JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Focusing on removal of Manganese from wastewater by various techniques

S.Sophie Beulah
Government College of Engineering, Tirunelveli, Tamilnadu

ABSTRACT

Industrial effluents attribute to environmental degradation. Heavy metal ions in industrial effluents pose a significant threat to water sources. Manganese is one of the contaminants of wastewater necessitating efficient and sustainable removal methods. This paper reviews various techniques that have been used to treat manganese containing wastewater.

Key Words: Manganese, Wastewater, Advanced oxidation, Adsorption, Electrochemical treatment, Bioremediation, Chemical precipitation.

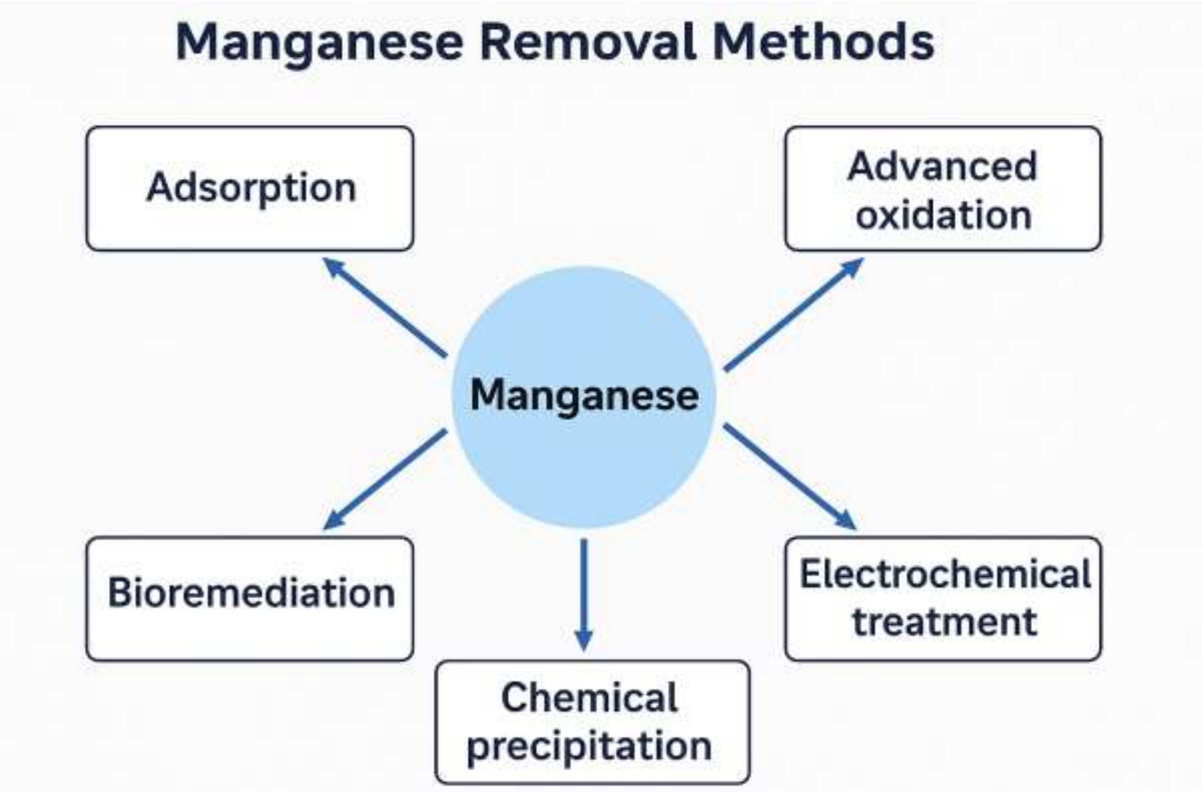
INTRODUCTION

Manganese (Mn), a reddish-gray metal is the twelfth most abundant element with 0.095% estimated concentration in the Earth's crust. The name for this element is derived from the Latin word, magnes which means magnet, referring to the magnetic properties of its ore pyrolusite. Manganese has an atomic number of 25 with atomic weight 54.938 and electron configuration $4s^2 3d^7$. It belongs to 4^{th} period, d-block and the sub group VIIB of the periodic table. It exists in four allotropic modifications: alpha-, beta-, gamma- and delta forms [1].

Manganese (Mn) is an essential nutrient for human life, and numerous enzymes utilize the redox properties of this element. However, high levels of Mn in the water supply stain porcelain and cause an undesirable taste in beverages. Manganese is also toxic to humans when present in excessive concentrations in water. Emerging health studies have shown that its half-life in bones is about 8–9 years, once Mn is absorbed by humans. Even worse, Mn can be transported directly to the brain, leading to nerve toxicity. A disease called called manganism causes anxiety, ataxia and dementia[2]

Given the adverse effects of Mn on human health, the World Health Organization in 2004 suggested a guidance value of 0.2 mg/L in freshwater. Many countries have also set limits for Mn concentration in water bodies. For example, the European Commission and the United States Environmental Protection Agency have set the Mn level in drinking water at 0.05 mg/L [3,4].

This review paper gives different approaches of removal of Manganese removal from wastewater like advanced oxidation process, adsorption, electrochemical treatment, bioremediation, Chemical precipitation.



DIFFERENT APPROACHES OF REMOVAL

ADVANCED OXIDATION PROCESS

Advanced oxidation process uses hydroxy radicals to oxidize and remove pollutants from wastewater. Common types include ozonation, UV/H_2O_2 and Fenton processes.

Jeirani et al evaluated the effectiveness of batch UV, ozone, and UV/ozone induced oxidation processes in treatment of manganese and organics in reverse osmosis concentrate stream. Although UV-ozonation could remove manganese completely at initial ozone concentration of 15.2 ppm, oxidation with ozone alone at initial concentration of 6.2 ppm is found to be the most suitable condition for manganese removal. At low initial ozone concentration of 6.2 ppm, the removal for manganese reached 97.2%. [5]

ADSORPTION

Adsorption is a process where heavy metal ions from wastewater attach to the surface of a solid material called an adsorbent.

Ashraf Ali hydrolyzed Banana peels with alkali followed by bleaching with sodium chlorate ($NaClO_3$). The grafting co-polymerization of acrylonitrile onto the bleached pulp was carried out using Fenton's reagent (Fe^{+}/H_2O_2) as initiator.. The adsorption of Mn(II) onto grafted banana peels was recorded to be 94%. The adsorption equilibrium was fitted well by Langmuir isotherm model[6]

Eugeniu vasile et al investigated the removal of Mn(II) ions from wastewater using magnetite nanomaterial. Maximum efficiency was observed at *p*H 11.5 resulting in a yield of 97.50%. At a lower *p*H 8, the maximum depollution efficiency was 91%. The treatment time required to reach the maximum capacity of the magnetite nanomaterial in order to remove the Mn(II) ions was 500 min[7]

Ashenafi Zeleke Melaku examined and found that the maximum percent removal of manganese ion obtained from laboratory synthetic wastewater at equilibrium are 98.90 % and 97.93 % by M. stenopetala bark and seed, respectively. Thus, adsorption by bark best fits of Temkin model with R^2 value of 0.9707, while adsorption by seed follows the Langmuir model with R^2 value of 0.9733. Adsorption kinetics result indicated that pseudo second-order model well fitted with R^2 value of 0.9912 and 0.9947 for bark and seed adsorbents[8]

ELECTROCHEMICAL TREATMENT

Electrochemical treatment uses electric current to remove pollutants and heavy metals like manganese from wastewater.

Du et al studied peroxymonosulfate (PMS)-assisted iron electrolysis for electro-oxidation/coagulation (EO/EC) pretreatment combined with a ceramic ultrafiltration (UF) membrane for simultaneous manganese (0–1.0 mg/L) and phosphorus (0–0.8 mg/L) removal from surface water. The optimum EO/EC operation conditions appear were current(I) of 0.2 A with an electrolysis time of 60 s at pH 7.5 under a PMS dosage of 100 μM. [9]

BIOREMEDIATION

Bioremediation uses microorganisms such as bacteria, fungi or algae to convert pollutants from wastewater into harmless forms.

Li et al analysed use of Mn-oxidizing bacteria (MnOB) and microalgae for the bioremediation of manganese from wastewater.MnOB can efficiently oxidize dissolved Mn(II) to Mn(III, IV) through enzymatic catalysis. Microalgae can also accelerate Mn(II) oxidation through indirect oxidation by increasing solution pH and dissolved oxygen production during its growth. Microbial oxidation and the removal of Mn(II) have been effective in treating artificial wastewater and groundwater under neutral conditions with adequate oxygen For Mn ore wastewater, its intense acidity and the lack of DO can inhibit Mn(II) removal using traditional biological Mn oxidation. However, these limitations may be addressed using microalgae because algal growth can increase solution DO levels and pH values, thereby offering optimum conditions for microbial Mn(II) oxidation in acid mine waters.[10].

CHEMICAL PRECIPITATION

Precipitation is a method in which contaminants (in dissolved or suspended form) are separated from the solution as a sediment, which can then be filtered, centrifuged, or otherwise separated from the liquid part. Chemical precipitation is an effective and widely used process in the industry. It is characterized by simplicity and it is inexpensive to operate. It can be used to remove pollutants from municipal and industrial wastewater. It can also be used for water softening, heavy metal removal from metal plating wastes, oil and grease removal from emulsified solutions, and phosphate removal from wash-waters and other wastewater[11, 12].

Li et al studied carbonate precipitation for dissolved Mn recovery. At the wastewater treatment station of CITIC Dameng Mining Industries Limited (Daxi City, China), sodium carbonate was added to a tank containing 150 m^3 of manganese mine wastewater after the initial solution pH was adjusted to 8.5–9.0, where a frame filter removed the solid product. X-ray diffraction (XRD) analysis of the filter residue indicated its main component was $MnCO_3$, and some Mn(IV) was also found[13].

CONCLUSION

The removal of manganese from wastewater is essential to prevent environmental and health hazards. Various treatment methods have shown effective results under different conditions. However some challenges like high operational cost, large scale study remain. Future research should focus on developing hybrid method for greater efficiency and eco-friendliness.

REFERENCES

1. Deepti S. Patil, Sanjay M. Chavan, John U. Kennedy Oubagaranadin,(2016) A review of technologies for manganese removal from wastewaters, Journal of Environmental Chemical Engineering, 4(1), 468-487.

2. Li, Y.; Xu, Z.; Ma, H.; Hursthouse, A.S(2019). Removal of Manganese(II) from Acid Mine Wastewater: A Review of the Challenges and Opportunities with Special Emphasis on Mn-Oxidizing Bacteria and Microalgae. Water, 11, 2493.

3. Council directive 98/83 about water quality intended for human consumption. Off. J. Eur. Communities L 1998, 330, 32–54.

4. United States Environmental Protection Agency. Secondary Drinking Water Regulations: Guidance for Nuisance Chemicals; USEPA: Washington, DC, USA, 2013.

5. Jeirani, Z., Sadeghi, A., Soltan, J., et al., 2015. Effectiveness of advanced oxidation processes for the removal of manganese and organic compounds in membrane concentrate. Separ. Purif. Technol. 149, 110–115.

6. Ashraf Ali(2017)Removal of Mn(II) from water using chemically modified banana peels as efficient adsorbent,Environmental Nanotechnology, Monitoring & Management,
7,57-63.

7. Vasile, Eugeniu & Covaliu Mierla, Cristina Ileana & Stoian, Oana & G., Paraschiv & Matei, Ecaterina & Alina, Catrina & Ciric, Alexandru. (2020). Manganese Ions Removal from Industrial Wastewater. Revista de Chimie. 71. 391-396.

8. Ashenafi Zeleke Melaku(2023), Removal of manganese from wastewater using Moringa stenopetala plant parts as an adsorbent material,Heliyon,9(12).

9.Du, X., Zhang, K., Xie, B., et al.,(2019). Peroxymono sulfate-assisted electro oxidation/coagulation coupled with ceramic membrane for manganese and phosphorus removal in surface water. Chem. Eng. J. 334–343

10.Li, Y.; Xu, Z.; Ma, H.; S. Hursthouse, A.(2019) Removal of Manganese(II) from Acid Mine Wastewater: A Review of the Challenges and Opportunities with Special Emphasis on Mn-Oxidizing Bacteria and Microalgae. Water, 11, 2493.

11. US Environmental Protection Agency (US EPA) (2000). Wastewater technology fact sheet chemical precipitation, 832-F-00-018, Washington, DC.

12. Fu, F., & Wang, Q. (2011). Removal of heavy metal ions from wastewaters: a review. Journal of Environmental Management, 92, 407–418.

13. Li, M.; Yang, Y.; Lu, Q.; Liang, Y.; Nong, Z.; Liu, H.; Li, Q.(2017)Treatment and resource utilization of wastewater with high manganese concentration. China's Manganese Ind. 35, 51–54.