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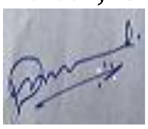
Editorial Note

CSIBER International Journal of Environment (CIJE) offers a venue where relevant interdisciplinary research, practice and case studies are recognized and evaluated. Increasingly, environmental sciences and management integrate many different scientific and professional disciplines. Thus the journal seeks to set a rigorous, credible standard for specifically interdisciplinary environmental research. CIJE is a multidisciplinary journal, publishing research on the pollution taking place in the world due to anthropogenic activities. CIJE welcomes submissions that explore environmental changes and their cause across the following disciplines like atmosphere and climate, biogeochemical dynamics, ecosystem restoration, environmental science, environmental economics & management, environmental informatics, remote sensing, environmental policy & governance, environmental systems engineering, freshwater science, interdisciplinary climate studies, land use dynamics, social-ecological urban systems, soil processes, toxicology, pollution and the environment, water and wastewater management, etc.

We invite authors to contribute original high-quality research on recent advancements and practices in Environment Management. We encourage theoretical, experimental (in the field or in the lab), and empirical contributions. The journal will continue to promote knowledge and publish outstanding quality of research so that everyone can benefit from it.

Er. D. S. Mali
Editor, CIJE



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Contents

Removal of Hexavalent Chromium from Industrial Waste by using Iron Nanoparticles

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Abstract

In recent decades one of the most significant areas of research has been the recycling and removal of toxic chemicals and heavy metals from industrial waste recognized as a sustainable and cost-effective strategy among hazardous heavy metals hexavalent chromium stands out as a genotoxic and carcinogenic by-product of various manufacturing activities often released into the environment in harmful concentrations. Globally chromium exists in two forms trivalent chromium which is natural and essential for metabolism and hexavalent chromium which is highly toxic and poses serious health risks including lung cancer hexavalent chromium is commonly used in industries like electroplating tanning dyeing and coating and research indicates it can be very harmful to human health consequently researchers have focused on remediation techniques for removal of hexavalent chromium. In this context, we have chosen synthesized iron nanoparticles produced through the co-precipitation method which have been characterized by their heat sensitivity up to 60^{0}C, pH stability between 2 and 10 and spectrometric absorption properties making them suitable adsorbents for hexavalent chromium removal from industrial effluents. The reduction of chromium levels was verified using UV-spectrometry before and after the addition of synthesized iron nanoparticles. our observations indicated that the addition of iron nanoparticles to industrial wastewater containing chromium resulted in a noticeable reduction in colour and an increase in absorption time and a rise in UV absorption levels in the future this method will be considered for chromium (VI) remediation.

Keywords: Hexavalent Chromium, Iron Nanoparticles, Chromium Remediation

Introduction:

Heavy metals contamination in water is a significant factor contributing to global health and environmental issues. Industrial discharges and sewage sludge introduce various pollutants into water bodies, subsequently infiltrating rivers and contaminating groundwater and drinking supplies. The presence of these HMs has exacerbated water pollution problems, leading to detrimental effects on both the economy and public health (**Irshad *et al.*, 2023; Singla, 2022; Kowalik *et al.*, 2021; Irshad *et al.*, 2021; Ahmad *et al.*, 2021**). Among these, chromium (Cr) stands out as one of the most dangerous metals, entering the environment from various natural and anthropogenic sources, thereby posing threats to all forms of life, including humans. Consumption of water contaminated with chromium can lead to serious health issues affecting the cardiovascular and urinary systems, as well as causing bone deformities, hypertension, infertility, and emphysema (**Shaari *et al.*, 2022; Haider *et al.*, 2021; Burakov *et al.*, 2018**).

The rapid pace of industrialization has led to a concerning increase in the levels of this toxic metal in our environment. The growing demand for clean water, coupled with its natural composition and the environmental repercussions stemming from inadequate safety measures and public regulations regarding industrial waste discharge, poses a significant risk of future water scarcity. Consequently, there is a pressing need for more effective and cost-efficient wastewater treatment methods to supplant traditional approaches (**Masood *et al.*, 2021; Vikrant *et al.*, 2019**). The management and removal of chromium (Cr) from wastewater represent critical environmental challenges for researchers, policymakers, and manufacturers, given the serious threats it poses to ecosystems (**Othmani *et al.*, 2022; Borah *et al.*, 2018**). Various conventional techniques have been employed in wastewater treatment facilities to address the issue of chromium contamination; however, these methods often fall short, as wastewater typically requires additional processing before disposal. Thus, identifying and assessing effective sorbents for chromium removal has become a significant challenge. Numerous nanomaterials have been developed as highly efficient, cost-effective, and environmentally friendly adsorbents for chromium extraction from wastewater. These nanomaterials offer distinct advantages over traditional sorbents, such as activated carbon and zeolite, due to their unique physicochemical properties, which include a high specific surface area, reduced diffusion pathways, and customizable active surface sites that enhance their sorption capabilities.

This study provides a comprehensive analysis of the efficient removal of chromium (Cr) from wastewater utilizing nanomaterials. It explores the significance of nanotechnology in tackling wastewater contaminated with Cr.

Unlike conventional methods, this article presents a thorough examination of the advantages, challenges, opportunities, and limitations related to the application of nanomaterials for chromium removal. The primary objective is to offer an extensive overview of the existing literature on Cr removal and recovery, emphasizing the detrimental environmental impacts of Cr pollution and the interactions of Cr adsorption with various nanomaterials. This study aims to deepen the understanding of environmental professionals regarding the potential of nanomaterials and their relevance in research from laboratory to pilot scale. It serves as a valuable resource for researchers and practitioners interested in exploring nanotechnology-based strategies for effective and sustainable remediation of Cr, while also taking into account the broader environmental implications.

Materials and Methods

Materials

Iron (II) chloride, $FeCl_2.4H_2O$ and iron (III) chloride, $FeCl_3$ were purchased from Sigma-Aldrich Company Thermo Fisher Scientific supplied Sulphuric acid (H_2SO_4) and sodium hydroxide (NaOH).

Synthesis of Iron Nanoparticles:

In this experiment, Fe_2O_3 nanoparticles were produced through the co-precipitation method. Specifically, 0.7954 g of iron (II) chloride, $FeCl_2.4H_2O$, and 1.2974 g of iron (III) chloride, $FeCl_3$, were dissolved in distilled water. The mole ratio of iron (II) chloride to iron (III) chloride was consistently maintained at 1:2 during the entire process. The resulting solution was stirred for 30 minutes on a hot plate with a magnetic stirrer. Throughout the mixing, various parameters, including temperature, pH, and stirring rates, were carefully adjusted. Following this, the mixed solution underwent centrifugation at 4000 rpm for 15 minutes to isolate the precipitate. The obtained precipitate was then dried in an oven at 100 °C for 24 hours. Finally, the dried dark brown precipitate was collected and finely powdered using a pestle and mortar. **(Hui and Salimi, 2020).**

Adsorption of Cr (VI) removal

During this experiment, Cr (VI) removal was performed in a 250 mL beaker with a magnetic stirrer frequency of 400 rpm. Each beaker contained 0.01 g crude nanoparticles and 100 mL Cr (VI) wastewater containing approximately 1gm/L concentration collected from industrial waste. Various operational parameters were examined, such as the dosage of the adsorbent (ranging from 0.2 to 1 g/L), pH levels (from 2 to 10), and contact durations (from 5 to 60 minutes). 2 mL solution was sampled and filtered through a 0.22 µm syringe filter. The concentrations of Cr (VI) in the solutions were determined using the absorbance of Cr (VI) was measured on a UV–vis spectrometer (UV- spectrometer, Bioera, Pune, India). **(Hui and Salimi, 2020) and (Saranya *et.al.* 2017)**

Particle Characterization Technique:

The Fe_2O_3 nanoparticles produced under various processing conditions can be thoroughly analyzed regarding their functional groups, phase composition, crystallite size, and morphological structure. This analysis can be conducted using Fourier Transform Infrared Spectroscopy (FTIR), X-ray diffraction (XRD), and Scanning Electron Microscopy (SEM), respectively. **(Hui and Salimi, 2020).**

Results and Discussion:

Characterization of Iron Nanoparticles by UV–Vis Spectral Analysis:

According to the literature, the solution's colour changed during nanoparticle formation. We notice the colour change after the addition of iron solution indicates the formation of nanoparticles (**Abdelfatah *et al.* 2021**). The synthesized nanoparticles absorption spectra, with an intense peak at 275 nm confirm the production of Iron nanoparticles. The zero-valent iron state was assigned a peak range of 250 - 290 nm, which is entirely consistent with the outcomes of other studies (**Desalegn *et al.* 2019; Naveed *et al.* 2023**).

Figure 1. Synthesized Iron Nanoparticles

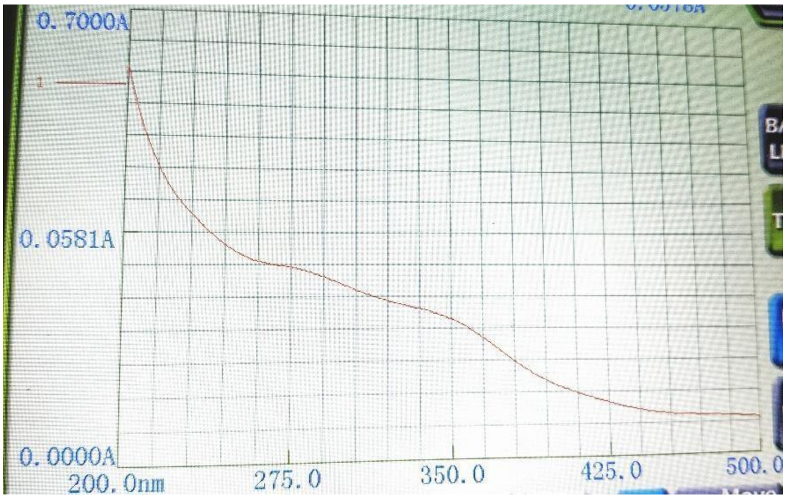
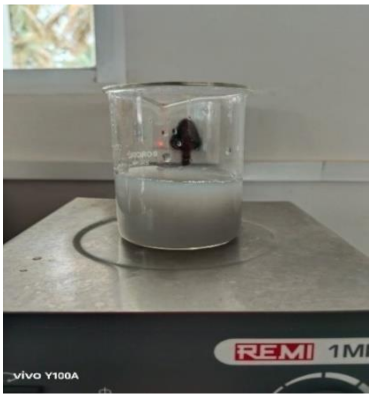


Figure 2. UV-Visible Spectra of synthesized nanoparticles

Effect of pH on Cr (VI) Adsorption:
In our study, we examined the effectiveness of Cr (VI) adsorption across various pH levels ranging from 2 to 10, employing HCl (0.1N) and NaOH (0.1N) for pH adjustments. We combined 10 mg of iron nanoparticles with 50 mL of a 10 mg/L Cr (VI) solution and allowed the mixture to stir for 60 minutes at room temperature. Our results demonstrate that the adsorption capacities for Cr (VI) remain fairly consistent from acidic pH 2 to 6. However, a notable change in adsorption capacity is observed when the pH exceeds 6. This alteration is linked to the ionization of the iron nanoparticles' surface as the pH shifts from acidic to alkaline, which impacts the electrostatic interactions between the adsorbates and adsorbents (**WooáLee and BináKim 2011; Zou *et al.* 2016**). Existing literature emphasizes the importance of maintaining an optimal pH for iron nanoparticles, as acidic conditions can increase iron corrosion. In contrast, alkaline conditions may hinder reactive sites, promoting iron precipitation. Our study indicates that the pH significantly affects the removal of Cr (VI) by iron nanoparticles, resulting in the reduction of Cr (VI) to Cr (III) at alkaline pH (**Djellabi *et al.* 2017; Xu *et al.* 2021)**. Additionally, it is noteworthy that the industrial wastewater sample analyzed contains chromium and other pollutants, which can alter the pH from acidic to alkaline during the Cr (VI) adsorption process.

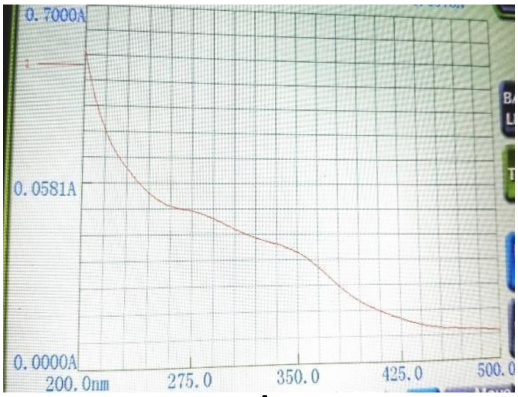
Effect of Temperature on Cr (VI) Adsorption:
To determine the optimal processing temperature, we explored a range from 40 ºC to 60 ºC, while the stirring rates varied between 450 rpm and 600 rpm. Our findings indicate that a temperature of 50 ºC is most effective for Cr (VI) adsorption. Additionally, the stirring rate is a crucial factor, with maximum absorption observed at 460 rpm. Conversely, as the stirring rate increases, the absorption tends to decrease. This phenomenon can be attributed to the high level of agitation, which introduces significant energy into the suspension medium, leading to the dispersion of the solution into smaller precipitates. Consequently, the stirring rate influences both nucleation and aggregation, ultimately affecting particle size. (**Yusoff *et.al* 2018**, **Prabu *et.al.* 2006**, **Li *et.al.* 2006**).

A.

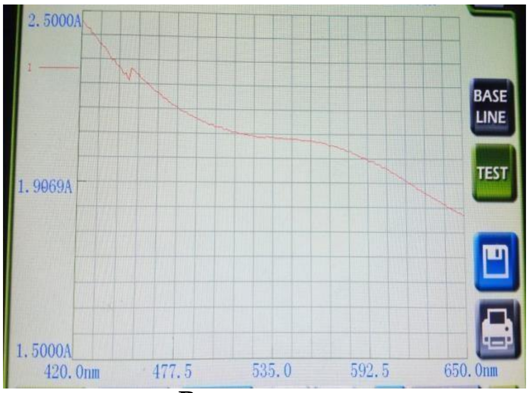


B.

Figure 3. A. Initial colour of Industrial wastewater and 3.B. After remediation colour change.



A.



B.

Figure 4.A. UV Spectra of industrial wastewater before the remediation process

4.B. UV Spectra after 20 mins during the process.

The data is presented in Figure 4. A indicates that the collected industrial wastewater containing Cr (VI) exhibits a prominent peak in the range of 275 to 350 nm, confirming the presence of Cr (VI) in its natural state. This observation closely aligns with the standard peak value associated with Cr (VI). In Figure 4. B, it is illustrated that Cr (VI) gradually reduces to Cr (III), with a peak detected between 420 and 477 nm. This finding suggests that a reduction of chromium has taken place during the remediation process. Additionally, the colour of the Cr (VI) solution changed from sky blue to grey upon treatment with synthesized iron nanoparticles, signifying the successful conversion of Cr (VI) to Cr (III). The Particle Characterization by SEM and XRD analysis were under process which gives complete characterization.

The interaction time of iron nanoparticles with Cr (VI) ranges from 2 min. to 60. We noticed that the time increases the absorption also increases.

Conclusion:

The study finds that synthesized iron nanoparticles effectively and sustainably remove Cr (VI) from industrial wastewater. Their characteristics depend on factors like pH, temperature, stirring, and contact time. Further research is needed to determine the exact remediation rate. Particle size and shape are influenced by optimal temperature and pH. This approach supports Cr (VI) remediation and aligns with circular economy principles. Future studies will aim to improve the performance and long-term stability of iron nanoparticles in real wastewater conditions for Cr (VI) and other pollutants.

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