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Evaluation of well water in the site Technical Agricultural College - Mosul for its validity in the growth and yield of three varieties of the cotton plant (Gossypium hirsutum L.)

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Abstract. Groundwater is one of the most important sources of water storage in the world, which is used as an alternative when rains are scarce and the drainage of the Tigris River is low. Wells have been dug in the site Technical Agricultural College - Mosul (Rashidiya area) and used for various purposes without prior planning. Therefore, it is necessary to conduct a study on the quality of groundwater in the Agricultural Technical College to demonstrate the validity of its use for agriculture, especially the cotton plant within the fields of the Cotton Research Unit. 4 wells were selected in the study area, which were used to irrigate the cultivation of 3 varieties of the cotton plant (1. Ashore V1, 2. Lashata V2, 3.Coker 310 V3) Water samples were collected from the wells and some on-site tests were conducted for them, and then the physical examinations were performed, represented by (their electrical conductivity, refractive index, surface tension, density and viscosity) as well as the chemical tests that included (acidic function, total dissolved salts, total hardness, and positive ions such as calcium, magnesium, sodium, and ions). The negative results represented by chlorides and sulfates in them. The results showed that there are differences between the wells in all the measured characteristics due to the difference in the geological nature between the wells because some of them contain gypsum and lime components that are soluble in water. Plant height, number of fruiting branches, number of blooming bolls and total yield of cotton blossom per unit area (kg/hectare).

Keywords: water tail, cotton varieties, chemical analysis, sulfate effect, sodium effect.

Introduction

The study of groundwater quality is necessary to determine the specifications of this water and its suitability for various uses, as it is one of the important natural sources of fresh water, especially areas far from rivers and lakes, and most agricultural lands depend on preparing their water on wells dug for this purpose[1].
In general, most groundwater contains different concentrations of dissolved substances higher than their surface counterparts because they dissolve many minerals during their passage under the surface of the earth in the different rocky layers, but in spite of this, the groundwater is characterized by its purity as it is far from direct sources of pollution as well. Its temperature is often moderate during the different seasons [2].
Many researchers have studied the qualitative characteristics of groundwater in various regions of Iraq, where[1] conducted a hydrogeochemical evaluation of some wells in the city of Mosul and assessed their suitability for irrigation purposes. The previous study[3] showed the validity of water for irrigation of some crops that are resistant to high salinity and evaluated the water quality of a group of wells in the areas of Rashidiya and Kubba,

and they indicated that the water quality of the wells in the region is between good and bad and that this water contains a high concentration of salts, especially sulfates, calcium, bicarbonate, and sodium.

The fields of groundwater used depends on its quality, which in turn depends on its chemical properties. Therefore, it is very necessary to conduct hydro-chemical studies of groundwater before starting to use it in various fields, since groundwater passes through thousands of voids and pores of the rocky layers and thus it is often characterized by high concentrations. Chemical ions compared to river water[4].

Chemical analyzes of water were carried out in order to identify and quantify the chemical elements and properties of specific water, including the pH, main cations, anions, and trace elements[5,6,7].

The study of water is of great importance for human life, for agricultural uses, for the purpose of food industries, etc. Therefore, water varies in its chemical composition, as water enters the earth through the soil in the first stage is enriched with carbon dioxide (CO_2) gas resulting from the activities of plants, as it helps in the dissolution of the various carbonaceous and siliceous rocks. This process takes place on the scale of the soil and from the soil penetrates into the rock layers under the different soil[8].

The nature of rocks plays a big role in determining the chemical properties of water. In the case of siliceous rocks such as sedimentary sandstone rocks, the water is characterized by small quantities of dissolved salts in it and low concentrations of some elements, especially chlorine and sulfate (SO_4), and is characterized by the presence of other elements such as sodium (Na), calcium (Ca) and magnesium (Mg).

In carbonate rocks, the most abundant elements are calcium (Ca) and bicarbonate (HCO_3), and in some cases, magnesium (Mg) is present. In evaporate rocks such as gypsum and anhydrite, groundwater contains large quantities of sodium chloride (NaCl), calcium (Ca), and sulfates (SO_4) Groundwater varies according to the porosity and permeability of the rocks that make up the aquifer. In clay rocks, the movement of groundwater is slow and consequently, it enriches in greater quantities than (Ca, Mg, Na, SO_4). For water in igneous and basaltic rocks, groundwater runs in fissures due to its non-porosity and the sodium element (Na) dominates all the positive ions. In granitic rocks, as for basalt rocks, water is characterized by a greater percentage of calcium (Ca) and magnesium ((Mg). Groundwater is subjected to many processes such as evaporation, irrigation, plant and biological activities in addition to various human influences. All these processes affect the quality of water and its chemical composition[4,8]. Some processes lead to the chemical change of the entire water, such as sewage pollutants near wells The study of the chemical composition of groundwater in all regions and in all layers of water and the factors affecting its quality is important in evaluating water resources in any region and determining the suitability of different water for human uses and consumption (drinking water) and agriculture[3].

The cotton crop is one of the strategic crops grown for the purpose of producing fiber as well as extracting oil from its seeds, and it is one of the development industries in Iraq, especially textile. Cotton cultivation in Iraq has faltered in recent years for reasons related to the difficulty of conducting agricultural operations and weak agricultural orientation and was dependent on the cultivation of a single variety, Coker. 310, as its qualities deteriorated due to the repeated cultivation of it annually, as new varieties were introduced as an experiment that is more suitable for the Iraqi conditions, and the length of the cotton growth period, which exceeds 150 days for most of the varieties, which is considered one of the stressful crops for the soil (Al-Fahdawi et al 2011)[9], in addition to its needs Hydroponics because it grows and bears fruit in very hot conditions, and therefore it needs a lot of water, which is a major problem in its cultivation, as[10] indicated that the irrigation system plays a major role in influencing the behavior of crop growth, which is reflected in the outcome. Specifically, it was necessary to use well water at the site of the Agricultural Technical College/Mosul due to the lack of fresh irrigation water, which was called to be a determining factor in irrigating the crop. The aim of this research is to study the chemical analysis processes of wells water near cotton fields in the areas of Rashidiya to know its suitability for irrigation during crop growth stages and for a number of genotypes available in the research plan programs for the purpose of cultivating field crops (cotton), the cultivation of 3 varieties of cotton plants (1. Ashore of Iraqi origin V1, 2. Lashata of Spanish origin V2, 3. Coker 310 American origin V3).

Materials and Analysis Methods

Study Area:

The study area is located in Nineveh Governorate in northern Iraq. Four wells of ground water were selected at the Agricultural Technical College site near the Tigris River in the areas of Rashidiya, with depths of up to 15m, for watering the cotton plant grown in the flat land next to it, whose Silty loam soil is mixed. The research was carried out in the water of the aforementioned wells for the year 2019-2020, which were used to water the cultivation of 3 varieties of cotton plants (1. Ashore of Iraqi origin V1, 2. Lashata of Spanish origin V2, 3. Coker 310 American origin V3).

Sample Collection: Samples were collected from each well once every two months because the groundwater is isolated from weather conditions, starting from April 2020 until September 2020, when the well pump is running for about 10 minutes to eliminate the effects of the pump on the type of water and to ensure that the sample represents the well water, after that some local tests are examined such as measuring the temperature and the pH-value, and then the samples are taken to the Chemical Industries Laboratory (in the Department of Chemical and Petroleum Industries Techniques) in 2.25 liter plastic bottles and placed in the refrigerator at (+4°C) for the rest of the tests, based on ISO standards[11]. The samples follow the standard protocols and methods of American Public Health Organization (APHA)[12] and American Society for Testing and Materials (ASTM) using different calibrated standard instruments[13].

Methods of analysis or Laboratory analysis

Physical analyses were performed, such as electrical conductivity, refractive index, surface tension, density and viscosity, according to the standard methods of APHA[12,13].

On-Site measuring of temperature was carried out at the site of sample collection.

Samples conductivity was measured using a Digital Electrical Conductivity Meter (model JENWAY 4510). The calibration of the probe was made by using a standard solution that has known conductivity. The probe was submerged in the water sample and the reading was recorded after the disappearance of the stability indicator. After each sample measurement, the probe was washed with deionized water to shun cross-contamination among different samples. The results are expressed in units of (mhos/cm) or (μ.s/cm), where three readings are taken for each sample then the rate is taken for them.

Refractive index[14]**:** The refractive index (n) of a material is the ratio of the speed of light in a vacuum to its speed in a material. It varies with the wavelength of the light used to measure it and the temperature. The samples refractive index was measured by Bellingham and Stanley Limited Refractometer. The refractive index can also be defined as the ratio of the sine of the angle of incidence to the sine of the angle of refraction. The measurement of the refractive index is mainly used to give an indication of the proportion of impurities present in the water and it is measured using a Refractometer.

Surface tension[15]: It is defined as the force applied perpendicular to a unit of length towards a tangent to the surface of the liquid. Surface tension is symbolized by γ. Surface tension is measured in units of (N/m), or dyne/cm. The surface tensile strength of a liquid is measured by the capillary elevation method. Surface tension is responsible for the phenomenon of high fluid rise in the capillary tubes. This phenomenon has been used to determine the amount of surface tension of a liquid according to the following equation **(1)**:

$$\gamma = 1/2\ h\ d\ g\ r \quad ....(1)$$

Where represents the surface tensile strength **γ** in units (dyne/cm), **h** represents the height of the fluid in the capillary tube as cm, **d** the fluid density (g/cm^3), **g** is ground acceleration and is equal to 980 (dyne.cm/s^2) and **r** is the radius of the capillary tube as cm.

Density[16]: is defined as the mass of the unit volume of that fluid and is given by relation. **D** is the density of the liquid: **(d = m/v)** and its unit is g/cm^3 or kg/m^3 where the mass of the liquid and its volume is v and m. It is measured using the density vial and the temperature fixed at 20°C, this process was repeated twice.

Viscosity measurements[16]:

viscosity is the amount of resistance of a substance to change the shape or resistance to the flow of a liquid, for liquids, the viscosity is measured with a tool called a viscometer to determine the viscosity of water using a viscometer, Ostwald-type viscometer, and dynamic viscosity is measured by the time of the descent of a certain volume of liquid through a tube Lattice per second can be calculated from the following equation **(2)**:

$$\upsilon = c.t \quad ....(2)$$

Where **υ** the viscosity of the liquid, the viscosity unit is Poise, **c** the viscometer constant according to the capillary diameter of the viscometer, and **t** the liquid descent time in units of **s** seconds. As for the kinematic viscosity, it is calculated from the following equation **(3)**:

$$\mu = \upsilon.d \quad ....(3)$$

μ kinematic viscosity, **d** liquid density, and **υ** dynamic viscosity.

As for the chemical analyses that included the acidic function pH, Total Dissolved Solids TDS, total hardness TH , positive ions such as (calcium Ca^{+2}, magnesium Mg^{+2} and sodium Na^{+1}), Total Alkalinity and Total Acidity, and the negative ions represented by (sulfates SO_4^{-2} and chlorides Cl^{-1} in them), standard methods were used for water tests and the tests were conducted in the Chemical Industries Laboratory at the Technical Institute/Mosul at the Northern Technical University.

pH-Value[12,17]: The (model JENWAY 4310) pH meter was used to define the pH of samples after calibrating with three different buffer solutions (pH 4.0, 7.0, and 10.0), before taking the measurements. The value of each sample was possessed after submerging the pH probe in the water sample and holding it for a couple of minutes to attain a stabilized reading. After the measure of each sample, the probe was washed with deionized water to avoid cross-contamination between different samples.

Total Dissolved Solids TDS [12,13]: The TDS of the water samples were determined by the gravimetric method. After filtration, the filtrate was evaporated and dried to constant mass at 103–105^{o}c for 2 hours, then cooled in desiccator to room temp. The remaining mass of the residue represents the amount of TDS in a sample.

Total hardness (TH)[13,17]: It was estimated using the titration method with Na_{2}-EDTA (Disodium Ethylene Diamine Tetra Acetic Acid) (EDTA Titrimetric Method) and water hardness is usually expressed as the concentration of calcium carbonate in water in units per million parts. (ppm). The method used here is to estimate the sum concentration of calcium and magnesium ions by forming complex compounds with Na_2EDTA, where both calcium and magnesium ions react in a 1:1 ratio with Na_2-EDTA in the presence of the Eriochrome Black-T dye as a reagent at the appropriate pH = 10 and express the results in mg $CaCO_3$/l.

Calcium Hardness CaH[13,17]: Ca^{+2} alone was determined by titrating the water sample with a standard 0.01M Na_{2}-EDTA solution in the presence of Eriochrome Black-T reagent at pH = 12 using a buffer of (20 % Solution of potassium or sodium hydroxide) and express the results in mg $CaCO_3$/l.

Magnesium hardness MgH[13,17]: was calculated mathematically from the following equation**(4)**:

MgH (mg/L) = (TH - CaH) X 0.243 ……(4)

MgH Magnesium hardness**, CaH** calcium hardness.

Sodium ion[12,13,17]: measured using Flame Photometer in order to calculate sodium percentage and sodium adsorption ratio (SAR).

The validity of the water of the study area's wells for agricultural uses (cotton cultivation) was determined by calculating the percentage of sodium adsorption (SAR) according to the following relationship **(5)**[12,13]:

SAR = Na / (((Ca + Mg) / 2)) ^ 0.5 ……..(5)

and that after calculating the equivalent concentrations of sodium, calcium, and magnesium.

Total Alkalinity[12,17]: It was determined by titrating the water sample with sulfuric acid and using the methyl orange as the reagent, in order to define (CO_3^{-2} and HCO_3^{-1}) and the results were expressed in the unit of mg $CaCO_3$/l.

Total acidity[12,17]: It was estimated by titrating the water sample with a sodium hydroxide base solution (0.02N) and using the phenolphthalein dye as a reagent, the results were expressed in the unit of $CaCO_3$ mg/l. As for the mineral acidity, it was determined by titrating the water sample with a solution of sodium hydroxide base (0.02N) and using methyl orange as a reagent. The results are expressed in mg $CaCO_3$/l.

The sulfate (SO_4^{-2}) in the water sample was determined using the gravity method (by Burning sediment)[13]: applied to water whose sulfate value is more than 10% by sedimentation using a 10% barium chloride solution in a dilute acid environment.

Chloride ion (Cl^{-})[12,13,17]: was determined using Mohr's Method (Argent metric Titration Method) by titrating the water sample and distilled water with silver nitrate 0.0141M, the approved method for determining the chloride ion in clear water that contains low concentrations of chloride, neutral and slightly alkaline water. Using potassium chromate as a reagent, and express results in mg/l.

Agricultural experiment design and operations:

The research was applied in the field of Cotton Unit - Agricultural Technical College for the season 2021, using three varieties of different origins (1. Ashur V1. 2. Lachata V2. 3. Coker 310 V3).

Cotton seeds were sown for the three above-mentioned varieties on 15/4/2020 after performing the irrigation to determine the site of planting the seeds, the seeds were soaked with water for 24 hours before planting and preparing the allocated land, from the remnants of the previous crop and plowing it with a rotating disc plow twice in an orthogonal manner, then the process of softening the soil and dividing the field into beds with a length of three meters and a width of 90 cm. The data or traits under study are plant height (cm), number of fruiting branches, number of bolls per plant, and total yield of flower cotton (kg/ha), which was implemented as a factorial experiment in the design of randomized complete blocks, The first factor is the three cotton varieties: Ashore, Lashata and Coker 310, the second factor is 4 models of well's water: Well No. 1, Well No. 2, Well No. 3 and Well No. 4, meaning that the total number of transactions is

12 treatments. The transactions were randomly distributed among the experimental units with four replicates in four locations of the wells. The necessary service operations were performed as needed, including the irrigation process by following the method Surface irrigation, hoeing, weeding, control of insect and disease pests, and fertilization operations, where urea fertilizer 46% nitrogen was added to all treatments both in two periods. The first period on stage of vegetative growth and the second period at the beginning of the formation of flower buds and bolls growing after 45 days from the first harvest and the growth of the plant continued until the first of October, when the flower cotton yield was harvested, which is the first harvest on 1/10/2020, and the second harvest was on 1/11/2020, and the following data were recorded:

1.The height of the plant, which was recorded once in the vegetative growth stage.

2.The number of fruiting branches recorded In the stage of bolls formation.

3.The number of blooming bolls was recorded in the final stages during the process of harvesting crops.

4.The yield of cotton and considered the total yield per unit area and twice as previously mentioned and estimated on the basis of kg/ha.

The averages of transactions were taken to compare between varieties and irrigation treatments according to the design followed and compared These averages of the different parameters according to Duncan's test 5% probability level [18,19].

Results and Discussion

That the physical and chemical characteristics are important in determining the suitability of well water for irrigation of the cotton plant. For comparison of the physical and chemical tests, the Iraqi Standard No. 417) of 2001 issued by the Central Organization for Standardization and Quality Control was approved as a local standard[20].

The pH-value: The pH values of the four study samples were showed in Table 1. and the followings were noted: The pH-values of the study samples were close to the neutral within the range of 7.6, while the Iraqi and American standards set[20.21] the pH value between (8.5-6.5) Which makes the four models conform to the Iraqi specifications[22]. This is due to the regulatory capacity of the bicarbonate-containing water, in addition to the calcite and dolomite rock components that enter the water as a result of their dissolution - which works to neutralize the acidity of the water at the total base of the water when it occurs[23]. This confirms that it was found that upon finding the total basicity, it represented the basicity of bicarbonate only in the current model of the four wells.

As for the temperature, it ranges from 26 to 27°c for the aquifer, and it was characterized by the narrow range of temperature change. Thus, the studied wells are classified as being of the category of warm groundwater according to Round[24].

Table 1. Some of the physical and chemical characteristics of water wells under study in the Agricultural Technical College and its comparison with the Iraqi standard specification No. 417 of 2001.

The Sequence	Water Sample Number / The Test	1st	2nd	3rd	4th	The limits of IQS/No. 417/ 2001 for water [20]
1	Electrical conductivity EC (µs/cm)*10^3 at 25°c	2.81	3.49	2.20	1258	(1.5)*10^3 max
2	Temperature °c	26	26	27	27	10-12
3	Kinematic viscosity υ(cSt) at 25ºc	1.365	1.412	1.435	1.400	
	Dynamic viscosity µ (cp) (g/m.s) at 25°c	1.328	1.374	1.394	1.113	
4	Density (g/cm^3)	0.9723	0.9727	0.9716	0.9749	
5	Refractive index	1.30	1.301	1.30	1.30	
6	Surface tensile strength	54.789	49.331	43.800	65.923	
7	Acidic function pH-Value	7.6	7.6	7.6	7.6	6.5-8.5
8	Total Dissolved Salts	2280	2720	2220	5160	1000 max.

	(mg/l) TDS					
9	Insoluble solids (mg/l)	30000	2820	3120	920	
10	Total basic represents bicarbonate basicity only in this model (mg/l).	216	368	136	304	
11	Total acidity (mg/l)	0.0	0.0	0.0	0.0	
12	Sulfate (SO_4^{-2}) (mg/l)	2222.1	1048.5	3889.4	2006.4	250 max.
13	Chlorides (mg/l)	127.744	107.784	31.99	135.957	250 max.
14	Total hardness (mg/l)	1464	1920	760	1776	500 max.
15	Calcium concentration (Ca) (mg/l)	32.064	28.858	0.0	28.858	50 max.
16	Magnesium concentration (Mg) (mg/l)	310.016	413.952	170.24	381.696	50 max.
17	Sodium concentration (Na) (mg/l)	445.528	523.526	471.24	1091.898	200 max.
18	Sodium adsorption ratio SAR	34.066	35.184	51.077	76.210	
19	The percentage of %Na	56.567	54.629	73.461	72.674	

Total dissolved salts TDS: Table 1. shows the results of testing the total dissolved salts and the followings were noted, the values of the total dissolved salts (TDS) concentration ranged between (2280-5160 mg/l), which makes this variable and for all the examined samples higher than the upper limit allowed in the Iraqi standard (1000 mg/l)[20]. Despite the high values of total dissolved solids, there are differences between the wells of the study area, and the highest value was recorded in Well No.(4) and it was 5160 mg/l, as it is the case with electrical conductivity, where it was $1258*10^3$ µs/cm, while well No. (3) it was the lowest value, but all wells had higher values than the Iraqi standard for drinking water No. (417) for the year 2001[20].

The reason for the high concentration of TDS in wells 1, 2, 3 and 4 is attributed to the fact that it is located within the Al-Fatha formation, where gypsum, anhydrite, and dolomite rocks are rocks rich in salts that are more soluble in groundwater than surface water[25].

Electrical conductivity: This measurement expresses the total concentration of dissolved salts. The value of the electrical conductivity, as shown in Table 1., has reached high levels of $1258*10^3$(µs/cm) in well No.(4), while the value of the electrical conductivity decreased to $2.2*10^3$(µs/cm) in well No.(3). When comparing the results of the electrical conductivity values from Table 1., it was found that well No.(3) of the type C_3 is of high salinity (750-2250) µmose, while wells No.1,2, and 4 are of type C_4 very high salinity according to the classification of the American Salinity Laboratory and its water is suitable for plants of very tolerant to salinity and on permeable soils with good drainage[13,26].

Total hardness (TH): It represents the concentration of calcium and magnesium ions, and it is the main ions that cause hardness in natural waters[26]. The nature of geological formations through which natural waters pass is the reason for the difference in the concentration of total hardness in these waters, where the total hardness values ranged between (1920-760) $CaCO_3$/l, which is higher than the maximum permissible limit in the Iraqi standard (500) mg $CaCO_3$/l, is considered very hard according to classification Todd[27], as it exceeds 300 mg $CaCO_3$/l. The salts affect the yield of the crop through their effect on osmosis. This is in addition to the concentration of cationic ions that cause water extraction from the soil mud and thus lead to leaching[28].

Cationic ions:

Calcium ion Ca^{+2}: The calcium ion concentration values of the study samples were shown in Table 1., and the following are noted from it, the values of calcium ion concentration in the study samples ranged between (0.0-32.064 mg/l), which is less than the upper limit allowed in the Iraqi standard (50 mg/l)[20]. That is, within the permissible limits and there is a perfect match between the samples and the Iraqi specification. The reason for this is due to the geological layers incubating water with rocks with little content of calcareous components, and calcium plays a role in reducing the sodium content of the water used for agriculture.

Magnesium Ion Mg^{+2}: Table 1. shows the results of examining the magnesium ion concentration of the study samples and notes from the table the following:

The values of the magnesium ion concentration in the tested samples ranged between (170.24-4133.952) mg/l, which is higher than the upper limit allowed in the Iraqi standard specifications (30 mg/l) for the concentration of magnesium ion[20]. The reason for this difference may be attributed to the difference in geological layers formed from dolomite rocks responsible for magnesium within the formation of the Al-Fatha that makes up the study site wells area[25]. However, increasing the concentration of magnesium in the groundwater is necessary for plants to build chlorophyll and It reduces the effect of the damages resulting from an excess of sodium ion[29].

Sodium ion Na^{+1}: The sodium ion concentration values of the study samples were explained in Table 1., and the following are noted from it, the values of the sodium ion concentration in the water samples under study ranged between (1091.898-445.528 mg/l). There is a discrepancy between the sodium ion values of the wells samples and there is another indicator for expressing the soda in irrigation, including the percentage of sodium, it turns out that the wells (1,2) are less than the upper limit allowed in the Iraqi standard, and it is less than (70%), as it is suitable for irrigation. There is a perfect match between the samples and the Iraqi specification. As for the wells (3,4) higher than (70%), they are not suitable for irrigation in terms of sodium, as they are very high in salinity. As the sodium interacts with the soil to reduce its permeability, the sodium concentration is therefore important in the classification of irrigation water[30].

When studied the wells water classification according to the US salinity laboratory for the purpose of irrigation, one of the common systems use, the sodium role is important in this classification, in which water is classified into (16) ranks on the basis of the combined effect of the value of the electrical conductivity and the ratio of adsorption of sodium SAR Sodium adsorption ratio)) shows that well No.(3) of the type C_3 with high salinity, while the wells (1,2,4) are of type C_4 had very high salinity according to the classification of the American Salinity Laboratory, and its water is suitable for plants that tolerate very salinity and on soils with good permeability[30].

Table 2. Classification of irrigation water according to chloride content.

Class of water	(Cl^{-1}) Conc. [ppm]	The water suitability	(Cl^{-1}) Conc. [mequiv./l]	The water suitability
(1) Little	< 200	this water is suitable for drinking and irrigation	< 2	Water is good for nearly all plants
(2) Moderate	200-500	Water quality is poor. It is used to irrigate plants with moderate salt tolerance.	2-4	The water is suitable for plants tolerant to the chloride ion, with slight to moderate damage visible to plants sensitive to chloride ion
(3) Medium	500-1000	It is used to irrigate plants that tolerate high salinity	4-8	The water is suitable for plants that are well tolerated by the chloride ion, with slight to moderate damage appearing on plants less tolerant to chloride.
(4) Intense	>1000	It is used to irrigate plants that are very tolerant to salt	> 8	The water is still suitable for plants that are well tolerated by the chloride

		ion, which can show minor to moderate damage

Sulfate ion SO4-2: It is known that the main source of sulfates is the dissolution of the gypsum rocks $CaSO_4.2H_2O$ and the anhydrite $CaSO_4$ present in the formation of the Al-Fatha, and there are also bacterial activities that cause it to dissolve, and sulfates are one of the main ions that cause permanent hardness, especially when it is associated with calcium and magnesium, and it is considered one of the causes of salinity. It is also an important factor in determining the suitability of water for irrigation[31,32,13].

The concentration of sulfates in the study samples was explained in Table 1. and the following is noted from the table: The values of sulfate concentration in the study samples ranged between (1048.5-3889.4mg/l), which in all cases is much higher than the maximum permissible limit in the Iraqi standard of (250 mg/l). This may be due to the geological formations of the area of the wells, and the variationis due to the geological variety of the area.

Table 3&4. shows the effect of cotton varieties on their response to the water of the four wells in the college, where there was a clear response to the variety Lashata, which was significantly superior to the characteristic of plant height, number of fruiting branches, number of blooming nuts, and total yield of cotton blossom per unit area ton/hectare compared with the two cultivars Ashore and Cocker 310 It is believed that the reason for this increase is due to the genetic differences between the varieties and their interaction with environmental conditions, and this is consistent with (Dawood et al (2002))[33] and Al-Fahdawi et al (2011)[9]. It was mentioned that the varieties differ genetically in cotton production and as a result of the influences of the surrounding environment and that the variety Montana surpassed the highest rate of hair cotton yield of 2422.3 kg/hectare from the rest of the varieties Sabouri Red, Natana, Lashata and Cocker 310 and Ashore and also excelled in technological characteristics in the average length of staple and softness of the fiber. Likewise (Al-Hajooj and Siddiq 2014) (and Al-Nuaimi 2016)[34,35,36] that the difference in genotypes is significant in plant height, number of fruiting branches, number of balls, average ball weight, and cotton flower yield, and concluded that the genotype is the main factor and determinant of the plant's ability to be discharged. This is consistent with the results obtained from the research under study.

Table 3. Effect of varieties on vegetative growth and total yield of cotton plant (*Gossypium hirsutum L.*)

varieties	Plant height cm	No. of Fruiting branches	No. of bolls	Total yield of cotton ton/hec
Ashore	**127.5 c**	**10.3 b**	**14.2 b**	**2.781* c**
Lashata	**149.0 a**	**15.5 a**	**19.2 a**	**4.344 a**
Coker 310	**141.5 b**	**12.2 b**	**15.4 b**	**3.149 b**

* Numbers that share the same alphabet, there are no significant differences between them.

Table 4. Effect of walls water on vegetative growth and total yield of cotton plant (Gossypium hirsutum L.)

No-of Wall	Plant height (cm)	No-of fruiting branches	No-of bolls opening	Total yield of Cotton ton/hec
1	147.3 a	15.1 a	18.8 a	4.059 * a
2	145.1 a	13.1 ab	17.2 ab	3.491 b
3	135.9 b	11.6 bc	15.9 bc	3.118 c

4	129.0 c	10.6 c	13.2 c	3.028 c

* Numbers that share the same alphabet, there are no significant differences between them.

Likewise, the same trend is observed in Table 5., which is the overlap between the genotypes and the location of the irrigation wells scattered in the areas of land in the college, where the variety excels Lashata and the location of the first well close to greenhouses, and this can be explained by the genetic makeup that characterizes the variety Lashata from the other two varieties. In addition to well number one, a pump was installed that works continuously, which led to the improvement of the chemical properties of the well water more than the rest of the wells under study. Therefore, there was a clear response of the class to the water of well number one. This is what Dawood et al (2002)[33] referred to as the superiority of the variety Lashata in the outcome. Blossom cotton gave 4016.18 kg/hectare compared to the variety Coker 310 (2835.6) kg/hec and the Ashore variety 2645.6 as well in the yield components and staple characteristics better than that of the variety Coker 310 and Ashore. These results are consistent with the results indicated understudy for the three varieties: Lashata, Cocker 310, and Ashore. In the characteristics of vegetative growth and yield of cotton blossom.

Table 5. It displays the characteristics of the yield of cotton varieties that were irrigated with well water in the Mosul Agricultural Technology Zone

varieties of cotton*	Qualities No. of the well	Plant height (cm)	Number of fruiting branches	Number of open bolls	Total yield of cotton Ton/hec
Ashore	1	132.8 de	12.8 d	15.6 ef	*3.650 b
	2	140.6 cd	10.2 ef	15.0 ef	2.828 cd
	3	121.1 ef	9.5 ef	14.2 fg	2.412 de
	4	115.6 f	8.8 f	12.1 fg	2.232 e
Lashata	1	168.6 a	18.8 a	22.6 a	4.922 a
	2	156.2 b	16.5 b	20.1 b	4.528 b
	3	141.6 cd	14.1 c	18.5 c	4.125 bc
	4	135.8 d	12.6 d	15.6 ef	3.802 bc
Coker 310	1	146.5 c	14.6 c	18.1 c	3.606 b
	2	138.6 d	12.5 d	16.2 de	3.122 cd
	3	145.1 c	11.1 de	15.1 ef	2.816 cd
	4	135.7 cd	10.6 ef	12.1 g	3.050 cd

* Numbers that share the same alphabet, there are no significant differences between them.

Conclusions and recommendations

The study concluded the following: It is noticed from the foregoing that the rocks incubating water in the four wells understudy played a major role in the quality of their groundwater, which led to the water of the four wells making the percentage of each of the (total dissolved salts, magnesium, sodium, and sulfate ions) in them higher than the upper limit of the Iraqi Standard No.(417) of 2001 in particular Well No.(4). These elements led to an increase in the percentage of physical characteristics (electrical conductivity, surface tension, density, and viscosity) and the high percentage of chemical properties (concentration of magnesium ions, sodium, and sulfates, and the percentage of sodium and the percentage of sodium adsorption), which made its water unsuitable for growing most plants except for salt-resistant or which need a lot of these items.

It follows from the foregoing the possibility of recommending the cultivation of the variety Lashata and in areas with abundant fertility and with favorable environmental conditions. It was found that the variety Lashata was significantly superior in all characteristics, plant height, number of fruiting branches, number of open bolls, and the total yield of cotton blossom in comparison with other varieties Ashore and Coker 310.

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Competing Interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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