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Green Adsorbents as a Sustainable Alternative for Water Environments: A Review

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Abstract*: The presence of heavy metal, chromium (VI), in water environments leads to various diseases in humans, such as cancer, lung tumors, and allergies. This review comparatively examines the use of several adsorbents, such as biosorbents, activated carbon, nanocomposites, and polyaniline (PANI), in terms of the operational parameters (initial chromium (VI) concentration (Co), temperature (T), pH, contact time (t), and adsorbent dosage) to achieve the Langmuir's maximum adsorption capacity (qm) for chromium (VI) adsorption. The study finds that the use of biosorbents (fruit bio-composite, fungus, leave, and oak bark char), activated carbons (HCl-treated dry fruit waste, polyethyleneimine (PEI) and potassium hydroxide (KOH) PEI-KOH alkali-treated rice waste-derived biochar, and KOH/hydrochloric acid (HCl) acid/base-treated commercial), iron-based nanocomposites, magnetic manganese-multiwalled carbon nanotubes nano composites, copper-based nanocomposites, graphene oxide functionalized amino acid, and PANI functionalized transition metal are effective in achieving high Langmuir's maximum adsorption capacity (qm) for chromium (VI) adsorption, and that operational parameters such as initial concentration, temperature, pH, contact time, and adsorbent dosage significantly affect the Langmuir's maximum adsorption capacity (qm). Magnetic graphene oxide functionalized amino acid showed the highest experimental and pseudo-second-order kinetic model equilibrium adsorption capacities.*

Keywords: Biosorbent, Graphene, Nanocomposite

I. INTRODUCTION

Wastewater is becoming more challenging worldwide, especially in developing countries, due to rapid industrial and agricultural development, urbanization, and lifestyle changes. Wastewater containing heavy metals is toxic, carcinogenic, and highly water-soluble, which originates from various sources such as fixing agents, metal complex dyes, pesticides, fertilizers, bleaching agents, mordants, pigments, etc. Moreover, heavy metals in wastewater and industrial effluents pose significant environmental concerns to human and marine life. The heavy metals of the most concern include chromium, nickel, mercury, lead, cadmium, zinc, arsenic, and copper, as represented in Fig. 1. Chromium (Cr), a commonly known heavy metal, is extensively used in various applications such as chrome plating, catalysts, leather tanning, electroplating, glass industries, textile industries, petroleum refineries, wood preservation, etc. It is found in

aqueous solution/industrial wastewater in two states - trivalent (Cr(III)) and hexavalent (Cr(VI)). Hexavalent chromium (Cr(VI)),which exists primarily as the chromate ion (Cr2O4), can penetrate the cellular membranes about 500–1000 times more effectively as compared to the Cr(III). For example, dyes containing several toxic heavy metals (especially chromium) are vigorously used in textile industries to impart color to the products/raw materials. Examples of the various industries contributing to Cr(VI) pollution are summarized. The discharge of industrial effluents from various sources containing Cr(VI) into the water bodies poses a risk to aquatic life because of its toxic and corrosive nature. It is quickly collected and bio-magnified in the species through fish. It leads to an enhanced.

Biosorbents

Biomass-based adsorbents, commonly known as biosorbents, are extensively used to remove heavy metals. Biosorbents from low cost agricultural waste can remove and recover heavy metal contaminants such as chromium ions from

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wastewater streams [37–44]. Examples of biosorbents used for the removal of Cr(VI) from wastewater include Macadamia nutshells [45], pine cone biomass [46], Cannabinus kenaf [47], Masau stones [48], sawdust [49], almond green hull [50], grape peelings [51], lemon peel powder [52], coir pith [53] and fungal biomass [54]. Activated carbons are used extensively as adsorbent material for removing chromium due to their high surface area (500–1500 m2 g 1), well-developed microporous structure, and a wide spectrum of surface functional groups like the carboxylic group [55,81]. It is the most commonly used adsorbent for chromium adsorption [93]. It is used extensively for chromium adsorption during wastewater treatment [56,81,93].

Biosorbents and Langmuir adsorption isotherm

The maximum adsorption capacity is dependent on the type of biosorbent. Several biosorbents, such as fruit waste biosorbent, fungal biosorbent, leaf biosorbent, and biochar biosorbent for Cr(VI) adsorption, have been used. The Langmuir adsorption isotherms of the biosorbents are evaluated based on the maximum adsorption capacity, Langmuir constant (KL), and R2 value. The best maximum adsorption capacity of biosorbent is exhibited by the mango kernel bio-composite (fruit waste biosorbent) mortality rate, mucous secretion, scale erosion, discoloration, abnormal swimming and osmoregulatory function disruption in fishes [18,19]. Thus, Cr(VI) enters the terrestrial food chain and gets into humans through fish in extremely bio-magnified amounts. It poses various health-related issues like genotoxicity, liver damage, kidney damage, neurotoxicity, lung cancer, asthma, immunotoxicity, skin ulcers, mutagenic, teratogenic, and carcinogenic [20–25]. Furthermore, Cr(VI) is the cause of various health issues such as hepatopathy, skin irritation, lung cancer, and pulmonary congestion [26,27]. The rats reportedly undergo functional and structural abnormalities of the thyroid and pituitary glands due to Cr(VI) injection [28]. Thus, an effective technique for Cr(VI) remediation from wastewater should be adopted. The international regulatory body "World Health Organization," commonly known as WHO, has set 50 μg L 1 as a Cr(VI) limit in drinking water to avoid endangered drinking water and human health [29]. Hence, developing effective technologies and strategies to remove Cr(VI) from wastewater is essential.

II. CONCLUSION

Heavy metals in wastewater are a severe concern for human and marine life. Hexavalent chromium in wastewater leads to various diseases, such as cancer, lung tumors, and allergies. Different adsorbents are being used to remove the hexavalent chromium from wastewater, such as biosorbents (fruit waste, leaves, fungus, and biochar), activated carbon (acid-treated, base treated, and acid/base treated), nanocomposites (Fe-based, Mn-based, Cu based, and graphene-based) and PANI. It is observed that the magnetic graphene oxide functionalized amino acid and PANI functionalized transition metal adsorbents have been found to have the highest Langmuir's maximum adsorption capacity. Furthermore, the magnetic graphene oxide functionalized amino acid has been found to have the highest experimental and pseudo-second-order kinetic model equilibrium adsorption capacities while following the multilayer adsorption and chemisorption. The highest heterogenous adsorption capacity is found in iron oxide functionalized calcium carbonate nanocomposites following mono-layer adsorption and chemisorption. It is important to consider operational parameters such as initial Cr(VI) concentration, temperature, pH, contact time, and adsorbent dosage for optimal results in adsorption experiments. These operational parameters play a vital role in Langmuir's maximum adsorption capacity. The Langmuir isotherm plays a significant role in determining the adsorption mechanism of the adsorbents by correlation co-efficients (R2). It has been observed that the source of the adsorbent significantly highlights the monolayer and multilayer adsorption mechanisms. Several adsorbents showed monolayer adsorption, such as biosorbent, activated carbon adsorbent, nanocomposite, and PANI-based adsorbent. Hexavalent chromium is an important naturally occurring metal extensively found in several industrial wastewaters, including leather tanning and electroplating. Tannery wastewater treatment for hexavalent chromium adsorption using syzygium cumini bark biosorbent has the highest Langmuir's maximum adsorption capacity among other adsorbents and other sources of industrial wastewaters due to the higher initial hexavalent chromium concentration, while following Freundlich adsorption isotherm and pseudo-second-order kinetic model indicating multi-layer adsorption, heterogeneity of syzygium cumini bark biosorbent, and chemisorption.

REFERENCES

[1] S. Chowdhury, R. Balasubramanian, Recent advances in the use of graphene-family nanoadsorbents for removal of toxic pollutants from wastewater, Adv. Colloid Interface Sci. 204 (2014) 35–56, https://doi.org/10.1016/j.cis.2013.12.005.

[2] H. Wang, X. Yuan, Y. Wu, H. Huang, X. Peng, G. Zeng, H. Zhong, J. Liang, M. Ren, Graphene-based materials: fabrication, characterization and application for the decontamination of wastewater and wastegas and hydrogen storage/generation, Adv. Colloid Interface Sci. 195–196 (2013) 19–40, https://doi.org/10.1016/j.cis.2013.03.009.

[3] X. Li, K. Schneider, Control-flow guided clause generation for property directed reachability, in: 2016 IEEE Int. High Lev. Des. Valid. Test Work., 2016, pp. 17–24, https://doi.org/10.1109/HLDVT.2016.7748250.

[4] K.S. Rao, M. Mohapatra, S. Anand, P. Venkateswarlu, Review on cadmium removal from aqueous solutions, Int. J. Eng. Sci. Technol. 2 (2010).

[5] S.K. Gunatilake, Methods of removing heavy metals from industrial wastewater, Methods 1 (2015) 14.

[6] S. Mehdipour, V. Vatanpour, H.-R. Kariminia, Influence of ion interaction on lead removal by a polyamide nanofiltration membrane, Desalination 362 (2015) 84–92, https://doi.org/10.1016/j.desal.2015.01.030.

[7] M. Bhaumik, K. Setshedi, A. Maity, M.S. Onyango, Chromium(VI) removal from water using fixed bed column of polypyrrole/Fe3O4 nanocomposite, Sep. Purif. Technol. 110 (2013) 11–19, https://doi.org/10.1016/j.seppur.2013.02.037.

[8] N.H. Kera, M. Bhaumik, N. Ballav, K. Pillay, S.S. Ray, A. Maity, Selective removal of Cr(VI) from aqueous solution by polypyrrole/2,5-diaminobenzene sulfonic acid composite, J. Colloid Interface Sci. 476 (2016) 144–157, https://doi.org/10.1016/j.jcis.2016.05.011.

[9] H. Huang, X. Yuan, G. Zeng, H. Zhu, H. Li, Z. Liu, H. Jiang, L. Leng, W. Bi, Quantitative evaluation of heavy metals' pollution hazards in liquefaction residues of sewage sludge, Bioresour. Technol. 102 (2011) 10346–10351, https://doi.org/10.1016/j.biortech.2011.08.117.

[10] J. Belagyi, M. Pas, P. Raspor, M. Pesti, T. P´ali, Effect of hexavalent chromium on eukaryotic plasma membrane studied by EPR spectroscopy, Biochim. Biophys. Acta Biomembr. 1421 (1999) 175–182