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Assessment of Irrigation with Low-Quality Water on Soil and Plant Pollution

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ABSTRACT

The current investigation assesses and the use of : Nile water (NW), agriculture drainage water (DW), Nile water mixed with agriculture drainage water (NW+DW) and agriculture drainage water which is mainly sewage water (SW), on wheat and soils irrigated with them. Contents (mg L^{-1}) in NW, DW, NW+DW and SW were " in respective sequence " : 11.6, 17.9, 14.4 and 23.2 for N ; 3.29, 4.12, 3.66 and 5.58 for P ; 6.12, 8.29, 7.23 and 10.3 for K. Contents (µg L^{-1}) were : 728, 1109, 887 and 1382 for Fe ; 325, 398, 338 and 516 for Mn ; 258, 305, 271 and 387 for Cu ; 36.6, 77.7, 58.2 and 90 for Zn; 313, 616, 480 and 751 for Pb ; 12.8, 37.7, 23.9 and 48.4 for Ni ; 7.35, 12.8, 9.2 and 20.6 for Cd. Wheat yields (Mg ha^{-1}) in respective sequence were : 8.78, 6.38, 6.76 and 6.00 for straw ; 5.69, 3.86, 4.26 and 3.57 for grains [Egyptian feddan = 0.42 ha]. Macronutrients contents (g kg^{-1}) of in straw " in respective sequence" were : 10.2, 12.1, 11.1 and 14.6 for N ; 2.7, 3.4, 3.1 and 3.95 for P ; 28.1, 31.3, 28.9 and 35.6 for K . Micronutrient and heavy metal contents (mg kg^{-1}) in straw were : 73.2, 99.5, 95.9 and 103 for Fe ; 60.3, 75.6, 72 and 78.9 for Mn ; 10.7, 13.0, 11.8 and 16.2 for Cu ; 23.5, 25.3, 24.3 and 27.4 for Zn ; 10.7, 19.1, 16 and 23 for Pb ; 14.3, 17.0, 15.7 and 21.6 for Ni ; 22.6, 27.9, 24.3 and 34.2 for Cd. Respective macronutrients in grains (mg kg^{-1}) were : 19.1, 21.4, 20.8 and 22.0 for N ; 3.9, 4.5, 4.35 and 4.6 for P ; 23.3, 25, 24.7 and 25.5 for K. Those for the others (mg kg^{-1}) were: 63.5, 77.2, 76.3 and 82.4 for Fe ; 50.9, 59.2, 51.9 and 68.9 for Mn ; 9.1, 12.2, 11.7 and 14.2 for Cu ; 16.8, 24.2, 22.6 and 25.9 for Zn ; 10.0, 13.3, 11.9 and 16.4 for Pb ; 3.04, 8.6, 5.08 and 11.8 for Ni ; 17.3, 29.7, 24.2 and 32.1 for Cd. Contents of available elements in soils after harvest (mg kg^{-1}) were: 61, 67.7, 64.7 and 69.4 for N ; 4.47, 4.63, 4.5 and 4.66 for P ; 191, 198, 197 and 202 for K ; 5.73, 8.89, 7.79 and 10.9 for Fe ; 3.74, 6.22, 5.91 and 8.32 for Mn ; 0.68, 2.03, 1.01 and 4.16 for Cu ; 9.4, 15.7, 13.6 and 19.7 for Zn ; 4.81, 6.87, 6.27 and 7.39 for Pb ; 7.6, 11.3, 10.6 and 15.4 for Ni ; 1.48, 3.50, 2.56 and 4.58 for Cd.

Key words : Irrigation source, nutrients, heavy metals, accumulation, wheat nutrition and production

Introduction

Wheat (*Triticum aestivum* L.) is the principal winter crop in Egypt and the most important grain crop in the world. The world production of wheat exceeds that of any other grain crop. In many respects it represents the main human food. Wheat is the major bread making cereal, and Egypt has to supplement production by importing just over half of its needs to satisfy the annual demands (Abo Soliman *et al.,* 2008). Wheat provides 20% of energy in human diets (Ahmadi *et al*., 2004).

It is of great importance to increase wheat cultivated area with irrigation waters available from different sources. Irrigation water quality is critical for proper management necessary for sustainable agriculture. Thus, there may be a need to use some low-quality water such as drainage or sewage waters for irrigation of wheat. El-Hawary (2003) reported that an area of approximately 0.42 million hectares in the Nile Delta depends on drainage water for irrigation. El-Sayed (2001) noticed that the average concentrations of nitrate and ammonium nitrogen in sewage water are higher than their concentration in Nile water by four folds. Mostafa (2001) found that the irrigation with Nile water gave wheat grain yield of 5.45 Mg ha^{-1} compared with 5.38 Mg ha^{-1} by agriculture drainage water and 5.26 Mg ha^{-1} by sewage water. FAO (1992) mentioned that potassium in waste water causes no adverse effect on plants. El-Skeikh (2000) suggested that the irrigation with drainage water for two months or up to crop harvest decreased available phosphorus. The main objective of the current study is to assess and using low quality water of drainage and sewage waters for irrigation of wheat in comparison to Nile water.

Materials and Methods

Field Experiments were conducted in four locations different in their irrigation with different water canals at El- Sharkia Governorate, Egypt. The water canals were El-Hosania canal "Nile water", Bahr–Hadoos

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drain "agriculture drainage water", El- Salam canal "a mixture of Nile water + agriculture drainage water" and Bahr El-Bakar drain "mainly water with sewage effluent" using wheat (*Triticum aestivum* L., Sakha, 69). Physical and chemical properties of the soils and irrigation sources are shown in tables 1 to 3. Thus the water sources were: Nile water (NW), agriculture drainage water (DW), Nile water mixed with agriculture drainage water (NW+DW) and drainage water which is mainly sewage water (SW).

Table 1: Physical properties of the soils under irrigated with different water sources.

Irrigation water source	Organic matter ($g\ kg^{-1}$)	$CaCO_3$ ($g\ kg^{-1)}$)	Particle size distribution			
			Sand (%)	Silt (%)	Clay (%)	Textural Class
Nile water (NW)	9.90	21.4	50.5	17.6	31.9	Clay loam
Drainage water (DW)	12.2	40.6	45.1	18.3	36.6	Clay loam
Nile water plus Drainage water (NW+DW)	11.0	37.8	45.8	23.2	31.0	Clay loam
Sewage water (SW)	13.4	31.4	53.5	15.5	31.0	Clay loam

Table 2: Chemical properties of soils irrigated with different water sources.

Irrigation water source	pH (1:2.5)	EC dSm^{-1}	Soluble ions ($mmolc\ L^{-1}$)							
			Cations				Anions			
			Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	CO_3^{2-}	HCO_3^-	SO_4^{2-}
Nile water (NW)	7.64	3.01	13.3	0.78	5.47	10.5	11.0	Nil	2.68	16.3
Drainage water (DW)	7.81	5.49	32.6	0.64	10.4	11.4	18.3	Nil	6.85	29.9
Nile water plus Drainage water (NW+DW)	7.87	4.43	28.8	0.71	5.64	9.39	16.3	Nil	5.17	23.0
Sewage water (SW)	7.85	5.33	30.6	0.65	9.69	12.3	21.0	Nil	6.88	25.3

Table 3: Chemical properties of irrigation water used in the current study.

Irrigation water source	pH	EC dSm^{-1}	SAR	Soluble ions ($mmolc\ L^{-1}$)							
				Cations				Anions			
				Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	CO_3^{2-}	HCO_3^-	SO_4^{2-}
Nile water (NW)	7.49	1.16	1.20	2.45	0.89	4.52	3.78	4.49	Nil	1.36	5.79
Drainage water (DW)	7.92	1.59	5.45	8.98	1.49	2.48	2.95	4.9	Nil	2.1	8.9
Nile water plus Drainage water (NW+DW)	7.73	1.34	2.83	5.38	0.82	2.71	4.51	4.31	Nil	1.66	7.45
Sewage water (SW)	7.88	1.55	4.33	7.45	1.12	2.71	3.22	4.19	Nil	2.54	8.77

Soil and plant samples were collected at harvest (120 days from sowing) and subjected to analysis. The following analysis of soil, irrigation water and plant were performed. In soils: Particles size distribution of the soil was determined according to Piper (1950). Total soil soluble salts, soil pH, soil calcium carbonate were determined according to Jackson (1967). Soluble cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) and anions (Cl^-, CO_3^{2-}, HCO_3^- and SO_4^{2-}), organic matter content and available nitrogen were determined according to Black *et al.* (1965). Available nitrogen was determined by steam - distillation procedure using MgO-Devarda alloy according to Bremner and Keency methods as described by Black *et al.* (1965). Available phosphorus in soil was determined by extraction with 0.5 M $NaHCO_3$ and pH adjusted at 8.5 (Olsen *et al*., 1954); and determined colourimetrically using the ascorbic acid method (Watanabe and Olsen, 1965). Available potassium was extracted by 1.0 M ammonium acetate at pH 7.0 Jackson (1973) and determined by the flame photometer. Available macronutrients (N, P and K) and micronutrients (Fe, Zn, Cu and Mn) and extractable heavy metals (Ni, Cd and Pb) were determined according to Soltanpour and Schwab (1977). Total contents of macronutrients (N, P and K), micronutrients (Fe, Zn, Cu and Mn) and heavy metals (Ni, Cd and Pb) were extracted by digestion with concentrated H_2SO_4+$HClO_4$ and determined according to Chapman and Pratt (1961). Irrigation water: salinity EC, pH, and nutrients and heavy metals were also determined. Yield efficiency was calculated according to the equation of "[grains ÷ (straw + grains)] ×100". Yield quality (protein percent in grains) was calculated by multiplying N concentration x 5.7 (Bishni and Hughes, 1979).

Results and Discussion

Nutrients and heavy metals in irrigation water sources:

Concentration of nutrients and heavy metals in all water sources used for irrigation are presented in Table 4. Data show that the concentration of macronutrients ($mg\ L^{-1}$) in NW, DW, NW+DW and SW were 11.6, 17.9, 14.4 and 23.2 respectively for N ; 3.29, 4.12, 3.66 and 5.58 respectively for P ; 6.12, 8.29, 7.23 and 10.3 respectively for K. El-Sayed (2001) found that the concentrations of NO_3-N and NH_4-N in drainage water during the year are considered higher than its concentration in Nile water.

The concentrations of micronutrients (μg L^{-1}) in NW, DW, NW+DW and SW were 728, 1109, 887 and 1382 respectively for Fe ; 325, 398, 338 and 516 respectively for Mn ; 258, 305, 271 and 387 respectively for Cu; 36.6, 77.7, 58.2 and 90 respectively for Zn. The recommended limits for concentration of micronutrients in irrigation water as given by NAE (1972) are 5-20 mg L^{-1} for Fe, 0.2-10 mg L^{-1} for Mn and 2.0 – 10 mg L^{-1} for Zn, Fawzy (1986) stated that concentration of Fe, Zn, Mn and Cu in Nile water were 2700, 90, 50 and 220 μg L^{-1} for Fe, Zn, Mn and Cu, respectively. El-Sebaey (1995) stated that Fe, Zn, Mn and Cu in drainage water were 700, 680, 50 and 60 μg L^{-1} for Fe, Zn, Mn and Cu, respectively. The concentrations of heavy metals (μg L^{-1}) in NW, DW, NW+DW and SW were 313, 616, 480 and 751 respectively for Pb ; 12.8, 37.7, 23.9 and 48.4 respectively for Ni ; 7.35, 12.8, 9.2 and 20.6 respectively for Cd. Such concentrations of heavy metals in all irrigation water are generally low.

Table 4: Nutrients and heavy metals concentrations of irrigation water used in the current study.

Irrigation water source	Macronutrients (mg L^{-1})			Micronutrients (μg L^{-1})				Heavy metals (μg L^{-1})		
	N	P	K	Fe	Mn	Cu	Zn	Pb	Ni	Cd
Nile water (NW)	11.6	3.29	6.12	728	325	258	36.6	313	12.8	7.35
Drainage water (DW)	17.9	4.12	8.29	1109	398	305	77.7	616	37.7	12.8
Nile water plus Drainage water (NW+DW)	14.4	3.66	7.23	887	338	271	58.2	480	23.9	9.20
Sewage water (SW)	23.2	5.58	10.3	1382	516	387	90.0	751	48.4	20.6

Growth, yield components and yield quality of wheat:

Plant growth characters, yield and yield components of wheat under irrigation water sources are presented in Table 5. Data show that the plants irrigated with NW showed plant heights of 82.5 cm compared with 66.7, 70.8 and 64.4 cm for those irrigated with DW, NW+DW and SW, respectively. The highest spike length (11.4 cm) was obtained in plants irrigated with NW, compared with 10.8, 11.3 and 9.99 cm under irrigation with DW, NW+DW and SW, respectively. Weight of 1000 grains of wheat grains irrigated with NW was the highest. The values were 46.2, 38.5, 40.9 and 35.3 g under irrigation with NW, DW, NW+DW and SW, respectively. Plants irrigated with NW gave straw yield of 8.82 Mg ha^{-1} compared with 6.38, 6.76 and 6.00 Mg ha^{-1} for those irrigated with DW, NW+DW and SW, respectively. The highest grains yield (5.59 Mg ha^{-1}) obtained in the present study was observed under irrigation with NW, compared with 3.86, 4.26 and 3.81 Mg ha^{-1} under irrigation with DW, NW+DW and SW, respectively.

Table 5: Plant growth attributes, yield and yield components of wheat plant under different irrigation water sources.

Irrigation water source	Plant height (cm)	Spike length (cm)	Weight of 1000 grains (g)	Straw yield (Mg ha^{-1})	Grains yield (Mg ha^{-1})	Yield efficiency (%)	Yield quality (%)
Nile water (NW)	82.5	11.4	46.2	8.78	5.59	38.9	10.9
Drainage water (DW)	66.7	10.8	38.5	6.38	3.86	37.7	12.2
Nile water plus Drainage water (NW+DW)	70.8	11.3	40.9	6.76	4.26	38.7	11.9
Sewage water (SW)	64.4	9.99	35.3	6.00	3.57	37.3	12.5

Yield efficiency (%) of plants irrigated with NW was the highest. The values were 38.9, 37.7, 38.7 and 38.8 under irrigation with NW, DW, NW+DW and SW, respectively. Yield quality (protein percent in grains) of wheat plants irrigated with SW was the highest. The values were 10.6, 12.2, 11.9 and 12.5 under irrigation with NW, DW, NW+DW and SW, respectively. The higher yield quality under the irrigation with SW was probably due to the high contents of plant nutrients. Shani and Dudley (2001) stressed that the maximum yield and the corresponding irrigation water quantity for poor quality water were less than those for good quality water. Data *et al.* (1998) reported that the optimum yield obtained from irrigation water of 1.5 dSm^{-1} was 5.9 Mg ha^{-1}, followed 5.69 Mg ha^{-1} by 6 dSm^{-1}, and 5.39 Mg ha^{-1} by 9 dSm^{-1}. They added that yield of treatment irrigated with saline water of 12dSm^{-1} was 5.0 Mg ha^{-1}; while yield for 15dSm^{-1} was 4.51 Mg ha^{-1}.

Nutrients and heavy metals in straw and grains of wheat:

Macro and micronutrients as well as heavy metals concentrations in straw and grains of wheat under all water sources used for irrigation are presented in Tables 6 and 7**.**

Macronutrient concentrations:

Nitrogen concentrations in straw and grains of wheat plants irrigated with SW was greater than those irrigated with NW or DW or NW+DW. Values (g kg^{-1}) under irrigation with NW, DW, NW+DW and SW, were 10.2, 12.1, 11.1 and 14.6 respectively for straw; 19.1, 21.4, 20.8 and 22.0 respectively for grains.

Phosphorus concentrations in straw and grains of wheat plants irrigated with SW was greater than those irrigated with NW or DW or NW+DW. Values (g kg^{-1}) under irrigation with NW, DW, NW+DW and SW were 2.7, 3.4, 3.1 and 3.95 respectively for straw; 3.9, 4.5, 4.35 and 4.6 respectively for grains.

Potassium concentrations in straw and grains of wheat plants irrigated with SW was greater than those irrigated with NW or DW or NW+DW. Values (g kg^{-1}) under irrigation with NW, DW, NW+DW and SW were 28.1, 31.3, 28.9 and 35.6 respectively for straw; 23.3, 25, 24.7 and 25.5 respectively for grains.

Micronutrient concentrations:

Iron concentrations (mg kg^{-1}) in straw and grains of wheat plants irrigated with NW, DW, NW+DW and SW were 73.2, 99.5, 95.9 and 103 respectively for straw; 63.5, 77.2, 76.3 and 82.4 respectively for grains. Mostafa (2001) reported that Fe concentrations in barley grain for plants grown under irrigation with sewage water were greater than in those irrigated with Nile water or agriculture drainage water.

Manganese concentrations (mg kg^{-1}) in straw and grains of wheat plants irrigated with NW, DW, NW+DW and SW were 60.3, 75.6, 72.0 and 78.9 respectively for straw; 50.9, 59.2, 51.9 and 68.9 respectively for grains; such values are below the toxic level in plants (100-1000 mg kg^{-1}) suggested by MacNicol and Beckett (1985).

Copper concentrations (mg kg^{-1}) in straw and grains of wheat plants irrigated with NW, DW, NW+DW and SW were 10.7, 13, 11.8 and 16.2 respectively for straw; 9.1, 12.2, 11.7 and 14.2 respectively for grains; such values are below the critical range in plants (15-30 mg kg^{-1}) reported by MacNicol and Beckett (1985).

Zinc concentrations (mg kg^{-1}) in straw and grains of wheat plants irrigated with NW, DW, NW+DW and SW were 23.5, 25.3, 24.3 and 27.4 respectively for straw; 16.8, 24.2, 22.6 and 25.9 respectively for grains; such values are below the critical range in plants (60-250 mg kg^{-1}) reported by MacNicol and Beckett (1985).

Table 6: Concentrations of nutrients and heavy metals in wheat straw under different irrigation water sources.

Irrigation water source	Macronutrients (g kg^{-1})			Micronutrients (mg kg^{-1})				Heavy metals (mg kg^{-1})		
	N	P	K	Fe	Mn	Cu	Zn	Pb	Ni	Cd
Nile water (NW)	10.2	2.70	28.1	73.2	60.3	10.7	23.5	10.7	14.3	22.6
Drainage water (DW)	12.1	3.40	31.3	99.5	75.6	13.0	25.3	19.1	17.0	27.9
Nile water plus Drainage water (NW+DW)	11.1	3.10	28.9	95.9	72.0	11.8	24.3	16.0	15.7	24.3
Sewage water (SW)	14.6	3.95	35.6	103	78.9	16.2	27.4	23.0	21.6	34.2

Table 7: Concentration of nutrients and heavy metals in wheat grains under different irrigation water sources.

Irrigation water source	Macronutrients (g kg^{-1})			Micronutrients (mg kg^{-1})				Heavy metals (mg kg^{-1})		
	N	P	K	Fe	Mn	Cu	Zn	Pb	Ni	Cd
Nile water (NW)	19.1	3.90	23.3	63.5	50.9	9.10	16.8	10.0	3.04	17.3
Drainage water (DW)	21.4	4.50	25.0	77.2	59.2	12.2	24.2	13.3	8.60	29.7
Nile water plus Drainage water (NW+DW)	20.8	4.35	24.7	76.3	51.9	11.7	22.6	11.9	5.08	24.2
Sewage water (SW)	22.0	4.60	25.5	82.4	68.9	14.2	25.9	16.4	11.8	32.1

Heavy metals concentrations:

Plants absorb heavy metals through roots or through leaves (Jassir *et al*., 2005). Absorption through roots depends on many factors such as the soluble content of heavy metals in soil, soil pH, growth stage type of plant as well as fertilizers and soil (Sharma *et al.,* 2006). Deposition of heavy metals from industrial and emission by motor cars on crops foliar surfaces may occur during formation, transportation and marketing of crop product (Jassir *et al.,* 2005).

Lead concentration in straw and grains of wheat plants irrigated with SW exceeded those for plants irrigated with NW or DW or NW+DW. Values (mg kg^{-1}) under irrigation with NW, DW, NW+DW and SW were 10.7, 19.1, 16.0 and 23.0 respectively for straw; 10.0, 13.3, 11.9 and 16.4 respectively for grains; such values are below the toxic level in plants (30-50 mg kg^{-1}) suggested by VanL and Schoot *et al*. (1984).

Nickel concentrations in straw and grains yield of wheat plants irrigated with SW were greater than those irrigated with NW or DW or NW+DW. Values (mg kg^{-1}) under irrigation with NW, DW, NW+DW and SW were 14.3, 17.0, 15.7 and 21.6 respectively for straw; 3.04, 8.6, 5.08 and 11.8 respectively for grains. The values for straw are below the critical level in plants (10-60 mg kg^{-1}), while those for grains are within the critical range (10-60 mg kg^{-1}) suggested by MacNicol and Beckett (1985).

Cadmium concentrations in straw and grains for plants irrigated with SW were greater than those irrigated with NW or DW or NW+DW. Values (mg kg^{-1}) under irrigation with NW, DW, NW+DW and SW were 22.6, 27.9, 24.3 and 34.2 respectively for straw; 17.3, 29.7, 24.2 and 32.1 respectively for grains. Such values exceed the critical level (5-10 mg kg^{-1}) suggested by MacNicol and Beckett (1985).

Aljaloud (2010) found that the sewage water has a high nutrient loads; containing high contents as N, P, K, Fe, Mn, Zn and Cu, and stated that it may contribute in providing plants with plant nutrients.

Nutrients and heavy metals in the soil after harvest:

Macro and micronutrients as well as heavy metals concentrations in the soil after harvest are presented in Table 8.

Macronutrient concentrations:

Available N concentration in soils irrigated with SW was greater than each of those irrigated with NW or DW or NW+DW. Values (mg kg^{-1}) under irrigation with NW, DW, NW+DW and SW were 61, 67.7, 64.7 and 69.4, respectively. Available P concentration in soils irrigated with SW was greater than each of those irrigated with NW or DW or NW+DW. Values (mg kg^{-1}) under irrigation with NW, DW, NW+DW and SW, were 4.47, 4.63, 4.5 and 4.66, respectively. Available K concentration in soils irrigated with SW was greater than those irrigated with NW or DW or NW+DW. Values (mg kg^{-1}) under irrigation with NW, DW, NW+DW and SW, respectively were 191, 198, 197 and 202. Mohammed *et al.* (2014) reported that in sewage water the permissible levels of N, P and K are essential nutrients for productivity and soil fertility.

Table 8: Nutrients and heavy metals concentration in the soil at harvest under different irrigation water sources.

Irrigation water source	Macronutrients (mg kg^{-1})			Micronutrients (mg kg^{-1})				Heavy metals (mg kg^{-1})		
	N	P	K	Fe	Mn	Cu	Zn	Pb	Ni	Cd
Nile water (NW)	61.0	4.47	191	5.73	3.74	0.68	9.4	4.81	7.6	1.48
Drainage water (DW)	67.7	4.63	198	8.89	6.22	2.03	15.7	6.87	11.3	3.50
Nile water plus Drainage water (NW+DW)	64.7	4.50	197	7.79	5.91	1.01	13.6	6.27	10.6	2.56
Sewage water (SW)	69.4	4.66	202	10.9	8.32	4.16	19.7	7.39	15.4	4.58

Micronutrients concentrations:

Available Fe concentrations (mg kg^{-1}) in soils irrigated with NW, DW, NW+DW and SW were 5.73, 8.89, 7.79 and 10.92, respectively. These values exceed the 4.5 mg Fe kg^{-1} critical level reported by Lindsay and Norvell (1978).

Available Mn concentrations (mg kg^{-1}) in soils irrigated with NW, DW, NW+DW and SW were 3.74, 6.22, 5.91 and 8.32, respectively. These values are higher than the range of 0.1-1.0 mg Mn kg^{-1} suggested as a critical level by Soltanpour and Workman (1981); also exceed the 1.2 mg Mn kg^{-1} critical level reported by Lindsay and Norvell (1978).

Available Cu concentrations (mg kg^{-1}) in soils irrigated with NW, DW, NW+DW and SW were 0.68, 2.03, 1.01 and 4.16, respectively. These values are higher than the critical level of 0.2 mg Cu kg^{-1} suggested by Lindsay and Norvell (1978); and below the critical level for tolerance (160 mg kg^{-1}) reported by Xuexum and Linhi (1991).

Available Zn concentrations (mg kg^{-1}) in soils irrigated with NW, DW, NW+DW and SW were 9.4, 15.7, 13.6 and 19.7, respectively; such values exceed the 0.8 mg Zn kg^{-1} reported by Lindsay and Norvell (1978) as deficient level of Zn.

Kiziloglu *et al.* (2008) showed that irrigating the soil with sewage water increases the content of available N, P, K, Ca, Mg, Na, Fe, Mn, Zn and Cu.

Heavy metals concentration:

Contents of available Pb in soils irrigated with SW were greater than those irrigated with NW or DW or NW+DW. Values (mg kg^{-1}) under irrigation with NW, DW, NW+DW and SW were 4.81, 6.87, 6.27 and 7.39, respectively; such values are below the critical level in soil (20 mg kg^{-1}) suggested by Xuexum and Linhi (1991).

Available Ni concentrations in soils irrigated with SW were greater than those irrigated with NW or DW or NW+DW. Values (mg kg^{-1}) under irrigation with NW, DW, NW+DW and SW were 7.6, 11.3, 10.6 and 15.4, respectively. These values are below the level of 100 mg kg^{-1} suggested as tolerable by Tietjen (1975).

Available Cd concentrations in soils irrigated with SW were greater than those irrigated with NW or DW or NW+DW. Values (mg kg^{-1}) under irrigation with NW, DW, NW+DW and SW were 1.48, 3.50, 2.56 and 4.58 respectively, Which are below the tolerable level at 50 mg kg^{-1} reported by Tietjen (1975).

Khaskhoussy *et al.* (2013) showed that irrigation with treated sewage water led to significant increase Na, Cl, Ca, Mg as well as N, P and K and heavy metals of Cu, Zn, Co, Cd, Pb and Ni in soil and maize plants.

Conclusion

Although some low-quality waters contain high amounts of heavy metals, there may be a possibility of using certain low-quality waters in irrigation. Using sewage water and agricultural drainage water in irrigating wheat showed a limited accumulation of heavy metals in straw and less accumulation in grains. Using the water which is mainly sewage effluent of Bahr El-Bakar was the most hazardous, followed by water of Bahr Hadoos drain which is not contaminated with sewage effluent. The least Hazardous water was that of El-Salam canal which contains a mixture of agriculture drainage waters and Nile fresh water of Hossania canal is the most appropriate water for irrigation.

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