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Reducing the Water Hardness by Using Electromagnetic Polarization Method

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Abstract

Hard water does not pose a threat to human health but may cause precipitation of soap or results stone in the boilers. These reactions are caused by the high concentrations of Ca and Mg. In the industry they are undesirable because of higher fuel consumption for industrial use .Electromagnetic polarization water treatment is a method which can be used for increasing the precipitation of Ca^{2+} and CO_3^{2-} ions in hard water to form $CaCO_3$ which leads to decrease the water hardness is research has been conducted by changing the number of coil turns and voltage of the system. The spectroscopy electron microscope was used for imaging the produced crystals. Results of the investigation indicated that the electromagnetic polarization can be used in precipitation to decrease the hardness of water due to increase in the precipitation percent of $CaCO_3$.

Keywords *: Electromagnetic polarization, water hardness,$CaCO_3$.*

1. Introduction

Water hardness is a measure of the capacity of water to its reaction with soap. Hard water causes more soap foaming. The reason for this is not a single substance, but a diverse dissolved polyvalent metal ions, mainly cautions of calcium, and magnesium, although much less contributing and other cautions, e.g., barium, iron, manganese, strontium and zinc.

Hardness is usually expressed in mg /L $CaCO_3$, the German, French and English Degrees of hardness are expressed as follows :

1. German hardness = 10 mg CaO in 1 liter of water
2. French degree of hardness = 10 mg $CaCO_3$ in liter of water
3. English hardness = 10 mg $CaCO_3$ in 0.7 liters of water.

Because the distribution of the earth's crust, magnesium is present in natural waters, where together with calcium makes total hardness of water. The concentrations of **Mg** ions are particularly high in the area dominated by dolomite rocks. This is the case of ground water in the vicinity of Tikrit university. In this area, natural waters are characterized by a high content of magnesium, whose concentration can be up to 200 mg / dm^3, which makes them unfavorable for use in the public water supply, since the maximum concentration of magnesium in drinking water according to current regulations is limited to 50 mg / dm^3 [1].

In the experiments presented in this paper the reduction of the concentration of magnesium in the water that flows into an abandoned mine shaft "undermine" is discussed. This water has shown a stable composition and a negligible presence of microorganisms, and as such has been introduced in the water supply system in the vicinity of Tikrit city . The only drawback is the high content of magnesium, which ranges up to 100 mg / dm^3. However, as the river water has variable composition, that is, it often causes reduction the quality of raw water, thereby the consumption of

large amounts of coagulants and flocculants to ensure its physical and chemical safety is increased[3]. The total solute (Total Dissolved Solids) of inorganic salts are dissolved in water with. Unit of milligram per liter (mg / l). The majority of salts consisting of cautions of calcium, magnesium, sodium and potassium, and anions are carbonate, bicarbonate, chloride, sulfate and nitrate. The dissolved substance introduced can affect its taste. On the basis of the measured values the palatability of the drinking water is evaluated. Table (1) shows some parameters of water [4].

Table 1,
parameters of water hardness.

Water	mg / L $CaCO_3$	German degrees° d
Soft	<71.4	<4
Easy hard	71.4 to 142.8	4 -8
Moderately hard	142.8 to 321.4	8 -18
Hard	321.4 to 535.7	18 -30
Very hard	> 535.7	> 30

1.1. Background

Water is essential raw material for industrial production, energy, food industry for communal needs and more. Most requirements for water purity set the food industry (beer, juices) and municipal systems to supply drinking water to citizens. Therefore of great importance all processes for treating raw water which must be removed, suspended solid, organic and inorganic chemical compounds, bacteria and chemicals which gives a bad taste and odor. Due to the high prices of raw water treatment, appropriate technologies must be combined as best way to establish a balance between the price and the resulting water quality. The processes to treat and recover raw water is the use of electromagnetic field. Hydrate ion interaction forces can be influenced by mechanical agitation, temperature, concentration ion and electromagnetic fields. Electromagnet field can weaken the ion and water molecules and increase the collision between the Ca^{2+} and CO_3^{2-} ions, thus accelerating the rate of nucleation and precipitation of $CaCO_3$[5] .

The chemical features of groundwater depende on the type and amount of dissolved mineral substances. Measure the intensity of the melting of rocks in the process, ie corrosion, is hardness water. Increased hardness is a sign of intense corrosion and vice versa. Determined in forming calcium and magnesium ions in water. Total hardness shapes all the calcium and magnesium salts in water[6].

Carbonate hardness make hydrogen carbonates and carbonates of calcium and magnesium. The calcium and magnesium hardness values and relationship depend on the composition of the rocks through which water flows. Groundwater generally is stiffer than surface water. The concentration of minerals in groundwater increases with length of detention or the flow of water through underground cavities[7].

Some studies about the water reported that Water hardness can be divided into:

- carbonate hardness, comes from **Ca** and **Mg** ions in the form of bicarbonate
- Non-carbonate hardness, comes from **Ca** and **Mg** ions in the form of sulphates, chlorides and nitrates.
- Boiling water bicarbonates is converted into carbonates, which are insoluble in What disappears carbonate hardness, left non-carbonate (permanent) hardness.
- The waters are classified into four levels of hardness, if hardness is expressed in mg / L CaCO3 [8].

2. Methodology

The principle of this method is to provide an electromagnetic field with certain frequencies in the hard water that flows through a coil with a certain winding number that can promote the process of precipitation of $CaCO_3$.

This creates small seed crystals in water in the form of very small particles of calcium carbonate prior to entry of the water zone at high temperature. Calcium carbonate adheres to the surface of these very small particles and grow in size. These larger particles tend to be removed by the flow . Faraday law associated with Lenz's law states that the electric field is induced in the magnetic coil when the magnetic field changes with time. The magnetic field is proportional to the current in the coil winding when current changes in coils; the alternating magnetic field is an electric field resisting these changes. This induced AC voltage is high on the side of inspection and tube coil decreases to nothing at the tube coil shows ionic configuration of particles in a magnetic field .Pipe center coil and the coil shown in Figure (1).

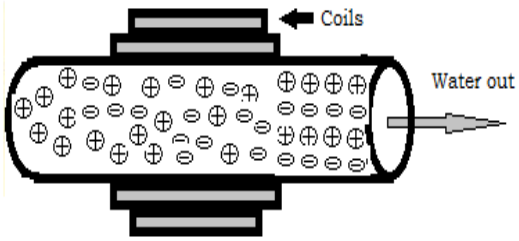

Fig. 1. Configuration of ionic particles in a magnetic field.

The carbonate ions CO_3^{-2} will react with calcium ions Ca^{+2} ,and the result will produce some precipitation and crystallization of calcium carbonate .as illustrated in equation number (1) [9] :

$$Ca^{+2} + CO_3^{-2} \rightarrow CaCO_3 \quad \ldots(1)$$

2.1. Experimental Work

Treatment Process had been conducted by mixing the prepared solution (50 ml) for about 10 minutes with rate of (19.02 ml /s) ,the solution temperature equals to the room temperature (25 ^{o} C) as follows:

1. EWT system used consisted of copper pipe wrapped with copper wire and Power supply as shown in figure (1) . Sample of hard water is circulated through the electromagnet field using silicon tube (ID 6 mm) and peristaltic pump as shown in Figure (2).

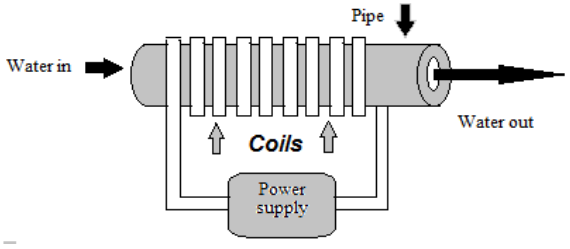

Fig. 2. Schematic of electromagnet Equipment.

2. After the EWT treatment, solution in the reservoir tube again was introduced to the testing process to measure the content of Ca^{+2} ions contained in the solution and to examine the type and number of crystals formed.

3. The average values of $CaCO_3$ concentration for the two cases ,before and after electromagnetic field water treatment were cpmpared .

3. Results and Discussion

A- Figure (3) shows the effect of voltage changing on the precipitation of $CaCO_3$. An increasing in the applied voltage will cause some increasing in the precipitation percent of $CaCO_3$. Any increasing in the voltage will cause some increasing in the current through the solenoid coil on EWT tool. This will increase the induction of electromagnetic fields on water according to Faraday's law. As a result the increased induction of electromagnetic fields will improve the effectiveness and impact energy between the ions of Ca^{+2} and CO_3^{-2} in solution so that the rate of precipitation of $CaCO_3$ increases. Results of changing the voltage source are shown in table (2) and the graphical representation is shown in Figure (3).

Table 2,
Applied voltage vs. percentage of $CaCO_3$ precipitation .

Voltage (v)	$CaCO_3$ Precipitation %
1	14
2	15
3	17
4	19
5	20
6	22
7	24
8	27
9	28
10	13
11	33
12	35

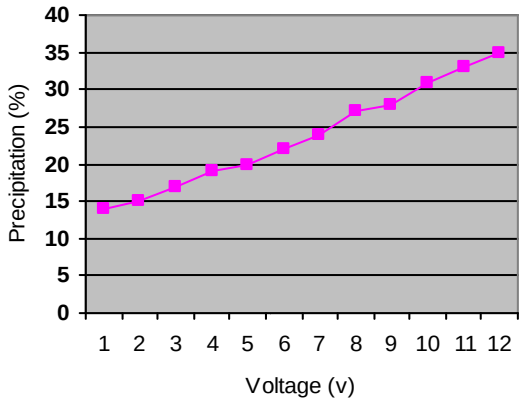

Fig. 3. Effect of voltage source changing on precipitation of CaCO3 .

B- From figures (4,5) it can be seen that the precipitation of $CaCO_3$ is increased when voltage is duplicated .

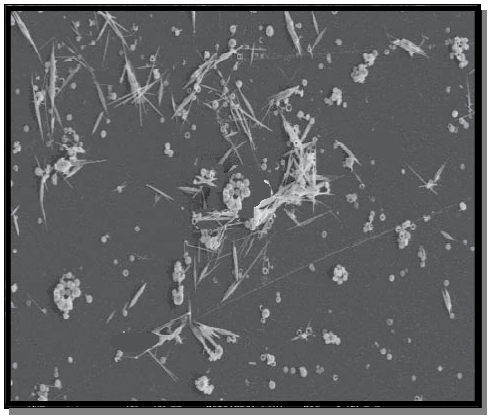

Fig. 4. (A) : Precipitation of CaCO3 when voltage source of (6 V).

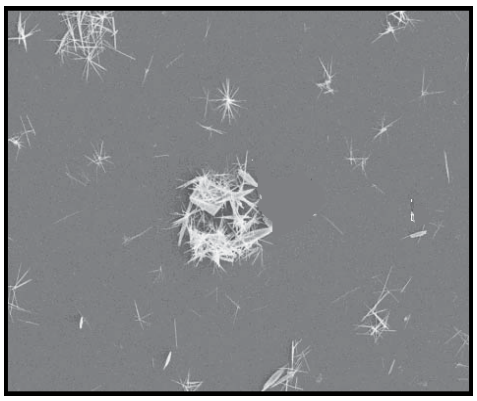

Fig . 5. Precipitation of CaCO3 when voltage source of (12 V).

C- Results of changing the turns number are shown in table (3) and the graphical representation is shown in Figure(6).

Table 3,
Number of turns vs. Percentage of CaCO3 precipitation.

Number of turns	$CaCO_3$ Precipitation %
50	24
100	32
150	35
200	39
250	43

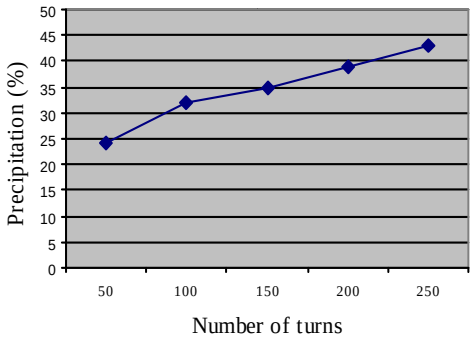

Fig. 6. Effect of changing the number of turns on the precipitation of CaCO3 .

D - The greater the number of turns are used, the larger electromagnetic fields induced received by the water hardness in the coil. This has an impact on increasing the effectiveness of collisions between Ca^{2+} and CO_3^{2-} ions thereby increasing the precipitation of $CaCO_3$ .Figures (7,8) shows the increasing percent of the precipitation of $CaCO_3$ with increasing the number of turns.

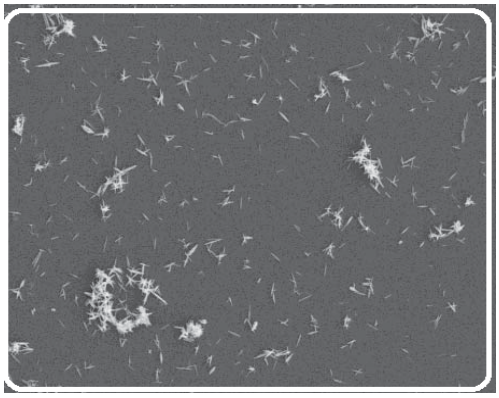

Fig. 7. Precipitation of CaCO3 when coil with 100 turns.

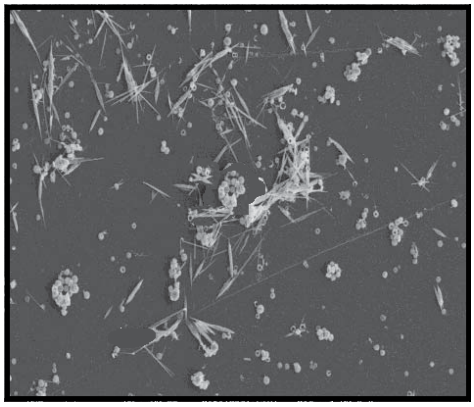

Fig. 8. Precipitation of $CaCO_3$ when coil with 250 turns

4. Conclusion

Depending on where the rain falls, the water remains naturally soft, or becomes contaminated with various contaminants. Water is the best solvent, and as it passes through the soil it, collects various pollution. No method for purifying water can produce laboratory water cleaned of all contaminants. Only a combination of effective and economical method can produce satisfactory laboratory water quality. For high efficiency treatment water is used in combination of several methods .Results showed that the electromagnet field affected an increase in the precipitation amount of $CaCO_3$ up to 34% compared to non electromagnetic fields. Increasing the voltage, the number of turns of coil causes an increase in precipitation $CaCO_3$. Increasing the electromagnetic field levels caused the $CaCO_3$ particle to unit with each other to form larger groups .The benefit of this method is in the reduction or elimination of chemical additives method.

5. References

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تقليل عسرة المياه بطريقة الاستقطاب الكهرومغناطيسي

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الخلاصة

الماء العسر قد لا يشكل خطرا على صحة الإنسان ولكنه قد يسبب ترسب الصابون أو تكلس كتل حجرية في سخانات المياه والتي تنتج نتيجة التفاعلات الكيمياوية بين الكالسيوم والمغنيسيوم ذات التراكيز العالي اما في هذه الصناعة فيعد غير مقبول للاستخدام الصناعي.ان معالجة عسرةالماء هي العملية التي يتم إجراؤها لجعل المياه أكثر صلاحية للاستخدام . إن معالجة عسرةالماء بطريقة الاستقطاب الكهرومغناطيسي هي الطريقة التي يتم فيها زيادة ترسيب أو اختزال ايونات الكالسيوم الموجبة Ca^{2+} وايونات الكربونات السالبة CO_3^{2-} في المياه العسرة لتكوين حبيبات $CaCO_3$ مما ينتج عنه زيادة تنقية الماء العسر وجعله أكثر ملائمة للاستخدام. تم إجراء البحث بطريقتين : الأولى بتغيير عدد لفات الملف والطريقة الثانية هي بتغيير الجهد المسلط .تم استخدام الميكروسكوب لتصوير الحبيبات الناتجة ودراستها قبل وبعد زيادة الجهد الكهربائي المسلط وقبل وبعد تغيير عدد لفات الملف حول الأنبوب . النتائج الحاصلة أثبتت فاعلية الاستقطاب الكهرومغناطيسي في زيادة نسبة ترسيب وبلورة حبيبات أل $CaCO_3$.