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The Effect of Magnetic Field on Properties of pipeline Water in Basrah Province south of Iraq

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Abstract
The present study investigates the influence of a static magnetic field on the physicochemical properties of piped tap water in Basrah province, southern Iraq. Water was exposed to a permeant neodymium magnet producing an approximately 0.2 tesla field oriented perpendicular to the flow. Exposure durations were instant5,10,15,60 and 120 minutes, and the distance from the magnetic source was varied (25-100 cm). parameters including pH, total dissolved solids (TDS), electrical conductivity (Ec), dissolved oxygen (DO), total hardness, total alkalinity and temperature were measured in accordance with APHA standards methods. Results were compared against the world health origination (WHO) guidelines for drinking water quality (2017). overall, pH remained within the preferred WHO range (6.5-8.5). electrical conductivity (Ec) and total dissolved solids (TDS) decreased over time, indicating reduced mineral impurities. Total hardness and alkalinity decreased after prolonged exposure, supporting the effectiveness of this technology in reducing scale deposits in pipes. Water temperature decreased from 35°C to 22-26°C 35c to 22-26c over time, indicating greater physical stability. the findings suggest that the magnetic treatment can be considered a supportive, non-chemical option to enhance selected water quality indicators in Basrah province.

Keywords
magnetic water; static magnetic field; Basrah; water treatment.

I. INTRODUCTION

The future of water for civilization is uncertain because of water pollution and global climate change. Most countries face significant challenges in meeting the increasing demand for clean water. Water makes up more than 70% of the crust of the Earth, of which 97% is found in seas and oceans and the remaining 3% is fresh water. About 75% of this freshwater is accessible as glaciers, 24.5% as groundwater, 0.04% as atmospheric water vapor, and roughly 0.34% as rivers that are used to make drinking water and generate electricity [1]. Water is necessary for ecosystem health and all forms of socioeconomic development. Water resources are under increasing pressure due to population growth and development, which necessitates greater allocations of surface and groundwater for domestic, agricultural, and industrial uses [2]. This puts undue strain on the environment and causes tensions and conflicts among users. It is seriously concerning that freshwater resources are under more stress due to global pollution, escalating demand, and careless use. The sustainability of the base of natural resources is threatened by water scarcity, which has an impact on all spheres of society and the economy. To manage water resources in a way that maximizes economic and social welfare while maintaining the sustainability of essential ecosystems, addressing water scarcity calls for an intersectoral and multidisciplinary approach [3,4]. Iraq continues to suffer from a lack of fresh water and water contamination, which has an indirect impact on millions of people [5]. Getting drinkable water for various purposes is therefore a major concern. Groundwater, bore well water, treated wastewater, and treatment using magnetic technique are being used for various purposes instead of potable water. The excessive use of locally available water and the lack of potable water can be addressed in part by the Magnetic-Field-Treated Water technology. Here, the water travels through the magnetic field and becomes magnetized. The optical characteristics of water and its infrared absorption property are changed by magnetization [6]. The water hardness potential separates the colloids internally, thereby reinforcing the magnetic field. This has led to the development of a new technique for producing clean water because it significantly affects the magnetic intensity and length of time that water is exposed to magnetic fields. Additionally, magnetization significantly alters the physiochemical characteristics of the magnetic water [7,8].

The objective for this study comes from the fact that such a simple technology has beneficial effect on many applications and impact on industries utilizing water. The technology of magnetic tap water is cheap, requires no energy to run, and creates no pollutants. Besides the method of magnetic treatment of water requires no chemical reagents, and is therefore environmentally friendly.

II. LITERATURE REVIEW

Coey & Cass (2000) [11] showed that passing water through a strong magnetic field reduces calcium carbonate buildup. This reduces scale formation inside pipes and heat exchangers. Otsuka & Ozeki (2006) [10] concluded that magnetized water shows a temporary change in surface tension and contact angles, and that the changes gradually return to normal within hours. Da Silva and Dobránszki (2014) [13] focus on the use of magnetic water (MW) to alter plant growth. They showed that MW could be one of the most promising ways to enhance agricultural production in an environmentally friendly way in the future. Magnetic fields were reported to have a significant effect on the physical and chemical parameters of water by Khater and Ibraheim (2015) [16]. Wang & et al. (2018) [12] found that the properties of tap water changed following the magnetic field treatment when they discussed the effect of a magnetic field (MF) on the physical properties of water. Hassan & et al. (2018) [15] studied how magnetic fields affect water properties in aquaculture systems. The results showed increases in dissolved oxygen, pH, and EC, solving the problem of water quality. The AQUA remote sensing device was used by Al Bahrani (2018) [17] to compare the differences between non-magnetic and magnetic salty water, as well as to detect the effects of magnetic fields on water. Shaker& et al. (2021) [14] investigated the difference in the effects of magnetized water (MW) on accelerating the transport of nutrients in sandy soil and on the absorption of those nutrients by citrus fruits. Abu-Saeed et al. (2023) [18] studied the influence of a magnetic field on the physicochemical properties of water molecules while growing cucumber plants in an arid region. They concluded that the magnetic field may improve water quality and increase plant growth

III. METHODOLOGY

A. Magnetic Water Preparation

The experimental setup consists of a 20L tank connected to a 0.5-inch diameter metal tube fitted with neodymium permanent magnets to create a static magnetic field. The magnetic field intensity at the pipe wall was approximately 1500 Gauss (0.2 tesla). the magnetic field lines oriented perpendicular to the direction of water flow to maximize interaction as shown in figure 1. A control valve regulated the water flow rate, which was maintained at 1.5 L/min thought the tests. Figures (2 and 3) shows a schematic diagram of the experimental setup. Exposure durations included instant, 5,10,15,60 and 120 minutes. The distance between the sample location and the magnet was varied at 25,50,75 and 100 cm.

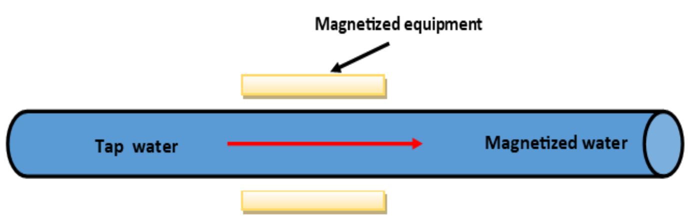
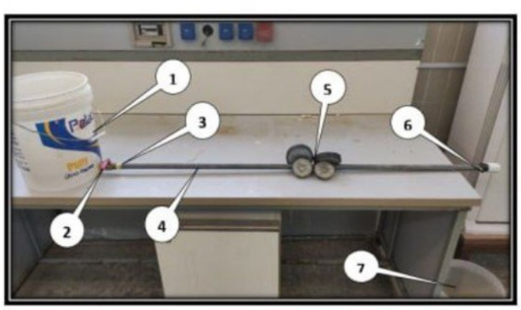


Fig.1: The schematic diagram of magnetization



1.tank of 20 L
2. Control valve
3. Magnetization distance
4. metal tube of diameter 0.5 inch
5. magnet
6. Control valve
7. Drainage collection

Fig.2: Magnetic water setup Rag

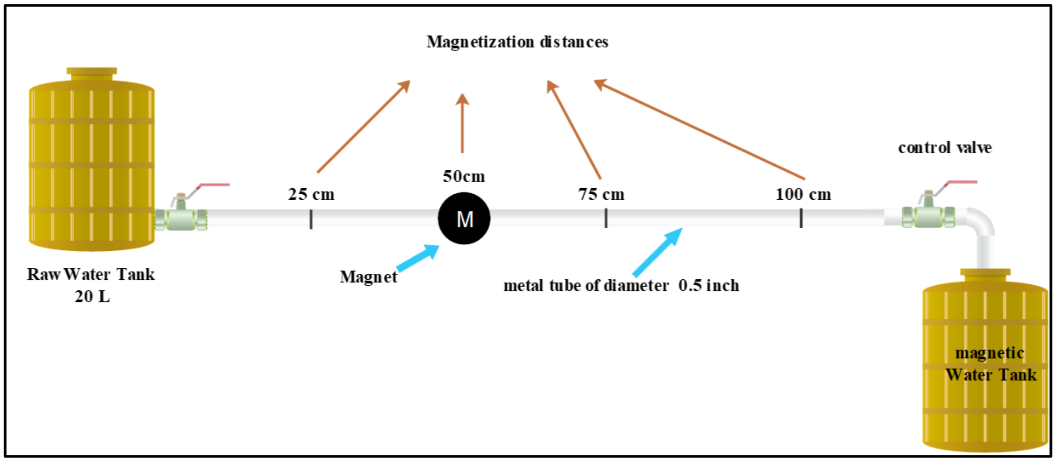


Fig. 3. Schematic diagram of magnetic water setup.

B. Sampling & Analysis

Tap water samples were collected in Basrah province, Iraq during September- October 2024 using sterilized 1L glass containers. The majority of the tests were performed immediately after the samples were collected with a field device in the sanitary laboratory at the College of Engineering, University of Basrah. A control (non-magnetized) samples were collected prior to exposure. Sampling followed APHA standards methods (23rd ed.,2017) [9]. Measurement of pH, Ec, Temperature, Do and TDS were obtained using a calibrated multiparameter devices as shown in figure 4, while total hardness and alkalinity were analyzed by titration (as CaCo3). All analyses were performed at 25 ±2˚ C. To assess practical acceptability, results were compared against the WHO guidelines for drinking water quality (4th ed., 2017).

Fig. 4. Digital metal used in laboratory experiments

C. Test Procedure

Water was stabilized by continues pumping for approximately 10 minutes to remove flow disturbance. Control samples (normal water NW) were collected before exposure. The water then held in pipe at different distance (25,50,75 and 100 cm) and exposed for specific durations (5,10,15,60 and 120 minutes). Each test was repeated three time to ensure reproducibility. Results of tested samples were compared against control values.

D. Benchmarks Standards for Comparison

To evaluate improvement in water quality, results were compared against the world health organization (WHO) guidelines for drinking-water quality (4th edition incorporation the first addendum, 2017). The following benchmark values were considered:

1. pH:6.5-8.5 acceptable range
2. TDS ≤600 mg/L (desirable), ≤ 1000 mg/L (max. acceptable)
3. Total hardness ≤ 500 mg/L as CaCo3
4. Dissolved oxygen (Do) ≥5 mg/L
5. Electrical conductivity ≤1500-2000 µS/cm (operational range).

IV. RESULTS AND DISCUSSIONS

A. Results

Tables 1-5 summarizes the effects of exposure time (5,10,15,60 and 120 minutes) and distance from the magnetic source (0-100 cm) on pH, dissolved oxygen (DO), total dissolved solids (TDS), electrical conductivity (Ec), total alkalinity, total hardness and temperature. Figures 5-10 illustrate the trends observed across the different parameters. In general, pH increased gradually with exposure, reaching value above 8.3 at longer durations and distances. Dissolved oxygen improved significantly, rising from~ 6.6 mg/L at initial measurement to more than 8.5 mg/L after 120 minutes. Electrical conductivity and TDS decreased consistently over time, indicating a reduction in dissolved ions and improved water clarity. Total hardness and alkalinity also decreased with exposure, particularly after 60-120 minutes, suggesting reduced scaling potential in pipeline. Water temperature showed gradual from 35℃ TO 22-26˚C.

TABLE 1. EFFECT OF MAGNETIC FIELD ON WATER PROPERTIES AFTER 5 MINUTES

Distance (cm)	pH (-)	EC (µS/cm)	TDS (mg/L)	DO (mg/L)	Temp. (Ċ)	total alkalinity (mg/L as CaCo3)	total hardness (mg/L as CaCo3)
0	6.67	1650	676	6.97	35	180-240	425
25	7.37	1772	727	6.56	35	210	425
50	7.76	1654	694	6.62	34.6	210	425
75	7.96	1617	686	6.91	34	210	425
100	8.14	1614	687	6.67	33	210	425

TABLE 2. EFFECT OF MAGNETIC FIELD ON WATER PROPERTIES AFTER 10 MINUTES

Distance (cm)	pH (-)	EC (µS/cm)	TDS (mg/L)	DO (mg/L)	Temp. (Ċ)	total alkalinity (mg/L as CaCo3)	total hardness (mg/L as CaCo3)
0	7.43	1664	676	34.3	6.89	180-240	425
25	7.37	1772	727	33.4	6.56	180-240	425
50	7.76	1664	694	33	6.62	180-240	425
75	7.96	1598	686	33.4	6.91	180-240	425
100	8.14	1612	687	33	6.67	180-240	425

TABLE 3. EFFECT OF MAGNETIC FIELD ON WATER PROPERTIES AFTER 15 MINUTES

Distance (cm)	pH (-)	EC (µS/cm)	TDS (mg/L)	DO (mg/L)	Temp. (Ċ)	total alkalinity (mg/L as CaCo3)	total hardness (mg/L as CaCo3)
0	7.82	1643	763	6.6	35	180-240	425
25	7.89	1680	737	6.85	33.5	180-240	425
50	7.83	1670	739	6.97	31.2	180-240	425
75	7.25	1568	748	7.06	29.5	180-240	425
100	8.3	1689	759	7.18	28	180-240	425

TABLE 4. EFFECT OF MAGNETIC FIELD ON WATER PROPERTIES AFTER 60 MINUTES

Distance (cm)	pH (-)	EC (µS/cm)	TDS (mg/L)	DO (mg/L)	Temp. (Ċ)	total alkalinity (mg/L as CaCo3)	total hardness (mg/L as CaCo3)
0	8.3	1743	780	8.21	26	180	425
25	8.59	1640	778	8.1	25	180	< 425
50	8.25	1570	721	8.11	23.4	180	< 425
75	8.28	1535	745	8.37	22.2	180	< 425
100	8.55	1513	747	8.5	22.1	180	< 425

TABLE 5. EFFECT OF MAGNETIC FIELD ON WATER PROPERTIES AFTER 120 MINUTES

Distance (cm)	pH (-)	EC (µS/cm)	TDS (mg/L)	DO (mg/L)	Temp. (Ċ)	total alkalinity (mg/L as CaCo3)	total hardness (mg/L as CaCo3)
0	8.33	1523	652	7.5	32.7	120	425
25	8.31	1182	569	7.63	26.3	120	< 425
50	8.45	1227	591	7.27	25	120	< 425
75	8.01	1294	614	7.27	23.9	120	< 425
100	8	1310	601	7.38	23.3	120	< 425

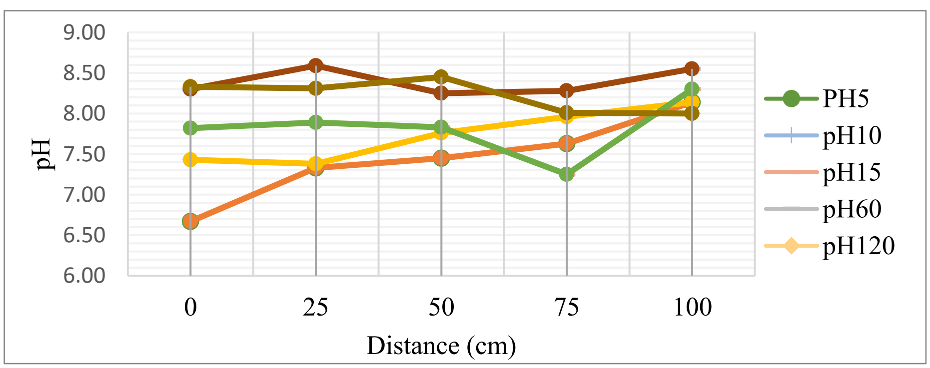


Fig. 5. Effect of magnetic field on water pH

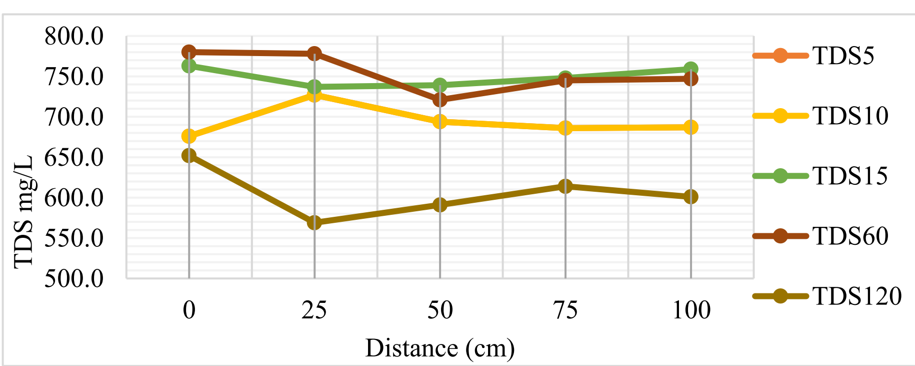


Fig. 6. Effect of magnetic field on water TDS

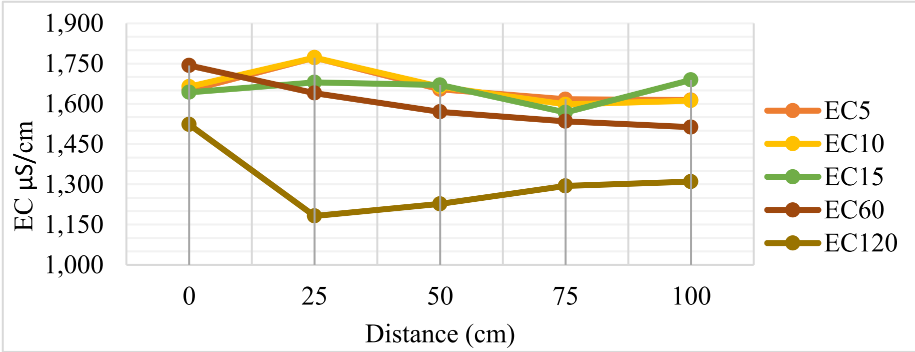


Fig. 7. Effect of magnetic field on water EC

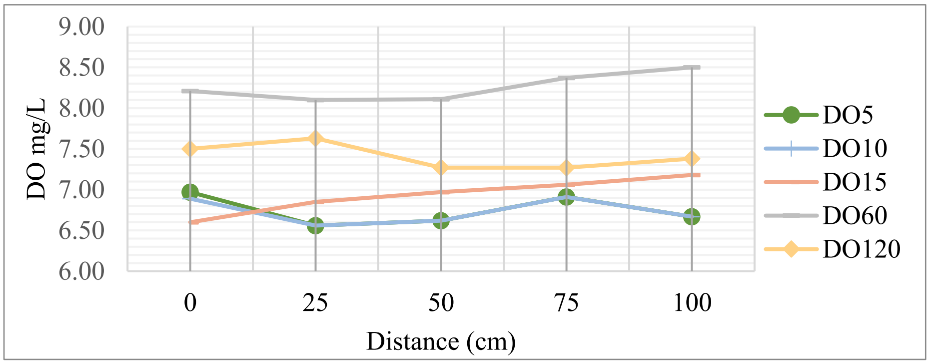


Fig. 8. Effect of magnetic field on water DO

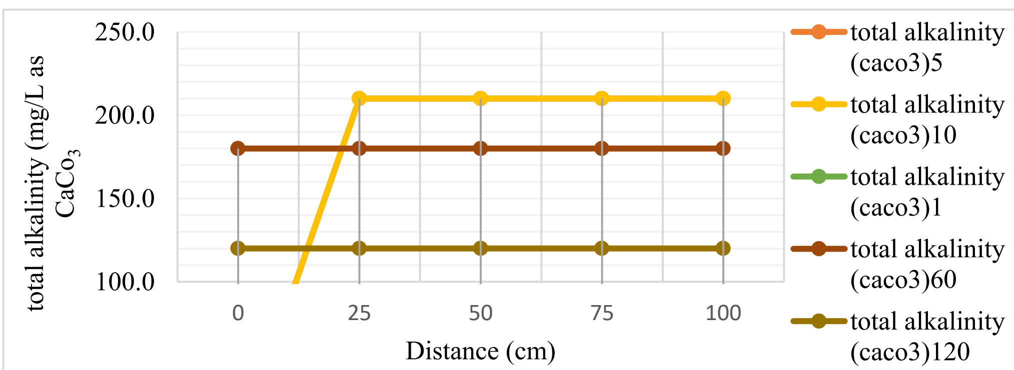


Fig. 9. Effect of magnetic field on total alkalinity of water

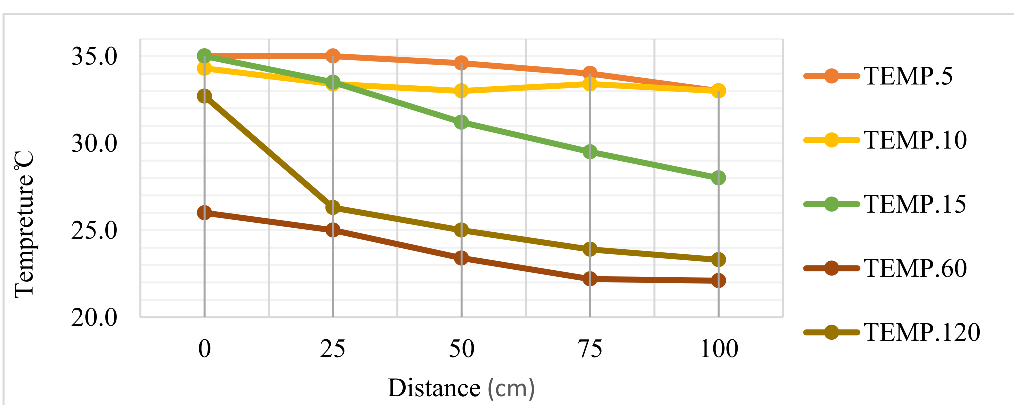


Fig. 10. Effect of magnetic field on water temperature

B. Discussion

The experimental results demonstrated that, exposure to the static magnetic field induced significant changes in the physicochemical properties of piped water. the study was designed to quantify these changes and assess their practical relevance by comparing them with previous research findings and international water quality standards from the world health organization (WHO).

1) changes in pH and alkalinity

A consistent increase in pH values was observed with longer exposure durations and greater distance from the magnetic source, indicating a shift towards higher alkalinity. This phenomenon can be attributed to the dissociation and organization of carbonate ions under magnetic influence, consistent with findings by Khater and Ibraheim (2015), who reported that, magnetic field alter carbonate equilibrium and promote salt dissociation in water systems [16]. Such an increase in alkalinity suggests a potential improvement in water chemical stability, although the pH values remained within the WHO recommendation range of 6.5 to 8.5, ensuring practical acceptability.

2) Decrease in Electrical Conductivity and TDS

The decrease in electrical conductivity (Ec) and total dissolved solids (TDS) indicates a reduction in the concentration of dissolved ions. this aligns with studies by Wang et al. (2018), which found that, magnetically treated water exhibited lower ion mobility and conductivity, likely due to changes in ion clustering and the hydrogen-bonding network [12]. these improvements are significant for reducing scaling risks in water distribution systems and enhancing water quality.

3) Enhanced dissolved oxygen levels

Dissolved oxygen (Do) levels increased consistently after magnetic treatment, reaching values above 8.5 mg/L after 120 minutes. This elevation is crucial, as higher DO supports aquatic life and maintains ecological balance. Similar enhancement was documented by Hassan et al. (2018) in aquaculture applications, were magnetic treatment improved oxygen availability and ecosystem performance [15].

4) Reduction of Hardness and Total Alkalinity

Total hardness and alkalinity decreased after prolonged exposure, which suggests that magnetic treatment influences the crystallization behavior of calcium and magnesium salts, transforming them into less stable crystalline forms. This finding confirms previous work by Coey & Cass (2000), who demonstrated that, magnetic treatment reduces the precipitation of calcium carbonate ($CaCo_3$), thereby mitigating scaling in pipelines [11].

5) Temperature Effects

The treated water exhibited a temperature decrease from approximately 35˚C to 22-26˚C. although less commonly reported. this temperature reduction likely reflects improved physical stability and alterations in the internal energy distribution of water molecules, consistent with indirect thermal effects of magnetic fields observed in other laboratory studies.

In summary, the outcomes of this study confirm that magnetic field exposure can simultaneously improve several water quality parameters enhancing alkalinity and dissolved oxygen, reducing ionic content and mitigating scaling risks. Thes findings are consistent with earlier studies (Khater& Ibrahim,2015; Coey & Cass, 2000; Wang et al., 2018; Hassan et al., 2018) and validate the role of magnetic treatment as a sustainable, non-chemical approach for improving water quality in arid regions such as Basrah province.

V. CONCLUSION

This study demonstrates that, static magnetic field exposure can improve several physicochemical properties of Basrah pipeline water. Magnetization increased pH and dissolved oxygen while reducing electrical conductivity, total dissolved solids, hardness and alkalinity. These improvements remain within or close to WHO guideline values, confirming the potential of magnetic treatment as a low-cost, non-chemical method for enhancing water quality and reducing scaling risks in arid regions.

VI. RECOMMENDATION

Based on the study findings, it is recommended to:

1. Test magnetic treatment in pilot water supply systems in Basrah to validate large-scale performance.
2. Conduct further studies on microbial safety and long-term stability of magnetized water.
3. Explore applications in agriculture and industry where reduced scaling can bring economic benefits.

Conflict of Interest

The authors have no conflict of relevant interest to this article.

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