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# Validity and quality control of water wells, the University of AL-Qadisiyah to irrigate green spaces within the University with identifying prevailing species of phytoplankton/AL-Diwaniya/Iraq.

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**ABSTRACT**

Studied quality wells University of AL-Qadisiya was the identification and selection of five wells distributed in separate colleges. Some physical and chemical tests and a full year of biomass (from January 2015 until December of the same year). chemical analyses of major ions ($Ca^{2}$, $Mg^{2}$, $Na^{+}$, $K^{+}$, $SO4^{=}$) function calculated pH conductivity and total dissolved solids. Validity has been determined these water wells for irrigation purposes through the use of sodium adsorption ratio(S.A.R.) and percentage of sodium, conductivity and appropriate study results showed both acid function and the percentage of sodium Na% based on the classification of global measurements for irrigation while there were increases in most standards examined the results of the study also indicated the absence of harm from the use of water wells, University based on adsorption of sodium, except English well water was moderately. The biological aspect in this study has involved identifying some types of algae in the water wells, and Bacillariophyceae formed the highest number of species of phytoplankton in the study area.

**Keywords:** water wells, green spaces, chemical analysis, phytoplankton

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## INTRODUCTION

Facing most countries in the world, critical water situation, the progress of civilization than the individual requirements of water as a result of rising living standards and concern for food security and public health awareness and concern for the environment and so increase the concerns of the world provide further potable water per capita, and the quality of the water which include the physical and chemical characteristics and biomass of key aspects in determining the suitability of water for so many countries of the world have tended to develop specific measures to assess and classify , Groundwater is one of the most important parts of the water resources, they accounted for 1.7% of the total water available worldwide and%71.7of safe drinking water in the world and includes groundwater wells and springs which originate mainly from rainfall and irrigation water that spews into the ground and stored underground in non-porous layers to form reservoirs of groundwater [1]. Sticky maintain the natural balance of environmental groundwater need is to be them and preventing the arrival of pollutants at it from sources related to human uses or exploitation wasteful water which includes a range of measures to protect groundwater from contamination, including security exploitation of groundwater so that aquifers remains constant in the long term [2].And the need to use water to all aspects of life, drinking, irrigation and others became necessary to resort to underground water as a second source of water sources, but this kind of water to suffer some problems concerning the increase in soluble salts concentration as a result of their exposure to the rocks and geological layers in addition to the contamination of fertilizers and waste liquid and solid and leaking it through the acrid classes[3].And the city of Diwaniya was one of the sites affected by groundwater as the groundwater level in Al-Qadisiyah province is close to the surface and fluctuating depending on the uses of water daily as most cities of the province without sewage systems, except the county and of the city of Diwaniya, where the sewage network covers (25 %) of the area of the city In addition, the site of Al-Qadisiyah clear impact of the high water table, which occupies the center of the northern part of the sedimentary plain that is already weighed down by higher and fluctuating groundwater levels[4].The groundwater of my favorite sources of water so as not to need to be addressed in most cases, and the fact that the temperature and density relative steady throughout the year about where helped to provide water budget as the main source for drinking or other uses as are groundwater use ground to irrigate reclaimed for cultivation and utilizedasa source Important[5]. It is worth mentioning the aquatic environment contain huge numbers of living or objects bacteria, plant and animal plankton and other, as live phytoplankton generally on the water's surface and in its depths are found in all water that is exposed to sunlight sources and so it is one of the most prominent high impact in saving energy objects as its energy comes from photosynthesis[6]. And there are many factors that contribute to the marked variations in the diversity of phytoplankton in the water bodies, and these factors are working in different times and places as the covariance seasonal algae linked largely to seasonal Changes temperature, lighting and nutrients and that these factors are working on changes unbalanced and an increase in diversity in the ecosystem[7]. The choice was signed on the study of wells Al-Qadisiyah University in Diwaniyah province because this water resource in the university did not get his share of the study and the survey and the fact that these wells are the main source of water upon which the cultivation of green spaces in the university, therefore the current study aimed to conduct a survey of the waters of some wells Al-Qadisiyah University and assess suitability to irrigate the green spaces in the university and the study of phytoplankton, diversity and vulnerability to physical and chemical variables of water.

**The study area:**

Has been set number of wells in the University of Qadisiya, which is located within the city of Diwaniya, Qadisiya province, as was the choice of five wells Confined astronomically between longitudes 44.88, 19.50 east longitude, 32,00,10,39 Table (1) and used these water wells for the purpose of watering gardens and green spaces in the university and the below numbers and locations of the wells taken to study the form of (1)

1-The well is located in the College of Education, Department of Chemistry.
2- well near the presidency of the University of Qadisiya.
3-well located in the College of Education / FSM physics.
4-the well located at the Faculty of Science
5-well located in the College of Education, Department of English Language near Playground.

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**Table (1): study sites and coordinates recorded by a device of the space positioning (GPS)**

| No. Well | latitude north | longitude east |
|---|---|---|
| 1 | 32,00,10,39 | 44,88, 19, 50 |
| 2 | 32.00, 27, 90 | 44,88, 26, 49 |
| 3 | 32.00,28, 68 | 44,88 ,17, 31 |
| 4 | 32.00, 06, 92 | 44,88, 25, 96 |
| 5 | 32,00,20,15,5 | 44,88, 27, 86 |

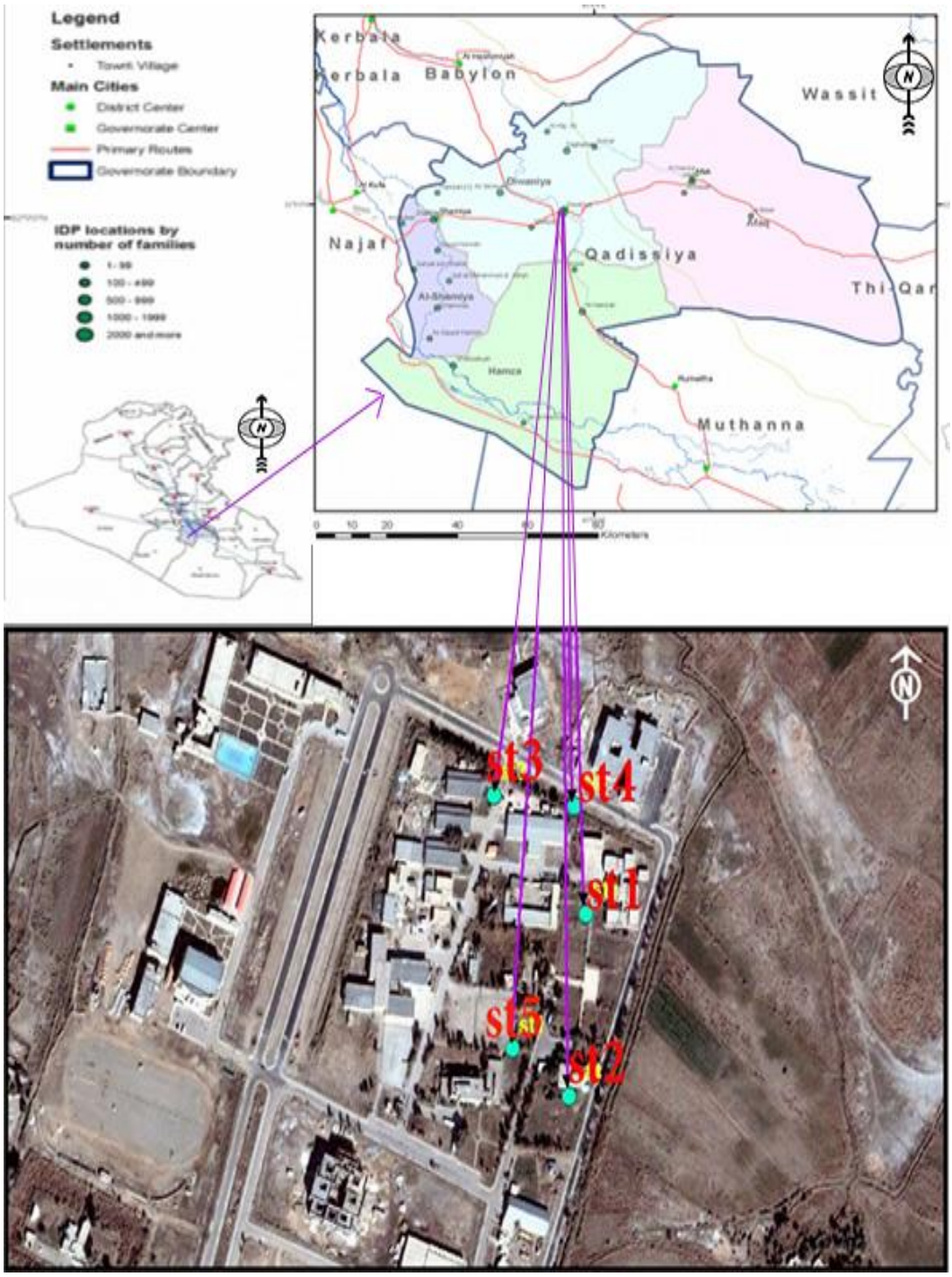


**Figure (1): A map of Al-Qadisiya University describes the study sites**

## MATERIALS AND METHODS

Relied search method to collect water samples from five wells have been drilled in the University of Qadisiya was deep inside ranging from 10.6 meters form of (1) as models of wells under study water collected during the month of January 2015 until the month of December 2015 by extracting the amount of water from inside the well, through the operation of an electric pump installed in each well after the disposal of the existing amount of water in the tube pump down to the extraction of water from inside the well Put water samples in bottles Polyethylene clean 2.5-liter. The tests included the measurement of the pH using a pH meter type Milwaukee Model 801 Sm calibrated intravenously buffer standard, The electrical conductivity measured using electrical conductivity device and across all output (µs / cm).The calcium measured and then calibrated by EDTA sample with the use of dye Meroxiad and the addition of sodium hydroxide solution was estimated magnesium mathematically by the difference between the total of brackish and calcium hardness[8].As has been measuring ion ($N^+$, $K^+$) by flame spectrometer device (Flam-Photometer) and sulfate were measured using the method described in brownish[10]Using the equation: SAR=Na $/ \sqrt{(Ca + Mg)/2}$. While the percentage was calculated (sodium) Na% by the following equation: $Na\% = \frac{rNa+rK}{rCa+rMg+rNa+rK} \times 100$Where rNa, $rCa^2$, $rMg^2$rK calculated in units ofmeq. $l^{-1}$.

On the other hand algae available was studied in water samples taken from wells and followed the method of deposition of the concentration of algae and counting[11]The study has examined the quality of the algae after the boat of the type CYANO-lab preparing temporary slides under the microscope using a drop of the sample and examined and diagnosed species relying on sources,[12,13,14].Results were analyzed statistically using a statistical program [15] to study the effect of different factors on the traits and compared the moral differences between the averages Least significant difference-LSD test.

## RESULTS AND DISCUSSION

Table (2) the most important chemical and physical properties of the water wells under study and that gives a comprehensive overview of the evaluation and the validity of water wells in the university to irrigate green spaces, as follows:

**PH :**

According to laboratory research study, as shown in table 2and figure(2) rate in the study area was (7.3-7.44), and this means that the waters of these wells generally tend to (basal), and when the comparison these values with the international standards show that water wells studied did not exceed the allowed amount for irrigation and the border (6.5 - 8.5) depending on specifications and Agriculture Organization food [16]Results of statistical analysis did not show a significant difference in pH between the values of all the water wells, it may be due to the possibility of the presence of the water reservoir within a limited area.

**Electric conductivity and Total dissolved solid:**

classification[17] crops, depending on the degree to bear crops and sessile, medium and high endurance of the total soluble salts and reflect the total dissolved salts and electrical conductivity for salinity as one of the fastest and the most important indicators in the evaluation of water for irrigation, dependingon the classification[10]A four grades as follows:

C 1 brackish water is used to irrigate most types of plants
C 2 medium salinity and water used to irrigate plants medium endurance salts.
C 3 water used for some types of plants resistant to salts.
C 4 very salty water unsuitable for irrigation and use of plants that bear high salinity.

The research results showed high electrical conductivity values, which is an indication of the salinity property as it was recorded the lowest rate of conductivity (2915 )(µs / cm) in the well (W4) located at the of College of Science and the highest rate (14 748)(µ s / cm) in the well (W5)The object of English Department table (2) and Figure (3) there was a significant difference (P≤0.05) and these values commensurate with the amount of soluble salts college except for the rise in the well (W3) located in the College of Education /

Department of Physics table( 2) and Figure (4) has been Conductive high values for wells to increase the concentration of dissolved salts and return it to the water in contact with the soil as well as the possibility of deposition of salts in these wells with age and lack of a drainage operations of the waters of these wells, which leads to increased salinity [18].As used wells in the summer for the purposes of watering some trees and ornamental plants, leading to soil washing and ran irrigation water loaded with concentrations of salt in a glass high and this leads to raise the concentration of salinity and in general the accent saline groundwater changes monthly and seasonally and annually, according to land use, irrigation methods and conditions of drainage and weather conditions and the use of groundwater (water withdrawal) [19].

**Calcium and magnesium**

The groundwater contains a quantity of salts which are mostly calcium salts and magnesium, and from the data in Table( 2) and Figure( 5-6) note that the values of calcium and magnesium was the highest level 599) and 180.62( mg / L), respectively, and these high concentrations this makes the water hardness, due to exposure to substances soluble in geological formations as well as salts in which movable [20].

**Sodium:**

through Table (2) and Figure (7) ranged sodium ion values between 182.25-750.25 (mg/ L) may be the reason for the sodium rise of this magnitude in these wells that these wells is a surface wells where the leak to salts of the surface layer and It is known that groundwater containing varying concentrations of salts, which in turn affect the quality and the sodium salt, which is the one causing the elements of salinity in the water and therefore affect in some physical properties of the soil as it works to bring the dispersion of the minutes of soil and demolition totals than It leads to a decline in water conductivity and poor ventilation may have a secondary and a detrimental effect on the plant where the symptoms begin to increase it to burn the tissue edges of old leaves[21].

**Potassium:**

Potassium is one of the important elements in plant installation, but little damage except for being included in the increased value of dissolved solids ,and through thoughtful values ranged between (83.5-176.5) mg / L (Table 2 and Figure 8) and are located all values outside the limits of the Organization for Agriculture and food of water for irrigation, and the reason for increasing the concentration of potassium due to the presence in the sedimentary rocks [22].

**Sulfates**

The present study had the highest value for sulfate, which amounted to 2797 mg / L Table (2) and (Figure 9) in the well (W5) object in the College of Education Department of the English language as the groundwater advantage of the height of sulfates[23],This is the phenomenon more common in the general Iraqi waters as where there are high concentrations of sulfate ions[24] The presence of salts, gypsum in the Earth's crust increases the concentrations of sulfates in the groundwater ,the results of statistical analysis revealed significant differences temporal and spatial at ($P \leq 0.05P$) between the wells , the findings came matching [1] In her study of groundwater in the city of Babylon.

**Sodium Absorption Ratio (S.A.R.):**

The sodium adsorption ratio (SAR) one of the indicators that rely on arable Water Assessment, one of the transactions hydro chemical that illustrate the relationship between the proportion of salts (sodium) to salts (calcium and magnesium), operating increase in irrigation water to break down the soil building as well all converted in some cases to alkaline soil is not easily reclaimed, which requires monitoring this ratio continually in irrigation water is the value of (S.A.R.) of the basic factors to determine the validity of the water for irrigation, as divided [10] sodic into four grades:

S 1 low-sodium water and are suitable for most types of plants
S 2 water medium sodium and be used in the land gypsum acrid
S 3 Many waters sodium and be used for irrigation in rare cases

S 4 water contains a very large proportions of sodium, used for plants that bear high concentrations in some very rare cases.

When calculating the ratio (adsorption sodium) for water wells, the study area, as in the table (2) and (Figure 10) and compare what is stated in the table (4) notice that the water wells (1, 2, 3 and 4) in each of the Department of Chemistry, the presidency of the university , the Department of Physics and Faculty of Science, the whole row and fell under the category S1, a low-sodium water and are suitable for most types of plants and thus be valid for irrigation in all kinds of dust with a little risk to form dangerous concentrations of sodium stainless sharing either the well water (5) located in the College of Education, Department of English language near pitch it occurred under the category S2 is valid water to irrigate the sandy dust or membership with good permeability ,In general, the sodium adsorption ratio was as a laboratory brackish system dangerous to all wells except for a water well the English language section was medium risk. The validity of the study, water for irrigation purposes as stated in the agriculture and food system organization[25].

And if you compare the results of the study (Table 2) with what is stated in Table( 5) were wells (2, 3 and 4) suitable to irrigate all plants, either wells 1 and 5, they serve to irrigate most plants average sensitivity to salinity and some medium-plant resistance to salinity with the need for management good and add laundry needs% (20) of the water consumption of the plant.

**Percentage sodium (Na %):**

It is one of the indicators to detect the extent of the water authority to irrigation, because the concentration of (sodium ion) is important in the classification of irrigation water, it reacts sodium with the soil and reduces permeability and increases the validity of a result for ion exchange between positive ions (calcium and magnesium) with (sodium) in the clay minerals and when calculating percentage (sodium) in water wells study, as shown in the table (6), we find that the waters of all the wells are classified as water (excellent) for irrigation because the percentage rate of the sodium in less than (20%), This means that all the wells are valid for agricultural use, depending on the index (the percentage of sodium) [26].

**Dangerous salinity:**

Water was classified based on the electrical conductivity values and S.A.R. values to the extent of water wells university suited for the purposes of green lands irrigation within the university, as was the water classification depending on the US classification proposed by the laboratory American salinity [10] where there were varieties of water under the category(C3-S1 , C4-S1 and C4-S2)waters that took place under the category C3 is well water(4) in the Faculty of Science, it is water with high salinity using this water there is a network of effective Drainages and plants high endurance of salinity ,either water remaining wells were signed under the category C4 which water with very high salinity unfit for irrigation in normal circumstances and can be used only in the case of high-permeability soils and good drainage and crops is very high tolerance to salinity any use of relatively high-laundering requirements up to (15-20 %)[27].This means that water from these wells is very high salinity [28] and this is what has been observed in the field as the plants that suffer from the effect of salinity are dwarf and with small leaves slanting to the color bluish green and symptoms of wilt has been observed on the affected plants salinity and in general the groundwater in the city of Diwaniya, with a high content of salts the reason for the high proportion of salt in them to the surface of the Al-Qadisiyah province is characterized by limited natural drainage which made the groundwater in most areas close to the surface and poor quality[29].

From the above, we conclude that there are a number of factors that affect the feasibility of water wells University of exploitation in landscape irrigation and include the concentration of the different elements and the ratio between some elements (such as sodium, calcium and magnesium) and relies concentrations allowed on the extent of the permeability of the soil , the topography of the land , the depth of the groundwater , the amount of wastewater , the method of irrigation ,crop type and climatic conditions, where most of the water wells occurred in this study within the class of higher water salinity, which are suitable for the cultivation of plants resistant to salinity and that the use of this water for irrigation leads to the accumulation of salts in the soil, which in turn adversely affect the growth of plants, especially in the months hot, dry summer as a result of increased evaporation surface of the soil and because of the high water table

capillary active in raising the groundwater to the surface layer and thus evaporates, leading to increased soil salinity.

**Algae diagnosed:**

showed that taxonomic units diagnosed reached (29) ordered rank in Wells studied table (7) during the study period from January until December 2015 as a result of appropriate environmental conditions to some extent and abundance of plant nutrients the phytoplankton were present for the duration of the study the present study agreed with most of the local and global studies where the class Bacillariophyceae was the peace prize from among the highest recorded totals taxonomic record for percentage of 65.51% return Most of diatoms Return to (pennales), followed by blue-green algae Division by 27.59% then came seaweed row Greens 6.9%. attributable to favorable rule diatoms in water environmental conditions for growth and reproduction of diatoms as the abundance of silica and as they might be in different types of water bodies and its ability to withstand extreme environmental conditions [30] it seems that agricultural activities and fertilizer use clearly affect all environmental indicators including density of phytoplankton. As the results of the current study showed changes in types of phytoplankton taxonomic units recorded higher following a number of species during the study period (*Oscillatoria*sp,*Navicula*sp. and *Nitzschia*sp) .

And record *Oscillatoria* more types in the number of blue-green algae species and algae tenue *Phormidiumtenue*person also known as prevalence in Iraqi waters [31].

study showed that spring is characterized by being the top in the number of types of phytoplankton and registered in other chapters of the study, probably associated with the increased temperature and light intensity and photoperiod provides many detritus .

## CONCLUSIONS

1-conclude from the foregoing that the wells University contain saline concentrations making it unsuitable for sensitive plants high salinity found in water have a negative impact on those plants,
2-could be used well water for irrigation of green areas (Weed yards) and ornamental salinity resistance results were encouraging and good .
3-must take adequate care and washing and add organic material and plaster if Earth free ones as needed so that the use of this water increases the likelihood of Increased sodium absorbed the rung may cause deterioration of poor land in organic matter.

**Table (2) rates of property values for the sampled wells studied(mg.l$^{-1}$,meq. l$^{-1}$units)-during the study period**

| English5- | 4-science | 3-physics- | -2-University President | 1-emistry | Unity | Well number / Properties |
|---|---|---|---|---|---|---|
| 7.44 | 7.38 | 7.41 | 7.3 | 7.42 | - | pH |
| 14748 | 2915 | 12837.5 | 8927.25 | 12431.5 | dS.m$^{-1}$ | EC |
| 5886 | 1506 | 6419 | 4214 | 6216 | mg.l$^{-1}$ | TDS |
| 599 | 323 | 476.5 | 453.75 | 465.5 | mg.l$^{-1}$ | $Ca^{++}$ |
| 27.45 | 16.15 | 23.8125 | 22.6875 | 23.25 | meq. l$^{-1}$ | |
| 180.62 | 65.835 | 144.17 | 101.1825 | 97.5175 | mg.l$^{-1}$ | $Mg^{++}$ |
| 8.1625 | 3.6975 | 14.685 | 6.975 | 4.465 | meq. l$^{-1}$ | |
| 750.25 | 479 | 182.25 | 224.75 | 591.25 | mg.l$^{-1}$ | $Na^{+}$ |
| 37.6775 | 6.7825 | 10.08 | 9.61 | 26.5925 | meq. l$^{-1}$ | |
| 176.5 | 83.5 | 106.75 | 91.75 | 140 | mg.l$^{-1}$ | $K^{+}$ |
| 4.505 | 2.1325 | 2.725 | 3.595 | 3.58 | meq. l$^{-1}$ | |
| 2797 | 725 | 2245.25 | 2773.75 | 2451.25 | mg.l$^{-1}$ | $SO_4^{=}$ |
| 58.175 | 15.0775 | 46.697 | 34.042 | 50.985 | meq. l$^{-1}$ | |
| 9.755 | 2.1025 | 2.3475 | 2.945 | 7.345 | - | SAR |
| 8.3675 | 2.895 | 5.15 | 3.815 | 5.7925 | - | Na % |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2080 | 1212.5 | 1672.5 | 3240 | 3497.5 | $mg.l^{-1}$ | Total Hardness |
| C4-S2 | C3-S1 | C4-S1 | C4-S1 | C4-S1 | | Water class 1954 USDA |

**Table 3-Classification of irrigation water based on salinity EC values[10]**

| **Level** | EC(µm/cm) | )TDS(mg/l | **Hazard and limitations** |
|---|---|---|---|
| $C_1$ | < 250 | 160-0 | Low hazard; no detrimental effects on plants, and no soel buildup expected |
| $C_2$ | 750-250 | 480-160 | Sensitive plants may show stress; moderate leaching prevents salt accumulation in soil |
| $C_3$ | 2250-750 | 1440-480 | Salinity will adversely affect most plants; requires selection of salt-tolerant plants, careful irrigation, good drainage, and leaching. |
| C4 | > 2250 | 3200-1440 | Generally unacceptable for irrigation, except for very salt-tolerant plants, excellent drainage, frequent leaching, and intensive management |

**Table 4-** Classification of irrigation water based on SAR values [20].

| **Level** | SAR | **Hazard** |
|---|---|---|
| $S_1$ | <10 | No harmful effects of sodium |
| $S_2$ | 10-18 | An appreciable sodium hazard in fine-textured soils of high CEC but could be used on sandy soils with good permeability. |
| $S_3$ | 18-26 | Harmful effects could be anticipated in most soils and amendments such as gypsum would be necessary to exchange sodium ions |
| $S_4$ | >26 | Generally unsatisfactory for irrigation |

**Table 5-The limits of validity of water for irrigation purposes[25].**

| | Elements | first group | second group | third group |
|---|---|---|---|---|
| 1 | Ec | (7500-3000) µs/cm | (3000-700) µs/cm | 700 >µs/cm |
| 2 | Na | 207ppm < | (207-69)ppm | 69 >ppm |
| 3 | Cl | 355ppm < | (355-142)ppm | 142 >ppm |
| 4 | SAR | 9 < | (9-3) | 3 > |
| | | Serve to irrigate all plants at 90% of production | Suitable for most plants average sensitivity to salt and some plants average resistance to salinity with the need for good management and add laundry needs % (20) of the water consumption of the | Suitable for irrigating plants resistant to salinity and cultivated lands good permeability with add washing water (% 20-25) of the water consumption of the plant |

| | | | | |
|---|---|---|---|---|
| | | | plant | |

**Table 6-Classification of irrigation water based on Na% values[26].**

| Na% | 20 | 20-40 | 40-60 | 60-80 | >80 |
|---|---|---|---|---|---|
| Water quality | Excellent | Good | Permissible | Doubtful | Unsuitable |

**Table 7: Distribution of algae in five wells diagnosed during the study period**

| Algae diagnosed | Well number and itspresence | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Cyanophyceae | | | | | |
| *Aphanocapsa sp.* | - | - | - | - | + |
| *Chroococcus* | - | - | + | - | - |
| *Phormidium*spp. | - | - | + | - | - |
| *Phormidiumtenue* | - | - | - | + | + |
| *Oscillatoriaacutissima* | - | + | + | - | + |
| *Oscillatoria sancta* | + | + | - | + | - |
| *Oscillatoria Formosa* Bory | - | - | + | - | - |
| *Spirulina major Kuetzing* | + | - | - | - | - |
| Chlorophyceae | | | | | |
| *Chlamydomonas*sp. | - | - | + | - | - |
| *Chlorella* sp. | - | - | + | - | - |
| Bacillariophyceae | | | | | |
| Centrals | | | | | |
| *Cyclotellacomota (Her.) Kutz* | - | - | - | - | + |
| *StephanodiscustenuisHustedt* | + | - | - | - | - |
| Pennales | | | | | |
| *Achnanthes*spp. | + | - | + | - | - |
| *CocconeispediculusEhr.* | - | - | + | - | - |
| *CocconeisplacentulaEhr.* | - | - | - | + | - |
| *CymbellaaffinisKutz.* | + | - | - | - | - |
| *Diatoma*sp. | - | - | - | - | + |
| *Naviculahalophila (Grun) Cleve* | + | - | - | - | + |
| *N. hungaricaGrunow* | + | - | + | - | - |
| *N. longirostrisHust* | - | - | + | - | + |
| *N. parva (Menegh.) Cleve. Euler* | - | - | + | - | - |
| *N. placentula (Ehr) Grun* | - | - | - | + | - |
| *Nitzschiadissipata (Kutz) Grun* | - | - | - | - | + |
| *N. granulate Grun* | - | - | - | - | + |
| *N. hungaricaGrun* | - | - | + | - | - |
| *N. longissima (Brebisson) Ralfs* | + | - | - | - | - |
| *N. lorenzianaGrun* | + | - | - | - | - |
| *Pinnulariatabellaria* | - | - | - | - | + |
| *SynedraacusKutz* | + | - | + | - | - |

(+)Means an existing type; (-) means a non-existent type.

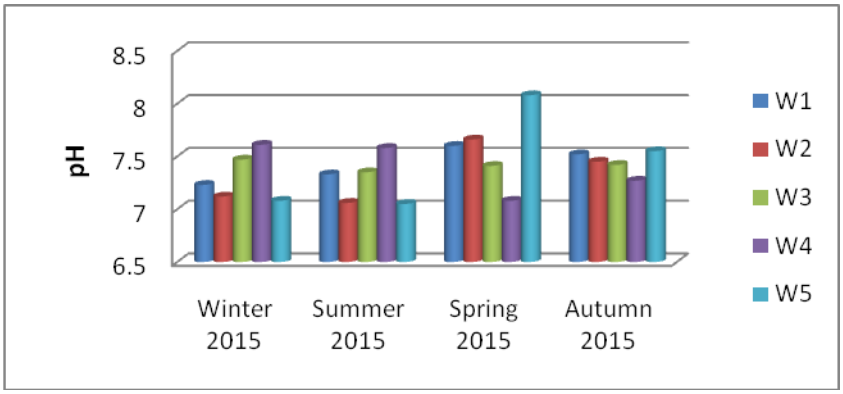


**Figure 2: Rates of pH in water wells during the period of study**

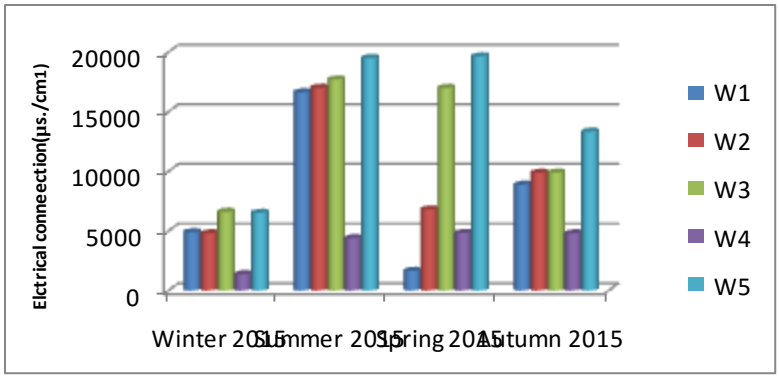


**Figure 3: Electrical connection values rates (µs/cm) in wells during the period of study**

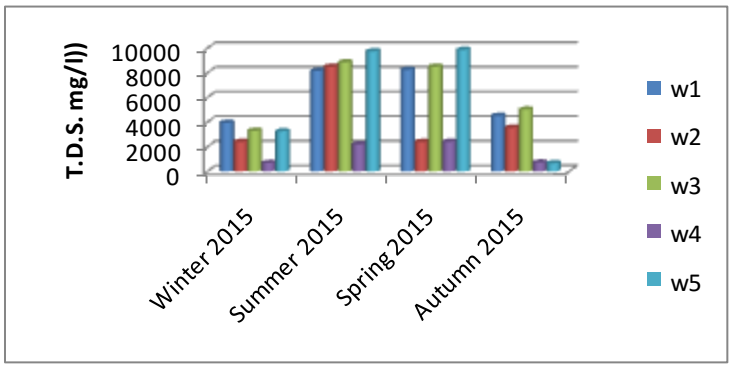


**Figure 4: Rates of total T.D.S. values mg/l in water wells during the period of study**

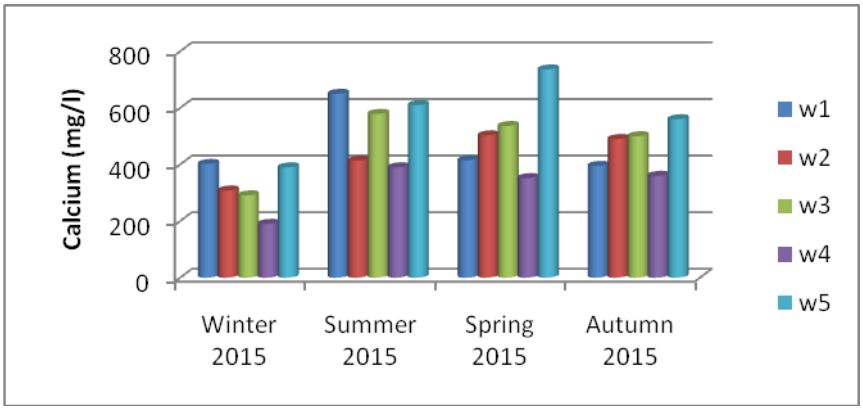

Figure 5: Value rates of calcium (mg/l) in wells during the period of study

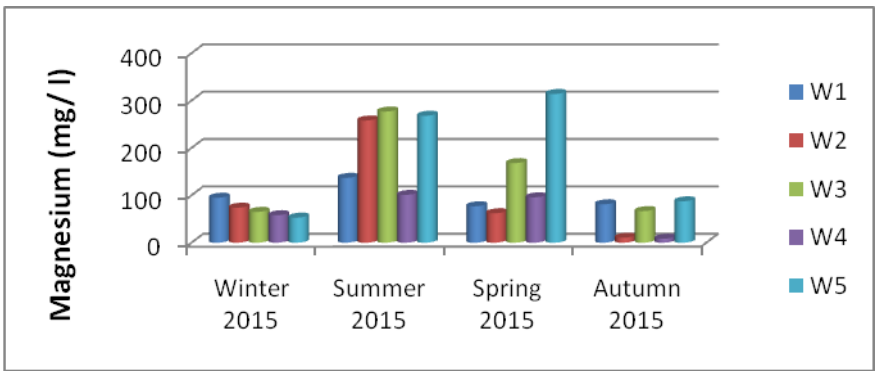


Figure 6: Value rates of magnesium (mg/l) in wells during the period of study

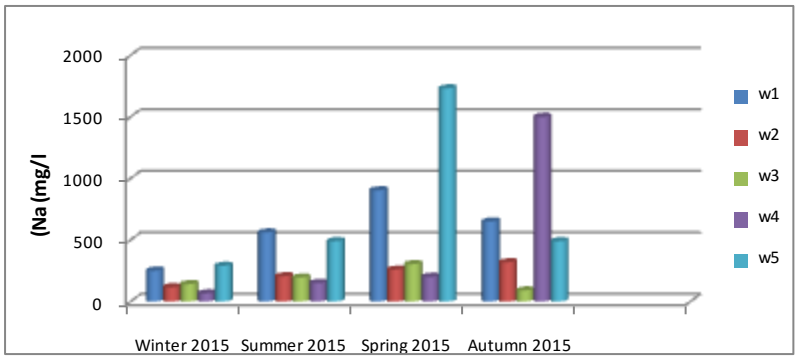


Figure 7: Rates of sodium ion Na values in wells during the period of study

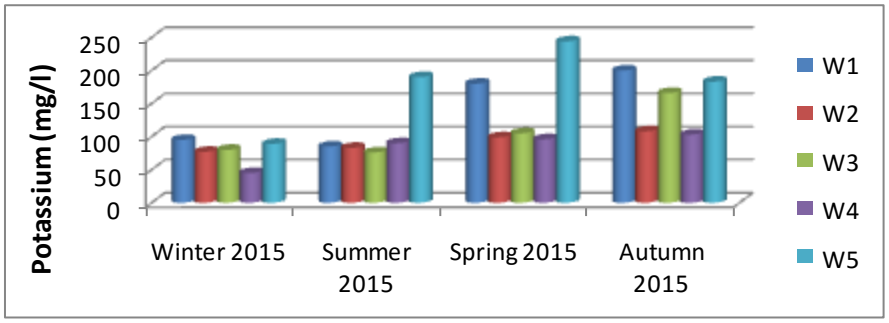


Figure 8: Value rates of potassium (mg/l) in wells during the period of study

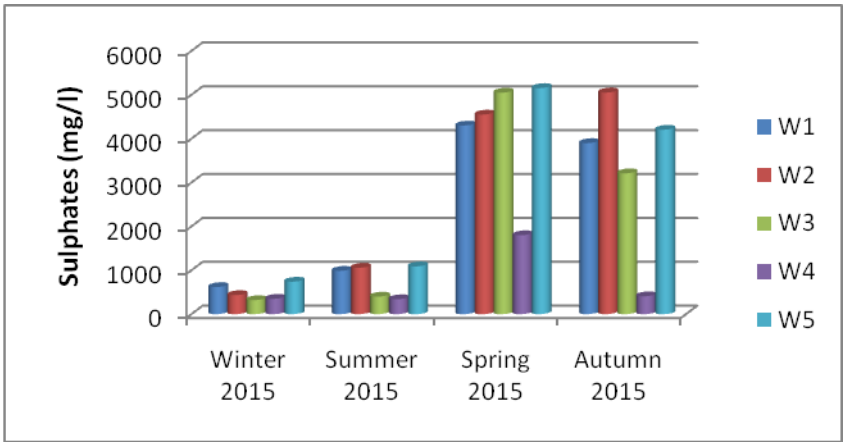


**Figure 9: Value rates Sulfates(mg/l) in wells during the study period**

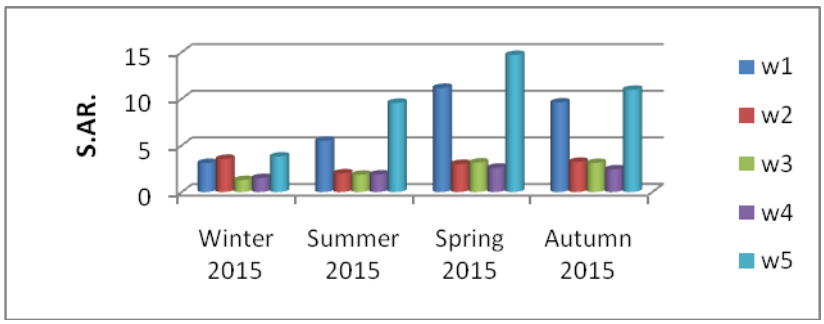


**Figure 10: Sodium adsorption ratio values rates S.A.R. in wells during the study period**

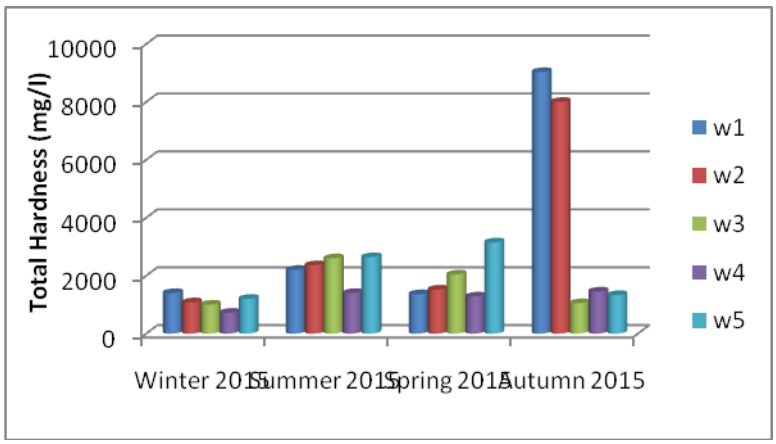


**Figure 11: Value rates Total Hardness (mg/l) in wells during the period of study**

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