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Review Article

RECENT TRENDS IN TREATMENT OF HEAVY METALS FROM WASTE WATER

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ABSTRACT

Methods for treating industrial wastewater containing heavy metals often involve technologies for reduction of toxicity in order to meet technology-based treatment standards. This article was focused on the recently developed and newly applicable various treatment processes for the removal of heavy metals from industrial wastewater. Metal removal from wastewater using peat, fish scales, sea-shells, membrane filtration pf PGA- based nano particles, novel biofiltation methods, activated charcoal were discussed. Their advantages and drawbacks in application were evaluated.

KEYWORDS: *Heavy metals, Treatment, Removal, Advanced methods.*

INTRODUCTION

A heavy metal which is in the form of ion can be removed from waste water, by the addition to the waste water, a metal scavenger together with at least one of sodium polysulfides ,sodium monosulfide and sodium hydrogensulfide to form a metal ion containing floccule/floc. The resulting floc is then removed from the waste water by filtration method. The metal scavenger contains at least one carbo-di-thio group and/or at least one carbo-di-thioate salt group as N-substituents per molecule.

Different Trends in Treatment of Heavy Metals from Waste Water:

Metal Removal from Wastewater Using Peat:

Peat has been investigated by as a sorbent for the capture of dissolved metals from waste streams by various researchers. The mechanism is as follows- the metal ion binding to peat remains an area of controversy with ion-exchange, complexation, and surface adsorption being the prevalent theories. Factors affecting adsorption include pH, the presence of competing metals and loading rates. The optimum pH range for metals capture is generally 3.5–6.5. The presence of more than one metal in a solution creates competition for sorption sites and less of a particular ion may be bound, the total sorption capacity has been found to increase. Studies have also shown that metals removal is most efficient when the loading rates are low. In addition, recovery of metals and regeneration of the peat is possible using acid elution with little effect on peat's sorption capacity [1].

Advantages:

- This method is simple, effective and economical means of pollution remediation.
- Peat is plentiful and inexpensive.

Seashells for Heavy Metals Clean-Up:

Researchers have completed tests on a new way to combat water pollution that could save millions of lives in coastal cities in the developing world on the banks of the Saigon river in vietnam. Toxic metals like zinc, lead, cadmium and iron were cleaned using seashells. A new investigation by the Dr. Köhler's team has found that pouring metal and acid-laden water over a bed of crushed clam or mussel shells provides an easy fix. These shells are made of aragonite, a form of calcium carbonate that readily swaps its calcium atoms in favor of heavy metals and locking them into a solid form. The shells are alkaline – a pH of 8.3 when dissolved and needs to be maintained so by adding more shells [3].

A Novel Method for Heavy Metal Removal Using Fish Scales:

Effective removal of metal ions from industrial wastewater by using fish scales was studied. A series of static tests were performed with 10 g of dried fish scale adsorbent which was pulverized to micron sizes of 37 or less. Such tests were conducted for lead ions (from lead nitrate solution) at concentrations of 25 ppm, 12.5 ppm, and 6.25 ppm. The dynamic equilibrium results were based on tests on 50 ppm of cobalt chloride solution (flow rate 1 ml/min), followed by 100 ppm of cobalt solution (flow rate 7 ml/min), and then a mixture of cobalt chloride ($CoCl_2$), lead nitrate ($Pb(NO_3)_2$), zinc nitrate hexahydrate ($Zn(NO_3)_2.6H2O$) and strontium nitrate

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($Sr(NO_3)_2$) solutions. The proposed sorption technique offers an acceptable solution for removal of heavy metal ions from wastewater streams. The potential application of this study is an enormous energy cost savings in the electroplating industry, which requires the replacement of wastewater and the burial of metal sludge in landfills. Also, the trimming of energy costs in oil drilling and pipeline corrosion is possible by potential formation of biopolymers developed from "adsorbed scale" [2].

Removal of Heavy Metals from Industrial Wastewaters by Adsorption onto Activated Carbon Prepared From an AgriculturalSolidWaste:

Activated carbon was prepared from coirpith by a chemical activation method and characterized. The adsorption of toxic heavy metals, Hg(II), Pb(II), Cd(II), Ni(II), and Cu(II) was studied using synthetic solutions and was reported elsewhere. In the present work the adsorption of toxic heavy metals from industrial wastewaters onto coirpith carbon was studied. The percent adsorption increased with increase in pH from 2 to 6 and remained constant up to 10. As coirpith is discarded as waste from coir processing industries, the resulting carbon is expected to be an economical product for the removal of toxic heavy metals from industrial wastewaters [6].

Toxic Heavy Metal Ions Removal from Waste Water by MembraneFiltrationof PGA-based Nanoparticles:

Polymer enhanced ultrafiltration is a feasible method to remove metal ions from diluted waste water stream. Poly-acids are widely investigated for this application. For separation of toxic heavy metal ions, including lead ions synthetic polymers and natural poly gamma glutamic acid (PGA) and other natural polymers have been investigated. Formation of nanoparticles of poly-gamma glutamic acid with bivalent metal ions is described in this study. In aqueous solution the size of particles varies in the range of 50 nm to 350 nm depending on the pH. The polyacid has high affinity and binds proportional toxic heavy metal ion. The stable nanoparticles were visualized by TEM measurements. The polymer-lead complex was separated by ultrafiltration and the lead ions were concentrated in the retentate. The biopolymer is useful for treating waste water [4].

Novel Bio-filtration Methods for the Treatment of Heavy Metals from Industrial Wastewater:

Most heavy metals are well-known carcinogenic agents and toxic when discharged into the wastewater pose a serious threat to the human population and also to the flora and fauna of the receiving water bodies. In the present review paper, the sources have discussed the industrial source of heavy metals contamination in water, their toxic effects on the fauna and flora and the regulatory threshold limits of these heavy metals. The various parameters of the biofiltration processes, their mechanism for heavy metals removal along with the kinetics of biofilters and its modeling aspects have been discussed. The comparison of various physico-chemical treatment and the advantages of biofiltration over other conventional processes for treatment of heavy metals contaminated wastewater have also been discussed. The applications of genetic engineering in the modification of the microorganisms for increasing the efficiency of the biofiltration process for heavy metals removal have been critically analyzed. The results show that the efficiency of the process can be increased three to six folds with the application of recombinant microbial treatment [5].

Microbial and Plant Derived Biomass for Removal of Heavy Metals from Wastewater:

Adverse effects on the environment are due to the discharge of heavy metals from metal processing industries. Conventional treatment technologies for removal of heavy metals from aqueous solution are not economical and thus they generate huge quantity of toxic chemical sludge. Biosorption of heavy metals by metabolic inactive non-living biomass of microbial or plant origin is an innovative and alternative technology for removal of these pollutants from aqueous solution and due to unique chemical composition biomass sequesters metal ions by forming metal complexes from solution and obviates the necessity to maintain special growth-supporting conditions. Biomass of Aspergillus, Penicillium-chrysogenum, Rhizopus nigricans,Ascophyllum nodosum, Sargassum natans, Chlorella fusca, Oscillatoria anguistissima, Bacillus firmus and Streptpmyces sp. have highest metal adsorption capacities ranging from 5 to 641 mg g^{-1} mainly for Pb, Zn, Cd, Cr, Cu and Ni. Biomass generated as a by-product of fermentative processes offers great potential for adopting an economical metal-recovery system. The purpose of this paper was to review the available information on various attributes of utilization of microbial and plant derived biomass and explores the possibility of exploiting them for heavy metal remediation [8].

Physico–Chemical Treatment Techniques for Wastewater Laden with Heavy Metals:

This article reviews the technical applicability of various physical and chemical treatments for the removal of heavy metals such as Cu(II), Ni(II), Zn(II), Cd(II), Cr(III) and Cr(VI) from contaminated wastewater. A particular focus is given to chemical precipitation, coagulation–flocculation, flotation, ion exchange and membrane filtration. Their advantages and limitations in application are evaluated. Their operating conditions such as pH, dose required, initial metal concentration and treatment performance are presented. About 124 published studies (1980–2006) are reviewed. It is evident from the survey that ion exchange and membrane filtration are the most frequently studied and widely applied for the treatment of metal- contaminated wastewater. Ion exchange has achieved a complete removal of Cd(II), Cr(III), Cu(II), Ni(II) and Zn(II) with an initial concentration of 100 mg/L, respectively. The results are comparable to that of reverse osmosis (99% of Cd(II) rejection with an initial concentration of 200 mg/L). Lime precipitation has been found as one of the most effective means to treat inorganic effluent with a metal concentration of higher than 1000 mg/L. It is important to note that the overall treatment cost of metal-contaminated water varies, depending on the process employed and the local conditions. In general, the technical applicability, plant simplicity and cost- effectiveness are the key factors in selecting the most suitable treatment for inorganic effluent [7].

Removal of Heavy Metals from Wastewater by Membrane Processes: A ComparativeStudy:

Wastewater containing copper and cadmium can be produced by several industries. The application of both reverse osmosis (RO) and nanofiltration (NF) technologies for the treatment of wastewater containing copper and cadmium ions to reduce fresh water consumption and environmental degradation was investigated. Synthetic wastewater samples containing $Cu2+$ and $Cd2+$ ions at various concentrations were prepared and subjected to treatment by RO and NF in the laboratory. The results showed that high removal efficiency of the heavy metals could be achieved by Reverse Osmosis

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process (98% and 99% for copper and cadmium, respectively). NF, however, was capable of removing more than 90% of the copper ions existing in the feed water. The effectiveness of Reverse Osmosis and NF membranes in treating wastewater containing more than one heavy metal was also investigated. The results showed that the RO membrane was capable of treating wastewater with an initial concentration of 500 ppm and reducing the ion concentration to about 3 ppm (99.4% removal), while the average removal efficiency of NF was 97%. The low level of the heavy metals concentration in the permeate implies that water with good quality could be reclaimed for further reuse [9].

Low-Cost Adsorbents for Heavy Metals Uptake from Contaminated Water: A Review:

Effluent In this article, the technical feasibility of various low-cost adsorbents for heavy metal removal from contaminated water has been reviewed. Instead of using commercial activated carbon, researchers have worked on inexpensive materials, such as chitosan, zeolites, and other adsorbents, which have high adsorption capacity and are locally available. The results of their removal performance are compared to that of activated carbon and are presented in this study. It is evident from our literature survey of about 100 papers that low-cost adsorbents have demonstrated outstanding removal capabilities for certain metal ions as compared to activated carbon. Adsorbents that stand out for high adsorption capacities are chitosan (815, 273, 250 mg/g of Hg2+, Cr6+, and Cd2+, respectively), zeolites (175 and 137 mg/g of Pb2+ and Cd2+, respectively), waste slurry (1030, 560, 540 mg/g of Pb2+, Hg2+, and Cr6+, respectively), and lignin (1865 mg/g of Pb2+). These adsorbents are suitable for inorganic effluent treatment containing the metal ions mentioned previously. It is important to note that the adsorption capacities of the adsorbents presented in this paper vary, depending on the characteristics of the individual adsorbent, the extent of chemical modifications, and the concentration of adsorbate [10].

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