IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 5, Issue 3, April 2025

Impact Factor: 7.67

Adsorptive Removal of Chromium from Waste Water Using Low-Cost Adsorbents

Dilip D. Anuse

Department of Chemistry

Dahiwadi College Dahiwadi, Maharashtra, India

dilipanuse11@gmail.com

Abstract: *Now-a-days because of the aggressive world population increment, rapid industrialization, agricultural and household activities, civilization leads to high levels contamination of water in terms of inorganic and organic pollutants. Variety of chromium ions present in industrial waste water can adversely affect to terrestrial and aquatic ecosystems. Trivalent chromium is essential element in small amount and also less toxic than hexavalent chromium. Hexavalent chromium is more toxic than trivalent chromium and also non-essential element thus needs to be removed from industrial waste water. Different techniques have been developed by number of researchers for removal of hexavalent chromium from waste water. This included precipitation, evaporation, electroplating and ion exchange. However, these processes works with various limitations which included removal of hexavalent chromium is restricted to a certain concentration of chromium ions. Thus, adsorption is an alternate process for removing Chromium ions. Adsorptive removal of chromium ions from waste water is an economical one because of the enhanced characteristics of the process of adsorption such as cost-effectiveness, improved adsorptive properties, and increased availability. Therefore, the process of removal of hexavalent chromium by using low-cost adsorbents can be assumed as an eco-friendly one. This review provides a brief summary of the related literature which exists on the low-cost adsorption for removing Chromium from industrial wastewaters this review will also explore the various existing adsorption models. These include the isotherm, kinetics, and thermodynamics along with the impact of various factors on the process of adsorption*

Keywords: Low-cost adsorbents, Adsorption, chromiumions

I. INTRODUCTION

Water is the most important and widespread natural resource in the universe needed for supporting all forms of life and affect development of industries Heavy metals are necessary for all existing organisms in minute amounts for our bodies to function very well. For instance, manganese is required for the metabolism of carbohydrates and the synthesis of fats vital for a healthy reproductive system. It also has some association with the development of organs and tissues [1]. Rapid industrial development causes huge pollution on our planet especially contamination in the heavy metals that result from the mining industries, large world traffic...etc, that chromium to passive effects on the plants and ecology [2]. One of the higher toxicity elements is the Chromium, it's contaminating the water, soil and the ecology system in general. Chromium discharges mostly coming from the textile, leather tanning, metal extraction factory, and electroplating as effluents [3]. Common states of the Chromium oxidation are trivalent state and hexavalent state, they are more stable and constant. The Chromium in the hexavalent state considered higher toxicity than the Chromium in the trivalent state due to form a complex compound with Oxygen such as Cr2O2 − and CrO4 −2 oxoanions [4]. Conventional treatment techniques employed for the removal of heavy metals from wastewater include chemical precipitation flocculation and coagulation reverse osmosis membrane filtration electro dialysis and evaporative recovery. These methods have been long used to treat wastewater prior to releasing it in to aquatic bodies [5]. However, these wastewater treatment methods are associated with high maintenance and operation costs. Chemical precipitation methods are reliable but on the other hand, require voluminous settling tanks for precipitation of alkaline sludge and subsequent treatment by separation is required [6]. Among all these technologies, adsorption is one of the simplest, economically viable, and effective techniques useful for the removal of heavy metals from effluents. It is defined as a process whereby a substance travels from a liquid or gaseous phase and establishes a superficial monomolecular layer on the solid or liquid phase [7]. Activated carbon (Ac) is mostly used as an adsorbent due to its high adsorption capacities, but it has notoriety for high production prices. Therefore, the utilization of waste materials as low-cost adsorbents is acknowledged as a possible and economical application for wastewater treatment. This is reflected in the increasing numbers of periodicals, that show using low-cost materials as adsorbents in the literature. These mainly conclude the immense interest in finding appropriate adsorbents for the process of adsorption [8-9]. This review provide an outline for the elimination of chromium ions from waste water by adsorption processes utilizing low-cost adsorbents. This will be achieved by underlining the characteristics of the adsorbents, their optimum parameters, and their adsorption capacity. The major aim of the manuscript is to offer a survey about the latest studies which are related to the adsorption processes using low-cost materials as adsorbents to Chromium ions elimination.

II. FACTOR AFFECTING ON ADSORPTION OF CHROMIUM BY VARIOUS ADSORBENT MATERIALS

In this review article various conditions for adsorption of chromium are considered including pH of solution, concentration of metal ion, contact time and dose of adsorbent etc. Adsorption capacity of various adsorbents obtained from waste materials under different conditions are also summarized

EFFECT OF PH

Chromium ion adsorption from waste water is usually dominated by solutions pH. The factor pH on which the adsorption of chromium depends, susceptibly,[10]. The effect of pH on adsorption capacity of different adsorbent is given in table No. 1. The pH range for removal of chromium was best attain range in between 2-4. With increase in pH adsorption of chromium decreases. It is seen that for adsorption of chromium acidic pH is more suitable. For most of adsorbent the suitable pH for adsorption of chromium is found to be 2.

EFFECT OF INITIAL CONCENTRATION

The removal of chromium by various adsorbent using different initial concentration of chromium is tabulated in table No.2. The initial concentration ranges between 10 mg/L - 100mg/L. The corncob reported the maximum removal capacity was 208 mg/g at pH 2. The maple waste reported minimum adsorption efficiency 5 mg/g at pH 6 with 10 mg/L initial concentration.

EFFECT OF ADSORBENT DOSE

Adsorbent dosage is useful variable in determining the adsorbents capacities at known concentration of adsorbate. Different adsorbent materials with adsorbent dose were investigated is given in table No.3. The data indicate that maximum adsorption capacity was obtained at higher adsorbent dose, because of increase in surface area of adsorbent. Adsorption dose range is 0.01 – 5 g/L

EFFECT OF CONTACT TIME

Information in Table no. 4 indicate that, the contact time have vital role in adsorption of chromium, Cane papyrus shows maximum adsorption capacity 154 mg/g in 90 min at pH 6.

Table -1. Effect of pH

Adsorbent	pH	Adsorption Capacity mg g^{-1}	Ref
Mixed waste tea	2	94.34	[11]
Coffee ground	2	87.72	[12]
Peanut shell	4	8.31	[13]
Coconut shell charcoal	4	10.88	[14]
Treated waste newspaper	3	59.88	[15]
Walnut shell	2	40.83	[16]

Fertilizer industry waste	4	15.24	[17]
Rice husk	2	13.1	[18]
Tamarind hull based	2	81	[19]

TABLE -2. EFFECT OF INITIAL CONCENTRATION

Adsorbent	pH	Initial Concentration Mg/L	Adsorption Capacity mg g^{-1}	Ref
Corncob	2	100	208	[20]
peanut shell	2	100	8.31	[21]
groundnut husk	2	12.5	131	[22]
Sunflower	2	1000	4	[23]
Fly ash	1	60	4	[24]
Maple waste	6	10	5	[25[

TABLE-3. EFFECT OF DOSE

Adsorbent	pH	Dosage	Adsorption Capacity mg g^{-1}	Ref
Banana skin	1.5	5 g/L	249.4	[26]
Cassia fistula biomass	5.2	0.01 g/mL	96.21	[27]
Chemically modified date pits (CMDP) & olive stone (CMOS)	2	4 g/L	CMDP: 82.63, CMOS: 53.31	[28]
Date palm empty fruit bunch	2	0.3g	70.49	[29]
Ficus nitida leaves	1.5	0.8 g	21	[30]
Tea waste	5.2	0.6g/L	99.2	[31]
Treated pine sawdust	2	4 g	-	[32]

TABLE-4. EFFECT OF CONTACT TIME

Adsorbent	pH	Interaction time (Min)	Adsorption Capacity mg g^{-1}	Ref
Peat and coconut fibre	7	80	1.25	[33]
Carrots	2	120	26.2	[34]
Rice husk	4	120	102.96	[35]
Cane papyrus	6	90	154.76	[36]
Fermentation Waste	6	90	35.17	[37]
Coir pith	6	60	79.6	[38]
Groundnut hull	6	60	40	[39]
Eggshell	6	120	49.5	[40]

TABLE-5. ADSORPTION ISOTHERM

Adsorbent	pH	Adsorption Capacity mg g^{-1}	Isotherm	Ref
Banana Peel	8	38.46	Langmuir	[41]
Orange peel	8	41.66	Langmuir	[42]
Pomegranate peel	5.5	93.75	Freundlich	[43]
Pomegranate peelpolypyrrole	1	95.35	Freundlich	[44]
Tangerine peel	8	17.54	Langmuir	[45]

TABLE-6. KINETIC STUDY

Adsorbent	pH	Adsorption Capacity mg g^{-1}	Kinetic Model	Ref
Banana Peel	8	38.46	Pseudo second order	[46]
Orange peel	8	41.66	Pseudo first order	[47]
Tamarind pod shell	5	92.34	Pseudo first order	[48]

III. CONCLUSION

Adsorption plays very important role in removal of hazardous materials from waste water. This review article gives comprehensive information about use of low-cost adsorbent for removing of chromium ions utilizing adsorptive procedure. This review article reveals that, various adsorption capacities of for various low-cost adsorption materials. The adsorption capacity of low-cost adsorbents also depends on various factors. The equilibrium data were analysed using different isotherm models from this Langmuir isotherm better fitted for most of the adsorbent materials. Isotherm kinetics was modelled by using the pseudo first and second order kinetic equation. In conclusion, for removal of toxic chromium metal from waste water low-cost adsorbents has broad applications.

ACKNOWLEDGMENT

Author of this paper would like to thank the Department of Chemistry Shivaji University Kolhapur, Dahiwadi College Dahiwadi & Rajarshi Chhatrapati Shahu College, Kolhapur.

REFERENCES

[1]. Hsu, H. W., Bondy, S. C., & Kitazawa, M. (2018). Environmental and dietary exposure to copper and its cellular mechanisms linking to Alzheimer’s disease. Toxicological sciences, 163(2), 338-345.

[2]. Hussein, A. A., & Alatabe, M. J. A. (2019). Remediation of lead-contaminated soil, using clean energy in combination with electro-kinetic methods. Pollution, 5(4), 859- 869.

[3]. Jun, R., Ling, T., & Guanghua, Z. (2009). Effects of chromium on seed germination, root elongation and coleoptile growth in six pulses. International Journal of Environmental Science & Technology, 6, 571-578.

[4]. Antoniadis, V., Zanni, A. A., Levizou, E., Shaheen, S. M., Dimirkou, A., Bolan, N., & Rinklebe, J. (2018). Modulation of hexavalent chromium toxicity on Origanum vulgare in an acidic soil amended with peat, lime, and zeolite. Chemosphere, 195, 291-300.

[5]. Lim, A. P., & Aris, A. Z. (2014). A review on economically adsorbents on heavy metals removal in water and wastewater. Reviews in Environmental Science and Bio/Technology, 13, 163-181.

[6]. Marchioretto, M. M., Bruning, H., & Rulkens, W. (2005). Heavy metals precipitation in sewage sludge. Separation science and technology, 40(16), 3393-3405.

[7]. Crawford, C. B., & Quinn, B. (2017). The interactions of microplastics and chemical pollutants. Microplastic pollutants, 131-157

[8]. jaafar Al-atabi, M. (2018). A novel approach for adsorption of copper (II) ions from wastewater using cane papyrus. International Journal of Integrated Engineering, 10(1).

[9]. Alatabe, M. J. A., & Al-Sharify, Z. T. (2019). Utilization of low cost adsorbents for the adsorption process of lead ions. International Journal of Modern Research in Engineering and Technology, 4(11), 29-48.

[10]. Cherdchoo, W., Nithettham, S., & Charoenpanich, J. (2019). Removal of Cr (VI) from synthetic wastewater by adsorption onto coffee ground and mixed waste tea. Chemosphere, 221, 758-767.

[11]. Cherdchoo, W., Nithettham, S., & Charoenpanich, J. (2019). Removal of Cr (VI) from synthetic wastewater by adsorption onto coffee ground and mixed waste tea. Chemosphere, 221, 758-767.

[12]. Al-Othman, Z. A., Ali, R., & Naushad, M. (2012). Hexavalent chromium removal from aqueous medium by activated carbon prepared from peanut shell: adsorption kinetics, equilibrium and thermodynamic studies. Chemical engineering journal, 184, 238-247.

[13]. Babel, S., & Kurniawan, T. A. (2004). Cr (VI) removal from synthetic wastewater using coconut shell charcoal and commercial activated carbon modified with oxidizing agents and/or chitosan. Chemosphere, 54(7), 951-967.

[14]. Dehghani, M. H., Sanaei, D., Ali, I., & Bhatnagar, A. (2016). Removal of chromium (VI) from aqueous solution using treated waste newspaper as a low-cost adsorbent: kinetic modeling and isotherm studies. Journal of molecular liquids, 215, 671-679.

[15]. Gupta, V. K., Rastogi, A., & Nayak, A. (2010). Adsorption studies on the removal of hexavalent chromium from aqueous solution using a low cost fertilizer industry waste material. Journal of Colloid and Interface Science, 342(1), 135-141.

[16]. Sugashini, S., & Begum, K. M. M. S. (2015). Preparation of activated carbon from carbonized rice husk by ozone activation for Cr (VI) removal. New carbon materials, 30(3), 252-261.

[17]. Verma, A., Chakraborty, S., & Basu, J. K. (2006). Adsorption study of hexavalent chromium using tamarind hull-based adsorbents. Separation and Purification Technology, 50(3), 336-341.

[18]. Manzoor, Q., Sajid, A., Hussain, T., Iqbal, M., Abbas, M., & Nisar, J. (2019). Efficiency of immobilized Zea mays biomass for the adsorption of chromium from simulated media and tannery wastewater. Journal of Materials Research and Technology, 8(1), 75-86.

[19]. Al-Othman, Z. A., Ali, R., & Naushad, M. (2012). Hexavalent chromium removal from aqueous medium by activated carbon prepared from peanut shell: adsorption kinetics, equilibrium and thermodynamic studies. Chemical engineering journal, 184, 238-247.

[20]. Owalude, S. O., & Tella, A. C. (2016). Removal of hexavalent chromium from aqueous solutions by adsorption on modified groundnut hull. Beni-suef university journal of basic and applied sciences, 5(4), 377-388.

[21]. Jain, M., Garg, V. K., & Kadirvelu, K. (2009). Chromium (VI) removal from aqueous system using Helianthus annuus (sunflower) stem waste. Journal of hazardous materials, 162(1), 365-372.

[22]. Vaid, U., Mittal, S., & Babu, J. N. (2014). Removal of hexavalent chromium from aqueous solution using biomass derived fly ash from Waste-to-Energy power plant. Desalination and Water Treatment, 52(40-42), 7845-7855

[23]. Yu, L. J., Shukla, S. S., Dorris, K. L., Shukla, A., & Margrave, J. L. (2003). Adsorption of chromium from aqueous solutions by maple sawdust. *Journal of hazardous materials*, *100*(1-3), 53-63.

[24]. Park, D., Lim, S. R., Yun, Y. S., & Park, J. M. (2008). Development of a new Cr (VI)- biosorbent from agricultural biowaste. Bioresource Technology, 99(18), 8810-8818.

[25]. Abbas, M., Nadeem, R., Zafar, M. N., & Arshad, M. (2008). Biosorption of chromium

[26]. (III) and chromium (VI) by untreated and pretreated Cassia fistula biomass from aqueous solutions. Water, Air, and Soil Pollution, 191, 139-148.

[27]. Mangwandi, C., Kurniawan, T. A., & Albadarin, A. B. (2020). Comparative biosorption of chromium (VI) using chemically modified date pits (CM-DP) and olive stone (CM- OS): Kinetics, isotherms and influence of co-existing ions. Chemical Engineering Research and Design, 156, 251-262.

[28]. Rambabu, K., Bharath, G., Banat, F., & Show, P. L. (2020). Biosorption performance of date palm empty fruit bunch wastes for toxic hexavalent chromium removal. Environmental research, 187, 109694.

[29]. Ali, I. H., & Alrafai, H. (2016). Kinetic, isotherm and thermodynamic studies on biosorption of chromium (VI) by using activated carbon from leaves of Ficus nitida. Chemistry Central Journal, 10, 1-7.

[30]. Khalil, U., Shakoor, M. B., Ali, S., & Rizwan, M. (2018). Tea waste as a potential biowaste for removal of hexavalent chromium from wastewater: equilibrium and kinetic studies. Arabian Journal of Geosciences, 11, 1-9.

[31]. Uysal, M., & Ar, I. (2007). Removal of Cr (VI) from industrial wastewaters by adsorption: Part I: Determination of optimum conditions. Journal of Hazardous Materials, 149(2), 482-491.

[32]. Henryk, K., Jarosław, C., & Witold, Ż. (2016). Peat and coconut fiber as biofilters for chromium adsorption from contaminated wastewaters. Environmental Science and Pollution Research, 23, 527-534.

[33]. Lilli, M. A., Syranidou, E., Palliou, A., Nikolaidis, N. P., Karatzas, G., & Kalogerakis,

[34]. N. (2017). Assessing the impact of geogenic chromium uptake by carrots (Daucus carota) grown in Asopos river basin. Environmental research, 152, 96-101.

[35]. Vieira, M. G. A., de Almeida Neto, A. F., Silva, M. G., Nóbrega, C. C., & Melo Filho,

[36]. A. (2012). Characterization and use of in natura and calcined rice husks for biosorption of heavy metals ions from aqueous effluents. Brazilian Journal of Chemical Engineering, 29, 619-634.

[37]. Alatabe, M. J. A., & Hussein, A. A. (2017). Isotherm and kinetics studies, adsorption of chromium (III) ions from wastewater using cane papyrus. Themed Section: Engineering and Technology, 3(6), 676-686.

[38]. Park, D., Yun, Y. S., Kim, J. Y., & Park, J. M. (2008). How to study Cr (VI) biosorption: Use of fermentation waste for detoxifying Cr (VI) in aqueous solution. Chemical Engineering Journal, 136(2-3), 173-179.

[39]. Suksabye, P., Thiravetyan, P., Nakbanpote, W., & Chayabutra, S. (2007). Chromium removal from electroplating wastewater by coir pith. Journal of Hazardous Materials, 141(3), 637-644.

[40]. Qaiser, S., Saleemi, A. R., & Umar, M. (2009). Biosorption of lead (II) and chromium

[41]. (VI) on groundnut hull: Equilibrium, kinetics and thermodynamics study. Electronic journal of Biotechnology, 12(4), 3-4

[42]. Ghazy, S. E., El-Asmy, A. A., & El-Nokrashy, A. M. (2008). Separation of chromium (III) and chromium (VI) from environmental water samples using eggshell sorbent. Indian Journal of Science and Technology, 1(6), 1-7.

[43]. Al-Qahtani, K. M. (2016). Water purification using different waste fruit cortexes for the removal of heavy metals. Journal of taibah university for science, 10(5), 700-708.

[44]. Al-Qahtani, K. M. (2016). Water purification using different waste fruit cortexes for the removal of heavy metals. Journal of taibah university for science, 10(5), 700-708.

[45]. Rafiaee, S., Samani, M. R., & Toghraie, D. (2020). Removal of hexavalent chromium from aqueous media using pomegranate peels modified by polymeric coatings: effects of various composite synthesis parameters. Synthetic Metals, 265, 116416.

[46]. Rafiaee, S., Samani, M. R., & Toghraie, D. (2020). Removal of hexavalent chromium from aqueous media using pomegranate peels modified by polymeric coatings: effects of various composite synthesis parameters. Synthetic Metals, 265, 116416.

[47]. Al-Qahtani, K. M. (2016). Water purification using different waste fruit cortexes for the removal of heavy metals. Journal of taibah university for science, 10(5), 700-708.

[48]. Al-Qahtani, K. M. (2016). Water purification using different waste fruit cortexes for the removal of heavy metals. Journal of taibah university for science, 10(5), 700-708.

[49]. Al-Qahtani, K. M. (2016). Water purification using different waste fruit cortexes for the removal of heavy metals. Journal of taibah university for science, 10(5), 700-708

[50]. Vaza, J. S., & Bhalerao, S. A. (2018). Removal of hexavalent chromium by using citric acid modified Tamarind Pod Shell powder (Tamarindus indica L.). Int J Trend Sci Res Dev, 3, 200-215.

[51]. Vaza, J. S., & Bhalerao, S. A. (2018). Removal of hexavalent chromium by using citric acid modified Tamarind Pod Shell powder (Tamarindus indica L.). Int J Trend Sci Res Dev, 3, 200-215.

[52]. Ahalya, N., Kanamadi, R. D., & Ramachandra, T. V. (2008). Biosorption of Chromium (VI) by Tamarindus indica pod shells. Journal of Environmental Science research international, 1(2), 77-81