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Magnetic Treatment of Irrigation Water and its Effect on Water Salinity

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Abstract. The influence of magnetic field on the structure of water and aqueous solutions are similar and can alter the physical and chemical properties of water-dispersed systems. With the application of magnetic field, hydration of salt ions and other impurities slides down and improve the possible technological characteristics of the water. Magnetic field can enhance the characteristic of water i.e. better salt solubility, kinetic changes in salt crystallization, accelerated coagulation, etc. Gulf countries are facing critical problem due to depletion of water resources and increasing food demands to cover the human needs; therefore water shortage is being increasingly accepted as a major limitation for increased agricultural production and food security. In arid and semi- arid regions sustainable agricultural development is influenced to a great extent by water quality that might be used economically and effectively in developing agriculture programs. In the present study, the possibility of using magnetized water to desalinate the soil is accounted for the enhanced dissolving capacity of the magnetized water. Magnetic field has been applied to treat brackish water. The study showed that the impact of magnetic field on saline water is sustained up to three hours (with and without shaking). These results suggest that even low magnetic field can decrease the electrical conductivity and total dissolved solids which are good for the removal of salinity from the irrigated land by using magnetized water.

Keywords: water treatment, magnetic field, brackish water, salt content

1. Introduction

The influence of magnetic field on the structure of water and aqueous solutions are similar and can alter the physical and chemical properties of water-dispersed systems [1]. With the use of magnetic field, hydration of salt ions and other impurities slides down and improve the possible technological characteristics of the water [2]. Magnetic field can enhance the characteristic of water, such as better salt solubility, kinetic changes in salt crystallization, accelerated coagulation, etc. From the literature and reports, it is evident that all structural changes of water dispersed systems treated by magnetic field are due to the ionic substances present in the water and colloidal particles of considerable magnetic susceptibility. Among various desalination technologies of water treatment [3], effect of magnetic field on irrigation has been emerging throughout the world in the last decade [4]. Apart from magnetic treatment electrolysis of saline water can also play an important role to reduce the salinity [5].

When salts are dispersed in water and passed through magnetic field; it can affect individual electron shells and polarization of electron clouds in molecules [6]. The later gains induced magnetic moment anti-parallel to external magnetic field and the energy of hydrogen bonding changes. The bending of bonds causes re-alignment of water molecules which results in the alterations of water structure. In simple the treatment by magnetic field can bring about changes in density, surface tension, viscosity and other water properties [7].

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Magnetic field is known to create the asymmetry of hydrated shells due to its effects on water molecules positioned around the ion (near and far). Similarly, magnetic field weakens the bonds between certain ions with subsequent bonding magnification of others. These changes result in conditions for *ionic associates* or *crystal embryos*. The reversal of magnetic flux and, consequently, modified direction of ion movements greatly facilitate the formation of ion pairs and more sophisticated aggregates. This can be attributed to a higher probability of attracting particles to close with one another.

The world, especially GCC, is facing critical problem due to depletion of water resources and increasing food demands to cover the population needs; therefore water shortage is being increasingly accepted as a major limitation for increased agricultural production and food security. Water on a global scale is 97% saline and 2.25 % is trapped in glaciers and ice, leaving only 0.75 % available in fresh water aquifers, rivers and lakes. Most of this fresh water (69 %) is used for agricultural production, 23 % for industrial purposes and 8 % for domestic purposes. Whenever good quality water is scare, water of marginal quality has to be considered for used in agriculture [8].

In arid and semi- arid regions sustainable agricultural development is influenced to a great extent by water quality that might be used economically and effectively in developing agriculture programs [3]. Soil desalination under such conditions is a crucial problem for agriculture. Agriculture suffered from both salt-affected soils beside saline underground brackish water contains varying amounts of dissolved salts used for irrigation.

In the literature, it has been reported that the possibility of using magnetized water to desalinate the soil is accounted for the enhanced dissolving capacity of the magnetized water, which has been registered repeatedly. It has been highlighted that magnetized water can remove 50 % to 80 % of soil salinity, compared to a removal of 30 % by normal irrigation water. Laboratory tests have shown that desalination of a saline soil was 29 % greater in the first leaching and 33 % greater in the second leaching with magnetized water compared to untreated water [8]-[10].

2. Methodology

The water quality classification is a complicated task. The total salt concentration is the major quality factor generally considered for the use of saline water for crop production. The chemical analysis by inductive couple plasma (ICP) of brakish water from different tube wells reveals the elemental analysis in µg/ml (Table 1).

Table 1: Chemical analysis of brakish water by ICP

Concentrations (µg/ml)

Element	S#1 T. well	S#2 T. well	S#3 T. well	S#4 T. well	S#5 T. well	S#6 T. well	S#7 T. well	S#8 T. well	S#9 Drain
As	0.04	ND	0.11	ND	ND	ND	ND	ND	ND
B	0.96	1.12	1.21	1.79	1.23	1.52	1.29	0.91	0.94
Ca	32.46	25.28	24.77	7.8	27.45	12.88	8.63	27.76	111.46
Fe	ND	ND	ND	ND	ND	0.06	ND	ND	0.12
K	13.77	15.61	12.00	20.60	20.14	17.4	21.48	17.27	59.53
Li	0.06	0.06	0.06	0.07	0.06	0.04	0.06	0.06	0.08
Mg	42.31	37.33	36.32	34.94	41.47	27.73	18.46	36.69	95.85
Mn	ND	ND	ND	ND	ND	ND	ND	ND	0.08
Mo	0.03	0.04	0.05	0.05	0.04	0.05	0.04	0.03	ND
Na	1443.40	1556.77	1455.34	2099.73	1778.72	1433.86	1888.51	1728.61	1807.36
SO_4	1055.73	1077.14	1015.58	1410.26	1135.44	922.78	1189.87	1197.90	536.43
Si	9.07	8.96	9.28	5.82	8.28	8.29	7.44	7.90	19.82
Sr	1.11	1.20	0.88	0.36	1.16	2.40	0.37	1.03	2.78
Zn	ND	ND	ND	ND	ND	ND	ND	ND	ND

RSD ≤ 2% ND = Not detected NA = Not Analyzed

After sampling, hardness of all tube well water samples has been carried out using volumetric analysis along with pH of the water. All values are listed in Table 2.

pH is the accumulative effect of cations and anions. Higher values of pH were observed for those samples where higher concentration of sodium and phosphate were detected. pH higher than 8 requires treatment of water for using in irrigation. From these results we note that total dissolved solids and electrical conductivity is on the higher side for the usage of this water for irrigation.

In order to reduce the concentration of dissolved salts in brakish water, the fallowing treatments have been carried out.

Table 2: Volumetric Analysis

Sample Number	Hardness (ppm as $CaCO_3$)	pH	Total Dissolved Solids (ppm)	Electrical conductivity (μS/cm)
Tubewell-01	240	7.7	4389	6270
Tubewell-02	224	8.0	4599	6570
Tubewell-03	204	7.7	4060	5800
Tubewell-04	152	9.3	5152	7360
Tubewell-05	248	8.2	5096	7280
Tubewell-06	152	8.0	3577	5110
Tubewell-07	104	9.0	4879	6970
Tubewell-08	236	8.6	5271	7530
Drain-09	636	7.6	5012	7160

2.1. Electrolysis

In our first approach, we deal with the high salt content by using electrolysis of water provided from different tube wells. Keeping in mind the cost of the project, we selected Aluminium foil as a cathode and anode material. Brackish water (250ml) has been used as a started solvent in a Pyrex beaker. Two aluminium strips were connected with the positive and negative terminal of the power supply. With the increase of voltage, a reaction started in the beaker and around 30 volts a current of 1-2 amperes flow showing the occurrence of reaction of Aluminium strip with the water. The flow of current through the beaker causes rise in the temperature of the beaker which results in the evaporation of water. This rise in temperature can cause problem which has been sorted out by putting the beaker in the cold water bath. With the passage of time white precipitate formed which float at the surface of the water in the beaker. After half an hour, reaction slows down and white precipitates were formed in the beaker. This beaker was then placed in the refrigerator and after 16 hours the whole beaker was covered with thick white precipitate. In a different experiment, aluminum strips were replaced by Cu strips and the same procedure was adopted. This time bluish color precipitates were formed which were of $CuSO_4$. In both experiments, aluminum and copper reacts with brackish water to form hydroxide of aluminum and copper sulphate, respectively.

2.2. Treatment with magnetic field

The elemental analysis of tube well water from ICP shows possibility of exploring effects of magnetic field due to absence of iron and manganese in this brackish water (see Table 1). We made a set up in which a copper pipe having 24mm diameter was connected with a cylinder, as shown in Fig. 1.

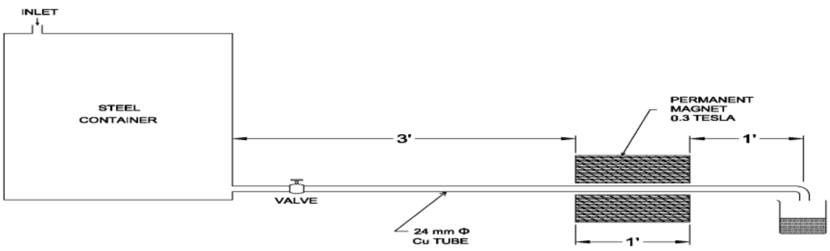

Fig. 1: Flow chart diagram of treatment of water under magnetic field

We used two types of magnet; one was permanent magnet (0.3 T) and other one electromagnetic with field up to 0.7 T. The copper pipe was passed through the magnet in such a way that we can attain good flow of water. We precede with the water from tube well 7 and 8. First we investigated the effect of magnetic field on tube well 7 and then we added different salts to understand the effect of magnetic field.

3. Results

These results are interesting in a sense that with the application of small field like 0.3T a visible change in the electrical conductivity and total dissolved solid has been observed. In order to improve the magnetic field effect we added permanent magnets in series and pass copper pipe through all these permanent magnets.

Electrical conductivity remains same for the water sample which passes through 2 and 3 permanent magnets. From these results we can infer that structural and chemical changes which are caused by the application of magnetic field occur under the first applied magnetic field; adding magnetic field in series does not make any further change. A good option may be to enhance the field effect by amplifying the field of first permanent magnet. In case of electromagnet where the field strength was higher, it's like 0.7T, the electrical conductivity is lower than that of permanent magnet results. Since, the electro magnet poles are at the left and right of the pipe where as top and bottom was without field, hence we can conclude the direction of field is also very important for the treatment of brackish water. From Table 1, it is obvious that all samples have high content of sodium elements indicating the presence of high sodium salts in all samples. We made 5 N NaCl solutions in 100 mL of water of tube well # 7 and then dissolved in 6L of water of tube well #7. The electrical conductivity increases to 9580 µS/cm and with the application of magnetic field the electrical conductivity drops to 8270 µS/cm. These results encourage us to schematically approach on the behavior of magnetic field on water of Tube well 7 & 8 (Table 3). The electrical conductivity results and TDS show an increasing trend with the addition of different salts. With the increase in salt concentration the impact of magnetic field is also increasing which results in an appreciable decrease in the electrical conductivity and TDS values. Now we change the scheme of adding chemicals to see the impact of addition of salts and effect of magnetic field to reduce the electrical conductivity. We added NaCl first and then sodium sulphate salts followed by sodium acetate salts and then measured the electrical conductivity and TDS with and without magnetic field (Table 4).

Table 3: Effect of magnetic field on water of tube well 7

Sample name	Electrical conductivity (µS/cm)	TDS (ppm)
Tube well 7	6970	4879
Tube well 7 + Perm mag	6760	4732
Tube well 7 + two Perm mag	6760	4732
Tube well 7 + three Perm mag	6760	4732
Tube well 7 + Elect. mag	6870	4809
TB#7 + (5M NaCl in 100ml)	9580	6706
TB#7 + (5M NaCl in 100ml) + Elect. Mag.	8270	5789

Table 4: Magnetic field effect on water of tube well #7 with the addition of different salts

Sample name	Electrical conductivity (µS/cm)	TDS (ppm)
Tube well 7.	6970	4879
Tube well 7 + Perm mag.	6760	4732
Tube well 7 + (I N Na_2SO_4in 100mL).	16590	11613
Tube well 7 + (I N Na_2SO_4in 100mL) + Perm. Mag.	14840	10388
Tube well 7 + (I N Na_2SO_4in 100mL) + (1N NaCl in 100 mL).	16790	11753
Tube well 7 + (I N Na_2SO_4in 100mL) + (1N NaCl in 100 mL) + Perm. Mag.	15280	10696
Tube well 7 + (I N Na_2SO_4in 100mL) + (1N NaCl in 100 mL) + (1 N $Na_2C_2O_4$).	17300	12110
Tube well 7 + (I N Na_2SO_4in 100mL) + (1N NaCl in 100 mL) + (1 N $Na_2C_2O_4$) + Perm. Mag.	15870	11109

From above studies it can be inferred that higher values of salts will increase the impact of applied magnetic field. Since, the water obtained from some wells has electrical conductivity higher than 6000 µS/cm, which comes under the saline water range. It is suggested that if a magnetic field higher than 1.5 T is applied and maintain good speed of water flow through the pipe, results can be improved.

The possibility of using magnetized water to desalinate the soil is accounted for the enhanced dissolving capacity of the magnetized water. The elemental analysis showed no iron/manganese contents which suggest that application of magnetic field can improve the quality of agricultural water, resulting better agricultural production. Further our study shows that the impact of magnetic field on saline water is sustained up to three hours (with and without shaking). These results suggest that even low magnetic field can decrease the electrical conductivity and total dissolved solids which are good for the removal of salinity from the irrigated land by using magnetized water for irrigation.

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