



# Design and Construction of Electrical Magnate to Study its Efficiency and the Optimum Parameters to Produce Alkaline Magnetic Water and Treating the Sea Water to be Suitable for Irrigation

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## Abstract

Electrical magnate was designed and constructed, the optimum Magnetic flux and the effect of time on the physical properties of the alkaline (magnetic water) produced from the bottled drinking water [the total dissolved solids (TDS) or the electrical conductivity, and pH] were studied, to simulate ZamZam water in Mekka Saudi Arabia. Also, the efficiency of magnetic field from this designed electrical magnate in decreasing the TDS of sea water (of 1500 ppm NaCl Content), to convert it to water suitable for irrigation (TDS<1000 ppm) was investigated in this work. The results show that the magnetic flux from our designed electrical magnate in the range of (0.013- 0.08) Tesla and 30 minutes magnetic treatment time is sufficient to produce alkaline water with pH similar to ZamZam water (pH from 7.85- 8). While 60 minutes of magnetic treatment results to higher values of pH and the maximum pH value of 8.9 is obtained when the magnetic flux is 0.026 Tesla. The investigation for reducing the TDS of water having 1500 ppm NaCl show that , the maximum decrease in TDS is took place when the magnetic flux is 0.013 Tesla (coil of 100 turn and 1.5 V) and the time for magnetic treatment is 30 minutes where the TDS of 1730 ppm reduced to 1290 ppm is obtained .The effect of magnetic treatment on the pH change of high NaCl content water give maximum pH value of 8.1 when the magnetic flux is 0.013 and 0.028 Tesla (the voltages is 1.5 & 3 V respectively and 100 turn coil) and the time period of magnetic treatment is 30 minutes. The trend of results agreed well with previous studies, where the magnetic treatment lead always to increase of pH, decrease in TDS and electrical conductivity

**Keywords:** *Electrical magnate, Magnetic water, alkaline water, Design of electrical magnate, TDS, pH, ZamZam water.*

## 1. Introduction

Magnetic water (MW) is the water which passed for a certain period of time through magnetic field [1]. MW is used in industry, agriculture and medical applications , in industry is used to prevent the scales from the inner tubes and in agriculture it is used to increase the flowering of the fruits [2]. In Medical applications, MW can be used to dissolve the stones in kidney and dissociating the salts of solid mass, it is also used to decrease the cholesterol and salts from arteries, decreasing the resistance of pumping the blood by the heart. In the broken bones the MW will increase the immigration of the calcium ions to the broken bones and

accelerating the joining of the bones.; Magnetic water increases the immunity cells in the body and helps to be a way from constipation. Open the appetite and regulate the working of bile. Drinking daily a cup of magnetic water will give the body with super animation and activating it [3].

Drinking alkaline water decrease the epidemics of our body. Water represent 70% of our body composition, so we should be well hydrated by water having beneficial minerals and which should be free from pollutants. Good water have the ability of purifying the blood and strengthen the immune system and to counter the effect of free radicals. It was proven that water have many health promoting properties[4].

The alkaline ionized water was made by splitting the filtered tap water into alkaline ionic water and acidic water. The first commercial ionizers for making alkaline water was available in Japan in 1958. The magnetic treatment for water was used long times ago and the first commercial device used was in Belgium in 1945[5].

Magnetic field will change many physical properties of water as pH, TDS and thus electrical conductivity, pH is normally increased and TDS is decreased and thus electrical conductivity. Magnetic field can be obtained from permanent or by electrical magnate. Hardness of water changes as the magnetic intensity changes[6].

In this study, the optimum magnetic field intensities generated by an electric magnate and the optimum time required to get the required increase of the pH and decrease of TDS and thus the electrical conductivity of the water were investigated. Also, the effect of number of turns of the magnetic coil on the change of pH, TDS and electrical conductivity properties of the treated water were investigated.

The water treatment with magnetic phenomena has been reported effectively in numerous instances [7]. Scale control from water by magnetic treatment is an increasing important role among chemical water conditioning methods. The use of magnetic field concentrated on permanent magnate [8]. Crystallization of sparingly soluble diamagnetic salts of weak acids such as phosphates and carbonates is accelerated by use of magnetic field [9].

Factors affecting the degree of water magnetizing are; force of magnetic field, quantity of water magnetized, and time of contact between the water and magnetic field [10].

When a current flows through a conductor, a magnetic field surrounds the conductor. The lines of magnetic field increases while the current flow increases. If a conductor is twisted in a coil, current will be generated when cutting the lines of magnetic field, when the number of turns of the coil is increased the magnetic field will be stronger, furthermore when the coil is wrapped around a piece of iron the current becomes stronger [11]. Traditionally most people judge the properties of water from the standpoint of pH, in other words water is acidic or alkaline.

The higher pH blood contains excess oxygen, the heart doesn't have to work so hard. Drinking alkaline ionized water is beneficial for any health complaint where there is excess tissue acidity and damage being caused by free radicals.

The list of specific diseases that have been connected with excess tissue acid waste and the damage done by harmful free radicals is extensive and includes the following:

- Cardiovascular disease including the building up of cholesterol deposits.
- High blood pressure Diabetes,
- Cancers,
- Hypothyroidism,
- Osteoporosis,
- Arthritis,
- Kidney problems,
- Gastro intestinal inflammation,
- Skin problems including eczema, Gout, Candida infections.

ZamZam water has healing effects. The Prophet Mohammed said: " Water of ZamZam is good for whatever purpose it has been drunk". Concentrations of minerals in ZamZam water and tap water is shown in table 1 [12].

**Table 1,**  
**Chemical analysis of ZamZam and Tap water (ppm).**

Mineral	ZamZam water	Tap water
Sodium	133	37.8
Calcium	96	75.2
Magnesium	38.88	6.8
Potassium	43.3	2.7
Bicarbonate	195.4	70.2
Chloride	163.3	73.3
Florid	0.72	0.28
Nitrate	124.8	2.6
Sulphate	124.0	107
TDS Alkaline	835	350

Most of the previous works relating production of magnetic and alkaline water used commercial magnetizers composed of permanent magnate [1,5,13], but in our study electrical magnate was designed and constructed, the optimum Magnetic flux and the effect of time on the physical properties of the alkaline (magnetic water) produced from the bottled drinking water [the total dissolved solids (TDS) or the electrical conductivity, and pH] were studied, to simulate ZamZam water in Mekka Saudi Arabia. Also, the efficiency of magnetic field from designed electrical magnate in decreasing the TDS of sea water (of 1500 ppm NaCl Content), to convert it to water suitable for irrigation (TDS<1000 ppm) was investigated in this work.

## 2. Theory

### 2.1. The Electromagnetic Field

The magnetic field from a wire carrying electrical current is a loop wraps the wire. The magnitude is decreased when increasing the distance from the wire. The magnitude of the magnetic field flux density (B) at a distance from a long straight wire carrying a current I is given by [14]:

$$B = \mu_0 I / 2\pi r \quad \dots(1)$$

where:

$\mu_0$  is the permeability of free space equal to  $(4\pi \times 10^{-7}) \text{ T}\cdot\text{m}/\text{Amp}$ ; T=tesla)

The field at the center of the *circular loop* of radius r carrying a current I is given by:

$$B = \mu_0 I / 2r \quad \dots(2)$$

For N loops aligned together to form a flat coil, the field is just multiplied by N such that:

$$B = \mu_0 NI / 2r \quad \dots(3)$$

If a number of current carrying loops are stacked on top of each other to form a cylinder or, equivalently, a single wire is wound into a tight spiral, the result is known as solenoid.

Magnetic water treatment device is permanent magnets or electromagnets that attached to water lines in order to condition it.

The amount of magnetic field in a coil is proportional to the current through the wire And multiplied by the number of turns of the coil (NI). [15].

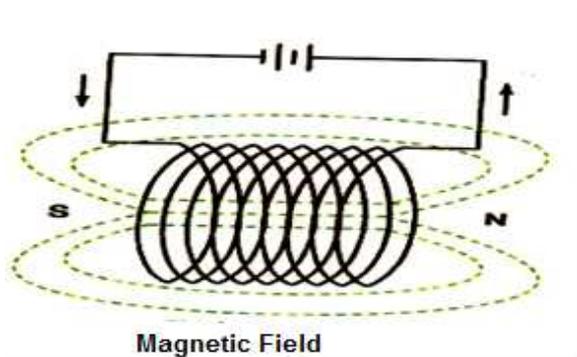


Fig. 1 The circuit of making electrical magnet.

Magnetic flux density 10,000 gauss (G)= 1tesla (T)

The field along the axis of the solenoid has a magnitude of:

$$B = \mu_0 nI \quad \dots(4)$$

where  $n = N/L$  is the number of turns per unit length [14].

B and H are related by the permeability:

$$B = \mu H [15] \quad \dots(5)$$

where H is the magnetic field strength.

Always the magnetic field is perpendicular to the direction of the current. The magnetic field generated from a loop of wire carrying a common amount of current is always weak magnetic field can be stronger with the same amount of current carrying in it by Increasing the number of turns and making a coil. [16]

### 2.2. Magnetic Flux

The unit of magnetic flux ( $\phi$ ) is Webber (wb). One Webber is equal to  $1 \times 10^8$  magnetic field lines ( $\text{Wb} = 10^8 \text{ Maxwell} = \text{tesla} \cdot \text{m}^2$ ).

The magnetic flux density is related to magnetic flux such that:

$$B = \phi / A \quad \dots(6)$$

B= magnetic flux density in Tesla (T)

$\Phi$ = magnetic flux in Webbers (Wb)

A= area in square meters ( $\text{m}^2$ )

where

The result is that in SI unit for flux density is Webbers per square meters ( $\text{Web}/\text{m}^2$ )

### 2.3. Magneto motive Force (mmf)

Is the strength of a magnetic field in a coil of wire.

$$F_m = \text{ampere} \cdot \text{turns} = NI \quad \dots(7)$$

### 2.4. Field Intensity

$$H = F_m / L = NI / L = At / m \quad \dots(8)$$

When the coil length decreased the intensity increased

### 2.5. Relative Permeability

$$\mu = \mu / \mu_0 \quad \dots(9)$$

$\mu$  = Straight or absolute permeability ( $\text{T}\cdot\text{m}/\text{Amp}$ .)

$\mu_0$  = Permeability of free space vacuum equal to  $(4\pi \cdot 10^{-7} \text{ T}\cdot\text{m}/\text{Amp})$ .

## 3. Experimental Work

### 3.1. Materials

Bottled water and water having 1500 ppm NaCl to simulate sea water are used. The instruments and details of materials used are as follows:

Drinking water (from bottles and water having 1500 ppm NaCl to simulate sea water).

Insulated Copper wire type S.W.G. 19 diameter of 1mm.

OVA meter for measuring voltage, electrical current and resistance.

pH meter Allafrance company with 0.1 resolution.

TDS & Electrical conductivity for water measurement device (EC/TDS/Temperature) Made by Hanna, H199301 in Romania , having 0.01 mS/cm resolution for EC and 0.01ppt(g/l) resolution for TDS.

DC batteries of 1.5 V type D and 9 V battery. Immersed water pump H=1.8m ,Q=1200L/H and power 20 W .

Rubber tubes.

Galvanized iron bush of 10 cm length.

Table 2 shows the physical properties of water used in this study for magnetic treatment.

**Table 2,  
Specifications of bottled drinking water and sea water.**

No.	Type of Water Used	pH	TDS ppm	Electrical Conductivity mS
1	Drinking water from bottles	6.6	180	0.37
2	Drinking water from bottles having 1500 ppm NaCl (Sea water)	7.53	1730	3.47

### 3.2. Design Calculations

The number of turns of the copper wire of 1 mm diameter and type SWG 19 is taken as 100 turns in this work.

The range of the magnetic flux density that will be used in producing magnetic water will be chosen such that:

$$B = \mu H \quad \dots(10)$$

where:

$\mu$ = absolute magnetic permeability

H: magnetic intensity At/m which is calculated as:

$$H = F/L \quad \dots(11)$$

where:

$$F = NI \quad \dots(12)$$

F: magnetic force At

N: Number of turns of coil

I: Current, Ampere

L: length of magnetic lines m

### Sample of Calculations

$$B = \mu H$$

$\mu_r = 5000$  for iron,

$\mu_0 = 4\pi \times 10^{-7}$  Absolute permeability

$$\mu_r = \mu / \mu_0$$

Assuming the magnetic flux needed is 0.01 Tesla

$$0.01 = 4\pi \times 10^{-7} \times 5000 \times H$$

$$H = 0.01 / 4\pi \times 10^{-7} \times 5000$$

$$H = 1.592 \text{ At/m}$$

$H = F/L = NI / L = 100 I / 0.1$  (in our design the length of magnetic field = 10 cm = 0.1 m)

$$I = 0.00159 \text{ A} = 1.59 \text{ mA.}$$

From Table 3

$$V = 1.5 \quad I = 2.1 \text{ mA} = 2.1 \times 10^{-3} \text{ A}$$

$$B = \mu_0 \cdot \mu_r \cdot N \cdot I / L = 4\pi \times 10^{-7} * 5000 * 100 * 2.1 \times 10^{-3} / 0.1$$

$$B = 0.013 \text{ Tesla}$$

Water is tested by the EC/TDS/ Temperature device manufactured by HANNA, H 199301 made in Romania.

### 3.3. Experimental Procedure

The experimental setup used for magnetic treatment to water in our study is as shown in Fig. 2 and Fig. 3.

Magnetic treatment are done on two types of water (Drinking bottled water to produce alkaline water similar to ZamZam water and bottled water having 1500 ppm NaCl to simulate sea water to make it suitable for irrigation purposes). Waters having (pH, TDS, Electrical conductivity) as given in table 1. The effectiveness of the designed magnetic treatment setup ,the optimum time and the optimum applied magnetic flux are investigated for getting the required change in pH which make the water of high alkaline suitable to health benefits and to make the sea water suitable for irrigation (Low TDS).

The physical properties of water passed through the electrical copper coil were tested every 30 minutes.

pH is tested by the portable pH meter made by Allafrance company .The TDS and the electrical conductivity of the water are tested by HANNA,H 199301 Romanian made.

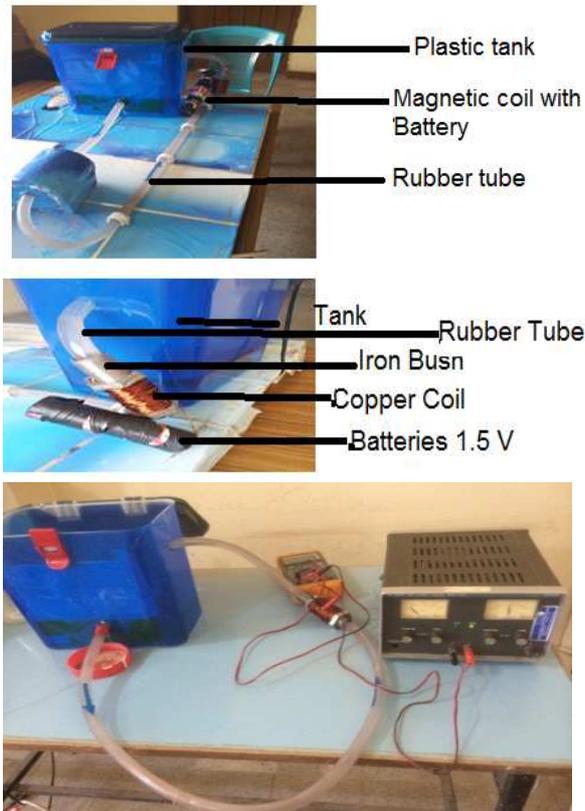


Fig. 2. Pictures showing the System Setup used in the magnetic treatment of water.

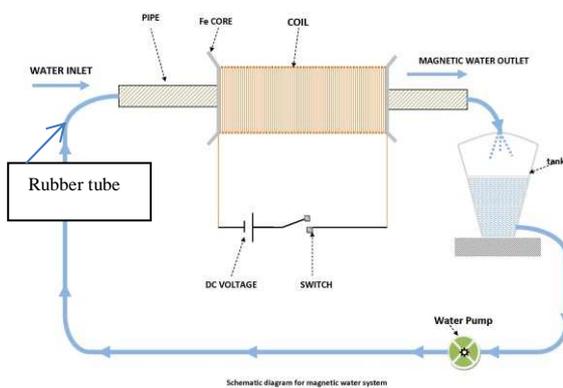


Fig. 3. Layout showing the System Setup used in the magnetic treatment of water (open circulation with a rate of circulation 1000-1200Lt/h).

Two liter of water is used in each test to fill a plastic tank containing the immersed pump (H=1.8m, Q=1200 Lt/hr.) as shown in Fig. 2 .

The designed copper magnetic coil having 100 turns around the galvanized iron bush surrounding the rubber tube circulating the water from the tank.

The circulation of water is continued for 120 minutes in each experiment and tests are made

every 30 minutes for the physical properties of pH, TDS and electrical conductivity.

The range of magnetic flux density applied is (0.013 – 0.08) Tesla as shown in Table 3 below. The different magnetic flux densities used is obtained by using different voltages applied to the copper coil which gives different electrical current and then different magnetic force around the copper coil in which the water is moving across it as shown in Table 1 to specify the optimum magnetic flux

The copper coil wounded around galvanized iron bush of 10 cm length, of 2 cm inside diameter.

Ampere meter is used to measure the real electrical current passing through the copper coil and to be sure that the connections for the circuit is good.

One DC battery of 1.5 V type D is used as power supply of 1.5 V and multiple 1.5 V batteries are used as power supply of (3, 4.5, 6 V) potential voltage. while one DC battery type of 9 V is used as 9 V power supply to get the required current in the copper coil.

Table 3, Amount of magnetic flux generated with our designed electrical magnate of 100 turns according to Voltage applied.

Power supply(V) volt	Current (I) mA	Magnetic flux of electrical magnate of 100 turn( B ) Tesla
1.5	2.1	0.013
3	4.5	0.028
4.5	6.4	0.04
6	8.5	0.056
9	12.8	0.08

#### 4. Results

Figure 4 show the change of pH of drinking bottled water vs. time when magnetically treated. Fig. 3 shows that, the treatment of drinking water whose specifications are given in Table 2 with magnetic flux generated from a copper coil of 100 turns, diameter of copper wire is 1mm and using magnetic flux of range (0.013-0.08) Tesla. Results to an increase of pH and this is in compatible with researches related to this subject [1].

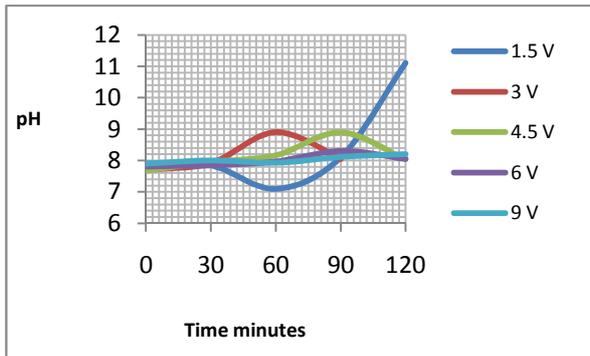


Fig. 4. The relationship of pH vs. time for magnetic treatment of bottled drinking water using different voltages potentials (magnetic flux densities).

Regarding the electrical conductivity (EC) & the total dissolved solids (TDS) physical properties of water having 1500 ppm NaCl (sea water) and magnetically treated, Figures (5,6) show that the optimum voltages were 1.5 & 4.5 Volts (0.013 & 0.04 Tesla respectively) to decrease the value of TDS and then the Electrical conductivity of bottled drinking water. The minimum values reached for the TDS are 1290 ppm with magnetic flux of 0.013 Tesla and 1360 ppm with magnetic flux of 0.04 Tesla. The minimum value of electrical conductivity which is 2.61 mS is reached with magnetic flux of 0.013 Tesla. The period for magnetic treatment enough to achieve the above minimum values is 30 minutes only.

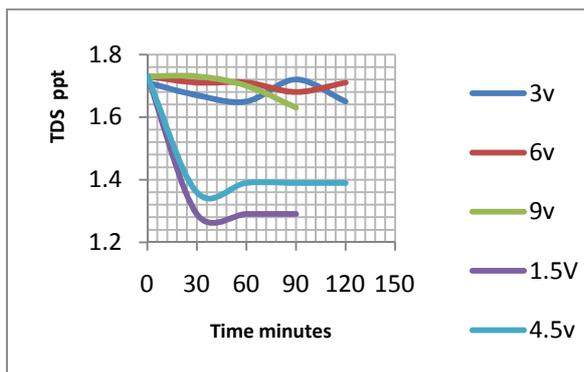


Fig. 5. Effect of different voltages on the variation of TDS for treated sea water(1500 ppm NaCl) .

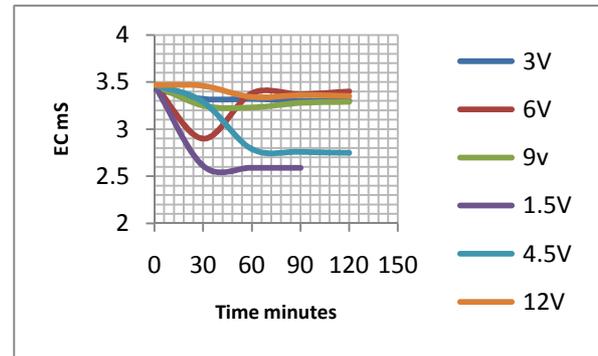


Fig. 6. Effect of different voltages on the variation of electrical conductivity for treated sea water (1500 ppm NaCl).

Figure 7 show the results of pH change of sea water (having 1500 ppm NaCl) when was treated with magnetic fluxes in the range of (0.013 – 0.08) Tesla. It can be noticed that at 30 minutes of magnetic treatment the maximum pH reached to 8.1 value when the magnetic flux is 0.013 Tesla (13mT). When the magnetic treatment 60 minutes, pH reached a value of 8.4 with 0.056 Tesla (56mT) magnetic flux.

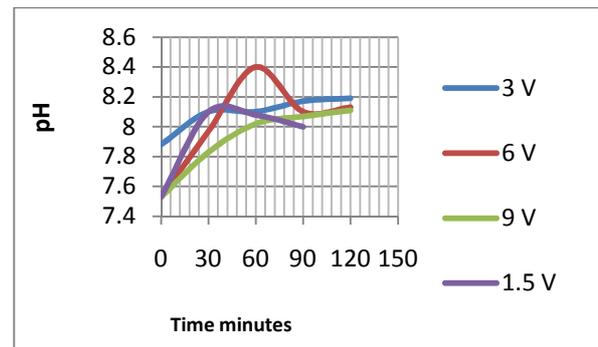


Fig. 7. Effect of different voltages on the variation of pH of treated sea water (1500ppm NaCl) .

### 5. Conclusions

According to the discussion of the obtained results , the conclusions extracted are as follows:

- Using copper wire of SWG 19 with 100 turns and potential DC voltages in the range (1.5,3,4.5,6,9) V is good for producing magnetic flux suitable for producing magnetic water and the capacity of production magnetic water during 30 minutes is two liters because our tank is of two liters , Studies can be done on large tanks with large circulation rate water pumps.
- The magnetic treatment for sea water with (1500 ppm NaCl) by our designed electrical magnate

is successful for decreasing the Total dissolved salts (TDS) and hence the electrical conductivity, Also it is successful in increasing the pH for water which is desirable in using alkaline water for health ,irrigation , industrial and medical sectors.

- Increasing the magnetic flux by increasing the potential voltage applied will result to increase the time required to reach the required pH or may be resulting to inverse results (decrease in pH) , for example in our study we noticed that increasing the potential from 3 to 4.5 V a time required to get the pH of about 8.9 increased from 60 to 90 minutes , So a study should be done for every actual case to determine the optimum magnetic flux density and the time required to get the desired alkaline pH of water.
- pH value of drinking water of 8.1 and 8.9 can be get easily by our designed electrical magnate with a magnetic treatment period of 60 minutes only and the magnetic flux density in the range of (0.013 – 0.08 ) Tesla is very good for this job.

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## تصميم وإنشاء مغناطيس كهربائي لتحديد كفاءته ودراسة الشروط المثلى لاستخدامه في إنتاج الماء القاعدي و الماء المغناطيسي ومعاملة مياه البحر لجعلها صالحة للسقي

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### الخلاصة

تم تصميم وإنشاء مغناطيس كهربائي وتم دراسة كثافة الفيض المغناطيسي الأمثل وتأثير الزمن على الخواص الفيزيائية للماء المغناطيسي القاعدي المنتج (المواد الصلبة الذائبة الكلية (TDS) أو التوصيل الكهربائي والذالة الحامضية (pH)) من ماء الشرب المعبأ. تم إجراء هذا العمل من أجل مشابهة الماء المنتج مع مواصفة ماء زمزم في مكة المكرمة في العربية السعودية. كذلك تم دراسة كفاءة الفيض المغناطيسي المنتج من المغناطيس الكهربائي المصمم من قبلنا في تقليل كمية الاملاح الذائبة الكلية (TDS) الموجودة في مياه البحر (ماء غير صالح للاستخدام في مياه السقي،  $TDS > 1500$ ) وجعله صالحاً للسقي ( $TDS < 1000ppm$ ). أظهرت نتائج البحث بأن كثافة فيض مغناطيسي منتج من المغناطيس الكهربائي العائد لنا ضمن مدى (0.013-0.08) تسلا ملائمة لإنتاج ماء قاعدي مشابه لمواصفة ماء زمزم من ناحية الذالة الحامضية (7.85-8) وضمن فترة 30 دقيقة بينما تكون فترة المعاملة المغناطيسية للماء 60 دقيقة نحصل على أعظم ذالة حامضية مقدارها 8.9 عندما يكون كثافة الفيض المغناطيسي تساوي 0.028 تسلا. كما أظهرت النتائج الخاصة بتقليل نسبة المواد الذائبة الكلية TDS من الماء الحاوي على نسبة عالية من ملح كلوريد الصوديوم بنسبة عالية 1500ppm ، أن أعظم انخفاض الى كمية TDS حدث عند استخدام كثافة فيض مغناطيسي مقداره 0.013 تسلا (فولتية مقدارها 1.5 فولت وعدد لفات مقدارها 100 لفة ) حيث انخفضت كمية TDS من 1730 ppm إلى 1290 ppm وبالنسبة لتغير الذالة الحامضية للماء الحاوي على 1500ppm من ملح كلوريد الصوديوم فقد ارتفعت الذالة الحامضية pH إلى 8.1 كحد أقصى عند استخدام كثافة فيض مغناطيسي مقداره 0.013 و 0.028 تسلا (فولتية 1.5 و 3 فولت على التوالي وملف يتكون من 100 لفة ) وزمن معالجة مقداره 30 دقيقة. كما كانت النتائج العامة متفقة مع جميع التقارير الموثقة في الأدبيات العلمية السابقة المتعلقة بالموضوع حيث ان معاملة الماء بالفيض المغناطيسي تؤدي دائماً الى زيادة الذالة الحامضية وانخفاض الاملاح الذائبة الكلية TDS والتوصيل الكهربائي .