ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 5.2
IJAR 2017; 3(7): 474-477
www.allresearchjournal.com
Received: 09-05-2017
Accepted: 10-06-2017

Tara Vishvkarma
M-Tech., Department of Chemical Engineering, Ujjain Engineering College, Ujjain, Madhya Pradesh, India

Dr. Ashok Sharma
Associate Professor, Department of Chemical Engineering, Ujjain Engineering College, Ujjain, Madhya Pradesh, India

Dr. Sarita Sharma
Associate Professor, Department of Chemical Engineering, Ujjain Engineering College, Ujjain, Madhya Pradesh, India

Correspondence
Tara Vishvkarma
M-Tech., Department of Chemical Engineering, Ujjain Engineering College, Ujjain, Madhya Pradesh, India

Removal of chromium from aqueous solution-Review

Tara Vishvkarma, Dr. Ashok Sharma and Dr. Sarita Sharma

Abstract
Chromium is highly toxic heavy metal for our environment and it poses a serious threat to human health and aquatic life in water. Its high concentration present in water causes several health diseases such as lung, cancer, and developmental defects among children due to industrial activities. It is used in various industrial processes like electroplating, leather tanning, ferrochromium production etc. The maximum permissible limit of chromium in drinking water is 0.05 mg/l (WHO). Some factors also affect the adsorption of chromium from waste water.

Keywords: Chromium, wastewater, Adsorption, Heavy Metals, environment

Introduction
One of the most important and toxic heavy metals in wastewater is chromium. Cr (VI) is released from different industrial operations (Khatoon *et. al.,* 2013) [4]. It is a common pollutant introduced into natural waters due to the discharge of a variety of industrial wastewaters. In industrial wastewater mostly the chromium is found in two forms, one is hexavalent and the other is trivalent, whereas the hexavalent form is more common and hazardous to biological activities (Talokar, 2011).
According to the World Health Organization (WHO) drinking water guidelines, the maximum allowable limit for total chromium is 0.05 mg/l. It is a chemical element in the periodic table that has the symbol Cr and atomic number 24. It is a steel-gray, lustrous, hard metal that takes a high polish and has a high melting point. It is present in the environment in several different forms. The most common forms are chromium (0), chromium (III), and chromium (VI). Chromium (VI) and Chromium (0) are generally produced by industrial processes (Owlad *et. al.*, 2008) [3]. Over the decades, extensive use of chromium in tanning industries have resulted in chromium contaminated soil and ground water at production sites which pose a serious threat to human health, fish and other aquatic biodiversity. Cr(VI) causes skin, lung and throat cancers, infertility, increased incidences of birth and developmental defects among children living around tanneries, leather and chrome industries. The conventional methods for the removing of Cr (VI) from wastewater have been developed such as adsorption, ion exchange, reverse osmosis chemical precipitation, electro-deposition, photo catalysis reduction, and solvent extraction (Khatoon *et. al.*, 2013) [4].
Adsorption method is used for the removal of substances from either gaseous or liquid solutions. Adsorption phenomena are operative in most natural physical, biological, and chemical systems. Separation of a substance from one phase accompanied by its accumulation or concentration at the surface of another is carried out in adsorption. Van der waals forces and electrostatic forces between adsorbate molecules and the atoms which compose the adsorbent surface are involved in physical adsorption. Adsorption capacity depends on properties of adsorbent, adsorbate chemical properties, temperature, ph, and etc. Several adsorbents like activated carbon, silica gel, and activated aumina have been used to treat industrial wastewater (Raut *et. al.*, 2015) [6].
Other methods include ionexchange, electrolysis and reverse osmosis. which are not only expensive and high energy processes, but are also ineffective in removal of metal ions present at lower concentration in large volume of wastewaters. Environmentally friendly processes, therefore, need to be developed to clean-up the environment without creating harmful waste by-products. Biosorption involves application of microorganisms in removal of heavy metals and has been recognized as a potential alternative to the conventional methods for treatment of contaminated wastewaters (Sen and Dastidar, 2010) [5].

Sources of Chromium

Chromium emission sources can be divided into two broad classes, direct and indirect. The direct category primarily includes sources that either produce chromium or consume chromium or a chromium compound to manufacture a product.

The sources categories within the direct category are (H Sunil *et. al.*, 2014) [2]:

Chromites ore refining	60%
Ferrochromium production	71%
Refractory production	3%
Chromium chemicals	17-18%
Chromium plating	70%
Steel production	12-28%
Leather tanning	90%

Chromium is the naturally occurring element which is found in the volcanic-ash, volcanic-gases, soil and rocks. Chrome plating, leather tanning, combustion of natural fuels (gas, oil, coal), catalysts, fertilizers, dye manufacturing industries, battery making, printers, emission from cooling towers, air condensers and incineration of sewage sludge, municipal refuse and other solid wastes, are the anthropogenic sources of chromium emission in the environment. More than 1, 70,000 metric tonnes of chromium wastes are discharged annually in environment as a result of industrial and manufacturing activities. The leather industry is the major cause for the high influx of chromium to the biosphere, accounting for 40% of the total industrial use. Chromium exists in food, air, water and soil, mostly in the trivalent form. It is only as a result of human activities that substantial amounts of Cr (VI) become present in environment. Cr-(III) is comparatively insoluble while Cr(VI) is quite soluble and is readily leached from soil to groundwater or surface water (Jain *et. al.*, 2014) [8].

International and Indian Scenario of Chromium:

16 million people are at risk for exposure to chromium globally with estimation of 3 millions diseases. Upto 2015 about 300 toxic sites are identified around the world. In India Sukinda valley in Jaipur, Kanpur, Yamuna River, Bay of Bengal, Harike wetland (Ramsar site) are facing problem of heavy metal pollution. 14 districts found contaminated with chromium. Andhra Pradesh, Assam, Rajsthan, Punjab, Orissa, Tamilnadu Uttar Pradesh, Karnataka, Himachal Pradesh, Haryana, Madhya Pradesh and five blocks of Delhi. 11 major Indian Rivers, Ganga, Hasdeo, Tel, Ramganga, Ong, Ib, Hamp, Jonk, Kwano, Mahanadi and Mayurakashi found to have chromium concentration exceeding the tolerance limit of 50µg/L which is found about 0.34 mg/L (Gumfawar and Godboley, 2015) [7].

Health Effects of Chromium

Exposure to chromium causes damage to the gastrointestinal, respiratory and immunological system, reproductive and development and causes cancer. It causes skin rashes, upset stomach and ulcers It also effects on aquatic life. It is mutagenic, carcinogenic. Consumption of Cr (VI) causes alteration of genetic material weakened the immune system and may cause death. Its inhalation may cause nose irritation and nosebleed (Gumfawar and Godboley, 2015) [7].

Current technologies available for treatment methods of heavy metal (Ariffin *et. al.*, 2017) [18]

Methods	Advantages	Disadvantages
Oxidation	Rapid process for toxic pollutants removal	High energy costs and formation of by products
Ion exchange ls	Good removal of a wide range of heavy meta LS	Concentrated sludge production and expensive
Adsorption	Flexibility and simplicity of design, ease of operation and insensitivity to toxic pollutants	Adsorbents require regeneration
Coagulation/flocculation	Economically feasible	High sludge production and Formation of large particles.
Electrochemical treatment	Rapid process and effective for certain metal ions	High energy costs and formation of large particles.
Ozonation	Applied in gaseous state; alteration of volume	Short half life
Photochemical	No sludge production	Formation of by-product
Electrokinetic coagulation	Economically feasible	High sludge production
Biological treatment	Feasible in removing some metals	Technology yet to be established and commercialized

Factor affecting adsorption of heavy metal (Ariffin *et. al.*, 2017) [18]

Effect of pH: The surface charge of the solution, degree of ionization, and the adsorbate species influenced by the pH of the solution. Most of the metal adsorbed increase with the increasing of pH of the solution until certain point and followed by reduction if further increasing of pH.

Effect of adsorbent dosage: Dose of adsorbent also is one of the main points to determine the capacity uptake of heavy metals by adsorbents. Usually, increase in the dose of adsorbents will increase in the adsorbed capacity until its reach a limit. If further increase the dose, the adsorption capacity will be constant.

Effect of initial concentration: Adsorption dosage gain a strong effect by initial concentration of heavy metals. Generally, adsorption capacity increased with the increased initial concentration of heavy metals. Playing as important driving force, initial concentration influence in overcome all mass transfer resistance between solid and aqueous phases. Several studies have shown that removal efficiency of heavy metal is concentration dependent and there exist decreasing trend if further increase initial concentration.

Effect of contact time: The interaction of functional group between the solution and the surface of adsorbent result in the adsorption capacity if adsorbate into adsorbent. Specific time needed to maintain equilibrium interaction therefore the adsorption process undergo completion.

Literature Review

The most abundant metal existing in wastewater is Chromium and is considered the most dangerous metal due to it being mutagenic and carcinogenic. Adsorption is a process that collects, or adsorbs, dissolved substances in water to the surface of the materials being used as adsorbent. Adsorption has not been readily used to treat wastewater, but as the demands for better water quality become more rigorous, extensive research have been conducted on the process of adsorption to provide better quality and reduced toxicity of water (Bhattacharjee and Patel, 2017) [9]. Table shows several low cost adsorbent used in adsorption process for removal of chromium from water.

S. No.	Adsorbent	Contact time	Initial Metal Ion Conc.	pH	Dose	% Removal	References
1	Neem	120	30 gm/100ml	2	8 g	85 %	Jain *et. al.*, 2014 [8]
2	Groundnut	5-14min	50 - 300mg/ L	2	2 -20g	51.7- 69 %	H Sunil *et. al.*, 2014 [2]
	Neem powder					79.4 - 87.3 %	
	Modified neemleaf powder					81.9 - 95.7	
	Wheat bran					78.8 - 83.35	
	Activated charcoal					89 - 97.6	
3	Acacia nilotica leaf	90 min	50-200 mg/L	2	0.2 g	96 %	Thilagavathy & Santhi, 2012 [10]
4	Rice Straw	50 min	20 mg/L	4	8 g	91%	Brahmaiah *et. al.*, 2016 [11]
5	Activated coconut shell	60 min	10 ppm	2	1g	88 %	Gupta *et. al.*, 2011 [12]
6	Coffee Husk	60 min	80 mg/L	2	3 g	98.19	Berihun, 2017 [13]
7	Sawdust,	180 min	300mg/L	-	0.5g to 2.5g	76.66%	Mane *et. al.*, 2016 [14]
	Sugarcane bagasse					59.98%	
	Orange peels					39.95%	
8	Ficus racemosa bark	120 min	-	5	6 g	92.3%	Donadkar *et. al.*, 2016 [15]
9	Tamarind Seeds	240 min	200 mg/l	2	10 g	98 %	Gayathri *et. al.*, 2013 [13]
10	Custard apple peel powder	120 min	5 mg/L	3	0.4 g	90.47%	Krishnaa and R. Sree, 2013 [17]

Conclusion

Researchers used many methods for removal of Cr(VI) from waste water. Methods are adsorption, membrane filtration, ion exchange, and electrochemical treatment etc. Adsorption is one of the effective methods for removal of chromium from wastewater. Low cost adsorbent such as neem powder, coconut shell, fly ash, rice husk etc. used for removal of heavy metal. It is very simple method as compared to other expensive methods. The main objective of study to reduce the contamination of chromium from wastewater by using suitable low cost adsorbents.

References

1. Talokar AY. Studies on Removal of Chromium from Waste Water by Adsorption using Low Cost Agricultural Biomass as Adsorbents. International Journal of Advanced Biotechnology and Research. 2011; 2(4):452-456.
2. Sunil H, Karthik KV, Pradeep HN, Shetty Mahesh Kumar. Removal of Chromium (VI) metal ions from waste water using alternative adsorbents-A comparative study. International Journal of Scientific and Research Publications. 2014; 4(1):1-9.
3. Owlad Mojdeh, Aroua Mohamed, Kheireddine, Daud Wan Ashri Wan, Baroutia Saeid. Removal of Hexavalent Chromium-Contaminated Water and Wastewater: A Review Article: Water Air and Soil Pollution, Research Gate, 2008.
4. Khatoon Naseema, Khan Altaf Husain, Pathak Vinay, Agnihotri Neeraj, Rehman Masihur. Removal of Hexavalent Chromium from Synthetic Waste Water using Synthetic Nano Zero Valent Iron (Nzvi) as Adsorbent. International Journal of Innovative Research in Science, Engineering and Technology. 2013, 2(11):6140- 6149.
5. Sen M, Dastidar Ghosh M. Chromium Removal using Various Biosorbents. Iran. J. Environ. Health. Sci. Eng. 2010; 7(3):182-190.
6. Raut Pranay A, Chahande Anup, Moharkar Yogesh. Various techniques for the removal of Chromium and lead from Waste water: Review. International Journal of Emerging Trends in Engineering and Basic Sciences. 2015; 2(2):64-67.
7. Gumfawar Swati, Godboley Buddharatna JA. Review on Removal of Heavy Metal (Cr and Cd) Using Plant Seeds for Purification of Water. International Journal of Science and Research. 2015; 6(20):934-937.
8. Jain Rahul N, Patil SB, Lal DS. Adsorption of Cr (VI) from Aqueous Environment Using Neem Leaves Powder. International Journal of Research in Engineering and Technology. 2014; 3(9):25-28.
9. Bhattacharjee Raka, Patel Reshma. Adsorption of Chromium (Vi) Using Neem Leaves and Pomegranate Peels. Journal of Emerging Technologies and Innovative Research. 2017; 4(5):64-70.
10. Thilagavathy P, Santhi T. Adsorption of Cr (VI) Onto Low-Cost Adsorbent Developed from Acacia Nilotica Leaf Activated with Phosphoric Acid: Kinetic, Equilibrium Isotherm and Thermodynamic Studies. International Journal of Science and Research. 2012; 3(5):308-314.
11. Brahmaiah T, Spurthi L, Chandrika K, Chandra L, Kausalya L, Yashas S. Removal of Heavy Metals from Waste Water Using Low Cost Adsorbent. International Journal of Trend in Research and Development. 2016; 3(1):63-69.
12. Gupta Asha, Yadav Reena, Devi Parmila. Removal of Hexavalent Chromium Using Activated Coconut Shell And Activated Coconut Coir as Low Cost Adsorbent. IIOAB Journal. 2011; 2(3):8-12.
13. Berihun Dessalew. Removal of Chromium from Industrial Wastewater by Adsorption Using Coffee Husk, Journal of Material Sciences & Engineering. 2017; 6(2):1-6.
14. Mane VB, Suryawanshi MA, Kumbhar GB, Sahu Prashant L, Gajbhiye Pratiksha S. Adsorption for the Removal Of Chromium Using Natural Adsorbents, International Research Journal of Engineering and Technology. 2016; 3(8):1951-1955.
15. Donadkar DK, Rahangdale PK, Gour K. Purification of Cr (VI) Contaminated Water Using FRBAC as Low Cost Adsorbent, Der Pharma Chemica. 2016; 8(10):230-235.

16. Gayathri R, Thirumarimurugan M, Kannadasan T. Removal of Chromium Ions From Aqueous Solution Using Tamarind Seeds as an adsorbent. International Journal of Pharmaceutical and Chemical Sciences, 2013; 2(2):984-991.
17. Krishnaa D, Sree Padma R. Removal of Chromium from Aqueous Solution by Custard Apple (Annona Squamosa) Peel Powder as Adsorbent, International Journal of Applied Science and Engineering, 2013; 11(2):171-194.
18. Ariffin Nurliyana, Abdullah Mohd Mustafa Al Bakri, Mohd Arif Zainol Mohd Remy Rozainy, Murshed Mohd Fared, Zain Hariz, Faris Meor Ahmad, Bayuaji RIDHO. MATEC Web of Conferences, ETIC, 2017; 97:1-8.