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PHYSICAL, CHEMICAL AND MACRO-MICROMORPHOLOGICAL CHARACTERISTICS OF SOME ALLUVIAL SOILS IRRIGATED WITH DIFFERENT WATER RESOURCES

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ABSTRACT :

In addition to the Nile River, which is the main resource of water, there are alternative sources, i.e. groundwater, agricultural drainage water and sewage water are used for irrigation in many parts of Egypt. The aim of this work was to study the morphological and micromorphological features as well as some physical and chemical properties of the alluvial soils irrigated with these waters at Assiut city.

Four sites were chosen to represent the soils irrigated with different water sources, i.e. the fresh Nile water, artesian water, Nile water polluted with incompletely treated sewage water and Nile water polluted with agricultural drainage water. One profile was chosen and dug to represent the soils of each site. The profiles were morphologically described and some physical and chemical characteristics of their layers were measured. Thin sections were prepared from undisturbed surface and subsurface soil samples, then micromorphologically examined.

The obtained results revealed that the studied soils are generally flat to almost flat, deep, of water table deeper than 150 cm and are moderately well drained (the sites irrigated with artesian and agric. drainage polluted Nile waters) to well drained (the sites irrigated with Nile and polluted sewage waters). Although, the surface and subsurface layers of soils irrigated with Nile, artesian and sewage polluted Nile waters have the same texture grade (sandy loam), some properties such as, matrix colour, structure and consistency, differ in the surface layer irrigated with sewage polluted Nile water. Soil irrigated with sewage polluted Nile water has the highest contents of organic matter, pH, available Zn, Cu and Pb, whereas, irrigated with artesian water has the highest amounts of calcium carbonate, EC, ESP, soluble Ca, Mg and K, and extractable Fe, B and Ni. Moreover, the soil irrigated with agric. drainage polluted Nile water contains higher values of soluble Na, CEC and available Mn than the others.

Micromorphological features of the studied soil samples indicate that they have apedal soil materials, with mainly primary structure. Porphyroskelic and agglomeroplasmic fabrics characterize the soil surfaces representing soils irrigated with fresh Nile, artesian and sewage polluted Nile waters, while samples irrigated with agric. Drainage polluted Nile water show silty-sized grains embedded in dense soil plasma. The argillasepic plasmic fabric predominates over the other in the examined samples of the studied soils. Plasma separations are noticed as vo-in-sepic in all studied samples. The dominant void type is vugh, that is mainly interconnected, irregular, ortho and/or metavugh. Vesicles are noticed in all-surface samples. Channels and chambers are seen in the subsurface samples irrigated with fresh Nile and artesian waters as well as the subsurface ones irrigated with other water resources. Planes are present as subparallel, skew and craze in the soils irrigated with sewage and agric. drainage polluted Nile waters. Thin stress opaque organo-argillans were presented on the walls of grains and voids, as well as argillaceous and carbonate nodules in the soils irrigated with fresh Nile and agric.drainage polluted Nile waters. However, void walls and embedded grains are coated with ferri-arrgillans, as well as sesquioxidic, manganiferrous and ferromanganic-carbonate nodules are noticed in the examined samples of the soils irrigated with artesian and sewage polluted Nile waters.

INTRODUCTION:

The population increase requires an addition of new agricultural lands. Therefore, there has always been an urgent need to increase the water amount and/or an optimum usage of current irrigation water. The main resource of water is the Nile River that supplies Egypt with a limited amount of water. So, alternative sources, i.e. groundwater and reuse of agricultural drainage as well as sewage waters are used for irrigation in many parts of Egypt.

The use of sewage effluents as a supplementary water resource for irrigation is becoming widespread in arid and semiarid zones (El Nenna *et al*., 1982). The effect of sewage water and material in improving soil structure, aeration, water retention of soil and other physical properties is well documented (Spotswood and Rayner, 1973; El-Nashar, 1985; Awad, 1991;Badaway and Helal, 1997; El-Desoky and Gameh, 1998). On the other hand, Sagik *et al*. (1979) stated that land application of either effluents or sludges might introduce both deleterious chemicals, including heavy metals and persistent organic chemicals and pathogenic micro-organisms into soil systems. Moreover, Doran *et al*. (1996) showed that the contaminated soils might lead to contaminated surface and groundwater supplies as well as presence of unhealthy factors such as toxic metals, pesticides and human diseases.

El-Kobbia and Ibrahim (1989) pointed out the used sewage waters for irrigation in Nile Delta contained much higher concentration of soluble salts, Fe, Zn and Cu than did tap water. No marked variations were observed between B, Pb and Ni contents. They added that these sewage waters could be used for irrigation purposes with most of the crops, particularly on light and medium textured soils with little possibility of any problem.

The groundwaters in the young and old plain provinces, in both east and west sides of Nile, at Assiut Governorate have the same meteoric origin of the surface water. They are characterized by the increase of Na and K concentrations (in the young plain), Cl and SO4 concentrations (in the old plain) and concentrations of Fe, Zn and Mn (in both plains). This different chemical relation between the groundwater, especially in the old plain province, and Nile water is due to the impact of the water-rock interactions upon water quality (Abu El Ella, 1997).

Micromorphological features of the Nile alluvial soils have been investigated by many authors (El-Kady, 1970; Abd El-Hamid, 1973; Abdel-Kader and El-Husseiny, 1974; Wahdan, 1974; Labib *et al*., 1975; Fathi *et al*, 1976; Hanna and Stoop, 1977; Abd El-Rahman, 1981; El-Husseiny, 1985; Gobran *et al*., 1991; El-Husseiny and El-Saadani, 1992; Amira, 1997; Amira and Ibrahim, 2000; Faragallah, 2001).

Incompletely treated sewage waters of Assiut city discharge into the branch of El-Mallah canal at the southwest of the city. Another polluted irrigation water source with agricultural drainage water (El-Sohagya canal) is found at the west of Assiut city. The present work aims to examine the morphological and micromorphological features of soils irrigated with these polluted waters as well as fresh Nile and artesian waters and also to study some physical and chemical characteristics of these soils.

MATERIAL AND METHODS

Four sites were chosen to represent the soils irrigated with different water sources at Assiut city. Profiles 1, 2, 3 and 4 represent soils irrigated with fresh Nile, artesian, polluted by incompletely treated sewage water and polluted by agricultural drainage waters, respectively (Fig. 1). Selected soil sites were chosen in the same neighborhood, in order to minimize the difference of sedimentation mode among them. Representative profiles were dug to 150 cm and morphologically described according to Soil Survey Staff (1999). Soil samples were collected from each horizon and layer according to the morphological features, carried to the lab and prepared for analysis. Water samples that have been used for irrigation in these sites were collected, carried to the lab and subjected to chemical analyses (Table 1).

The physical and chemical analyses of the studied soils and water samples were carried out according to Page (1982) and Klute (1986). Some metals, i.e. Fe, Zn, Mn, Cu, Ni, B and Pb, were extracted from soil samples using the diethylene triamine pentaacetic acid (DTPA) method (Lindsay and Norvell, 1978) and determined using model 1999 Perkin-Elmer atomic absorption.

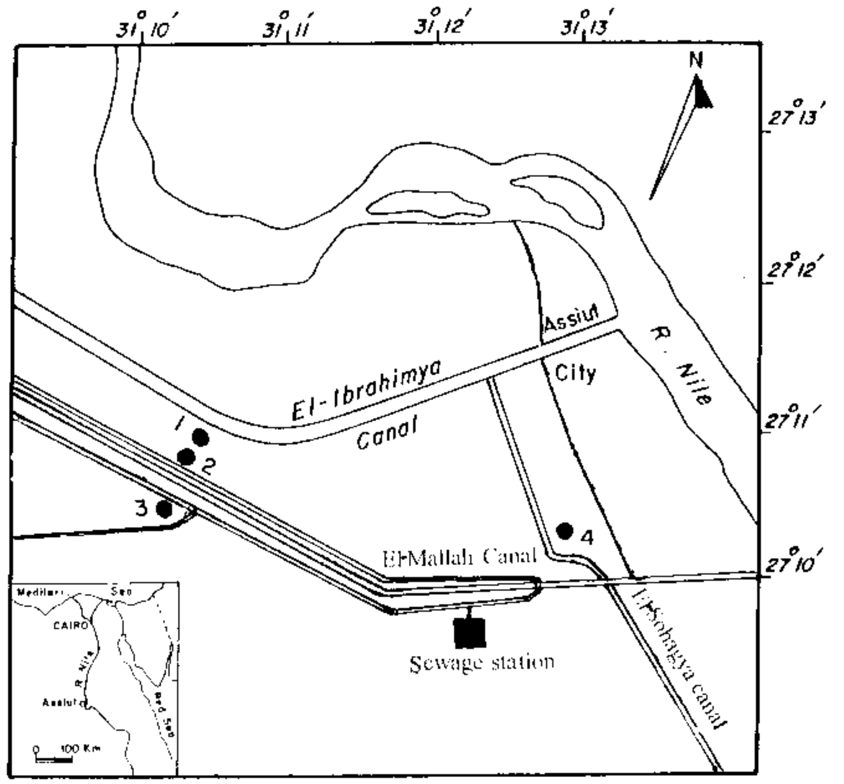

Fig.(1) Location of the studied soil profiles

Table (1): Some chemical properties of the irregation waters used

Character	Fresh Nile	Artesian	Sewage polluted Nile	Agric. drainage polluted Nile
pH	7.28	7.37	7.40	8.20
EC(ds/m)	0.40	1.09	0.96	0.77
SAR	1.79	1.66	3.51	2.66
Cations(meq/l):				
Ca^{+2}	0.80	1.00	1.20	0.80
Mg^{+2}	0.80	3.00	1.20	2.00
Na^{+}	1.60	2.35	3.85	3.15
K^{+}	0.20	0.40	0.65	0.20
Anions(meq/l):				
CO_3^{--}	0.40	0.80	0.20	0.40
HCO_3^{-}	2.40	6.20	4.80	3.80
Cl^{-}	0.60	2.00	1.80	2.20
SO_4^{--}	0.40	1.50	2.20	1.20
Heavy metals (ppm):				
Fe	0.14	0.28	0.35	0.16
Mn	0.08	0.12	0.24	0.10
Zn	0.08	0.10	0.18	0.08
Cu	0.02	0.04	0.16	0.04
Ni	0.03	0.03	0.10	0.03
B	0.09	0.10	0.14	0.09
Pb	0.13	0.09	0.25	0.14

Undisturbed soil samples were taken from the surface and subsurface layers of the studied profiles and carried to the lab for preparing thin sections according to the procedure outlined by Abd El-Hamid (1973). The micro-morphological description and interpretation were achieved according to the systems of Brewer (1964) and Brewer and Sleeman (1969) and photographed, using a polarizing microscope.

RESULTS AND DISCUSSIONS:

1-Soil Morphology:

The morphological description of the studied profiles is given in Table (2). Generally, the studied soils are located at moderately high elevation about 51 m a.s.l., with flat to almost flat topography. The profiles are deep of water table deeper than 150 cm, indicating that these soils have drainage class from moderately well drained (profiles irrigated with artesian and agric. drainage polluted Nile waters) to well drained in the rest of profiles. Although, the surface and subsurface layers of soils irrigated with fresh Nile, artesian and sewage polluted Nile waters have the same texture grade (sandy loam), the matrix colour is darker in surface samples of soil irrigated with sewage polluted Nile water. It is dark greyish brown (10YR 4/2) when dry and very dark grayish brown (10 YR 3/2) when moist, in the soil surface irrigated with sewage polluted Nile water, which could be ascribe to added the organic materials in suspensions. Also, the surface horizon of soil irrigated with sewage polluted Nile water has both different structure and consistency from those soils irrigated with other waters. It has a

weak, very fine to medium subangular blocky structure and its consistency is soft when dry, friable when moist and slightly sticky when wet. Regarding the boundaries, clear smooth was observed between the surface and subsurface layers in all profiles. Whereas abrupt smooth boundary is shown between the second and third layers in all profiles except the profile irrigated with sewage polluted Nile water, which is present as abrubt wavy.

2- Physical and chemical properties:

Data in Table 3 show that most layers of the studied soils (sites irrigated with fresh Nile and sewage polluted Nile waters; the surface and subsurface layers of site irrigated with artesian water) have relatively coarse texture (mainly sandy loam; sand). Whereas soils irrigated with agric. drainage polluted Nile water and the lower layer of soils irrigated with artesian water have finer textures (mainly loam and clay loam). The data also indicate that the soils irrigated with sewage polluted Nile water have higher organic matter content, especially in the surface layer (2.29%) compared to other soils. The soil surface irrigated with artesian water has the highest content of calcium carbonate (3.68%) followed by that irrigated with sewage polluted Nile water (3.39%). Moreover, the lower layer of the soil irrigated with fresh Nile water has the lowest amounts of organic matter (0.29%) and calcium carbonate (0.42%).

Generally, all the studied soils are considered moderately alkaline of pH values range from 7.78 to 8.23. The lowest value is recorded for the surface layer of soil irrigated with fresh Nile water followed by those irrigated with sewage polluted Nile water. The highest values of pH are found in the lower layer of soil irrigated with sewage polluted Nile water, followed by the soils irrigated with agric. drainage polluted Nile and artesian waters (Table 3).

Concerning the salinity, these soils are salt-free, where the ECe values are up to 3.18 dsm^{-1}. The highest values are found in the soil irrigated with artesian water, followed by the soils irrigated with agric. drainage polluted Nile, sewage polluted Nile waters and then, the soil irrigated with fresh Nile water. The highest values of soluble cations i.e. Ca^{+2}, Mg^{+2} and K^{+} are found in the soils irrigated with artesian water, while the highest value of soluble Na^{+} was recorded for the surface horizon of the soils irrigated with agric. drainage polluted Nile water. Exchangeable sodium percentage (ESP) values of the studied soils are less than the critical value (15%). They range from 0.03 to 3.96% and their highest values are measured in the soils irrigated with artesian and agric. drainage polluted Nile waters, but the lowest value is detected in the soils irrigated with sewage polluted Nile water. Concerning the cation exchangeable capacity (CEC), highest values were measured in the soil irrigated with agric. drainage polluted Nile water and the lower layer of the site irrigated with artesian water, indicating that the clay content is the most effective than the water source (Table 2&3).

Most of the previous results clearly reflect the role of irrigation water and its constituents in affecting soil properties determined. Similar results, particularly for soil irrigated with sewage polluted Nile water were obtained by Waly *et al.* (1987), Awad (1991), Amira (1997), El-Gendi *et al.* (1997) and El-Desoky and Gameh (1998).

Extractable metals determined are presented in Table (4). The results reveal that the contents and distributions of these metals do not give a specific trend for the different studied soils. Where the soils irrigated with

artesian water have the highest extractable Fe, Ni and B. The soils irrigated with agric. drainage polluted Nile water show a relatively higher value of Mn than the others. Also, the soils irrigated with sewage polluted Nile water have relatively greatest extractable Zn, Cu and Pb.

Table (4): Concentrations (ppm) of metals in the studied soil samples

Profile No.	Depth (Cm)	Fe	Mn	Zn	Cu	Ni	B	Pb
1	0 - 15	13.71	9.68	1.65	3.08	0.43	0.66	0.39
	15 - 45	14.89	7.56	0.52	1.79	0.26	0.57	0.28
	45 - 150	10.21	5.22	0.31	0.54	0.22	0.45	0.36
2	0 - 25	15.25	18.97	1.16	2.44	0.64	1.16	0.43
	25-65	15.62	6.44	0.50	1.75	0.35	1.07	0.39
	65-150	15.65	16.50	0.91	2.69	0.60	1.13	0.29
3	0-10	8.17	13.73	1.63	3.63	0.48	0.70	0.49
	10 30	12.41	24.90	1.62	2.55	0.50	0.80	0.24
	30-150	14.24	4.84	0.52	1.06	0.28	0.44	0.36
4	0-25	7.67	5.58	0.58	2.49	0.49	0.57	0.06
	25-45	11.40	22.83	0.63	2.61	0.32	0.49	0.16
	45-150	4.24	28.18	0.53	3.24	0.48	0.58	0.25

3-Soil Micromorphology:

Micromorphological features of thin sections prepared from undisturbed surface and subsurface soil samples of the studied profiles are summarized in Table (5) and illustrated in photos 1-8. They are described in the following:

a-Soil matrix:

Skeleton grains: They are mainly attributed to the natural sedimentation pattern of the Nile alluvial deposits, since these grains are poorly sorted without wide variations among the irrigated soils with different water sources. The examined samples are mainly characterized by coarse subrounded to rounded mono and polycrystalline, sometimes craked, quartz grains. Few angular to subangular fine grains of quartz were observed. The presence of fine angular to subangular quartz grains with coarse rounded ones could be referred to the action of some geologic processes under prevailing arid conditions, including in situ disintegration of the coarse grains to fine ones and/or mixing with aeolian sand (El-Husseiny and Saadani, 1992). These soils contain also little amounts of feldspars, opaques (iron oxides), mica flakes and rock fragments (chert and some volcanics) as well as heavy minerals.

Skeleton-plasmic fabric: It is mainly porphyroskelic and agglomeroplasmic fabrics for soil surfaces irrigated with Nile, artesian and sewage polluted Nile waters. Agglomeroplasmic with intertextic fabrics characterize the subsurface samples of both soils irrigated with fresh Nile and artesian waters, but porphyroskelic with intertextic fabrics are for the soils irrigated with sewage polluted Nile water. Plasma occurs as a dense groundmass, in which silty sized quartz grains were embedded, in the soil surface and subsurface irrigated with agric. drainage polluted Nile water with a porphyroskelic fabric. The similarity in soil fabric, in most of studied soils, can probably be due to the similar deposition mode and the less clear effect of management practices in changing it.

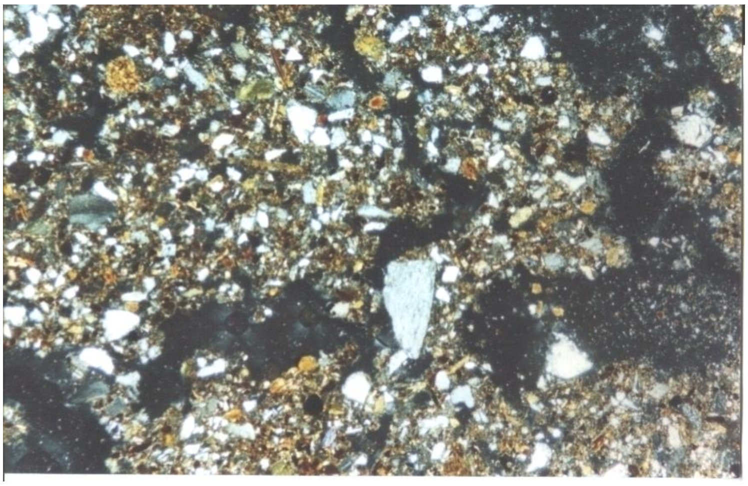

Photo (1): Porphyroskelic plasmic fabric with interconnected irregular orthovughs, channels and chambers (surface of profile 1, CN. 25X).

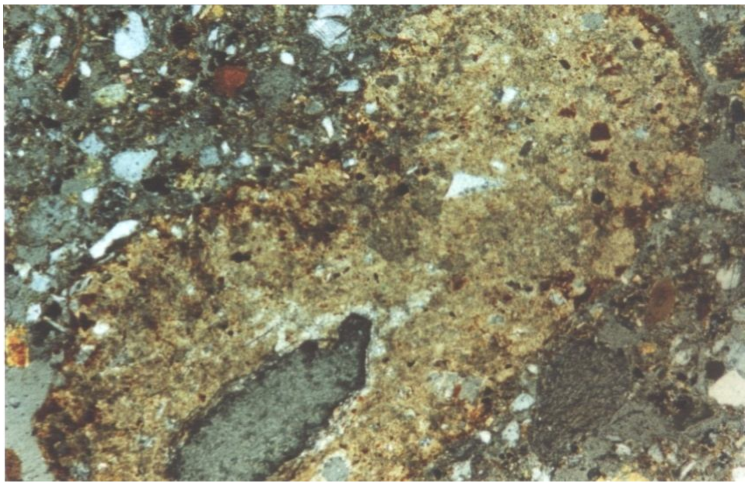

Photo (2): Carbonate nodules with internal quartz and voids (surface of profile 1, CN. 50X)

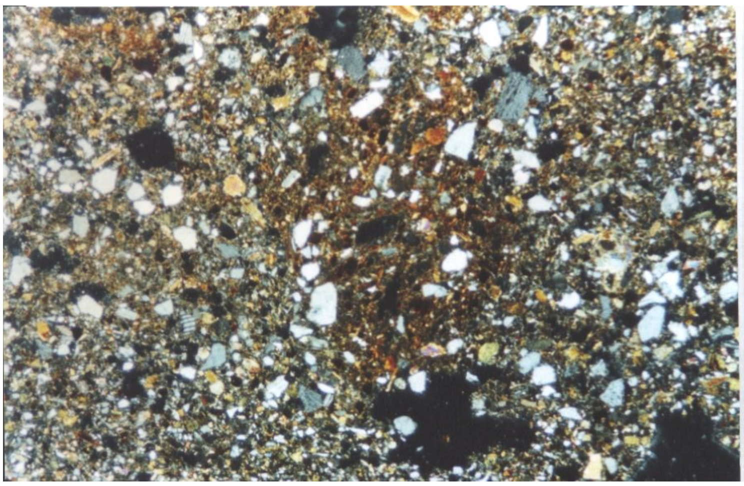

Photo (3): Silasepic plasma fabric, with frequent silt-sized quartz particles (sub-surface of profile 1, CN. 25X)

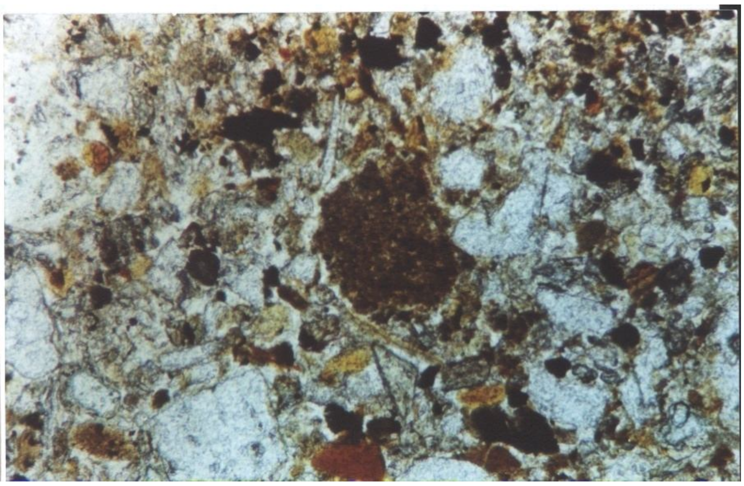

Photo (4): Magniferrous and fine sesquioxidic nodules (surface of profile 2, PL. 100X)

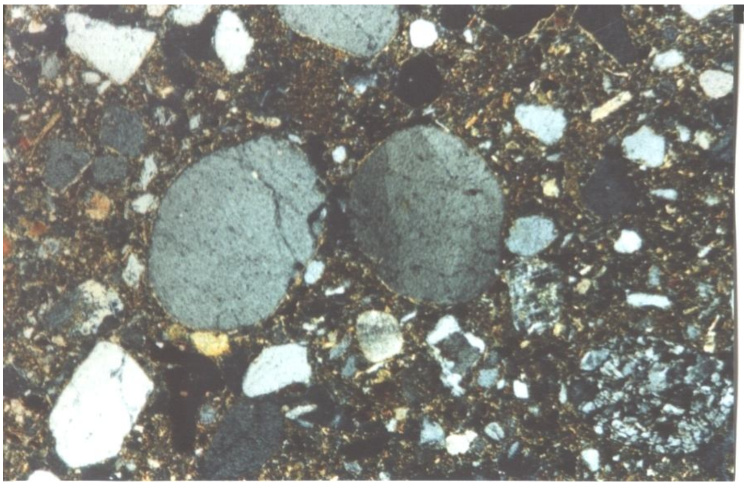

Photo (5): Rounded to subrounded slightly cracked medium to coarse quartz grains, skelsepic and embedded grains, coated with ferri-argillans (surface of profile 2, CN. 50X)

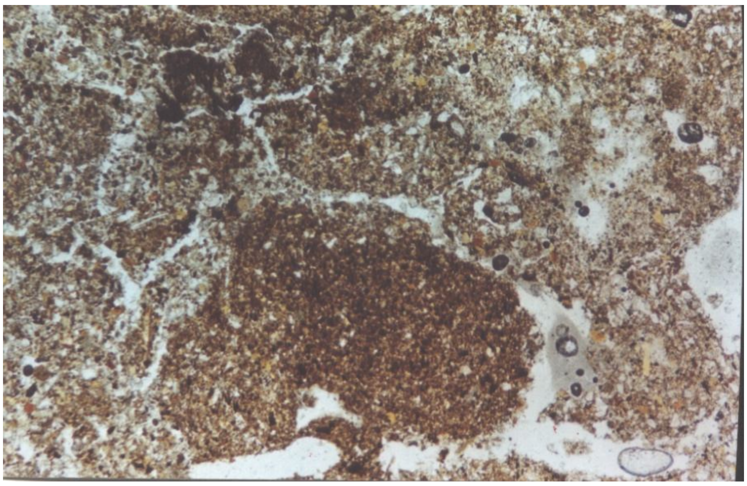

Photo (6): Vesicles, vughs, skew and craze planes with organo-argillaceounodules (surface of profile 4, PL. 25X)

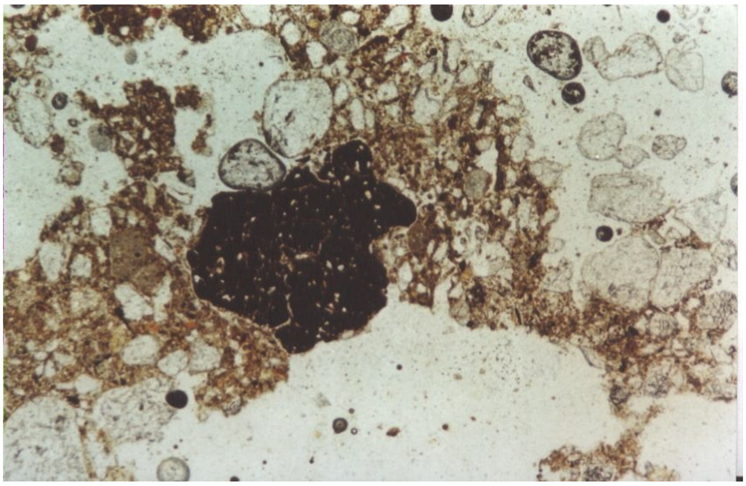

Photo (7): Irregular magniferrous nodule
(sub-surface of profile 3 PL. 25X)

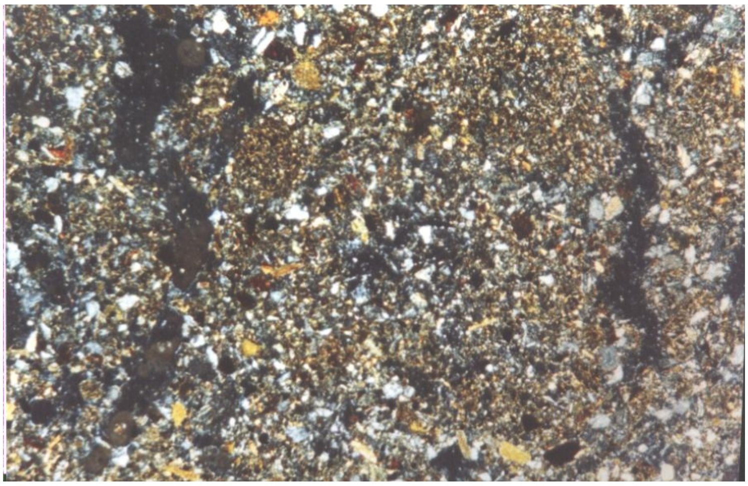

Photo (8): Dense plasma with silty sized grains,
subparallel grains insepic and fine argillaceous nodules
(sub-surface of profile 4, CN. 50X).

Plasma: **The argillasepic plasmic fabric predominates in the examined samples of the studied soils, except in the subsurface of both soils irrigated with fresh Nile and artesian waters that have silasepic plasmic fabric. This may be inherited from Nile alluvium deposits. Plasma occurs as brownish grey in the surface and light brown in the subsurface of soils irrigated with artesian and sewage polluted Nile waters due to the relatively higher iron content of the water. Moreover, plasma separations are noticed as vo-in-sepic in all studied samples. Skelsepic fabric is observed in the surface samples of soils irrigated with Nile, artesian and sewage polluted Nile waters, also in the subsurface of the latter.**

Voids: **The dominant type in the investigated samples is vughs that mainly appear as interconnected irregular ortho and/or metavughs. Some mammillated vughs were recorded in the surface of sites irrigated with fresh Nile, artesian waters, as well as the subsurface of soil irrigated with artesian and**

agric. drainage polluted Nile waters. Vesicles are noticed in all surface samples. Channels and chambers are seen in the surface samples irrigated with fresh Nile, artesian and the subsurface ones irrigated with the other water sources. Skew planes are few in the surface of soils irrigated with sewage polluted Nile water and agric. drainage polluted Nile waters, and the latter, also has craze planes, while sub-parallel are shown in the subsurface samples irrigated with agric. drainage polluted Nile water. These observed voids, i.e. vughs may be formed by adhesion of plasma particles to each others and to the coarse skeleton grains or by differential weathering of mineral grains and complete removal of the weathering products by leaching. Vesicles are formed by bubbles of gas or steam. Channels and chambers are commonly formed by the activity of plant roots, soil fauna, earthworms and termites. Planes can be originated through swelling and shrinkage during wetting and drying of soil material (Brewer, 1964). So, the presence of these types of voids suggest that more than mechanism is involved.

b-Pedological features:

These are mainly cutans, subcutans and glaebules:

Cutans and subcutans: Thin stress opaque organo-argillans were present on the surface of grains and walls of voids in the surface layer of soil irrigated with fresh Nile and agric. drainage polluted Nile waters, whereas argillans occur in the subsurface ones. However, walls of voids and embedded grains were slightly coated with ferri-argillans in the examined samples of soil irrigated with both artesian and sewage polluted Nile waters. This may be attributed to the relatively high iron content in these waters. This phenomena suggests a slight movement of weathering products from soil surface and their illuviation in the subsurface (Farragallah, 2001), and also effect of irrigation processes where iron move in the soluble form (Fe^{+2}) and then reoxidized and precipitated on surfaces of skeleton grains and on walls of voids (El-Husseiny and El-Saadani, 1992).

Glaebules: They include nodules and concretions that occur in various sizes. Organo-argillaceous and carbonate nodules with internal quartz and voids are observed in the surface and subsurface layers of soils irrigated with both fresh Nile and agric. drainage polluted Nile waters. On the other hand, sesquioxidic, manganiferrous and ferromanganic-carbonate nodules are noticed in the soils irrigated with either artesian or sewage polluted Nile waters. Iron and manganese in soluble forms (Fe^{+2} and Mn^{+2}) move downward in the soil and oxidize under soil conditions and precipitated around the carbonate nodules to form ferromanganic-carbonate concretions or within the matrix as ferromanganic nodules (El-Husseiny and El-Saadani, 1992). Formation of carbonate nodules is controlled by carbonate-bicarbonate equilibria. Precipitation of $CaCO_3$ may be caused by the decreased CO_2 partial pressure, raised pH, increased evaporation and by biological activity (Goudie and Pye, 1983). The voids within carbonate nodules could be attributed to water evaporation and CO_2 release during $CaCO_3$ precipitation (El-Husseiny and El-Saadani, 1992). The relatively high degree of adhesitivity and diffusitivity either for carbonate and ferromanganic nodules or for ferromanganic-carbonate concretions, provide a good evidence for their orthic origin and in situ formation. Sharpness of boundaries and roundness of some nodules are related to the periodic desiccation and to the processes of formation (Brewer, 1964).

c-Pedality:

All studied soil samples have apedal soil materials. This reflects their young nature and also their weak signs of development.

d-Level of organization:

It is mainly primary structure, that includes glaebular (argillaceous and carbonate nodules) cutanic (organo-argillans) vughy vosepic fabric in the soils irrigated with the fresh Nile and agric.dranaige polluted Nile waters. Whereas, it is glaebular (sesquioxidic, manganiferrous and ferromanganic-carbonate nodules) cutanic (ferri-argillans) vughy vosepic porphyroskelic fabric in soil irrigated with the artesian and sewage polluted Nile waters.

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الخصائص الطبيعية والكيميائية والمورفولوجية و الميكرومورفولوجية لبعض الأراضى الرسوبية النهرية المروية بمصادر مائية مختلفة فى محافظة أسيوط-مصر

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بجانب مياه النيل التى تعتبر المصدر الرئيسى للمياه فى مصر، توجد مياه أخرى تستغل فى الزراعة بمناطق عديدة مثل المياه الجوفية وإعادة استخدام مياه الصرف الصحى والزراعى.

هدف هذا البحث إلى دراسة الخصائص المورفولوجية والميكروموفولوجية والطبيعية والكيميائية لبعض الأراضى الرسوبية النهرية المروية بهذه المياه المختلفة فى محافظة أسيوط. وقد اختيرت لهذه الدراسة أربعة قطاعات أرضية كل قطاع تمثل الأراضى التى تروى بنوع معين من هذه المياه. وتم حفر هذه القطاعات حتى عمق 150سم ووصفت مورفولوجيا. ثم أخذت العينات اللازمة من كل طبقة وقدرت الخواص الطبيعية والكيميائية المطلوبة. وأعدت شرائح رقيقة من العينات السطحية وتحت السطحية كما هى موجودة فى الطبيعة (الغير مثارة) وتم دراسة الظواهر الميكرومورفولوجية بها.

وقد أظهرت النتائج المتحصل عليها أن طبوغرافية القطاعات مستوية إلى شبه مستوية وحالة الصرف بها جيدة ومستوى الماء الأرضى عميق (أكثر من 150 سم). بالرغم من أن الطبقة السطحية وتحت السطحية للأراضى المروية بمياه النيل والمياه الجوفية والمياه الملوثة بالصرف الصحى لها نفس القوام (Sandy loam) إلا أن الطبقة السطحية المروية بالمياه الملوثة بالصرف الصحى كانت مختلفة فى اللون والبناء والمقاومة. وقد وجد أنها تحتوى على أعلى قيم للمادة العضوية ، pH وكل من الزنك والنحاس والرصاص المستخلص بواسطة DTPA بينما احتوت الأرض المروية بالمياه الجوفية على كميات عالية من كربونات الكالسيوم والأملاح ESP وكل من الكالسيوم والماغنسيوم والبوتاسيوم الذائب وكذلك الحديدو النيكل والبورون المستخلص بينما احتوت الأرض المروية بالمياه الملوثة بالصرف الزراعى على قيم عالية من الصوديوم الذائب CEC والمنجنيز المستخلص.

وفيما يخص دراسة الظواهر الميكرومورفولوجية فقد وجد أن البناء المفكك Apedal للعينات التى تم فحصها من النوع Primary مع وجود بعض الحصيات والعقد الطينية والجيرية فى الأراضى المروية بمياه النيل وبالمياه الملوثة بالصرف الزراعى، بينما وجدت بعض الحصيات والعقد الحديدية والحديدو منجنيزية والجيرية فى الأراضى المروية بالمياه الجوفية وبالمياه الملوثة بالصرف الصحى. وهذه الدراسة توضح أثر نوعية مياه الرى المستخدمة فى التغيير الطفيف على بعض خواص التربة الطبيعية والكيميائية والميكرومورفولوجية والذى يمكن أن يغير من صفاتها ومحتواها خاصة من العناصر الغير مرغوب فيها باستمرار استخدام مياه الرى وخاصة الأرتوازية، مياه الصرف الصحى والصرف الزراعى لسنين عديدة.