Gypsiferous soils and their reclamation:

The studies were focused on the following points in Gypsiferous soils:
1-Definition of Gypsiferous soil.
2-Problems of Gypsiferous soils with examples in Iraq.
3-Area of Gypsiferous soil in the world and Iraq.
4- Classification of Gypsiferous in Iraq.
5-Principles Gypsiferous soil reclamation.

Introduction

Large areas of the Earth's surface are covered with soils that are susceptible to significant decreases in bulk volume when saturated. These materials, known as collapsing soils, include a particularly problematic type called gypseous soils.

Gypseous soils, sometimes referred to as gypsiferous soils, contain sufficient quantities of gypsum (hydrated calcium sulfate, CaSO4·2H2O) to impact both agricultural productivity and engineering stability. Such soils have been reported in various regions worldwide, including the Arabian Peninsula, Russia, Armenia, the United States, and Spain.

The presence of gypsum significantly affects the behaviour of these soils, especially when subjected to changes in water content. When wet, gypseous soils may dissolve and soften, becoming highly compressible. This characteristic poses challenges not only in agriculture but also in civil engineering, leading to issues such as structural damage.

In Iraq, gypseous soils are particularly widespread, covering over 20% of the total land area, which amounts to approximately 8.7 million hectares out of a total of 43.5 million hectares. Gypsum deposits are commonly found in arid and semi-arid regions, where they occur in various sedimentary rock formations.

Characteristics of Gypsum

- Gypsum is a mineral and rock is a soluble salt widely distributed in sedimentary rocks of various geologic formation with different ages.
- It can be found in recently formed sediment as isolated or massive crystals and may be accompanied with other salts and minerals in gypseous soils.
- Gypsum or rock may be present in the form of hydrated calcium sulphate ($CaCO_4.2H_2O$).

- Its solubility is 2.6 g/l of pure water at 25^0C and a pressure of 1 atmosphere. The maximum solubility occurs at 35-50 ^{0}C.

Gypsum content %	Classification
0-0.3	Non-gypsiferous
0.3-3.0	Very slightly gypsiferous
3-10	Slightly gypsiferous
10-25	Moderate gypsiferous
25-50	Highly gypsiferous

The problems can be summarizing as follow:

1-Agricultural problems

High gypsum content (over 25%) can decrease the availability of macro and micronutrients essential for plant growth. Such soils lack plasticity, do not bind well, and become unstable when wet, leading to severe erosion.

To improve productivity in rainfed conditions, several strategies can be employed:

- **Soil terracing** on the deep hilly soils to prevent erosion.
- **Supplementary irrigation** where water resources are available.
- Harrowing the land after harvest to enhance water infiltration and conserve moisture.
- Rotating fallow periods with small-grain leguminous crops to boost soil organic matter.
- Subsoiling to break up cemented gypsic subsoil, improving root penetration and drought resistance.
- Applying fertilizers, particularly nitrogen and phosphorus, to support cereal crops.

2- Engineering problems such as destroying or damaging buildings, bridges, irrigation projects, dams…. etc.

More than 20% of total Iraqi area or soil is gypsiferous or 8.7 million ha is gypsiferous since the total area of Iraq =43.5 millions ha.

The relatively high solubility of gypsum (calcium sulfate) in irrigation water, especially in gypsiferous areas, can create several important problems:

 Nutrient Competition: High levels of calcium from dissolved gypsum can interfere with the uptake of other essential nutrients, such as magnesium and potassium, potentially leading to deficiencies in crops.

 Soil Structure Changes: Gypsum can improve soil structure by promoting aggregation, but in excess, it can lead to a compacted layer that restricts water infiltration and root penetration, negatively impacting plant health.

 Leaching Requirements: Managing salinity due to gypsum requires leaching, which means applying more water to flush salts away from the root zone. This can lead to increased water use, potential groundwater depletion, and environmental impacts.

 Economic Costs: The need for additional water management strategies, such as leaching and soil amendments, can increase operational costs for farmers.

 Irrigation Scheduling: The solubility of gypsum can complicate irrigation scheduling, as farmers must monitor salinity levels closely to avoid damaging crops, making irrigation management more challenging.

Principles of reclamation gypsiferous soils:

The principles of gypsiferous soil reclamation is conversion or change the gypsum to less soluble compounds as shown below:

1-$CaSO_4.2\,H_2O + BaCl_2 + H_2O \rightarrow CaCl_2 + BaSO_4 + 4H_2O$

2-$CaSO_4.2H_2O + (NH_4)_2C_2O_4.H_2O \rightarrow CaC_2O_4.H_2O + (NH_4)_2SO_4$

3-$CaSO_4.2H_2O + K_2C_2O_4.H_2O \rightarrow CaC_2O_4.H_2O + K_2SO_4 + 2H_2O$

4-$CaSO_4.2H_2O + (NH_4)_2CO_3 \rightarrow CaCO_3 + (NH_4)_2SO_4 + 2H_2O$

5-$6CaSO_4.2H_2O + 4(NH_4)_3PO_4.3H_2O \rightarrow 2Ca_3(PO_4)_2 + 6(NH_4)_2SO_4 + 24H_2O$

Compound (Gypsum and amendments)	**Solubility product**
1-$CaSO_4.2\ H_2O$	$2.4 * 10^{-5}$
2-$CaC_2O_4.H_2O$	$1.3 *10^{-9}$
3-$BaSO_4$	$0.50*10^{-9}$
4-$CaCO_3$	$4.7*10^{-9}$
5-$Ca_3(PO_4)_2$	$1.0 *10^{-28}$