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5. SUMMARY

In Egypt, there are urgent needs for the horizontal and vertical expansion to meet the demands of increased population. So, the agricultural utilization projects of clayey salt affected soils at Sahl El-Hossinia , El-Sharkia Governorate should be increased fast the scale efforts to bring additional new areas. To achieve this target, the proposal reclamation technique in the current work aims to introduce water management practices as well as alternative water resources that will prevent wasting of fresh water throughout leaching the excess of salts and lowering the ESP values. The available water resources are namely saline drainage water of Bahr El-Bakar drain (contaminated with sewage effluent), El Salam canal (drainage water mixed with fresh Nile water at a ratio of 1:1) and Bahr Hadoos drain. Also, the magnitude of their utilization has been executed under economical aspects of land use during the reclamation steps, as follows:

a. Continuously leaching on a fish-pond farm.

b. Continuously leaching on a rice field.

c. Alternatively leaching on a wheat field.

Three field experiments were conducted on chosen areas at Bahr El Bakar, El Salam canal and Bahr Hadoos, each one was divided into three pilot units, i.e., initial state of soil, soils subjected to continuously leaching by using the aforementioned water resources for periods of 3 and 5 years under fish-pond farms. Then, all these pilot units were cultivated with rice (Giza 178) during 4 months

summer season of 2001/2002 under continuously leaching of salts, followed by wheat (Sakha 8)during 6 months in the winter, under alternatively leaching of salts.

The results obtained could be summarized in the following:

I. Characterization and suitability criteria of the available water resources for irrigation:

a. Water salinity (EC_{iw}):

The EC_{iw} values of the available water resources ranged between 1.92–2.75, 1.68–2.14 and 2.31–2.44 dS/m for Bahr El-Bakar drain, El-Salam canal and Bahr Hadoos drain, respectively, through the cultivation periods of both rice and wheat crops. These EC_{iw} values indicate that all the studied available water resources are categorized into a moderate saline from the point view of water suitability for irrigation **(Ayers and Westcot, 1985 and Kandiah, 1990)**. The fluctuations in the EC_{iw} of the available water resources during the studied growing season are more related to the differentiations in weather conditions, especially the evaporation rate throughout either summer season (rice) or winter one (wheat), where it is relatively high in the summer season ad compared to the winter one.

b. Water sodicity (SAR):

The SAR values of the available water resources ranged between 3.61 and 6.80 for all water samples taken through the two growing seasons, i.e., summer (rice) and winter (wheat). In general, the SAR values of irrigation water in the case of wheat are relatively higher than those obtained during rice cultivation, this may be due the higher contents of Na-salts. These SAR values are listed within

those of required slight-moderate restrictions as irrigation water. The relatively high SAR values for rice (6.54) and wheat (6.80) crops were recorded before planting at Bahr Hadoos and Bahr El Bakar, respectively.

c. Distribution patters of soluble ions:

The soluble ions of Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, HCO_3^- and Cl^- could be arranged according their amounts as shown in the following order :

Bahr El- Bakar drain > Bahr Hadoos drain > El-Salam canal

In all the available water resources, Na^{+} represents the dominant cation followed by Mg^{2+}, Ca^{2+} and K^{+} vs a dominancy SO_4^{2-} as soluble anion, followed by Cl^- and HCO_3^- in the case of Bahr El-Bakar drain and El-Salam canal, but Cl^- was the dominant anion in Bahr Hadoos drain followed by SO_4^{2-} and HCO_3^-

d. Nitrogen content as NO_3-N and NH_4-N forms:

Data indicate that there are relatively high NH_4-N values in Bahr El Bakar water reached 21.71 mg/L for rice after 45 days from planting, and 26.40 mg/L just wheat planting. On the other hand, the relatively high NO_3-N values in El Bakar water were 8.61 and 6.32 mg/L just rice and wheat planting, respectively. These values for both forms still lay within the slight-moderate range of > 5- 30 mg/L.

e. Phosphorus content:

The P values in all the available water resources ranged between 4.6 and 7.4 mg/L for all studied water samples. The relatively high P values was found at Bahr Hadoos area after 90 days from wheat

planting, while the lowest one was associated with El-Salam canal water just wheat planting.

f. Potassium content:

K content in the different available water resources ranged between 10.21 and 22.60 mg/L. The highest value was found in Bahr El-Bakar drain which is contaminated with sewage effluent after 45 days from wheat planting, while the lowest one was associated with Bahr El-Bakar drain also just rice planting.

g. Micronutrient contents:

Data reveal that there are relatively high contents of Fe, Mn, Zn and Pb were observed in Bahr El-Bakar drain, with Fe values of 0.92 and 0.76 mg/L just rice planting and after 45 days of wheat planting; Mn values of 0.54 and 0.49 mg/L after 45 days of rice and wheat planting; Zn values of 0.66 and 0.55 mg/L just rice and wheat planting; Pb values of 0.45 and 0.42 mg/L just rice and wheat planting, respectively.

Boron (B) content was relatively low for all studied water resources (0.013-0.087 mg/L), the relatively high B values were 0.087 and 0.035 mg/L just rice and after 45 days of wheat planting at El Salam canal water, respectively. These values lay within the slight-moderate range of > 5- 30 mg/L.

In general, the concentrations of all the studied microelements lay in the safe range, and it can be used these water resources in irrigation purposes for plants without any hazardous effects.

II. Effect of the available water resources on soil chemical properties and fertility status:

a. Soil salinity (ECe):

In general, the soil ECe values tend to decrease with increasing the leaching and cultivation periods in all the studied experimental pilot units. In the case of the soils subjected to continuously leaching using the water of Bahr El-Bakar drain under fish-pond farms, the relative decreases in soil EC_e values (as profile means) were 62.86 and 72.42 % after 3 and 5 years, respectively. The corresponding values were 43.72 and 54.52 % at El Salam canal vs 30.97 and 63.02 % at Bahr Hadoos, respectively.

In the case of the soils subjected to continuously leaching using the water of Bahr El-Bakar drain under rice field, the relative decreases in soil EC_e values (as profile means) were 39.74 and 52.07 % after 3 and 5 years, respectively. The corresponding values were 28.8 and 36.2 % at El Salam canal vs 33.27 and 41.65 % at Bahr Hadoos, respectively.

In the case of the soils subjected to alternatively leaching using the water of Bahr El-Bakar drain under wheat field, the relative decreases in soil ECe values (as profile means) were 5.34 and 10.86 % after 3 and 5 years, respectively. The corresponding values were 7.67 and 11.51 % at El Salam canal vs 14.75 and 24.4 % at Bahr Hadoos, respectively.

These results indicate that the efficiency use of the available water sources for leaching salts could be arranged as the following order:

Bahr El-Bakar > Bahr Hadoos > El-Salam canal

b. Soil sodicity (ESP):

The obtained ESP values in the studied soils show a markedly decrease reached a nearly equilibrium state with those of the applied water resources during leaching periods and under fish-pond, rice and wheat fields.

c. Distribution patterns of soluble ions:

It is obvious from the soluble ion distribution patterns that the leaching process under both continuously and alternatively techniques was effectively reduced the easily soluble salts NaCl and Na_2SO_4. Also, it is noticed that the Na^+ in soil profile was the dominant soluble cation followed by Mg^{++}, Ca^{++} and K^+ and a possible increase in Na+ concentration with increasing the mixed ratio of drainage water .The distribution of soluble anions showed that the soluble Cl^- was higher anion followed by SO^{-2}_4, while HCO^-_3 concentration was approximately constant.

It is worthily to mention that the superiority of Bahr El-Bakar water as compared to the other available water resources is more related to the occurrence of active organic acids that released from the suspended sewage effluent. These organic acids provided a substantial modification of soil physical properties, especially soil structure as well as soil aggregation and drainable pores. Consequently, these favorable conditions are positively affected soil permeability and encourage the downward movement of leaching water that enhance progressive removal for Na-salts and decrease the SAR as well as lowering the calculated ESP values.

d. Available macronutrients of N, P and K:

The N, P and K ranged 32–79, 5.6–14.1 and 234- 639 mg/kg soil, respectively. The highest values were found in the soils irrigated with Bahr El-Bakar drain after 5 years of leaching, especially under rice cultivation. Whereas, the lowest N, P and K values were associated with the initial state of soils at the experimental pilot units of El-Salam canal, Bahr Hadoos and Bahr El Bakar, respectively. The relatively high contents are more related to the relatively high organic matter content, which is actually accumulated at the uppermost layers from the sewage effluent, fish-pond and plant residues.

In general, it can be arranged the water resources according to their positive effect on N, P and contents in soils, as follows:

Bahr El-Bakar drain > Bahr Hadoos drain > El-Salam canal, for rice and wheat fields.

d. Available micronutrient element contents:

It is evident that pronounced increases in soil available micronutrients contents of Fe, Mn, Zn and B, beside Pb (heavy metal) were achieved as a result of continuously leaching periods of 3 and 5 years under fish-pond farm, with a superiority for the latter period. This is more related to the residual organic compounds that directly nourish the fish after different biochemical and chemical changes, which led to released more available microelements. In addition, the relative increases of these elements in the soils of the experimental pilot unit at Bahr El-Bakar drain, due to the accumulation of the suspended organic colloids that derived from

the contaminated sewage effluent. It is worthy to mention that the contents of all the studied available microelements, in general, lay within the sufficient limits of Fe and Mn or in the critical limits identical division for the others (**FAO, 1992**).

III. Effect of available water sources on the plants grown on the studied soils:

a. Plant growth and crop yield (straw and grains):

The results obtained of soil chemical properties and fertility status positively or negatively reflected on plants growth, and in turn their yields of straw and grains. Data obtained show that the values of dry mater yield of both rice and wheat crops increased with increasing period of leaching, due to more reduction in soil salinity and sodicity. The yields of rice straw and grains tend to increase as a result of continuously leaching for 3 and 5 years under fish-pond farms at Bahr El-Bakar area, with the relative increases of 121.57 and 224.05 % for straw and 162.93 and 369.33 % for grains , respectively. The corresponding relative increases at El-Salam canal area were 124.31and 229.41 % for straw and 189.00 and 258.33 % for grains vs 186.82 and 322.72 % for straw and 184.37 and 314.12 % for grains, respectively at Bahr Hadoos area.

Also, the corresponding relative increases in straw yield of wheat at Bahr El-Bakar area were 12.90 and 29.61 %, for straw vs 122.60 and 208.22 %, for grains, while at El-Salam canal area were 30.27 and 109.54 % vs 132.18 and 163.03 % for the grains yield, respectively . The relative increases in straw and grains at Bahr

Hadoos area were 29.79 and 92.81 % for straw and 136.30 and 190.77 % for grains under 3 and 5 years of leaching , period.

It could be noticed that as leaching period increase the soil productivity increase, mainly due to decreasing soil salinity and sodicity. Moreover, the highest straw and grain yields are recorded in the case of irrigation water that contaminated with sewage effluent of Bahr El-Bakar drain

b. N, P and K concentrations in rice and wheat plants:

The low values of N, P and K-plant concentrations were, in general, observed at Bahr Hadoos area, while the highest ones were obtained from plants irrigated with Bahr El-Bakar drain after 5 years leaching period. Meanwhile, plants irrigated from El-Salam canal (Nile water mixed with agricultural drainage water) exhibit intermediate NPK concentrations. These findings are explained the high N, P and K efficiency of the sewage effluent that may be accounted on the effluent contains detectable amounts of most plant nutrients, and such irrigation resource might have been able to provide plants with completed and balanced nutritive culture.

c. N, P and K uptake by rice and wheat plants:

The data obtained of N, P and K uptake by rice and wheat plants (straw + grain) show relatively decreases with increasing soil salinity levels. It is evident from the distribution patterns of N, P and K uptake by both rice and wheat that it could be arranged according to their uptake by rice or wheat straw and grains in many different orders (seven orders).

d. Trace element concentrations in rice and wheat plants:

The data obtained show that applying the different available water as irrigation water resources caused markedly increases in the concentrations of Fe, Mn, Zn, B and Pb for rice and wheat plants, with a more pronounced increase with increasing the leaching period from 3 to 5 years.

The relative increases of the studied micronutrients (Fe, Mn, Zn and B) in rice and wheat crops (straw and grains) are mainly depend on the used irrigation water quality, as it could be arranged as follows:

contaminated Bahr El-Bakar > El-Slam canal > Bahr Hadoos

With respect to the non-nutritive Pb, the relative increase could be arranged according to the applied water resources , as follows : contaminated Bahr El-Bakar drain > Bahr Hadoos drain > El-Salam canal.

e. Trace elements uptake by rice and wheat plants:

Data show that the trace elements of Fe, Mn, Zn, B and Pb uptake by straw and grains depend on soil salinity levels of both irrigation water and soil. It is evident from the uptake distribution patterns of Fe, Mn, Zn, B and Pb that it could be arranged the applied water resources into 8 orders according to the studied elements uptake by straw and grains of rice and wheat crops.

Finally, it is concluded that the concentrations of micronutrients in plants, generally, reflect their available contents in soil and long leaching period under different water resources used.