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LONG-TERM EFFECTS OF SUBSURFACE DRAINAGE SYSTEMS ON SOME SOIL PROPERTIES OF EL-SHARKIA GOVERNORATE

Hassan, E.A.*; E.E. Fouda*; E.A. Abdel-Bary* ; M.A. Emara and M.S. Tahoun***

* Soil Sci. Dept., Fac. Agric., Zagazig University, Egypt
** Drainage Res. Inst., National Water Res. Center, Egypt

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ABSTRACT: Waterlogging and salinity problems arise as a result of poor water management in irrigated agriculture. These problems are serious constraints for crop production in the arid and semi arid regions of the world. Although high investments have been made in irrigation, limited success was achieved due to lack of adequate drainage. Unfortunately, the natural drainage in many areas is not enough to account for the excess irrigation water which results in a rising watertable situation. Artificial drainage is often necessary to maintain the productivity of agricultural lands.

A research work was conducted in two areas provided with subsurface drainage systems since 1978 at Nebtit area and 1980 at Mashtul pilot area to study the long-term effect of subsurface drainage systems on some soil chemical properties. The results of this study indicated that the higher values of soluble calcium concentration is found at 100-150 cm and 150-200 cm soil depths at the three studied soil profiles in drainage units 7, 8 and 9 at Mashtul pilot area. The values of soluble calcium concentration at all soil depths in Mashtul are considerably lower than the values obtained in Nebtit area. The same conclusions are also obtained in the case of soluble sodium, magnesium and potassium. Also, higher concentrations of both soluble magnesium and sodium are observed at different soil depths at the three studied soil profiles at Nebtit area compared with lower concentrations observed at Mashtul pilot area for the same soluble cations. Moreover, soils of Nebtit area at studied locations showed higher concentrations of soluble chloride and sulphate compared with the soils in the other studied locations at Mashtul pilot area. It can be concluded also that leaching of soluble salts in Mashtul pilot area is higher than in Nebtit area due to the proper function of subsurface drainage system in Mashtul pilot area. The most important conclusion obtained is that the performance of subsurface drainage system in Mashtul pilot area is much better than the ones in Nebtit area which needs rehabilitation of the old subsurface drainage system.

INTRODUCTION

Several factors contribute to the failure of a drain line installed such as excessive joint width between successive sections of concrete pipes, improper alignment of successive sections of concrete pipes, improper connections between collector and lateral drain pipes, improper perforation area in plastic tubes or gap width between concrete pipes, failure or collapse of drain tubes due to excessive loads or inadequate pipe strength, and improper design, location, selection, manufacturing and application of drain envelopes. Therefore, appropriate subsurface drainage materials are required to ensure adequate drainage of agricultural lands. Shallow watertable will encourage soil salinization. Soluble salts are then left behind and precipitate within the root zone. Shallow watertable is often identified as the main cause of soil salinization in the Nile Delta of Egypt. This shallow watertable can be the result of over irrigation, discharge of groundwater from upper to lower areas or canal seepage. In arid and semi-arid areas, the permissible depth of the water table must not only provide sufficient aeration within the root zone but must also ensure that the watertable is sufficiently deep to prevent upward capillary flow of saline water into the root zone. Most of the upward capillary flow of saline water to the root zone occurs during the non-irrigated season and a net downward flow prevails during irrigation (Abu-Sinna, 1991). Moreover, Balbaa (1981) stated that the most prevalent salts in saline soils of the Nile Delta are sodium chloride and sodium sulphate. Also, El Mowelhi (1972) found that alkali spots were formed in poorly drained areas (Kafr El Sheikh Governorate) where the groundwater table was about 68 cm from soil surface. He stated that salt accumulation is considered to be the first stage in the process of alkalinizaiton. In alkali spots soluble cations are dominated by sodium. Therefore, sodium is the predominant adsorbed cation. In addition, Moustafa *et al.,* (1990a) studied the effect of tile drainage on soil properties and productivity at Fayoum Governorate. They found that both soil salinity and alkalinity have been reduced by tile drainage system. Hence, soil productivity increased as a result of the reduction of salinity. Also, Wahdan *et al.,* (1992) showed that applying subsurface drainage for 12 years to silty clay loam soil significantly reduced the salinity of the soil profile. The reduction was increased as the drain spacing decreased under the drain depth, i.e., 120 and 150 cm.

The main objectives of this study are to evaluate the efficiency of old subsurface drainage system and to study the effect of subsurface drainage systems on some soil chemical properties at Sharkia Governorate.

MATERIALS AND METHODS

Selected areas:

Mashtul and Nebtit areas are selected for this study, Figure 1. The first area is selected and situated in the East Bahr Saft area, about 7 km north of Zagazig city. It encompasses a gross area of about 260 feddan. The area was provided with subsurface drainage system in 1980. The second selected area is located in Mashtul El Sook and named Nebtit area, about 40 km south of Zagazig city. In Mashtul and Nebtit areas , collector drain pipes are made of concrete, while lateral drains are made of corrugated plastic PVC drain tubes with inner diameter of 72 mm and outer diameter of 80 mm. Collector (I) was chosen at Mashtul area and served an area of about 52.4 ha throughout the course of the study. Three drainage units were selected at collector (I), number 7, 8, and 9 which have served area of 3.75 ha, 4.15 ha , and 3.9 ha respectively. Each unit was provided with four lateral drains with spacing of 30 m, while the drain depth is 1.20 m in drainage units 7, and 9 and 1.5 m in drainage unit 8. The subsurface drainage system in Nebtit area has been constructed since 1978 and three collector drains were selected to carry out this study including collector drains 5, 6, and 19. Soil sampling was made to determine pH, EC, soluble cations and anions, and saturation percentage according to Rhoades (1982). One auger-hole was made at each selected drainage unit in which soil samples were collected at depths of 0-25, 25-50, 50-100, 100-150, 150-200 cm below soil surface. The soil samples were collected from the same locations in which observation wells are installed at the same auger-holes.

Water samples were collected from each observation well at certain intervals. Also, one water sample was collected at the outlet of collector I and repeated during the measuring period. The pH, EC, soluble cations and anions, and SAR are measured in these water samples according to Jackson 1967. Soil sampling was collected from each selected collector. Sampling was made twice, at the beginning of summer season and by the end of winter season during the measuring period. The pH, EC, cations, anions, and saturation percentage were carried out on these collected soil samples using the same method mentioned before. One auger-hole was made at each selected collector in which soil samples are collected at the same soil depths used in Mashtul area.

Water samples were collected from the nine observation wells at certain intervals during the measuring period. Also, three water samples were collected at the outlets of the three studied collector drains and repeated during the measuring period. The pH, EC, soluble cations and anions, and SAR were measured in these water samples.

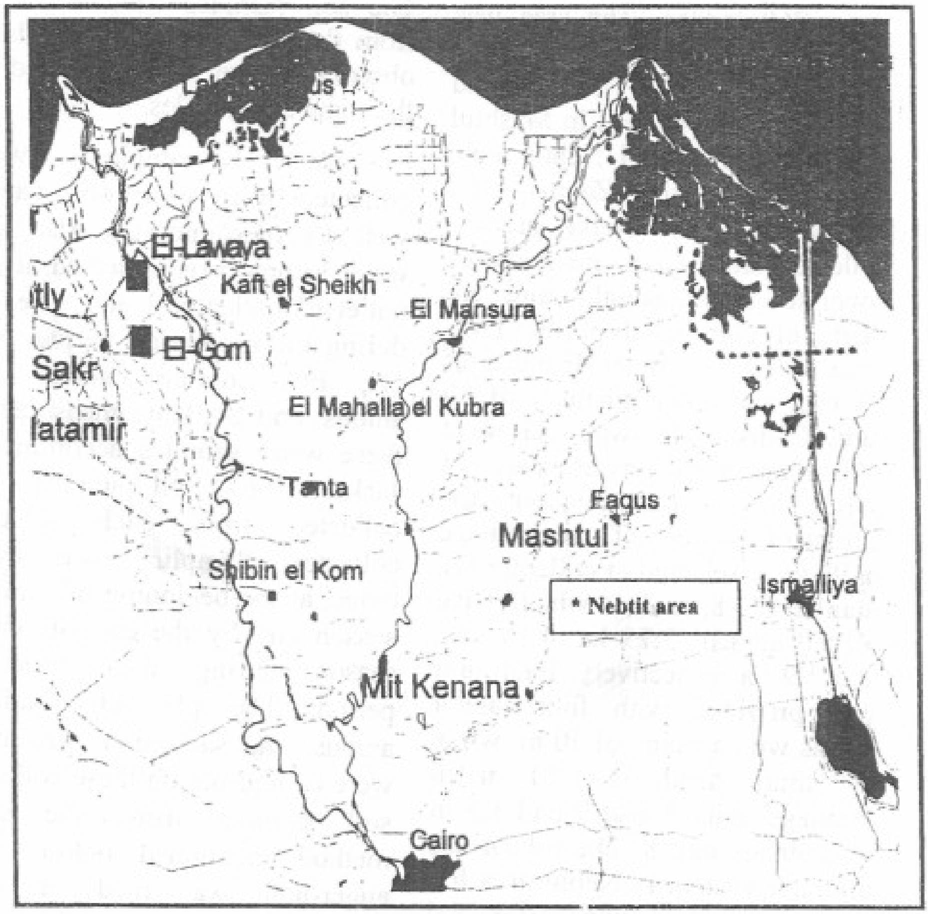

Figure 1. Location of the studied areas.

RESULTS AND DISCUSSION

Effect of subsurface drainage on watertable salinity:

Figures (2, 3, and 4) show the results of the chemical composition of the groundwater table measured in the observation wells at both studied areas. Figure (2) illustrates the average salinity values of the groundwater table. It is obvious that the average salinity of groundwater table in which collectors (5 and 19) in Nebtit area show lower values compared with other average values at collectors (8) and (I) (2.3 to 3.5 dS/m). Also, the highest average salinity is obtained at collector (I) at Mashtul pilot area. Also, Figure (3) shows the average SAR values obtained from different observation wells at different studied collector drains in Mashtul and Nebtit areas. It is obvious that there are no significant differences between the results at different collector drains. The highest average value is obtained at collector (8) in Nebtit area (5.67-7.03). In addition, Figure (4) shows the average values of soluble cations and anions in the groundwater table obtained from different observation wells at different studied collector drains in Mashtul and Nebtit areas. The highest values of soluble calcium, magnesium and sodium are observed at collector (I) at Mashtul pilot area compared with other collector drains, while the lowest values are obtained at collector (19) in Nebtit area. Moreover, the average potassium values are low and varied between 0.47 to 0.57 meq/l. Also, the highest values of soluble chloride and sulphate are observed at collector (I) at Mashtul pilot area compared with other collector drains. In the case of soluble bicarbonate, collector drains (I), 5, and 8 showed similar results, while the lowest value is obtained at collector drain (19).

Effect of subsurface drainage on some soil chemical properties

Soil salinity:

Figure (5) shows the results of soil salinity (EC) at both Mashtul and Nebtit areas. The overall average of soil salinity at Mashtul pilot area is 0.44 dS/m. These results are attributed to the role of subsurface drainage system which encourages the leaching processes of salts from the soil profile with the recession of the watertable. Regarding Nebtit area, the overall average of soil salinity at collectors 19, 8 and 5 are 7.24, 2.62,and 5.6 dS/m respectively. It can be concluded that soil salinity at Nebtit area are high compared with Mashtul pilot area. The increase of soil salinity in Nebtit area could be attributed to the poor performance of subsurface drainage systems at this area.

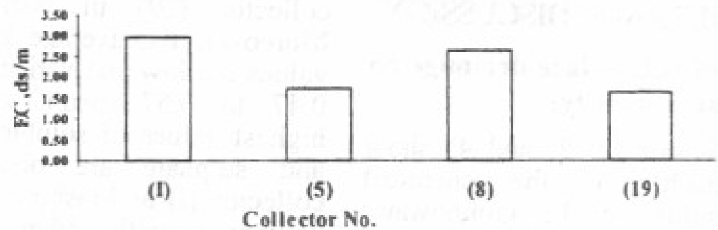

Figure 2. Average salinity of groundwater table obtained from different observation wells at different studied collector drains in Mashtul and Nebtit areas.

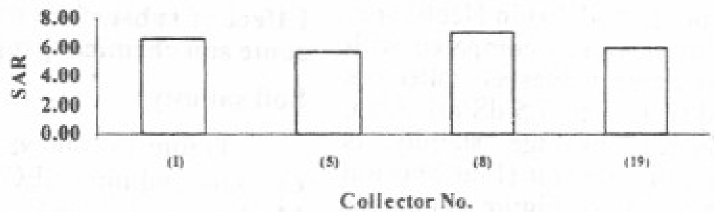

Figure 3. Average SAR of groundwater table obtained from different observation wells at different studied collector drains in Mashtul and Nebtit areas.

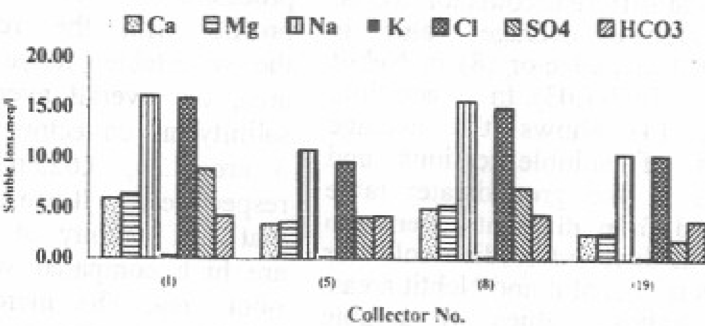

Figure 4. Average soluble ions of groundwater table obtained from different observation wells at different studied collector drains in Mashtul and Nebtit areas.

Soluble ions :

Figures (5,6,and7) illustrated the average concentrations of soluble calcium, magnesium, sodium, and potassium in Mashtul and Nebtit areas. In Mashtul area, the average concentration of the soluble calcium varied between 0.66 to 1.52 meq/l at studied locations. Moreover, average soluble magnesium varied from 0.95 to 2.53 meq/l. In addition, the average soluble sodium varied between 6.16 to 12.0 meq/l, while the average soluble potassium varied between 0.06 to 0.10 meq/l. Figures (5, 6, and 7) show also the results of soluble calcium, magnesium, sodium and potassium in Nebtit area in which the average concentration of the soluble calcium varied between 4.92 to 11.14 meq/l. Average soluble magnesium varied from 6.56 to 18.74 meq/l. Moreover, the average soluble sodium varied between 15.8 to 41.28 meq/l, while the average soluble potassium varied between 0.54 to 0.65 meq/l. Comparing the results of both studied areas, the following conclusions can be drawn:

1- The higher values of soluble calcium concentration are found at 100-150 cm and 150-200 cm soil depths at the three studied soil profiles in drainage units 7, 8 and 9 at Mashtul pilot area. The values of soluble calcium concentration at all soil depths in Mashtul are considerably lower than the values obtained in Nebtit area. The same conclusions are also obtained in the case of soluble sodium, magnesium and potassium.

2- Higher concentrations of both soluble magnesium and sodium are observed at different soil depths at the three studied soil profiles at Nebtit area compared with lower concentrations observed at Mashtul pilot area for the same soluble cations.

3- The results indicate that subsurface drainage constructed at Mashtul pilot area still performing satisfactory even after more than 20 years while the drainage system could be poor at Nebtit area and can not satisfactorily control soil salinity. It can be also concluded that, the drainage systems at Nebtit area needs rehabilitation.

Figures (7and 8) representing the average results of soluble anions at Mashtul and Nebtit area. The average soluble concentrations of chloride in the studied locations at Mashtul pilot area varies between 2.94 to 6.64 meq/l. In addition, the average soluble concentrations of chloride in the studied locations in Nebtit area varies between 16.44 to 48.62 meq/l. Also, data illustrated in Figures (17, 18, and 19) show the results of soluble chloride, sulphate, and bicarbonate in both Mashtul and Nebtit area. The average soluble concentration of sulphate varies between 2.35 to 5.05 meq/l in Mashtul pilot area, while in Nebtit area it varies between 6.08 to 18.49 meq/l. The average results for soluble bicarbonate concentrations at different studied locations in Mashtal pilot area fluctuate between 2.96 to 3.56 meq/l, while in Nebtit area it varies between 4.7 to 5.16 meq/l. From the aforementioned results it can be concluded that soils in Nebtit area at studied locations show higher concentrations of soluble chloride and sulphate compared with the soils in the other studied locations at Mashtul pilot area. In general, these results reveal that leaching of soluble salts in Mashtul pilot area is higher than in Nebtit area due to the proper function of subsurface drainage system in Mashtul pilot area. Moreover, it is clear from soil chemical results that the performance of subsurface drainage system in Mashtul pilot area is much better than the ones in Nebtit area.

CONCLUSIONS

The main conclusions of this study can be summarized as following:

a- The average salinity of groundwater table at collectors (5 and 19) in Nebtit area show lower values compared with other average values at collectors (8) and (I) (2.3 to 3.5 dS/m).

b- The highest average salinity is obtained at collector (I) at Mashtul pilot area.

c- The highest average SAR values are obtained at collector (8) in Nebtit area (5.67-7.03).

d- The highest values of soluble calcium, magnesium and sodium are observed at collector (I) at Mashtul pilot area compared with other collector drains, while the lowest values are obtained at collector (19) in Nebtit area. Also, the highest values of soluble chloride and sulphate are observed at collector (I) at Mashtul pilot area compared with other collector drains. In the case of soluble bicarbonate, collector drains (I), 5, and 8 showed similar results, while the lowest value is obtained at collector drain (19).

e- The soil salinity at Nebtit area is significantly higher than the ones at Mashtul area. This might be due to poor or lower drainage efficiency of the existed subsurface drainage system.

f- It is observed from the obtained results at both Mashtul and Nebtit areas that all soil profiles had pH values less than 8.5 indicating that no alkalinity problems are existed.

g- Comparing the results of soluble ions at both studied areas, the following conclusions can be drawn:

- The higher values of soluble calcium concentration is found at 100-150 cm and 150-200 cm soil depths at the three studied soil profiles in drainage units 7, 8 and 9 at Mashtul pilot area. The values of soluble calcium concentration at all soil depths in Mashtul are considerably lower than the values obtained in Nebtit area. The same conclusions are also obtained in the case of soluble sodium, magnesium and potassium.

- Higher concentrations of both soluble magnesium and sodium are observed at different soil depths at the three studied soil profiles at Nebtit area compared with lower concentrations observed at Mashtul pilot area for the same soluble cations.
- Soils of Nebtit area at studied locations show higher concentrations of soluble chloride and sulphate compared with the soils in the other studied locations at Mashtul pilot area.
- Leaching of soluble salts in Mashtul pilot area is higher than in Nebtit area due to the proper function of subsurface drainage system in Mashtul pilot area.
- The performance of subsurface drainage system in Mashtul pilot area is much better than the ones in Nebtit area which needs rehabilitation of the old subsurface drainage system.

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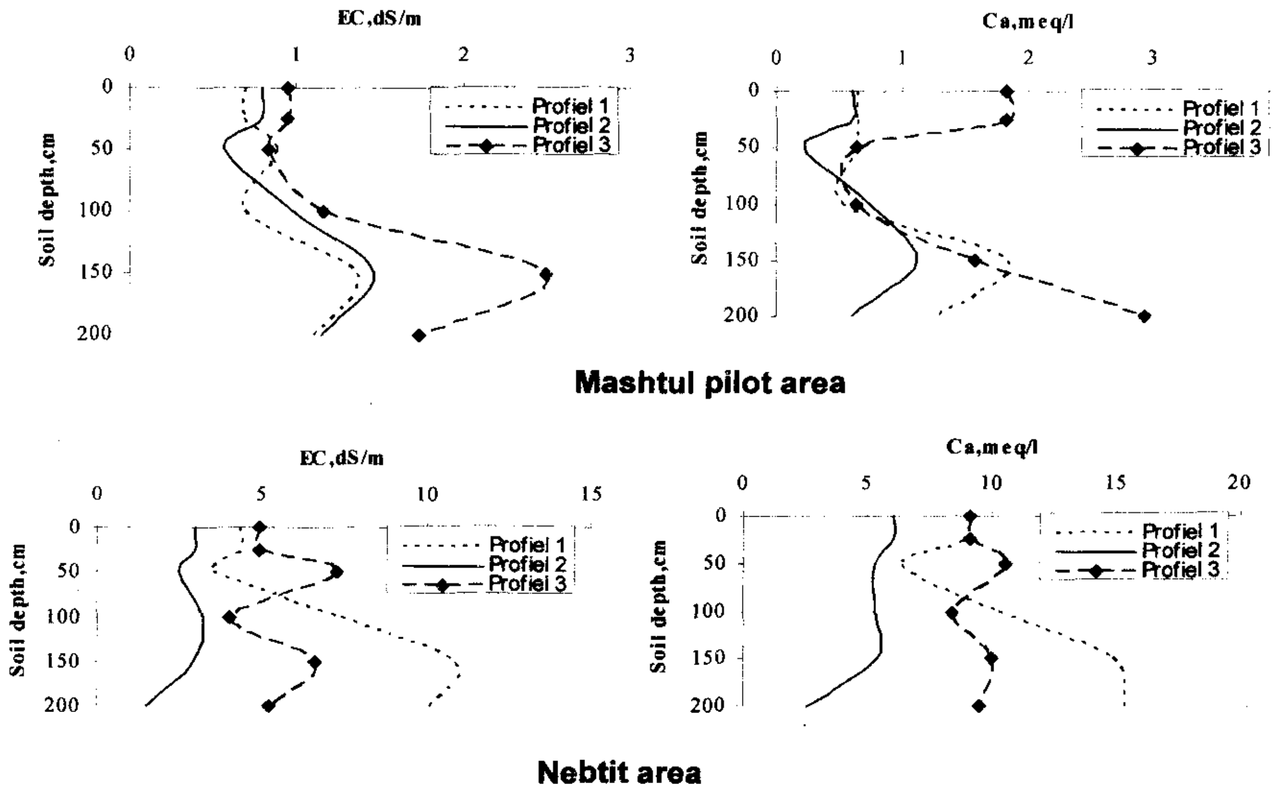

Figure 5. Average soil electrical conductivity (ECe) and soluble calcium in the collected soil samples at different soil profiles at Mashtul and Nebtit areas

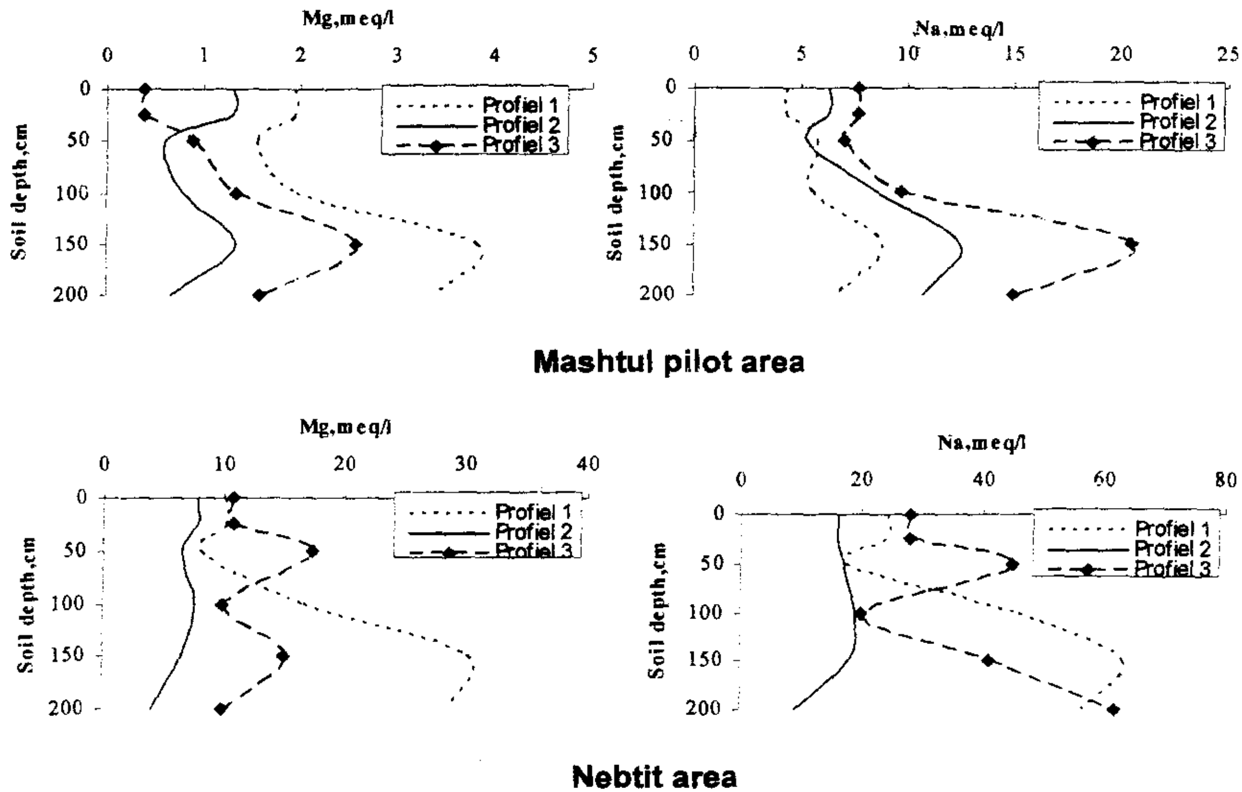

Figure 6. Average soluble magnesium and sodium concentrations in the collected soil samples at different soil profiles at Mashtul and Nebtit areas.

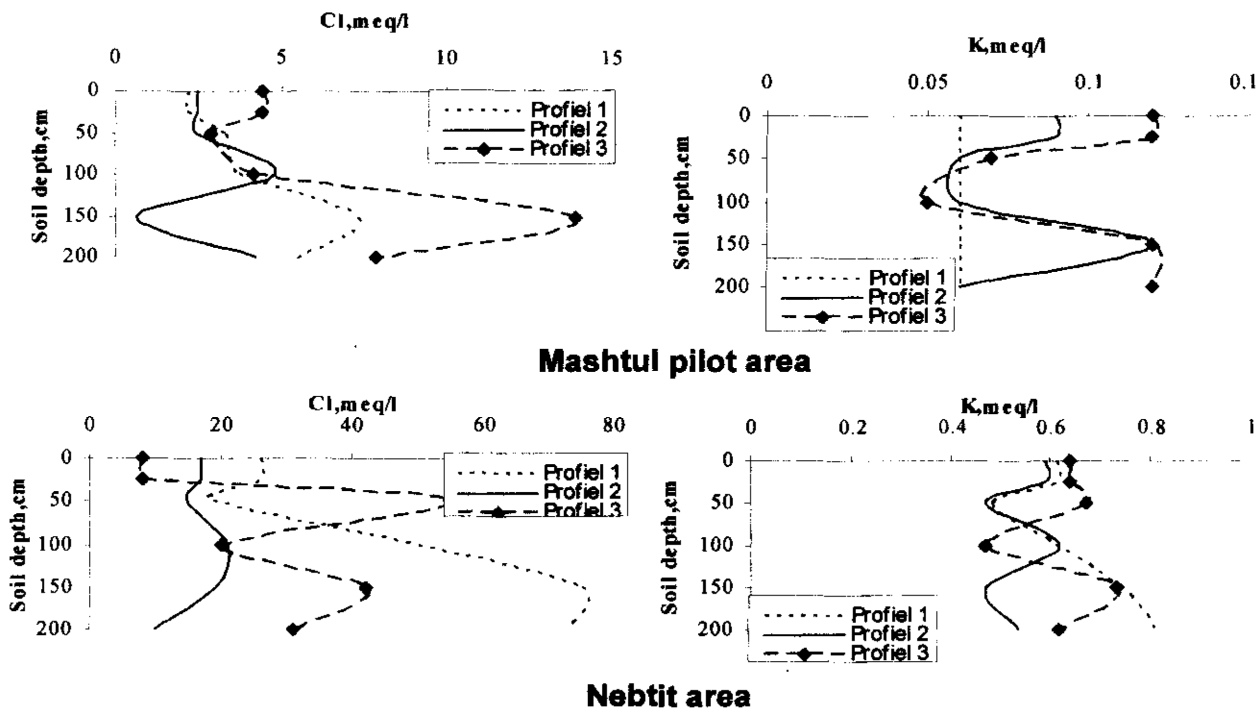

Figure 7. Average soluble potassium and chloride concentrations in the collected soil samples at different soil profiles at Mashtul and Nebtit areas.

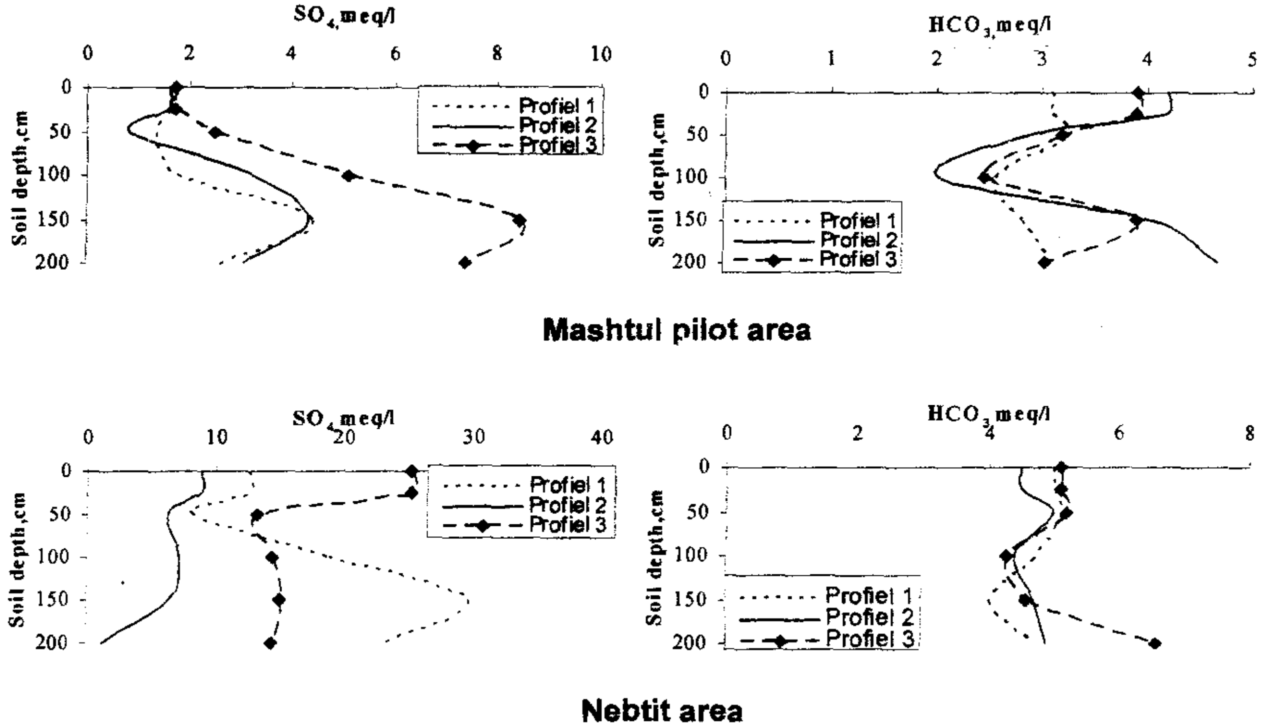

Figure 8. Average soluble sulphate and bicarbonate concentrations in the collected soil samples at different soil profiles at Mashtul and Nebtit areas.

التأثير الطويل المدى لنظام الصرف المغطى على بعض خصائص الأراضى بمحافظة الشرقية

الشحات عبد التواب حسن* – السيد السيد فودة* – السيد عبد النور عبد البارى* – محمد أكمل عمارة* – محمد شحاته طاحون**

* قسم الأراضى – كلية الزراعة – جامعة الزقازيق – مصر

** معهد بحوث الصرف – المركز القومى لبحوث المياه

تظهر مشكلة ارتفاع الماء الأرضى والملوحة نتيجة لسوء الإدارة المائية فى الأراضى المروية. وتعتبر هذه المشاكل أحد معوقات إنتاج المحاصيل فى المناطق الجافة وشبه الجافة فى العالم. والصرف الطبيعى فى عديد من المساحات غير كافى للتخلص من الماء الزائد وبالتالى يصبح الصرف الصناعى ضرورة للمحافظة على إنتاجية الأراضى الزراعية.

تم إجراء هذا البحث فى منطقة نبتيت ومنطقة مشتول بمحافظة الشرقية والمنطقتين منفذ بهما شبكة صرف مغطى منذ عام ١٩٧٨ للمنطقة الأولى، والثانية منذ عام ١٩٨٠م وذلك بهدف تقييم كفاءة نظام الصرف المغطى الطويل المدى ودراسة تأثير الصرف المغطى الطويل المدى على بعض الخواص الكيميائية للأراضى. ويمكن تلخيص أهم النتائج فيما يلى:

أعلى محتوى الكالسيوم الذائب فى الأرض وجد عند عمق ١٠٠ – ١٥٠سم، ١٥٠ – ٢٠٠سم فى القطاعات الأرضية ٧ ، ٨ ، ٩ فى منطقة مشتول.

قيم محتوى الكالسيوم الذائب فى جميع الأعماق فى أراضى منطقة مشتول أقل من القيم المتحصل عليها فى منطقة نبتيت وكذلك نفس النتيجة بالنسبة لكل من الصوديوم والماغنسيوم والبوتاسيوم.

مناطق الدراسة فى منطقة نبتيت أوضحت احتوائها على محتوى أعلى من الكلوريد والكبريتات بالمقارنة بمناطق الدراسة الأخرى فى منطقة مشتول.

اتضح كذلك أن غسيل الأملاح الذائبة فى منطقة مشتول أعلى من منطقة نبتيت وهذا يرجع إلى كفاءة الصرف المغطى فى منطقة مشتول.

ومما سبق يتضح أن كفاءة الصرف المغطى فى منطقة مشتول أفضل من منطقة نبتيت والتى تحتاج إلى إعادة تجديد.