



**REMOVAL OF HEAVY METALS FROM WATER AND WASTE WATER BY
BATCH ADSORPTION PROCESS.**

Prof. Dr. Anil Kumar and *Prof. Dr. P. P. Vishwakarma

SahuJain (P G) College Najibabad ,Distt- Bijnor (U P) 246763.

***Corresponding Author: Prof. Dr. P. P. Vishwakarma**

SahuJain (P G) College Najibabad ,Distt- Bijnor (U P) 246763.

Article Received on 10/02/2023

Article Revised on 02/03/2023

Article Accepted on 23/03/2023

ABSTRACT

Heavy metals are toxic and detrimental water pollutant. Their presence not only affectshuman beings but also animals and vegetation because of their mobility in aqueous ecosystem, toxicity and non- biodegradability. Removal of heavy metals from the effluent is one of the majorresearches carried out by researchers in the field of environment. The present study is focused on the heavy metals removalbased on the performance of various adsorbents such as natural materials, industrial byproduct and agricultural waste. The objective of this study is tocontribute in the search for low cost adsorbents and investigate the parameters that influence theadsorption of heavy metals on adsorbents.

KEYWORDS: Adsorption; wastewater; Heavy metals; NaturalIndustrialadsorbents.

1 INTRODUCTION

Heavy metals are discharged into water from various industries. They can be toxic or carcinogenic in nature and can cause severe problems for humans and aquatic ecosystems. Due to increasing awareness about the environment and stringent environmental regulations, wastewater treatment has always been a key aspect of research. Water is a vital component for theeconomic prosperity of any country. In coming years, the economic importance of water is expected togrow with the global economic growth, industrial development and urbanization. Industrial wastewatercontains the variety of inorganic compounds which are characterized as toxic, carcinogenic andmutagenic which when persist in the environment have the potential to cause adverse effect on manand vegetation. The heavy metals present in the industrial waste water such as Pb, Cd, Cr, Ni, Zn, Moand As are the most toxic and perilous materials among the other toxic materials from the chemicaland allied industries.^[1] Hence there is burning need for the removal of heavymetals from the wastewater. Various technologies that are currently used for the removal of heavymetals are evaporation, Ion exchange, precipitation, membrane filtration, and adsorption.^[2] Among all these technology batch adsorption process appears to be more favorable technology as it is low cost, require low maintenance, economical and is energy efficient. In this articlethe heavy metals removal performance of various adsorbents such as natural materials, industrialwaste and agricultural waste is reviewed.

2 Heavy Metals and Industrial Waste water

Heavy metal is defined as a metallic element having relatively highdensity, specific gravity or atomicweight. Industrial waste water can contain heavy metals such as Arsenic, Lead, Cadmium, Mercury, Chromium, Nickel, Molybdenum, Cobalt etc.The heavy metal present in waste water does not possess a property to degrade naturally andarealso very toxic to aquatic life even at low concentrations and hence it is essential to remove heavymetals from waste water.

2.1 Heavy Metals Sources and Toxicity

Different metals have different toxicity or toxic profiles depending upontheir chemical form. Thesource of heavy metal includes natural source, mining, smelting, agrochemicals and sewage sludgeapplications and livestock manure uses. Exposure to heavy metals may occur through inhalation oringestion through food, drink, fume or dust which leads to affect the human health. The table:1 givesthe source, permissible limit and impact of most hazardous heavy metals on the human health.

Table 1: Source, Permissible limit and Impact of most hazardous heavy metals on human health.^[3]

S. N	Heavy Metals	Source and permissible limit	Impact
1	Lead (Pb)	Sources include paint, mining wastes, incinerator ash, water from lead pipes and solder, and automobile exhaust. 0. 1 mg/l ^[4]	Causes damage to kidneys, nervous system, learning ability, ability to synthesize protein, and nerve and red blood cells.
2	Cadmium (Cd)	Causes damage to kidneys, nervous system, learning ability, ability to synthesize protein, and nerve and red blood cells. 0. 005 mg/l ^[4]	Causes kidney disease. Renal Disorder, Human carcinogen.
3	Arsenic (As)	Enters the environment through herbicides, wood preservatives, and mining industry. 0. 01. mg/l ^[4]	Causes damage to skin, Eyes, and liver. May also cause cancer. Vascular disease.
4	Chromium (Cr)	Source includes cement industry, effluents from chemical plants, tobacco smoke and contaminated land fill. 0. 05 mg/l ^[4]	Can Cause Pulmonary fibrosis, lung cancer, Headache, Diarrhea, Nausea vomiting, Carcinogenic.
5	Nickel (Ni)	Source includes metal plating industry, table-ware plating, metal finishing, small parts fabrication, plating plants, silver refineries and automotive plating of zinc base casting etc. 1. 0 mg/l ^[5]	Affects air packets of lungs and causing lung cancer, retards plant growth, liver damage. Human carcinogen Chronic asthma, Nausea coughing.
6	Molybdenum (Mo)	High concentrations of Mo are in the aqueous, solid and airborne effluents from many industrial operations. 10 ppm in drinking water. ^[6]	Toxic to ruminant animals. Molybdenosis in ruminants is characterized by diarrhoea, loss of appetite, discoloration of hair, joint abnormalities, osteoporosis, lack of sexual interest, degeneration of testes and in several cases death.

2.2 Treatment Methods for Heavy Metals Removal

The various industrially used methods for the removal of heavy metals are Ion exchange, Chemical precipitation, floatation, electrochemical deposition, adsorption, etc. All these methods are used in industries are expensive and may even produce a large quantity of sludge which further need treatment. Batch adsorption process is currently considered as one of the upcoming process for the treatment of wastewater containing heavy metals.^[7]

3. Adsorption

Adsorption is a process where the atoms, ions or molecules of dissolved solids from liquid grips on the surface of solid; i.e. it is a process of mass transfer in which the dissolved solid from liquid gets deposited on the surface of solid because of physical or chemical interaction.^[8] The major factors of this method are the technical applicability and the cost effectiveness that needs to be considering while selecting adsorbent to treat wastewater. Adsorbents are of different types and are

classified as natural materials, industrial waste, agricultural and biological waste.

3.1 Adsorption on Natural materials

It is well understood by the study of many researcher that limestone is an effective natural geological material for the treatment of water contaminated with heavy metals. However, the reported metal removal efficiency of limestone is lower than expected or desired for intensive remediation operations, particularly with regard to the fundamental factors that affect adsorption processes.^[9] The influence of mechanical milling of natural Serbian clay on removal of heavy metals from an aqueous medium.^[10] This study revealed that a complete adsorption of Cd (II), Cr (III) and Pb (II), (about 98% of the initial concentration) was achieved, while Ni(II) was adsorbed only 90% of their initial concentration^[11] found that by using natural industrial materials. Removals of heavy metals by natural materials are listed below in table: 2.

Table 2: Percentage Removal Capacity of modified industrial materials as adsorbents for heavy metals.

Adsorbents	Percentage Removal Capacity					
	Pb (II)	Cd (II)	Ni (II)	As (III)	Cr (III)	Mo (VI)
Fly ash	98.00	97.00	81.33	83.00	99.00	77.21
China clay	99.00	98.00	90.00	95.00	93.00	79.38
Red mud	96.00	88.00	85.00	89.00	92.00	91.83
Haematite	89.00	87.00	67.00	82.00	81.00	75.34
Activated carbon	87.00	89.00	82.50	91.00	95.00	78.35

The efficiency of adsorbents for the removal of different types of heavy metals from their aqueous solution under the similar conditions of concentration, temperature and pH is in the following order.

(1) For Pb (II) removal,

China clay > Fly ash > Red mud > Haematite > Activated

carbon (2) For Cd (II) removal,

China clay > Fly ash > Activated carbon > Red mud

> Haematite (3) For Ni (II) removal,

China clay > Red mud > Fly ash > Activated carbon

> Haematite (4) For As (III) removal,

China clay > Activated carbon > Red mud > Fly ash

>Haematite(5)For Cr (III) removal,
Fly ash > Activated carbon>China clay > Red mud
>Haematite
(6)For Mo (VI) removal,
Red mud>China clay > Activated carbon > Fly ash
>Haematite
Generally, it was found that China clay was a good adsorbent for the removal of heavy metals and Haematite was bad adsorbent for the removal of such heavy metals, because China clay has more active sites on their outer surface as compare to Haematite as adsorbent.

4. Future Scope

In recent years study of new low cost adsorbents is done most frequently for the treatment of the heavy metal-contaminated wastewater. As many of researcher have claimed that adsorbents such as industrial waste material show good adsorption capacity for the removal of heavy metals and are also easily available at low cost but requires a pretreatment and high handling cost for sludge disposal. It is seen that use of low-cost adsorbents is the keen interest of research for heavy metals removal, more study is required to focus on reducing the cost of pretreatment, regeneration and disposal. Although various different adsorbents can be employed for the treatment of wastewater laden with heavy metals. It is important to note that the selection of the most suitable adsorbent for metal-contaminated wastewater also depends on some basic parameters such as pH, initial metal concentration, the overall treatment performance compared to other technologies, environmental impact as well as economics parameter such as the capital investment and operational costs. Finally, technical applicability, plant simplicity and cost effectiveness are the key factors that play major roles in the selection of the most suitable adsorbent for the process. All the factors mentioned above should be taken into consideration in selecting the most effective adsorbents for the heavy metals removal process most efficiently and effectively.

REFERENCES

- Bernard E., Jimoh A. and Odigure J.O, (2013) Heavy metals removal from industrial wastewater by activated carbon prepared from coconut shell, *Research Journal of Chemical Sciences*, 3(8): 3–9.
- Fenglian Fu, Qi Wang, (2011) Removal of heavy metal ions from wastewaters: A review, *Journal of Environmental Management*, 92(3): 407–418.
- Lars Jarup, (2003) Hazards of heavy metal contamination, *British Medical Bulletin*, 68(1): 167–182.
- Organization WHO, Guidelines for drinking-water quality: recommendations, World Health Organization, 2004.
- Indian standard, Tolerance limits for industrial effluents discharged into Inland surface water, IS, 1963; 5, 2490.
- Vlek, P.L.G. and Lindsay, W.L. "The geochemistry, Cycling and Industrial uses of Molybdenum", Chapter, 1977; 9: 619.
- M.A. Barakat, (2011) New trends in removing heavy metals from industrial wastewater, *Arabian Journal of Chemistry*, 4: 361–377.
- Sandhya Babel, Tonni Agustiono Kurniawan, (2003) Low-cost adsorbents for heavy metals uptake from contaminated water: a review, *Journal of Hazardous Materials B*, 97: 219–243.
- Ali Sdiri, Teruo Higashi, Fakher Jamoussi, Samir Bouaziz, (2012) Effects of impurities on the removal of heavy metals by natural limestones in aqueous systems, *Journal of Environmental Management*, 93(1): 245–253.
- Andjelka Djukic, Uros Jovanovic, Tamara Tuvic, Velibor Andric, Jasmina Grbovi, Novakovic, Nenad Ivanovic, Ljiljana Matovic, (2013) The potential of ball-milled Serbian natural clay for removal of heavy metal contaminants from wastewaters: Simultaneous sorption of Ni, Cr, Cd and Pb ions, *Ceramics International*, 39(6): 7173–7178.
- M.A. Shavandi, Z. Haddadian, M.H.S. Ismail, N. Abdullah, Z.Z. Abidin, (2012) Removal of Fe(III), Mn(II) and Zn(II) from palm oil mill effluent (POME) by natural zeolite, *Journal of the Taiwan Institute of Chemical Engineers*, 43(5): 750–759.