As per UGC guidelines an electronic bar code is provided to secure your paper

International Journal for Modern Trends in Science and Technology
Volume 11, Issue 05, pages 1278-1280
ISSN: 2455-3778 online
Available online at: http://www.ijmtst.com/vol11issue05.html
DOI: https://doi.org/10.5281/zenodo.15546053

A Review on Removal of Dyes from Aqueous Solution by Various Adsorbents

S.Sophie Beulah

Government College of Engineering, Tirunelveli, Tamilnadu

To Cite this Article
S.Sophie Beulah (2025). A Review on Removal of Dyes from Aqueous Solution by Various Adsorbents. International Journal for Modern Trends in Science and Technology, 11(05), 1278-1280. https://doi.org/10.5281/zenodo.15546053

Article Info
Received: 05 May 2025; Accepted: 28 May 2025.; Published: 29 May 2025.

KEYWORDS

Dyes, water, Adsorption, Adsorbents

ABSTRACT

The quality of water resources is declining due to urbanization, unsustainability practices, industrialization and pollution. Various dyes and metal ions cause contamination of water bodies. Dyes are released from leather, pigment and textile industries. They alter the colour, taste and odour of water, decreases oxygen concentration, endangering aquatic life and cause serious health issues in humans. Among the effluent treatment technologies adsorption is considered as efficacious and reliable. In this review paper a list of literature has been compiled with regard to various adsorbents used for the removal of dyes from wastewater.

1. INTRODUCTION

Dyes are coloured compounds used for colouring textiles , fibres and wool. Dyes are usually classified based on their chemical structure, such as anionic, cationic, and non ionic [1]. Dyes are released from several industrial sources including textile, paper, leather, rubber ,cosmetic, and printing industries[2]. The direct disposal of untreated dye-containing effluent into natural water bodies has an adverse effect on the photosynthetic activity in aquatic ecosystems.[3] It creates mutagenic or teratogenic effects on aquatic organisms and fish species due to the existence of metals and aromatics.[4] Further, the presence of dyes in the environment has mild to severe toxic effects on human health, including carcinogenic, mutagenic, allergic, dermatitis effects, and kidney disease[5]. Remediation of dye wastewater is carried out using coagulation/flocculation, electrocoagulation, filtration, ion-exchange, advanced oxidation processes, activated sludge processes and adsorption.

Bio adsorbents are the recent materials employed in various sectors to remove dyes and other pollutants. Charcoal, peat, chitin, microbial biomass (fungi, bacteria, yeast, etc.), wood bark, and other agricultural and industrial wastes are frequently used bio-adsorbents[6]. Owing to eco-friendly, low cost, and good surface characteristics, biomass-based adsorbents are attracting attention and are widely studied. Also other adsorbents like composites, fly ash textile filters fabricated by UV Irradiation, Industrial waste materials, nanocomposites etc are also studied for dye removal. This review assesses the potential of various adsorbents utilized for the removal of dyes from wastewater.

2. LITERATURE REVIEW

Jennifer Yhon et al assessed the use of banana peel as an adsorbent in a continuous process for the removal of methylene blue. The adsorption efficiency of lab-scale continuous systems using a stock solution of 0.5 g/L methylene blue was analyzed. The best performance was found at pH 6, with a particle size of 0.08–0.3 mm and a fixed bed height of 7.5 cm. The total adsorption capacity was 22.11 mg/g based on experimental data and 25.40 mg/g based on mathematical modelling (Thomas model). The saturation time was 53 h[7]

Ismat Ara Eti et al produced composite film comprising chitosan, polyvinyl alcohol, and corn starch incorporating nanocellulose (CPCN). The composite film was prepared by a blending method wherein nanocellulose was extracted using a chemical method from banana bract. The maximum adsorption was found to be up to 63.13 mg/g Methylene Blue with a pH of 10, adsorbent dosage of 2 g, an initial concentration of 150 ppm, and contact time of 120 min at room temperature (25°C). The Langmuir adsorption isotherm model fitted well with MB dye adsorption data.[8]

Sujin Ryu et al modified the surface of a textile substrate, Nylon fabric through UV irradiation to create a monomer capable of facilely bonding with dyes. At a monomer concentration of 10%, the fabricated filter exhibited a dye removal efficiency of 97.34% after 24 h, all without the need for a pressure treatment or temperature increase. It displayed an adsorption capacity of approximately 77.88 mg per 1 g of filter material[9]

Syieluing Wong et al investigated the adsorption of Reactive Black 5 and Congo Red from aqueous solution by coffee waste modified with polyethylenimine. The removal percentages of both dyes increased with amount of polyethyleneimine in the modified adsorbent. The adsorbent possessed higher maximum adsorption capacity towards Reactive Black 5 (77.52 mg/g) than Congo Red (34.36 mg/g), due to the higher number of functional groups in Reactive Black 5 that interact with the adsorbent[10]

Jain et al. used steel and fertilizer industrial waste as an adsorbent material for the adsorption of ethyl orange, metanil yellow, and Acid Blue 113 dyes. In this process, they achieved an adsorption capacity of 198, 211, and 219 mg/g respectively.[11]

Mahapatra et al. reported a maximum adsorption capacity of 416.66 mg/g at pH 7 for the adsorptive decolorization of Congo red dye on an Fe_2O_3–Al_2O_3 nanohybrid. This higher adsorption capacity was due to the interaction of the amine functional group of the Congo red dye molecules with the oxy-hydroxide group of the nanohybrid material[12]

Haque et al. developed highly porous MIL-101 Metal Organic Frameworks to study the adsorption of Methyl Orange. The high adsorption capacity of 194 mg/g depicted the significance of pore size and porosity in the adsorption of Methyl Orange, following the mechanism of electrostatic interaction on MIL-101[13]

Ahmad et al. utilized lemongrass leaf-based activated carbon to remediate methyl red from contaminated water. Their findings showed an optimum dye adsorption capacity of 76.923 m/ g at pH 2 within 5 h. An increase in the adsorption rate of methyl red dye was mainly observed with an increase in temperature, dye concentration, and contact time[14]

Ayisha Sidiqua and Priya found that binded clay along with prepared activated carbon from sapindus seed gave a better basic yellow dye removal efficiency of about 86% at alkaline pH of 9. Freundlich model fitted the data with a relatively higher R^2 values[15]

Sachin et al synthesized a powdered adsorbent ZnOS+C, modified zinc peroxide with sulfur and activated carbon to effectively remove Fast Green dye from wastewater. Results of batch adsorption experiments suggested that ZnOS+C had the maximum adsorption potential of 238.28 mg/g for FG dye within 120 min of adsorption equilibrium for a wide range of pH ranging from 2 to 10 pH. The adsorption process conformed to the Freundlich isotherm model, [16]

Maria Harja et al removed Congo Red dye from a simulated textile wastewater solution using fly ash from a local power plant.. The influence of four parameters (contact time, initial concentration, adsorbent dose, and temperature) was analysed. CR dye adsorption capacity improved with increasing CR initial concentration, temperature and contact time. The Langmuir model fitted the experimental data, with a maximum adsorption capacity of 22.12 mg/g[17]

3. CONCLUSION

This review has given an overview of the various adsorbents used for the removal of dyes from wastewater. It is possible to use new raw materials as adsorbents instead of expensive commercial activated carbon to remove dye from aqueous solutions. Textile industries usually comprise a mixture of many dyes. Further studies can be conducted with mixed pollutants to enhance the requirement of wastewater treatment.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] Heidari, M., Varma, R., Ahmadian,M., Pourkhosravani, M., Asadzadeh, S., Karimi,P., et al. (2019). Photo-Fenton like Catalyst System: Activated Carbon/CoFe2O4 Nanocomposite for Reactive Dye Removal from Textile Wastewater. Appl. Sci. 9, 963–1015.

[2] Piaskowski, K., Świderska-Dąbrowska, R., and Zarzycki, P. K. (2018). Dye Removal from Water and Wastewater Using Various Physical, Chemical, and Biological Processes. J.AOAC Int. 101, 1371–1384

[3] Nasar A, Mashkoor F(2019). Application of polyaniline-based adsorbents for dye removal from water and wastewater-a review. Environ Sci Pollut Res Int. ;26(6):5333-5356

[4] Lau EV, Gan S, Ng HK, Poh PE.(2014) Extraction agents for the removal of polycyclic aromatic hydrocarbons (PAHs) from soil in soil washing technologies. Environ Pollut. ;184:640-9

[5] Lellis, B., Favaro-Polonio, C. Z., Pamphile, J. A., & Polonio, J. C. (2019). Effects of Textile Dyes on Health and the Environment and Bioremediation Potential of Living Organisms. Biotechnology Research and Innovation, 3, 275-290.

[6] Kumar, A., Singh, R., Kumar Upadhyay Sanjay Kumar, S., Charaya, M. U., and Charaya, M. U. (2021). Biosorption: the Removal of Toxic Dyes from Industrial Effluent Using Phytobiomass- a Review. Plant Arch. 21, 1320–1325.

[7] Yhon, J.; Mendoza, J.;Osorio, E.; Domínguez, M.P(2023) Continuous Removal of Dyes from Wastewater Using Banana-Peel Bioadsorbent: A Low-Cost Alternative for Wastewater Treatment. Sustainability, 15, 9870.

[8] Ismat Ara Eti, Marufa Khatun, Most. Afroza Khatun, Md. Owaleur Rahman, K. M. Anis-Ul-Haque,2 and Md. Jahangir Alam,"(2023) Removal of Dye from Wastewater Using a Novel Composite Film Incorporating Nanocellulose" Advances in Polymer Technology, Article ID 4431941, 9 pages

[9] Ryu, S.; Park, Y.K.; Shim, J.; Lim, S.; Kim, M.(2024) Highly Sustainable Dyes Adsorption in Wastewater Using Textile Filters Fabricated by UV Irradiation. Polymers, 16, 15.

[10] Wong S, Ghafar N.A, Ngadi N, Razmi F.A, Inuwa I.M, Mat R & Amin N.A.S (2020), "Effective removal of anionic textile dyes using adsorbent synthesized from coffee waste", Scientific Reports, 10(1), Article 2928.

[11] Jain AK, Gupta VK, Bhatnagar A, Suhas(2003) Utilization of industrial waste products as adsorbents for the removal of dyes. J Hazard Mater, 4;101(1):31-42.

[12] Mahapatra, A. & Mishra, B.G. & Hota, Garudadhwaj. (2013). Adsorptive removal of Congo red dye from wastewater by mixed iron oxide–alumina nanocomposites. Ceramics International. 39. 5443–5451

[13] Enamul Haque, Ji Eun Lee, In Tae Jang, Young Kyu Hwang, Jong-San Chang, Jonggeon Jegal, Sung Hwa Jhung(2010) Adsorptive removal of methyl orange from aqueous solution with metal-organic frameworks, porous chromium-benzene dicarboxylates,Journal of Hazardous Materials,Volume 181, Issues 1–3, Pages 535-542,

[14] M. A. Ahmad, N. B. Ahmed, K. A. Adegoke and O. S. Bello(2019) Sorption studies of methyl red dye removal using lemon grass(Cymbopogon Citratus) Chem. Data Collect. 22, 100249

[15] M. Ayisha Sidiqua, V.S. Priya,(2021) Removal of yellow dye using composite binded adsorbent developed using natural clay and activated carbon from sapindus seed, Biocatalysis and Agricultural Biotechnology,Volume 33

[16] Sachin, Biplob Kumar Pramanik, Harshit Gupta, Shrawan Kumar, Jai Shankar Tawale, Kalpit Shah, Ezhilselvi Varathan and Nahar Singh(2023) "Development of a ZnOS+C Composite as a Potential Adsorbent for the Effective Removal of Fast Green Dye from Real Wastewater" ACS Omega, 8, 10, 9230–9238.

[17] Harja, M., Buema, G. and Bucur(2022) D. Recent advances in removal of Congo Red dye by adsorption using an industrial waste. Sci Rep 12, 6087.