HEAVY METALS (Pb^{+2} , Ni^{+2} , Zn^{+2}) REMOVAL FROM WASTEWATER USING LOW COST ADSORBENTS: A REVIEW

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Abstract: Pollution with heavy metal ions lead, zinc and nickel resulting from industrial wastewater for various industries such as electroplating industry, batteries, metal refining mines and other factories which discharge into the environment causing damage and pollution to the environment, living organisms, and the majority of heavy metals carcinogenic due to its high toxicity and its containment of dangerous chemicals. Potential danger to human health in all forms by ingestion, inhalation, or skin contact pose by heavy metals ions such as lead, nickel, zinc, and others. To prevent hazards, they must be removed before disposal by different methods such as ion-exchange, chemical separation, filtration, membrane separation, and adsorption. The purpose of this research is to review different low cost adsorbent materials to remove heavy metal ions lead, zinc and nickel from wastewater.

Keywords: Heavy metals (Pb^{+2} , Ni^{+2} , Zn^{+2}), adsorption, adsorbent, wastewater, low cost.

1. Introduction

Environmental contamination is currently one of humanity's most pressing problems. In the last few years, it has developed at an unprecedented rate, reaching startling proportions in term of its impact on living beings. Toxic heavy metals are a form of pollution that has a significant impact on humans and animals [1]. The majority of heavy metals dumped into wastewater have been found to be poisonous and carcinogenic, posing a potential danger to human health [2]. Pb, Zn, Ni, Cr, Cd, Hg, and other heavy metal

ions are commonly present in industrial waste water effluents problems [3]. These metals are linked to environmental contamination as well as biological toxicity issues [4]. The majority of factories dump untreated wastewater and effluent containing hazardous chemicals into waterways. Industrial contaminants from mines, metal refining, tanneries, pharmaceuticals, fertilizer, agricultural materials, rubber and plastics, and timber and wood products are the most common point sources of heavy metal contaminants. Heavy metals are carried downstream from the factory site by rain water, contaminating water supplies. To prevent health risks, hazardous heavy metals must be removed from waste water before it is disposed of. Various technologies such as chemical precipitation [5], ion exchange [6], membrane filtration [7], electro coagulation [8], reverse osmosis [9], filtration percolation [10] and adsorption [11,12] are presently used for the elimination of heavy metals. Attract the attention of scientists but all of these industrial processes are costly, and they can also contain a considerable amount of sludge that requires further treatment. Adsorption is a physical and chemical treatment methods for removing heavy metals from aqueous solutions that has been

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proved to be efficient in addition to an economical, convenient and very easy operating technology that is manufactured in a fast way for all types of water treatment [13-15]. For the handling of wastewater with heavy metals, a variety of adsorbents and biosorbents may be used [16] such as potato peels [17], eggshell [18], coffee husks [19], seed shells [20], black gram husk [21], sugar-beet pectin gels [22], sugarcane bagasse [23], fungal dead biomass composite with bentonite [24], waste banana [25], olive stone [26]. The aim of this review is to remove heavy metals (Pb^{+2} , Ni^{+2} , Zn^{+2}) by using low cost adsorbent.

2. Impacts of heavy metals

Heavy metals can be found in many of the products we've used. Heavy metals can be found in plants, liquids, and the air we breathe. Only little of heavy metals, such as zinc, copper, cobalt, and manganese, are needed. When the quantity of these healthy heavy metals is too great, they become poisonous to humans, and it only takes a small amount to be too much. Drinking, chewing, inhaling, and skin and eye touch are all ways heavy metals penetrate the blood stream. Once within the body, they cause cellular damage by producing toxic free radicals. They inflict cellular disruption, which can lead to cancer and a variety of other diseases [27].

3. Source and Toxicity of Heavy Metals (Pb^{+2} , Ni^{+2} , Zn^{+2}) on Human Health

Lead is a highly poisonous substance that degrades the ecosystem and causes a variety of health problems. lead poisoning causes mental retardation, encephalopathy, kidney damage, gastrointestinal damage, liver damage, high blood pressure, and lowers heliopathy output [28,29,30]. Excessive lead consumption causes a lack of appetite. Paints, bombs, photographic

products, glass and coatings, petrochemicals, oils, dyes, and rubber factories all contain lead, which is a significant pollutant [31]. It is important to note that the maximum quantity of lead permitted in water sources is 0.1 mg/L, as per environmental regulations [32]. Zinc is a common supplement, overdosing it is highly harmful and should be avoided. Zinc overdose can result in paralysis and neurological complications [33]. It is an important metal used in a variety of industries, including ceramics, rubber, garments, corrosion-resistant metal coatings, mining, and battery production. Catalysts, wood preservatives, and photographic paper are all made with the salts. Zinc is found in drainage from acid mining and galvanizing plants, and it is a natural substitute. An individual may also experience depressive symptoms. Such side effects include dizziness, respiratory difficulties, chest pressure, and a variety of others. World health organization (WHO) limits the amount of zinc in drinking water to 5.0 parts per million (ppm) [34, 35, 36]. Nickel is a carcinogenic toxic metal that is also a pollutant in the atmosphere. It is a gleaming metal that is often used in jewelry. Nickel sensitivity causes skin rashes in people who come into contact with it. Inhaling nickel can increase a person's risk of lung cancer [33]. Additionally, it can also leads to nausea, coughing, infertility, nervous system defects and many more. Nickel has adverse consequences at higher concentrations, including stomach inflammation, liver, renal complications, skin dermatitis, headaches, dizziness, chest discomfort, among other health issues. Nickel concentrations in metal plating wastewater vary from 6 to 12 mg/L [32-34]. It is a poisonous metal that is emitted by industries such as battery manufacturing, electroplating, plating, paint, mining, metallurgy, battery manufacturing, and fertilizer manufacturing [35, 36]. As stated by environmental protection

authorities, the permissible permitted content of nickel in drinking water is 0.1 mg/L [37].

4. Research on Various Low Cost Adsorbent for Removal Of Heavy Metals (Pb^{+2} , Ni^{+2} , Zn^{+2})

Nikolic et al. [38] used leftover tea fiber to remove Ni, Zn, and Pb ions from wastewater. It has been studied in the current research. The tea fibers were treated with a solution of ferric oxide and nitric acid. Properties such as area of the surface, pore size and particle size are improved. Surface properties the adsorbents were determined using SEM and FTIR analysis. As compared to the other models, the results fit the freundlich model best. The sorbents treated with ferric oxide were better compared to the adsorbents treated with nitric acid mainly due to the properties of the surface.

The zinc from the wastewater was adsorbentized using Nigerian grass waste by Salian et al. [39] to improve properties such as pore depth, particle size, and surface area, the waste was treated with sulphuric acid. SEM and FTIR analysis were determined the surface properties of adsorbent. To examine the adsorption process, the equilibrium data from the single component mode were compared to different models. For zinc, the equilibrium results are based on the Langmuir isotherm.

Robert and Girish [40] used Lantana Camara to extract nickel and lead from a multicomponent mixture. Sulphuric acid was used to increase the adsorption qualities as well as the pore volume, surface area, and particle size of the material. The surface properties were investigated using FTIR and SEM analyses. Isotherm models were used to verify the single component results for lead and nickel. It was discovered that the Langmuir model suited the isotherm data better. In binary solution mode, the interaction impact

of two metals was investigated. Nickel was discovered to have a synergistic effect, whereas lead had no interaction with other substances.

Singanan [41] studied the possibility of using *Tridaxprocumbens* plant leaves (*Astrasia*) to remove of lead (II) from wastewater. Batch adsorption tests were carried out to investigate the effects of pH, touch time, solute concentration, and adsorbent dosage on adsorption. For lead straight, the optimal pH for maximal adsorption was discovered to be 4.5. The maximum contact time for equilibrium conditions is 180 minutes at a 2.5 g adsorbent dose rate. The maximum lead removal efficiencies by bio carbon were 95%. The results are good equipped with Langmuir and Freundlich isothermal models.

Batch adsorption studies were used to optimize adsorption influencing factors including pH, dosage, and time Chand and Pakade [42] for maximal Pb (II) adsorption on AP (apple pomace), a 0.8 g dosage, a pH of 4.0, and an 80-minute contact period time were used. With values of, the adsorption isotherms (Langmuir and Freundlich) were well matched to the results q_{max} (16.39 mg/g; $r^2=0.985$) and K (16.14 mg/g; $r^2= 0.998$) respectively. According to this study the pseudo-second-order kinetic explained the experimental data. The major functional group responsible for Pb (II) binding on AP was characterized by FTIR analysis. The maximum removal of Pb (II) was 94%.

Abbas et al. [43] studied the biosorption of Pb (II) from simulated aqueous solutions was investigated using baker's yeast biomass. The equilibrium isotherm data for Pb(II), as well as the adsorption rate constants, were determined using batch type experiments. The findings revealed that the Pb (II) uptake mechanism followed the pseudo-second-order rate model with (R^2), 0.979 when kinetics pseudo-first and

second-order rate models were added to the adsorption data to approximate the rate constant for each solute. Five theoretical models were used to match the equilibrium isotherm results. With (R^2) 0.9987 for Pb (II), the Langmuir model is the best match for the experimental findings Pb (II). For Pb (II), the effect of different influent adsorbate concentrations and flow rates on the efficiency of fixed bed adsorbate was discovered.

Shrestha et al. [44] studied the elimination of Ni (II) ions from aqueous solution was achieved using activated carbons made from Lapsi seed stone after treatment with H_2SO_4 and HNO_3 . To eliminate of Ni (II) ions, 2 activated carbons were prepared from Lapsi seed stones by treating them with concentration H_2SO_4 and a 1:1 mixture of H_2SO_4 and HNO_3 by weight. Nickel pH adsorption is found to be optimal at 5. The Langmuir equations match the adsorption data better than the Freundlich adsorption equation to explain the equilibrium isotherms. For H_2SO_4 and a combination of H_2SO_4 and HNO_3 , the overall adsorption potential of Ni (II) on the resulting activated carbons was 28.25.8 mg/g1 and 69.49 mg/g1 respectively.

To eliminate of Ni (II) from wastewater, activated carbon made from hazelnut shell was used as an adsorbent by Demirbaş et al. [45] PH, concentration of metal ion, agitation speed, temperature, and particle size were all investigated adsorption of Ni (II) batch mode adsorption experiments were performed. To achieve equilibrium, 180 minutes of contact time was needed. The Langmuir, Freundlich, and Temkin isotherms were used to assess the equilibrium results. Every isotherm's characteristic parameters were calculated. For Ni (II) into activated carbon, the Langmuir isotherm given the strongest association.

Malakahmad et al. [46] for separating Ni^{2+} and Zn^{2+} ions from aqueous solution they studied the physical properties and effectiveness of wasted black tea (WBT) as a low-cost sorbent. The high concentrations of carbon and calcium, as well as the high porosity and abundance of functional groups, suggested that WBT could be used as an efficient sorbent. The parameters effects such as pH, contact time, and adsorbent dose on the dynamics of sorption were investigated at pH 5, contact time of 250 minutes, and adsorbent concentration of 20 g/L, the highest percentages of metal ions were removed. WBT has a significant adsorption potential, according to the isotherm analysis. The Freundlich and Langmuir models fitted the sorption data well. WBT's full potential under ideal conditions could be 90.91 mg Ni/g adsorbent and 166.67 mg Zn/g adsorbent. This experimentation proved that tea waste can be used as an efficient, long-lasting, and low-cost adsorbent for removing heavy metal ions.

Etorki et al. [47] used fava beans as low-cost sorbents to remove lead (II) and zinc (II) ions from wastewater. The samples were made without any further processing. Standard sieves of 250-500 m are used to sort them according to particle diameter. Batch adsorption tests were carried out to investigate the adsorption mechanism and many basic parameters such as adsorbent pH, contact time, amount of adsorbent, and concentration of metal. Although other variables were kept stable, any of the previously effects of described parameters on adsorption potential were investigated. It was found that the maximum removal efficiency obtained from fava beans for Pb (II) 100% and for Zn(II) 36.86%. The data obtained followed Langmuir isotherm model.

A new adsorbent polymer was tested for extracting lead ions from aqueous solutions by Kumar and Acharya [48] they used NCRH

(sodium carbonate treated rice husk) for sorption of Pb (II) from aqueous solution. They looked into a variety of factors, including sorbent dose, contact time, and temperature. The removal efficiency for NCRH was 98%. Also they observed that the pseudo second-order kinetic model fitted the experimental data.

For removal of three heavy metals Pb^{+2} , Zn^{+2} , and Ni^{+2} , orange peel xanthate was used by Liang et al. [49] Various parameters were investigated such as pH, time of adsorption, and initial concentration of metal ion on adsorption process. The obtained data fitted with Langmuir adsorption isotherm. The capacity of maximum adsorption for Pb^{+2} , Zn^{+2} , and Ni^{+2} were 218.34, 49.85, and 15.45 mg/g, respectively. It was found that pseudo second-order kinetic model explained the experimental data.

Ghorbani et al. [50] carried out investigation on isolation lead ions from wastewater samples by using red mud (bauxite ore mining waste). The effects of some key parameters in lead adsorption on red mud, such as pH, red mud dosage, and solution-adsorbent contact time, were studied. Red mud as a low-cost adsorbent has been discovered to be effective in removing lead ion from aqueous solution.

5. Conclusions

Previous research indicates that there are various absorbents of low cost, such as agricultural wastes, natural material etc., that are able to remove heavy metal (Pb^{+2} , Ni^{+2} , Zn^{+2}) from industrial wastewater and by the effect of multiple variables such as PH, contact time, adsorbent dose, particle size, metals concentration, and using the two most common adsorption isotherm models, Langmuir and Freundlich.

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Conflict of Interest

The authors confirm that the publication of this article causes no conflict of interest.

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