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# CHEMICAL, PHYSICOCHEMICAL AND BIOLOGICAL INVESTIGATION OF GROUNDWATER IN AL-QASSIM REGION OF CENTRAL SAUDI ARABIA

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## ABSTRACT

In this work, 16 samples of underground water in Al-Qassim region of Central Saudi Arabia were chemically, physicochemically and biologically investigated. Quantitative determination of Ca, Mg, Na, K, $(SO_4)^{2-}$, $(CO_3)^{2-}$, along with EC and pH measurements. In addition, microbiological activity of all water samples was also investigated. The results clearly show the very high EC values for 50% of the water samples reaching a maximum of 16.66 mmhos/cm indicating potential irrigation problems affecting both plant and soil. However, the other part of the samples have reasonable EC values ranging from 1.01 to < 4.0 mmons/cm. The very high EC values were discussed in terms of high ionic concentration. No coliform bacteria was detected in any of the samples indicating the absence of mixing between sewage water and underground water.

## INTRODUCTION

Qualitative and quantitative laboratory analysis of dissolved salts in irrigation water is of vital importance in view of 2 main aspects, namely:

a) – the suitability of the water for irrigation of certain crops

b) – the damage to soil that may occur from irrigation by a high salty water (Al-Fakhrani, 1998).

The suitability of irrigation water is thus reflected in its effect on the type of plants to be grown and the soil in which these plants are grown. Plant growth abnormalities indicate very evidently one or more unfavourable conditions. These conditions may be unbalanced nutrient composition in soil and/or water used for irrigation (Bennett, 1994). Thus analysis of irrigation water is directed towards investigation of macro- and micronutrients.

The analysis of such data enables recognition of the type of plant to be grown as well as the type of soil amendment in relation to the proper use of the required fertilizer. Thus, the determination of dissolved salts as estimated by measurement of EC points to the type of crop or vegetable to be grown since some of these require specific limits of EC values (Al-Fakhrani, 1998).

Potassium is needed for turgor buildup in plants and maintains the osmotic potential of cells (Huber, 1985), which in guard cells controls stomatal openings. This osmotic regulation indicates the role of K in water relations to plants (Mengel, 1985). It is also required as an activator for more

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than 60 enzymes in meristematic tissue (Suelter, 1985 and Tisdale et al, 1985). Many other roles are attributed to K such as the production of high-energy phosphate (ATP) and is involved in protein and starch synthesis (Tisdale et al, 1985), lipid metabolism (Blevins, 1985) and carbohydrate metabolism (Huber, 1985).

Calcium occurs in plants as Ca-pectate which is a component of every cell wall. It plays a role in mitosis and in grain an seed formation (Follett et al, 1981 and Bould et al, 1984).

Magnesium is an essential part of chlorophyll molecule. It plays the role of a cofactor for a number of enzymes including transphosphorylase, dehydrogenase and carboxylase, besides assisting in the formation of sugars, oils, fats as well as polypetide chains from amino acids (Follett et al 1981 and Tisdale et al, 1985).

Sodium is a micronutrient involved in osmotic regulation an in some cases performs the function of K (Tisdale et al, 1985).

Investigation of bacterial contamination of groundwater is also of great importance in that it indicates the possibility of mixing of groundwater with sewage water.

In this present investigation 16 groundwater samples were chemically, physicochemically and biologically analysed for the presence of the macronutrients K, Mg, Ca, and the micronutrient Na along with EC and pH measurements as well as the ions sulphate and carbonate. Bacterial contamination was also investigated by culture of water samples.

## MATERIALS AND METHODS

Sixteen underground water samples were collected during April 2000, from different localities in Al-Qassim region of Central Saudi Arabia and analysed quantitatively for the presence of K, Ca, Mg, Na, carbonate and sulphate anions and measurements of EC, pH and bacterial count.

EC was measured by Beckman Saltbridage Type. The equipment was calibrated using KCl solution (0.01N) adjusted at 25°C.

The pH was measured using meterohm pH-meter model 632 calculated by 2 buffer standard solutions of pH 7.0 and 9.0 .

Carbonate was determined by titration against standard dilute sulphuric acid (0.009N) using phenolphthalein as an indicator.

Sulphate was determined turbidimetrically using model ANA-14A Turbidmeter (Toko-photo-electric co, Japan).

Ca and Mg were determined by titration against ethylenediaminetertacetic acid (EDTA) disodium salt (0.01N).

Sodium and K were determined by flame photometer model M 410 instrument.

Microbiological investigation was carried out for water samples and the most probable number of coliform bacteria was determined using lactose-broth (Difco) according to the standard method for bacterial examination of water (APHA. 1985; Geldreich, 1975) in which test tubes were incubated at 37°C for 48 hrs. The single tube that showed growth was cultured in brilliant green-bile broth (Difco) and incubated at 37°C for 48 hrs for confirmation of the presence of coliform bacteria.

## RESULTS AND DISCUSSION

Sixteen underground water samples from Al-Qassim region of central Saudi Arabia were investigated with the intention of studying the suitability of the water for irrigation. Thus, EC, pH, K, Ca, Mg, Na, sulphate and carbonate anions were determined along with bacterial investigation. The results are included in Table 1.

**Table 1. Means of pH, minerals concentration, anions and coliform bacterial counts.**

| No | PH | EC mmhos/cm | K ppm | Ca ppm | Mg ppm | Na ppm | $(CO_3)^{2-}$ ppm | $(SO_4)^{2-}$ ppm | Coliform |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.93 | 10.69 | 236 | 525 | 359 | 1268 | 165 | 1920 | -- |
| 2 | 8.24 | 1.017 | 29 | 45 | 20 | 171 | 134 | 19 | -- |
| 3 | 7.97 | 7.75 | 106 | 537 | 236 | 925 | 147 | 1226 | -- |
| 4 | 7.98 | 6.03 | 30 | 469 | 274 | 678 | 143 | 1450 | -- |
| 5 | 7.5 | 7.86 | 66 | 579 | 344 | 895 | 122 | 2078 | -- |
| 6 | 7.6 | 7.94 | 122 | 549 | 295 | 1113 | 144 | 1697 | -- |
| 7 | 7.6 | 7.75 | 111 | 580 | 266 | 1105 | 165 | 1714 | -- |
| 8 | 7.88 | 11.86 | 157 | 670 | 378 | 1750 | 144 | 2021 | -- |
| 9 | 7.86 | 16.66 | 243 | 751 | 515 | 2450 | 24 | 2774 | -- |
| 10 | 7.94 | 1.34 | 22 | 74 | 65 | 203 | 131 | 334 | -- |
| 11 | 8.09 | 3.66 | 51 | 68 | 141 | 610 | 134 | 689 | -- |
| 12 | 8.3 | 1.12 | 35 | 55 | 57 | 161 | 96 | 331 | -- |
| 13 | 8.21 | 1.15 | 34 | 60 | 34 | 154 | 116 | 166 | -- |
| 14 | 8.29 | 3.17 | 16 | 184 | 121 | 230 | 114 | 640 | -- |
| 15 | 8.3 | 2.68 | 13 | 112 | 129 | 365 | 101 | 682 | -- |
| 16 | 8.29 | 2.64 | 3 | 79 | 164 | 318 | 111 | 821 | -- |

A close look into the data presented in this table reveals that 50% of the water samples investigated have quite high EC values reaching a maximum of 16.66 mmhos/cm showing that water contains very high concentrations of conducting ions. This is evidenced by the very high concentration of anions and cations determined. The value of EC determines to a large extent the suitability of irrigation water to a particular plant. For instance, quite low EC values of about 2 mmhos/cm, which is suitable for most plants, yet it is in fact quite unsuitable to some others that are very sensitive to salts like beans. Increase in EC values are known to bring about dramatic reduction in percentage yield of crops eg EC value of 6.4 mmhos/cm produces reduction of upto 25% of wheat yield (Al-Fakhrani, 1998). However, most field crops, vegetables, fruits and the like suffer no reduction in percentage yield when EC values fall between 1.1 to < 4.0 mmhos/cm. It was reported that EC value of 12 produced 50% reduction in the yield of barley (Al-Fakhrani. 1998).

The other part of water samples has quite reasonable EC values ranging from 1.01 to < 4 mmhos/cm, which is suitable for most plants.

The pH of all water samples fall in the fairly alkaline zone of pH scale (around 8.0). This slight alkalinity may be attributed to alkali metals (Na, K) and the alkaline earth metals (Mg, Ca).

Al-Qassim region is characterized by the dominant sandy soil that is known to be quite poor in macro- and micronutrients (El-Nadi et al, 1995 and Abdel Magid et al, 1994). Thus, mineral and organic fertilizers are usually added to this soil in order to improve soil fertility as well as soil physical condition. However, the presence of appreciable amounts of these nutrients in irrigation water helps to reduce the quantity of the added fertilizers that are known to contain such nutrients.

The microbial assay of underground water showed very clearly that none of the samples contained coliform bacteria. However, the single water sample that showed bacterial growth failed to give a positive confirmatory coliform bacterial test. This finding shows that there is no mixing between sewage water and groundwater.

Frequent analysis of groundwater used for irrigation prior to its usage is of formidable importance since the quality of water determines the type of crop or vegetable to be grown, its effect on soil utilized for agriculture and the type of fertilizer to be employed. It is well known that the level of groundwater undergoes seasonal and secular changes and consequently its chemical composition may undergo similar changes (Bowen, 1980).

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## دراسة كيميائية وفيزيوكيميائية و بيولوجية للمياه الجوفية بمنطقة القصيم في الإقليم الأوسط بالمملكة العربية السعودية

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تم في هذا البحث تحديد كميات الكلسيوم و الماغنسيوم و الصوديوم و البوتاسيوم و الكربونات و الكبريتات بجانب قياس كل من التوصيل الكهربي و تركيز أيون الهيدروجين و درجة التلوث البكتيري في ١٦ عينة من المياه الجوفية بمنطقة القصيم. وأوضحت النتائج أن التوصيل الكهربي في ٥٠% من عينات المياه يمتاز بقيمة عالية يصل أقصاها إلى ١٦,٦٦ ملمون/سم مما يدل على مشاكل الري المترتبة عند استخدام هذه المياه. أما الجزء الآخر من العينات فتعتبر قيمة التوصيل الكهربي فيه مناسبة حيث تتراوح بين ٠١.١ و اقل من ٤ ملمون/سم. نوقشت القيم العالية للتوصيل الكهربي على ضوء التركيز الأيوني العالي. لم تحتو أي من العينات علي بكتيريا قولونية مما يدل على عدم اختلاط المياه الجوفية بمياه الصرف الصحي.