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Heavy Metals from Industrial Waste Water: Elimination Methods

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Abstract:

Now a days, heavy metals has become a major issue because these heavy metals are discharged from numerous chemical industries and mixed with water sources. They are dangerous to all alive creatures. So, it is necessary to remove or minimize the risk of taking these heavy metals through plants, human and animal. For removing the heavy metals, various methods are developed and extensively examined. The original procedures for treating industrial water for heavy metals involves procedures for decreasing the toxicity of metals i.e. chemical precipitation, membrane purification, adsorption, ion exchange, coagulation-flocculation and floatation. In this review paper, discuss about the methodologies by eliminating toxic metals on or after water waste including, chemical precipitation, membrane filtration, ion exchange, coagulation-flocculation and electrodialysis with their advantages and limitations because of its inexpensiveness, accessibility and eco-friendly nature.

Keywords: *Electrodialysis, Flocculation, Adsorption, Heavy Metals*

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Introduction

Heavy metals are refer to as metal components that have high atomic weight and high density. Developed industries like fertilizer industry, metal processing, pulp-paper industry, mining activities, rubber-plastic industry, batteries etc. which is discharge heavy metals contaminated water into nearby water bodies. At low concentration, heavy metals are highly toxic and are carcinogenic but not biodegradable. By these heavy metals, cause serious threat to human life and to aquatic, vegetation cover. These heavy metals are absorbed and stored in human body that produce serious health disease such as cancer, damaging of nervous system, organ damage even death. The density of Heavy metals exceeds 5g per cubic centimeter. These toxic heavy metals can dissolved in water and well-known toxics and hazardous agents. These toxic metals are copper, Lead, Silver, Gold, Cadmium, Nickel, Mercury, Cobalt etc. In the industries of wood in which copper-arsenate wood is treated through which arsenic containing wastes are produced. In the same way, inorganic stain production produce pigments that have cadmium sulfide and chromium compounds, petroleum purifying produces catalysts adulterated with vanadium, nickel and chromium and similarly, photographic film produces that also has the high amount of silver and ferrocyanide. These generator produces a huge amount of water waste remains and mud which is considered as hazardous wastes and need extensive waste treatment. If heavy metals are present in low amounts, are highly toxic in nature. So, there is necessary for the reduction of toxic metals with the residue of water water which has been made a subject to strict legislations.

In the chemical industries, effective and well-organized methods are required to eliminate the heavy metals from residues of waste water i.e., membrane filtration, ion exchange, electrodialysis, flotation etc.

Methods used for Heavy Metals Reduction

Chemical Precipitation

It is suitable and most broadly used technique for removing the toxic metals from inorganic unused in industry. In this method, chemical react with heavy metals that is present in waste water and formation of insoluble precipitation. These precipitates are removed by using sedimentation technique and clear water is poured. The precipitates of heavy metals is insoluble which contains carbonate, hydroxide, sulfide and phosphate. The procedure's mechanism is based on the insoluble metal precipitation production proceed from the soluble metals in solution and precipitant. This precipitate methods produce very fine particles and then another different methods like chemical precipitants, flocculation and coagulants procedures are used to enlarge their elemental size that can be removed easily in the form of mud. In can be easily removed in case of metal precipitate and form solids and discharged the low metal concentration. In solution, removal proportion of metal ions may be detached to optimal by altering main factors i.e., initial concentration, pH, temperature, ion charge etc.

Coagulation and Flocculation

Coagulation is a technique which use coagulants are designed through the combination of organic matter and insoluble particle into large mixtures. There are many coagulants like Magnesium Chloride (MgCl2), Aluminum Sulphate (alum), Polyaluminium Chloride (PACL), and Aluminum Hydroxide Oxides. Lead is removed from waste water with the presence other metals like zinc and iron with aluminum sulphate, polyaluminum chloride, magnesium chloride. For the reduction of toxic metals, coagulant process are used that creates so many issues in which increment of heavy metal in water, production of large sludge and health problems are included. To eradicate these issues, use alternative coagulant must be considered such as chitosan, biopolymers.

Flocculation is widely used technique to eliminate the heavy metals from waste water. In this process, flocs bind with particles that forms the bridges in between which convert into large agglomerates or clumps and some flocculation such as sodium dodecyl sulphate, polyferric sulfate and polyacrylamide are used for waste water treatment.

Ion Exchange

Ion exchange technique is broadly used for waste water treatment in industry which transfer soluble ions from fluid stage to solid stage. In this procedure, low cost materials and convenient operations are used to treat the water having low heavy metal concentration. In this procedure, cation and anions are used widely for the reduction of metal ions in the mixture of two compound. And for the ion exchangers, artificial organic ion exchange resins are

used which can also be used for small concerted metal way out and the technique is extremely delicate through pH of aqueous phase.

It is able to absorb positive and negative charged ions from the solution of electrolyte because it is water soluble solid substance that also release other ions having same charges into solution with equal quantity. In this solution, positive electric ions like sodium and hydrogen ions are replaced by means of another positive electric ions like Cu, Ni as well as Zn ions. In the same way, the negative ions in the mastics like chloride and hydroxyl ions can be replaced with other negative electric ions like sulfate, chromate, cyanide, nitrate, and soluble organic carbon.

Membrane Filtration

This process is capable of eliminating the organic compounds, suspended solid, and inorganic contaminants (heavy metals). It can be retained that is depend on particle size and it contains various kinds of membrane filtration i.e., nano-filtration, and reverse osmosis, ultrafiltration, can be used for reduction of toxic metals from wastewater solution.

Ultrafiltration (UF): This type of method have low pressures and eliminates liquefied as well as colloidal components. There are two kinds of this technique, first one is Micellar Enhanced Ultrafiltration (MEUF) and another is Polymer Enhanced Ultrafiltration (PEUF). One of the separation technique named MEUF is considered as physicochemical membrane where there is anionic surfactant addition in the waste water. Due the separation phenomenon, the monomers of anionic surfactant combined and formed micelles. Because of electrostatic force, micelle's outer part stuck the heavy metals. In some cases, heavy metal are stuck in the micelle's outer part and remained surfactant are passed by the ultrafiltration membrane. MEUF has numerous advantages as it produces high flux, remove high quantity of heavy metals and low cost and disadvantages as it increases operating cost as well. PEUF uses water soluble polymer in waste water. If the size of these polymers is exceed from the molecular weight then it is reserved in the membrane and cut off the membrane. PEUF is very helpful to remove the small solute molecules which cannot remove by traditional UF.

Reverse Osmosis (RO): This process is derived by pressure. According to Mohsen-Nia et al. has removed Copper and Nickel from waste water that using disodium salt removed Cu and Ni from wastewater using disodium salt ethylenediaminetetraacetic acid (Na2EDTA). Na2EDTA is added to increase the size of chelated ion of copper and nickel, due to which refusal efficacy has been improved up to 99.5%. Removal heavy metals was found greater than 95%.

Nano-filtration: Ranging pore size in between UF and RO in the nanofiltration that is the type of membrane filtration. Nano-filtration membranes are made up of the synthetic polymers that have charged groups is positively charged polyethylimine crosslinked polyimide nano-filtration membrane (PEI) that has good chemical, thermal and mechanical characteristics. But has one limitation: it give the refusal efficacy only for the multivalent cations. This membrane is modified for the elimination of toxic metals from waste water solution.

Electrodialysis

Electrodialysis is based on the membrane separation technique and by applying an electric potential, ion exchanged membrane passes the ionized species present in the solution. This membrane are formed from plastic material's thin sheets having either cationic or anionic features. When mixture is passed through cell membrane that containing ionic species, then anions travel in the direction of the anode and vise-versa, junction of the anion interchange and cation interchange membrane. It contains disadvantages like membrane replacement and corrosion process. Membrane is used with advanced ion interchange ability that give outcome in better cell presentation. At different concentration, there are many issues like impact of flow rate, temperature and voltage that use two kinds of marketable membranes, research laboratory ED cell, for the elimination of lead.

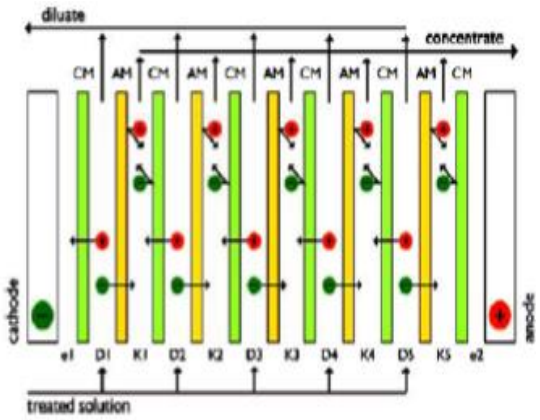

Figure: Electrodialysis Process

This process provides the outcomes in which increased power and temperature enhanced cell presentation and with the increment in flow rate, separation percentage decrease.

Flotation

Flotation method is well known method for removing of heavy metals. It contain numerous advantages like recovery of selective metal ion, generation of low sludge and has high separation efficacy. According to Scorzelli et al. it use sodium dodecyl sulfate (SOS) is used as gatherer while isopropanol and methyl isobutyl carbinol (MIBC) are used in the form of frother for the removal of cadmium from unused water. But according to Polat and Erdogan, Ion floatation technique is much better for the reduction of zinc, copper and chromium from unused water. Ion floatation has numerous benefits like need of less energy, fast process, less amount of metals, need of small zone, having less cost of operating.

Review of Literature

Orhan and Buyukgungor (1993), stated ion the removal of Cr (VI), Cd (II) and Al (III) from waste water that are agricultural waste. Adsorption reaction can be described by first order reversible reaction and sorption equilibria data can be approximately to Freundlich isotherm.

Qaiser, Saleemi and Ahmad (2007), for chromium and lead, the leaves powder of Ficus religiosa has very good adsorbent. For both metals, it has good absorption capacity that is 5.66 ± 0.43 mg g-1 for hexavalent chromium and 16.95 ± 0.75 mg g-1 capacity for lead. Absorption was relied on pH and optimal pH that were 4 and 1 for lead and chromium. For chromium, optimal temperature was 40ºC but 25ºC for lead. In case of lead, there is exchange of ion between protons and metal cations but in case of hexavalent chromium, ion exchange between metal anions and hydroxyl ions.

Hsu, Peng and Lee (2009), stated that adsorption capacity increased with prolongation of reaction times and decreased as the particle size increased. For metal adsorption, optimum pH values were in range of 4~6. Phyllostachys pubescens was the most effective method of reduction of heavy metal belongs to aqueous solutions in bamboo samples. By hot water extraction treatment, removal of heavy metals efficiency of raw bamboo can be greatly and easily improved. The removal of hot-water extracted bamboo waste was better than that of bark, exhausted coffee, and exhausted tea. The hot-water-extracted bamboo wastes may be potential alternative biosorbent that is able to remove the toxic metals from industrial discarded.

Dhabab (2011), in this paper, he discussed about the removal percentage of toxic metal ions after unused water using adsorption technique. With experimental conditions like time, pH, weight of loading material and initial concentration the amount was noticed between 50 to 94ppm. Heavy metal removal percentage was Pb2+ (94%), Zn2+ (72%), Cu2+ (65%), and Fe2+ (50%).

Salam, Reiad and ElShafei (2011) suggested for the low cost absorbent like fly ash, peanut shell charcoal, and usual zeolite that are very suitable for the elimination of zinc or copper ions from aqueous mixtures. In this paper, uses batch technique i.e., absorbent dose, pH, contact time, and concentration of metal at an ambient temperature (27± 2 ºC). This optimal pH i.e., 6-8 was used for sorption of zinc and copper removal. Zinc and Copper ions were collected on adsorbents immediately in the duration of 2-3 h for Cu and Zn ions expending another adsorbents.

Suryan and Ahluwalia (2012), dictated about the biosorption technology for the reduction of heavy metals in which living and dead biomass are used that has major disadvantage i.e., expensive for the growth of sufficient amount of bacterial fungal or algal biomass. There are many factors like pH that affects the absorption of ions that is above 70% in which metal ions covers having range of pH from 2 to 5.

Tanchuling, Resurreccion and Ong (2012), in this paper, discuss about the "Growth and Analysis of Coco-peat Filter Bed as Sorbent Material". After doing the study on scale of laboratory, they observed that coca-peat is a feasible material for absorption, due to its absorption abilities and locally-available, abundant and cheap.

Hegazi (2013), concluded that the elimination of toxic metals through the use of low charge adsorbents having the range of concentration as 20-60mg/l. Rice husk material was suitable for the reduction of Fe, Ni and Pb while fly ash was appropriate for the elimination of Cadmium as well as Copper. Percentage removal of toxic metals was relied on amount of low cost adsorbent. For heavy metal adsorption, optimum pH range is 6-70.

Malik, Lata and Singhal (2015), concluded that treatment of contaminated lead waste water by using adsorbent method. At 4.5 pH, adsorbant has the maximum capacity. As the pH decrease, the percentage adsorption as well as uptake capacity of adsorbent are increased. Lead should be remove from aqueous solution by using MAV leaf powder that are very efficiently and thermodynamic parameters are supported by adsorption process. The adsorption procedure was exothermic and spontaneous at ambient and slightly higher temperatures in his research.

Raouf and Raheim (2017), dictated that removal of heavy metals by using conventional technologies that contain sources and hazardous effects. It was recognized that the improvement in the environmental by removing the pollutants of toxic metals through adsorption is more helpful than other procedures. Mentioned the technologies that is helpful in the reduction of heavy metals of agricultural waste.

Conclusion

Methodologies play an significant role in the reduction of toxic metals from waste waters solution. Here, many methods are discussed like ion exchange chemical precipitation, flotation, electrodialysis, membrane filtration etc. All methods are contain some advantages and disadvantages. First one is chemical precipitation that is simple but expensive and it has drawback as produce large sludge. This method is useful for those heavy metal which have high concentration and ineffective for low concentrated heavy metal. Coagulation-flocculation method contains advantage i.e., sludge settling and dewatering but has disadvantages like expensive and huge chemicals intake. The ion exchange technique has benefits like no alteration in pH and excellent reliability but has drawbacks like expensive membrane, resin regeneration and need of resin entangling. Actually, methods are selected on the basis of capital investment, initial metal concentration, operational budget and environmental effect.

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