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MODERN METHODS FOR TREATING WASTEWATER CONTAINING CHROMIUM (VI)

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Introduction. Chromium (VI) in industrial wastewater poses serious environmental and health risks due to its high solubility and persistence (Bashir, 2021). Used in electroplating, tanning, and metal processing, improper disposal leads to soil and water contamination (Nahid et al., 2020). Unlike the less toxic Cr (III), Cr (VI) is a strong oxidizer linked to respiratory diseases and carcinogenicity even at low concentrations (Shekhawat et al., 2015; Barakat, 2010). Treatment is challenging due to its high toxicity and mobility (Ziwen et al., 2020), interference with biological methods (Shekhawat et al., 2015), and the risk of secondary pollutants from chemical treatments (Pilipenko & Spassonova, 2020).

Methods for Chromium (VI) Removal

Chemical Precipitation and Reduction. The most common industrial method involves reducing Cr (VI) to Cr (III) using reducing agents such as sodium bisulfite, sulfur dioxide, or ferrous sulfate (Wiryawan et al., 2018). The reduced Cr (III) precipitates as chromium hydroxide in an alkaline medium. This method is cost-effective but increases the salinity of treated water, requiring further purification (Jayarathna et al., 2015).

Electrochemical Treatment. Electrochemical processes, including electrocoagulation and electrochemical reduction, effectively convert Cr (VI) into Cr (III) (Pilipenko & Spassonova, 2020). These methods offer high efficiency but require significant energy input and specialized equipment (Suvorin et al., 2019).

Adsorption Techniques. Adsorption is a widely studied method due to its simplicity and effectiveness (Barakat, 2010). Various adsorbents, including activated carbon, clay minerals, and biochar, have shown high efficiency in Cr (VI) removal (Gorshkova et al., 2015). However, adsorbent regeneration and disposal remain challenges (Jayarathna et al., 2015).

Biological Treatment. Microbial and plant-based remediation strategies leverage natural bioadsorption and bioreduction processes (Gorshkova et al., 2015). Certain bacteria and microalgae can reduce Cr (VI) to Cr (III) and accumulate heavy metals. Although promising, these methods require further research to enhance efficiency and adaptability for industrial applications (Suvorin et al., 2019).

Future Prospects and Recommendations. Improving Cr (VI) removal efficiency and sustainability requires hybrid technologies integrating chemical, electrochemical, and biological methods (Pilipenko & Spassonova, 2020). Advancements in nanomaterials and functionalized adsorbents can enhance adsorption capacity (Barakat, 2010), while genetically engineered microorganisms offer promising bioremediation potential (Gorshkova et al., 2015).

Conclusion. Effective removal of Cr (VI) from industrial wastewater requires a combination of treatment approaches tailored to specific industrial needs. While conventional chemical methods remain widely used, advancements in electrochemical, adsorption, and biological techniques offer promising alternatives. Continued research and innovation are essential for developing cost-effective and environmentally sustainable solutions.

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