

The Effect on Solubility and pH of Sodium Chloride Solution by Magnetic Field

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Abstract—On the whole world's major environmental problem is water pollution, due to pollutant water increases in microscopic harmful living organism's counts and it causes change in water odour, taste and colour, which causes the spread of dangerous epidermal diseases. A physical treatment using magnetic field it is beneficial for the medical, food industry, control and removing of the scale formation on the walls, in medical, in food industry and heating equipment's but the efficiency of this treatment is still a controversial question. In the present study, like physical parameters total dissolved salts (TDS), electrical conductivity (EC) and pH of sodium chloride solution have been evaluated under the effect of different strength of magnetic field (0.05T-0.15T) for different exposure time (3 hours, 5 hours and 7 hours). The electrical conductivity and total dissolved salts rapidly increasing with the exposure of time and pH is increase with time as compared to control but for 3 hours is more and for 7 hour is less. Data collected during the experiment was analyzed statistically (SPSS-20.0). This analysis shows that the increase in TDS, EC and pH under the effect of magnetic field was significant ($p < 0.05$). The regression analysis was used to show linear relation between TDS and EC of water.

Keywords—Electrical conductivity, Hard water, Magnetic field, pH, Total dissolved salt.

I. INTRODUCTION

Water is essential to start and to continue the human life. It is directly related to each other. Water has spiritual values in many cultures and is associated with birth, spiritual cleansing and death. It is nutrient source and makes chemical reactions to happen. Water has unique properties it act as; solvent, an environmental, a temperature, a reactant and a molecule with cohesive properties. Use of hard water is the main problem in industry, domestic, agriculture and environmental. Scale formation is the solid deposits present in the exchanger of heat instrument and creates the heating of the hard water and makes contact with pipes and walls of the heat exchanger. Too many years used chemical method to control and remove the mineral fouling. It requires

handling and disposal of hazardous chemicals, raising environmental concerns. Chlorine treatment of water is used then changes of odour, colour, hydrogen sulphide, growth of algae and germs. But due to the physical treatment it is beneficial for the control and removing of the scale formation on the walls and heating equipment's, this method is beneficial not only to the industry but also to the environment. The water treated by the magnetic field or passes through the magnetic device is called magnetized water. By the magnetic field strength change the physical and chemical properties as compared to ordinary water but not the acquired magnetic field strength. The hydrogen bond in liquid water is highly affected by magnetic field. These uncharacteristic properties of water are unique and results showed that many fluctuations of macroscopic properties Reddy *et al* (2014). Due to the magnetic field reduce the bond angle; these water clusters can break down but the increase solubility. The influence of magnetic field on liquid water has been deeply studied from last fifty years. To many people, magnets are complete mystery. Ibrahim (2006) study that the rate of flow is decreases with the increasing of magnetic field strengths, due to the application of magnetic field on water may also make alignment of water clusters and increasing of the magnetic field strength may also increases the alignment of water molecules. The alignment of water clusters may increase its electric current. According to (Gholizadeh *et al* 2008) magnetic treatment of water operates on the principle that a Lorentz force is experienced by each ion as the water is allowed to pass through a magnetic water softener. The frequency of collisions between ions increases due to redirection of the particles, positive and negative ions combine to form an insoluble compound. So, calcium carbonates dispatched from the solution as a mud which can be easily remove from the water. Musa and Hamoshi (2012) have observed that water may be levitated in very high magnetic field, which increases the tetrahedrality at the time. By the magnetic field is some disorder in the hydrogen bonding and improvement of salt mobility in hard water; the large water clusters are cut and break down to

form smaller water clusters or twice water molecule. Hassan and Rahman (2016) observed that squeezes the bond pairs to close and deflects the bond pairs by the magnetic field then bond angle decreases from 104.5° to 103° . The magnetic charge is lost by the existence of the metallic layer inside the pipes and then purified which flows out of the tap and is no longer magnetized (Al-Khazan *et al* 2011). Such a simple technology can have many beneficial impacts on industries utilizing water, truly motivates its deep study. Thus in view of this, the present study was planned to see the effect of magnetic field at different time intervals on the electrical conductivity, total dissolved salts and pH of the NaCl solution (hard water). The study of inherent properties of hard water such as electrical conductivity, TDS and pH give more insight to the concept of magnetic water treatment.

II. MATERIALS AND METHODS

The Haritron electromagnet (Model EM-20) was used for applying magnetic field to hard water. Larger magnetic field is produced when number of coil is more. The dimensions of electromagnet are diameter 9.0 cm and length 27.5 cm with total number of turns 3000 per coil. The distance between poles of electromagnet is adjustable up to 7 cm. The power supply of electromagnets has output voltage 0-100 volts and output current 0-10 ampere. To determine the nature of magnetic field, the magnetic field strength for different positions between the poles of electromagnet at different currents were measured by Digital gauss meter (DGM-102) to assure uniformity of field. Distilled water was prepared in the laboratory with of distillation of tap water. To study the effect of magnetic field on TDS, electrical conductivity and pH of hard water, at 0.05% concentrations of NaCl solution. For preparation of 0.05% NaCl solution, 0.05g of sodium chloride was dissolved in small volume of distilled water. Once the sodium chloride salt dissolved completely (after swirls the flask gently if necessary), water was added to make up the final volume as 100 ml of flask. In a similar way, other concentrations were prepared in laboratory by using distilled water. The parameters electrical conductivity and total dissolved salts of hard water were measured with the help of waterproof HANNA probe 98311 with range TDS (0-2000 ppm) and EC (0-3999 $\mu\text{S}/\text{cm}$). The HANNApH waterproof tester having pH range from -2.0 to 16.0 was used to measure pH of hard water. Hard water solution stabilise for 1 day. After 1 day, take 40ml solution in the beaker placed in the electromagnets centre with the distance of poles. Apply the magnetic field on hard water solution for 3 hours. After 3

hour beaker out the electromagnets then HANNA EC/TDS/pH temperature meter in the solution. The EC/TDS/pH of the solution measure with variation of temperature. It is same procedure on 5 hours and 7 hours time duration. Same procedure repeated on different magnetic strength (0.05T, 0.15T, 0.25T).

III. RESULTS AND DISCUSSION

3.1 Effect of magnetic field strength on TDS and EC at different exposure time

In this experiment measurement were made on TDS/EC of NaCl solution having on 0.05% concentration at different magnetic field strength (0.05T, 0.15T and 0.25T) and different time intervals (3 hours, 5 hours and 7 hours). The plot has been shown in fig.1.1 to fig.1.6. After magnetization the solution changes the physical, chemical and microbiological properties. It has been observed that TDS/EC increases linearly with variation of temperature. The increase in electrical conductivity is more for 7 hours and less for 3 hours with exposure time for all concentrations. Which means TDS/EC depends upon time of exposure. The increase in TDS/EC with concentration is due to increase in NaCl ions concentration. The values of regression coefficients a and b, its coefficient of determination R^2 are given below in Table 1.1 to 1.2.

Table 1.1 Regression coefficient for EC (μS) at different magnetic field

Concentration (w/v)	Magnetic field strength	Time (hrs)	a	b	R^2
0.05%	0.05T	0	17.651	481.036	0.999**
		3	17.916	493.806	0.999**
		5	17.988	508.130	0.998**
		7	17.848	532.152	0.998**
	0.15T	0	17.651	481.036	0.999**
		3	17.874	494.200	0.999**
		5	18.008	513.355	0.999**
		7	18.197	533.530	0.998**
	0.25T	0	17.651	481.036	0.999**
		3	18.372	485.785	0.999**
		5	18.842	497.355	0.998**
		7	19.186	515.427	0.997**

Table 1.2 Regression coefficient for TDS (ppm) at different magnetic field

Concentration (w/v)	Magnetic field strength	Time (hrs)	a	b	R ²
0.05%	0.05T	0	8.832	240.170	0.999**
		3	8.963	246.506	0.999**
		5	8.995	253.927	0.998**
		7	8.932	265.730	0.998**
	0.15T	0	8.832	240.170	0.999**
		3	8.915	248.303	0.999**
		5	9.020	256.542	0.999**
		7	9.093	267.088	0.999**
	0.25T	0	8.832	240.170	0.999**
		3	9.192	242.548	0.999**
		5	9.414	248.724	0.998**
		7	9.586	257.852	0.997**

** Significant at 5% level of significance ($p < 0.05$)

The increase due to temperature is due to increase in kinetic energy of the ions. They have analyzed similar type of variation shown in Mousa *et al* (2008) and Pang (2013). According to Barron *et al* (1994) the mobility of ions in solution is increased with the increase in temperature. With the dissociation of molecules, the number of ions in solution increases on increasing the temperature. The electrical conductivity depends on these factors then an increase in the solutions temperature leads to as an increase in its electrical conductivity. Hassan *et al* (2016) investigated that magnetism decreases the bond angle between hydrogen and oxygen atoms within each water molecule from 104.5° to 103° degrees. Due to decrease in bond angle, the water molecules cluster together in groups of 6-7 rather than groups of 10-12 molecules and higher. As the cluster size decreases, consequently the absorption of water increases. Pang (2013) show that electrical conductivity of magnetized water increases with increasing the frequency of externally applied electromagnetic field and magnetized time. This is due to changes of nature of charged ions and velocity of hydrogen ions as well as the changes of polarized features under the influences of electromagnetic fields.

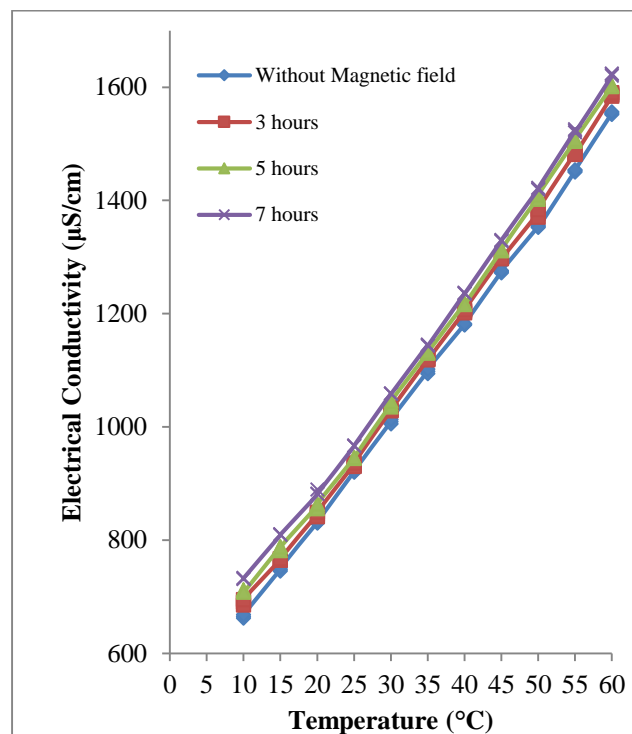


Fig.1.1 Variation between the electrical conductivity and temperature for different exposure time 0.05T (0.05%)

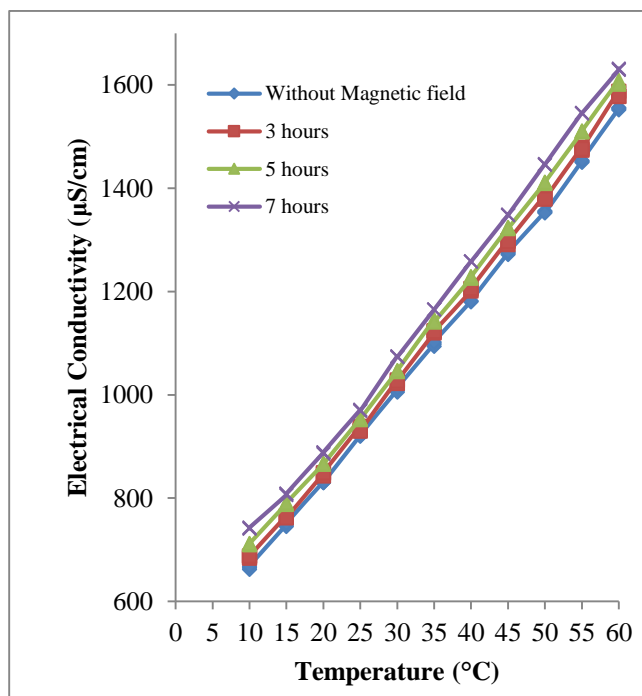


Fig. 1.2 Variation between the electrical conductivity and temperature for different exposure time 0.15T (0.05%)

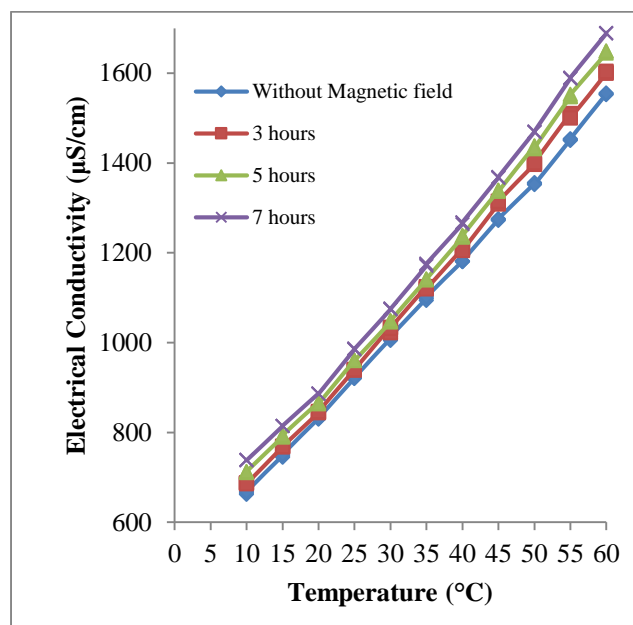


Fig.1.3 Variation between the electrical conductivity and temperature for different exposure time 0.25T (0.05%)

Moosa *et al* (2015) investigated that higher magnetic field strength increased the TDS. For exposing time less than 5 min, the rate of dissolving is slower than for exposing time greater than 5 min, where rate is much greater which mean more exposure of time greater solubility of solution. While for higher field intensity the increase in TDS is very sharp.

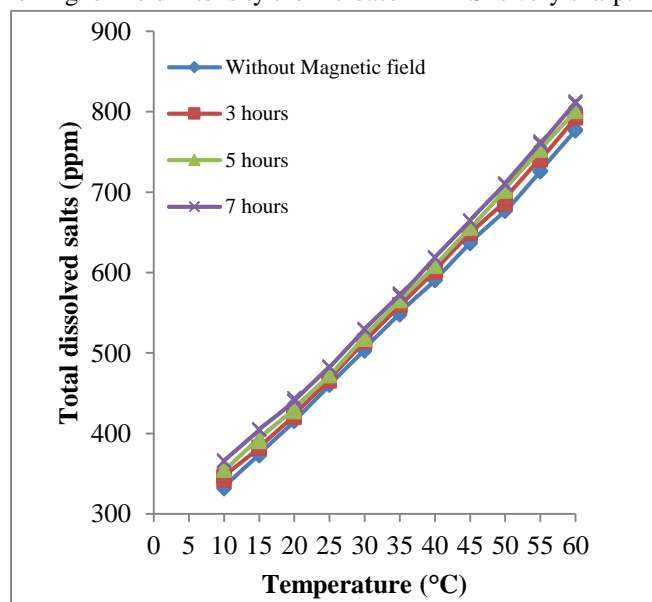


Fig.1.4 Variation between total dissolved salts and temperature for different exposure time 0.05T (0.05%)

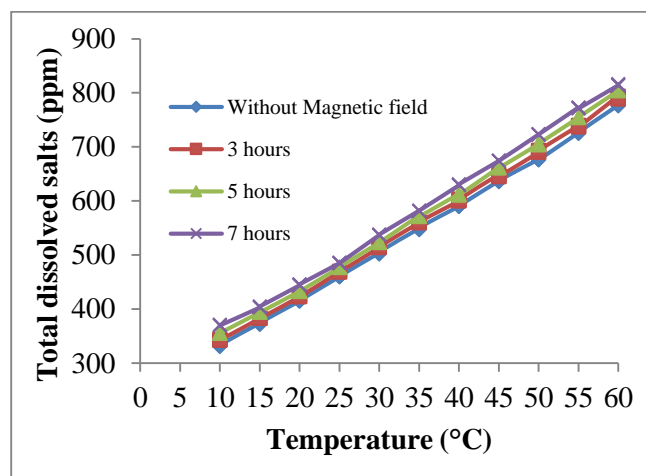


Fig. 1.5 Variation between total dissolved salts and temperature for different exposure time 0.15T (0.05%)

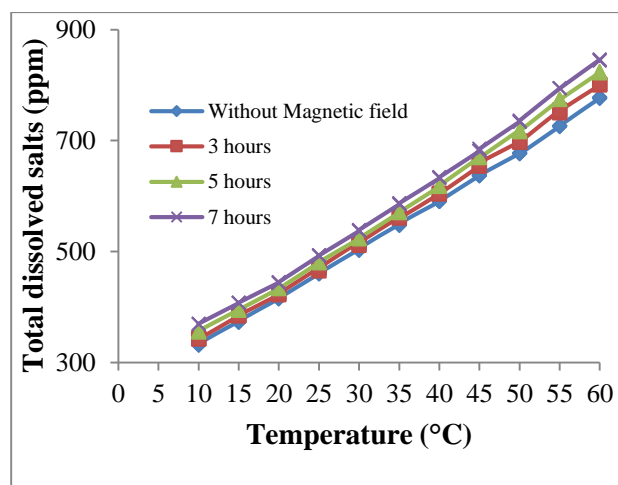


Fig. 1.6 Variation between total dissolved salts and temperature for different exposure time 0.25T (0.05%)

3.2 Relationship between the TDS and EC

The relationship between electrical conductivity and total dissolved salts shown in *fig.2.1*. It shows linear relationship between electrical conductivity and total dissolved salts for different temperature (10°C - 50°C). The conductivity is directly proportional to twice of total dissolved salts. Increase in electrical conductivity with increase of temperature and magnetic field strength. A high value of electrical conductivity indicates high total dissolved salt concentration. Iyasele *et al* (2015) found that total dissolved salts in water; an electrical conductivity value is more. Temperature effect the electrical conductivity value increases from 2 up to 3 % per 1 degree Celsius. Estimation of the electrical conductivity when number of total

dissolved salts in solution. When conduct electrical current of water measured by electrical conductivity. Salts dissolve into positively charged ions and negatively charged ions.

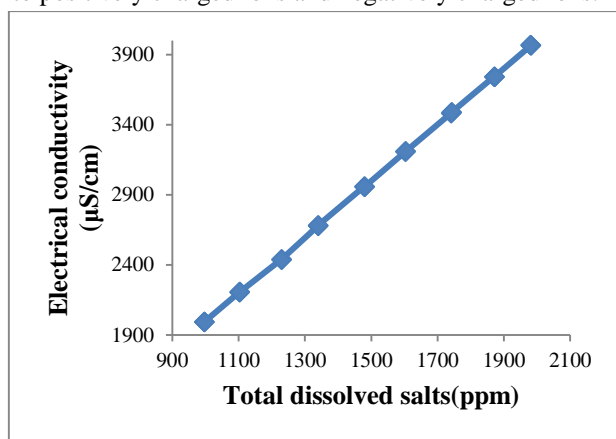


Fig.2.1 Relationship between the electrical conductivity and total dissolved salts

3.3 Effect of magnetic field on pH at different exposure of time

At 0.05% of NaCl solution at three different magnetic fields (0.05T, 0.15T and 0.25T) for different time exposure (3 hours, 5 hours and 7 hours) has been shown in fig.3.1 to fig.3.3. The variation of pH with temperature shows smooth and regular variation. The increase in pH is more for higher exposure time and higher magnetic field strength at higher concentration. The pH of 0.05% NaCl solution increases from 5.54 to 5.93 at 0.05T and from 5.64 to 6.13 for 0.15T field strength at 10°C temperature for exposure time. The pH of the solution change which means that there must be hydrolysis reaction happens in the solution because of ions polarization ability. Ionization reaction happens when inorganic salts dissolve in water, these ions forms. Then ions interact with H^+ or OH^- which are form water molecules ionization. The ions with good polarization ability can bind with H^+ or OH^- which can form weak electrolyte. Then the number of charged ion changes. This process, which is called hydrolysis reaction, promotes water hydrogen bonds breakage and breaks aqueous ionization balance.

The effect of magnetic field on NaCl solution is obtained to measurement of pH. Increasing magnetic field strength then pH of hard water is increase as compared to untreated hard water. The separation between the exposures of time is more than magnetic field strength is increase. We have more exposure of time pH is decreased for different time intervals. The reason behind pH is decreased due to large exposure of time that acidity of NaCl solution

increases due to the number of hydrogen bonds increase. The total dissolved salts increased by magnetic field strength then acidity of hard water are increased.

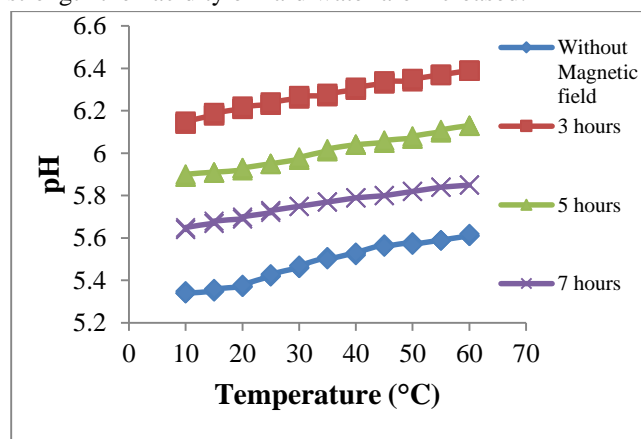


Fig. 3.1 Variation of pH with temperature for at 0.05% concentration and field strength 0.05T

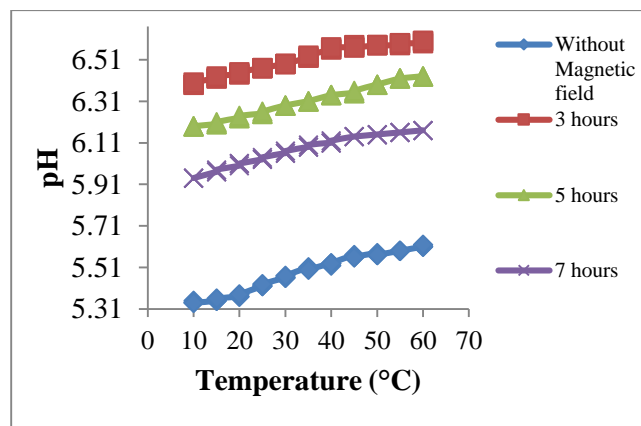


Fig. 3.2 Variation of pH with temperature for at 0.05% concentration and field strength 0.15T

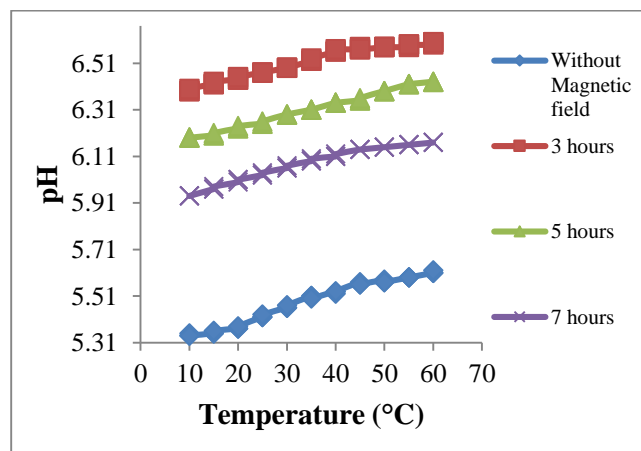


Fig.3.2: Variation of pH with temperature for at 0.05% concentration and field strength 0.25T

Hassan and Rahman *et al* (2016) reported a higher 12% increase in water pH after magnetization. The effect of the exposure to the magnetic field was increased pH of water. The effect depends on the time of exposure to the magnetic field. Moosa *et al* (2015) studies pH value increases with exposing time this is due to the decreasing in the hydrogen ion concentration, while pH value increases with increasing magnetic field for distilled water due to the polarization of water molecules and the decreasing of hydrogen ion concentration the water molecules will arrange in one direction.

Table.3.1: Regression coefficient for pH at different magnetic field

Concentration (w/v)	Magnetic field strength	Time (hrs)	a	b	R ²
0.05%	0.05T	0	0.006	5.278	0.974**
		3	0.009	5.875	0.933**
		5	0.008	5.683	0.934**
		7	0.007	5.505	0.951**
	0.15T	0	0.006	5.278	0.974**
		3	0.005	6.111	0.988**
		5	0.005	5.836	0.991**
		7	0.004	5.615	0.982**
	0.25T	0	0.006	5.278	0.974**
		3	0.004	6.363	0.956**
		5	0.005	6.133	0.994**
		7	0.005	5.912	0.966**

** Significant at 5% level of significance ($p < 0.05$)

3.4 Relationship between the EC and pH

There was a proportional relationship between the electrical conductivity records and pH values. It was found that the increase in pH value is more effective with the elevation in temperature degree. The reason behind pH is decreased due to large exposure of time that acidity of NaCl solution increases due to the number of hydrogen bonds increase. The electrical conductivity increased by magnetic field strength then acidity of hard water are increased.

3.5 Relationship between time and TDS/EC

The plot shown in fig 5.1 to 5.2. TDS/EC gradually increases with time at different temperature. The TDS/EC is more for 20°C and less for 60°C.

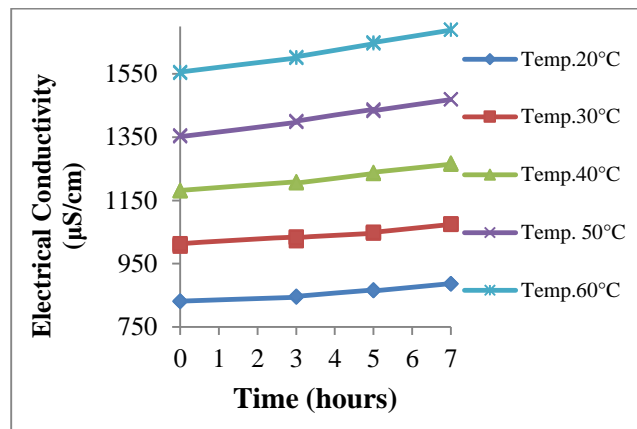


Fig. 5.1 Variation between time and EC at different temperature

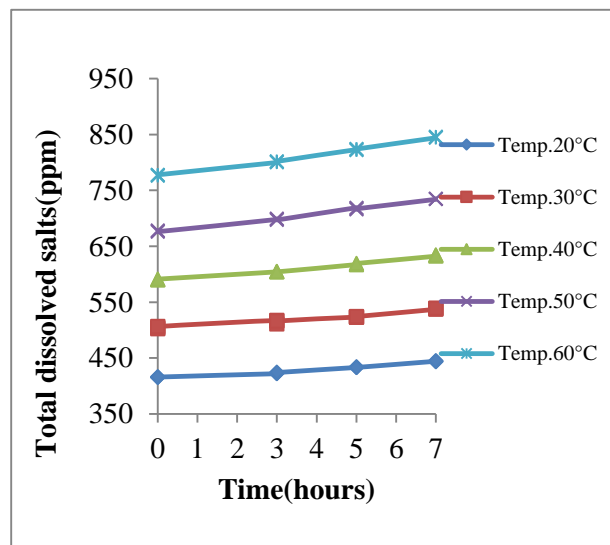


Fig.5.2 Variation between time and TDS at different temperature.

IV. CONCLUSIONS

- The TDS/EC of NaCl solution gradually increased with different magnetic field strength at different exposure time.
- The values of pH increase with magnetic field strength; at different exposure time but for 3 hours are more and for 7 hour are less.
- The changes in total dissolved salts, electrical conductivity and pH of hard water under the effect of magnetic field strengths have been observed significant at 5% level of significance.

- (iv) The solubility of NaCl solution is increased because value of EC/TDS significantly increased by magnetic field strength.
- (v) It results beneficial for removing of kidney stone and production of sea food.

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