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Effect of Magnetic Field on Some Physical Properties of Tap Water

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Strictly as per the compliance and regulations of:

Effect of Magnetic Field on Some Physical Properties of Tap Water

Ashish Soni [α], Karishma Sharma [σ] & SS Verma [ρ]

Abstract- Passing water through a magnetic flux has been claimed to boost chemical, physical and medicinal quality of water in many alternative applications. Though, the treatment method has been used for many years, it still remains within the realms of fallacy. If the claims of treating water with magnets are a unit true, the method offers enhancements on several of our applications of water in today's world. A big range of peer-reviewed journal articles have according contradictory claims concerning the treatment. A number of the foremost useful claimed water applications from magnetically treated water embody improvement in scale reduction in pipes and increased crop yields with reduced water usage. However, we are still unsure whether or not the technology works and researchers do believe it works and are still attempting to know the mechanisms of how it works. Several analysis papers are setting out to develop similar theories behind the mechanism of the treatment. The majority of the experiments performed throughout this analysis were determined to own deficient controls to provide conclusive results. The conclusions from this analysis were centred on coming up with improved experiments to produce additional conclusive results. While the experimental results weren't conclusive, the results earned backed the idea. Magnetically treated water doesn't do all that it's claimed it will. However, a number of the positive results obtained throughout this analysis recommend that the improved experiments developed from this analysis might give conclusive results on this moot topic.

Keywords: magnetic field, surface tension, conductivity, resistivity, electromagnet.

I. Introduction

Magnetized water is the water passed through a magnetic field. it's cheap, environmental friendly water treatment that incorporates a little installation fee and thus no energy necessities. The effects of magnetic field on water, is that the subject of disputable discussion. Several scientific journals and analysis claim that the magnetic field has no result on water and also the current successes haven't been able to be reproduced. Today, there square measures many reviewed papers and experiments that have done on magnetic water treatment with a considerable share attaining success within the treatment. Water could be a most tough substance to look at properties, because it carries the varied sort of particles within the type of small contaminants and alternative dissolved solids or liquid. This adds to the confusion regarding magnetized water with several claiming that bound chemicals within the water verify the success rates of the treatments. Round the world, in numerous laboratories, the water being treated varies from experiment to experiment, except once using water [1].

The development of water treatment with associate applied magnetic field has been familiar for several years and has been reported as effective in various instances however the Investigation on effects of magnetic field (MF) on water continues to be a disputable subject. Several articles and reports square measure out there in literature that reported that magnetic water treatment is helpful and magnetic water treatment has received attention from the scientific community. In nearly all cases researchers report some magnetic result, it absolutely was found that some properties of water were modified, and plenty of recent and strange phenomena were discovered when magnetization. Magnetic water is absolutely having magnetism. These results show that the molecular structure of water is extremely sophisticated, that wants to find out deeply.

a) Background

At now in time, magnetic water is classed by several to be pseudoscience whereas others are enjoying the advantages of this unknown science. The motivation for this study comes from the actual fact that such an easy technology will have helpful impacts on industries utilizing water. Water is one among nature's most significant gifts to human race. Essential to life a person's survival depends on drinking water. Water is one among the foremost essential components to physiological state -- it's necessary for the digestion and absorption of food; helps maintain correct muscle tone; provides gas and nutrients to the cells; rids the body of wastes; and is a natural air-con system. Health officers emphasize the importance of drinking a minimum of eight glasses of fresh water on a daily basis to take care of physiological state, water could be a key part in determinant the standard of our lives. Nowadays [2] folks square measure involved concerning the standard of the water they drink. Though water covers quite seventieth of the planet but only one of the planet water is accessible as a supply of drinking. Nevertheless our

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society continues to contaminate this precious resource. Water is understood as a natural solvent. Before it reaches the consumer's faucet it comes into content with many alternative substances as well as organic and inorganic matter chemicals and different contaminants. several public water systems treat water with Cl to destroy manufacturing contaminants which will be present within the water though medical aid is a very important step within the treatment of transportable water, the style and odour of Cl is objectionable and also the disinfectants that square measure accustomed prevents malady will produce by-products which can cause vital health risks/ nowadays potable treatment at the purpose of use isn't any longer a luxury it's a necessity customers square measure taking matters into their own hands and square measure currently determinant the standard of the water they and their families can drink by putting in a potable system that may offer them clean refreshing and healthier water.

b) Scope

This project is aimed at experimenting on the properties and applications to get an understanding of what is possible from magnetisation of water. Here is a list of some of the claims on magnetic water:

- The molecule increases in size and this increases the water solubility
- Magnetized water tastes better and is more clean
- Drinking of magnetic water may also promotes a more alkaline pH in the body
- The surface tension of water changes
- Conductivity of water changes.

From above properties in our project work the water to be used in the experiments includes:

- Surface Tension of water: tap water, water with salt and sugar.
- Conductivity of Water: tap water, water with salt and sugar.

c) Current Theories of Magnetised Water

The principle of this phenomenon is still not well understood and various contradictory hypotheses have been proposed. A journal article from explains the molecular makeup of water and its polarity. A molecule of water consists of one atom of oxygen and two atoms of hydrogen, H2O [7]. The covalent bond that holds each hydrogen atom to the oxygen atom results from a pair of electrons being shared. Because of the two hydrogen atoms sharing electrons on one end, the molecule possesses a positive charge on one end and a negative charge on the other. Some suggest this may cause the molecule to act similarly in some ways to a small bar magnet. This is referred to as the dipole moment of a molecule and is responsible for solubility of water. Figure 2.3 shows how the dipole moment of a water molecule is like a magnet. According to Quinn [8] the polar molecules attain different orientation under the influence of a magnetic field. The stronger is the magnetic field, the greater is the number of dipoles pointing in the direction of the field. The unusual properties of water can be attributed to extensive hydrogen bonding between its molecules.

In a magnetic field, magnetic force can break apart water clusters into single molecules or smaller cluster that contain equal number of water molecule. Therefore, the activity of water is improved. It should be noted that theories of water clusters are just that, theories and have not been proven yet [10]. Scientists are still unsure of the exact mechanisms by which treating water with magnets modifies its behaviours. There are numerous scientifically accurate theories, as well as several theories that apparently defy science as we know it. It is proper to point here that our current science isn't guaranteed 100% accurate and that we do not know everything about elements and molecules in the universe. We cannot throw new theories easily away just because they don't match with our past theories. We cannot throw new technology away either, just because we don't understand why it works [11].

II. Methodology

a) Measuring surface tension by capillary rise method

Surface tension molecular theory is very much a part of school physics curricula. Accordingly, a molecule well within a liquid is surrounded by other molecules on all sides. The surrounding molecules attract the central molecule equally in all directions, leading to a zero-net force. In contrast, the resulting force acting on a molecule at the boundary layer on the surface of the liquid is not zero, but points into the liquid. This net attractive force causes the liquid surface to contract toward the interior until the repulsive collisional forces from the other molecules halt the contraction at the point when the surface area is a minimum. If the liquid is not acted upon by external forces, a liquid sample forms a sphere, which has the minimum surface area for a given volume. Nearly spherical drops of water are a familiar sight, for example, when the external forces are negligible [12]. The surface tension 'γ' is defined as the magnitude 'F' of the force exerted tangential to the surface of a liquid divided by the length 'l' of the imaginary line on the liquid surface over which the force acts in order to maintain the liquid film.

$$\gamma = F/l$$

Capillarity is the combined effect of surface tension and cohesive & adhesive forces that causes liquids to rise in tubes of very small diameter. In case of water in a capillary tube, the adhesive force draws it up along the sides of the glass tube to form a meniscus. The cohesive force also acts at the same time to minimize the distance between the water molecules by pulling the bottom of the meniscus up against the force of gravity as shown in Fig. 1.1 and Fig. 1.2.

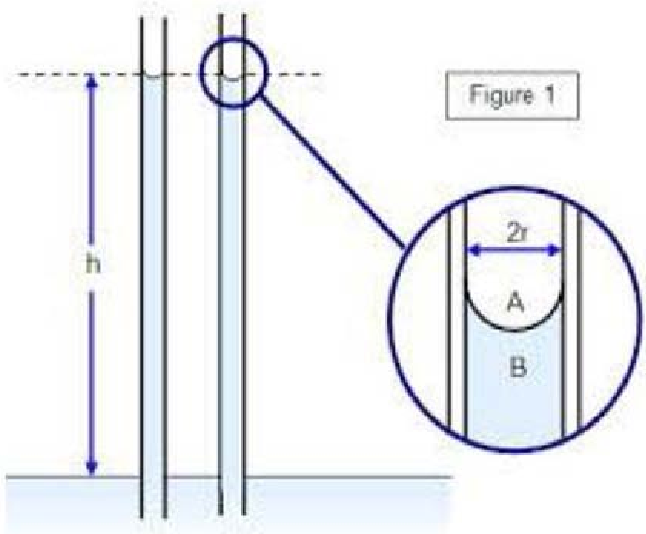

Fig. 1.1: Capillary rise

If the cross-section area of the capillary is circular and its radius is sufficiently small, then the meniscus is semi-spherical. Along the perimeter of the meniscus there acts a force due to the surface tension as:

$$f_1 = 2\pi r\gamma cos\theta$$

Where: r – the capillary radius,

γ – the liquid surface tension,

θ – the wetting contact angle.

The force f_1 is equalized by the mass of the liquid raised in the capillary to the height 'h', that is the gravity force f_2. In the case of non-wetting – it is lowered to a distance – h.

$$f_2 = \pi r^2 hdg$$

Where:

d – the liquid density (g/cm3) (actually the difference between the liquid and the gas densities),

g – the acceleration due to gravity.

In equilibrium (the liquid does not move in the capillary) that is $f_1 = f_2$, and hence:

$$2\pi r\gamma cos\theta = \pi r^2 hdg$$

Or

$$\gamma = \frac{rhdg}{2cos\theta}$$

If the liquid wets the capillary walls the contact angle θ = 0, and Cos θ = 1 then the surface tension can be determined as:

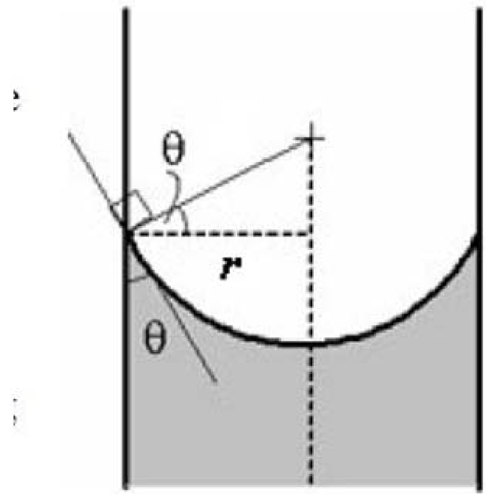

Fig. 1.2: Meniscus of water

$$\gamma = \frac{rhdg}{2}$$

Similar considerations can be made for the case of convex meniscus.

b) Conductivity of Water

Conductivity of a substance is defined as its ability or power to conduct and transmit the heat, electricity or sound. When an electric field is placed across a conductor, then the flow of its movable charges gives rise to an electric current and this property is called conductivity. Conductivity is a measurement of the ability of an aqueous solution to carry an electrical current. An ion is an atom of an element that has gained or lost an electron which will create a negative or positive state. For example, water molecule consists of hydrogen ions (H+) and oxygen ions (O-2) held together. The electrical conductivity can be expressed as mhos (reciprocal of ohms) or as Siemens. The conductivity of water is a measure of the ability of water to carry an electric current in most water is a the measure of ability of water to carry an electric current in most of the water the conductivity is very low so milli-Siemens or micro-Siemens are used as units foe conductivity. Pure water is bad conductor of electricity as it doesn't have any free ions that can circulate to pass electrical energy. If we add impurities, this becomes a good conductor of electricity as we get free ions that can pass energy. can conduct electricity because of these ions. The electrical resistivity ρ is defined as:

$$\rho = R\frac{A}{l}$$

Here R – The electrical resistance of a uniform specimen of the material, l-Length, A – The cross-sectional area of the specimen. Conductivity σ is defined as the inverse of resistivity: $\sigma = \frac{1}{\rho}$ or $\sigma = \frac{l}{RA}$ and has SI units of Siemens per meter (S/m).

III. Experimental Procedure

a) Apparatus used

i. Magnetic field arrangement

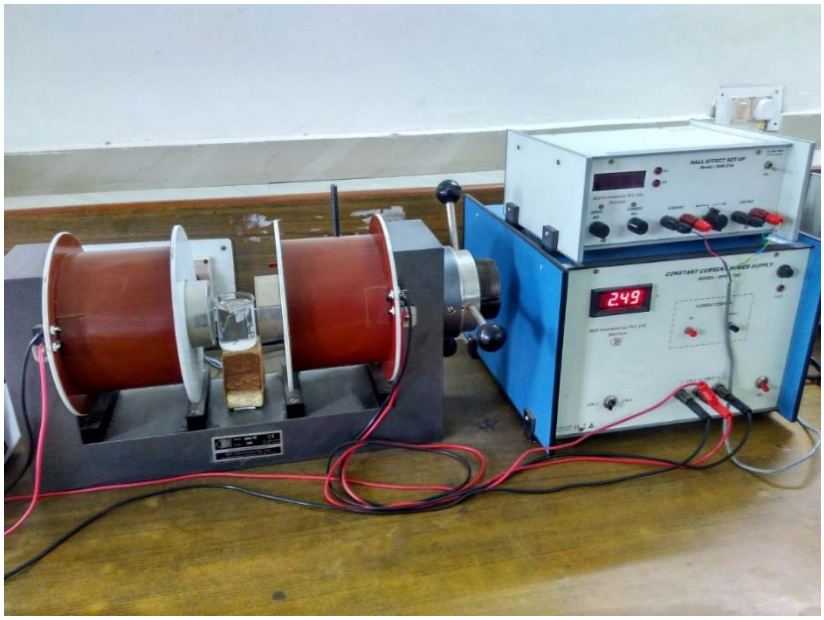

Fig. 2: Magnetic field arrangement

Fig, 1.2 shows the arrangement for magnetic field. We use the electromagnet which has power range from 0 to 3000 gauss. There is two pole of electromagnet between which there is an arrangement for keep the beaker of water so that we can magnetise the water and then measure the required properties of that magnetised water.

ii. Surface Tension Arrangement

To measure the surface tension, the arrangement is shown in fig 1.2 there is a stand and a capillary tube arrangement by which we can measure the surface tension at the different magnetic field.

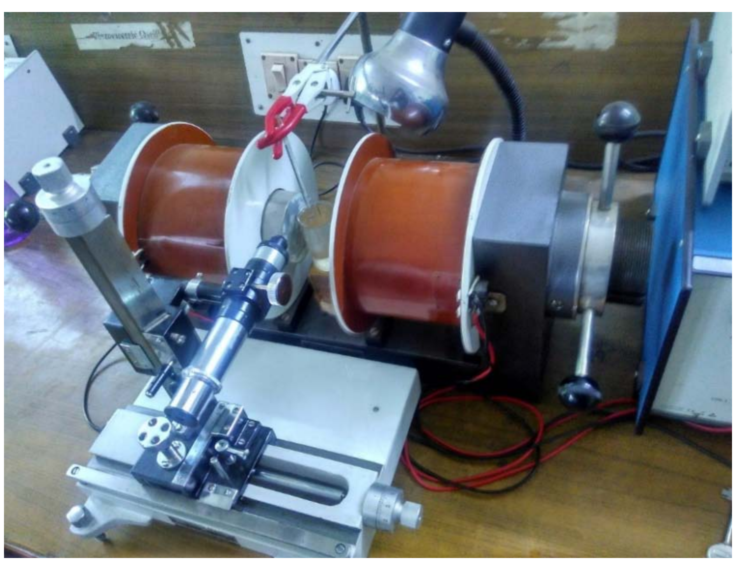

Fig. 3: Surface tension arrangement

iii. *Conductivity Arrangement*

To measure the conductivity of water we used a multimeter by which we can first measure the resistance of water, and further we calculate the conductivity.

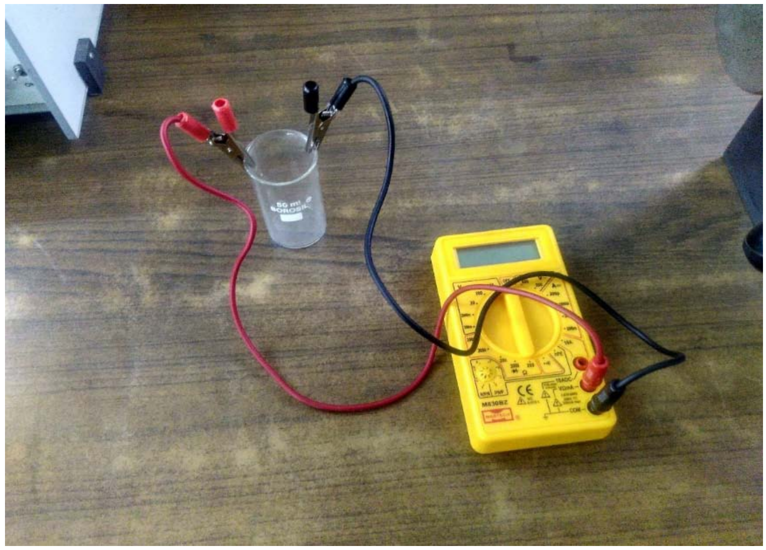

Fig. 4: Conductivity measurement arrangement

b) Calibration of the Electromagnet

i. *Magnetic field v/s current*

We use the electromagnet having range 0 – 3000 gauss to see the effect of the magnetic field on the water to do so we need to calibrate the values of the magnetic field at different values of current because in electromagnet we produce the magnetic field by applying current. So First of all I have note the digital gauss meter readings to calibrate the values of magnetic field i.e. the variation of magnetic field with current applied. If we take the values of the magnetic field at the centre of the pole of the electromagnet, the magnetic field is increases linearly with applied current. Graph shows the variation of magnetic field with increasing value of current.

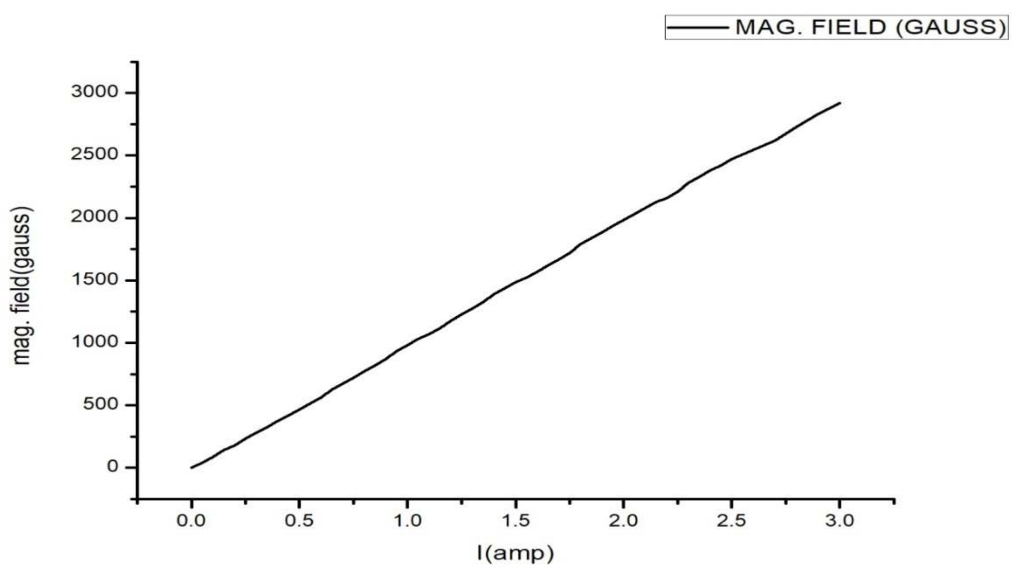

Fig. 5: Variation of the magnetic field with current

ii. *Magnetic field v/s distance*

Now we note the readings of magnetic field in the centre of the two pole of electromagnet with the change of the distance between the poles the variation of magnetic field with the distance is shown in figure.

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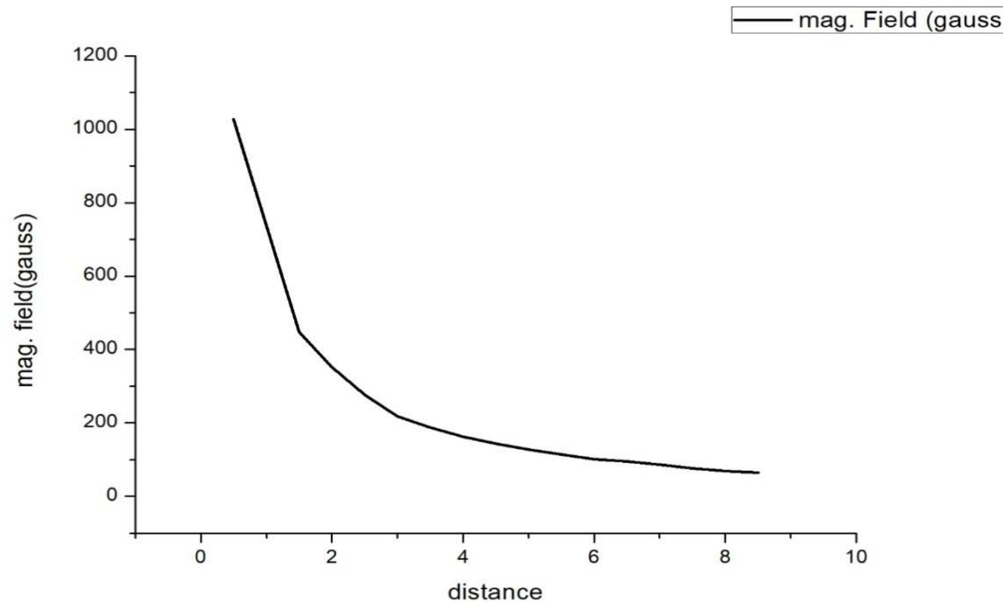

Fig. 4.5: Variation of the magnetic field with distance

c) Measurement of Surface Tension of Water at Different Magnetic Fields

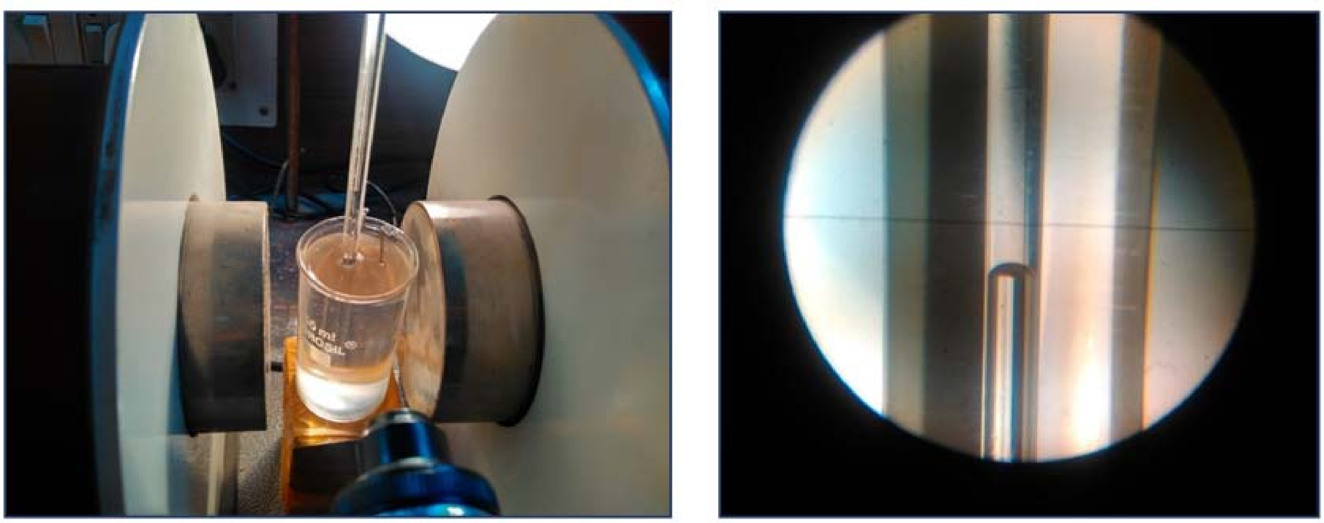

Fig. 6: Meniscus of water under microscope

- Firstly, to find the radius of the tube, fix the capillary tube in the stand horizontally.
- Focus the tube using travelling microscope to clearly see the inner walls of the tube. Let the vertical crosswire coincide with the left side inner wall of the tube. Note the reading of vertical diameter (say L1). Turn the microscope screws in horizontal direction to view the right side inner wall of the tube. Note down the reading of horizontal diameter (say R1). Thus, the radius of the tube can be calculated as ½(L1~R1).
- Now for the Hight of water Fix the capillary tube in the clamp stand and stick a pin on the capillary tube for water reference level and check that the tube is perfectly vertical.
- Keep the beaker filled with water on the support base in between the poles of the electromagnets.
- Now bring the stand near the beaker. Let the tubes dipped in the water. Adjust the needle so that the lower tip of pin just touches the water surface.
- Determine the Vernier constant of the travelling microscope to be used.
- Focus the travelling microscope so that you can see the inverted meniscus of water. Adjust the horizontal crosswire to be tangential to the convex liquid surface. Note down the readings on the vertical scale.
- After noting the position of liquid surface for the tube, move the microscope further horizontally and

focus to the needle. Now move the microscope vertically and let the lower tip of the needle be focused at the point of intersection of the two cross wires. Note down the readings on the vertical scale.

- Thus, from the difference of the two readings noted above, the height of the liquid can be calculated.
- Finally calculate the surface tension by repeating the above procedure at different magnetic field and for different time period.

d) Measurement of Conductivity of Water at Different Magnetic Fields

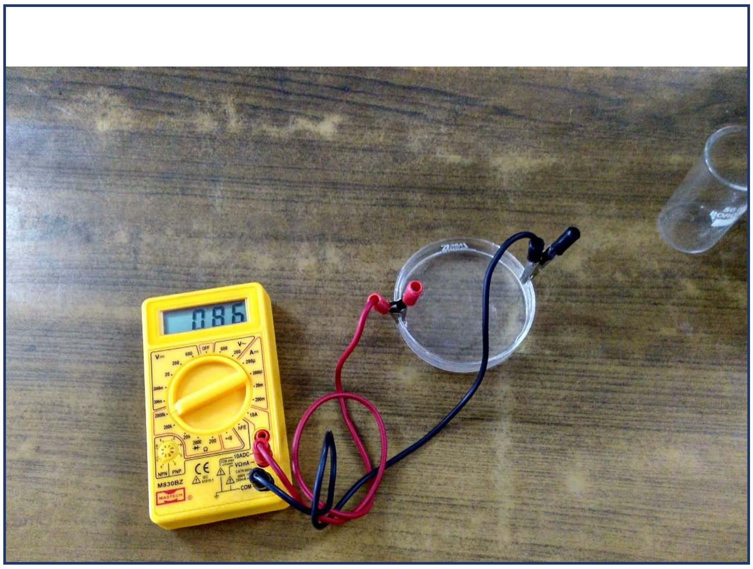

Fig. 7: Measurement of conductivity with multimeter

- Insert the red and black leads of the multi-meter into its positive and negative ports, respectively. The red lead represents positive, while the black lead represents negative.
- Now fill the beaker with water and put it in the magnetic field for some time (say t_1).
- Turn on the digital multi-meter and then change its measurement dial to the resistance setting. Resistance is denoted by the capital Greek letter Omega(**Ω**).
- Connect the leads at opposite ends of the longest dimension of the glass beaker filled with water.
- Measure the length, width and depth of the glass beaker in centimeters. The resistance in ohms that appears on the screen.
- Multiply the value of width by the depth to obtain the area of the sides of the glass dish in square centimeters.
- Divide the length by the product of the resistance and the area to arrive at the conductivity in units of Siemens per meter. The Siemens units equal one divided by the ohm.

IV. Results and Discussion

This chapter deals with the results of experiments carried out during the course of present study. We use the tap water, water mixed with salt and water mixed with sugar to see the effect of magnetic field on it.

As we see in the literature survey the Magnetic field can be affect many different properties of water like

- pH value
- Solubility
- Heat capacity
- Conductivity
- Surface tension

We focus our self only on last two properties that is the surface tension and the conductivity of tap water.

a) Results on surface tension test in normal tap water

The variation of surface tension with magnetic field at different magnetic field and for different time intervals is shown in the table below:

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Table 1: Variation of surface tension with magnetic field using tap water

Time	Surface tension (N/m)			
	1030 gauss	1529 gauss	2030 gauss	2470 gauss
0 min	72.528	72.552	72.409	72.647
30 min	72.766	72.671	72.408	72.766
60 min	72.885	73.005	72.719	73.029
90 min	72.886	73.029	73.148	73.649
120 min	73.172	73.124	73.363	74.031

With the increasing magnetic field the surface tention of water shows very small changes at low magnetic field like at 1030 gauss the change is only one unit even for two hours but at higher magnetic field the change is comparetively large. It can be seen in the graph that slop of the magnetic field curve is more in the case of higher magnetic field and It is flat in the case of low magnetic field.

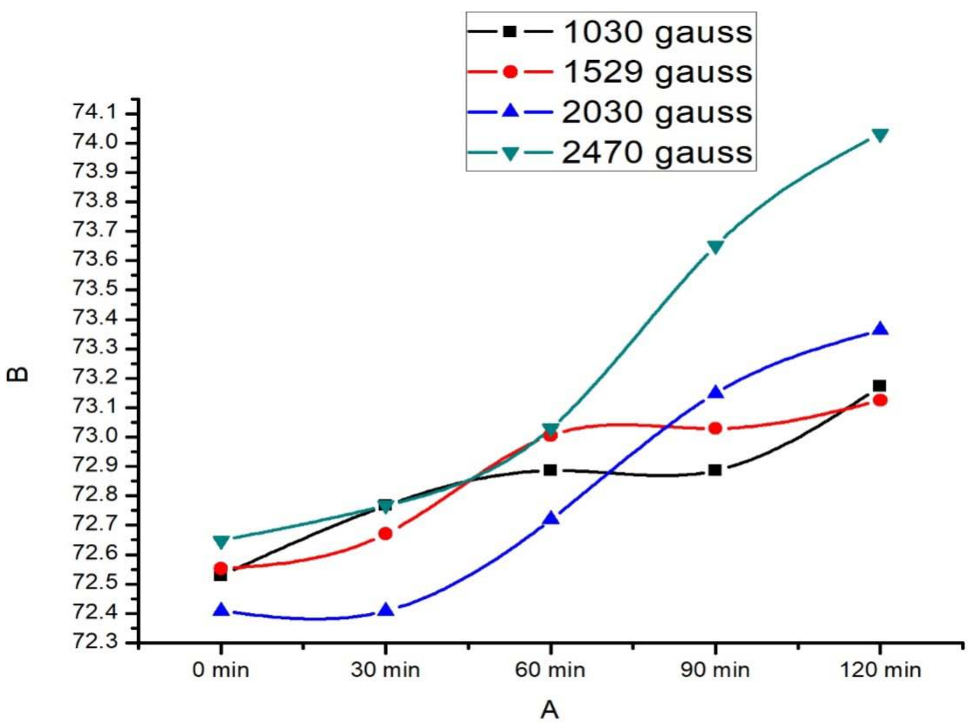

Fig. 8: Plot for variation of surface tension with the magnetic field using normal tap water

b) Result on conductivity test in normal tap water

Conductivity is also showing the variation with increasing magnetic field. We can see from the graph that the conductivity increases slowly for 60 minutes and after that, it increases rapidly. That is the effect of magnetic field is more if we put the water for a long time in the magnetic field.

Table 2: Variation of conductivity with the magnetic field using normal tap water

Time	Conductivity (Siemens per meter)			
	1030 gauss	1529 gauss	2030 gauss	2470 gauss
0 min	0.0162	0.016	0.015	0.017
30 min	0.0188	0.022	0.017	0.020
60 min	0.029	0.031	0.033	0.031
90 min	0.075	0.054	0.052	0.051
120 min	0.092	0.103	0.110	0.124

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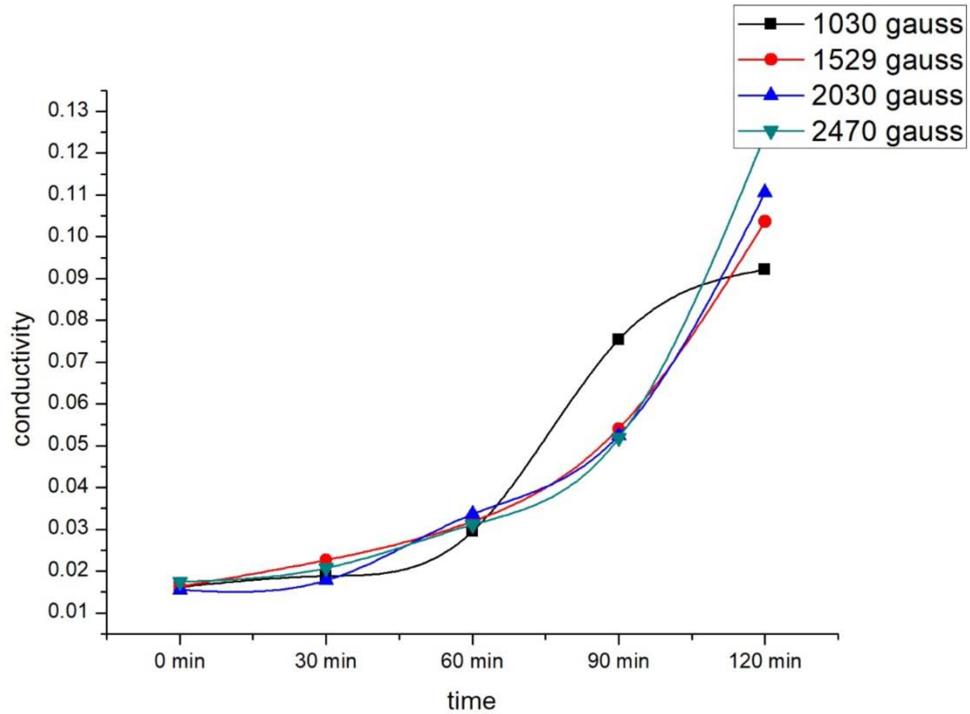

Fig. 9: Plot for variation of conductivity with magnetic field using normal tap water

c) *Results on surface tension of tab water mixed with salt*

Same experiment is done with the salted water and observes the variation of surface tension with magnetic field. The concentration of salt in water is 0.1 gram per ml of water. After adding the salt surface tension again increasing with increasing magnetic field. The variation of surface tension is shown in fig. 2.1

Table 3: Variation of surface tension with magnetic field using tap water mixed with salt

Time	Surface tension(N/m)		
	1030 gauss	1529 gauss	2030 gauss
0 min	72.838	72.361	75.893
30 min	73.172	75.057	76.513
60 min	74.890	77.778	78.899
90 min	77.801	79.281	79.281
120 min	79.49	80.403	79.615

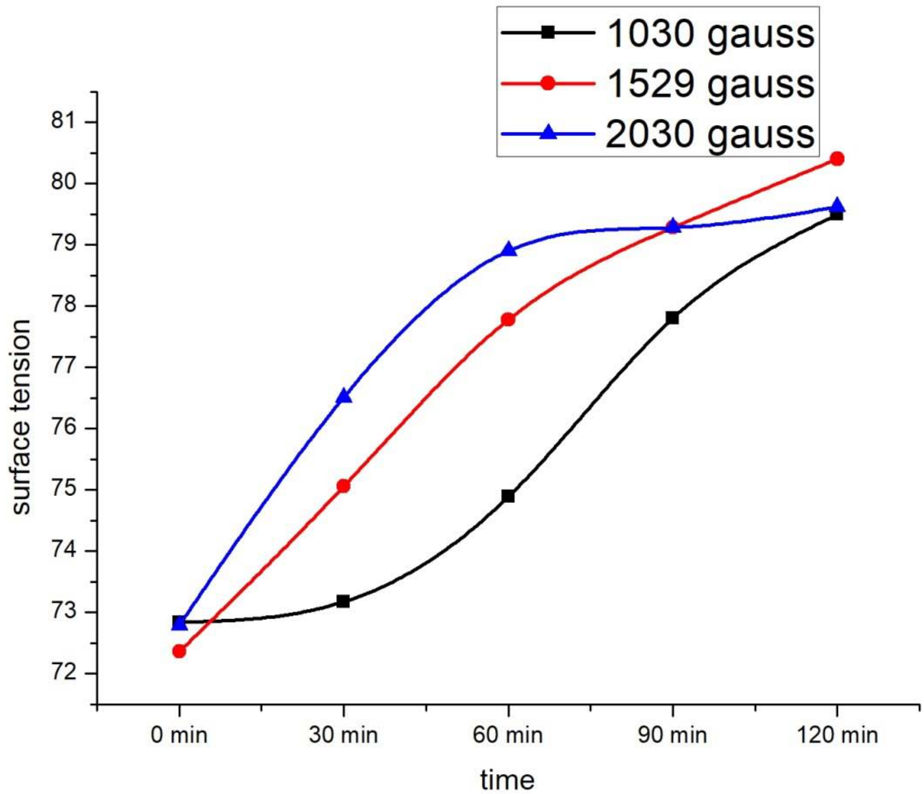

Fig.10: Plot for variation of surface tension with magnetic field using tap water mixed with salt

d) Results on conductivity test of tap water mixed with salt

In this case the conductivity of water is not so much varies but even it is increasing with very small value.

Table 4: Variation of conductivity with magnetic field using tap water mixed with salt

Time	Conductivity(Siemens per meter)		
	1030 gauss	1529 gauss	2030 gauss
0 min	0.131	0.138	0.134
30 min	0.142	0.155	0.155
60 min	0.146	0.165	0.155
90 min	0.146	0.165	0.155
120 min	0.146	0.165	0.155

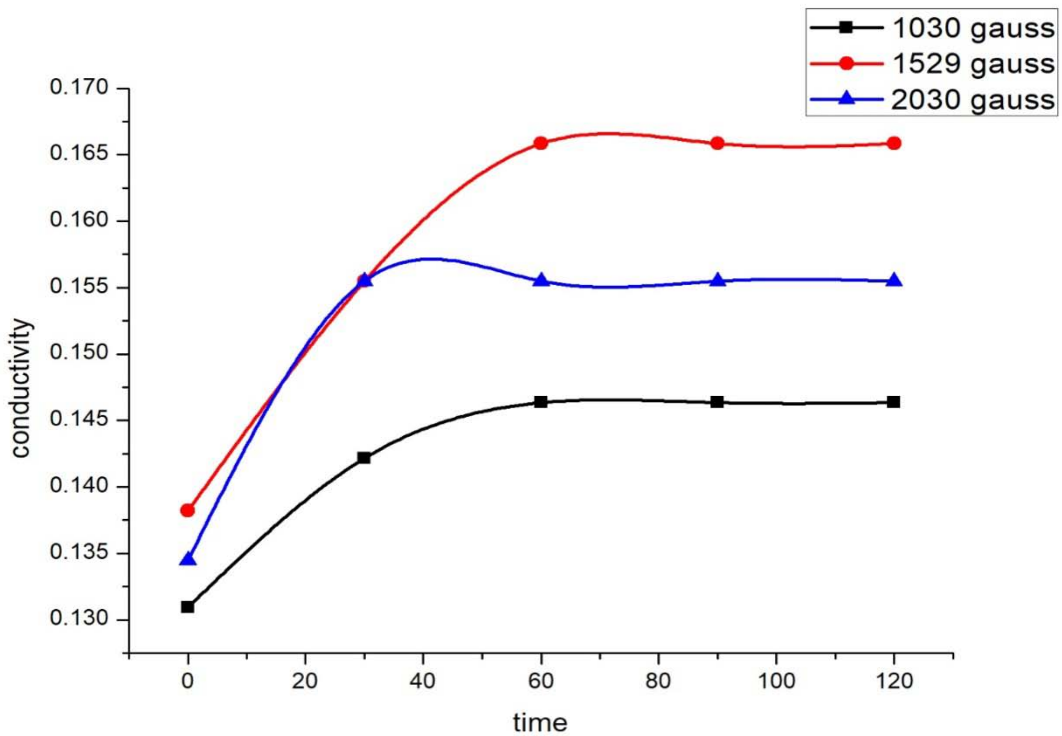

Fig. 11: Plot for variation of conductivity with magnetic field using tap water mixed with salt

e) Result on surface tension of tap water mixed with sugar

Now we have add sugar in water the concentration of sugar in water is 0.1 gram/ml. After adding sugar the surface tension of water again increasing with large variation in the values. The range of variation is from ~73 N/m to ~80 N/m. The measured values of surface tension are given in the following table 5.5.

Table 5: Plot for variation of surface tension with the magnetic field using tap water mixed with sugar

Time	Surface tension (N/m)		
	1030 gauss	1529 gauss	2030 gauss
0 min	74.747	73.220	72.695
30 min	74.890	74.460	75.17
60 min	79.138	79.281	79.925
90 min	80.259	80.832	81.190
120 min	82.908	85.172	82.956

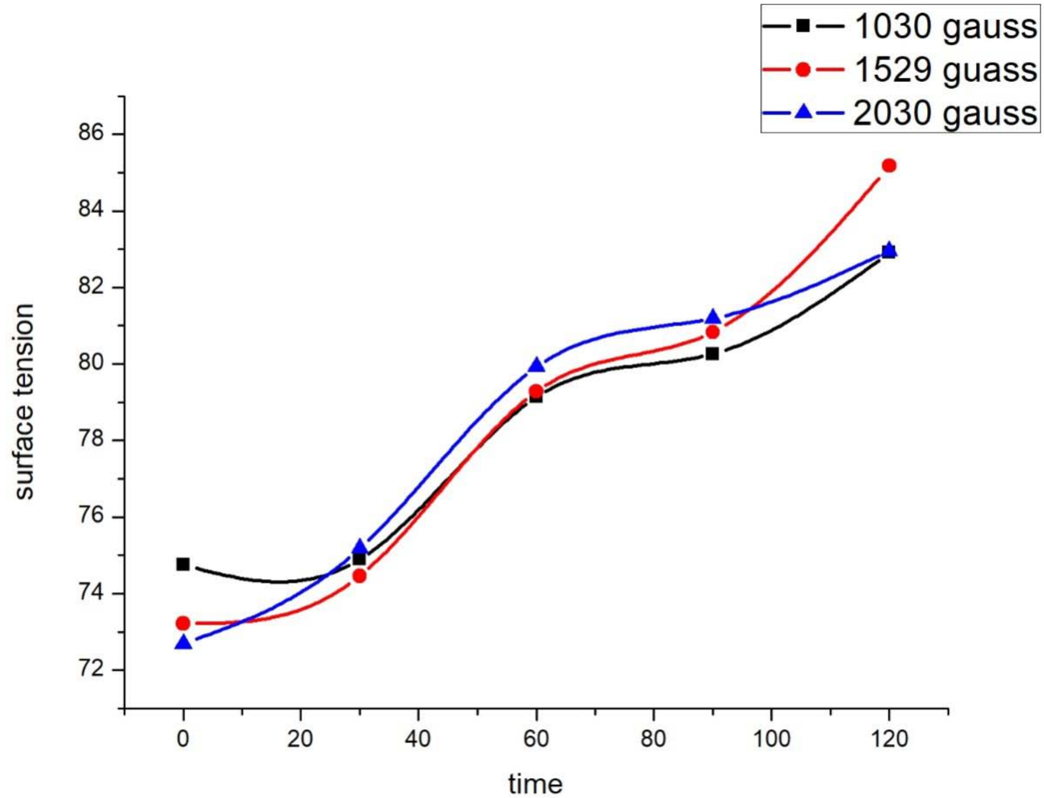

Fig. 12: Plot for variation of surface tension with magnetic field using tap water mixed with sugar

f) Result on conductivity of tap water mixed with sugar

Now, the same experiment is performed with the sugar addition in water and we found that there is also a change in conductivity but this time it decreases instead of increasing. So we can conclude that the conductivity can be decreased with the help of magnetic field. The values of conductivity are shown in the table. 5.6.

Table 6: Variation of conductivity with the magnetic field using tap water mixed with sugar

Time	Conductivity(Siemens per meter)		
	1030 gauss	1529 gauss	2030 gauss
0 min	0.071	0.071	0.065
30 min	0.064	0.065	0.061
60 min	0.061	0.062	0.052
90 min	0.055	0.054	0.049
120 min	0.051	0.051	0.047

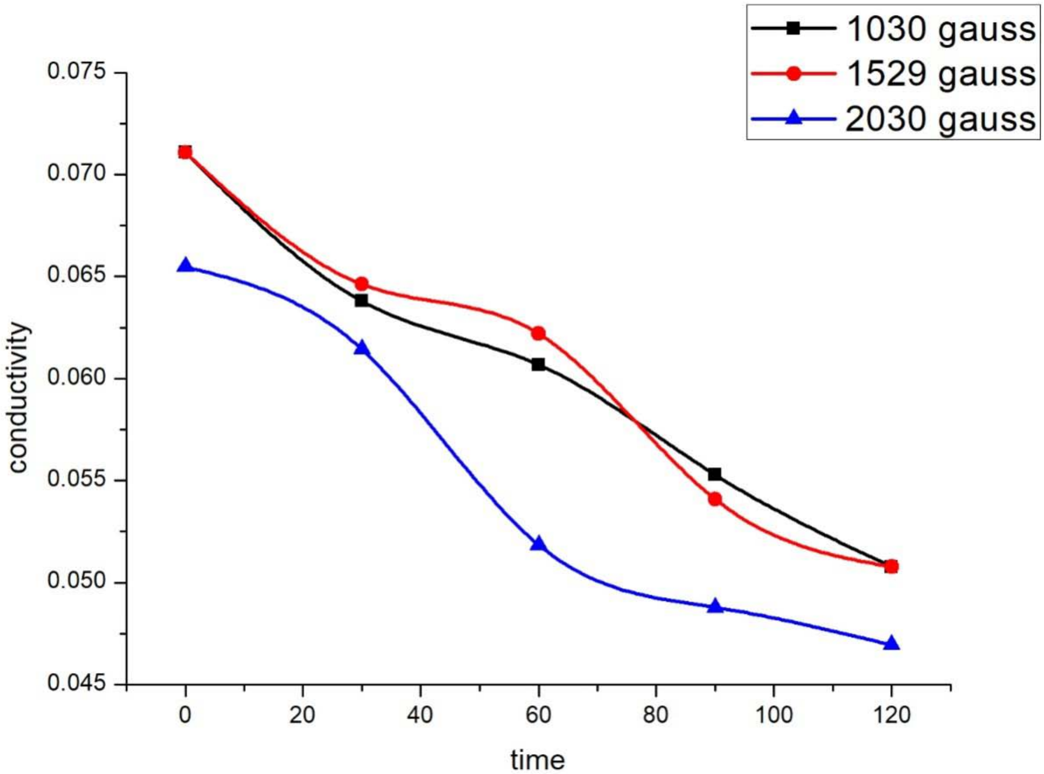

Fig. 13: Variation of conductivity with the magnetic field using tap water mixed with sugar

g) The brief summary of properties

S.No.	Type of Water	Surface Tension	Conductivity
1.	Normal tab Water	Increases	Increases
2.	Water mixed with salt (concentration 0.1 gram/ml)	Increases	Increases slightly and become constant
3.	Water mixed with sugar (concentration 0.1 gram/ml)	Increases	Decreases

V. Conclusions

In this work, it is found that the surface tension and conductivity of water changes in the magnetic field with time and for more time the effect is also more. Hence, we can change these properties of water using the magnetic field and thus magnetized water then can be used for any useful applications. The different findings of present investigations can be summarized as:

- After magnetization, the surface tension of tap water, water mixed with salt and water mixed with sugar has increased, this shows that the role of magnetization in water surface tension is working through water molecules. However, to the conclusion, we cannot rule out the effect of impurity atoms and the ion which still needs to be discussed in the further experiment.
- Surface Tension of water is related to the intensity of the magnetic field applied, for low magnetic fields like ~1000 gauss there is the minimum increase in surface tension while at a high magnetic field like ~2000 gauss there is comparatively large increment.
- Conductivity also changes with magnetic fields, and this is also directly related with the intensity of magnetic field.
- If we mix some amount of salt or sugar there is a change in the result as the surface tension in increasing at a high rate with the magnetic field. In tab water the range of surface tension is small (from 72n/m – 74 n/m) but after mix, the salt and sugar the range is increased (from 72n/m- 80n/m)
- For water and with salt the conductivity is found to be increasing, but after mix, some amount of sugar in water the conductivity is found to be decreasing.

References Références Referencias

1. *Kai- Tai Chang and cheng-I Weng,* The Effect of an External Magnetic Field on the structure of liquid water using molecular Dynamics Simulation, Journal of applied physics, 043917(2006) 1-6.
2. *Y. Fujimura and Y. Iino*, Magnetic Field incrassates the surface tension of water international workshop on materials analysis and processing in magnetic fields, IOP publishing, Journal of physics: Conference series 156(2009) 012028
3. *Alkhazan, M.M.K., Saddiq, A.A.N*. The effect of magnetic field on the physical, chemical and microbiological properties of the lake water in Saudi Arabia. Journal of Evolutionary Biology Research. 2(2010) 1:7- 14.
4. *Craig Andrew McMahon*, Investigation of the quality of water treated by magnetic fields, B.Tech thesis, Faculty of Engineering and surveying, University of southern Queensland, (2009).
5. *Lin and J. Yotvat*, Exposure of Irrigation and drinking water to a magnetic field with controlled power and direction, Journal of Magnetism and Magnetic material, 83(1990) 525-526.
6. *L.P. Semikhina and V.F. Kiselev*, Effect of weak magnetic fields on the properties of water and Ice, UDC 541.67, (1996) 351-354.
7. *Sheng Yue, Paul Pilon and George Cavaedia's*, the influence of autocorrelation on the ability to detect trend in hydrological series, published online in Wiley Inter Science (www.interscience.wiley.com). DOI: 10.1002/hyp.1095.
8. *C. Jack Quinn*, Magnetic treatment of water prevents mineral build up, Project Engineer-superior Manufacturing Div., Magnatech corp, (1997) 47-53.
9. *Nan Su; Yeong-Hwa: and Wu: and Chung-Yo 2000,* Effect of magnetic water on engineering properties of concrete containing granulated blast furnace slag. Cement and Concrete Research, Department of Construction. National Yunlin University of Science and technology Section 3,123 University Road, Touliu 640, Taiwan.
10. *Pang, X.F. and B. Deng (2008),* Investigation of changes in properties of water under the action of a magnetic field, Science in china series. GPhysics Mechanics Astron. 51(2006) 1621-1632
11. *Evelyn J.L. Toledo, Teodorico C. Ramalho, Zuy M. Magriotis,* Influence of magnetic field on physical–chemical properties of the liquid water: insights from experimental and theoretical models, Journal of Molecular Structure 888 (2008) 409–415.
12. *HUO Zhong-feng, ZHAO Qian, ZHANG Ying-huac,* Experimental study on effects of magnetization on surface tension of water, Procedia Engineering 26 (2011) 501 – 505.