Contribution of GIS to evaluate the environmental impact of using mixed irrigation water in Fayoum soils, Egypt.

***Mahmoud M. Shendi, E. A. Khater, and **M. H. Abdel Motaleb**

**Soils and Water Dept., Faculty of Agriculture, Fayoum University, Egypt.*
*** El Fayoum General Court.*

Corresponding Author: Mahmoud Mohamed Shendi, Soils and Water Dept.,
Faculty of Agriculture, Fayoum University, Egypt.
Tel: +20 2 8350837, Mobile: 0105350018, Fax: +20 84 334964,
E-mail: mmshendi@yahoo.com

ABSTRACT

The present work aimed to investigate the contribution of GIS for studying the environmental spatial impacts of using mixed irrigation water on soil pollution in El Fayoum Governorate. To achieve this target, different localities affected by mixed irrigation water were selected at Tamia Districts, Fayoum Governorate. Aerial photo-interpretation followed by conventional field check and laboratory analyses were integrated with the GIS to provide a suitable base map for the study. The main physical and chemical characteristics of 52 soil profiles, representing the different mapping units, were stored into ILWIS GIS. The Geopedologic aspects of the area were assessed and discussed. Three map units were selected from the geographic database in such a way that part of the unit is irrigated with fresh water and the other part with mixed water. An obvious increase of the micro elements and heavy metals concentration (Fe , Mn, Cu, Pb, Cd, Zn) in the mixed water, as compared to the fresh water, is recorded. Data of the impact of using mixed irrigation water on soil salinity and pollution reflected some hazard trends on soil properties, where remarkable increases in soil salinity, micro elements and heavy metals in all the studied soils irrigated with mixed water occurred. The observed hazard effects varied among the different soils in the area, mainly due to texture and drainage conditions.

Key Words:
GIS, mixed irrigation water, environmental impacts, soil pollution, Tamia soils.

1. INTRODUCTION

Many of Egypt's environmental problems are related to the compound effects of intensive irrigation with low quality irrigation water, extreme aridity, and very high population . The inventories of Egypt's natural resources assess their degradation, especially with respect to the severe problems of soil damage, water pollution, and waterborne diseases . Soil damage and acute salinization affect at least 28% of the countries irrigated soils. Salinization, together with associated water logging, reduce agricultural output by some 30% in damaged areas and poor irrigation management is responsible for much of the current situation. Egypt's water pollution problems result from several factors: salinized drainage water from irrigated areas, agricultural pesticides, industrial effluents, sewage disposal, and over pumping of aquifers. Recently, different environmental pollution problems were reported in El Fayoum

Governorate. Many farmers are complaining from the degradation of their soils. Soil salinity and quality of irrigation water were the common factors.

1.1 Research objectives

The present work aimed to achieve the following objectives;

a) To setup a suitable geographic soil database for Tamia District soils that can be used in different agricultural development and management processes.

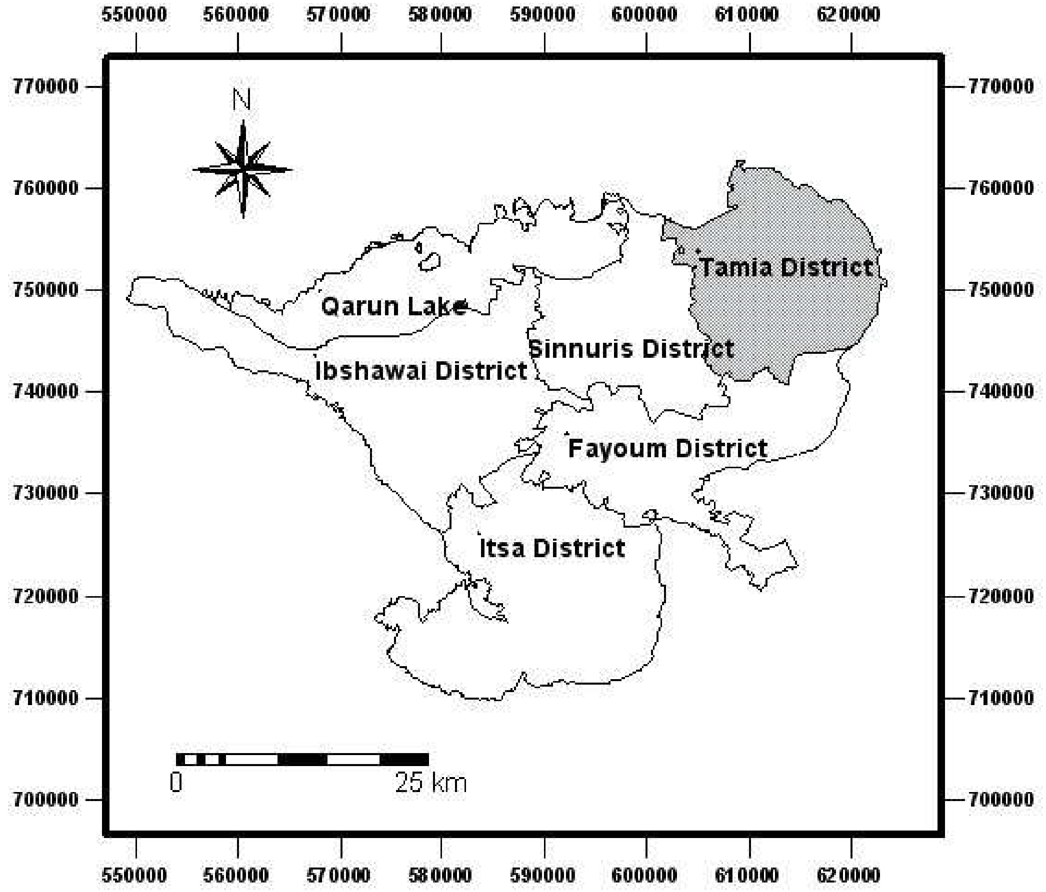
b) To investigate the possible environmental impacts of using mixed irrigation water, that has been practiced in the area since 1993, on soils.

c) To investigate the contribution of GIS and remote sensing in studying such environmental problems.

1.2 General description of the studied area

The study area is located in the eastern part of El-Fayoum Governorate, pounded between longitudes 30° 43’ 34” and 31° 4’ 55” E and latitudes 29° 20’ 14” and 29° 23’ 50” N , Map (1). The annual mean temperature is 22 C° and the annual mean rainfall is only 8 mm, whereas the mean daily evaporation is 6.75 mm.

Map 1. Location of the studied Tamia District.



1.3 The geological setting of the studied area

The geology of the area can be summarized after, Said (1962), as the following;

a) El_Fayoum depression itself is excavated in Middle Eocene rocks, which form the oldest exposed beds in the area and are composed essentially of gyps-ferrous shale, white marls, limestone and sand (known as Ravine beds).

b) d) The Oligocene beds, followed the Upper Eocene beds, are composed mainly of fluvio-marine variegated sands and sandstone, with alternating beds of shale-marls and calcareous grits containing silicified wood (Qatrani formation). Above the Qatrani formation, basalt intrusions fissured as a horizon about 20 - 25 m thick.

c) The Pleistocene deposits which are mainly of fluvio_lacustrine origin, are forming the subsurface zone between the uppermost recent deposits of Holocene (Nile alluvial) and the Middle Eocene deposits at the bottom of the Fayoum depression. These Pleistocene deposits are mainly composed of gravels and sands .

2. MATERIALS AND METHODS

The work of the present study had been conducted in 2002 to include the following;

2.1. Aerial photographs with scale ± 1:40,000, dated 1956 were used for photo interpretation. The photographs were studied stereoscopically using the geopedologic approach as outlined by Zinck (1989).

2.2. The resulting photo interpretation map and the topographic maps, scale 1: 50000, EGSA 1996, were scanned, geo-referenced and digitized accurately to ILWIS GIS software Version 3.1 (ITC, 2002). Map updating was carried out with the help of the topographic maps and the TM satellite image dated June 1998.

Interpolation between contours was made to obtain the Digital Elevation Model (DEM), Map 2. A slope map was obtained from the DEM layer and classified into three classes, Map 3.

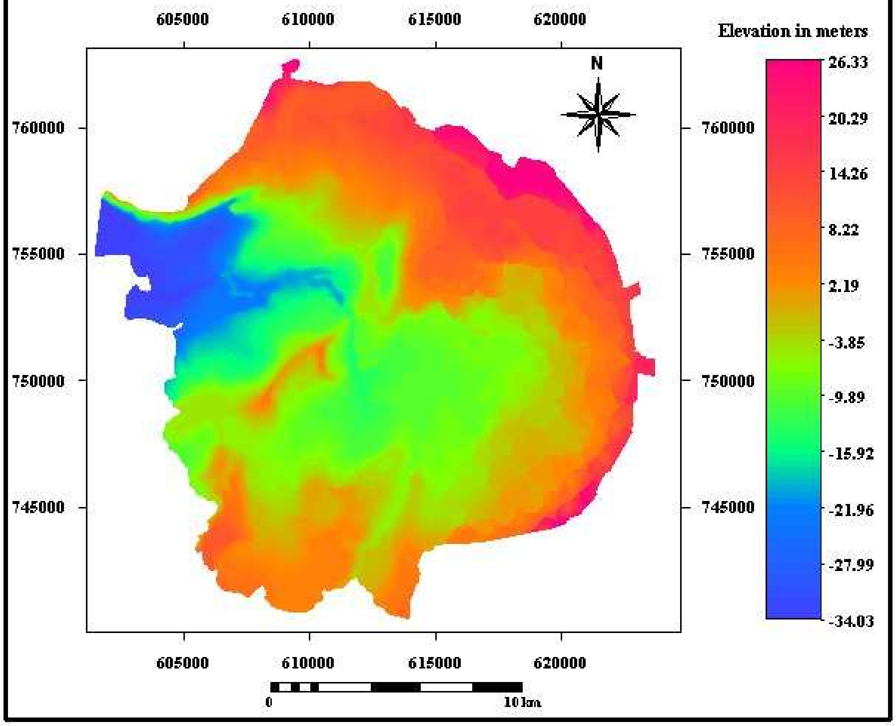
To increase the accuracy and purity of soil mapping units to be more suitable for the geographic data-base, GIS crossing was made between the classified slope map and the geopedologic map; as described by Shendi (2000). This produced the final soil map SMUs, Map 5 and Table 1.

2.3. Reconnaissance survey tracks were planed to cross the majority of the different mapping units and to cover the significant land features that occur in the area. The accessibility to these transects for fieldwork was also considered. The different irrigation network canals were overlayed on the soil map in order to investigate the soils irrigated from different water quality sources.

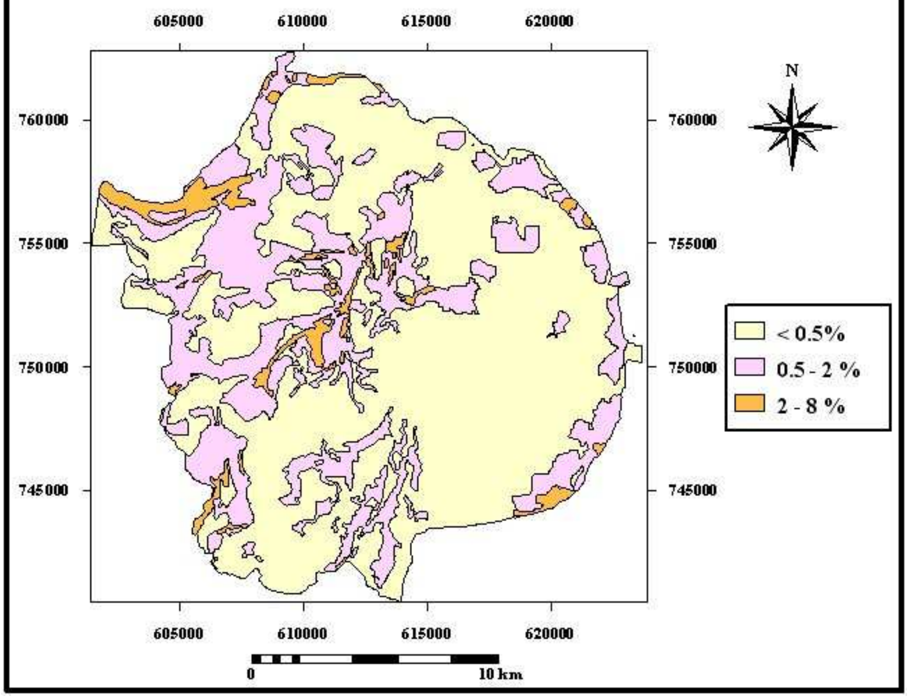
In order to integrate the research works done before by Fayoum Faculty of Agriculture in Tamia district and to represent all the resulted soil-mapping units with modal profiles, data of 44 soil profiles were integrated from the previous works of Hassanein (1986), Al-Sharif (1987), Ibrahim (1988), El-Sayad (1988), Abdel All

(1990), Shendi (1990), Al-Sharif (1994),) Abd El-Motaleb (1997) and Awadalla (1998). Moreover, sum of 8 soil profiles were done to represent the remaining unrepresented SMUs, Table 3.

Map 2. Digital Elevation Model of the studied area.



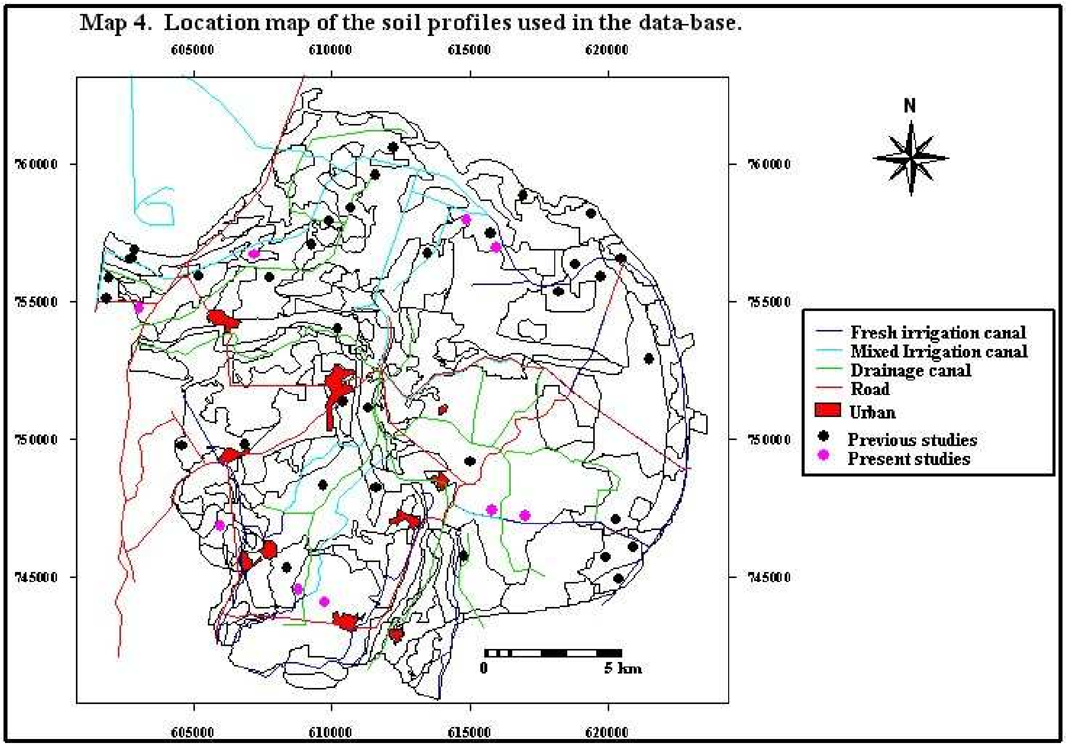
Map 3. Slope map of the studied area.



A general reconnaissance survey was done first where testing auger samples were intensively made to check the validity of interpretation boundaries, detect new missing boundaries, allocate the model profiles position, estimate the soil mapping unit composition and to estimate the main characteristics of the different mapping units. Eight soil profiles were examined in the different sample areas. The exact location of the different transects and soil profiles observations are recorded by the GPS and indicated in Map 4. Detailed morphological description was recorded for each of the studied soil profiles, on the bases outlined by FAO (1977) and classified according to Soil Survey Staff (2003).

A total of 41 disturbed and undisturbed samples were collected for physical and chemical analyses.

Map 4. Location map of the soil profiles used in the data-base.



2.4. Soil attributes of the different mapping units were added after the analysis of the modal soil profiles representing the dominant main soil. The main soil characteristics were stored as an attribute table for the SMU map. Geo-correlation to each ID mapping unit is made and the geopedologic soil data-base resulted. The physical and chemical properties of the studied soil profiles were stored in relational tabular format correlated with the ID of SMU map, Table 2.

2.5. To investigate the effect of using mixed irrigation water on soil pollution, a geographic soil database was outlined first on ILWIS GIS, then the different irrigation network were digitized and overlayed on soil map. Three different mapping units were selected, each one has some parts irrigated with fresh Nile water and with mixed water in other parts. The selected mapping units were governed also by different textural classes and origins which were considered with the help of the resulting geographic database.

Six mini pits were made to represent the selected map units. Three mini pits were allocated in areas irrigated with Nile fresh water and the other three in the areas irrigated with mixed water. Representing soil and irrigation water samples were collected for different laboratory analysis.

3. RESULTS AND DISCUSSIONS

3.1. Geographic soil data base

One of the main problems facing the creation of geographic soil database is how to represent the spatial variability associated within the same mapping unit. Fuzzy boundary models using raster GIS usually provide suitable solution for thematic maps, whereas the common soil maps usually use vector GIS. During the physiographic photo-interpretation, some generalizations usually occur and result associations or complex mapping units due to the heterogeneity of the soils. This leads to a problem of how to represent such mapping units with only one modal soil profile as a basic requirements for geographic database. Such problem is usually common in semi-detailed or general reconnaissance soil surveys, whereas detailed soil surveys usually result consociation mapping units that are more suitable for the GIS representation.

To increase the accuracy and purity of soil mapping units to be more suitable for the geographic data-base, GIS crossing was made between the classified slope map and the geopedologic map and the final soil map SMUs was formed, Map 5 and Table 1.

The physical and chemical properties of the studied soil profiles were stored from the selected modal profile for each mapping unit and coded in relational tabular format correlated with the ID of SMU map. Different thematic maps were able to be resulted as attribute maps from the geographic soil database, Map 6 & 7. The different studied soil properties are given in Tables (2, 4 ,5,6 &7).

3.2. The effect of slope map crossing on the purity of soil mapping units

By comparing the soil classification and the main soil characteristics after crossing the soil map with the slope map, (Tables 1&2), it is conclude that the crossing operation succeeded to increase the soil map purity in four different map units; Pl111, Pl211, Pl411 and Pe111. The main soil in the high terrace tread “Pl111” in the study area is estimated in the field to cover about 70% of the mapping unit and are classified as Typic Clacitorrerts . After crossing with the slope map, it was able to distinguish units with Typic Haplotorrets in areas with slope of 0.5-2%. In the moderately high terrace tread “Pl211” and in the low terrace tread “Pl411”, new mapping units of Typic Haplocalcids were distinguished in the same slope class 0.5-2%. Whereas, Typic Haplosalids were recognized in the dissected tread “Pe111”. The results indicate the importance of the applied methodology to increase the soil mapping units purity for maps resulting from aerial photo-interpretation.

Map 5. Soil map of the studied area.

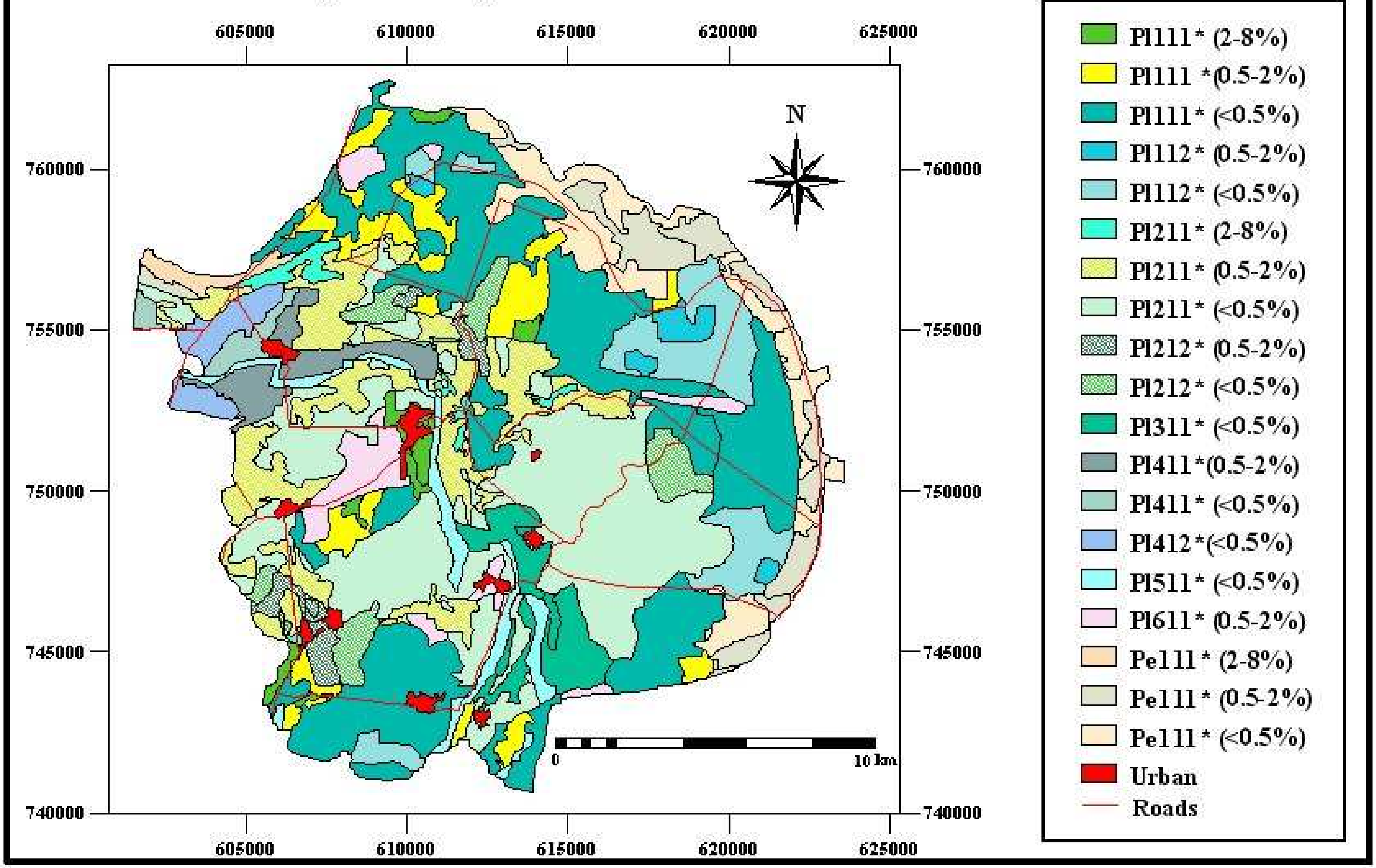


Table 1. Geo-pedomorphic legend of the studied soils.

Landscape	Relief	Lithology	Landform	Map unit	Main soil classification %	Map unit*Slope	Area (feddans)
Plain	High Terrace	Nile alluvial and residual limestone	Terraces tread	Pl111	Typic Calcitorrerts 70% Typic Haplotorrerts 30%	Pl111*(2 - 8%) Pl111*(<05 - 2%) Pl111*(<.5%)	905.95 3810.12 17407.14
			Basin	Pl112	Typic Calcitorrerts 60% Typic Haplotorrerts 40%	Pl112*(0.5 - 2%) Pl112*(<.5%)	754.76 4141.67
	Moderately High Terrace	Nile alluvium and residual limestone	Terraces tread	Pl211	Typic Torrifluvents 50% Typic Haplocalcids 40% Vertic Torrifluvents 10%	Pl211*(2 - 8%) Pl211*(0.5 - 2%) Pl211*(<.5%)	767.86 7244.64 14842.26
			Basin	Pl212	Typic Torrifluvents 60% Vertic Torrifluvents 30% Typic Calcitorrerts 10%	Pl212*(0.5 - 2%) Pl212*(<0.5%)	1044.64 2110.71
	Moderately Low Terrace	Nile alluvium and residual limestone	Terraces tread	Pl311	Typic Calcitorrerts 60% Typic Haplotorrerts 30% Vertic Torrifluvents 10%	Pl311*(<0.5%)	2435.71
	Low terrace	Fluvio-Lacustrin	Terraces tread	Pl411	Typic Aquisalids 65% Typic Haplosalids 20% Typic Haplocalcids 15%	Pl411*(0.5 - 2%) Pl411*(<0.5%)	1672.02 670.83
			Basin complex	Pl412	Typic Torripsamments 80% Typic Torrifluvents 20%	Pl412*(<.05%)	1182.74
	Incision	Nile alluvium	Swales	Pl511	Typic Haplotorrerts 80% Typic Calcitorrerts 20%	Pl511*(<0.5%)	1880.95
	Hillock	Residual limestone shale's	Slope facet complex	Pl611	Typic Calcigypsids 80% Typic Calcitorrerts 20%	Pl611*(0.5-2)	2240.48
Peneplain	Dissected plain	Colluvium and residual limestone	Tread	Pe111	Typic Torripsamments 60% Typic Haplocalcids 20% Typic Haplosalids 20%	Pe111*(2 - 8%) Pe111*(0.5 - 2%) Pe111*(<0.5%)	529.76 3173.81 4373.81

Table 2. Main soil characteristics of the different soil mapping units SMUs.

Mapping unit	Taxonomic unit (sup-group)	Profile depth (cm)	Drainage *	Erosion	Salinity (dS / m)	CEC ($Cmol_c$ / kg)	$CaCO_3$ %	ESP	Texture **	pH (Soil paste)	H.C. (cm/h) ***	Bulk density (kg/m^3)	Available moisture %
Pl 111 (2-8)	Typic Calcitorrerts	120-150	M. W- D	Non	8 - 16	20 –25	10 – 15	15 – 20	SCL	7.55 -7.6	2.5 –3.5	1.25 – 1.5	15 – 20
Pl 111 (0.5-2)	Typic Haplotorrerts	120-150	M. W- D	Non	8 - 16	20 –25	5 – 10	10 – 15	CL	7.6 – 7.65	0.5 -0.2	1 -1.25	20 - 25
Pl 111 (<0.5)	Typic Calcitorrerts	120-150	M.W.D	Non	< 4	25 – 30	10 – 15	15 - 20	C	8.05 – 8.1	0.25 – 1.5	1 – 1.25	20 – 25
Pl 112 (0.5-2)	Typic Calcitorrerts	120-150	M. W- D	Non	< 4	25 – 30	10 – 15	10 – 15	C	7.95 – 8.0	0.5 – 1	1.25 -1.5	25 – 30
Pl 112 (<0.5)	Typic Calcitorrerts	120-150	W-D	Non	4 - 8	25 – 30	10 – 15	10 – 15	C	7.7 – 7.8	0.25– 0.5	1.25 – 1.5	25 – 30
Pl 211 (2-8)	Typic Torrifluvents	120-150	I-D	Non	< 4	15 – 20	5 – 10	10 – 15	SCL	7.85 – 7.9	4.25 -5	1.25 – 1.5	15 – 20
Pl 211 (0.5-2)	Typic Haplocalcids	120-150	W-D	Non	4 - 8	35 – 40	10– 15	10 – 15	C	7.7 – 7.75	0.25– 0.5	1 – 1.25	25 – 30
Pl 211 (<0.5)	Typic Torrifluvents	120-150	W-D	Non	< 4	30 – 35	5 – 10	10 – 15	SCL	7.65 – 7.7	2.0 -2.5	1.25 – 1.5	20 – 25
Pl 212 (0.5-2)	Typic Torrifluvents	120-150	W-D	Non	< 4	15 – 20	5 – 10	5 – 10	SCL	8.5 – 8.55	5.5 -6.5	1.25 – 1.5	15 – 20
Pl 212 (<0.5)	Typic Torrifluvents	120-150	M. W-D	Non	4 - 8	35 - 40	5 – 10	10 – 15	C	7.45 – 7.5	0.5 -1.5	1 – 1.25	25 – 30
Pl 311 (<0.5)	Typic Calcitorrerts	80-100	M. W-D	Non	4 - 8	35 – 40	15 – 20	5 – 10	C	7.71 – 7.8	0.25 – 1	1 – 1.25	25 – 30
Pl 411 (0.5-2)	Typic Haplocalcids	120-150	W-D	Non	< 4	20 – 25	10 – 15	5 – 10	SCL	8.1 – 8.2	0.5 – 2	1.25 – 1.5	15 – 20
Pl 411 (<0.5)	Typic Aquisalids	75-100	P-D	Non	16 - 32	10– 15	5 - 10	15 – 20	SL	7.6 – 7.7	2.5 -5	1 – 1.25	15 – 20
Pl 412 (<0.5)	Typic Torripsamments	120-150	W-D	Non	4 - 8	10 – 15	< 5	10 – 15	LS	7.9 – 8.0	2.5 -5	1 – 1.25	25 – 30
Pl 511 (<0.5)	Typic Haplotorrerts	100-150	M. W-D	Non	4 - 8	40 - 45	5 – 10	10 – 15	C	7.9 – 8.0	0.5-1.25	1.25 – 1.5	20 – 25
Pl 611 (0.5-2)	Typic Calcigypsids	10 - 50	M D	Non	>32	25 - 30	> 20	15 - 20	C	7.5 -7.6	3.5 – 5.5	1.25 – 1.5	20 - 25
Pe111 (2–8)	Typic Torripsamments	120-150	Ex	S. Wind	8 - 16	5 – 10	5 – 10	10 – 15	LS	8.00 – 8.05	2.5 -5.5	1.25 – 1.5	15 – 20
Pe111 (0.5-2)	Typic Haplosalids	75-100	Ex	S. Wind	16 - 32	5 - 10	15 – 20	15 – 20	SL	7.55 – 7.6	3.5 -5.5	1.25 – 1.5	15 – 20
Pe111 (<0.5)	Typic Torripsamments	120-150	W-D	Non	4 - 8	5 - 10	5 – 10	10 – 15	LS	7.6 – 7.65	5.5 – 6.5	1.25 – 1.5	15 – 20

*M = Moderately
W = Well
I = Imperfectly
P = Poorly
Ex = Excessively

** SCL = Sandy clay loam
CL = Clay loam
L = Loam
S = Sandy
C = Clay
LS = Loamy sand
SL = sandy loam

***H.C. = Hydraulic Conductivity (K saturated).

Table 3. Modal soil profiles for Tamia soil data-base.

Mapping Unit	Profile No.
Pl 111 (2-8)	8 (Shendi , 1990)
Pl 111 (0.5-2)	3 (Al Sharif , 1987)
Pl 111 (<0.5)	1 and 2
Pl 112 (0.5-2)	20 (El- Sayad 1988)
Pl 112 (<0.5)	5 (Al Sharif , 1987)
Pl 211 (2-8)	5
Pl 211 (0.5-2)	5 (Abd-All , 1990)
Pl 211 (<0.5)	3 and 4
Pl 212 (0.5-2)	8
Pl 212 (<0.5)	4 (Abd-All , 1990)
Pl 311 (<0.5)	11 (Al Sharif , 1987)
Pl 411 (0.5-2)	19 (El- Sayad 1988)
Pl 411 (<0.5)	14 (Abdel- Motaleb 1997)
Pl 412 (<0.5)	5 (Shendi , 1990)
Pl 511 (<0.5)	10 (Al Sharif , 1987)
Pl 611 (0.5-2)	6 Awadalla (1998).
Pe 111 (2-8)	12 (Abdel- Motaleb 1997)
Pe 111 (0.5-2)	15 (Abdel- Motaleb 1997)
Pe 111 (<0.5)	6 and 7

Table 4. Particle size distribution, $CaCO_3$ and organic matter contents of the studied soils.

Profile No.	Depth (cm)	Sand %		Silt %	Clay %	Texture class	$CaCO_3$ %	Organic matter %
		Coarse %	Fine %					
1	0-20	1.4	18.2	24.7	55.7	C.	20.83	1.77
	20-60	1.5	19.2	19.4	59.9	C.	21.21	0.58
	60-100	1.6	20.4	20.9	57.1	C.	25.60	0.50
	100-140	0.5	11.2	27.6	60.8	C.	13.17	0.40
2	0-20	2.9	25.3	21.4	50.5	C.	16.21	1.22
	20-60	12.6	20.0	16.9	50.6	C.	12.83	0.10
	60-100	1.4	23.8	24.9	49.9	C.	16.09	1.10
	100-140	1.6	23.5	27.6	47.3	C.	23.29	1.14
3	0-30	9.7	30.5	30.9	28.9	C.L.	14.57	0.79
	30-60	60.1	9.4	6.1	24.4	S.C.L.	9.15	0.08
	60-100	2.8	26.9	22.2	48.1	C.	13.45	0.40
4	0-25	46.9	20.3	6.1	26.6	S.C.L.	11.94	0.37
	25-60	51.5	19.3	4.2	25.1	S.C.L.	7.37	0.24
	60-100	38.4	29.0	8.2	24.5	S.C.L.	6.41	0.33
5	0-30	12.4	44.8	12.8	30.1	S.C.L.	8.66	1.46
	30-60	9.9	56.6	4.2	29.3	S.C.L.	6.90	0.78
	60-100	13.5	55.4	2.1	29.0	S.C.L.	6.13	0.20
	100-120	13.8	75.4	8.6	2.2	S.	6.68	0.20
6	0-30	14.1	33.9	21.7	30.4	S.C.L.	5.93	0.80
	30-60	5.6	49.1	17.3	28.1	S.C.L.	8.22	0.25
	60-100	5.3	44.2	11.0	39.6	S.C.	8.46	0.43
	100-120	11.8	71.1	7.6	9.5	L.S.	7.51	0.20
7	0-30	49.6	37.0	1.9	11.5	L.S.	4.45	1.73
	30-60	47.2	43.7	1.8	7.3	S.	3.74	0.97
	60-100	32.4	61.9	1.9	3.8	S.	5.66	0.28
8	0-30	5.5	41.6	24.4	28.5	S.C.L.	7.20	1.05
	30-80	3.7	43.8	46.2	6.3	S.L.	6.11	0.36
	80-100	1.0	85.5	7.2	6.3	L.S.	2.17	0.20
	100 - 140	0.5	61.6	25.6	12.3	S.L.	6.45	0.21

Table 5. Some physical characteristics of the studied soils.

Profile No.	Depth (cm)	Bulk density (kg / m^3)	Hydraulic Conductivity (cm / hr)	Soil moisture content %		
				Field capacity	Wilting point	Avail. water
1	0-20	1.10	0.120	45.67	21.77	23.90
	20-60	1.16	0.095	44.87	23.56	21.31
	60-100	1.20	0.089	43.95	22.96	20.99
	100-140	1.22	0.065	42.75	24.12	18.63
2	0-20	1.13	0.050	43.96	26.56	17.40
	20-60	1.17	0.040	43.87	26.91	16.96
	60-100	1.26	0.030	44.65	28.01	16.64
	100-140	1.28	0.030	42.77	27.71	15.06
3	0-30	1.16	0.950	36.65	19.69	16.96
	30-60	1.33	1.150	35.22	20.43	14.79
	60-100	1.22	0.070	42.96	28.64	14.32
4	0-25	1.32	3.200	39.28	15.00	24.28
	25-60	1.39	2.590	36.62	13.55	23.07
	60-100	1.42	1.260	35.46	13.98	21.48
5	0-30	1.24	4.960	36.91	15.30	21.61
	30-60	1.31	3.780	35.62	15.24	21.38
	60-100	1.34	2.630	35.10	15.00	20.10
	100-120	1.39	6.180	22.52	10.01	12.51
6	0-30	1.15	2.190	35.15	19.82	15.33
	30-60	1.21	1.910	37.62	22.48	15.14
	60-100	1.27	0.130	39.19	21.94	17.25
	100-120	1.33	5.270	22.65	14.64	8.01
7	0-30	1.31	5.680	24.51	7.26	17.25
	30-60	1.41	6.060	20.65	9.29	11.36
	60-100	1.50	5.770	71.76	11.61	10.15
8	0-30	1.26	4.230	35.26	12.74	22.52
	30-80	1.34	7.980	32.73	16.60	16.13
	80-100	1.41	8.130	21.73	12.61	9.12
	100-140	1.48	6.160	23.66	10.00	13.66

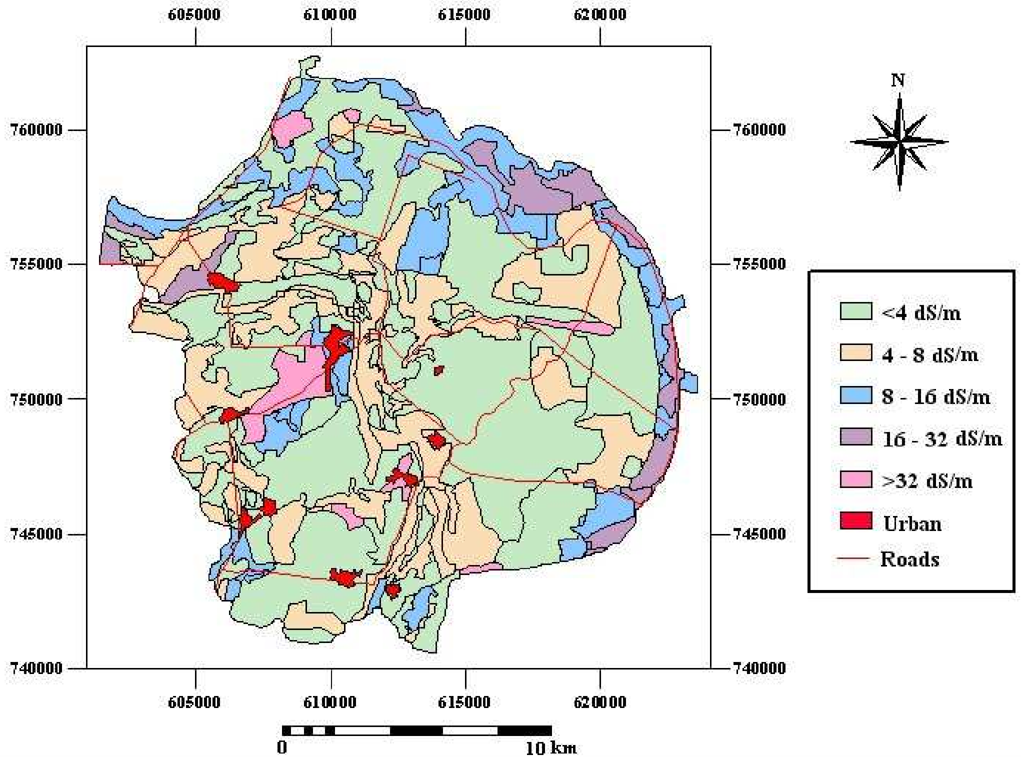
Table 6. Chemical characteristics of the studied soils.

Profile No.	Depth (cm)	pH (Soil paste)	ECe (dS/m)	Cations (meq/l)				Anions (meq/l)			SAR
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	SO_4^{--}	HCO^{-}	Cl^{-}	
1	0-20	7.72	2.63	3.14	4.34	18.34	0.23	3.57	2.68	19.80	9.48
	20-60	7.99	4.16	9.88	5.00	25.97	0.34	5.14	2.45	33.60	9.52
	60-100	8.00	5.15	10.06	7.49	34.57	0.44	20.88	2.61	29.07	11.67
	100-140	8.48	4.91	6.66	5.85	36.76	0.20	7.83	3.52	38.12	14.69
2	0-20	7.93	19.81	15.6	9.16	164.82	0.78	42.22	2.64	145.50	46.84
	20-60	7.92	17.12	16.00	8.83	156.54	0.63	32.91	2.79	136.30	41.58
	60-100	8.09	8.52	13.59	7.84	64.71	0.34	27.72	2.98	55.78	19.76
	100-140	8.15	6.78	6.39	6.58	55.27	0.23	15.35	3.42	49.70	21.70
3	0-30	7.65	7.69	5.84	3.09	68.45	0.59	26.35	2.12	49.50	32.39
	30-60	7.45	6.29	7.29	1.22	54.44	0.53	15.98	2.95	44.55	26.39
	60-100	7.74	6.11	3.55	2.55	56.16	0.46	7.51	3.24	51.97	32.15
4	0-25	7.41	0.88	2.95	1.26	5.23	0.14	1.66	1.80	6.12	3.60
	25-60	7.70	0.71	3.53	0.26	3.44	0.01	0.03	2.66	4.55	2.49
	60-100	7.86	1.26	1.96	0.43	10.50	0.06	0.17	2.88	9.90	9.60
5	0-30	7.78	1.82	5.79	2.20	11.78	0.21	5.57	2.04	12.37	5.89
	30-60	7.83	2.38	3.36	2.06	19.29	0.26	8.84	2.68	13.45	11.71
	60-100	7.95	1.78	2.88	1.38	14.52	0.20	1.35	2.88	14.75	9.95
	100-120	7.94	2.44	4.83	1.98	19.34	0.12	7.90	2.52	15.85	10.48
6	0-30	7.99	7.52	15.35	8.58	54.49	1.46	43.42	3.24	33.22	15.75
	30-60	8.09	10.48	16.77	7.17	81.53	1.51	47.41	3.36	56.21	23.56
	60-100	8.14	10.54	15.37	7.37	83.10	1.54	42.92	3.36	61.10	24.64
	100-120	7.87	7.67	18.18	7.83	52.57	1.41	36.65	3.64	39.70	14.57
7	0-30	7.43	1.02	2.85	1.82	5.07	0.39	0.80	2.21	7.12	3.31
	30-60	7.89	0.87	2.06	0.97	5.06	0.35	0.54	2.03	6.42	4.55
	60-100	7.50	0.75	3.00	0.64	4.31	0.14	0.83	2.31	6.61	3.19
8	0-30	8.07	1.29	4.15	1.32	7.90	0.09	3.80	2.24	7.42	4.77
	30-80	8.32	2.48	3.11	1.38	20.93	0.05	11.17	2.40	11.90	13.96
	80-100	8.76	4.37	3.55	1.54	39.16	0.12	13.22	2.88	28.27	24.54
	100-140	8.93	2.69	2.63	0.36	25.91	0.07	9.47	3.60	15.90	21.19

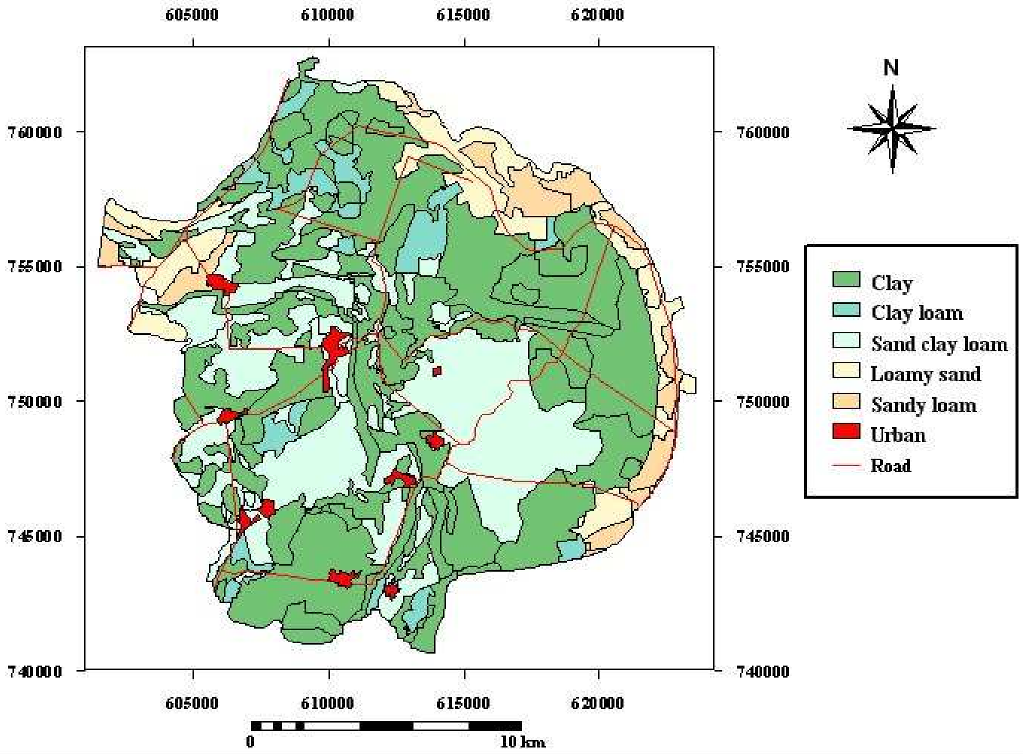
Table 7. Cations exchange capacity(CEC), exchangeable cations and exchangeable sodium percent (ESP) of the studied soil profiles.

Profile No.	Depth (cm)	CEC (cmolc/kg soil)	Exchangeable cations (cmolc/kg soil)				ESP %
			Ca	Mg	Na	K	
1	0-20	23.83	8.72	11.14	3.28	0.39	13.76
	20-60	26.00	13.27	8.62	3.42	0.37	13.15
	60-100	18.25	7.48	7.93	2.38	0.24	13.08
	100-140	28.13	13.99	9.36	4.16	0.28	14.80
2	0-20	22.00	8.39	7.71	5.25	0.38	23.89
	20-60	19.12	7.17	6.68	4.19	0.31	21.95
	60-100	18.16	7.26	6.61	3.82	0.25	21.06
	100-140	19.23	8.32	7.02	3.47	0.19	18.06
3	0-30	13.25	6.09	4.73	1.93	0.34	14.56
	30-60	15.05	8.31	4.20	2.26	0.10	15.01
	60-100	24.67	14.44	5.54	4.05	0.35	16.45
4	0-25	11.36	7.22	2.81	1.04	0.16	9.24
	25-60	15.30	8.86	4.31	1.75	0.19	11.43
	60-100	16.43	5.74	9.07	1.25	0.17	12.08
5	0-30	19.94	9.00	7.78	2.42	0.50	12.15
	30-60	18.56	8.37	7.23	2.45	0.37	13.14
	60-100	17.76	8.90	6.29	2.06	0.29	11.60
	1 100-120	3.51	2.00	0.97	0.33	0.17	9.62
6	0-30	20.91	10.28	5.03	4.85	0.49	23.19
	30-60	18.12	6.78	5.72	4.67	0.73	25.77
	60-100	29.03	13.45	9.88	4.75	0.60	16.36
	1 100-120	5.34	3.09	0.93	0.76	0.49	14.35
7	0-30	6.19	3.57	1.80	0.53	0.21	8.50
	30-60	4.55	2.19	1.75	0.44	0.06	9.71
	60-100	2.91	1.39	1.23	0.22	0.03	7.67
8	0-30	19.87	9.66	7.69	2.03	0.25	10.25
	30-80	4.84	2.90	1.36	0.34	0.18	7.10
	80-100	5.11	2.97	1.45	0.47	0.15	9.33
	100 -140	7.84	4.94	1.82	0.75	0.23	9.57

Map 6. Soil salinity of the studied area.



Map 7. Soil texture of the studied area.



3.3 The effect of using mixed irrigation water on soil pollution.

To investigate the effect of mixed irrigation water that has been used in the study area since 1993 on soil pollution, the resulted geographic soil database was used to select three map units, each of them is irrigated with fresh water in some parts and with mixed water in other parts. The selected map units were: Pl111* <0.5%, Pl211* <0.5% and Pe111*<0.5%, Map 8.

Soils of Pl111* <0.5% are Nile alluvium mixed with residual limestone which cover an area of 3065.64 feddans. The soils are characterized by clayey texture, high lime content and moderate salinity in areas irrigated by mixed water.

Soils of Pl211*<0.5% are formed of Nile alluvium and residual limestone covering an area of 7270.09 feddans. The soils possess sandy clay loam texture, slightly to moderate contents of $CaCO_3$ and moderate salinity in areas irrigated by mixed water.

The Pe111*<0.5% soils have colluvial and residual limestone parent material with an area reaching 1817.66 feddans. The soils are characterized by sandy clay loam texture, are slightly calcareous and moderately saline in areas irrigated with mixed water.

3.3.1. Chemical composition of mixed water versus Nile fresh water

Six mini pits were made, i.e. two in each map unit to represent the soils irrigated with fresh or mixed water. The chemical composition of Nile fresh water (N) and mixed Nile – drainage water (ND) used for irrigating the studied soils are given in Tables 8 and 9.

The data indicated a remarkable increase in the EC, values of the mixed water as it reached 0.95, 1.25 and 1.42 dS/m compared with 0.5, 0.85 and 0.88 dS/m for the fresh water in Bahr Allam, Bahr Hujmin and Bahr Wahby, respectively. An increase trend is also obtained in the SAR values. According to Richard(1954), the salinity values of the mixed water are classified under the second class. Ayers and Westcot (1985) noted that there is no severe problems for using such saline water for irrigation, but saline conditions could be developed if fresh waters are inadequate, which are the cases commonly encountered in soils of Tamia district.

Data of heavy metals in the irrigation water, Table 10, showed also an increase in the concentration of Fe, Mn, Cu, Pb, Cd and Zn in the mixed irrigation water samples, whereas Ni was not detected in both types of irrigation water (fresh Nile and mixed waters).

3.3.2. The impact of using mixed irrigation water on soil salinity

As indicated in Table 10, a remarkable increase in soil salinity levels occurred in soils irrigated with mixed water. The increase was very remarkable in the clayey textured soils, i.e., mini pits no 1&2 (the command area of Bahr Allam), where drainage condition was imperfect. Although there was a remarkable salinity increase in the medium textural classes also, i.e. mini pits 3, 4, 5 and 6 (command areas of Bahr Hujmin and Bahr Wahby), but the recorded salinity increase were less severe. This meets the requirements reported by Richards (1954) to limit the use of such saline irrigation water only under good management and favorable drainage conditions.

Table 8. Chemical composition of Nile waters (N) and mixed water (ND) used for irrigation in the studied area.

Sample No	Water type	EC (dS/m)	Soluble cations (meq/l)				Anions (meq/l)			SAR
			Ca^{++}	Mg^{++}	Na^+	K^+	SO_4^{--}	HCO^-	Cl^-	
1	N	0.50	1.02	0.77	3.73	0.11	0.12	2.10	3.41	3.94
2	ND	0.95	1.63	1.10	6.19	0.14	0.89	2.35	5.82	5.29
3	N	0.85	1.32	1.22	6.51	0.11	0.02	2.24	6.90	5.77
4	ND	1.25	1.52	1.62	8.90	0.28	0.62	1.80	9.90	7.10
5	N	0.88	1.79	1.33	6.08	0.13	0.12	2.16	7.05	4.6
6	ND	1.42	1.77	1.75	11.22	0.23	0.20	3.24	11.57	8.46

Table 9. Micro elements and heavy metals concentration of the studied irrigation waters (ppm).

Sample No	Water type	Fe	Mn	Zn	Cu	Pb	Cd	Ni
1	N	0.12	0.003	0.001	0.010	0.004	0.006	N.d.
2	ND	0.25	0.008	0.002	0.025	0.005	0.010	N.d.
3	N	0.08	0.015	0.003	0.005	0.003	0.008	N.d.
4	ND	0.3	0.060	0.005	0.014	0.007	0.020	N.d.
5	N	0.16	0.005	0.001	0.019	0.003	0.004	N.d.
6	ND	0.2	0.025	0.002	0.024	0.008	0.020	N.d.

N.d. = Not detected

Map 8. Location map of observation points for testing the effect of mixed water.

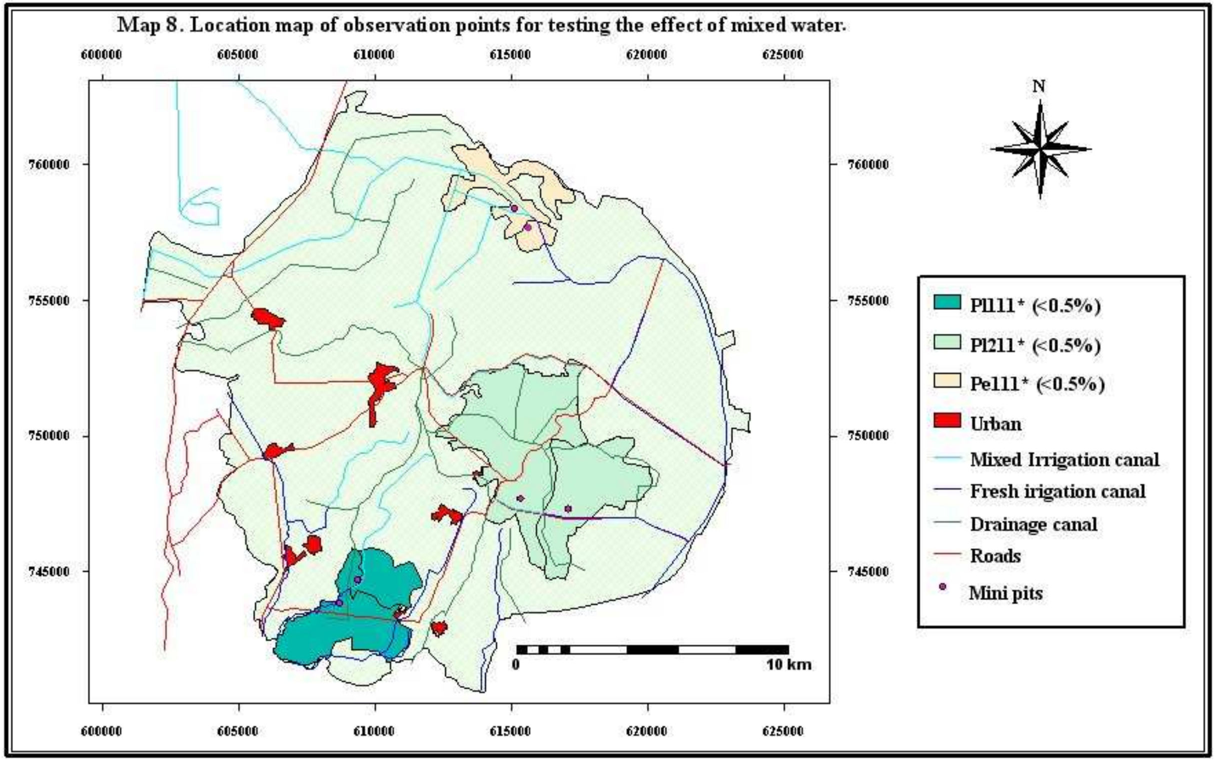


Table 10. Total (T.) and Extractable(E.) micro elements, heavy metal contents in mg /kg, ECe, texture class and $CaCO_3$ of the studied minipits.

Bahr Name/ Map Unit	Mini pits No.	Water type	Depth (cm)	Fe		Mn		Cu		Pb		Cd		Ni		Zn		EC_e (dS/m)	Tex. class	$CaCO_3$ %
				T.	E.	T.	E.	T.	E.	T.	E.	T.	E.	T.	E.	T.	E.			
Bahr Allam Pl111*<0.5%	1	N	0-20	20401.5	5.21	166.88	1.61	27.58	1.15	21.75	1.82	2.96	0.38	6.58	0.41	90.21	0.72	2.71	C	20.21
			20-60	18616.5	3.12	156.67	0.82	24.16	0.85	19.33	0.67	1.75	0.11	4.56	0.17	76.11	0.60	3.95	C	21.00
	2	ND	0-20	28364.5	10.16	197.36	3.12	44.15	2.02	33.57	3.65	4.43	0.74	11.23	0.67	130.52	1.23	20.01	C	19.45
			20-60	27096.0	8.24	156.67	2.92	39.57	1.74	29.28	2.86	3.25	0.33	7.97	0.29	120.15	0.92	18.05	C	20.05
Bahr Hujmin Pl211*<0.5%	3	N	0-20	12560.2	7.31	115.61	3.19	15.72	0.94	17.05	2.86	2.16	0.49	3.79	0.34	81.23	2.82	0.83	SCL	11.94
			20-60	11211.6	5.12	96.120	2.95	13.77	0.46	14.12	1.43	1.46	0.13	2.78	0.14	74.11	1.97	0.69	SCL	10.54
	4	ND	0-20	16306.0	9.62	158.84	4.92	32.22	1.95	30.64	4.82	3.82	0.99	9.66	0.72	119.52	3.52	7.81	SCL	12.56
			20-60	15102.5	7.15	132.27	3.11	26.78	1.13	27.78	3.54	2.83	0.53	6.08	0.31	115.96	2.41	6.35	SCL	11.05
Bahr Wahby Pe111*<0.5%	5	N	0-20	8266.5	4.52	76.260	1.53	10.23	0.51	13.90	1.25	1.51	0.21	1.89	0.15	68.19	0.85	1.66	SCL	5.77
			20-60	3962.1	3.61	57.010	0.8	9.33	0.32	9.66	0.86	0.86	0.13	1.36	0.06	49.17	0.72	1.51	SCL	6.95
	6	ND	0-20	15168.2	7.97	217.58	4.87	35.91	2.00	23.55	5.04	3.45	0.87	10.12	0.82	148.16	2.69	7.81	SCL	6.05
			20-60	15098.1	6.78	203.12	3.21	29.72	1.69	19.22	3.54	2.75	0.42	7.14	0.35	137.95	1.61	10.46	SCL	7.44
Average		N	0-20	13742.7	5.68	119.58	2.11	17.84	0.87	17.57	1.98	2.21	0.36	4.09	0.30	79.88	1.46	1.73		12.64
			20-60	11263.4	3.95	103.27	1.52	15.75	0.54	14.37	0.97	1.36	0.12	2.9	0.12	66.46	1.10	2.05		12.83
		ND	0-20	19946.3	9.25	191.26	4.3	37.43	1.99	29.25	4.50	3.90	0.87	10.34	0.74	132.73	2.48	11.88		12.69
			20-60	19098.9	7.39	164.02	3.08	32.02	1.52	25.43	3.31	2.94	0.43	7.06	0.32	124.69	1.65	11.62		12.85

3.3.3. The impact of using mixed irrigation water on soil pollution

The data of micro elements and heavy metals of (Fe, Mn, Cu, Pb, Cd, Ni and Zn) are presented in Table 9, indicated a remarkable increase in total, extractable and average contents for all the studied micro and heavy metals in the different command areas. The highest total values of Fe, Mn, Cu, Pb, Cd, Ni and Zn were recorded in the area represented by mini pits 2, 6, 2, 2, 2, 2 and 6, respectively .Whereas, the highest available contents of these metals were recorded in mini pits 2, 4, 2, 6, 4, 6 and 4 .

3.4. Effect of parent material on heavy metals contents.

Within the same texture class, sandy clay loam, the colluvial and residual limestone developed on the peneplain landscape, represented by mini pits 5 & 6, possess lower contents of both total and extractable heavy metals compared to the soils developed on the Nile alluvial plain (mini pits 3 & 4), Table (10).

3.5 Effect of soil texture on heavy metals content.

By comparing data of the clayey Nile alluvial soils (mini pits 1 & 2) versus the sandy clay loam developed on the same sediment (mini pits 3 & 4), it is noticed that the clayey soils possess higher total content of all studied heavy metals. This is in agreement with Reddy and Dun (1986), who showed that clay soils, with high CEC, had a larger capacity to adsorb Ni and Zn from solutions as compared with low CEC sandy soils.

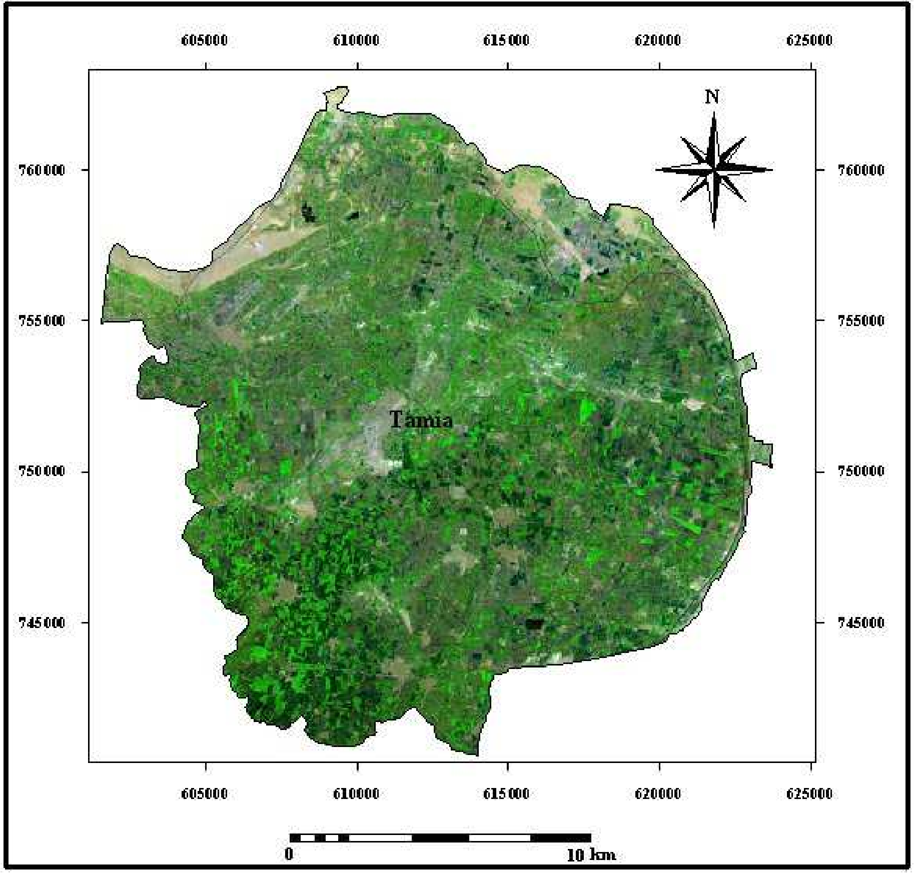
3.6. Incorporation of remote sensing for mapping the spatial distribution of the Polluted saline soils

To assess the spatial distribution of soils affected by the mixed irrigation water, the irrigation canals network were overlayed first on the selected soil map units. Then the map units were crossed with an enhanced natural color composite TM5 image of bands (7, 4 ,3). Then visual interpretation was made over the image of the tested mapping units to distinguish the spatial distribution of the affected soils. The polygon statistics were calculated within ILWIS GIS as indicated in Table 10, Map 9 & 10.

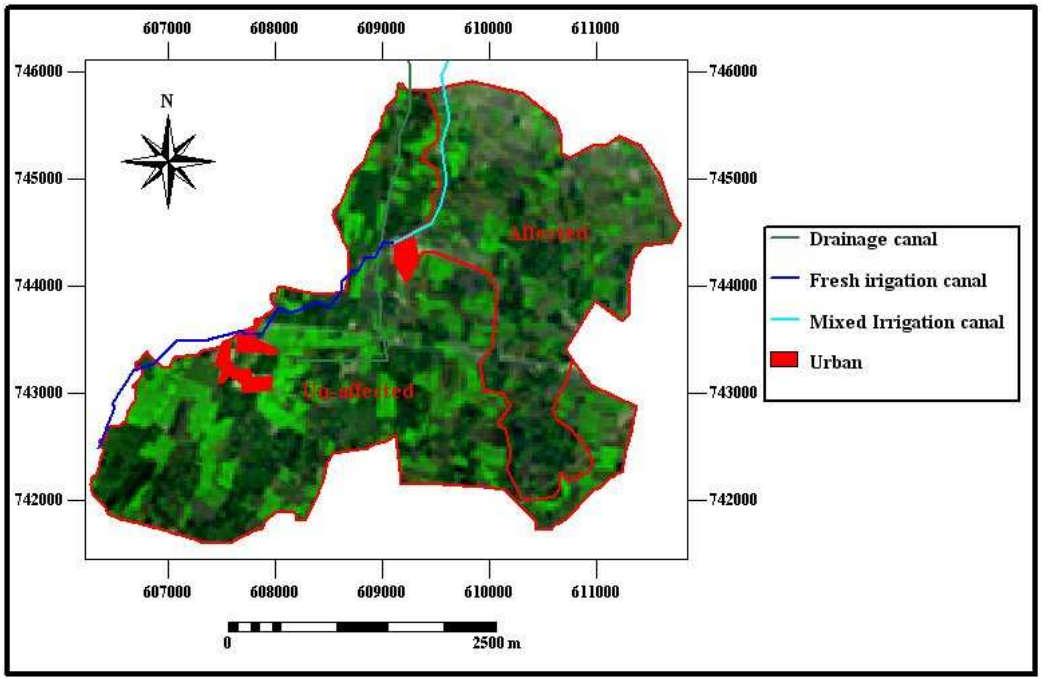
Table 11. Soils area (in feddans) which are affected and unaffected by pollution .

Map unit	Unaffected	Affected	Total	Affected Area %
Pl111* <0.5%	1959.36	1106.28	3065.64	**36.09**
Pl211* <0.5%	2555.80	4714.29	7270.09	**64.85**
Pe111*<0.5%	282.87	1534.79	1817.66	**84.44**

Map 9. TM Satellite Image of the studied area, bands (7,4,3), June 1998.



Map 10. Distribution of soils affected by mixed water in Pl 111*<0.5% map unit .



4. CONCLUSIONS

- There is a remarkable increase in soil salinity levels, micro elements and heavy metals as a result of using mixed water in irrigating the study area, especially in clayey soils.
- The use of GIS and remote sensing was very helpful in the study.
- Crossing the photo-interpretation map with the slope map succeeded to increase map units purity and it is recommended to use the methodology to update the old soil maps that were developed on aerial photo-interpretation.

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مساهمة أنظمة المعلومات الجغرافية فى تَقييم التأثيرِ البيئي لإستعمال ماءِ الرَيِّ المُخْتَلَطِ في أراضى الفيوم ، مصر.

***محمود محمد شندى ، *السيد عبد الحى خاطر، **مدحت حسنى عبد المطلب**
***–قسم الأراضى والمياه– كلية الزراعة بالفيوم، **– محكمة الفيوم العامة**
الناشر : محمود محمد شندى ، قسم الأراضى والمياه – كلية الزراعة – جامعة الفيوم
ت: 8350837 -202 ، **محمول :** 0105350018 **فاكس :** 084-6334964
البريد الأليكترونى: mmshendi@yahoo.com

الملخص

يهدّفَ العملُ الحاليُ لتَحرّي مدى مساهمةِ أنظمة المعلومات الجغرافية فى دِراسَة التأثيراتِ البيئيةِ المكانيةِ لإستعمال ماء النيل المختلط بماء الصرف وتأثير ذلك على تلوثِ التربةِ في محافظةِ الفيوم. وقد تم إختيار أماكن مختلفة تروى بماءِ رَيِّ مُخْتَلَطِ بمركز طامية ، محافظة الفيوم . وللحصول على خريطة أساس مناسبة للدراسةِ ، بدأت الدراسة بالتفسير الفيزيوجرافى للصور الجوية ، ثم تَلى ذلك إجراء مسح أرضى تقليدىِ بالتكامل مع أنظمة المعلومات الجغرافية واستخدام جهاز رصد المواقع بالقمر الصناعى GPS مع إجراء التحليلاتِ المعملية على العينات الممثلة للقطاعات . وقد تم دراسة الخصائص الطبيعية والكيميائية الرئيسية للمنطقة من خلال دراسة52 قطاع أرضى تُمثّلُ وحداتَ التربة المختلفةِ حيث خُزِنتْ هذه الصفات فى صورة قاعدة بيانات جغرافية لبرنامج ILWIS. ثم تمت مناقشة و تقييم السمات الجيوبيدولوجية للمنطقةِ وبالإستعانة بقاعدةِ البيانات الجغرافيةِ تم إختيار ثلاث وحدات خريطيةِ بحيث يكون جزء من الوحدةِ يروى بالماء العذبِ والجزءِ الآخرِ من نفس الوحدة الخريطية يروى بالماءِ المُخْتَلَطِ. وقد أظهرت النتائج زيادة واضحة فى محتوى العناصرِ الصغرى وِ المعادنِ الثقيلةِ (الحديد ، المنجنيز، النحاس، الرصاص، الكاديوم، والزنك) في الماءِ المُخْتَلَطِ بالمقارنة مع الماء العذبِ. كما أظهرت النتائج تأثيرِ إستعمال ماءِ الرَيِّ المُخْتَلَطِ على ملوحةِ وتلوثِ التربةِ مما يعكس بَعْض الخطرِ على تدهور صفات التربةِ، حيث إرتفعت ملوحةِ التربةِ، ومحتوى العناصر الصغرى والمعادن الثقيلة في كُلّ الأراضى المدروسةِ والتى يتم ريها بالماءِ المُخْتَلَطِ. وقد تباين التأثيرالضارِ بين الأراضى المختلفةِ في المنطقةِ طبقا لحالة الصرف وقوامَ التربة.

الكلمات الدالة :

ماء الرى المخلوط ، التأثيرات البيئية ، تلوث التربة ، أراضى الفيوم.