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DRAINAGE WATER QUALITY AND ITS EFFECTS ON SOIL PROPERTIES AND CHEMICAL COMPOSITION OF PLANTS

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ABSTRACT

The present study was carried out on Meraga drain located in EL-Gamalia district, Dakahlia Governorate(Middle Nile Delta) to evaluate the effect of drainage water quality on soil properties and chemical composition of plants. Meraga drain passes many villages dotted along it receiving their agriculutral drainage water, house waste waters and industrial effluents. Water samples were seasonally collected from 6 sites along this drain (EL-Gamalia city (0),1.5, 3.0, 4.5, 6 and 7.5 km.). Water samples were seasonally collected during June 2009 to March 2011. Also, soil samples and plant were collected seasonally from the distance of 1.5 to 6 km.

The main obtained results are presented as follows:

- Electrical Conductivity (EC) values increased slightly with northward direction. Also, Sodium Absorption Ratio (SAR) took the same trend, the quality of studied drainage water belong to C3 S1 and C4 S1 classes and could be re-use in irrigation purpose under special management.
- Boron (B) concentration, at most of locations have low concentration (B1) < 3 mg L^{-1} which less than the critical limit indicating (slight to moderate for restriction on use).
- Nitrate –N concentrations was ranged from 5-30 ppm in the Meraga drains in two summer seasonally 2009 and 2010 whereas, the other seasonally was higher than the critical limits.
- Micronutrients and heavy metal ions concentrations (Fe^{+2}, Mn^{2+}, Zn^{2+} Pb^{2+}) were less than permissible levels at all selected water samples.
- Using drainage water for irrigation, caused an increase in soil content of available micronutrients (Fe, Mn and Zn) whereas, heavy metals (Pb) was less than the permissible limits (500 mg kg^{-1}).
- Concentrations of heavy metal and micronutrients (Fe, Mn, Zn and Pb) in straw and grains of wheat and rice grown in the most locations were under the permissible limits except Pb and Fe concentration exceeds the critical levels in all locations.The concentration in straw of wheat and rice crops were higher than in the grain at all location.
- Zn and Mn concentrations were less than critical limits at all locations in shoot of clover plants and Pb and Fe concentrations were higher than critical limit at all locations.
- Finally, the rice crop had better effect on water quality than cotton then wheat and finally clover.

Keywords: Drainage water, plant chemical composition, soil properties and heavy metals.

INTRODUTION

Due to global population increasing, the gap between supplies and demands for water is widening and is reaching such alarming levels that in some parts of the world it is posing a threat to human existence. For human life, water scarcity is not only about droughts or rivers running dry, above all, it is about guaranteeing the fair and safe access they need to sustain their lives and secure their livelihood.

The River Nile is the main source of water in Egypt, with an annual allocated flow 55.5 Pelion m^3 yr^{-1} under the Nile waters Agreement of 1959 between Egypt and Sudan. However, the Egyptian population has increased rapidly while, the water income didn't change. Consequently, Egypt become under water poverty limit, EL-Hadidi *et al*., (2008).

Egyptian scientists are working to find suggest new ways of conserving water and looking for additional water supplies, hence it is an opportune time, to refocus on the secondary water resources such as drainage water.

The drainage water use in irrigation were officially and non-officially. Officially reuse is the practice of pumping part of the drainage water flow into the irrigation water system. Physically, officially reuse occurs lifting specified amounts of drainage water for mixing with better water quality canals. Unofficially reuse is practiced by individual farmers who decide, when and how drainage water will be used for supplementing their needs of irrigation water. Unofficially reuse of drainage water normally takes place near the tail ends of the irrigation canals, EL-Komy (2012).

The agricultural drainage water in Egypt is considered one of the most important untraditional water resources. The idea of reusing agricultural drainage water in irrigation started to take considerable place in the water policies, and the used agricultural drainage water was estimated by 4.5 bilion m^3yr^{-1} in Delta area (El-Eshmawiy *et al.,* 2006).

The government of Egypt has implemented EL-Salam canal project to reuse drainage water from Bahr Hadous and EL-Serw drains after blending with the Nile water to create new communities along the canal and to re-charting Egypt's population map (Hafez, Azza *et al.,* 2008). It is well known that the quality of drainage water resources in Dakahlia province is better than these drains, so it is necessary to extend reusing of these water in irrigation.

Therefore, the main objectives of our study is to evaluate the effect of irrigation with drainage water on some soil chemical properties and on plants.

MATERIALS AND METHODS

water samples were seasonally collected during Jun. 2009 to Mar. 2011, from six sites in Meraga drain (7.500 km.), These sites were on distances (0, 1.5, 3.0, 4.5, 6.0 and 7.5 km.)from the beginning to end of drain. Also, samples from surface soil and crops (rice, clover, cotton and wheat) irrigated by drainage water were collected seasonally from the beginning of the drain to the distance 6.0 km. and subjected to chemical analysis.

- **water analysis:-** salts content expressed as EC values were measured by using electrical conductivity meter, soluble cations and anions were determined according to Jackson (1973). Sodium adsorption ratio

(SAR) was calculated using Richard's equation (1954). NO3 –N was measured using microkjeldahl as described by Hesse (1971). Total phosphorous (meq L^{-1}) was measured by stannous chloride method using a spectrophotometer as described by APHA (1985).Boron was determined calorimetrically using cariumen according to Jackson (1973). For deyermined Pb, Fe, Mn and Zn content in the drainage water of Meraga drain, water samples were digested using nitric acid as described in standard methods-302 A (APHA, 1985).

- **Soil analysis:-** The available iron, manganese, zinc and load were extracted using the extracted solution of diethylen triamine penta acetic acid 0.005 M (DTPA), calcium chloride ($CaCL_2$)and triethanol amine, according to Lindsay and Norvell (1978).
- **Plant analysis:-** plants samples were dried, ground and digested (0.5 gm) using a concentrated mixtured of of sulfuric (H_2SO_4) and perchloric ($HCLO_4$) acids (1:1) as described by Peterburgski (1968).
- Water, soil and plant samples were measured using GBC Σ Aventa vir 1.3 atomic absorption for determined of Cu, Mn, Cd and pb content according to(Page *et al*. 1982).
- **Crop rotation:** the crop rotation are presented the period of the study in Table 1:

Table 1: Type of plant cultivation during the studding in two drains:

Location km. from start	Type of plant							
	2009			2010				2011
	Jun.	Sep.	Dec.	Mar.	Jun.	Sep.	Dec.	Mar.
1.5	Rice	Clover	Clover	Clover	Cotton	Cotton	Wheat	Wheat
3	Rice	Clover	Clover	Clover	Rice	Rice	Wheat	Wheat
4.5	Rice	Clover	Clover	Clover	Cotton	Cotton	Wheat	Wheat
6	Rice	Clover	Clover	Clover	Cotton	Cotton	Clover	Clover

- **Climatic conditions:**

The meteorological data were taken from Mansoura meteorological station according to the formal data from the Egyptian Ministry of Agriculture. Some meteorological data during the period of the study are presented in Table 2:

Table 2: Air temperature, relative humidity, pan evaporation and total precipitation during the period the study.

Year	Month	Temperature C°		Relative humidity %		Pan evaporation (mm/day)	Total precipitation (mm/month)
		max	min	max	min		
2009	Jun.	32.7	16.20	66.4	35.0	6.0	----
	Sep.	33.7	15.0	62.5	30.0	4.85	----
	Dec.	22.2	8.8	76.5	52.0	2.15	5.8
2010	Mar.	24.3	10.0	76.3	44.0	4.38	----
	Jun.	32.3	16.2	65.3	32.1	6.21	----
	Sep.	32.2	18.0	67.8	36.2	4.75	----
	Dec.	22.0	8.3	85.0	55.7	1.9	90.0
2011	Mar.	24.3	10.0	76.3	44.0	4.38	----

RESULTS AND DISCUSSION

Evaluation of Meraga drain water for irrigation purpose:-

The suitability of drainage water for irrigation purpose was determined by salinity, permeability and toxicity problems.

Table 3: Water chemical analysis and evaluation of Merag drain during the studied period from Jon. 2009 to Mar. 2011.

Distance km. from start	2009			2010				2011
	Jun.	Sep.	Dec.	Mar.	Jun.	Sep.	Dec.	Mar.
				EC dS m^{-1}				
0	1.50	1.58	1.71	1.62	1.52	1.55	1.75	1.54
1.5	1.65	1.86	1.90	1.74	1.78	1.84	2.04	1.72
3.0	1.70	2.25	2.00	1.84	1.87	2.09	2.32	1.87
4.5	1.85	2.58	2.54	2.39	2.13	2.15	2.86	2.07
6.0	2.13	2.64	2.87	2.59	2.31	2.66	3.05	2.64
7.5	2.29	2.73	3.41	2.76	2.59	3.32	3.36	2.93
				SAR				
0	6.21	6.36	6.46	6.47	6.10	6.28	6.42	6.16
1.5	6.51	6.83	6.78	6.59	6.70	6.76	7.17	6.53
3.0	6.51	7.30	6.91	6.99	6.89	7.26	7.69	6.78
4.5	6.76	7.76	8.33	8.32	7.47	7.34	8.97	7.27
6.0	7.47	7.80	8.88	8.90	8.00	8.31	9.06	8.08
7.5	7.61	7.87	9.50	9.13	8.36	9.16	9.49	8.82
				B ppm				
1.5	0.83	1.32	1.85	1.29	0.78	1.38	1.66	1.13
3.0	0.90	1.35	1.93	1.33	0.83	1.45	1.73	1.21
4.5	0.95	1.42	1.98	1.39	0.85	1.48	1.79	1.28
6.0	0.99	1.44	2.03	1.44	0.91	1.54	1.85	1.33
7.5	1.03	1.51	2.05	1.47	0.96	1.56	1.94	1.39
				NO_3^- ppm				
0	25.8	35.3	38.8	34.5	24.6	34.1	35.4	29.2
1.5	26.4	36.9	39.1	34.9	25.7	34.7	36.2	30.1
3.0	30.6	39.5	41.3	37.4	28.4	37.2	39.1	32.4
4.5	27.6	37.8	39.6	35.3	26.2	35.4	37.1	30.8
6.0	28.5	38.1	40.2	36.1	26.9	36.2	37.9	31.3
7.5	29.7	38.7	40.7	36.8	27.5	36.6	38.3	31.9

The salinity problem:-

The potential salinity problem caused by salts in Meraga drain is evaluated by U.S. salinity laboratory (1954) and FAO (1985). As shown in Table 3 and Fig 1, the drainage water can be classified into two groups as follow: The first group includes water having Ec values rangeing between 0.75 to 2.25 dSm^{-1} in Jun.2009(for beginning of drain to distance 6.0 Km), Sep., Dec. 2009 and Mar.2010 (from the beginning of drain to distance 3.0 Km), Jun., Sep. 2010 and Mar. 2011 (from the beginning of drain to distance 4.5 Km) and Dec. 2010 (0 – 1.5 Km). This drainage water group belongs to C3-class according to USDA Classification (1954) and is considered to cause increasing salinity problem FAO (1985). Therefore this water cannot be used for irrigation with restricted drainage system. To use this water for irrigation adequate drainage system and special management for salinity control are required and plants with high salt tolerance should be selected. The second group includes water samples having EC values more than 2.25 dS m^{-1} at the end of drain in Jun.2009, at distance 4.5 Km to the end of drain in Sep., Dec. 2009 and Mar. 2010, at distance 6.0 Km and the end of drain in Jun. and Sep. 2010 and Mar. 2011, at distance 3.0 Km to the end of drain in Dec. 2010. This drainage water group belongs to C4-class according to USSL classification and not suitable for irrigation under ordinary condition but may be used occasionally under very special circumstances.

Generally, EC values were higher in winter months than in summer. EC values were slightly varied from season to another, where the EC values were gradually increased from the beginning to the end of drain. The increase of EC in winter than in summer may be due to the winter closure period where the supply of irrigation water to the main canals is stopped or low during this period. Also, the salinity of drainage water is lower in summer than in winter, probably because of large amounts of water discharged to the drains. Increasing in EC values were recorded with the clover follow wheat then cotton and in finally, rice.

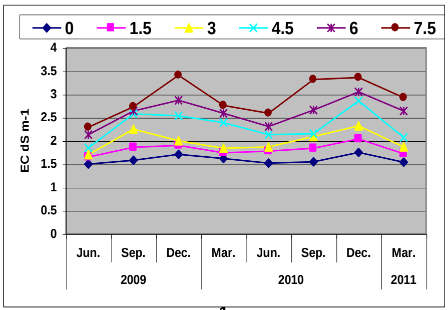

Fig. 1: EC dS m^{-1} values for Meraga drain water.

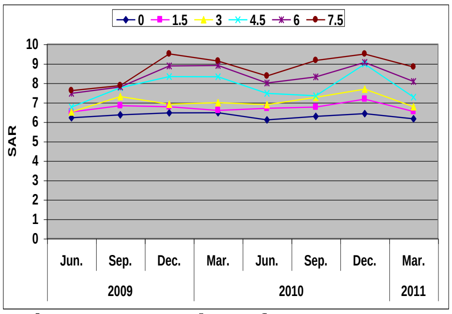

Fig. 2: SAR values for Meraga drain water.

The permeability problem:-

Permeability problem is related to water infiltration into and through the soil profile. The soil permeability is related to the effect of sodium concentration in irrigation water. As shown in Table 3 and Fig.2, drainage water samples of Meraga drain can be classified according to the values of SAR into one groups. This group includes drainage water having SAR values less than 10 for all locations study. This water group belongs to S1-class and it can be used for irrigation in all studied location with little adverse effect of the development of harmful levels of exchangeable Sodium (Richard, 1954) and it can be used without any restriction according to FAO (1985).

According to USDA (1954) water of the studies sites is entirey S1-class. The description of this class "alkalinity hazard" of water as low concentration of sodium thus, this water can be used for irrigation in most months, with adverse effects when using. However, sodium sensitive crops many accumulate injurious amounts of sodium.

The toxicity problem:-

- **Boron toxicity problem:-**

Data presented in Table 3and Fig 3 show that Boron concentration in the water varied between 0.78 and 2.32 ppm and B concentration in the water generally was increased with increasing salts content.

According to Gupta (1979) who classified irrigation water into five classed on the basic of Boron hazard, this water belongs to class B1< 3 ppm "normal water" in all sites studied. This water can be used for most of tolerant and semi-tolerant crops on all soil without any injuries effects on the grain yield.

According to FAO (1985), this water can be classified as slight to moderate degree of restriction on use.

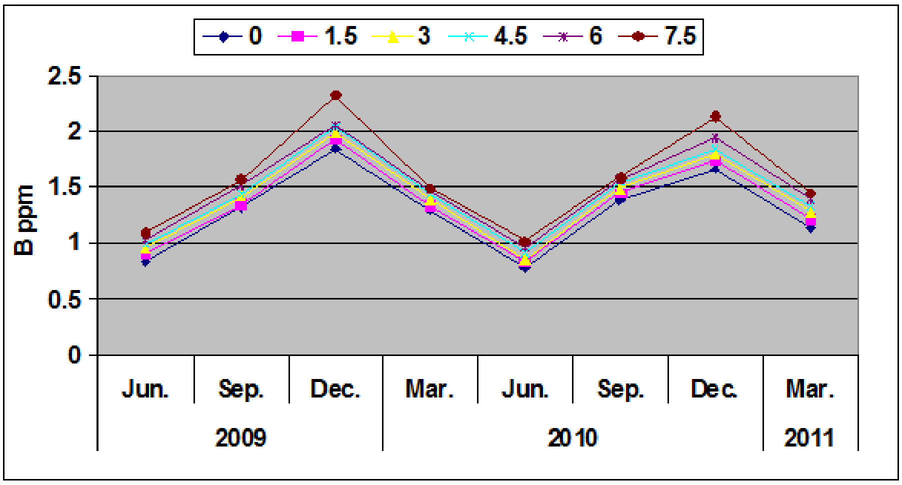

Fig. 3: B ppm values for Meraga drain water.

- **Nitrate toxicity problem:**

As show in Table 3 and Fig. 4 Drainage water samples of Meraga drain can be classified according to NO3–N into two groups. The first group was between 5-30 mg L^{-1} at all sites studied in Jun. 2009 and Jun. 2011 and at the beginning the drain in Mar.2011, it can be used in irrigation but special conditions. The second group was more than 30 mg /L and it cannot be used in irrigation because highly severity degree of restriction on use. According to the guideline of FAO (1985).

The increasing in NO_3^- concentration in distance 3.0 Km may be due to found the organic fertilizers factory and EL-Ibrahemia drain disposes its water in the Meraga drain before this site.

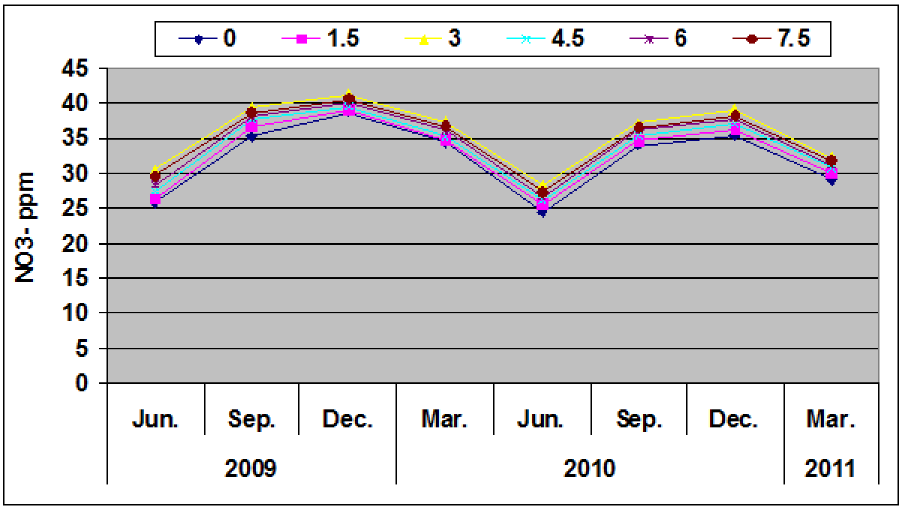

Fig. 4: NO_3^- ppm values for Meraga drain water

Micronutrients and Heavy metal toxicity problem:

The concentrations of Fe, Mn, Zn and Pb were slightly increased for beginning of drain to distance 3.0 km. and markedly increased in the other site (4.5 km. to the end of drain)as shown in Table 4 and Fig 5, 6, 7 and 8 this is may be attribute to found mechanical

According to FAO (1985) and NAS/NAE (1972) the values of Fe and Pb concentrations of in Meraga drain were less than the critical limits(5 and 5 mg L-1)at all sites of the study in all seasons, whereas, Mn and Zn were less than the critical limits (0.2 and 0.2, respectively), except at site 6.0 Km in Dec. 2009, Sep. and Dec. 2010 and Mar. 2011and the end of drain in Sep. and Dec. 2009, Mar., Sep. and Dec.2010 and Mar. 2011.

In general, the concentrations of these elements were lower in the summer than the winter and less than critical levels in both winter and summer seasons. This water can be used for irrigation purposes with out causing serious problems for plants and soil in short term. But, continuous use, especially in summer may cause an accumulation of these metals in plant tissues and soil profile and may lead to toxicity problems. Also the higher concentration for these in water found with clover follow wheat then cotton and finally rice.

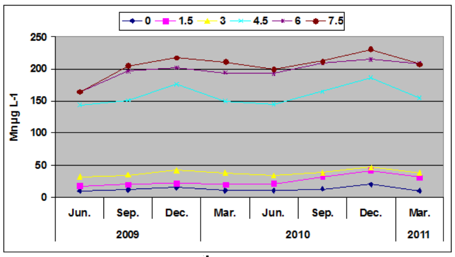

Fig. 5: Mn µg L^{-1} values for Meraga drain water

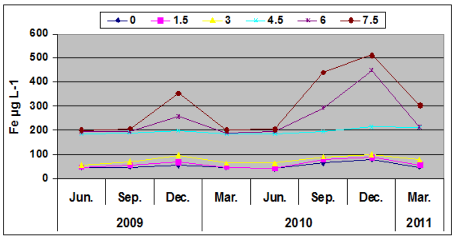

Fig. 6: Fe µg L^{-1} values for Meraga drain water

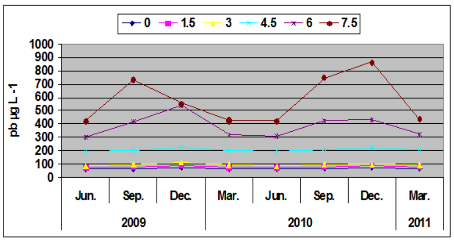

Fig. 7: pb µg L^{-1} values for Meraga drain water

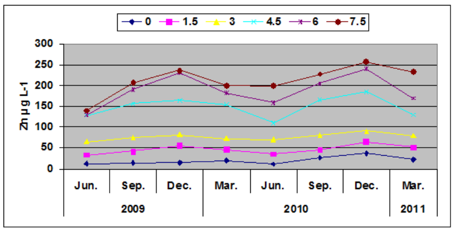

Fig. 8: Zn µg L^{-1} values for Meraga drainwater

Micronutrient and heavy metal contents in soils irrigated directly from Meraga drain:-

The effect of low quality water on available of heavy metal (Pb) micronutrients (Fe, Mn and Zn) of soil are presented in Table 5, which varied between 1.24 – 2.62, 5.48 – 28.69, 16.4 – 165.4 and 2.2 – 36.6 ppm, respectively. Data showed that, use low quality for irrigation led to increase available soil micronutrients, whereas, heavy metal (Pb) was decreased. This is may be due to increase soil salinity and change of soil PH Table 5. Generally, concentration of heavy metal and micronutrients in soil depend on some factors, such as total concentration of elements, type of cultivated plants, PH, total CaCO3, organic matter and soil texture **(Wild, 1988**). Data in Table 5 showe that, the availability of above mentioned element varied from site to site but it slight varied in both from Fe, Zn and Pb and wide varied in Mn between sites. The all concentrations were above permissible limit except Pb.

Generally, the long term application of poor quality and polluted drainage water increase the availability and contents of heavy metals and use of poor water quality in the irrigation processes may play a very bad role in the contamination and degradation of agriculture soil.

Table 4: Seasonally variations of micronutrients and heavy metal ($\mu g\ L^{-1}$) in Meraga drain during the studied period from Jon. 2009 to Mar. 2011.

Distance km. from start	2009 Jun.	2009 Sep.	2009 Dec.	2010 Mar.	2010 Jun.	2010 Sep.	2010 Dec.	2011 Mar.
Fe $\mu g\ L^{-1}$								
0	45	47	54	45	41	62	76	47
1.5	45	54	66	46	42	77	88	56
3.0	56	69	96	63	61	89	99	77
4.5	185	189	198	186	184	194	213	210
6.0	192	194	257	190	193	293	450	214
7.5	199	206	352	200	205	440	512	304
Mn $\mu g\ L^{-1}$								
0	10	12	15	11	11	13	20	10
1.5	18	20	22	20	21	32	41	31
3.0	32	35	42	38	34	39	47	38
4.5	144	151	176	150	145	165	186	155
6.0	164	196	202	194	193	210	215	208
7.5	164	205	217	211	199	212	230	207
Zn $\mu g\ L^{-1}$								
1.5	12	14	15	19	11	27	37	23
3.0	33	42	56	46	35	45	66	52
4.5	65	75	82	73	70	81	91	79
6.0	129	156	163	155	110	165	185	130
7.5	130	190	230	182	159	205	240	169
Pb $\mu g\ L^{-1}$								
0	63	65	73	64	65	67	75	66
1.5	77	80	89	78	79	83	91	80
3.0	85	99	112	95	85	99	101	95
4.5	196	202	225	200	195	213	220	209
6.0	301	420	540	315	310	424	431	322
7.5	422	735	555	427	425	745	865	436

Table 5: Micronutrients concentration and heavy metal in irrigated soil from drainage water during the studied period from Jon. 2009 to Mar. 2011.

Distance km. from start	2009 Jun.	2009 Sep.	2009 Dec.	2010 Mar.	2010 Jun.	2010 Sep.	2010 Dec.	2011 Mar.
Fe mg kg^{-1}								
1.5	9.36	28.49	6.14	12.35	6.05	20.82	24.45	27.23
3.0	6.23	23.82	28.69	17.80	5.48	17.36	17.63	7.75
4.5	11.92	27.01	28.37	27.61	7.24	11.92	27.24	22.88
6.0	4.68	6.66	17.77	18.12	5.58	5.29	7.42	19.21
Mn mg kg^{-1}								
1.5	112.4	101.6	100.6	113.2	79.2	104.6	72.4	17.2
3.0	28.6	123.0	69.2	141.6	24.6	158.4	165.4	23.8
4.5	92.6	114.0	151.0	72.2	19.8	79.8	82.0	22.0
6.0	78.0	79.0	64.8	79.6	16.4	81.4	76.4	25.2
Zn mg kg^{-1}								
1.5	5.2	6.0	4.2	16.0	2.4	25.8	57.4	28.4
3.0	5.0	4.2	7.8	5.0	2.2	17.8	15.4	32.6
4.5	3.8	6.6	7.2	18.8	2.6	31.0	34.2	31.0
6.0	3.0	3.4	2.4	12.8	1.6	23.0	20.4	36.6
Pb mg kg^{-1}								
1.5	1.52	1.48	2.18	1.42	1.60	2.24	1.86	1.70
3.0	1.24	1.42	1.48	1.54	1.48	1.56	1.94	1.58
4.5	1.72	2.16	1.46	1.80	1.58	1.68	1.58	1.60
6.0	1.68	1.94	1.88	1.68	1.60	1.68	2.62	1.34

Micronutrient and heavy metals in plants irrigated from drainage water:

The contents of heavy metals pb and micronutrients (Fe, Mn and Zn) in plants grown in the soil irrigated with drainage water were effected by total and available concentrations of these elements in soil ,soil PH and plant species.

Wheat and rice crops:

Data in Table 6 show that, the concentration of heavy metal pb and micronutrients (Fe, Mn and Zn) in straw of wheat and rice crops was higher in wheat than rice. Also, data reported that the concentration of heavy metal and micronutrients. They reported that the concentration of heavy metal in straw of wheat and rice was higher than in grains and in straw and grains of wheat were higher than in straw and grains of rice at all location. Concerning Mn and Zn concentration in straw of wheat plant were less than the critical limit in all locations**.** Pb and Fe concentrations in straw of wheat and rice plants were higher than the critical limit in all locations. This may due to concentrations of this elements in irrigation water and cultivated soil according to Alloway (1995).

The maximum Pb limit, for human health has established for edible parts of crop by WHO Standard, was 0.3 mg kg^{-1} (Codex, 2001).

clover plant:

Data in Table 6 show that, Zn and Pb (20ppm) concentrations were less than critical limits at all locations in shoot of clover plants except Pb at the end of drain in winter 2010 and spring 2011was higher than the critical limits. While, Fe concentrations were higher than critical limit at all locations according to Alloway(1995)

On the other hand Mn concentration was less than critical limit (400-1000 ppm) at all locations in shoot of clover plants. They found that pb concentration in fresh clover yield irrigated with drainage water was higher than the normal level.

The order of micronutrients and heavy metal concentration as follows:

Clover > wheat > rice > cotton

Finally, the concentration of the previous element in wheat (straw & grain), cotton and clover plants as affected by irrigation water quality (content of this element in irrigation water and fertilizers), total and available concentration in soil, soil PH and plant species.

Table 6: Micronutrients concentration and heavy metal in irrigated plant from drainage water during the studied period from Jon. 2009 to Mar. 2011.

Distance km. from start	2009			2010					2011	
	Jun.	Sep.	Dec.	Mar.	Jun.	Sep.		Dec.	Mar.	
Fe ppm										
1.5	3323	1835	1111	535	1250	462		3927	202	45
3.0	1327	6820	1310	616	2721	562	36	1813	550	210
4.5	1894	6303	601	591	743	675		4665	1023	550
6.0	2976	6435	567	737	991	2829		3430	1279	
Mn ppm										
1.5	112	70	41	29	39	29		90	11	4.00
3.0	137	279	50	75	119	147	12	66	42	7.00
4.5	152	353	39	22	36	34		104	26	5.45
6.0	125	208	28	27	36	55		85	38	
Zn ppm										
1.5	270	70	150	140	40	70		150	90	30
3.0	180	110	580	90	130	70	9	110	170	75
4.5	60	100	50	145	110	40		90	150	56
6.0	130	90	100	80	50	70		280	180	
Pb ppm										
1.5	6	17	13	16	12	8		13	9	1.80
3.0	8	19	18	13	5	3	0.89	16	14	2.09
4.5	7	18	22	20	10	9		11	6	1.15
6.0	3	13	17	19	13	10		23	20	

CONCLUSION

To safe reuse this water in irrigation, it is recommended that:-

- This water can be used at the head of the drains where the salinity levels of waters were approximately low.
- This water can be use in the summer season than in winter season compared to the spring and autumn where EC, SAR, B, Cl and NO_3 increased with the north direction from the beginning of drain to the end of drain.
- The water at the end part of the studied drain is not suitable for irrigation during the period of study (2009 to 2011).
- Proper management for water, soil and plant in needed to maximize drainage water utilization efficiency and to minimize the adverse effects. The soil must be permeable, drainage must be adequate, and irrigation water must e applied in excess amount to provide considerable leaching and high salt tolerance crops should be selected.

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تـأثير جـودة ميـاه الصـرف الزراعـي علـي خـواص التربـة والخـواص الكيميائيـة للنبـاتات.

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أجريت هذه الدراسة علي مصرف مرجا مركز الجمالية – دقهلية (وسط دلتا النيل) حيث يمر خلال العديد من القرى التي تنتشر علي طول المصرف. يستقبل مياه الصرف الصحي، مخلفات المنازل والنفايات السائلة. مصرف مرجا طوله 7.5 كم والذي قسم إلي 6مسافات (0، 1.5، 3.0، 4.5، 6.0 و 7.5 كم) تم تجميع عينات المياه موسمياً من يونيه 2009 حتى مارس 2011. كذلك أخذت عينات تربة ونبات موسمياً من مسافة 1.5 إلي 6 كم. من المواقع التي تروي مباشرة من مصرف مرجا.

وكانت أهم النتائج المتحصل عليها:

- أظهرت قيم التوصيل الكهربي(EC) زيادة طفيفة مع الاتجاه شمالاً حتي الوصول لنهاية المصرف كذلك نسبة الصوديوم المدمص (SAR) أخذت نفس الاتجاه وعليه وقعت كل عينات المياه في كل المواقع في رتبة C3S1 ما عدا عينات المياه عند نهاية المصرف وقعت في رتبة C4S1 .
- بالنسبة لتركيز البورن ، بينت النتائج أن تركيزه في كل المواقع كان أقل من 3 مليجرام / لتر (B1) والتي جميعها تحت الحدود المسموح بها لذا درجة استخدامها تكون خفيفة إلي معتدلة.
- تركيز النترات في مياه مصرف مرجا كانت تتراوح بين 5 – 30 مليجرام / لتر في موسمي صيف 2009 و 2010 بينما المواسم الأخرى كانت أعلي من الحود المسموح بها.
- تركيز العناصر الدقيقة والرصاص كانت أقل من الحدود المسموح بها في كل مواقع عينات المياه.
- استخدام مياه الصرف في الري أدت إلي زيادة محتوي التربة من العناصر الدقيقة بينما الرصاص كان أقل من الحدود المسموح بها (500 ملجم/ كجم).
- تركيز العناصر الدقيقة والرصاص في قش وحبوب نباتات القمح والأرز في معظم المواقع كانت أقل من الحدود المسموح بها ما عدا الحديد والرصاص كانت أعلي من الحدود المسموح بها. أيضاً تركيزات هذه العناصر في قش القمح والأرز كانت أعلي من الحبوب في كل المواقع .
- تركيزات الزنك و المنجنيز كانت أقل من الحدود المسموح بها في كل المواقع في نبات البرسيم بينما تركيزات الحديد والرصاص كانت أعلي من الحدود المسموح بها في كل المواقع طول فترة الدراسة.
- وأخيراً نبات الأرز كان أفضل محصول تأثيراً علي جودة المياه يليه القطن ثم القمح وفي النهاية البرسيم.

قام بتحكيم البحث

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