



ASSESSMENT OF APPLICATIONS OF SOME TECHNIQUES FOR TREATMENT OF SULFUR SPRINGS WATER

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ABSTRACT

The study aim to treating the sulfur water by using the Magnetic technique and Nanotechnology by studying the physical and chemical characteristics before and after the treatment of the sulfuric water. It was concluded that the physical characteristics were changed in both techniques, as the water color changed from yellow to transparent and their bad smell converted to odorless. Where after treatment by Magnetic technique some chemical properties changed as; the (PH) value changed varyingly from (6, 6.5, 9) to (7.1, 7.4, 8.4) after treatment. The (Ec) decreased from (1721, 1414, 871 ppm) to (17, 15.8, 9 ppm) after treatment, and the values of Total Dissolved Solids (T.D.S) increased from (3.5×10^3 , 2.8×10^3 , 1.7×10^3 ppm) to (3.8×10^3 , 3.1×10^3 , 1.8×10^3 ppm) after treatment due to the effectiveness of the treatment in increasing the solubility of water contents, and the values of sulfate (SO_4^{2-}) decreased from (1392, 945, 947 ppm) to (144, 101, 33 ppm) after treatment due to its decomposition into hydrogen sulfide gas and its volatilization in the atmosphere, which caused the emission of an unpleasant odor in the laboratory, these results are clear as in the Tables (1,2). And the nanotechnology treatment of Coal powder by laboratory tests showed in the chemical properties where the (PH) value changed unevenly (6, 6.5, 9) to (7.3, 7.5, 8) after treatment, while the (Ec), which increased from (1721, 1414, 871 ppm) to (1755, 1427, 901 ppm) after treatment, and (T.D.S) showed a significant increase from (3.5×10^3 , 2.8×10^3 , 1.7×10^3 ppm) to (3.7×10^3 , 3.0×10^3 , 1.8×10^3 ppm) after treatment, while the values of sulfate (SO_4^{2-}) decreased greatly from (1392, 945, 947 ppm) to (525, 410, 150 ppm) after treatment, as in Tables (1,3). And the Nanotechnology treatment with the powder of sugarcane plant, the (PH) values showed a varying change from (6, 6.5, 9) to (7, 7.1, 7.4) after treatment, and the (Ec) from (1721, 1414, 871 ppm) to (1727, 1426 and 880 ppm) after treatment, while the (T.D.S) showed a slight increase from (3.5×10^3 , 2.8×10^3 , 1.7×10^3 ppm) to (3.5×10^3 , 2.9×10^3 , 1.8×10^3 ppm) after treatment, the values of sulfate (SO_4^{2-}) decreased from (1392, 945, 947 ppm) to (1200, 756, 211 ppm) after treatment as in Tables (1,4). We concluded from the research the necessity of conducting treatments for sulfuric water by using Magnetic technology, because the flows of treated water towards the river contributes to the enrichment of surface water, also investment of treated water in some uses, especially in agricultural irrigation.

Keywords: Sulfur water, Magnetic Technique, Nanotechnology, Sulfur springs, Iraq.

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INTRODUCTION

Water resources are one of the elements of the biosphere components, interacting with life and economic and social development, that achieving water security means achieving food security. Iraq is located in semi-arid area . Iraq's water resources suffer from many threats and a lot of damages , especially from neighboring countries such as Iran, Turkey and Syria, by building dams on the sources of rivers, which reflected on the drying of the marshes , that negatively affected on the biosphere, Water scarcity and pollution in Iraq is one of the most important environmental problems because it is related by the sustainability of human life, agriculture and biodiversity, as there is no life without water. The problem of water scarcity and the deterioration of its quality has emerged as a result of population growth, climatic changes, human activity, lack of rationalization of the consumption of water resources and technological progress, which caused a shortage and pollution in the water resources, which exist in two cases; as conventional water and desalinated water (treated water) , finally, the wastewater is considered one of the increasing water resources with the growth populations and human progress, unlike traditional water resources, which are often limited which are exposed to a state of depletion and pollution. The increased demand for water, especially in arid and semi-arid areas such as Iraq, poses a great danger to all aspects of development. Water resources suffer from many physical, chemical and biological changes, and these changes occur due to water pollution, from the sources of pollution the flow of sulfur springs water towards rivers and industrial pollution because the majority of industries are built on the banks of rivers, and industrial, health and agricultural wastewater flows into river basins, and there are no partial or total treatment units. The quality of springs water is bad by the result of high sulfur and salinity ,the reason of these components according to geological nature of region ,which to be formed from existence of thick layers from gypsum for sulfate rocks and clay stone. These stones be plays important role in limiting the quality of groundwater ,yet the reason of high sulfur concentration in these springs belong to the ecological and geological factors to existence sulfates rock in many forms as; Calcium sulfates, gypsum ,Calcium carbonate and Magnesium carbonate , therefore , not suitable for drinking and agricultural irrigation due to high temperature and bad taste to its containing of high Total Dissolved Solid(TDS) which gives for water bitter taste and bad smell ,so it require treatment [1] .As well as the loss of optimal and efficient use of water in agriculture, which is the most water consuming sector, up to 80%, which requires rationalization of water consumption by using sprinkler and drip irrigation systems, and the treatment of sulfur water, as well as the recycling of domestic and industrial wastewater and its use in the agricultural field, relieves the burden on freshwater resources. Sulfur water contains solids, dissolved gases and suspended solids, and the quality and quantity of these components depend on various factors, including biological and environmental, which are subject to changes as a result of the interaction of water with its surroundings that is in direct contact with it . The classification and evaluation of this water depend on the concentrations of the chemical components, based on which this water is classified, such as sulfur content, salinity, pH and alkalinity. And the treatment of sulfur water resources has become a necessary objective to raise the production and development efficiency of water resources in Iraq [2].Sulfuric water is water that contains a high amount of sulfate ion (SO_4^{-2}) . In Iraq the sulfuric is considered one of the polluted water resources due to the high content of sulfate more than the permissible rate (200-400 ppm) on the international scale, which reaches nearly (1000 ppm) in sulfur springs. which is emitted into the air in the form of hydrogen sulfide

gas (H₂S) leaving an unpleasant odor like the smell of rotten eggs [3]. One of the most important areas where sulfur water is found in the Nineveh Governorate in Iraq is the Mosul Dam project area and the Ainkebrit area in old Mosul and Hammam Al-alil district south of Mosul (The center of Nineveh Governorate). The sulfur water is a mineral water that flows through springs from inside the earth, which is characterized by a high temperature, which has medical importance. It helps heal wounds that affect the skin, sterilizes the body from harmful bacteria and germs, and relaxes muscles and is comfortable for the tired body. The sulfur content of these springs varies, but all spring water contains different amounts of sulfate [4]. The need to take advantage of sulfur water with high sulfur content and to fully invest for its water for irrigation purposes requires treating it and reducing the concentration of mineral salts in it, especially the sulfur content within the appropriate level for irrigation. Magnetic technology is a simplified attempt to completely imitate what happens in nature because when water passes through the natural magnetic field, it becomes more vital and active. It is true at the time that the shape of these charges is random in ordinary and polluted water. The magnetic treatment of water does not magnetize water. When exposed to a strong magnetic field, water is not like a magnetic material. However as is the case with all liquids it possesses the properties of diamagnetic materials when exposed to a magnetic field, that water will produce a weak magnetic field in the opposite direction. Therefore, modified water, conditioned water, or magnetically treated water is the correct expression [5]. Nanotechnology (micro materials technology), is one of the modern technologies that still needs a lot of research and studies. The origin of word "Nano" is derived from the Greek word (Nanos - means dwarf and means everything that) and Nano is the technology of Nanomaterial's and Nanoscience is the study of the basic principles of molecules and compounds whose size does not exceed (100 Nanometers) and Nanometers is a unit of measurement equal to (1×10^{-9}) of a meter. The principle of this technique depends on capturing the infinitesimal atoms of any material, manipulating them, moving them from their original positions to other positions, and then merging them with atoms of other materials to form a crystal mesh to obtain Nano-dimensional materials with distinct properties of high performance [6]. The attempts made in previous studies to invest sulfuric water after treating it using modern technologies are few but rather rare, and the information about benefiting from it for irrigation purposes is not available enough to rely on it, so the current research was chosen to enhance that information. Where it was found in the study of the efficiency of using Technology magnetic treatment for the industrial waste water of the spinning and weaving factories in Mosul and the Nineveh tanning factory before it was thrown into the Tigris River basin in the city of Mosul. Among the scientific recommendations for a panel discussion prepared by the Nineveh Agriculture Directorate in mid-2011 in cooperation and coordination with the University of Mosul and the General Al-Kindi Company affiliated with the Ministry of Industry and Minerals, where the company established, with Iraqi innovations and efforts, a system to remove sulfur from the water of wells installed in the Al-Quseyat area. (North of the city of Mosul), where this unit contributes to obtaining water suitable for irrigation because the water of the area contains high levels of sulfur which may reach 600 mg/liter), which is toxic and not suitable for all uses. It was also found utilizing the technique of Nanotechnology by using charcoal extracted from palm for treating sulfur water as cheap materials with low economic costs and simple techniques in the area of Hit (Ramadi, western Iraq) located on the Euphrates River, where the results of the study proved a high efficiency in the disposal of sulfur ion and improving some physical and chemical properties of water after treatment [7,8]. That found the efficiency of removing sulfate ions from sulfur springs water reached 99% which is confirmed by comparison with concentrations before treatment [9].

MATERIALS AND METHOD

This research was conducted in Mosul city in Nineveh province of Iraq at the Technical Institute in Department of Water Resources, where three areas of the city of Mosul were selected that containing sulfur water, which is located; the first (A) in the Mosul Dam area, the second (B) in the Ainkebrit area more center of Mosul city), and the third (C) in Hammam Al-alil area, samples

were taken at a rate of (20) liters from each area has been kept at a temperature of 25°C. The water samples of the three types (A, B, C) were analyzed by laboratory tests for physical and chemical properties, from the physical properties that have been studied are Electrical conductivity (EC) by using Electrical conductivity meter, PH value by using Philips-pPW9421 meter, Total dissolved solids (T.D.S) and Sulfate (SO_4^{-2}), which was estimated by the gravimetric method with ignition of residue).The following is a description of the devices, equipment and materials used:

- a. The magnetic device: which has three magnetic poles that give (1000, 2000, and 3000 gauss) respectively, and these poles are connected through a network of metal tubes that close and open by means of taps so that each pole can be operated alone. And for the purpose of passing water for magnetization, it is placed in a basin, and in this basin, a suitable water pump with plastic tubes is placed in a way that allows the water to pass through a closed circuit during the duration of the experiment.
- b. Mechanical mixer : used to mix Nanomaterial.
- c. Charcoal powder: Ordinary Charcoal that has been crushed into a very fine powder.
- d. The powder of sugarcane plant : has been crushed into a very fine powder.
- e. The practical experiments were carried out in the following manner:
Coding the samples before starting the processing , after taking sulfur water samples from the three areas, those samples were coded by giving the symbol (A) for the Mosul Dam project area, the symbol (B) for the Ainkebrit area, and the symbol (C) for the Hammam Al-alil area, has been conducted physical tests (color and smell) and Chemical tests (pH, EC, TDS and ion of SO_4^{-2}), which were the tests that were conducted in the laboratory of the Department of Chemical Industries and Oil Refining Techniques at the Technical Institute / Mosul. After treatment, the samples were coded according to the technique used and the duration of implementation. The symbol (M) was given for the magnetic technique, the symbol (NC) for the Nanotechnology using ordinary coal powder, and the symbol (NS) for the Nanotechnology using the sugar powder of cane, where the symbol (ANC-15) means the sulfur water for the Mosul Dam project using the Nano technique with ordinary coal powder after a mixing period of 15 minutes.
- f. Implementation of treatment using Magnetic technology: Samples of sulfur water were passed through the magnetizing device (with a magnetic field of 1000 joules) separately for a period of (15) minutes, and a sample of that treated water was taken after this period, then the magnetization process continued for (30) minutes and a sample of water was also taken this duration. In the end, samples were collected and the same qualitative tests were conducted as applied before treatment.
- g. Implementation of the treatment using the Nano technique:
The two treated materials (Charcoal powder and the powder of sugarcane plant) were added at an amount of (25) g per (500) ml of sulfur water with (10) g of table salt and placed in a glass beaker and mixed with a mechanical mixer for (15) minutes. And a sample was taken from that treated water after this period, then the mixing processes continued for (30) minutes, and a sample of water was also taken after this period. After a short period of time until the sedimentation of suspended substances, the samples were collected and filtered into the glass flask and the same tests were performed for those samples as applied before treatment.

RESULTS AND DISCUSSION

Water resources in general are suffering from depletion and pollution. Achieving sustainable development in water resources requires innovating techniques for treating polluted water, which sulfur water is a one part. The Magnetic technique of pollution water treatment is a new technology applying as an Ecofriendly system. The Magnetic field exposure to changes the physical and chemical properties of water molecules. Magnetized water has shown various properties with possible applications in different fields as; soil enhancement, plant growth

improvement, crop yield increase, water saving and wastewater treatment. That the Magnetic treatment for water doing restructures the water molecules into tiny, uniform and hexagonally structured clusters easing their moving through the passageways in cells. In addition, that the toxic agents cannot enter in the magnetized water structure [10,11].The results of magnetic treatment of irrigation water in agriculture had a positive effect on the germination rate, reaching 100% after (9) days of planting compared to the control treatment in which water was used directly without treatment, which gave germination rates (76%) for both wheat and barley. Magnetic technology on the productivity of these crops has achieved an increase in productivity[12].One of the problems of clogging water transmission pipes is the precipitation of Calcium sulfate in the form of (CaSO₄.2H₂O), known as gypsum, which is deposited and solidified in the hollows of the surfaces of the water transmission pipes. Where it was treated with Magnetic technology as a means to reduce Calcium sulfate deposits on pipe walls using a Magnetic device, the treatment was evaluated by measuring (Ec, pH and TDS) of the magnetically treated water and compared with the results of untreated water, which indicates the efficiency of magnetic treatment in reducing the following properties ; Sulfate compound concentration, Electrical conductivity, and Calcium sulfate deposition in the pipeline due to the ability of the magnetic field to dissolve sulfur compounds and prevent their precipitation [13,14].that the magnetic treatment improve quality of water, therefore, the magnetization process submits improvements on water applications in several areas such as industry, agriculture and medicine [15,16].Therefore, this research was carried out for the purpose of treating sulfur water with some of the available techniques. Where table (1) refers to the results of the qualitative tests that were conducted for sulfur water samples for the three areas before the treatment. The purpose is to compare them with the results obtained after the treatment process by the two techniques.

Table: 1- Characteristics of sulfur water before treatment

Samples	Physical tests		Chemical tests			
	Color	Odor	pH	EC	TDS	SO ₄
			-	PPM	PPM	PPM
A	Non-transparent	Stinky	6.00	1721	3.5×10 ³	1392.00
B	Non-transparent	Stinky	6.50	1414	2.8×10 ³	945.00
C	Non-transparent	Stinky	9.00	871	1.7×10 ³	247.00

The table (2) show the results of the qualitative tests that were conducted for sulfur water samples for the three areas after treatment using the two techniques, namely, the magnetization technique for a period of 15 minutes and 30 minutes, and the Nanotechnology using ordinary coal powder and the powder of sugarcane plant , as well as the process of mixing materials Nanoparticles with table salt in suitable concentrations, it is noted from these tables the amount of change that occurred in the results of qualitative tests, which indicates the superiority of magnetic treatment for Nanotechnology.

Table: 2-Characteristics of sulfur water after treatment by Magnetization technique

Samples	Physical tests		Chemical tests			
	Color	Odor	pH	EC	TDS	SO ₄
			-	PPM	PPM	PPM
AM-15	Transparent	Very acceptable	7.20	17.00	3.7×10 ³	144.00
AM-30	Transparent	Very acceptable	7.10	16.90	3.8×10 ³	141.00
BM-15	Transparent	Very acceptable	7.50	15.00	3.0×10 ³	101.00
BM-30	Transparent	Very acceptable	7.40	15.80	3.1×10 ³	95.00
CM-15	Transparent	Very acceptable	8.70	9.00	1.8×10 ³	33.00
CM-30	Transparent	Very acceptable	8.40	9.08	1.8×10 ³	26.00

The PPM (part per million): is one part per million and is a global unit of measurement (1 milligram of a substance per 1 liter of water).

Table: 3 - Characteristics of sulfur water after treatment by using coal powder as Nanotechnology technique

Samples	Physical tests		Chemical tests			
	Color	Odor	pH	EC	TDS	SO ₄
			-	PPM	PPM	PPM
ANC-15	Transparent	Acceptable	7.30	1750.00	3.6×10 ³	525.00
ANC-30	Transparent	Acceptable	7.00	1755.00	3.7×10 ³	512.00
BNC-15	Transparent	Acceptable	7.40	1425.00	2.9×10 ³	410.00
BNC-30	Transparent	Acceptable	7.50	1427.00	3.0×10 ³	408.00
CNC-15	Transparent	Acceptable	8.50	895.00	1.8×10 ³	150.00
CNC-30	Transparent	Acceptable	8.00	901.00	1.8×10 ³	141.00

Table: 4- Characteristics of sulfur water after treatment by using the powder of sugarcane plant as Nanotechnology technique

Samples	Physical tests		Chemical tests			
	Color	Odor	pH	EC	TDS	SO ₄
			-	PPM	PPM	PPM
ANS-15	Transparent	Acceptable	7.00	1725.00	3.5×10 ³	1200.00
ANS-30	Transparent	Acceptable	7.00	1727.00	3.5×10 ³	1195.00
BNS-15	Transparent	Acceptable	7.10	1423.00	2.9×10 ³	756.00
BNS-30	Transparent	Acceptable	7.00	1426.00	2.9×10 ³	743.00
CNS-15	Transparent	Acceptable	8.00	879.00	1.8×10 ³	211.00
CNS-30	Transparent	Acceptable	7.40	880.00	1.8×10 ³	206.00

It is clear from the above three tables (2, 3, 4) when compared with the table (1) and depending on the international standards, the extent of the change that occurred in the properties of the treated sulfur water, where the water became transparent color and odorless. As for the chemical tests that were conducted before treatment and after treatment with the two techniques of magnetization and Nano techniques, we can conclude the following:

1. Acidity (pH)

The values of (pH) tended towards neutralization after treatment with the two techniques and the two treated materials, whether Magnetic or Nano (15 and 30 minutes) were sufficient to affect the neutralization process, except for cold water (C) that may need a longer period or a greater magnetic field strength and the concentrations of Nano may be greater .

2. Electrical Conductivity or Salinity (EC)

The (EC) values decreased significantly (approximately 99%) when using Magnetic technology, and this indicates the ability of Magnetic treatment to dismantle sulfate particles and release hydrogen ions in water (1-3%) and its values are almost stable when using the powder of sugarcane plant . The addition of table salt may have caused this in whole or in part, although the process of adding table salt is important because it helps in the precipitation of the sulfate ion, and it can be said that the reason for the stability of salinity when using the powder of sugarcane plant has neutralized.

3. Total dissolved solids (TDS):

The values of (TDS) were increased (6-8%) after treatment, the process of magnetic or Nano were contributing to the precipitation of many materials, and its values are stable in some cases when using Nanotechnology.

4. Sulfate ion (SO₄⁻²):

Sulfates contribute to the formation of permanent hardness in water, especially if they are in the form of Calcium or Magnesium sulfate, and they are among the elements that cause salinity, as they give a salty taste to that water. It was observed that significant change occurred in the decrease of the sulfate value by 90% in the treated water by Magnetic technology. While the Nanotechnology recorded a change less than that by (43%-60%) when using Charcoal powder and (14%-21%) when using the powder of sugarcane plant , which can be explained by the fact that Nano treatment, especially the powder of sugarcane plant , may contain some sulfate inclusions. It

was concluded that the Magnetic techniques showed positive results as the percentage of sulfate and salinity decreased by more than (90%) and the acidity tended towards neutrality, while the Nanotechnology showed some negative results. It is clear from the results of the research that most of the qualitative characteristics of sulfur water are outside the scope of international standards in terms of Acidity, Electrical conductivity, High hardness, and High dissolved. Therefore, treating sulfur spring water is the best method for environmental protection, whether at the level of the biosphere, to get rid of the causes of pollution and add an additional water resource to the river, or to benefit from it for secondary uses, and this is one of the ways to solve the problem of water depletion and pollution. It can be seen from the foregoing that the results of magnetic treatment by comparing tables (1) and (2) showed that all values decreased except for the values of total soluble solids, where they increased due to the dissolvent & dissolution of the particles. And the results of the Nano-treatment with Charcoal powder compared between Tables (1) and (3) showed significant effects in each of the properties (pH, TDS and SO_4^{2-}) and not significant in (Ec), while the results of the Nano-treatment with the powder of sugarcane plant showed significant effects in each of the properties of (pH, TDS and SO_4^{2-}). in compared between Tables (1) and (4) with significant effects in each of the characteristics (pH and SO_4^{2-}) and none significant effects in (Ec and TDS). We conclude that treatment sulfate water constitutes an additional water source in increasing the water resources, which showed success in Magnetic technology treatment in getting rid of sulfate and possible of investing it in agricultural irrigation.

CONCLUSION

We concluded from the research the following:

1. The Magnetic technique used is very effective in reducing salinity and sulfate ions in comparison to Nanotechnology.
2. The salt added in Nano materials had a negative effect when used with charcoal powder, as it increased salinity, and this effect did not appear when using the powder of sugarcane plant.
3. Although there was an increase in the salinity of the treated water when using the Nanotechnology using Charcoal powder, the salinity remained unchanged when using the powder of sugarcane plant. However, the main purpose was achieved in getting rid of the effect of the sulfate ion.

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