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RESEARCH ARTICLE

MAGNETIC TREATMENT OF WASTEWATER REDUCES HEAVY METAL CONCENTRATIONS

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ABSTRACT

This study investigates the effectiveness of magnetic treatment as an eco-friendly technique for reducing heavy metal concentrations in wastewater. A laboratory-scale magnetic treatment device was designed with three parallel PVC pipes exposed to different magnetic field intensities (1000, 3000, and 5000 G). Wastewater samples were tested before and after treatment to evaluate variations in lead (Pb^{2+}) and nickel (Ni^{2+}) concentrations using atomic absorption spectrophotometry. The results revealed a significant reduction in Pb and Ni concentrations, which increased with higher magnetic field intensity, longer exposure time, and alkaline conditions (pH 10). The findings demonstrate that magnetic treatment provides a sustainable, low-energy, and non-chemical approach to improving wastewater quality and reducing heavy metal pollution

KEYWORDS

Magnetic treatment, Wastewater, Heavy metal, Lead (pb+2), Nickel (Ni+2)

1. INTRODUCTION

Water is a diamagnetic material. One oxygen atom and two hydrogen atoms make up the water molecule (H2O), bonded in an isosceles arrangement by two covalent bonds or shared pair of elections to form an angle of 104.45º at the apex (refer to figure1), due to the existence of two pair of unshared electrons associated with the oxygen, the water has a slight favorably charged hydrogen atoms location and a minor the oxygen's negative charge. Hence this orientation of the water molecule will act as a magnetic dipole. As Result, the water molecules will reverse itself by a hydrogen bond, this bond can gather the water molecules as you can see in figure2. Water has four properties as result of the hydrogen bonds between molecules: it is denser in its liquid form than solid; it bonds to itself and has a high boiling point; and it has a high solvent power (Boufa, 2021).

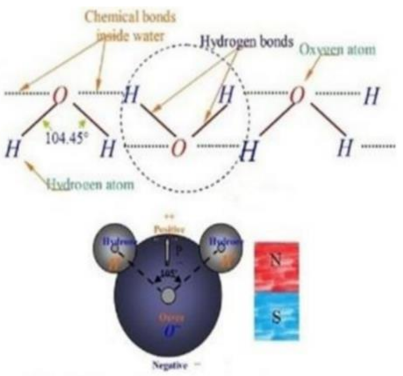

Figure 1: Normal Water molecule (Boufa, 2021)

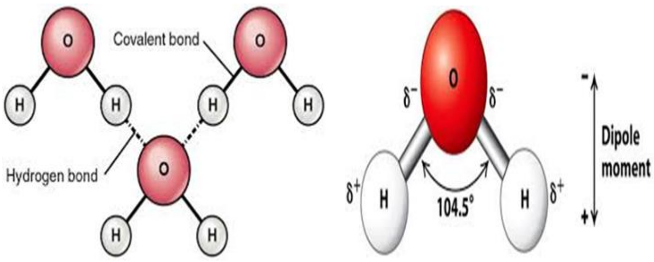

Figure 2: Normal Water Molecule

Hydro chemical hydrogen cracking hydrogen order from one cluster of water between one direction of order along MF and the perpendicular direction of order when water is exposed to MF Magnetization can influence two forces working against one another influence water structure in positive or negative way also Decrease angle transformation from 104.45°→.103° (Karkush et al., 2019) .

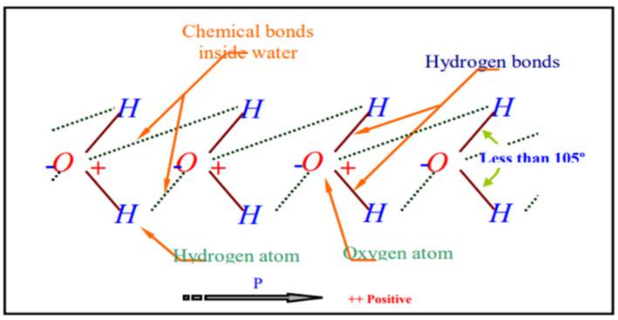

Figure 3: Water molecule under effect of MF

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2. Magnetic Wastewater Treatment

In recent years, magnetic methods, especially static magnetic fields (SMFs) based techniques, have attracted considerable interest as novel, green and sustainable technologies for treating wastewater. They are based on applying a continuous, constant magnetic field to affect the physicochemical and bio physico chemical processes in waste (Pang and Deng, 2008). The hydrogen bonding network of water molecules can be changed by exposure to static magnetic fields. It results in the alteration in surface tension, viscosity and the other thermo-dynamic properties and hence could enhance the pollutant solubility and reaction concentrations into those in water (Toledo et al., 2008). It is indirect and works by minimizing ionic action and lowering the charge on particles to assist in the coagulation and sedimentation of suspended particles, which they have also shown to be like this tendency found in most instances since the magnetic fields. This leads to efficient elimination of suspended solids and turbidity (Ji et al., 2019). Furthermore, research has also shown that magnetically treated water improves flocculation as reflected in higher sedimentation rates and the formation of dense sludge (Ziaeifar et al., 2015).

3. Heavy Metals

High atomic number and high density elements found in nature (usually greater than 5 g/cm2) are known as heavy metals.and are often toxic or harmful to humans and the environment, especially in elevated concentrations. These elements include but are not limited to lead (Pb), arsenic (As), chromium (Cr), copper (Cu), nickel (Ni), zinc (Zn), mercury (Hg), and cadmium (Cd). They are characterized by their persistence, bioaccumulation in ecosystems, and their non-biodegradable nature.

Although the term "heavy metal" is widely used, it lacks a strict scientific definition. Instead, it is a classification used in toxicology, environmental science, and industrial chemistry to denote metals and metalloids with known adverse health and ecological effects They naturally occur in the Earth's crust and are discharged into the surroundings through weathering, volcanic activity, as well as man-made pursuits like mining, manufacturing, and farming (Duffus, 2002; Ali et al., 2019).

4. Experiment Method

The Magnetic Treatment Device (MTD) used in these experiments was designed to include a main PVC pipe divided into three parallel branches (Pipes 1, 2, and 3), each mounted on a locally assembled magnetic field of specific strength (1000 G, 3000 G, and 5000 G, respectively). The system does not require any external power supply for operation. Water is pumped through the system using a water pump, and each branch is equipped with a valve that regulates the flow rate. During operation, water is allowed to pass through only one branch pipe at a time while the other two and 20 minuet branches remain closed, as shown in figure (4).

Figure 4 : Magnetic Treatment Design

4.1 Measured concentration of heavy metals (Pb+2, Ni+2)

The magnetic treatment of water in the Tested was occurred before and after In Center for Market Research and Consumer Protection/University of Baghdad to Measuring Heavy metals. Destructive analysis is done by atomic absorption flame spectrophotometer analysis device as shown in Figure 5

Figure 5 : Atomic absorption flame spectrophotometer

4.2 Results of concentration of heavy metals

4.2.1 Lead (pb+2)

Figure (6) show the decrease in Concentration of Lead (pb+2) after using magnetic treatment, The greater the intensity of the magnetic field during treatment, the longer the time, and with a high flow rate, the concentration will decrease.

treatment containing heavy metals such as lead (Pb+2) has been shown to enhance removal efficiency through a set of physicochemical mechanisms. Primarily, the magnetic field alters the hydrogen bonding network of water molecules, reducing cluster size and increasing ion mobility and diffusion rates. This structural rearrangement facilitates the migration of Pb^{2+} ions toward reactive surfaces or adsorbents(Chibowski et al., 2018).

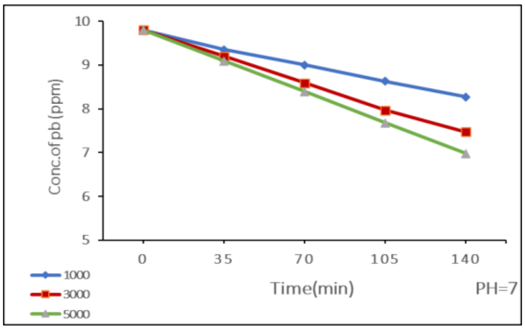

Figure 6: Relation between Concentrations of Lead (pb) and time at different intensities

Figure (7) Show the decrease in lead (Pb+2) concentration increased after using magnetic treatment, particularly at an alkaline pH of 10. The maximum decrease in concentration was observed at a magnetic field intensity of (5000 G), and it increased progressively with longer exposure times. this result agree with(Maletin et al., 2024)

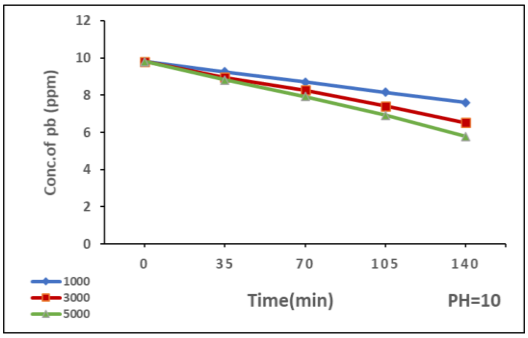

Figure 7: Relation between Concentrations of Lead (pb) and time at different intensities

4.2.2 Nickel (Ni+2)

Figure (8) (A) show the decrease in Concentration of nickel (Ni)after using magnetic treatment, at PH=7.

When a magnetic field is applied in this pH range, several mechanisms contribute to improved removal: (1) the enhanced mobility of Ni^{2+} ions due of the Lorentz force generated (2) increased collision frequency with adsorbent particles; and (3) possible structural changes in water clusters that affect ion hydration and facilitate surface interactions. this result agree with (Maletin et al., 2024).

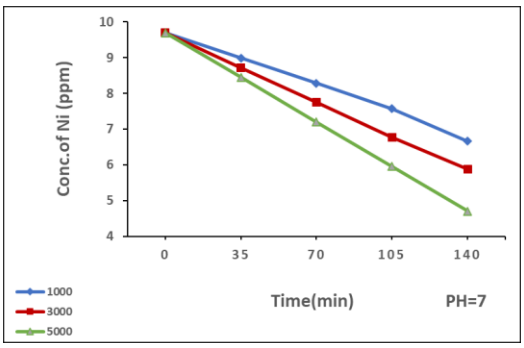

Figure 8 : Relation between Concentrations of Nickel (Ni) and time at different intensities

Figure (9) Showing the decrease in nickel (Ni) concentration has increased further after using magnetic treatment, at PH=10M, a strongly alkaline environment is established, which promotes the effective precipitation of nickel in the form of insoluble nickel hydroxide (Ni) $(OH)_2$) (Hase et al., 2017).

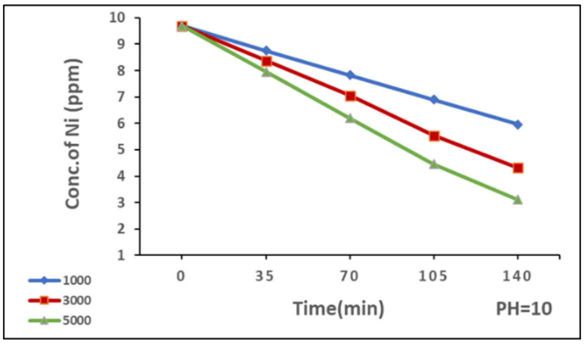

Figure 9: Relation between Concentrations of Nickel (Ni) and time at different intensities

5. Conclusion

The present study demonstrated that magnetic treatment is an effective and sustainable technique for reducing heavy metal concentrations in wastewater. The results clearly indicated that higher magnetic field intensities (1000-5000 G) and longer exposure times enhanced the removal efficiency of both Pb^{2+} and Ni^{2+} ions. The reduction was more pronounced under alkaline conditions (pH 10), where precipitation of insoluble metal hydroxides was facilitated. The observed improvements can be attributed to several physicochemical mechanisms, including alteration of the hydrogen bonding network of water, reduction of molecular cluster size, increased ion mobility, and enhanced interaction of metal ions with reactive sites.

Overall, magnetic treatment offers a low-energy, non-chemical, and eco-friendly alternative for improving wastewater quality. These findings suggest that magnetic technology could be applied as a complementary or pre-treatment step in wastewater management systems to mitigate heavy metal pollution and support

References

Ahmed, S. M. 2009. Effect of magnetic water on engineering properties of concrete. Al-Rafidain Engineering Journal, 17(1), Pp. 71–82.

Ali, H., Khan, E., and Ilahi, I. 2019. Environmental chemistry and ecotoxicology of hazardous heavy metals: Environmental persistence, toxicity, and bioaccumulation. Journal of Chemistry, 2019(1), 6730305.

Boufa, N. K. 2021. Investigation of the effect of magnetic field on some physical properties of water. International Science and Technology Journal, 26, 18.

Chibowski, E., Szcześ, A., and Hołysz, L. 2018. Influence of magnetic field on evaporation rate and surface tension of water. Colloids and Interfaces, 2(4), 68.

Duffus, J. H. 2002. Heavy metals a meaningless term? (IUPAC Technical Report). Pure and Applied Chemistry, 74(5), Pp. 793–807.

Hase, H., Nishiuchi, T., Sato, T., Otake, T., Yaita, T., Kobayashi, T., and Yoneda, T., 2017. A novel method for remediation of nickel containing wastewater at neutral conditions. Journal of Hazardous Materials, 329, Pp. 49–56.

Ji, L., Chen, J., Kuang, S., Zheng, Q., Chu, K., and Yu, A. 2019. Prediction of separation performance of hydrocyclones by a PC-based model. Separation and Purification Technology, 211, Pp. 141–150.

Karkush, M. O., Ahmed, M. D., and Al-Ani, S. 2019. Magnetic field influence on the properties of water treated by reverse osmosis. Engineering, Technology and Applied Science Research, 9(4). https://pdfs.semanticscholar.org/ cd57/b1e0a47b910e27f60aec 169a4 8 9764050583.pdf

Maletin, M., Nikić, J., Gvoić, V., Pešić, J., Cvejić, Ž., Tubić, A., and Agbaba, J. 2024. Optimization and efficiency of novel magnetic-resin-based approaches for enhanced nickel removal from water. Processes, 12(10), Pp. 2287.

Pang, X., and Deng, B. 2008. Investigation of changes in properties of water under the action of a magnetic field. Science in China Series G: Physics, Mechanics and Astronomy, 51(11), Pp. 1621–1632. https://doi.org/10.1007/s11433-008-0182-7

Toledo, E. J., Ramalho, T. C., and Magriotis, Z. M. 2008. Influence of magnetic field on physical–chemical properties of the liquid water: Insights from experimental and theoretical models. Journal of Molecular Structure, 888(1–3), Pp. 409–415.

Ziaeifar, N., Khosravi, M., Behnajady, M. A., Sohrabi, M. R., and Modirshahla, N. 2015. Optimizing adsorption of Cr (VI) from aqueous solutions by NiO nanoparticles using Taguchi and response surface methods. Water Science and Technology, 72(5), Pp. 721–729.