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EFFECT OF IRRIGATION WATER SOURCES ON NAVEL ORANGE TREES GROWN IN SANDY SOILS

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Field experiments were carried out at El-Salhiya, irrigated with Nile water (control); El-Gabal El-Asfar area, irrigated with sewage water and Bahr El-Bakar area, irrigated with drainage water. These areas were planted with orange trees for two seasons (2000-2001).

The results indicated that the contents of Fe, Mn, Zn, Cu, Cd, Ni, Co and Pb in irrigation water samples were lower than the max. permissible limits. Total heavy metals contents in the studied soil profiles showed that the highest values were recorded El-Gabal El- Asfar soil while El-Salhiya soil attains the lowest contents. Some physical and chemical properties of orange fruits were determined and discussed.

The highest values of Pb, Co, Ni, Cd, Zn, Mn, Cu and Fe were found in fruits and peel of trees irrigated with sewage effluent and drainage waters.Factors affecting total heavy metals in soils and plants were predicted through correlation coefficients. These factors are pH, EC, $CaCO_3$ and OM% for soils and plant. In conclusion, the investigated waters are not suitable for irrigating fruit trees that it can be used for irrigating forest trees.

Keywords: orange, sandy soils, Nile water, sewage water, drainage water, heavy metals.

The Egyptian government has devoted a great attention to land reclamation and agriculture development of desert soils within the frame of horizontal expansion to overcome the gap of food insufficiency. Therefore, efforts are made to use other water resources of low quality such as drainage and waste water, to be mixed with Nile water.

Sewage water usually has high content of organic matter, nutritional elements and several heavy metals. The released nutrients from decomposition of organic materials in soils can be utilized by the crops. Due to application of this water year after year, accumulation of some heavy metals in the upper layer of the soils take place. Heavy metals accumulation is considered one of the main limiting factors for using sewage water to irrigate edible crops. These heavy metals are also considered as soil pollutant, therefore, it should be carefully controlled. In this regard, the different irrigation water sources vary considerably in their chemical composition, it is expected that the use of these water will affect fruit trees production, quality, storage and marketing. From the economical point of view oranges are among the common and most popular fruits for local consumption and export.

Therefore, this investigation aims to study the effect of different irrigation water resources on growth and productivity of orange trees, as well as physical and chemical properties and storageability of fruits. In addition, the concentration of heavy metals in soil as well as in fruits and water permissible limits were studied to evaluate their level in regard to the international standard.

MATERIALS AND METHODS

The present investigation was carried out during the seasons 2000, 2001 in an attempt to study the effect of irrigation with different water resources on growth and productivity of "Washington" navel orange tress, as well as some physical and chemical properties of fruits. In addition, the concentrations of heavy metals in soil as well as in the fruits and water were compared to the permissible limits internationally recognized.

Therefore, three orange orchards were chosen in newly reclaimed lands where the first orchard was irrigated with Nile water at El-Salhiya area as a control, the second orchard was irrigated with sewage water of Cairo city at El-Gabal El-Asfar area and the third orchard was irrigated with drainage water at Bahr El-Bakar area. This study involved three analyses as follows:

Irrigation Water Analysis

1) The water salinity was measured conductimetrically by electric conductivity meter.
2) pH was measured by pH meter.
3) Soluble cations (Ca, Mg, Na and K) and anions (CO_3, HCO_3, Cl and SO_4) were determined in the filtrate of collected water samples according to the method of Hess (1971).
4) Heavy metals (Zn, Mn, Fe, Pb, Ni, Co, Cd and Cu) concentrations were determined by the unicam 929 atomic absorption spectrophotometer.
5) Boron was determined colorimetrically by carmine method according to Rainwater and Thatcher (1960).

Physical and Chemical Properties of Soils

The surface and subsurface layers of the studied soil samples were air- dried, crushed and sieved through a 2 mm sieve, then subjected to the following analyses.

Physical properties of soils

Since the soils are mainly coarse-textured (sandy), mechanical analysis was carried out by dry sieving acco rding to Piper (1950). Soil textural classes were then defined using the texture triangle diagram (Soil Survey Staff, 1962).

Chemical properties of soils

1) Calcium carbonate content was determined volumetrically by Collin's Calcimeter according to piper's method (1950) and expressed as percent of soil components.
2) Soil pH of the saturated soil extract was determined using a glass electrode, Beckman apparatus (Richards, 1954)
3) Organic matter content was determined by ferrous sulphate (Jackson 1958).
4) Total soluble salts of the soil saturation extract were determined by measuring the electrical conductivity (EC) in mmhos/cm at 25°C (Jackson 1958).
5) Soluble cations and anions were determined in the soil saturation extract by the methods outlined by Jackson (1958).
6) Total heavy metals in soils were determined according to Hess (1971).
7) Chemically-extractable content of heavy metals were extracted by DTPA according to the method of Lindsay and Norvell (1978). Determination of total and available heavy metals were carried out by the Unicam 929 atomic absorption spectrophotometry.

Plant Analysis

1) Average fruit weight (g).
2) Average fruit size (ml).
3) Average juice content per fruit (ml) according to the method of A.O.A.C. (1970).
4) The T.S.S. was determined in juice by hand refractometer and acidity was estimated as tartaric acid equivalent / 100 ml orange juice according to A.O.A.C. (1970).
5) Total sugars were determined by Picric acid method (Thomas and Dutcher, 1924).
6) Heavy metals (Zn, Mn, Fe, Cu, Pb, Co, Ni and Cd) were determined by the Unicam 929 atomic absorption Spectrophotometer after the wet ashing of the dry powdered sample as recommended by (Jackson, 1958).

Statistical Analysis

Tree parameters study was designed in a completely randomized block design according to Snedecor and Cochran (1980). All the collected data, were statistically analysed according to Waller and Duncan (1969) where the means were compared at the 5% level.

RESULTS AND DISCUSSION

The chemical analysis of different water resources (Nile water, sewage water and drainage water) indicated that:

1. Nile water (El-Salhiya): EC (0.56-0.57mmhos/cm), (0.55-1.44 SAR) class C_2S_1 medium salinity, low Na hazard, suitable for all types of soils and moderate salt tolerant crops with no hazards on plant growth .
2. Sewage water (El-Gabal El-Asfar): EC (1.86-1.96 mmhos/ cm), (1.64-4.87 SAR) class C_3S_1: High salinity, low Na hazard, requires regular leaching and special management for salinity control.
3. Drainage water (Bahr El-Bakar) EC (2.23-2.71 mmhos/cm), (3.83-5.22 SAR) class C_3S_1: High salinity, Medium Na hazard requires regular leaching and special management for salinity control.
4. The water have narrow range of boron concentration (0.679-0.859 ppm) thus, all water samples are suitable for irrigating different crops and trees including tolerant, semi-tolerant and sensitive plant crops.
5. Heavy metals content: The concentrations of Fe, Mn, Zn, Cu, Pb, Co, Ni and Cd in the irrigation water ranged from 0.260 to 1.150, 0.040 to 0.260, 0.040 to 0.410 ppm, 0.010 to 0.090, 0.010 to 0.090, 0.10 to 0.051, 0.00 to 0.039 and 0.00 to 0.014 respectively. The highest value is found in the main irrigation water resource at the drainage water (Bahr El-Bakar) except for Cu and Cd where the highest value is found in the sewage water (El-Gabal El-Asfar).

Soil Properties

Data in table (1) indicated that the soils of the three orchards was sandy, having very low $CaCO_3$ content that ranged from 0.63 to 1.2, 0.04 to 0.43% and 0.05 to 0.21% at El-Salhiya, El-Gabal El-Asfar and Bahr El-Bakar respectively. Organic matter content varied widely from 0.10 to 0.29%, 0.08 to 10.50 % and 0.11 to 13.36% for soils of El-Salhiya, El-Gabal El-Asfar and Bahr El-Bakar, respectively.

Soil salinity (Table 2) ranged from 0.69-1.0, 1.76-2.31 and 1.9-2.82 mmhos/cm, at El-Salhiya, El-Gabal El-Asfar and Bahr El-Bakar, respectively. The highest salinity value was detected in the top layers and decreased with soil depth to become salt-free in the deepest layers. The cationic composition of El-Salhiya soil saturation extract followed the order $Ca^{++} > Na^{+} > Mg^{++} > K^{+}$ while being $Na^{+} > Ca^{+2} > Mg^{+2} > K^{+}$ for the soils of El-Gabal El-Asfar and Bahr El-Bakar. The anionic composition of El-Salhiya, El-Gabal El- Asfar and the deepest layer of Bahr El-Bakar followed the order $Cl^{-} > SO_4^{--} > HCO_3^{-}$ while being $Cl^{-} > HCO_3^{-} > SO_4^{--}$ for the surface layers of Bahr El-Bakar.

Soil reaction of all studied soils was neutral, as indicated by pH values which ranged from 6.8 to 7.1.

The weighted mean of total heavy metals in the studied soil samples shows that the highest content of Pb, Zn, Mu, Cu and Fe were recorded in the soil samples of Bahr El-Bakar while the lowest content is that of El-Salhiya soils samples for all investigated heavy metals , and the soil of El-Gabal El-Asfar have the highest content of CO,Ni and Cd (Table 3).

TABLE (1). Particle size distribution, textural class, $CaCO_3$ and organic matter contents in the studied soils

Location	Depth (cm)	Coarse sand %	Medium sand %	Fine sand %	Soil texture class	$CaCO_3$ %	O.M. %
El-Salhiya	0-10	88.60	5.96	5.44	Sandy	0.63	0.29
	10-10	89.50	4.25	6.25	Sandy	0.71	0.18
	40-100	92.40	3.70	3.90	Sandy	1.20	0.10
El-Gabal El-Asfar	0-10	87.20	5.10	7.70	Sandy	0.10	10.50
	10-10	88.50	5.51	5.99	Sandy	0.04	0.73
	40-100	91.80	4.33	3.87	Sandy	0.43	0.08
Bahr El-Bakar	0-10	86.10	6.00	7.90	Sandy	0.12	13.36
	10-10	89.30	5.31	6.99	Sandy	0.05	0.85
	40-100	91.15	4.43	4.42	Sandy	0.21	0.11

TABLE (2). Chemical composition of the soil saturation extract of the studied soils

Location	Depth cm	pH	EC mmhos / cm	Cations (me/l)				Anions (meq/l)			
				Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
El-Salhiya	0-10	6.9	1.00	4.99	1.18	3.57	0.26	-	1.50	6.14	2.37
	10-10	6.9	0.98	4.80	0.70	3.91	0.46	-	2.38	4.76	2.66
	40-100	7.1	0.69	0.32	0.05	0.27	0.04	-	2.00	3.77	2.93
El-Gabal El-Asfar	0-10	6.8	2.31	9.27	2.21	10.52	1.10	-	4.96	13.11	5.21
	10-10	6.9	2.10	8.79	1.91	9.44	0.86	-	4.95	12.21	3.97
	40-100	6.8	1.76	7.11	1.53	8.10	1.21	-	2.56	11.36	3.61
Bahr El-Bakar	0-10	6.8	2.82	10.35	3.19	12.99	1.66	-	5.01	13.56	4.88
	10-10	6.8	2.65	11.18	2.48	11.29	1.54	-	5.16	17.56	3.85
	40-100	6.8	1.90	7.41	1.86	8.21	1.68	-	2.43	12.32	4.23

Chemically-extracted heavy metals shows that the soils still have very low to medium levels of heavy metals. Chemically extracted Fe varies widely from 8.16 to 19.80, 7.51 to 51.71 and 7.15 to 49.83 ppm in El-Salhiya, El-Gabal El-Asfar and Bahr El-Bakar soils, respectively. Chemically extracted Mn ranged from 2.86 to 9.00, 10.33 to 21.11 and 11.36 to 23.51 ppm, respectively. Chemically extracted Cu ranged from 0.85 to 4.18, 0.92 to 4.66 and 1.05 to 4.36 ppm respectively. Zn ranged from 2.19 to 9.88, 4.80 to 19.96 and 5.11 to 22.11 ppm, respectively. Co ranged from 0.09 to 0.71, 0.53 to 2.83 and 0.63 to 1.98 ppm, respectively. Cd ranged from 0.15 to 0.80, 0.63 to 2.11 and 0.91 to 1.91 ppm,respectively. Pb ranged from 0.32 to 1.73, 6.12 to 22.71 and 6.21 to 2.71 ppm, respectively.

TABLE (3). Weighted mean of total heavy metals in the studied soils and water ppm in 2000 and 2001 seasons.

Element location		Fe		Zn		Mn		Cu		Pb		Co		Ni		Cd	
		2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
El-Salhiya	Soil	2466.4	3222.1	20.1	21.2	27.6	29.1	17.5	18.8	24.9	25.3	2.8	3.00	8.6	8.7	2.9	2.9
	Water	0.260	0.310	0.040	0.050	0.040	0.050	0.000	0.010	0.010	0.030	0.010	0.030	0.000	0.010	0.000	0.001
El-Gabal	Soil	6017.1	6521.2	43.8	46.6	75.2	75.2	19.6	18.28	41.6	43.2	11.6	11.20	18.9	19.11	11.5	11.5
Al-Asfar	Water	0.750	0.860	0.160	0.210	0.280	0.390	0.070	0.090	0.080	0.090	0.035	0.051	0.026	0.029	0.010	0.014
Bahr El-Bakar	Soil	6288.8	6976.0	53.0	53.8	103.8	104.9	40.7	42.1	53.0	53.2	10.1	10.40	18.3	18.9	10.0	10.1
	Water	0.930	1.150	0.180	0.260	0.310	0.410	0.050	0.070	0.090	0.150	0.043	0.056	0.030	0.039	0.009	0.013

0.09 to 0.71, 0.53 to 2.83 and 0.63 to 1.98 ppm, respectively. Cd ranged from 0.15 to 0.80, 0.63 to 2.11 and 0.91 to 1.91 ppm, respectively. Pb ranged from 0.32 to 1.73, 6.12 to 22.71 and 6.21 to 2.71 ppm, respectively.

Data in table (4) show the correlation coefficient between total heavy metals and some soil properties such as pH, EC, $CaCO_3$ % and OM%. From the data its quite clear that:

- pH is positively correlated highly significant with Zn, Cu, Co in El-Salhiya soils and with Zn, Co, Ni and Cd in the studied soil samples of El-Gabal El-Asfar. Moreover, pH is positively correlated significantly with Pb and Ni, in the samples of El-Salhiya and with Cu, Pb and Ni in the studied soil samples of Bahr El-Bakar while the total heavy metal negatively correlated significantly with Pb and Cu in the soils of El-Gabal El-Asfar and Bahr El-Bakar, respectively.
- EC of the studied soil samples are highly significant positively correlated with Fe in El-Gabal El-Asfar and Bahr El-Bakar while being highly significant negatively correlated with Cu, Co (El-Salhiya), Cu, Cd, (EL-Gabal El-Asfar) and Cu, Co (Bahr El-Bakar).
- $CaCO_3$% recorded highly significant positive correlation with Cu, Co and Ni, (Fe,Co) in the soils of El-Salhiya and Bahr El-Bakar respectively, while being significantly correlated with (Pb), (Co, Ni) and (Mn, Cu, and Cd) in the samples of El-Salhiya, El-Gabal El-Asfar and Bahr El-Bakar, respectively. Also, the data show that $CaCO_3$ % recorded highly significantly negative correlation with Zn in the soils of El-Salhiya.
- Organic matter content is highly significant negatively correlated with Fe, Pb, Cu, Co, Ni and Cd (El-Salhiya), Fe, Mn, Co, Ni and Cd (El-Gabal El-Asfar) and Cu, Pb and Ni (Bahr El-Bakar).
- On the other hand, OM content is positively correlated significantly with Zn in El-Salhiya soils and highly significant correlated with Cd and Zn in soils of Bahr El-Bakar.

Relationship Between Chemically Extractable Heavy Metals and Some Soil Variables

El-Salhiya farm

Data in table (5) show that there are highly significant positive correlation between chemically-extracted Fe, Cu, Co and Ni and pH (r=0.769, 0.662, 0.679 and 0.699, respectively)

Also, chemically-extractable Fe is correlated positively and significantly with EC (r= 0.633) while chemically- extractable Zn and Co is correlated positive and significantly with soil organic matter content (r= 0.521, -0.547, respectively) .

TABLE (4). Correlation coefficients between total heavy metals in soil and some soil variables.

Location	Total Heavy Metals							
	Fe	Zn	Mn	Cu	Pb	Co	Ni	Cd
El-Salhiya								
		**		**	*	**	*	
PH	0.158	0.884	-0.330	0.766	0.485	0.936	0.578	0.167
				**	*	**	*	
EC	-0.215	0.356	0.275	-0.802	-0.534	-0.954	-0.624	-0.224
		**		**	*	**	**	
$CaCO_3$	0.285	-0.816	-0.205	0.843	0.594	0.973	0.679	0.293
	**	*		**	**	**	**	**
OM	-0.699	0.453	-0.274	-0.997	-0.900	-0.968	-0.943	-0.705
El-Gabal El Asfar								
		**		*	*	**	**	**
PH	-0.242	0.955	0.277	-0.474	-0.895	0.761	0.769	0.747
	**			**				**
EC	0.713	-0.114	-0.208	-0.693	-0.080	-0.082	-0.041	-0.758
						*	*	
$CaCO_3$	0.188	0.039	0.082	0.147	-0.148	0.557	0.373	0.316
	**		**	*		**	**	**
OM	-0.757	-0.166	-0.983	-0.572	0.005	-0.923	-0.918	-0.931
Bahr El-Bakar								
		*		*	*		*	
pH	0.211	-0.368	-0.240	0.498	0.411	0.299	0.389	-0.196
	**	*		**	*	**	*	
EC	0.699	0.457	0.162	0.907	-0.586	-0.830	-0.527	0.064
	**		*	*		**		*
$CaCO_3$	0.987	0.162	0.456	0.479	-0.011	0.997	-0.082	0.542
		**	**	**	**		**	**
OM	0.038	0.960	0.828	-0.929	-0.991	-0.167	-0.979	0.769

* Significant at 0.05 level
** Significant at 0.01 level.

El-Gabal El-Asfar farm

Data in table (5) show that chemically extractable Fe, Cu, Co, Ni and Cd are correlated positively and highly significant with pH (r =0.557, 0.684, 0.661, 0.803 and 0.799, respectively) while chemically-extractable Mn is correlated and positive non-significant.

Also, there is a positive highly significant correlation between chemically – extractable Fe and $CaCO_3$ % (r= 0.662) while chemically-extractable Zn and Pb are highly significant positively correlated with organic matter content in soils (r = -0.609 and -0.710, respectively).

exerts a harmful influence on plant metabolism. It is not easy, therefore, to make a clear division between sufficient and excessive quantities of heavy metals. Other soil components such as clays, organic matter, hydrous Fe, Mn oxides, Carbonate, biological residues, heat and soil moisture can react and affect the availability of trace or heavy metals.

Data show that pH which ranges from 6.8 to 7.1 plays a good role in availability of heavy metals such as Fe, Cu, Co and Ni at El-Salhiya farm which is irrigated by Nile water , also with Fe, Mn, Cu, Co, Ni, Pb and Cd in El-Gabal El-Asfar and Bahr El-Bakar farms which are irrigated by waste water (sewage or drainage water, respectively). These data agree with Misra and Pandy (1976), Cavallaro and McBride (1980) and Harter (1983).

Data also show that organic matter plays an important role in the chemical behaviour of heavy metals in soils and plants. Decomposition of organic matter active functional groups which have the ability to retain the metal may be in the complex and chelate form. The chemical behaviour of the metal changed with the release of organic acids which reduces the soil pH. The data are in agreement with Badhe *et al.* (1971), McBride (1982) and Neal and Spasito (1986).

Physical Properties of Fruits and Yield

As for the effect of different irrigation water resources on physical fruit properties of "Washington" navel orange trees, data in table (6) generally indicate that fruits of trees irrigated with drainage water were significantly higher in average fruit weight (200.4 gm) as well as fruit size (236.2 cm^3), pulp weight (168.07 gm) and average juice volume per orange fruit (113.12 ml) followed by trees irrigated with sewage water (185.67 gm, 218.00 cm^3, 161.68 mg and 107.22 ml, respectively) compared with trees irrigated with Nile water where these four parameters were 177.72 gm, 204.0 cm^3, 155.61 gm, and 103.26 ml, respectively. These data are in accordance with those reported by Zekri and Koo (1993) who pointed out on irrigation of mature citrus trees with reclaimed municipal waste water, out that the fruits were heavier than those of trees irrigated with Nile water.

In addition, data presented in table (6) showed that average fruit weight, fruit size, pulp weight and juice volume varied between 175.31-201.30 gm, 203.00 –237.40 cm^3, 155.10-168.83 gm and 102.60 – 113.32 ml, respectively due to the interaction between different irrigation water resources and experimental seasons. These data are in harmony with those obtained by Okudi *et al.* (1991) and Moustafa (1985).

Table (6) also demonstrates clearly that yield of orange trees (as total fruit weight and number of fruit/tree) irrigated with drainage water was significantly higher than that of trees irrigated with sewage and Nile waters. Such parameters were 94.5 kg and 587.10 fruits per trees irrigated with drainage water, 78.5 kg and 535.61 fruits per trees irrigated with sewage water and 83.0 kg and 477.41 fruits per trees irrigated with Nile water, respectively.

The variations in yield due to seasons were small enough to be considered of practical importance, whereas, the variations according to the interactions between different irrigation water resources and seasons were significant. The highest yield was found in trees irrigated with drainage water in the second season.

TABLE(5). Correlation coefficients between chemically-extractable heavy metals and some soil variables.

Location	Chemically extractable heavy metals							
	Fe	Zn	Mn	Cu	Pb	Co	Ni	Cd
El-Salhiya								
pH	** 0.769	0.465	0.498	** 0.662	0.478	** 0.679	** 0.699	0.484
EC	** 0.663	0.255	0.065	0.166	0.039	0.423	0.164	0.139
$CaCO_3$	0.488	0.131	0.015	0.469	0.240	0.387	0.440	0.112
OM	0.338	* 0.521	0.290	0.480	0.003	* 0.547	0.274	0.270
El-Gabal El-Asfar								
pH	** 0.557	0.071	* 0.535	** 0.684	0.129	** 0.661	** 0.803	** 0.779
EC	0.228	0.382	0.403	** 0.592	0.107	0.164	0.029	0.230
$CaCO_3$	** 0.662	0.131	0.382	0.077	0.294	0.136	0.015	0.215
OM	0.431	** 0.609	0.399	0.217	** 0.710	0.11	0.465	0.250
Bahr El-Bakar								
pH	0.481	256	0.170	0.308	0.199	* 0.509	0.107	0.313
EC	** 0.717	0.305	0.433	** 0.678	** 0.652	** 0.715	0.495	** 0.699
$CaCO_3$	0.279	0.490	0.214	0.350	0.274	0.326	0.056	0.185
OM	** 0.574	0.317	** 0.578	** 0.617	0.403	* 0.536	0.356	0.317

* Significant at 0.05 level
** Significant at 0.01 level.

Chemical Composition of Fruits

Effect of different irrigation water resources on T.S.S., total acidity, T.S.S./ acid ratio, total sugars and ascorbic acid of " Washington" navel-orange fruits were recorded in table (7).

Data presented in table (7) demonstrate significant differences at 5% level in the percent of T.S.S. due to different irrigation water resources. Fruits of trees irrigated with drainage water revealed higher percentage of T.S.S. (11.59%) than fruits produced from the trees irrigated with Nile and sewage water. The lowest percentage (10.55%)

was observed in fruit of trees irrigated with Nile water. The increase of T.S.S. percentage in fruits of trees irrigated with drainage water is due to the high content of fruits in total sugars and different elements in fruits. This result disagrees with those obtained by Zekri and Koo (1993) and Maurer *et al.* (1995) who found that T.S.S. in fruits of citrus trees irrigated with reclaimed waste water were lower than these trees irrigated with Nile.

Moreover, results of the titratable acidity in the three successive experiments showed that fruits of trees irrigated with Nile water and sewage water exhibited significant values of total acidity (2.65 and 2.40 citric acid/ 100 ml juice , respectively) than fruits irrigated with drainage water (2.20 citric acid/ 100 ml juice). These results agreed with those found by Zekri and Koo (1993) who reported that the fruits of mature citrus trees irrigated with reclaimed municipal waste water were lower in acids than those trees irrigated with Nile water. At maturity stage, acidity in fruits were inversely related to T.S.S.

The T.S.S./acid ratio in juice of navel orange varied significantly with different irrigation sources. Fruits of trees irrigated with drainage water are ranked as the richest in their T.S.S./acid ratio, being 5.29. On the other hand, the variations in T.S.S./acid ratio between other tested trees were small enough to be considered of practical importance, being 3.99 and 4.71 in fruits of trees irrigated with Nile and sewage waters, respectively. The increase in T.S.S./ acid ratio in juice of fruits for trees irrigated with drainage water was attributed to increased T.S.S. percentage and decreased titratable acidity in fruits at maturity stage.

In this concern, data presented in table (7) indicated that there are significant differences in T.S.S. %, titratable acidity and T.S.S./acid ration in juice of orange fruits and this may be due to seasons and the interaction between different irrigation sources and seasons. Such parameter ranged between 10.09-11.87 % for T.S.S., 2.10- 2.70% for titratable acidity and 3.74-5.65 for T.S.S./acid ratio. These results are in agreement with those obtained by Mustafa (1978), Samra (1985) and Sharawy (1992).

Data obtained in table (7) indicate clearly that the variations in total sugars and ascorbic acid for orange fruits were significantly affected by different irrigation sources. Generally, the highest contents for such parameters were evident in fruits of trees irrigated with drainage water followed by trees irrigated with sewage water than those in fruits of trees irrigated with Nile water. The increases of percentages for such parameters in relation to fruit of trees irrigated with Nile water were 20.40 and 3.22 %, respectively for fruits of trees irrigated with drainage water and 12.24 and 0.99% for fruits of trees irrigated with sewage water.

TABLE (6). Effect of different irrigation water sources on some physical properties and yield of navel orange fruits in 2000 and 2001 seasons.

Location	Fruit weight (gm)			Fruit size (cm)			Pulp weight / fruit (gm)			Juice volume/fruit (ml)			Total fruit weight / (kg)tree			Total fruit weight / No. tree		
	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean
El- Salhiya	180.13c	175.31c	177.72c	205.00c	203.00c	204.0c	155.10c	156.11c	155.61c	103.91c	102.60c	103.26c	80.0c	86.0c	83.0c	471.20c	483.63c	447.41c
EL- Gabal El Asfar	187.18b	184.15b	185.67b	217.00b	219.00b	281.0b	160.21b	163.15b	161.68b	107.41b	107.03b	107.22b	87.0b	88.0b	87.5b	530.15b	541.13b	535.61b
Bahr El-Bakar	199.5a	201.30a	200.4a	235.00a	237.4a	236.2a	167.31a	168.83a	168.07a	112.91a	113.32a	113.12a	93.0a	96.0a	94.5a	581.13a	593.12a	587.10a
Mean	188.94a	186.92b		219.0a	219.8a		160.87b	162.70a		108.08a	107.65b		86.67b	90.00a		527.49b	539.29a	

In each column, similar letter indicating nonsignificant differences ($P<0.05$).

TABLE (7). Effect of different irrigation water resources on some chemical properties of navel orange fruits in 2000 and 2001 seasons.

Location	T.S.S. %			Total acidity			T.S.S/ acid ratio			Total sugars gm glucose/ $100m^3$ juice			Ascorbic acid gm / $100m^3$ juice		
	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean
El- Salhiya	10.09b	11.0b	10.55b	2.70a	2.60a	2.65a	3.74c	4.23c	3.99c	8.64c	8.51c	8.58c	61.10b	60.12c	60.61c
EL- Gabal El Asfar	11.02a	11.50a	11.26a	2.50b	2.30b	2.40b	4.41b	5.00b	4.71b	9.73b	9.53b	9.63b	61.30b	61.11b	61.21b
Bahr El-Bakar	11.31a	11.87a	11.59a	2.30c	2.10c	2.20c	4.92a	5.65a	5.29a	10.15a	10.51a	10.33a	62.0a	63.11a	63.56a
Mean	10.81b	11.46a		2.50a	2.33a		4.36b	4.96a		9.51a	9.52a		61.47a	61.45a	

In each column, similar letter indicating nonsignificant differences ($P<0.05$).

Heavy Metals Contents in Fruits

The concentrations of heavy metals in fruit segments and peel of different irrigation water sources are summarized in tables (8, 9, 10 and 11)

The values presented in tables (8 and 9) indicate significant differences in fruits heavy metals content due to different irrigation sources which were significant at 5% level. In this respect, the highest values of Pb, Co, Ni, Cd, Zn, Mn, Cu as well as Fe were listed in fruit segments of trees irrigated with drainage water followed by trees irrigated with sewage water in relation to control (trees irrigated with Nile water).

The interactions between different irrigation water sources and seasons had a significant differences in heavy metals content in fruits of orange. Generally, the lowest heavy metals content was shown in the first season in fruits of trees irrigated with Nile water, while the highest content was listed in trees irrigated with drainage water in the second season except in case of Co and Cd which were shown in the first season.

According to the effect of different irrigation water sources on fruit-peel heavy metals contents data reported in tables (10 and 11) generally, demonstrated that irrigation of orange trees with waste water led to significant increase in the contents of heavy metals in peels as compared with trees irrigated with Nile water. In this respect, the highest values of Pb, Co, Ni, Cd, Zn, Mn, Cu and Fe were found in fruit peels of trees irrigated with drainage water followed by trees irrigated with sewage water. On the other hand, the lowest values of such heavy metals were obtained in fruit-peel of orange trees irrigated with Nile water.

Differences in heavy metals contents in fruit peels due to the interaction between different irrigation sources and seasons were significant at 5% level. The lowest heavy metals values were shown in the first season in fruit- peel of trees irrigated with Nile water, whereas the highest values were found in trees irrigated with drainage water in the second season.

Data in table (12) also show the correlation coefficient between heavy metals in fruit peel and some soil variables i.e. pH, EC, $CaCO_3$ % and O.M.%. From the data, it is quite clear that pH has positive significant correlation with Fe in El-Salhiya area while EC displayed negative significant correlation with Fe (El-Salhiya) and Co, Ni and Cd (El-Gabal El-Asfar).

The $CaCO_3$% shows significant positive correlation with Fe and Cu and Cd at El-Salhiya and El-Gabal El-Asfar, respectively.

On the other hand, $CaCO_3$% is significant negatively correlated with Fe in El-Gabal El-Asfar area.

TABLE (8). Effect of different irrigation water sources on Pb, Co, Ni and Cd (µg/ gm dry weight) contents of orange peel fruits in 2000 and 2001 seasons.

Irrigation sources	Pb			Co			Ni			Cd		
	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean
El-Salhiya	2.011c	2.730c	2.370c	30.111c	32.310c	31.210c	21.81c	25.382c	23.596c	1.511b	1.862c	1.687b
El-Gabal- El-Asfar	92.110b	94.331b	93.220b	65.460b	67.531b	66.496b	80.182b	82.210b	81.196b	3.880a	3.911b	3.896a
Bahr El-Bakar	96.301a	98.310a	97.306a	78.160a	82.031a	80.096a	90.150a	93.251a	91.701a	3.762a	4.161a	3.962a
Mean	63.474b	65.124a		57.910b	60.624a		64.047b	66.948a		3.051a	3.311a	

In each column, similar letter indicating nonsignificant differences (P<0.05).

TABLE (9). Effect of different irrigation water sources on Zn, Mn, Cu and Fe (µg/ gm dry weight) contents of orange peel fruits in 2000 and 2001 seasons.

Irrigation Sources	Fe			Zn			Mn			Cu		
	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean
El-Salhiya	61.800c	62.310c	62.055c	53.310c	53.111c	53.210c	6.450c	7.181c	6.815c	2.811c	3.110c	2.960c
El-Gabal El-Asfar	123.680b	123.911b	123.796b	118.210	121.180b	119.695b	17.511b	17.91b	17.711b	8.150b	8.311b	8.231b
Bahr El-Bakar	163.411a	165.100a	164.256a	141.110a	143.210a	142.160a	21.181a	25.160a	23.171a	10.130a	10.910a	10.52a
Mean	116.297b	117.107a		104.210b	105.834a		15.047b	16.750a		7.030a	7.443a	

In each column, similar letter indicating nonsignificant differences (P<0.05).

TABLE (10). Effect of different irrigation sources on Pb, Co, Ni and Cd (µg/ gm dry weight) contents of orange peel fruits in 2000 and 2001 seasons.

Irrigation sources	Pb			Co			Ni			Cd		
	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean
El-Salhiya	0.297c	0.306c	0.302c	11.621c	11.730c	11.675c	10.180c	11.012c	10.596c	1.013c	0.881c	0.947c
El Gabal El-Asfar	21.013b	22.011b	21.51b	31.11b	32.118b	31.614b	30.661b	31.390b	31.026b	2.331b	2.502b	2.417b
Bahr El-Bakar	25.100a	26.000a	25.55a	63.180a	62.116a	62.648a	43.116a	44.130a	43.623a	3.811a	3.601a	3.706a
Mean	15.471b	16.106a		35.303a	35.321a		27.986b	28.844a		2.385a	2.328a	

In each column, similar letter indicating nonsignificant differences (P<0.05).

TABLE (11). Effect of different irrigation sources on Zn, Mn, Cu and Fe (µg/ gm dry weight) contents of orange peel fruits in 2000 and 2001 seasons.

Irrigation sources	Fe			Zn			Mn			Cu		
	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean
El-Salhiya	36.501c	35.112c	35.807c	43.112c	44.210c	43.661c	15.311c	14.630c	14.971c	2.151c	2.630c	2.391c
El-Gabal El-Asfar	61.741b	60.331b	31.036b	125.560b	131.160b	128.360b	29.671b	31.661b	30.67b	5.221b	5.331b	5.276b
Bahr El-Bakar	66.801a	67.101a	66.951a	146.010a	153.112a	149.561a	35.115a	36.115a	35.615a	6.211a	6.791a	6.501a
Mean	55.014a	54.181b		104.894b	109.494a		26.699b	27.469a		4.528a	4.917a	

In each column, similar letter indicating nonsignificant differences (P<0.05).

Also, the correlation coefficients between heavy metals in peel fruit and organic matter content computed and illustrated in the table (12) show that O.M. content is significant negatively correlated with (Zn), (Pb, Co and Cd) and (Fe, Cu, Pb, Co and Ni) in the studied samples of El-Salhyia, El-Gabal El-Asfar and Bahr El-Bakar areas, respectively.

Data in table (13) show the correlation coefficients between heavy metals in fruits and some soil variables such as pH, EC, $CaCO_3$% and O.M.%. From the data it is quite clear that pH is significant positively correlated with (Zn), (Pb) and (Ni and Cd) in the orange fruits of El-Salhiya, El-Gabal El-Asfar and Bahr El-Bakar areas, respectively, while EC is significant negatively correlated with (Zn and Co), (Zn, Mn, Cu, Pb, Co, Ni and Cd) and (Cu, Pb, Co and Cd) in the orange fruits of El-Salhiya, El-Gabal El-Asfar and Bahr El-Bakar areas, respectively.

$CaCO_3$% is significant positively correlated with (Zn and Co) , (Fe, Mn, Cu and Pb) and (Co and Cd) in the orange fruits of El- Salhiya, El-Gabal El-Asfar and Bahr El-Bakar areas, respectively, while being significant negatively correlated with Zn in the area of El-Gabal El- Asfar. O.M.% shows negative significant correlation with (Zn, Pb, Co and Cd) and (Fe, Cu, Pb, Co and Ni) in the orange fruits of El-Salhiya, El-Gabal El-Asfar and Bahr El-Bakar areas, respectively.

TABLE (12). Correlation coefficients between heavy metals in peel fruits and some soil variables.

Location	Chemically extractable heavy metals							
	Fe	Zn	Mn	Cu	Pb	Co	Ni	Cd
El-Salhiya								
pH	0.537*	-0.205	-0.279	-0.059	-0.078	-0.100	-0.036	0.045
EC	-0.536*	0.184	0.272	0.030	0.075	0.090	0.036	-0.039
$CaCO_3$	0.533*	-0.156	-0.262	0.007	-0.071	0.076	-0.034	0.018
OM	-0.441*	-0.040	0.163	-0.242	0.036	-0.023	0.023	0.119
El-Gabal El-Asfar								
pH	0.232	0.23	-0.202	-0.272	0.027	0.027	0.053	-0.223
EC	-0.103	-0.040	0.138	-0.134	-0.080	-0.582*	-0.433*	-0.405*
$CaCO_3$	-0.684**	0.078	0.268	0.689**	0.049	0.051	0.005	0.716**
OM	0.510*	-0.116	-0.072	0.337	-0.087	-0.089	-0.067	-0.555*
Bahr El-Bakar								
pH	-0.011	-0.045	0.045	0.225	0.169	0.055	-0.079	-0.049
EC	-0.032	-0.007	-0.004	-0.125	-0.065	-0.080	-0.092	-0.308
$CaCO_3$	-0.008	0.094	-0.024	0.038	0.081	0.077	0.127	0.336
OM	-0.063	0.103	-0.036	-0.162	-0.009	-0.040	-0.001	-0.103

* Significant at 0.05 level.
** Highly significant at 0.01 level.

TABLE (13). Correlation coefficients between heavy metals in fruits and some soil variables.

Location	Chemically extractable heavy metals							
	Fe	Zn	Mn	Cu	Pb	Co	Ni	Cd
El-Salhiya								
pH	0.056	0.350*	-0.087	0.078	0.171	0.420	0.099	0.011
EC	-0.038	-0.365*	0.050	-0.097	-0.163	-0.405	-0.119	-0.033
$CaCO_3$	0.016	0.382*	-0.002	0.119	0.151	0.385*	0.144	0.062
OM	-0.130	0.441*	-0.303	-0.247	-0.054	-0.202	-0.282	-0.237
El-Gabal El-Asfar								
pH	-0.208	-0.015	-0.054	-0.083	0.481*	-0.178	-0.067	0.010
EC	-0.994**	0.423*	-0.914**	-0.936**	-0.936**	-0.541*	-0.530*	-0.558*
$CaCO_3$	0.912**	-0.824**	0.583*	0.985**	0.904**	0.040	0.027	0.061
OM	0.027	-0.028	0.155	-0.073	-0.387*	-0.427*	-0.346	-0.370*
Bahr El-Bakar								
pH	-0.057	0.034	0.094	0.132	0.260	0.155	0.374*	0.559*
EC	-0.244	-0.058	0.222	-0.762**	-0.476*	-0.541*	-0.322	0.444*
$CaCO_3$	0.026	0.084	-0.292	0.310	0.247	0.357*	-0.079	0.390*
OM	-0.376*	0.005	0.015	-0.893**	-0.493*	-0.467*	-0.633**	-0.265

* Significant at 0.05 level.
** Highly significant at 0.01 level.

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تأثير مصادر مياه الرى على إنتاجية أشجار البرتقال فى الأراضى الرملية

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تم فى هذا البحث دراسة تأثير نوعية مياه الرى على أشجار البرتقال المنزرعة فى المناطق التالية : الصالحية ، وتروى بمياه النيل ، الجبل الأصفر وتروى بمياه الصرف الصحى ومنطقة بحر البقر وتروى بمياه الصرف المجمع وتمت الدراسة خلال موسمى ٢٠٠٠ ، ٢٠٠١ .

وقد أوضحت النتائج أن محتوى التربة من الحديد والمنجنيز والزنك والنحاس والكادميوم والنيكل والكوبلت والرصاص كان أقل من الحدود المسموح بها . ووجد أن محتوى العناصر الثقيلة فى قطاعات التربة تحت الدراسة كانت أعلى قيم فى بحر البقر ، وأقل قيم فى الصالحية فيما عدا عنصرى الكوبلت والنيكل كان أعلى قيمة لها فى مزرعة الجبل الأصفر .

فيما يتعلق بمحتوى الثمار من العناصر الثقيلة فقد وجد أن أعلى قيم بمزرعة بحر البقر فيما عدا عنصرى الحديد والكادميوم حيث وجد أن أعلى تركيز فى ثمار الأشجار النامية بمزرعة الجبل الأصفر . وبالنسبة لمحتوى القشر من العناصر الثقيلة وجد أن أعلى تركيز لها فى الأشجار المروية بمياه الصرف الصحى ويليها المروية بمياه الصرف المجمع ، حيث وجد أن تركيز هذه العناصر بالقشرة أعلى منه فى الثمرة .

بالنسبة للصفات الطبيعية للثمار وجد أن وزن وحجم الثمرة وكذلك وزن اللب كان أعلى بمزرعة بحر البقر. وبالنسبة للصفات الكيماوية وجد أن مزرعة الصالحية أعطت ثمارا محتواها عالى من الحموضة بينما ثمار مزرعة بحر البقر كان محتواها من السكريات وفيتامين ج أعلى .

وقد تمت دراسة بعض عوامل التربة مثل الحموضة – درجة التوصيل الكهربى والمادة العضوية وكربونات الكالسيوم التى تؤثر على المحتوى الكلى للعناصر الثقيلة فى التربة والنبات من خلال معامل الإنحدار الإحصائى .

ومن هذه الدراسة نوصى بعدم رى أشجار الفاكهة بمياه الصرف الصحى أو المجمع إلا بعد معالجتها معالجة نهائية أو قصر الرى بهذه المياه على الأشجار الخشبية .