



ASPECTS OF SALT-AFFECTED SOILS IN THE ARAB WORLD

M.Hachicha¹ and G.Abdelgawed²

1: INRGREF- Tunisia

2: ACSAD – Syria



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INTRODUCTION

- ☞ Arab countries are characterized by an annual irregularity of the rain and **aridity** of the climate
- ☞ **Water** and **soils** resources are **limited**. The major part of the water resources is **affected by salts**
- ☞ **Soil and water salinization** has been identified as a major process of degradation in several countries
- ☞ There is an important **social and economic pressure** to **use marginal soil** and **water** in agriculture
- ☞ **Reclamation** of the **salt-affected soils** was realized for decades
- ☞ **Review** of extent, causes and management of salt-affected soils in some Arab countries

1-ASSESSMENT OF SOIL DEGRADATION DUE TO SALINITY

☞ According to Guideline for General Assessment of the Status of Human-Induced Soil Degradation (GLASOD) methodology (FAO/UNEP/ISRIC; Oldeman, 1988)

Degrees used for salinity assessment :

A. None Saline soils:	$ECe < 5 \text{ dS/m}$	$ESP < 15\%$	$pH < 8.5$
B. Slightly Saline:	$ECe: 5-8 \text{ dS/m}$	$ESP < 15\%$	$pH < 8.5$
C. Moderately Saline:	$ECe: 9-16 \text{ dS/m}$	$ESP < 15\%$	$pH < 8.5$
D. Severely Saline:	$ECe > 16 \text{ dS/m}$	$ESP < 15\%$	$pH < 8.5$

Degradation due to salinity is assessed as follows :

I-Slight Dégradation : When salinity changes from «none saline » to «slightly saline », or from «slightly saline» to «moderately saline», or from «moderately saline» to «severely saline »

II-Moderate Degradation : When salinity changes from «none saline» to «moderately saline» or from «slightly saline» to «severely saline»

III-Severe Degradation : When salinity changes from «none saline» to «severely saline»

Annual increase in salinity shall be estimated in the soil profile from a depth of 0-60 cm:

- Slight increase $< 2 \text{ dS/m}$ annually.
- Moderate increase from $2-3 \text{ dS/m}$ annually
- High increase from $3-5 \text{ dS/m}$ annually
- Very high increase from $> 5 \text{ dS/m}$ annually

Land degradation due to sodium shall be divided as follows :

- **Slight:** increase in sodium less than 1% annually
- **Moderate :** increase in sodium 1-2% annually
- **High increase :** in sodium 2-3% annually
- **Very high :** increase in sodium over 3% annually

☞ In order to determine the soils degraded due to salinity, Nikolai et al.(1999) used this factor in the land degradation map in Asia according to the following table :

Table 1. Indicators for assessing the Soil Degradation due to salinity (Nikolai et al., 1999)

Assessment Indicators	Slight	Moderate	Severe and very Severe
Soil salinity in proportion to the solids in the soil extract	0.2-0.4	0.40-0.60	> 0.60
Ground water salinity (mg/l)	3-6	6-10	10-30
Irrigation water salinity (mg/l)	0.5-1.0	0.5-1.0	> 1.5
Seasonal salt accumulation (ton/ha)	16-30	30-45	40-45
Loss of agricultural productivity of the main crop in the region (%)	< 15	15-40	> 40

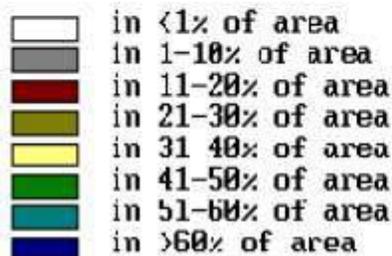
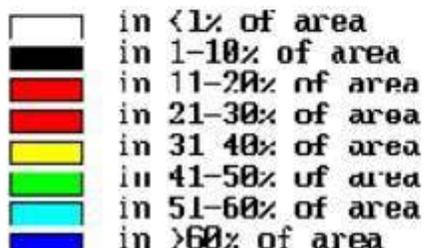
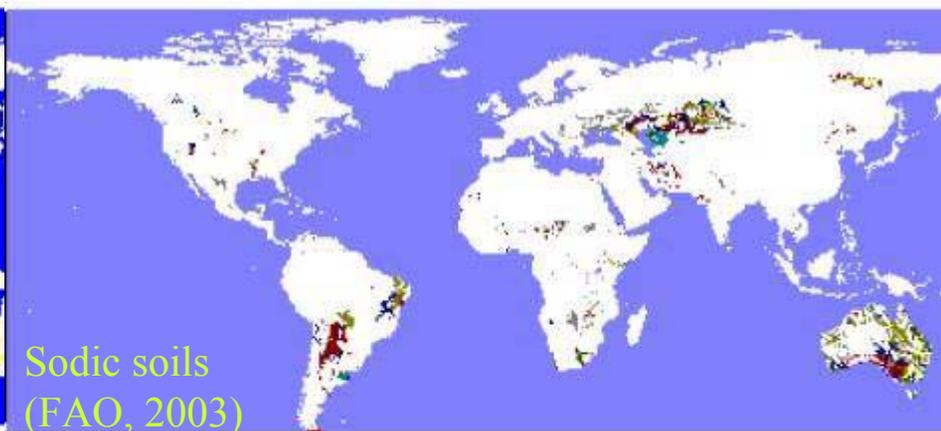
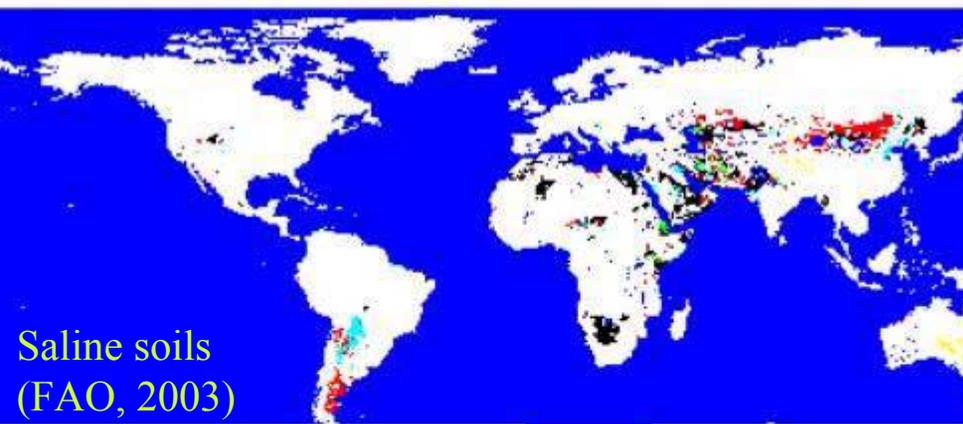
2. EXTENT OF SALT-AFFECTED SOILS IN THE ARAB COUNTRIES

In the World (Oldeman et al., 1991):

Total area of salt-affected lands = ~831 Mha: 397 Mha saline + 434 Mha sodic
 Total irrigated land = ~230 Mha: 45 Mha salt-affected (19.5%)
 Dryland agriculture = ~1,500 Mha: 32 Mha salt-affected (2.1%)

In the Arab World:

Total Arab land = ~1402 Mha Arable= ~197 Mha (14.1%)
 Cultivated= ~ 70 Mha (5%)
 Irrigated= ~ 9.5 Mha
 Salt-affected= ~82.7 Mha: 71.5 saline (86.5%)+11.2 sodic (13.5%)



3. CAUSES OF SALT-AFFECTED SOILS IN THE ARAB WORLD

- ☞ Salt-affected lands are reflected as saline seeps in dryland agriculture and secondarily salinized irrigated lands
- ☞ Salinity poses a major management problem in many non-irrigated areas where cropping relies on limited rainfall.
- ☞ Dryland salinity has been a threat to land and water resources in several parts of the Arab world
- ☞ For 9.5 Mha irrigated, about 20% is affected by human-induced salinization (1.9 Mha)
- ☞ In rainfed agriculture intrusion of saline seawater to areas lying near the sea can cause land salinization during dry periods.
- ☞ The scarcity, variability and unreliability of rainfall and high evaporation affect the water and salt balance of the soil
- ☞ Various types of Na, Mg and Ca salts are concentrated, mainly chloride and sulphate
- ☞ Two main salt accumulation cycles can be distinguished: natural and anthropogenic cycles
 - **Natural cycles:** marine cycles, continental cycles
 - **Anthropogenic cycles:** poor soil and water management, irrigation with saline water, irrigation mismanagement, excessive leaching with insufficient drainage, use of improper cropping patterns and rotations, poor land leveling, dry season fallow practices in the presence of shallow watertable

4. MANAGEMENT AND REHABILITATION OF SALT-AFFECTED SOILS

•Management of salt-affected soils :

- requires a combination of agronomic and management practices
- is largely dependent on water availability, climatic conditions, crop standing and the availability of resources.

☞ **Hydraulic practices:**

- Leaching is used to prevent accumulation of salt in the root zone
- Drainage is in many times necessary to manage salt-affected soils

☞ **Physical Management:**

- Several mechanical methods have been used to improve infiltration and permeability: land levelling, deep ploughing and tillage, subsoiling and planting procedures

☞ **Chemical practices:**

- Chemical amendments are used to neutralize sodic soil conditions, followed by leaching of salts derived from the reaction of the amendments with sodic soils. Gypsum, sulphur and sulphuric acid are commonly used but not in large scale in the Arab countries

☞ **Biological practices:**

- using OM, farm manure, growing legumes, mulching, crop residue and selection of salt-tolerant crops

☞ **Human aspects:**

- Farmers are active participants in the development of appropriate management systems and the main originators of technical solutions to their problems



5. 1. Salt-affected Soils in Arab Nile Countries: Egypt and Sudan

Egypt

Extent :

- About 3.5 Mha is irrigated agriculture land concentrated along the Nile Valley and its Delta
- Majority of salt-affected soils are located in the Northern-Central part of the Nile Delta and on its Eastern and Western sides
- Other areas are found in Wadi El- Natroun, El- Kebeir, the Oases, many parts of the Nile Delta and Valley and El-Fayoum province
- About 0.9 Mha suffer from salinization in cultivated irrigated areas: 6% of the Northern Delta region, 20% of the Southern Delta and Middle region and 25% of the Upper region
- About 1.26 Mha are salt-affected, as well as about 50% of the irrigated soils affected
- Sebkas areas are about 20 Mha

Causes:

- Saline soil distribution is related to climatic, geological, geochemical and hydrological conditions
- Poor soil and water management and intrusion of seawater are the main causes of salinization in addition to the use of slightly saline water without proper management and agronomic practices

Reclamation of saline soils includes: land levelling, drainage, salt leaching, cropping rotation, sub soiling and deep ploughing, incorporating organic matter, adapted irrigation system and drainage water re-use

Tina plain in the Northern Sinai: example of reclamation of 60,000 feddan (26,000 ha) of heavy saline clay soils. The irrigation water is the Nile River (50%) mixed with drainage water

Sudan

- Total area is 250.58 Mha, salt-affected soils are 4.8 Mha (1.9%)
- Majority of salt-affected areas are located in Northern Sudan in the higher terraces along the Nile River
- Causes: climate conditions, poor soil and water management, insufficient drainage system
- Management practices include using salt-tolerant varieties, chemical amendments (gypsum) and organic straw and irrigation intervals

5.2. Salt-affected Soils in Arab Euphrates/Tigris Countries: Syria and Iraq

Syria

Extent :

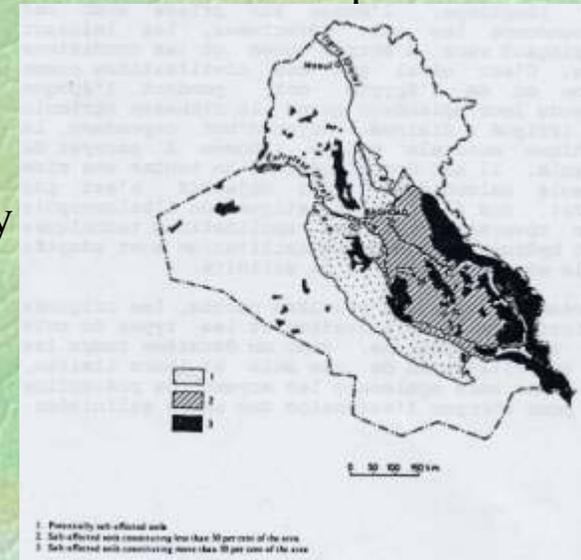
- ☞ Salinization process is found in the whole Syrian portion of the Euphrates River
- ☞ Salinity development has led to a reduction in the soil productivity
- ☞ Salinity and waterlogging are extensively present in relation to irrigated agriculture
- ☞ 532,000 ha, 40% of the total irrigated areas, are salt-affected soils
- ☞ **Examples of salt-affected soils are :** the Euphrates Valley extending as a strip from Helebia-Zalabia in the west, down to the Iraqi border in the east; strip along the Khabour river from Ras el Ain in the north, down to Sowar town near Deirezzor city in the south, the Ghab Valley, the Jabool area

Causes: over-irrigation, poor soil and water management, insufficient drainage systems, use of drainage, saline water or treated wastewater for irrigation

Management practices : establishing tile drainage network, use of salt-tolerant crops

Iraq

- ☞ Total area is 43.5 Mha
- ☞ Salt-affected soils: 1.3 Mha slightly affected, 6.7 Mha severely
- ☞ Causes: include natural occurring and human-induced salinity
- ☞ Soils of the Mesopotamian region have a long history of irrigation
- ☞ In these areas, salt accumulation in soils is mostly because of mismanagement of soil and water resources



5.3. Salt-affected Soils in GCC Countries + Jordan +Palestine + Somalia

- 👉 **Saudi Arabia:** about 2 Mha are sebkhas and about 3,641 Mha is affected by salinity 50,000 ha severely, 1.7 Mha moderately and 1.977 Mha and 1,3675 ha slightly (???)
- 👉 **Abu Dhabi (UAE):** UAE has about 4000 km² of coastal sebkhas. Salinity and waterlogging are also induced by irrigation with saline water. In Abu Dhabi, about 1,600 ha are affected. A clayey layer has reduced water infiltration thus inducing the waterlogging in irrigation season. A subsurface drainage network is created (ICBA)
- 👉 **Qatar :** 70,124 ha affected, 6,517 ha slightly, the rest severely
- 👉 **Bahrain:** 41,273 ha affected, 17,540 ha slightly, 22,473 ha severely
- 👉 **Kuwait :** 85,000 ha affected, 65,827 ha slightly affected
- 👉 **Oman :** 9.442 Mha affected, about 30% of the total area of Oman (309500 km²)
- 👉 **Yemen :** 483,467 ha affected
- 👉 **Jordan :** in the **Valley**, 6,500 ha affected, 1,400 ha slightly, 1,600 ha moderately, the rest severely. In the **Jordanian Desert**, soils contain an amount of salt content ranging from 1-10%
- 👉 **Palestine :** ???
- 👉 **Somalia :** Salinity increases along the Joba and Shabli rivers about 10,000 ha has been went out of production due to salinity



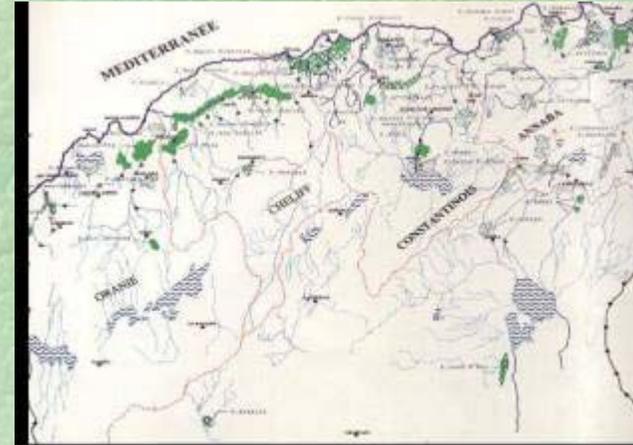
5.4. Salt-affected Soils in Maghreb Countries

Libya

- Salt-affected soils are about 700,700 ha: 199,300 slight, 174,400 moderate, 327,000 severe sebkhas and sodic soils
- Area affected by salinity and water logging is about 250,000 ha

Algeria

- Irrigated area is about 350,000 ha, 25% are salt-affected soils
- About 8% of the irrigation waters are very saline and 21% have moderate salinity
- Salinity and water logging affect some areas in the Northern West and the South. Some of them is constituted by the Chotts: Ghergui, Gharbi, Chargui, Hodna and Melhriri



Morocco

- Irrigated area is 1 Mha, about 21% are salt-affected, 57% of the Gharb irrigated area
- Salt-affected soils are 350,000 ha
- In the North and Northwest (Gharb and Loukkos), soils are affected by waterlogging induced by the rainfall excess and irrigation water
- In the South and East (Tadla, Moulouya, Ouarzazat and Tafilalet), soils are affected by the waterlogging and salinization induced by water table rising by irrigation

Mauritania

- Salt-affected soils: cover 86.3 Mha (38.3%)
- Most of the irrigated area along Senegal River is affected

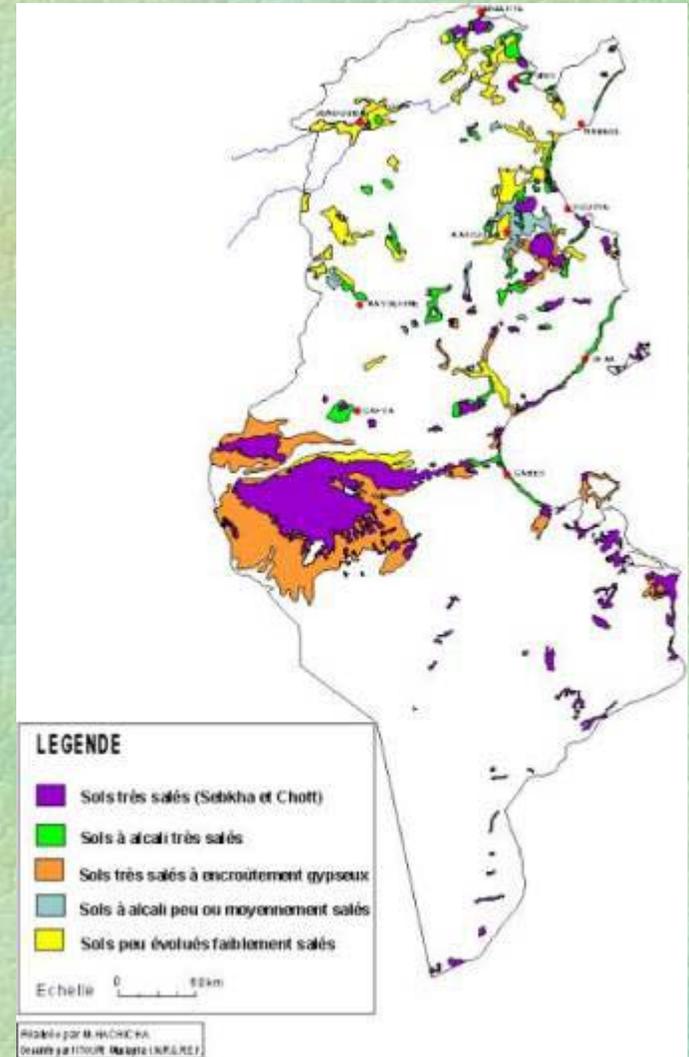
5.17. Salt-affected Soils and their reclamation in Tunisia

Extent:

- ☞ Salt-affected soils are about 1.5 Mha, 10% of the total area
- ☞ Salinization of irrigated areas results from the climatic deficit and the use of marginal water and soils resources
- ☞ Irrigated areas cover about 375 000 ha
- ☞ Salinization and waterlogging affected about 50% of the areas, 10% severely

Causes:

- ☞ Aridity of the climate and high evaporation, saline groundwater, seawater intrusion, poor water management and in proper agronomic practices and low water quality are the major causes of salt-affected soils commonly formed in depressions and low parts of the landscape
- ☞ Several geologic materials constitute the source of soluble salts



- ☞ The waters of rain enriched in soluble ions, make their way towards the low parts of basins
- ☞ From there two scenarios appear:
 - ☞ the basin possesses an exit and salts migrate downward
 - ☞ the basin is closed and a sebkha forms in the lowest part
- ☞ These phenomena are natural or induced by irrigation
- ☞ In the situation globally endoreic of Tunisia, the total quantity of salts in movement in the landscape, increases constantly in time
- ☞ From the geochemical aspect, sodium chloride, which we find in all the saline soils of Tunisia, serves as a reference salt. We find also salts much less soluble such as calcium carbonate and gypsum, or much more soluble
- ☞ In a homogeneous climatic region and for the same soil moisture regime, the more a salt is soluble, the more easily and quickly it will be leached outside the profile and outside the basin



Management of salt-affected soils

☞ The reclamation of salt-affected soils in Tunisia has more than a half century. It is based on the improvement of their physical and chemical properties by the decrease of the watertable level and the introduction of adapted crop species. This reclamation took place under rainfall conditions and under irrigation. In the Tunisian context, the leaching of salts is made by rains in winter. Among the 1.5 million hectares of saline soils, about 300 000 ha were improved.

The reclamation of salt-affected soils under natural conditions

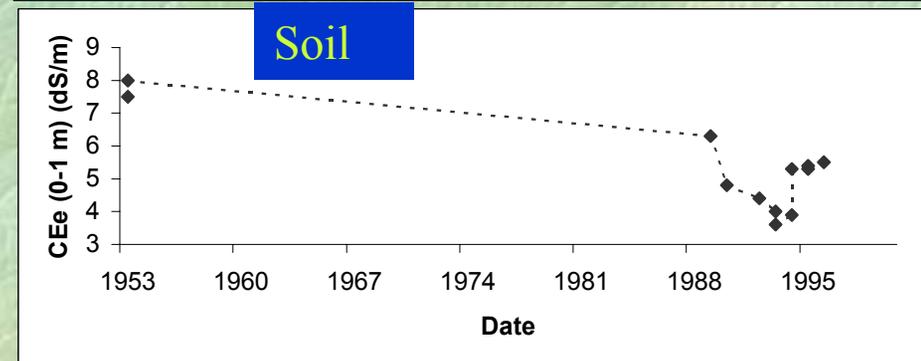
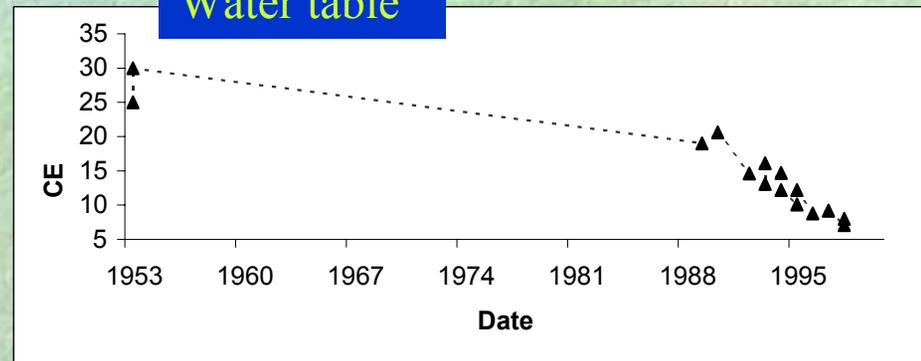
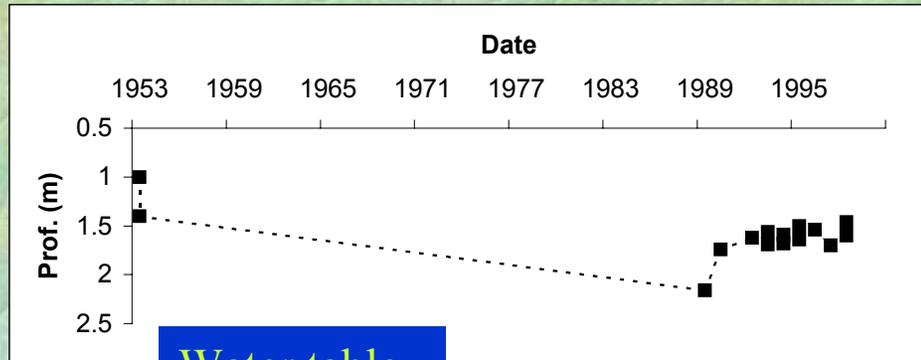
☞ **The saline sodic soils of the lunets of Mabtouha:** Evolution appears through new characters of organization and composition: reduction of the porosity and high desalinization

☞ **The saline soils of the borders of the coastal sebkhas:** large channels drains a major part of the waters to the sea. Thus, the water table level decreased below 1 m of depth in the higher zones, which were ploughed and sowed with forest trees. Several sebkhas show a double face. In summer, it can be likened to a continental sebkha: saline soil are more or less dry; while in rainy period, the sebkha is transformed into a lake. As halophyte vegetation reflects, in a given climatic context, the physical, chemical and hydrological conditions of the soils, different zones can be distinguished according to salinity and water logging level and regime and soil texture



The reclamation of salt-affected soils by drainage

- Several plains of the Centre and the North are drained by large canals
- The surface drainage of the rained plains allowed their progressive desalinization
- In several regions of the Mejerda Valley, surface and subsurface drainage were a preliminary activity for the land reclamation
- Irrigated area of Kalaat Landelous: an example of the reclamation of 3000 ha of salt-affected soils
- Results show:
 - decrease of the ground water level
 - dilution of the salt content of the ground water
 - desalinization of the soils
 - The salt balance shows a large amount of salt exported from the area, between 22 and 66 tons (for 3000 ha per year)



DISCUSSION AND CONCLUSION

- ☞ In the Arab world, several salt-affected soils were rehabilitated
- ☞ The reclamation is based in the first stage on the control of the regime of the ground water
- ☞ The decrease of the watertable level results in the genesis of a new soil proprieties
- ☞ In the second stage, the superficial layers grow rich in OM, thus contributing to the improvement of soil structure
- ☞ In the semi-arid areas, rains contribute to the salt leaching
- ☞ Deep ploughing and introduction of salt tolerant crops allow better reclamation of these soils
- ☞ Annual cereals and forage are used, and then gradually less tolerant crops are introduced.
- ☞ The water mobilization has reduced the water balance of the low lands by the decrease of the watertable level and soil salinity
- ☞ In the past, the reclamation of the salt-affected soils was based essentially on technico-economic criteria
- ☞ In the last decade, environmental aspect became a basic element in their management
- ☞ Finally, the situation being globally endoreic of many Arab countries, after the mobilization of big quantities of their water resources, the total quantity of salts in movement in the landscape increases constantly in time
- ☞ We must expect the salinization of soils and the genesis of new salt-affected areas in the low lands situated near irrigated areas. Beginnings of these new sebkhas are already perceptible in some depressions