflower cultivar. Some agronomic parameters such as plant height, leaf number, diameter of stem and the head yieldwere measured. The combined use of wastewater and well water is an alternative for the substitution of mineral fertilization with minimal damage to the productive potential and development of the sunflower crop. Mixing of 25%of waste water with 75% well water (T4) gave the most improvement in agronomic performance of sunflower plants and consequently produced the highest seed yield.

Key words: Wastewater treatments · Sequential extraction trace elements · Growth parameters · Chemical constituents · Sunflower plants

INTRODUCTION

Nowadays, surface water resources of Egypt have fully exploited and the ground water pump age reaching to the maximum limit [1]. Therefore, the need to looking for an alternative water resource is an urgent need. Treated municipal wastewater is a valuable water source for recycling and reuse in some industrial and agronomic application inMediterranean countries and other arid and semi-arid regions, which are confronting increasing water shortages. Water reuse can also help mitigation of climate change impacts on crop yields and dwindling water resources [2]. Landscape irrigation, groundwater recharge and industrial applications, among other activities, are also being performed with treated wastewater [3]. The use of treated, diluted and even raw domestic wastewater for agricultural irrigation is becoming an essential component of a more sustainable and integrated water resources management, especially in water-scarce regions Egypt. The use of wastewater in agriculture provides advantages such as reusing of water and the reducing the use of mineral fertilizers due to applied of organic matter and nutrients through irrigation and decreasing in the use of good quality water. On the other hand, it has disadvantages such as the occurrence of negative environmental impacts to the soil-plant system, contamination of soil, surface water and groundwater and toxicity to plants [4, 5]. Sunflower (*Helianthus annuus L.*) is an oleaginous plant with several uses such as wild bird food, livestock forage (silage), as ornamental in domestic

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garden, biodiesel production and some other industrial application edible, biodiesel, ornamentation, animal feed and honey production [6].

Many studies confirmed the benefits of using wastewater in sunflower, Carvalho [7] reported that treated domestic wastewater at the secondary level allowed the production of sunflower biomass within acceptable sanitary standards for food and feed. Weber [8] indicated that sunflower irrigated with well-water and water produced from the treated oil by filtration and reverse osmosis, evidenced that the water produced from filtered petroleum only modified the concentration of exchangeable salts in the soil, affecting the vegetative growth and the accumulation of nutrients in the roots and aerial parts of plants [9]. Rawashdeh [10] verified the maximization of seed yield and oil production in sunflower plants irrigated with treated domestic wastewater. Oliveira, [11] studied the effects of five dilutions of treated domestic wastewater in supply water on the development and production of sunflower. They reported that irrigation with wastewater caused insignificant change on external diameter of flower bud, beginning of flowering and the full opening of head, while the wastewater favored the development of sunflower, especially, when domestic wastewater was diluted with well water.

In assessing the environmental quality of contaminated soil, the prediction of mobility and bioavailability of metals is very important, since deposition of trace metals in agricultural soil may become detrimental to plant growth or to the consumers of the harvested vegetable crops, which depends upon the chemical form of elements present in the soils [12-15].

The form in which trace metals exist in soil is very important to the environmental chemists as well as others because of the close relation between toxicity and fractionation. Chemical fractionation of metals in soil may help to assess the bioavailable metals fractions and the possibility of mobilization of these metals in soil. Chemical fractionation was defined [16] as the process of classification of an analyte or a group of analytes from a certain sample according to physical (e.g., size, solubility) or chemical (e.g., bonding, reactivity) properties. Recently, interest in determining the chemical form of metals in environmental samples has increased. The interest has arisen largely because of the awareness that it is the chemical forms, rather than metal itself, that plays an important role in the transfer of metals along the water-soil-plant-animal-human chain [17].

MATERIALS AND METHOD

Field Experiments: A field experiment was carried out at *Al Gabal Al Asfar* Waste Water Treatment Plant (WWTP) during 2017to fulfill the objective of the present study, some chemical and physical properties of the investigated soil illustrated in Table (1).

The experimental treatments were as follows:

T1: Soil irrigated with 100% well water +100 % of recommended (RR) of fertilizers.
T2: Soil irrigated with 75% well water + SW 25% +75 % of recommended (RR) of fertilizers.
T3: soil irrigated with 50% well water + SW 50% +50 % of recommended (RR) of fertilizers
T4: Soil irrigated with 25% well water + SW 75% +25 % of recommended (RR) of fertilizers
T5: Soil irrigated with 0% well water + SW 100% +0 % of recommended (RR) of fertilizers

Sewage water effluents (100 %) were mixed separated with well water for each plots using farrow irrigation methods according the treatments described. Chemical and physical characterization of the irrigated waters presented in Table (2). Nitrogen fertilizer was added at three equal doses and potassium fertilizer was added only once at flowering stage; however, phosphate fertilizer was added to soil just prior to sowing. The experimental areas were ridged into sufficient numbers of experimental plots 30 m^2 each. Treatments were applied in a complete randomized block design with four replicates. Seeds of sunflower *(Helianthus annuus L. var. Euroflour)* Geza-102 were sown in the first week of April 2017. All agricultural practices were carried out as approved by Ministry of Agriculture and Land Reclamation. After harvesting, soil samples were collected to determine physical and chemical properties of the soil using methods described by [18].

Plants werecollected from each experimental plot, yield and its components/ plant were determined; macro- and micronutrient contents of seeds were determined. The obtained data were subjected to analysis of variance according to. [19]. the least significant differences (LSD) at P= 0.05 level was used to verify the difference between means of the treatments.

Laboratory Experiments: Fractionation of the investigated heavy metal carried out to ascertain the chemical partitioning of Fe, Mn, Zn Cu Pb Ni and Cd, in agricultural soils repeatedly irrigated with sewage

Table 1: Physical and chemical soil properties of the experimental site

Physical properties			Chemical properties							
Sand	Silt	Clay	Texture	pH	EC dSm^{-1}	$CaCO_3$ %	OM %	N	P	K
-----%-----								----(ppm)----		
43.21	46.46	10.28	loamy	7.30	0.74	0.45	0.59	107	3.0	57

water. For this purpose, five suitable sites were selected. The surface (0-30cm depth) soil samples were collected from these sites where sewage irrigation is being practiced on agricultural land. Bulking method was employed to harmonize the samples of each site. A conning and quartering method was applied repeatedly to reduce the sample volume of each site [20]. Each representative site sample was prepared by mixing one sample with the other replicates from different grids of the same site to overcome spatial variability. The soil samples were air-dried, sieved mechanically using 2mm sieve. Sequential extraction was performed using a five-step fractionation procedure recommended by [21-23] in which the metals are divided into five fractions: exchangeable (F1), adsorbed (F2), bound to organic matter (F3), bound to carbonates (F4) and residual (F5).

RESULTS AND DISCUSSION

Characteristics of Irrigation Water: Table 2 illustrate the chemical properties of irrigation waters, the quality of both waters are in permissible limits for irrigation purposes except the parameters BOD and COD according to the Egyptian code of practice (222/2002). However, the treated wastewater (100%WS) characterized by high salinity in terms of (electrical conductivity). Dilution of treated wastewater by well water reduced the salinity up to 45%. Data in Table 2 show that quality of well water used to irrigate the experimental field are classified in C2S1 group according to[24], where, there is no sever hazards for surface irrigation[25]. Salts concentration of wastewater is an important parameter determining its suitability for irrigation, according to salt tolerance of crops diagrams [26].

Data also showed high concentration of soluble salts might limit its use for irrigation due itseffects on crop yield. It can be observed that dilution of the absolute wastewater is the best practical option favored due to the availability of wastewater and its nutrients content makes it an attractive source of irrigation water with likely fertilizer cost saving [27] and shortage of fresh water particularly in Egypt, leading to the increasing use of wastewater [28]. The pH of the wastewater was 8.45, which is in acceptable range. Since the optimal range of pH of treated wastewater, treatment for irrigation is 6.5-8.4 [29]. Data alsoshow that the high salinity of wastewater in terms of electrical conductivity. However due to the dilution effects, electrical conductivity were gradually

Table 2: Chemical properties of diluted wastewater.

	100% FW	75%FW+25%WS	50%FW+50%SW	25%F.W+75%SW	100% SW
pH	7.21	7.45	7.75	8.17	8.45
EC	0.73	2.09	3.15	3.65	3.78
TSS mg^{-1}	467.2	137.6	2016	2336	2419.2
TDS mg^{-1}	198	936	4531	4489	75500
BOD mg^{-1}	59	89	103	178	383
COD mg^{-1}	101	131	183	438	798
SAR	9.75	29.51	35.41	41.8	49.3
Ca ppm	43	249	461	749	930
Mg ppm	27	210	431	541	671
SO_4 ppm	149	730	987	540	621
Na ppm	41	98.5	278	364	398
Cl ppm	209	612	2041	2198	2231
Cu ppm	0.19	0.25	0.38	0.41	0.68
Fe ppm	2.1	4.15	8.45	10.98	13.81
Zn ppm	0.68	2.1	2.31	3.48	5.98
Co ppm	0.095	0.18	0.51	0.98	1.49
Pb ppm	0.051	0.081	0.1	0.78	0.83
Ni ppm	0.063	0.095	0.21	0.31	0.78
Cr ppm	0.031	0.098	0.15	0.34	0.83
Mn ppm	1.25	1.54	1.67	1.93	2.78

Table 3: Characteristics of soil irrigated with diluted wastewater:

Parameter	T1	T2	T3	T4	T5
pH	7.30	7.48	7.91	8.18	8.72
EC	0.74	0.93	2.08	2.65	3.98
OM%	0.59	0.68	0.89	1.15	1.48
OC%	0.31	0.36	0.47	0.61	0.78
Ca	49.80	143	381	439	630
Mg	35.18	281	391	411	531
Na	50.30	118	435	598	720
N ppm	143	239	361	549	630
P ppm	2.17	2.9.0	4.61	5.41	6.71
K ppm	149	330	487	542	622
Cu	1.39	3.13	4.17	4.59	5.16
Fe	3.81	3.89	4.13	5.16	6.52
Zn	1.02	2.79	2.93	2.95	3.11
Co	0.48	0.61	0.79	1.02	1.31
Pb	0.73	1.12	1.31	1.48	1.83
Cr	0.39	0.48	0.51	0.98	1.49
Mn	2.61	2.48	2.59	3.78	5.83

minimized up to 45% particularly at (25% treated wastewater +75% deep well water) treated wastewater. Waste water not only is a supplemental irrigation water but also is a source of plant nutrients such as nitrogen, phosphorus; organic matter [30]. In addition, wastewater is a valuable source of plant nutrients and organic matter needed for maintaining fertility and productivity levels of the soil [31]. Lubtti [32] stated that physical and chemical characteristics varied considerably between the two applied irrigation water types. As expected, compared to the groundwater, the levels of most of the chemical parameters were significantly higher in the wastewater, including for EC, Na+, K^+, Ca^{2+}, Mg^{2+}, TSS, SAR, COD, BOD5, NH_4-N, phenols, PO_4-P and chlorides. However, in the wastewater, all of these measured parameters remained within the Egyptian code of practice (222/2002).

Characteristics of Soil Irrigated with Diluted Wastewater: Table (3) shows effect of wastewater treatments on chemical properties of treated soil. Data revealed that diluted wastewater, increased total concentration of cations Ca and Mg and soil organic matter in terms of organic carbon (O.C %), in this text. Zhang [33] observed significant increase in percentage of organic matter and improvement in soil structure due to the irrigation with wastewater. [34] Also, demonstrated similar results from irrigation with urban wastewater and wastewater sludge as manure. Moreover, soil salinity level increased in all wastewater treatments as compared with control (well water). The maximum soil salinity was obtained by wastewater irrigation during entire period of growing season. Electrical conductivity of soil solution in the control treatment increased from 0.74 up to 3.98 dS m^{-1}. The presence of soluble salt, sodium, magnesium and calcium in the wastewater can increase soil electrical conductivity [35, 36]. Higher values of macronutrients (N, P, K.Ca and Mg) in the soil irrigated with diluted compared with well water would suggest that there were improving in soil fertility, as indicated by severalresearchers using solid waste or irrigation with treated wastewaters [37-42]. They stated that concentration of N, P and K were significantly affected by irrigation with wastewater treatments, soil nitrogen increased by wastewater treatments, because of plentiful urea and nitrogen in urban wastewater. Nitrogen, phosphorus and potassium concentration increased by irrigation with wastewater rather well water.

[43] Reported that total soil nitrogen increased as the influence of urban wastewater or wastewater sludge irrigation. In addition, potassium and phosphorus increase in the soil due to wastewater application [34].

In other study authors studied, the effect of irrigation with diluted wastewater, treatments (T2, T3, T4 and T5) gradually increased all investigated heavy elements as compared with (T1) whichresulted in gradual accumulation of macro and micronutrients in irrigated soil [44]. Using large-scale indicated that wastewater irrigation on agricultural lands is a practice caused increases in some parameter in soil such as EC, OM, total nitrogen, CEC, sodium ion, manganese and nickel to be increased on the other hand, soil pH decreased. On contrast, Amin [45] reported that soil irrigated with wastewater do not have any effect on concentration of extractable cadmium and chromium.

Table 4: Effect of diluted waste effluents with well water and their effects on growth and yield of sunflower

Treatment	Plant height cm	Roots length cm	Leaf number	Stem Diameter cm	F.M Shoots gm.	F.M Roots gm.	D.M Shoots gm.	D.M Roots gm.	F.M of head gm.	D.M of head gm.	Cap Diameter cm	Seeds No./ head	Seed yield Kg fed[1]
T1	114.30	10.59	44.12	13.36	275.01	29.65	78.74	18.34	88.94	42.92	13.15	67.33	1243.8
T2	100.80	8.86	35.48	11.15	240.37	18.85	68.41	12.13	69.61	39.34	15.75	68.55	1249.77
T3	108.99	9.94	39.48	12.15	286.42	23.85	81.62	15.15	78.83	48.74	17.47	88.00	1356.11
T4	84.36	7.04	32.86	10.64	225.53	35.81	64.85	10.93	55.38	37.45	12.47	57.00	1123.82
T5	76.23	5.38	28.31	9.77	199.91	14.28	57.14	9.45	48.03	33.46	10.32	30.67	1118.52
LSD 5%	4.9	1.07	2.64	0.93	18.7	2.01	7.08	1.04	4.35	4.59	3.53	3.77	102.71

Table 5: Effect of wastewater treatments on the macronutrients concentration and uptake of shootsby sunflower plants

	Shoots											
Treatment	N	P	K	Na	Ca	Cl	N	P	K	Na	Ca	Cl
	%						Uptake mg/plants					
T1	1.46	0.17	2.3	0.57	0.84	0.52	1149.6	133.8	1811.0	448.8	661.4	409.4
T2	1.20	0.11	1.88	0.77	0.96	0.58	820.9	75.25	1286.1	526.7	656.7	396.8
T3	1.32	0.13	2.16	1.34	1.38	0.61	1077.4	106.11	1762.9	1093.7	1126.3	497.9
T4	0.87	0.11	1.74	1.5	1.53	0.70	564.2	71.33	1128.4	972.7	992.2	453.9
T5	075	0.10	1.44	1.63	1.68	0.76	428.5	57.14	822.8	931.4	959.9	434.3

Plant Growthand Yield: Plant height of sunflower was significantly affected by diluted wastewater with well water (Table 4). The highest plant height (114. 3cmwas reported from the plants irrigated only with well water and fertilized with the recommended rate of nutrient elements (T1). However, the lowest value of plant height (76.23 cm) was occurred by treatment of (T5). Application of inorganic fertilizers have become very popular practices because they are easily affordable and have the advantage of fast action owing to their prompt release of nutrients [46]

The reduction in plant height by about 40%, may be due to the salinity effect of wastewater as illustrated in Table (3) since high concentration of salts (Na and CL ions) can be responsible for growth reduction of sunflower besides nutritional imbalances. Many researchers, [47, 48, 49, 50, 51]reported that municipal wastewater is an important alternative source of water for irrigation especially in countries suffer from shortage water resources. From the sametable the results also show that application of diluted wastewater treatment (T2) reduced plant height by about 11%.

Data in Table (4) showed that most of growth and yield characters (plant height stem diameter, seeds weight / head, 1000 seeds weight, seeds yield kg fed-1), show slightly differences with application of diluted sewage water as a sources of irrigation. Whereas application of diluted sewage water had more pronounced effect on head diameter, seed number/head and seed yield kg/fed. Application of (soil irrigated with 50% well water + SW 50% +50 % of therecommended rate of fertilizers) as T3 stimulate the yield production of seed of sunflower as well as saving the fertilizers added by about 50% of the recommended. Percentages of diluted sewage water with well water gradually increase the yield production of seed by about 10%. The obtained results in a harmony with those obtained by [52, 53].

Chemical Composition: Table (5) illustrated that effect of dilution treatment of wastewater and their effects on the macronutrients concentration (N, P, K) concentration in sunflower plants. Data revealed that application of wastewater decreased the concentration of N, P and K in the shoots of sunflower plant. This might be due to salinity effects, which reduced plant N, P and K contents except for Na and Cl contents in plant shoots and seeds. This resembles the finding of [54] who showed that the amount of nutrient elements taken up by plants significantly decreased by increasing salinity. The higher the concentration of salts, the greater the decrease in total uptake of N, P and K Since sewage, water contains considerable amounts of total N, total P and K which are considered as essential macro- nutrients for crop productivity wastewater gradually increased the accumulation of salt in soil due to the salinity of waste water itself, Our finding were in agreement with those previously obtained by [55-57]. They reported that irrigation with sewage water increased soil salinity, exchangeable Na, K, Ca and Mg.

It stimulated the accumulation of Na^+, Cl^- and Ca^{+2} and increased by up to 50% in sunflower shoots due to using sewage water. Application of 50% of both well and sewage water gave the highest accumulation rate in shoots of sunflower plant. Salinity is known to influence morphological, physiological and biochemical changes in plants, which results on overall performance of the *plant*

Table 6: Effect of wastewater treatments on the macronutrients concentration and uptakeof seedsby sunflower plants

	Seeds											
	N	P	K	Na	Ca	Cl	N	P	K	Na	Ca	Cl
	%						Uptake Kg fed^{1}					
T0	2.40	0.25	1.49	0.18	0.32	0.18	29.85	3.11	18.53	2.24	3.98	2.24
T 25%	1.86	0.18	1.20	0.25	0.36	0.22	23.25	2.25	15.00	3.12	4.50	2.75
T 50%	2.21	0.20	1.33	0.40	0.50	0.26	29.97	2.71	18.04	5.42	6.78	3.53
T75%	1.70	0.16	1.08	0.44	0.66	0.33	19.10	1.80	12.14	4.94	7.42	3.71
T100%	1.73	0.16	0.87	0.48	0.73	0.34	19.35	1.79	9.73	5.37	8.17	3.80

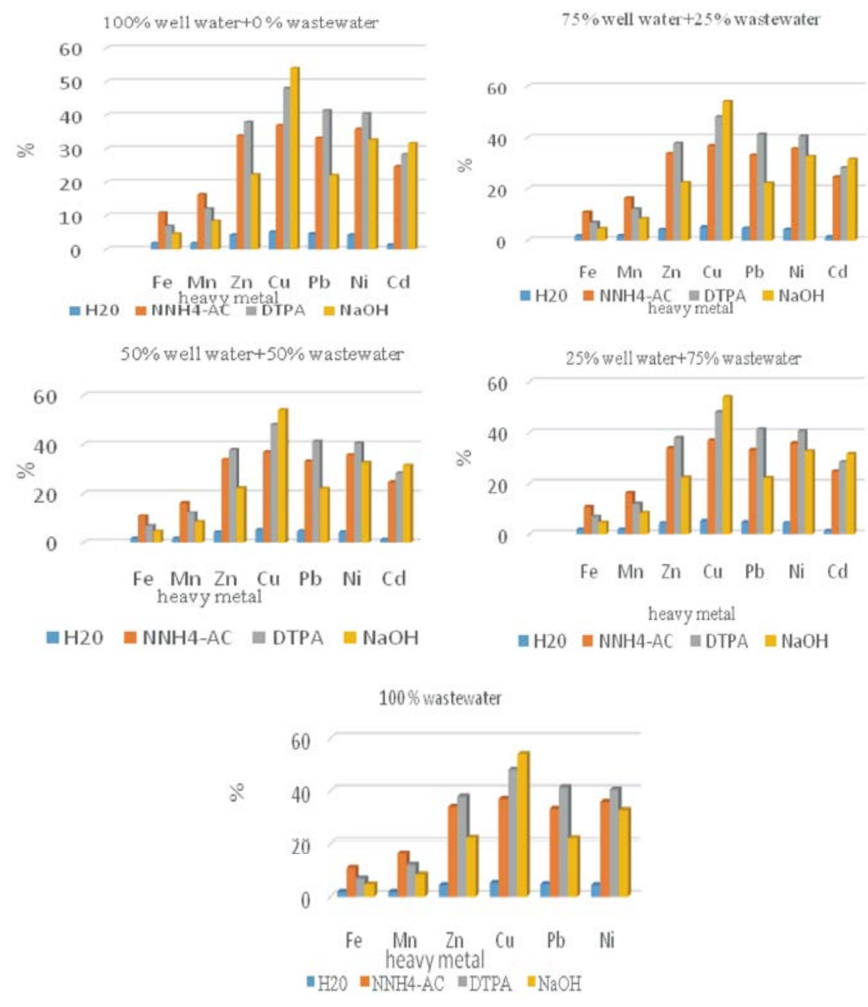

Fig. 1: Extractable fraction of heavy metal from soil irrigated with different dilution rates of wastewater with well water

[58-60]. In addition to the toxicity caused by ions, salinity and osmotic stress cause an imbalance of nutrients in plants and consequently all plant physiological performance will be negatively affected [50, 51].

Application of wastewater treatments resulted in a reduction of macronutrients (N, P and K) concentration and uptake in seeds of sunflower Table 6. Results also showed that salinity of irrigation water reduce both concentration and uptake of N, P and K by seeds. On contrast Na and Cl contents in plant shoots and seeds gradually increased. [54reported that nutrient elements significantly decreased by increasing salinity. Higher concentration of salts, in agriculture media are responsible for decreasing in total both concentration and uptake of macronutrient elements (N, P and K). Results also, revealed that all dilution treatments of wastewater tended to decrease N, P and K concentration and uptake in shoots and seeds as compared with well

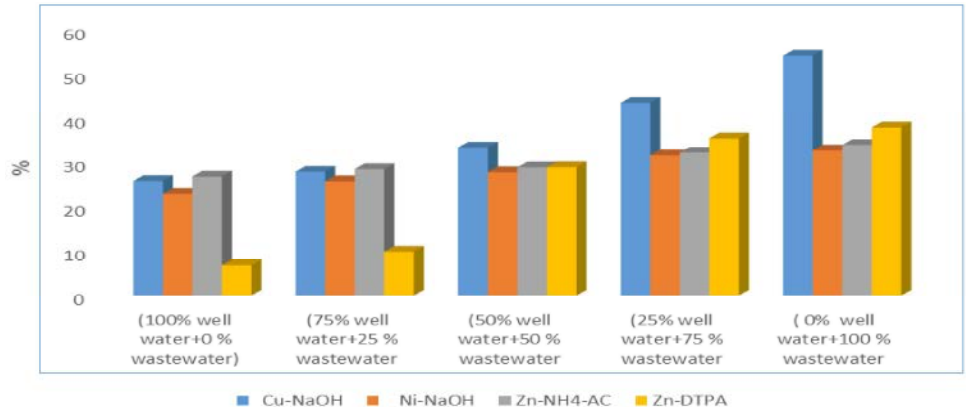

Fig. 2: Extractable fraction of copper and zinc with (NaOH, DTPA) from soil irrigated with different dilution rates of wastewater with well water

water alone. This will encourage plants to produce more substances that responsible for regulating ions and modify the movement of nutrients within the plant tissues under salt stress.

Fractionation of Heavy Metals: Data of fractionation experiment represented in Fig. (1) Showed that, distribution of HMs (Fe, Mn, Zn, Cu, Pb and Ni) in the fractions depended on the solid matrix composition and its properties, but it mainly depended on the nature of the metal itself. The distribution of the metal fractions varied widely for various metals. The water fraction of almost investigated metals only represented a small portion (less than 10%) for all treatments of the total amount of metal found in the sewage water treatments (T1, T2, T3, T4 and T5). This fraction shows the concentrations of the metal cations, which are non-specifically adsorbed and can be easily replaced by competition with divalent metal ions similar trend, were observed by [62].

Dilution rate of sewage water by well water play an important role for the extractable fraction of heavy metal in soil irrigated by diluted. wastewater. Results indicatedthat the extractable fraction of heavy metals in soil irrigated with treatment (T5) (100% wastewater) gave the maximum extractable fractions of investigated heavy metals whereas; diluted irrigated water gave lower extractable fraction.

Data in Fig.(1) showed also that irrigated soil with well water has a considerable amounts of the extractable fraction of heavy metals in soil, due to prolonged of waste water treated soil which can increase the accumulation of macro and micronutrients in ground water and the proper use enables the valuable OM and heavy metal to be recycled. Higher extractable fraction were noticed particularly in soil irrigated with (T5) treatment. It's evident that ammonium acetate had more pronounced effect on the extractable of Fe, Mn, Zn, whereas for Cu and Cd with NaOH had more effect due to the affinity of soluble organic matter to those elements Fig.(2).

REFRENCES

1. AbouZeid, K., K. Eltrawady and M. CEDARE, 2014. 2050 strategies version of treated wastewater Reuse in Egypt., Water Resources Programme-CEDARE.
2. Misra, A.K. and K. Lata, 2013. Modeling the effect of time delay on the conservation of forestry biomass. Chaos, Solitons & Fractals, 46: 1-11.
3. Bixio, B., H. De heyder, M. Cikurel, V. Muston, D. Miska, A.I. Joksimovic, A. Schäfer, A. Ravazzini, D. Aharoni and Savic, 2005. Municipal wastewater reclamation: where do we stand.An overview of treatment technology and management practice. Water Supply, 5(1): 77-85.
4. Angin I., A.V. Yaganoglu and M. Turan, 2005. Effects of long-term wastewater irrigation on soil properties. J. Sustain. Agr., 26: 31-42.
5. Rodrigues, M.B., M.A. Vilas Boas, S.C. Sampaio, C.F. Reis and S.D. Gomes, 2011. Efeitos de fertirrigações com águasresiduárias de laticínio e frigorífico no soloefrigorífico no solo e naprodutividade da alface. Eng. Ambient., 8(3): 173-182.
6. Fabio, R.S., I.M. Silva, D.M.P. Pellin, A.C. Bergamin and R.P. Silva, 2015. Característicasagronômicas do cultivo de girassolconsorciado com Brachiariaruziziensis. Rev. Cienc. Agron., 46(1): 110-116.

7. Carvalho, R.S., J.S. Santos Filho, L.O.G. Santana, D.A. Gomes, L.C. Mendonça and G.G. Faccioli, 2013. Influência do reuso de águasresiduáriasnaqualidademicrobiológica do girassoldestinado à alimentação animal. Rev Ambient Água., 8(2): 157-167.
8. Weber, O.B., L.A. Crisostomo, F.R. Miranda, A.F. Sousa, A.L.M. Mesquita and J.E.O. Cabral, 2017. Production of ornamental sunflower irrigated with oilfield produced water in the Brazilian semiarid region. PesqAgropec Bras., 52(6): 443-454.
9. Bezerra, C., G. Fabrícia, B. Oliveira, P. Rafael, O. Joaquim, N. Ferreira, A.S. Miguel, C. Maria, W. Simoes, Lima, L. Di Souza, P. Vieira and Roberto. 2018. Productive and morphogenetic characteristics of sunflower irrigated with domestic treated wastewater on northeast semiarid area. Australian J. of Crop Sci., 12(7).
10. Rawashdeh, H.M., 2017. Sunflower seed yield under trickle irrigation using treated wastewater. Afr J. Agric. Res., 12(21): 1811-1816.
11. Oliveira, A.F.M., F.G.B.C. Fernandes, R.O. Batista, L. Di Souza and M.T. Gurgel, 2014. Teores de metaispesadosemcambissoloirrigado com águaresiduáriadoméstica e água de poço. Rev. Ambient Água., 9(2): 302-312.
12. Ma, L.Q. and G.N. Rao, 1997. Chemical fractionation of Cd, Cu, Ni and Zn in contaminated soils.Journal of Environmental Quality, 26: 256-264.
13. Nasrabadi, T., G.R. NabiBidhendi, A.R. Karbassi and N. Mehrdadi, 2010. Partitioning of metals in sediments of the Haraz River (Southern Caspian Sea basin), Environmental Earth Sciences, 59: 1111-1117.
14. Taghinia Hejabi, A., H.T. Basavarajappa and A.M. QaidSaeed, 2010. Heavy Metal Pollution in Kabini River Sediments, Int. J. Environ. Res., 4(4): 629-636.
15. Vasanthavigar, M., K. Srinivasamoorthy, K. Vijayaragavan, R. RajivGanthi, S. Chidambaram, V.S. Sarama, P. Anandhan, R. Manivannan and S. Vasudevan, 2009. Hydrogeochemistry of Thirumanimuttar Basin: An Indication of Weathering and Anthropogenic Impact, Int. J. Environ. Res., 3(4): 617-628.
16. Templeton, D.M., 2000. Guidelines for terms related to chemical speciation and fractionation of elements. Definitions, structural aspects and methodological approaches (IUPAC Recommendations 2000). Pure ApplChem., 72: 1453-1470.
17. Rattan, R.K., S.P. Datta, P.K. Chhonkar, K. Saribatu and A.K. Singh, 2005. Long-term impact of irrigation with sewage effluent on heavy metal content in soils, crops and ground water- A case study. Agriculture, Ecosystem and Environment, 109(3-4): 310-322.
18. Cottenie, A., M. Verloo, L. Kiekens, G. Velghe and R. Camerlynck, 1982. Chemical Analysis of Plant and Soil. PP. 100-129. Laboratory of Analytical and Agrochemistry, State Univ. Ghent. Belgium.
19. Snedecor, G.W. and W.G. Cochran, 1980. Statistical Methods. 7th ed., Iowa State Univ. Press, Ames, Iowa, USA.
20. Jackson, M.L., XXXX. Soil chemical analysis. Verlag. : Prentice Hall, Inc., Englewood Cliffs, NJ.1958, 498 S. DM 39.40.
21. Emmerich, W.E., L.J. Lund, A.L. Pag and A.C. Chang, 1980. Movement of heavy metal in sewage sludge treated soil Journal of Environ. Qual., 11(2): 174-178.
22. Abou Seeda, M., 1995. Potential benefits and hazards of land application of sludges: A review Proc. Seminar: Production and use of chemical fertilizers and environment. 17-21 Dec., 301-323.
23. AbouSeeda, M.; A. Khater and. E.M. Khaled, 1997. Use of sewage sludge for sustainable agriculture and pollution preservation. I. Composting of sewage sludge. J. Agric. Sci. Mansoura Univ., 21(11): 4179-4193.
24. Miller, R.W. and R.L. Donahue, 1990. Soils: An Introduction to Soils and Plant Growth. Prentice Hall, New Delhi, India, ISBN-13: 9780138202262, pp: 768.
25. FAO. 1985. Guidelines: land evaluation for irrigated agriculture. Soils Bulletin 55. Food and Agriculture Organization of the United Nations, Rome, Italy.
26. Maas, E.V. and S.R. Grattan, 1999. Crop yields as affected by salinity. In: Agricultural Drainage, eds. R.W Skaggs and J. Van Schilfgaarde, pp: 55-108. Madison, WI: ASA.
27. Arenas-Lago, D., F.A. Vega, L.F.O. Silva and M.L. Rade, 2013. Soil interaction and fractionation of added cadmium in some Galician soils. Micro Chem. J., 110: 681-690.
28. Rahman, Muhammad Muhitur, Hagare Dharma and Maheshwari Basant, 2016. Bayesian Belief Network analysis of soil salinity in a peri-urban agricultural field irrigated with recycled water, Agricultural Water Management, Elsevier, 176(C): 280-296.
29. Ayers, R.S. and D.W. Wetcot, 1976. Water quality for agriculture. Food and Agriculture Organization of the United Nations. California., pp: 97.

30. Gibbs, P.A., B.J. Chambers, A.M. Chaudri, S.P. McGrath, C.H. Carlton-Smith, J.R. Bacon, C.D. Campbell and M.N. Aitken, 2006. Initial results from a long- term multi-site field study of the effects on soil fertility and microbial activity af sludge cakes containing heavy metals. Soil Use and Management, (22): 180-187.
31. Rusan, M.M.J., S. Hinnawi and L. Rousan, 2007. Long term effect of wastewater irrigation of forage crops on soil and plant quality parameters. Desalination, 215: 143-152.
32. Libutti, A., G. Giuseppe, G. Anna, V. Pompilio, P. Alfieri, B. Luciano, G. Disciglio and T. Emanuele, 2018. Agro-industrial wastewater reuse for irrigation of a vegetable crop succession under Mediterranean conditions, Agricultural Water Management, Elsevier, 196(C): 1-14.
33. Zhang, Y.L., J.L. Dai, R.Q. Wang and J. Zhang, 2008. Effects of long-term sewage irrigation on agricultural soil microbial structural and functional characterizations in Shandong, China. European Journal of Soil Biology, 44: 84-91.
34. Fuentes, E.R., C.L. Constantino, E.E. Silva and L. Dendooven, 2002. Characteristics and carbon and nitrogen dynamics in soil irrigated with wastewater for different lengths of time. Bioresource Technology, 85: 179-187.
35. Ghanbari, A., J. Abedikoupai and J. TaieSemiromi, 2007. Effect of municipal wastewater irrigation on yield and quality of wheat and some soil properties in sistan zone. Journal of Science and Technology Agricultural and Natural Recourse, 10: 59-74.
36. Mohammad, M.J. and N. Mazahreh, 2003. Changes in soil fertility parameters in response to irrigation of forage crops with secondary treated wastewater, Comm. Soil Sci. Plant Anal, 34: 1281-1294.
37. Mojid, M.A., S.K. Biswas and G.C.L. Wyseure, 2012. Interaction effects of irrigation by municipal wastewater and inorganic fertilizers on wheat cultivation in Bangladesh. Field Crops Research, 134: 200-207.
38. Chrysargyris, A. and N. Tzortzakis, 2015. Municipal solid wastes and mineral fertilizer as an eggplant transplant medium. Journal of Soil Science and Plant Nutrition, 15(1): 11-23.
39. Bernala, A.D., S.M.C. Ramosa, N.T. Tapiaa, V.O. Portugalb, J.T.F. Hernandezc and L. Dendoovena, 2006. Effects of tanneries wastewater on chemical and biological soil characteristics. Applied Soil Ecology, 33: 269-277.
40. Fonseca, A.F., A.J. Melfi and C.R. Montes, 2005a. Maize growth and changes in soil fertility after irrigation with treated sewage effluent. I. Plant dry matter yield and soil nitrogen and phosphorus availability. Communications in Soil Science and Plant Analysis, 36: 1965-1981.
41. Fonseca, A.F., A.J. Melfi and C.R. Montes, 2005b. Maize growth and changes in soil fertility after irrigation with treated sewage effluent. II. Soil acidity, exchangeable cations and sulfur, boron and heavy metals availability. Communications in Soil Science and Plant Analysis, 36: 1983-2003.
42. Abd El Lateef, E.M., J.E. Hall, A.A. Farrag, Abd El-M.S. Salam and A.A. Yassen, 2019. The Egyptian Experience in Sewage Sludge Recycling in Agriculture.American Eurasian Journal of Agronomy, 12(2): 12-18.
43. Rosen, C.J and B.P. Horgan, 2009. Preventing Pollution Problems from Lawn and Garden Fertilizer, Extention.umn.edu
44. Bernal, M., R.. Clemente, S. Vázquez and D. Walker, 2007. Aplicación de la fitorremediación a lossueloscontaminadospormetalespesadosenAznal cóllar. Ecosistemas, 16(2): 1-14.
45. Amin, S.M., R. Fargoud and A. Shabani, 2011. Groundwater Contamination by Heavy Metals in Water Resources of Shiraz Area. Iran Agricultural Research, 30(1& 2).
46. Rejeb, S., F. Gharbi, A.H. Mouneimne and M.H. Ghorbal, 2011. Effects of sludge on the metals levels of various edible crops grown in the field. J. Agric. Biol. Sci., 6: 8.
47. Bassil, E.S. and S.R. Kaffka, 2001. Response of safflower to saline soils and irrigation, part II. Crop response to salinity. Agric. Water Manage, 54: 81-92.
48. Sifola, M.I. and L. Postiglione, 2002. The effect of increasing NaCl in irrigation water on growth, gas exchange and yield of tobacco Burley type. Field Crops Research, 74: 81-91.
49. De Pascale, S., A. Maggio, C. Ruggiero and G. Barbieri, 2003b. Growth water relations and ion content of field-grown celery [*Apiumgraveolens* L. var (Mill.) Pers.] Under saline irrigation. J. Am. Soc. Hortic. Sci., 128: 128-135.
50. Cavagnaro, Juan B., T. Ponce, María Guzman, Javier and Cirrincione A. Miguel, 2006. ergentinean of cultivars of *Vitisvinifera* grow better than European ones when cultured in vitro under salinity. Biocell, January, 30(1): 1-7.

51. Song Jie, Ding Xiaodong, Feng Gu and Zhang Fusuo, 2006. Nutritional and osmotic roles of nitrate in a euhalophyte and a xerophyte in saline conditions. New Physiologist, 171(2): 357- 366.
52. Silva, B., H. Figueiredo, C. Quintelas, I.C. Neves and M.T. Tavares, 2012. Improved biosorption for Cr(VI) reduction and removal by *Arthrobacter viscosus* using zeolite. IntBiodeteriorBiodegrad, 74: 116-123.
53. Silva, B., E. Tuuguu and F. Costa, 2016. Permeable biosorbent barrier for wastewater remediation. In: 2nd EWaS International Conference: “Efficient & Sustainable Water Systems Management toward Worth Living Development, 1-4 June 2016. Chania, Crete, Greece.
54. El-Arquan, M.Y., Kh. H. El-Hamdi, E.M. Seleem and I.M. El-Tantawy, 2002. Nutrient uptake of sugar beet as affected by NPK fertilization and soil salinity levels. Egypt. J. Soil Sci., 42(4): 783-797.
55. Galavi, M., A. Jalali, M. Ramroodi, S.R. Mousavi and H. Galavi, 2010. Effects of treated municipal wastewater on soil chemical properties and heavy metal uptake by sorghum (Sorghum bicolor L.). J. Agr. Sci., 2(3): 235-241.
56. Rana, L., R. Dhankhar and S. Chhikara, 2010. Soil characteristics affected by long-term application of sewage wastewater. Int. J. Environ. Res., 4(3): 513-518.
57. Kiziloglu, F.M., M. Turanb, U. Sahina, Y. Kuslua and A. Dursunc, 2008. Effects of untreated and treated wastewater irrigation on some chemical properties of cauliflower (*Brassica olerecea* L. var. botrytis) and red cabbage (Brassica olerecea L. var. rubra) grown on calcareous soil in Turkey. Agric Water Manage, 95(6): 716-724.
58. Horie, T. and J.I. Schroeder, 2004. Sodium transporters in plants. Diverse genes and physiological functions. Plant Physiol., 136: 2457-2462.
59. Parida, A.K. and. A.B. Das, 2005. Salt tolerance and salinity effects on plants: a review, Ecotoxicol. Environ. Safety, 60: 324-349. Jaleel, C.A., R. Gopi, P. Manivannan, R. Panneerselvam, (2007). Responses of antioxidant defense system of Catharanthusroseus (L.) G. Don. To paclobutrazol treatment under salinity, Acta Physiol. Plant., 29: 205-209.
60. Khan, N.A., M. Shamim and P. Shambhoo, 2008. Biochemical changes in wheat plants in response to salinity. International Journal of Plant Sciences, 3(1): 11-15.
61. Yassen, A.A., E.F. Abdallah and M.S. Gaballah, 2011. Response of sunflower plants to nitrogen fertilizers and Phytohormones under drainage water irrigation. Australian Journal of Basic and Applied Sciences, 5(9): 801-807.
62. Ernestas Zaleckas, V. and Paulauskasnd S. Egle, 2013. Fraction of heavy metals in sewage sludge and their removal using low molecular-weight organic acids. J. of Environ. Engineering and Landscape Management, (21): 189-198.