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REMOVAL OF HEAVY METALS FROM WATER AND WASTEWATERBY BATCH ADSORPTION PROCESS

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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 favorabletechnology 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 henceit is essential to remove heavymetals from waste water.

2.1 Heavy Metals Sources and Toxicity

Different metals have different toxicity or toxic profiles depending uponttheir 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 tokidneys, nervoussystem, learning ability, ability tosynthesizeprotein, and nerve and red blood cells.
2	Cadmium (Cd)	Causes damagetokidneys, nervoussystem, learningability,ability to synthesizeprotein, andnerve andred blood cells. 0.005 mg/l [4]	Causes kidney disease. RenalDisorder, Human carcinogen.
3	Arsenic (As)	Enters the environmentthrough herbicides, wood preservatives, andmining industry.0.01 mg/l[4]	Causes damage to skin, Eyes, and liver. Mayalso causecancer. Vascular disease.
4	Chromium (Cr)	Source includes cementindustry,effluents fromchemical plants,tobaccosmoke and contaminated land fill. 0.05 mg/l[4]	Can Cause Pulmonary fibrosis, lung cancer, Headache, Diarrhea, Nauseavomiting, Carcinogenic.
5	Nickel (Ni)	Source includes metal plating industry, table-ware plating, metalfinishing, small partsfabrication, platingplants, silver refineriesand automotive plating of zinc base casting etc. 1.0 mg/l[5]	Affects air packets of lungs andcausing lung cancer, retards plant growth, liver damage.Human carcinogen Chronic asthma, Nausea coughing.
6	Molybdenum (Mo)	High concentrations ofMo are in the aqueous, solid and airborneeffluents from manyindustrial operations. 10 ppm in drinking water.[6]	Toxic to ruminantanimals. Molybdenosis in ruminants is characterizedby diarrhoea, loss of apetite,iscoloration of hair, joint abnormalities, osteoporosis, lack of sexual interest degeneration oftests 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, Chemicalprecipitation, floatation, electrochemical deposition, adsorption, etc. All these methods are used inindustries are expensive and may even produce a large quantity of sludge which further needstreatment. Batch adsorption process is currently considered as one of the upcoming process for thetreatment 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 thesurface of solid; i.e. it is a process of mass transfer in which the dissolved solid from liquid getsdeposited 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 tobe consideringwhile 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 geologicalmaterial for the treatment of water contaminated with heavy metals. However, the reported metalremovalefficiency 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 anaqueous 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) wasadsorbed only 90% of their initial concentration[11] found that by using naturalindustrial materials. Removals of heavy metals by natural materials are listed below in table: 2.

Table2: Percentage Removal Capacity of modifiedindustrial materials asadsorbents 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
Heamatite	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.

3.1.1 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, Ii 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 mostfrequently for the treatment of the heavy metal-contaminated wastewater.As many of researcher have claimed that adsorbents such as industrialwaste material show good adsorption capacity for theremoval of heavy metals and are also easily available at low cost but requires a pretreatment andhigh handling cost for sludge disposal.It is seen that use of low-cost adsorbents is the keen interest of research for heavy metalsremoval, more study is required to focus on reducing the cost of pretreatment, regeneration anddisposal.Although various different adsorbents can be employed for the treatment ofwastewater laden with heavy metals. It is important to note that the selection ofthe most suitableadsorbent for metal- contaminated wastewater also depends on some basicparameters such as pH, initial metal concentration, the overall treatment performance comparedto other technologies, environmental impact as well as economics parameter such as the capitalinvestment and operational costs. Finally, technical applicability, plant simplicity and costeffectivenessare the key factors that play major roles in the selection of the most suitableadsorbent for the process. All the factors mentioned above should be taken into consideration inselecting the most effective adsorbents for the heavy metals removal process mostefficiently and effectively.

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