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## Review

### Management and Use of Gypsiferous Soils in Iraq

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#### *Abstract*

This article aims to introduce one of the most important components of the main soils in the arid and semi-arid regions of the world, which constitute approximately 100 million hectares of the total soil area in the world, specifically gypsum, which has important effects on the overall chemical, physical, biological, and fertile properties of the soil. Physically, gypsum, added in measured quantities to the soil, will contribute to improving soil structure, drainage, and aeration as well as increase water conductivity, in addition to improving the aggregation of soil particles, which in turn will work to reduce the bulk density by improving the structure in natural conditions. On the other hand, the presence of gypsum in large quantities in the soil, or if it is more than 10% It, is considered a gypsum soil, which leads to weakness in its structure and bearing capacity, especially when moistened, due to its high solubility, and may cause collapses, settlement, and sinkholes of the soil. Chemically, gypsum is used in the reclamation of alkaline saline soils, as calcium replaces sodium in the exchange complex, lowering soil pH and reducing dispersion by replacing sodium ions with calcium ions on exchange sites. Therefore, it is used as a soil amendments for alkaline saline soils. The article also highlights methods for managing and utilizing gypsum soils in terms of modern tillage and irrigation systems. The presence of large quantities of gypsum in the soil causes many problems in all its properties. Therefore, adopting shortened tillage systems has proven more efficient than traditional tillage methods and is considered a viable alternative under agricultural conditions for gypsum soils. Furthermore, the irrigation systems used to irrigate gypsum soils have a significant impact on their optimal management, as irrigation science examines irrigation water sources, methods of controlling and utilizing them, and delivering them to agricultural lands. As for the modern and well-known concept of managing the irrigation process, it is the optimal use of water instead focusing on the

yield only. Modern irrigation is an advancement in understanding the water processes that take place , such as the movement of water from the soil the plant, which results in the best use of irrigation water ,lowering waste while raising yields and enhancing production quality to maintain global food security proportion to the rate of population growth.

**Keywords:** Gypsum soils, food security, production quality, chemical properties, physical properties.

## مقالة

### إدارة واستعمالات أراضي التربة الجبسية في العراق

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## المستخلص

هدفت هذه المقالة الى التعريف بأحد اهم مكونات التربة الرئيسية في المناطق الجافة وشبه الجافة من العالم والتي تشكل نحو ما يقارب 100 مليون هكتار من مساحة التربة الكلية في العالم والا وهي مادة الجبس والتي لها تأثيرات مهمة في مجمل الخصائص الكيميائية والفيزيائية والحيوية والخصوبية للتربة، فالجبس من الناحية الفيزيائية في حال إضافته بكميات مدروسة الى التربة سوف يسهم في تحسين بنائها والصرف والتهوية ويزيد من الايصالية المائية فضلاً عن تحسين دقائق التربة والذي بدوره سوف يعمل على التقليل من الكثافة الظاهرية من خلال تحسين البناء في الحالات الطبيعية ومن ناحية اخرى فان وجود الجبس بكميات كبيرة في التربة او اذا ما زاد عن حدود 10% فتعد ضمن تصنيف التربة الجبسية مما يؤدي الى ضعف بنائها وقوة تحملها لاسيما عند التزطيب بسبب ذوبانه العالي وقد يتسبب بانهيارات وهبوط التربة وتخسفاً. ومن الناحية الكيميائية فان مادة الجبس تستخدم في استصلاح التربة القلوية الملحية اذ يحل عنصر الكالسيوم محل الصوديوم على معقد التبادل مما يؤدي الى خفض رقم تفاعل التربة ويقلل من تشبثها عبر عملية استبدال ايونات الكالسيوم محل ايونات الصوديوم على مواقع التبادل، لذا فهو يستخدم كمحسن للتربة القلوية الملحية، كما وتسلط المقالة الضوء على طرائق إدارة أراضي التربة الجبسية واستعمالاتها من حيث أنظمة الحراثة والري الحديثة لان وجود مادة الجبس بكميات كبيرة في التربة يتسبب بمشاكل عديدة في مجمل خصائصها لذا فان اعتماد أنظمة الحراثة المختصرة قد اثبتت كفاءتها مقارنة باعتماد طرائق الحراثة التقليدية اذ تعد من البدائل الجيدة جدا تحت ظروف الزراعة للتربة الجبسية، كما وان لنظم الري المتبعة في ري التربة الجبسية بالغ الأثر في طرائق ادارتها بالشكل الأمثل اذ ان علم الري يبحث في مصادر مياه الري وطرق التحكم فيها واستغلالها وايصالها للأراضي الزراعية اما المفهوم الحديث والمتعارف عليه لإدارة عملية الري هو الاستعمال الأمثل للماء بدلاً من الغلة فالري الحديث هو تطوير لفهم العمليات المائية الحاصلة والتي تتضمن انتقالات المياه من التربة الى النبات مما يؤدي الى الاستعمال الأمثل لماء الري والتقليل من الهدر مع زيادة الحاصل وتحسين جودة الإنتاج لاستدامة الامن الغذائي في العالم بما يتناسب مع حجم الزيادة الحاصلة بالسكان في العالم.

الكلمات المفتاحية: التربة الجبسية ، الامن الغذائي ، جودة الإنتاج ، الخصائص الكيميائية، الخصائص الفيزيائية.

### **Introduction**

-Calcium sulfate, or what is known as gypsum, is one of the most important components of soils in arid and semi-arid regions of the world, where annual rainfall rates are less than 500 mm. It has important effects on all of its chemical, physical, biological, and fertile properties in relation to the quantity and quality of gypsum contains and the surrounding environmental conditions ( khudair et al.,2019).

-Gypsum soils are relatively strong and cohesive in the dry state due to the presence of gypsum between their grains, but they become brittle and weak in construction when water flows through them, which is the main reason for the collapses in their construction.

- Physically, gypsum, when added to soils, significantly contributes to improving their construction. drainage, and aeration, and increases water conductivity, as well as improving the aggregation of soil particles, which in turn will reduce the apparent density by improving construction.

-Additionally, the presence of large quantities of gypsum in the soil will certainly weaken its structure and load-bearing capacity, especially when moistened, due to its high solubility, and may cause soil collapses, settlement, and sinkholes.

- Chemically, gypsum is used in the reclamation of alkaline saline soils, as calcium replaces sodium on the exchange complex, which leads to a reduction in the soil pH and reduces its dispersion through the process of replacing sodium ions with calcium ions on the exchange sites. From a

fertility perspective, gypsum plays an effective role in improving fertility properties. When used as a fertilizer added to the soil, it works to reduce the soil pH, thus increasing the availability of most of the nutrients needed by the plant, except for molybdenum (Jafarzadeh et al.,2000).

### **The concept of gypsum soils**

-Gypsum soils can be defined as those soils that contain gypsum at a rate that may reach 2% in the surface horizons and more than 14% gypsum in the subsurface horizons, which may be in the form of real gypsum or anhydrite.

- Sometimes they are defined as soils that contain a gypsum horizon or a petrogypsum horizon at a depth of 100-125 cm from their surface.

-The critical limit for the presence of gypsum in the soil is 10%, for its negative effects to appear in the soil, leading to inhibition of plant root growth and breaking of the continuity of the soil mass.

-The gypsum horizon is known as a weak or incoherent horizon rich in secondary sulfates.

-The term Gypseous is used for soils containing more than 50% gypsum, and the term Gypsiferous is used for soils containing less than 50% gypsum. Gypsiferous soils in Iraq have been placed under the order Orthids and the major group Gypsiortnids, according to (Soil Survey Staaf,1975 and Salim,2001).

### **The areas occupied by gypsum soils and distribution in the world and Iraq**

Gypsum soils cover large areas of the world's soil, as they are represented in central and southern Australia, western Siberia, and eastern Syria.

- They are also found in central and northern Iraq, Iran, China, Algeria, Tunisia, eastern Spain, and southeastern Somalia.

- They constitute about 100 million hectares of the world's soil area, and what is found in Iraq it is about 7-8 million hectares. The gypsum soils in Iraq extend over approximately 88,000 km<sup>2</sup>, constituting 6% of the total gypsum soils in the world and about 20% of the total area of Iraq.

-Part of these soils are somewhat exploited agriculturally using management methods appropriate to the conditions of those soils, as they extend north from south of Sinjar and southeast of to the southern regions of Iraq and the western desert and the southern desert ( Jafarzadeh et al.,2000).

### **The origin of gypsum in gypsum soils.**

There are multiple sources of gypsum in soils, and scientists and researchers differ in their opinions regarding the origin of gypsum in different soil types.

-One of the most important reasons for gypsum formation in soils is the presence of the parent material of soils rich in Pyrite, a mineral belonging to the sulfate group.

-Pyrite is relatively rare in igneous, metamorphic, and sedimentary rocks found in soils worldwide. -Due to the continuous weathering and oxidation processes over time, the sulfur is converted into sulfuric acid, which in turn reacts with lime, especially in calcareous soils, thus initiating gypsum formation in the soil.

- Primary gypsum forms either as a result of the evaporation of saline groundwater by capillary action or through the precipitation of that water.

-The accumulation of gypsum in soils is primarily related to the weathering of parent material, which can dissolve to varying degrees under specific conditions due to the influence of permeable water. Weathering and dissolution of gypsum in the parent material, along with precipitation conditions, constitute the main mechanisms for gypsum formation in soils (Al-Khafaji,2016) . Furthermore, soil texture and ground perspective play a significant role in gypsum pedogenic formation, and crystallized gypsum has been found in light-textured soils, a finding confirmed by both (peyman,2011 and FAO,1990).

### **Shapes of gypsum crystals in gypsum soils**

-It is noted that the gypsum crystals formed in gypsum soils differ in shape, distribution, and size, which are closely related to the soil depth and the prevailing moisture regime in different areas.

- Many studies and research have proven the recording of differences in the length and thickness of gypsum crystals with the difference in moisture regimes, in addition to the diversity in the shape of the crystals as move towards the subsurface horizons of the soil, more than the surface horizons, in conjunction with the depth of the soil.

-These crystals can be found individually or as blocks within the pores of the soil. Some studies have shown that gypsum accumulates in the soils over time in a manner somewhat similar to the accumulation of calcium carbonate in them.

- As gypsum is initially formed in the form of thin lines that begin as a small knot, it eventually leads to the formation of complete, solidified, and cohesive gypsum horizons.

- It also seems that gypsum in the early stages of genetic formation appears in the form of small snowballs.

- The microscopic forms of gypsum appear different, including lenticular crystals with single particles, branched fibrous crystals, or granular crystals; tabular crystals are also present. One of the main reasons for the formation of lenticular gypsum crystals in soils is the increase in the concentration of sodium chloride in them.

- These crystals may be scattered in the soil mass, or they may partially or fill the gaps, voids, and channels, or they may be in the form of isolated prismatic grains scattered in the soil mass, or as fine grains intertwined with each other, hardened and appearing in an irregular form, forming hardened petrogypsum layers.

-As for Vacuum Gypsum, it appears as fine crystals filling voids or as a flat form. It occurs due to the accumulation of rising salts resulting from the rise in the levels of saline or highly saline groundwater in the deep layers of the soil. Gypsum crystals may be coarse grains that dominate the soil mass (Al-Bayati,2020 and Buck et al.,2002).

### **Properties of gypsum soil**

-As a result of numerous studies and research in the field of gypsum soils, many problems have been identified that these soils suffer from, such as poor fertility, the presence of impermeable layers, high salinity, the formation of sinkholes, and continuous collapses.

- Therefore, their management requires special scientific methods, especially for agricultural exploitation. Here, there seems to be an urgent need to expand to conduct diverse and comprehensive studies in the field of determining the chemical, physical, morphological, and micromorphological properties of gypsum soils, with a focus on studying the types of crops suitable for their economic exploitation (Al-Barzanji,1986) .

-Besides, many studies have indicated that the stability of soil aggregates with weak composition can improve markedly after several years of continuous cultivation, particularly with modern agricultural rotations that have been well studied and do not rely on deep plowing.

-Keeping parts of crop residues in the soil may have a positive impact on its physical and morphological characteristics, and the succession of both wetting and drying processes may lead to a significant decrease in its large pores and the formation of solid, surface layers.

### **Morphological characteristics of gypsum soil**

-Most studies specializing in gypsum soils have indicated a noticeable variation in gypsum in terms of shape, size, and distribution in different soils.

-Therefore, it is possible to distinguish several shapes of gypsum in gypsum soils in relation to their sizes according to the Unified Soil Classification System – USCS.

-Some of them appear in the form of lenticular or spindle-shaped crystals, the diameters of which may reach 2 mm, i.e., a size ranging from the size of silt to coarse sand.

-They may have crystalline faces that appear almost complete to complete. They may be in

the form of needle-shaped plates or have rough-textured crystalline diameters.

-They may take the form of clusters in some gypsum horizons.

-They may appear in the form of a fine powder depending on the different properties of the soils, the topographical location, and the distance from the main source of gypsum in the soils. (Buck et al.,2002 and Klein et al.,1985).

### **Physical properties**

-Texture is one of the most important stable, long-term physical properties and is crucial for understanding soil formation conditions and genetics.

- It is difficult to determine the specific soil texture in the field for characterization and classification of gypsum soils, along with other properties, depending on whether they are irrigated or rainfed, due to gypsum's solubility in water.

- Currently, there is no definitive method that can be used to determine this. In evaluating the particle size distribution and accurately identifying the texture classes of gypsum soils, the correct interpretations of the physical behavior of these soils are developed.

-However, most laboratory methods used to determine the particle size distribution of gypsum soils involve pretreatment to remove gypsum and the most soluble salts, as well as iron oxides.

-It should be noted that the presence of gypsum in the soil will give it a rough texture when assessing its texture in the field, unlike laboratory testing, due to gypsum's solubility in water.

-Thus, field estimation of the texture of gypsum soils is misleading because gypsum crystals

exist in varying sizes, some as small as sand grains.

- Consequently, the shape and degree of crystallization of gypsum particles will affect the soil texture. (Pearson et al.,2014 and Soil Survey Staff,2014b).

### **Chemical properties**

-Most studies and research in the field of studying gypsum soils for Iraqi soils have shown their very low content of organic materials due to the nature of the climatic conditions prevailing in arid and semi-arid regions characterized by low rainfall and leaching (Al-Bayati et al.,2017).

- This primarily results in sparse vegetation cover and reduced biodiversity.

- Organic matter content decreases with soil depth.

-Regarding the cation exchange capacity of gypsum soils, which reflects the soil's ability to retain nutrients adsorbed on exchange surfaces and subsequently exchange them for other elements, the CEC of gypsum soils is also low (Alawi et al.,2017).

- Thus, the extent of its availability to plants, which is considered a storehouse that supplies plants with the elements necessary to complete their life cycle, is ideal (Al-Maamouri et al.,2024).

### **Gypsum soil management**

-The process of exploiting gypsum soils agriculturally, which cover large areas of land, requires modern methods of managing them properly, which works to provide large quantities of food to the increasing numbers of the world's population annually, to sustain food security, which represents a major

challenge to nature and its outputs from gypsum lands.

-One of the most prominent problems with these soils is the gradual dissolution of gypsum, creating what are called sinkholes, and consequently causing the collapse of large areas of agricultural land, rendering them unusable and therefore unsuitable for agriculture.

-Therefore, the use of traditional tillage systems in gypsum soils has proven inefficient and completely unsuitable for these soils.

-The presence of large quantities of gypsum in the soil causes numerous problems in its overall properties. Many studies and research in this field have demonstrated that adopting shortened tillage systems has achieved significantly higher yields and yield components compared to traditional tillage methods.

- It is considered a very good alternative under agricultural conditions to gypsum soils, in order to save on energy and labor costs economically, as well as reducing soil erosion, promoting biological conditions, and improving soil quality in line with the conditions specific to gypsum soils.

-It also increases the accumulation of organic matter at the surface and increases the stability of the aggregates, thus improving their properties.

-Furthermore, adding fertilizers, including phosphates, by the dual-sided drip method of the crop has proven, through existing studies in this field, to be more efficient than using traditional methods such as broadcasting,

bunding, and one-sided drip application, which are not suitable for supplying plants with nutrients optimally in such soils.

-Therefore, the optimal management of tillage and fertilization systems for gypsum soils, in accordance with their nature, will inevitably reduce costs while increasing yield and quality to maximize the net production of crops grown in them.

-Moreover, the irrigation systems used in irrigating gypsum soils have a significant impact on their optimal management. Irrigation science examines irrigation water sources, methods of controlling and utilizing them, and delivering them optimally to agricultural lands.

- The general concept of irrigation is adding water to the soil to provide it with the appropriate moisture for plant growth.

- However, in the modern and widely accepted concept among irrigation management specialists, irrigation is the optimal use of water rather than yield.

- "Optimal" here refers to the most realistic approach to managing the irrigation process according to soil types, as determined by those concerned. Irrigation, within the modern concept, is the development of an understanding of the water processes occurring in soils of various types and characteristics, which include the transfer of water from the soil to the plant.

-This leads to the optimal use of irrigation water and the reduction of waste, while increasing yield and quality of production, in line with the scarcity of water resources that has recently emerged as one of the most

prominent problems facing the agricultural sector. (Obaid et al.,2017 and Salem et al .,2008 and Mahawish et al., 2016).

### ***Conclusions***

From the above, it can be concluded that the presence of gypsum in moderate quantities in the soil will physically contribute to improving its construction, drainage, and aeration, and will increase water conductivity, as well as improve the aggregation of its particles. On the other hand, soils are classified as gypsum soils if gypsum is found in them in large quantities or exceeding 10%, which leads to weakness in their structure and bearing capacity, especially when moistened, due to the high solubility of gypsum in water, and causes collapses, settlement, and sinkholes in soils. The process of exploiting gypsum soils, which cover vast areas of land worldwide, in the agricultural field requires modern methods of managing them, as one of the most prominent problems of these soils is the gradual dissolution of gypsum, causing what are called sinkholes, and consequently, the collapse of large areas of agricultural land, and their being out of service and unsuitable for agriculture. The adoption of shortened tillage systems has achieved high positivity in yield ratios and components compared to the adoption of traditional tillage methods, as it leads to the accumulation of organic matter on the surface and increases the stability of the aggregates, which improves soil properties. Also, the addition of fertilizers, including phosphates, by the dual-sided drip method of the crop has proven to be more efficient than the use of traditional methods.

### ***Recommendations***

This article highlights the urgency researchers to conduct broad studies to better understand the characteristics of gypsum soils to determine appropriate methods in their management method to ensure that they do not deviate from their agricultural scope for the sustainability of food security in the world and in a manner consistent with the nature of increasing population growth, which makes there an urgent need to provide food and energy sources.

### ***References***

1. Khudair, Lama Sadiq, and Saloum Barghouth Salem. 2019. The effect of gypsum content on some properties of the aquatic soil. Iraqi Journal of Agricultural Research. Volume (24). Issue (1).
2. Jafarzadeh, A.A, Zinck, J.A. 2000. Worldwide distribution and sustainable management of soil with gypsum”, ISD Ana sayfasi.
3. Soil Survey Staaf. 1975. Soil Taxonomy: A basic system of soil classification. Soil Survey Agric. Handbook No.436. U.S. Government Printing Office, Washington, D.C.
4. Salim, Qasim Ahmed. 2001. The effect of irrigation water quality and method of addition on the properties of gypsum soils in the Al-Dur area. PhD dissertation. College of Agriculture. University of Baghdad.
5. Al-Khafaji. AK. Ab-K.B 2016. Detecting the Pollution Status of Soils and water in the lake Sawa area Using remote Sensing Techniques. masters Thesis. College

- of Agriculture. Al-Muthanna University.
6. Peyman A., S.Mahmoodi, H.Torsbi, M.H.Masihabadi and M.Homaei. 2011. Morphological, Physico-Chemical.
  7. F.A.O.1990.Management of gypsiferous Soil.F.A.O.Soils bull.NO62.F.A.O.Rome.
  8. Al-Bayati, Mahmoud Ahmed Latif. 2020. A Study of the Mineral Composition of Some Gypsum Soils and Their Relationship to the Adsorption of Copper and Zinc. PhD Dissertation. College of Agriculture. Tikrit University.
  9. Buck, B.J., and J.G. Van Hossen. 2002.Snowball Morphology and SEM Analysis of Pedogenic Gypsum. Southern New Mexico,USA.J.Arid Environ.51:469-487.
  10. Al-Barzanji, Abdul Aziz, Qasim Ahmed Salim, and Buthaina Wadih Mansour, 1986. Chemical, Physical, and Mineralogical Properties of Gypsum Soils. Symposium on Gypsum Soils and Their Impact on Construction and Agriculture.
  11. Klein, C., and C.S. Jr. Hurlbut. 1985.Manual of Mineralogy. After J.D. Dana,20th Edition.John Wiley and Sons, New York.
  12. Pearson,J.M.,E.S.Monteith.,R.R.Ferguson, T.C.Hallmark, H.W.Hudnall, C.H.Monger.,G.T.,Reinsch.,T.L.West.2014.A method to determine particle size distribution in soils with gypsum. Geoderma.237-238:318-324.
  13. Soil Survey Staff. 2014b.Kellogg soil survey laboratory methods manual. Soil Survey Investigation Report No.42.Version 5.0. United States Department of Agriculture, Natural Resources Conservation Service,USA.100IP.
  14. Al-Bayati, Ali Hussein Ibrahim, Ahmed Saleh Muhaimid Al-Mashhadani, and Saleh Abdul Saleh Al-Jabri. 2017. Determining the mineral composition of fine sand separators in Faydhat Baribj as a model for the soils of the southern Iraqi desert. Iraqi Journal of Desert Studies. Vol. 7, No. 1. pp. 72-83.
  15. Alawi, Hussein Kadhim, Amal Radhi Jubair, and Safa Mahdi Abdul Kadhim. 2017. The effect of groundwater movement on the accumulation of gypsum content in the soils of the Karbala Governorate. Kufa Journal of Agricultural Sciences. Vol. 9, No. 1. pp. 160-170.
  16. Al Maamouri, Abdul Baqi D.S., and Al Shamy, Salwa H. K. 2024. EFFECT OF MINERAL COMPOSITION ON SEQUENTIAL EXTRACT OF LEAD AND CADMIUM IN SOME IRAQI SOILS. IRAQI JOURNAL OF AGRICULTURAL

SCIENCES, 55(6), 2060-2073. DOI: <https://doi.org/10.36103/k8mc7q15>.

17. Obaid, Dawood Fayyad, and Ramzi Muhammad Shihab. 2017. The effect of irrigation method and growth stage on potato root distribution in gypsum soil. *Tikrit Journal of Agricultural Sciences*. Volume (17). Issue (4).
18. Salem, Saif Al-Din Abdul-Razzaq, and Bahaa Abdul-Jabbar Al-Hadithi. 2008. The role of irrigation methods and bitumen in improving some physical properties of gypsum soil and yellow corn yield. *Iraqi Journal of Desert Studies*. Volume 1. Issue 2.
19. Mahawish, Nour El-Din Muhammad, and Khalaf Hussein Hamad Al-Majma'i. 2016. A new system for managing tillage and phosphate fertilization of wheat in gypsum soils. *Tikrit University Journal of Agricultural Sciences*. Volume (16). Issue (4). Pages: 130-143.