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Removal of heavy metal ions from industrial wastewater- Review

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Abstract— In today's era removal of toxic metal ions from industrial wastewater is a vexed issue. The aim of this study is to investigate different metal ions concentration discharge from industrial waste and various methods for removal of toxic metals ion. This study shows that the toxic metal ion's concentration has increased to unacceptable level as seen from the ecosystem point of view. Hence it becomes mandatory to remove these toxic metal ions. In this paper, concentration of different toxic metal ion is compared in a tabular form so the information can accessed easily.

Keywords: Toxic metals, Concentration level of toxic metals, Adsorption

I INTRODUCTION

The major source of pollution in water bodies is industrial wastewater. In the last century a huge amount of industrial wastewater was discharged into rivers, lakes and coastal areas. This discharge into water bodies resulted in serious pollution problems and caused negative effects on the eco-system and human's life. The amount of wastewater added to the water bodies depends on the technical level of process in each industry sector and can be gradually reduced with the improvement of industrial technologies. The higher rates of industrial wastewater in developing countries are thought to be much higher than those in developed countries. This fact predicts that industrial wastewater pollution, as a mean environment pollution problem, will shift from the developed countries to developing countries in the early century. [1]

Heavy metals are those that have high atomic weight and also have high specific gravity (>5). As from the past studies it has been found that there are total of 35 heavy metals but our present study is concerned only to toxic metals ion only. Toxic metals studied are Hg, Pb, Cd, Cr, As and Ni. All heavy metals are not toxic; among these only few are toxic if they exceed their permissible limit. Theses toxic metals when discharged from the industries, they come in the form of effluent which are not having the form of only metals but also contains the form of salt. When these salts as effluent mix-up with water, they may enter the food chain due to use of this water in agriculture and drinking purpose. They affect the central nervous system which damage kidney, lungs and even it becomes the cause of cancer. [3-5]

TABLE 1. VARIOUS APPLICATIONS OF HEAVY METALS AND THEIR EFFECTS ON HEALTH

Heavy metals	Application	Effects
Hg	Electrical switches, florescent light bulb, used as amalgams for filling cavities, preservatives, medications	Central nervous system
Pb	Automobile battery, weather proofing building, water pipes and ducts, sound proofing, roofing flashing	Calcium deficiency act as metabolic poison, deterioration of bones, dental cavities, increase blood pressure
Cd	Nicad battery, pigment, smelters	Liver kidney failure
As	Pesticide, production of iron, steel mining	Vomiting diarrhea liver damage diabetes lung cancer
Cr	Electroplating, corrosion protection leather tanning metal plating industries	Weak immune system
Ni	Electroplating industry and pharma sectors	neurological deficits, developmental deficits in childhood, and high blood pressure

Zn	Model rockets	pancreas and disturb the protein metabolism, and cause arteriosclerosis

II SOURCES

These toxic metals are discharged into the ecosystem by various types of industries. Some of the industries discharging heavy metals are steel and textile industry, automobile sectors, electroplating, mining, paint industry, petrochemical sectors and pharmaceuticals and nuclear medicine plants, tanneries [6-10]

TABLE 2. HEAVY METAL DISCHARGE CONCENTRATION FROM DIFFERENT SECTORS EFFLUENTS

Sectors	**Cr (mg/l)**	**Cd (mg/l)**	**Zn(mg/l)**	**Pb (mg/l)**	**Cu(mg/l)**
Pharmaceuticals	1.72-0.647	0.55	1-1.3	0.26	0.08-0.38
Textile	2.37-2.38	0.012-0.22	-	-	0.007-0.15
Tannery	5.32-9.45	0.070-0.082	-	0.02-0.10	0.018-0.26
Electroplating	7.0	1.2	4.2	0.6	4.5
Dye	-	2.0	5.0	-	3.0
Leather	2.0	-	-	-	-
Fertilizer	2.0	-	-	-	-

In above table, discharge concentration of heavy metals from various industrial sectors has shown. But this concentration range is not fixed and varies from point to point. Like as for pharma sectors its variation in the range of 1.72-0.647 mg/l for Cd, for Zn is 1-1.3 mg/l, for Pb 0.26 mg/l and for cu is 0.08-0.38 mg/l. this type of data has prepared from published research papers for metal concentration in pharmaceuticals areas. Also, it is not necessary that all heavy metals has found in any individual sector although we can find different heavy metals in different industry. Like electroplating sector, coating of nickel, cadmium and chromium is used so this sector only discharges these heavy metals impurities.[12-16] On the other hand in dye industry discharge cadmium, zinc and copper salts impurities are present. In leather and fertilizer sector effluent in the form of salt or mixes up with all other impurities and takes the different forms. [17]

WHO Permissible Limit

World health organization permissible limit for heavy metals has been presented and also maximum concentration level of
heavy metals has shown.

TABLE 3. WORLD HEALTH ORGANIZATION AND MAXIMUM CONCENTRATION LEVEL OF HEAVY METALS

Heavy metals	**Concentration limit(mg/l)**	**MCL (mg/l)**
Cu	0.5	As – 0.050
Fe	0.1	Cd – 0.01
Pb	0.01	Cr – 0.25
Zn	3	Ni – 0.20
Co	0.0002	Zn – 0.80
Cr	0.05	Pb – 0.006
Ni	0.02	Hg – 0.00003
Cd	0.003	Hg – 0.00006

III CONVENTIONAL METHODS USE FOR REMOVING TOXIC METALS

Many effective methods have been used in past years for removal of these toxic metals. These are reverse osmosis, ultra filtration, electodialysis, coagulation, precipitation and ion exchange. It has found from the past years studies that these all method gives effective result but these are not cost effective, environment friendly, safe and require lots of maintenance and investment. On the other hand, adsorption is most attractive process because metals values can be recovered along with their removal from the effluents. Adsorption is the process by which an ultrathin layer of one

substance forms on the surface of another substance. So it has advantages over other methods because of its simple design with a sludge free environment and also involves low cost. Adsorption is also known as surface phenomena because it has ability all substance to attract to their surface molecules of gases or solutions with which they are in contact. Solids that are used to adsorb gases called adsorbents and adsorbed molecules are usually referred to collectively as the adsorbate. Till today, in the field of adsorption, many adsorbents have been introduced but only low cost adsorbent has proved up to the mark because they are easy available and are not expensive by which it becomes very efficient and economic method for removal of these toxic metals.

TABLE 4. CONVENTIONAL METHODS FOR HEAVY METAL REMOVAL

Process	**Advantages**	**Disadvantages**	**References**
Reverse osmosis	Efficient	High operational cost	
Electrodialysis	High separation selectivity	High operational cost	Mohammadi et al. (2005)
Membrane filtration	High separation selectivity	High operational cost due to membrane fouling	Kurniawan et al. (2006)
Chemical precipitation	Simple operation, low capital cost	Sludge generation	Kurniawan et al. (2006)
Photocatalysis	Removal of metals and organic pollutant, less harmful by-products	Long time duration, limited application	Barakat et al. (2004)
Adsorption	Low cost, high metal binding capacity	Low selectivity	Babel and kurniawan (2003)

IV LIST OF ADSORBENTS

Heavy metal removal efficiency for different low cost adsorbent derived from biomass and agricultural products/ by-products has been presented. Low cost adsorbent are easily available, eco-friendly and inexpensive. Adsorption capacity i.e. the ability
of the solid surface of substance to take up various other substances with which they are in contact can be increased by chemical modification of the adsorbent. A list of available low cost adsorbent with their heavy metal removal efficiency is given in table1. [19-25]

TABLE 5. DIFFERENT LOW COST ADSORBENT AND THEIR REMOVAL EFFICIENCY

Adsorbent	**Heavy metal removal efficiency %**					
	Cr	**Ni**	**Cu**	**Zn**	**Cd**	**Pb**
Rice husk carbon			100	100	100	100
Sugarcane bagasse activated carbon	99.97	-	-	-	-	-
Untreated tree sawdust	-	91	86	75.7	-	-
Soybean hulls	98.1	95.6	99.7	96.40	-	-
Cottonseed hulls	-	47.6	58.8	59.50	-	-
Defated rice brans	-	29.2	71.5	38.40	-	-

In following table effect of Ph, effect of contact time, effect of temperature and maximum adsorption capacity for low cost adsorbent has presented.

TABLE 6. LOW COST ADSORBENT AND THEIR DIFFERENT PARAMETERS BEHAVIOR

Adsorbent	Heavy metal	Ph	Contact time	Temperature	Q max	References
Banana peel	Zn Ni Cu Pb Co	6.54 6.89 5.92 5.89 6.66			5.80 6.88 4.75 7.97 2.55	King et al.,2007
Cocoa shell	Pb	2	<120	22	6.2	Meunier et al. (2003)
Durian shell waste	Cr	2.5		60	117	Kurniawan et al. (2011)
Neem sawdust	Cr	2	60		58.82	Vinodhini and nilanjana das et al. (2009)
Palm tree leaves	Zn	14.7	10	25		Fahmi and abu (2006)
Rice husk	Zn		60		19.617	Arsari et al. (2010)
Rice straw	Ni Cd	5 6	90 90		35.08 144.19	El-sayed et al. (2010)
Sugarcane bagasse	Cr	2	180		23.8	Vinodhini and nilanjana das et al. (2009)
Tea waste	Ni	4		25	15.26	Malkoc and nuhoglu (2005)

V CONCLUSIONS

Industrial waste discharge contains several compounds together which must be examined before processing and this paper intended to present few such data. Treatment of such waste water is necessary as it contains several heavy metals which cause health hazards to living species. Adsorption is a very attractive technique for the removal of heavy metals from liquid effluent. Using agricultural byproducts or waste biomass in the production of adsorbents is proving quite cost effective approach. Many workers investigated numerous biomass derived sorbents in wastewater treatment. Various parameters including pH, contact time, adsorbent dosage, temperature and metal concentration which prominently affects the adsorption capacity and removal efficiency of such substrates. Though, number of biomass has been explored yet this field offers huge scope with the introduction of novel low cost adsorbent and better understanding of the process.

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