

Magnetic Field–Induced Modulation of the Physicochemical Properties of Water

Elchin Khalilov

20220003@wzu.edu.cn

Wenzhou University

Min Zhao

Wenzhou University

Safi Asim Bin Asif

Wenzhou University

Farid Elchin Khalilov

Wenzhou University

Wang Min

Wenzhou University

Xu Nuo

Wenzhou University

Article

Keywords: Magnetized water, physicochemical properties, magnetic field, hydrogen bonding, water cluster.

Posted Date: September 9th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10586230/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.
[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Magnetic fields are emerging as powerful modulators of water's molecular and ionic organization [1–3]. Here, we have shown that brief exposure of water to dynamic magnetic fields of 0.6 T and 1.2 T induced distinct and reproducible shifts in its physicochemical state. Instantaneous passage through a magnetic column led to a decrease in pH (i.e. decreased up to 5.71% by 0.6 T and 12.18% by 1.2 T) and pronounced increases in electrical conductivity (EC) (increased up to 30.83% by 0.6 T and 143.12% by 1.2 T), reflecting enhanced ionic mobility and solvation. The dissolved oxygen (DO) content exhibited a transient rise followed by a mild decline. This impact is owing to the reaction between hydrogen ion (H^+) and dissolved oxygen, lowering the concentration of DO available to aquatic life. Moreover, the oxidation–reduction potential (ORP) changed markedly (37.44% and 33.92% by 0.6T and 1.2T respectively), signifying redox tendency at the molecular level. Together, these results suggest that magnetic fields reorganize hydrogen bonding and charge distribution (i.e. dipoles) within water molecules. This research illustrates a controllable roadmap to modulate water's intrinsic physicochemical behavior, offering implications for environmental remediation, water treatment, catalysis, and biological systems where magnetically treated water could play a functional role.

1. Introduction

The quality of universal solvent, i.e. water has been measured by several water quality testing parameters, for example, pH, total dissolved solids (TDS), total suspended solids (TSS), oxidation-reduction potential (ORP), and dissolved oxygen (DO) concentration. These are among essential parameters in water treatment process [2–6]. Interestingly, most of these parameters (pH, ORP, DO etc.) involve transfer of electrons i.e. electron density on water molecules. Moreover, water's unique physicochemical behavior arises from its extensive hydrogen-bond network, which governs its thermodynamic, electron transportation and interfacial properties. This external magnetic field may induce measurable structural reorientation. In this context, several studies have previously been reported [4, 7–10]. These remarkable magnetic field effects on water molecules have fascinated global attention for their potential to modulate properties relevant to environmental remediation (e.g. water purification, agricultural, corrosion, and catalysis) and biological systems (e.g. decontamination of natural water from cyanobacteria).

Several studies have also reported that along with the magnetic field (MF) strength, magnetic exposure time also influences cluster size, viscosity, surface tension, zeta potential, pH, ORP, DO, electrical conductivity [4] and contact angle of water molecules [2, 4], however, the fundamental mechanisms remain debated. These are often inferred based on Lorentz force-induced microscopic perturbation or rearrangement in magnetically treated water, which leads to alteration in hydrogen bond network and reduces the water cluster size [4, 11–13].

Chen et al. [14] reported the properties of “electron-doped” water molecule such as reduced hydrogen bonds, lower heat capacity, shorter freezing time and stronger reductive activity. This increase in electron

density in water molecules promotes the redox reaction, which is promising in many applications, for examples wastewater treatment and disease remediation [15–20].

Understanding how magnetic fields reorganize water molecules at the microscopic level and its impact on water's macroscopic properties is essential for advancing magnetically treated water technologies ranging from waste-water treatment, plant growth enhancement, electrochemically catalyzing reactions, desalination, and pollutant degradation. In this study, we have presented a systematic and elementary investigation of magnetic field–induced transformations occurred in water molecules through an integrated suite of analytical techniques, including potentiometry, pH-metry and conductometry. This helped us to elaborate strong correlation exist between microscopic rearrangements and macroscopic physicochemical characteristics.

These findings revealed experimental evidence of magnetic field-driven reorientation within the hydrogen-bond network, suggesting that water's cluster structure and energy distribution can be transiently tuned by magnetic stimuli. Such insight expands the fundamental understanding of water structuring and offers new opportunities for controlling interfacial and reactive processes in sustainable water technologies.

2. Materials and Methods

Deionized (DI) water (Ultra-pure water) was used throughout the experiment of magnetization. DI was produced by Ultra-pure (LC-UPT-PLUS) water purifier system (LICHEN Scientific Group). The pH, EC, ORP, and DO concentration were measured using pH electrode (Smart Sensor, pH818M), conductometer (CT-2-meter, Lichen), ORP electrode (Hanna Instruments) and Handheld dissolved oxygen meter (AZ8403, China), respectively. The magnetic field of 0.6 Tesla (6000 Gauss) and 1.2 Tesla (12000 Gauss) were generated by using MagVortex® (3M and BM) devices.

2.1. Water Magnetization:

For the magnetization of deionized water, the water magnetization system named MagVortex® has been designed [21, 22] as shown in the schematic diagram (Fig. 1). The pH, EC, DO, and ORP of 30 mL of deionized water were measured before treatment (non-magnetized water) and after treatment (magnetized water). Controlled deionized water (non-magnetized) was used to validate the influence of magnetic effects on water parameters. These changes in water parameters were calculated and reported as percentage change based on Eq. 1.

$$\text{Percentage Change (\%)} = \frac{V_a - V_b}{V_b} \times 100 \text{ Eq. 1.}$$

Where V_a and V_b represent the measured values of water parameters after flowing and before flowing (through the magnetic field), respectively. A positive percentage changes signifies increment of parameter while negative percentage changes reveal decrement of water parameter.

3. Results and Discussion

3.1. Effect of magnetic field on water parameters

The Fig. 2. (a) and Fig. 2. (b) revealed that when deionized water flowed through magnetic devices 3M and BM having magnetic field 6000 Gauss (0.6 Tesla) and 12000 Gauss (1.2 Tesla), a better improvement in pH, EC, and ORP were achieved, while no significant improvement was achieved for dissolved oxygen (DO) concentrations. When deionized water flows through 3M and BM devices, a significant decrease in pH has been observed as 6.7% and 12.2% respectively. In contrast, there is drastic change in electrical conductivity (EC) which has been observed as 30.8% and 143.1% for 3M and BM MagVortex® devices respectively. Furthermore, almost same increment i.e. 37.4% and 33.9% have been monitored for the oxidation-reduction potential (ORP) after passing deionized water through the 3M and BM magnetic devices respectively. However, no significant changes have been observed for dissolved oxygen (DO) concentrations. It increased slightly by 1.4% for 3M and then decreased by 2.4% for BM devices respectively. Detailed data has been shown in supplementary information S1. Previously, it had been reported that the magnetization effect increases at low flow rate, which indicates the longer exposure time of water to magnetic field [23]. Therefore, MagVortex® devices were designed to maintain the low flow rate and consequently, provide long exposure time.

3.2. Statistical Analysis of Physical Parameters

The difference in physical parameters of deionized water after magnetization has been validated by applying statistical tests. On-way ANOVA (analysis of variance) has been employed to check the null hypothesis (H_0), which stated that all means are equal or alternate hypothesis (H_a), which stated that at least one mean is different. One-way ANOVA revealed a **significant effect** of magnetic field strength on all four dependent variables i.e. **pH** ($F_{(1,16)} = 961.72$, $p = 1.02 \times 10^{-15}$), **electrical conductivity (EC)** ($F_{(1,16)} = 50.50$, $p = 2.49 \times 10^{-6}$), **dissolved oxygen (DO)** ($F_{(1,16)} = 368.62$, $p = 1.79 \times 10^{-12}$), and **oxidation-reduction potential (ORP)** ($F_{(1,10)} = 90.94$, $p = 2.45 \times 10^{-06}$).

3.3. Proposed Mechanism of Magnetization of Water

Water molecules are polar owing to difference in electronegativity values of hydrogen and oxygen which consequences a net 1.85 D dipole moment value. These net dipole moment couple with hydrogen bonding, randomize the orientation (arrangement) of water dipoles to a least possible potential energy which makes the water molecules to be stable. The magnetization process temporarily affects the orientation of water dipoles and aligns them in well-structured order. These well-structured water molecules form more structured cluster water molecules, which strengthen the hydrogen-bonding network. Furthermore, these stronger and more structured hydrogen bonding stabilize the hydronium ion (H^+) which is furnished by self-ionization of water molecules. This autoprotolysis leads to small shift (forward) as shown in Eq. 2. according to Le-Chatelier Principal. Consequently, increase in H^+ ion leads to decrease in pH of water.

Since, Nernst equation defines that there is strong and inverse correlation between pH and potential (E) (ORP) as shown in Eq. 3. Therefore, ORP tends to increase on decreasing pH of water.

In this study, this proposed mechanism of magnetization of water has experimentally been proven as shown in Fig. 2(a) and Fig. 2(b).



$$E_{\text{cell}} = E^o - 0.0592 \text{ pH}$$

Or Eq. 3.

$$E_{\text{cell}} = E^o + 0.0592 \frac{1}{\text{pH}}$$

4. Conclusions

The profound effect of magnetic fields on the physicochemical parameters of water has been evaluated. The magnetic field has proved to have impact on reorientation of water dipoles (rearrangement and alignment of water molecules). Consequently, this strengthens the hydrogen bond network and breaks down large water cluster to smaller one. Due to which, hydronium ion's mobility has been affected and found alter in the pH, EC, DO, and ORP parameters of deionized water. These magnetic field-induced modulations have a potential application in waste-water treatment, biological system, and environmental remedy where these parameters play their crucial functions.

Declarations

Author Contribution

Elchin Khalilov; Concept, Review, Supervision, Project LeaderZhao Min; Project LeaderSafi Asim Bin Asif; Methodology, Analysis, Writing Manuscript, Review and analyse the data, Interpretation, sourcing and softwareFarid Elchin Khalilov; Support Wang Min; SupportXu Nuo; Support

Data Availability

All data supporting the findings of this study are available within the paper and its Supplementary Information.

Declaration of Interest Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability Statement

All data supporting the findings of this study are available within the paper and its Supplementary Information.

Research Funding Statement

No, this research did not receive funding.

References

1. Abdelsalam, H., et al., *Magnetization treatment effect on some physical and biological characteristics of saline irrigation water*. Scientific Reports, 2025. **15**(1): p. 19803.
2. Esmaeilnezhad, E., et al., *Characteristics and applications of magnetized water as a green technology*. Journal of Cleaner Production, 2017. **161**: p. 908-921.
3. Sronsri, C., K. U-yen, and W. Sittipol, *Analyses of vibrational spectroscopy, thermal property and salt solubility of magnetized water*. Journal of Molecular Liquids, 2021. **323**: p. 114613.
4. Yap, A.C.W., et al., *Electron generation in water induced by magnetic effect and its impact on dissolved oxygen concentration*. Sustainable Environment Research, 2021. **31**(1): p. 7.
5. Omer, N., *Water Quality Parameters*, in *Water Quality - Science, Assessments and Policy*, J.K. Summers, Editor. 2019, IntechOpen: London.
6. Ioka, S., et al., *In situ redox potential measurements as a monitoring technique for hot spring water quality*. Sustainable Water Resources Management, 2016. **2**(4): p. 353-358.
7. Lee, H.S., et al., *Increased electron density and dissolved oxygen level in water through magnetic effect*. IOP Conference Series: Earth and Environmental Science, 2019. **257**(1): p. 012010.
8. Yap, A.C.W., et al., *Investigation of the magnetic effects on water properties using permanent magnets*. AIP Conference Proceedings, 2019. **2157**(1).
9. Hassan, S.M. and R.A. Rahman. *EFFECTS OF EXPOSURE TO MAGNETIC FIELD ON WATER PROPERTIES AND HATCHABILITY OF Artemia salina*. 2016.
10. Yin, J., et al., *Influence of Water Physical and Chemical Performance by Magnetizing*. Advanced Materials Research, 2011. **281**: p. 223-227.
11. Toledo, E.J.L., T.C. Ramalho, and Z.M. Magriotis, *Influence of magnetic field on physical–chemical properties of the liquid water: Insights from experimental and theoretical models*. Journal of Molecular Structure, 2008. **888**(1): p. 409-415.
12. Silva, I.B., J.C. Queiroz Neto, and D.F.S. Petri, *The effect of magnetic field on ion hydration and sulfate scale formation*. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 2015. **465**: p. 175-183.
13. Chibowski, E. and A. Szcześ, *Magnetic water treatment—A review of the latest approaches*. Chemosphere, 2018. **203**: p. 54-67.

14. Chen, H.-C., et al., *Creation of Electron-doping Liquid Water with Reduced Hydrogen Bonds*. Scientific Reports, 2016. **6**(1): p. 22166.
15. Kai, T., et al., *Dynamic Behavior of Secondary Electrons in Liquid Water at the Earliest Stage upon Irradiation: Implications for DNA Damage Localization Mechanism*. The Journal of Physical Chemistry A, 2016. **120**(42): p. 8228-8233.
16. Zilio, P., et al., *Hot electrons in water: injection and ponderomotive acceleration by means of plasmonic nanoelectrodes*. Light: Science & Applications, 2017. **6**(6): p. e17002-e17002.
17. Che Mansor, M.S.A., et al., *Gold hybrid nanomaterials: Prospective on photocatalytic activities for wastewater treatment application*. Materials Chemistry and Physics, 2020. **241**: p. 122415.
18. Mulpuri, R.K., et al., *Zinc and boron co-doped nanotitania with enhanced photocatalytic degradation of Acid Red 6A under visible light irradiation*. Sustainable Environment Research, 2019. **29**(1): p. 29.
19. Chen, K.-T., et al., *Removal of ammonia from leachate by using thermophilic microbial fuel cells equipped with membrane electrode*. Sustainable Environment Research, 2020. **30**(1): p. 5.
20. Sasikala, S.P., et al., *Competitive photo-degradation performance of ZnO modified bentonite clay in water containing both organic and inorganic contaminants*. Sustainable Environment Research, 2019. **29**(1): p. 1.
21. F.E., K.E.N.K.T.S.K.A.E.K., *Device for magnetically treating liquids (MAGVORTEX)*, in *International Eurasian Patent. Bulletin of EAPO*. 2023.
22. F.E., K.E.N.K.T.S.K.A.E.K., *Device for magnetically treating liquids (MAGVORTEX)*, in *International Patent PCT, Bulletin of WIPO*. 2022: Geneva.
23. Zularisam Ab. Wahid, F.O., Johan Sohaili, *Electromagnetic Technology on Sewage Treatment*. Malaysian Journal of Civil Engineering, 2018. **13**(1).

Figures



Figure 1

The MagVortex® Devices

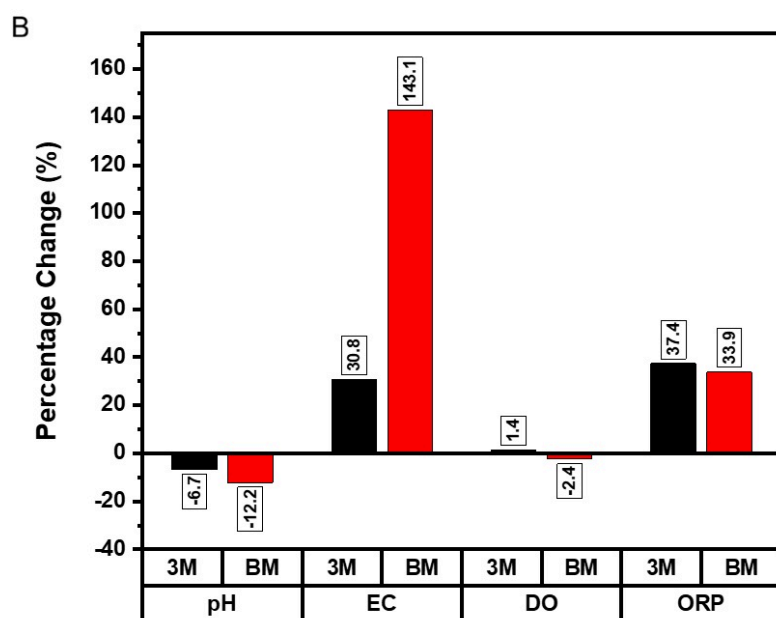
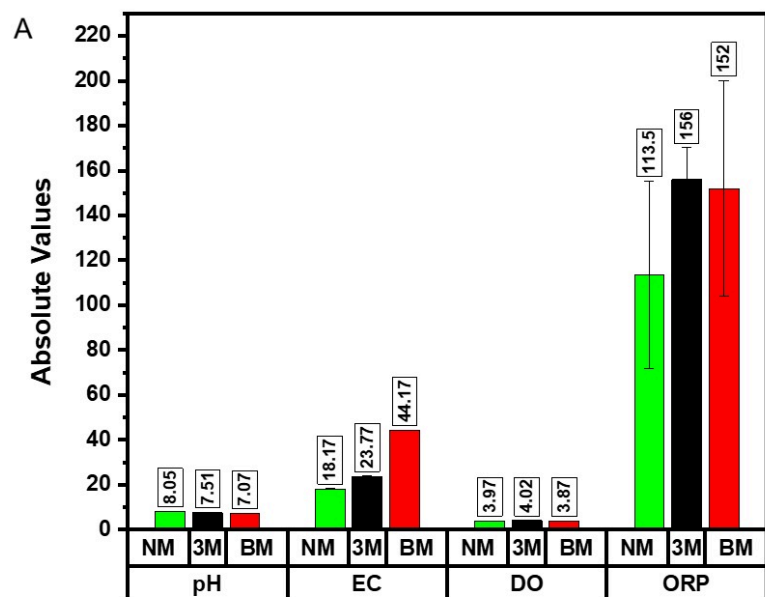


Figure 2

(a) Results of pH, EC, DO, and ORP of deionized water before magnetization (NM) and after magnetization by using 3M and BM MagVortex® devices

(b) Percentage change (%) in pH, EC, DO, and ORP of magnetically treated deionized water by using 3M and BM MagVortex® Devices with respect to non-magnetized water (NM)

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryInformation2.docx](#)