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LEAD REMOVAL FROM INDUSTRIAL WASTEWATER: A COMPREHENSIVE REVIEW

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Abstract–Lead is a poisonous metal whose prolific use has turned violent on the ecosystem and harmed people's health in the world. WHO established guidelines for lead tolerable consumption levels, which are 10 g/l in drinking water and 0.5 g/m^3 in the air. It's a multi-system toxin that affects the nervous, haematological, cardiovascular, and renal systems. Lead has no biological role in the human Body. In this review, we will mainly concentrate on lead recovery from wastewater using a variety of strategies including chemical techniques such as chemical precipitation, coagulation, and conjugate materials that exhibit different colours based on lead concentrations. Electrochemical methods has shown a robust performance and capability to adjust to variations in the influent composition and flow rate, degrading a wide range of contaminants. Most importantly biological processes, such as bioleaching, biofiltration, and biosorption, are particularly environmentally sustainable, reliable, and cost-effective. These are the techniques which are highly employed for removal of lead from wastewater in modern world.

INTRODUCTION

Wastewater is a physical, chemical, or biological properties are changed as a results of the introduction of certain substances which render to make it unsafe. Disposal of such sludge is difficult and becomes more difficult for treatment plants, particularly in developed countries with limited resources. Heavy metals are transported as leachate from open-dump sites seeps into ground/surface waters, and as they mix with the human food chain, a phenomenon known as "pollution magnification" arises. Wastewater Management, therefore, means handling wastewater to protect the environment to form sure public health, economic, social, and political sound Metcalf *et al.* (1991). The wastewater flow from industrial and other sources mostly contain heavy metals. Pb is one of the most dangerous to human health when it's consumed. Our history says that lead was one of the earliest metals discovered by humanity and was in use by 3000 B.C. After entering into the bloodstream, lead has no known biological function. It is well recognized that it has devastating consequences and It affects nearly all of the body's organ systems Flora *et al.* (2012). To decrease the high amounts of heavy metals like Pb found in the wastewater, a variety of traditional treatment technologies such as reverse osmosis, anaerobic digestion, membrane filtration, adsorption, coagulation, and flocculation are widely used Hussain *et al.* (2020).

Lead and its nature

Lead is a gray coloured metal that is soft and ductile and it exists in four isotopes. Pb will oxidise to form PbO when heated, and it will react with HNO_3 to form $Pb(NO_3)_2$ Zhang *et al.* (2015). Pb is earth abundant and inexpensive, it is one of the most recycled materials in the world Han *et al.* (2021). Heavy metal like lead are used in a number of industries to produce products like paints, batteries, cosmetics, power cable sheaths, polyvinyl chloride (PVC), and printed circuit boards as described by Sörme and Lagerkvist (2002). Pavlov and Technology (2011) stated that lead-acid battery has developed into one of the most commonly used portable sources of electric power in modern society transport vehicle, telecommunications, and information technology. Paint manufacturers have introduced lead to paint in the past because of its high-protective properties, which make paints more stable and improve paint adhesion to substrates/ surfaces has described by Gilbert and Weiss (2006). Lead (Pb) is commonly used in cosmetics including eye makeup, skin creams, lipsticks, and foundation cream Brandao *et al.* (2012). Lead is found in the Earth's crust at a concentration of about 15ppm. Lead is a major constituent of minerals, and galena(PbS), anglesite($PbS0_4$), and cerrusite($PbC0_3$) are widely found. Deep sea muds are significantly richer in lead, containing an average of about 60ppm lead. All the emissions of lead in the environment and its geological cycle on earth, are shown schematically in Fig. 1. In major metropolitan areas, the average lead concentration in the air is around 2.5 pg. /m^3, whereas it is less than 0.5 pg. /m^3 in rural areas Denny *et al.* (1996).

Lead Toxicity

Lead is classified as a hazardous occupational poison with well-known toxicological consequences. When lead is eaten by the human body joining the bloodstream, the lead's primary function is to usually mimics or binds with the body's enzyme functions. At blood lead levels of 40–60 ug/dL, chronic toxicity exists Flora *et al.* (2012). In nervous system lead poisoning causes encephalopathy, dullness, irritability, reduced attention span. Children may be inattentive, hyperactive, and irritable even at low levels of lead exposure has be described by Alisha and Gupta (2018). Renal functional disorders include acute and chronic nephropathy. A damaged tubular delivery mechanism and the involvement of nuclear inclusion bodies containing lead protein complexes are signs of acute nephropathy. Ischemic heart failure is another serious condition, according to the Department for Hazardous Chemicals and Disease Registry (ATSDR). Lead has a host of negative impacts on the reproductive organs of both men and women. In males, low libido, impaired spermatogenesis, and low serum testosterone are all typical side effects. Women are more likely to suffer infertility, miscarriage, and premature membrane

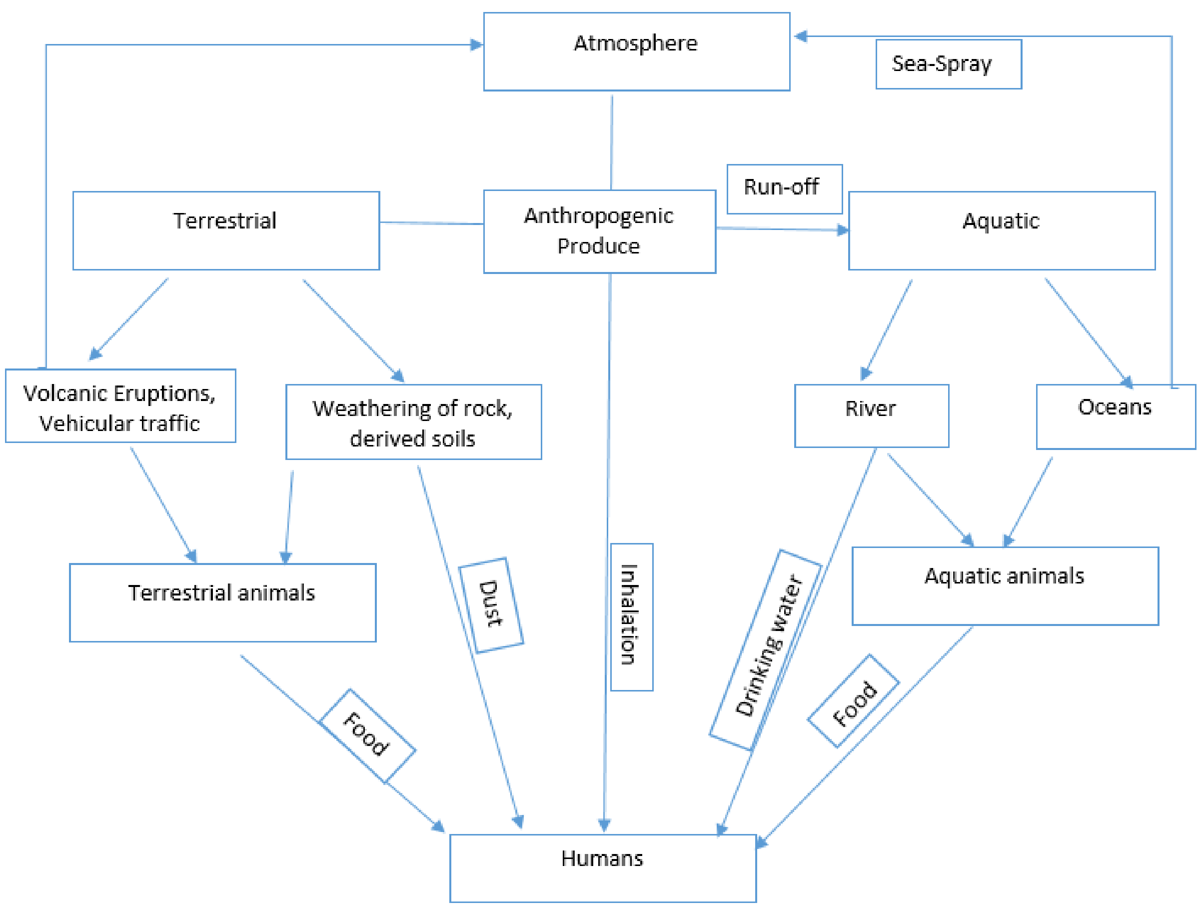

Fig. 1. Geological cycle of lead in the environment.

breakup. There are two forms of anaemia caused by lead poisoning: haemolytic anaemia and frank anaemia was described by Ab Latif Wani *et al.* (2015).

Remediation of lead metal

Chemical precipitation, ion exchange, reverse osmosis, ultrafiltration, is among the physical and chemical removal processes addressed. These types of techniques which are mainly employed for removal of lead.

Chemical methods

Chemical separation methods are commonly used in the removal of heavy metals. These chemical methods are widely used due to its flexibility and effectiveness low-cost, sterile treatment method that can be easily automated.

Chemical precipitation

Chemical precipitation is a widely used and low-cost, sterile treatment method that can be easily automated.The soluble metal ions are converted to the dissolved solid by interacting with a precipitant agent Azimi *et al.,* (2017). Chemical precipitation methods utilising lime ($Ca(OH)_2$), soda ash (Na_2CO_3), and sodium sulphide to remove heavy metals (Pb (II)) from aqueous solutions (Na_2S) Chen *et al.* (2018). Pohl and Pollution (2020) has described that chemical precipitation of hydroxides or sulphides is one of the most common techniques for removing metals from water and wastewater. The method is quick and cheap.

Conjugate materials

Pb(II) monitoring and removal were evaluated using ligand anchoring onto mesoporous silica-based conjugate materials. The sensitivity of the substance was calculated by increasing the colour with different concentrations of Pb(II) based on charge transfer elucidations of the complexation process. The effective pH range for major colour forming and high Pb removal efficacy was 5.20. The on-site sample had a low limit detection of 0.27 mg/l, which was excellent for ultra-trace Pb(II) monitoring Awual *et al.* (2019).

Electrochemical methods

Electrochemical processes have long been recognised. Electrochemical systems have a number of advantages over other systems, including the ability to operate at standard temperature and pressure, as well as robust performance and the ability to react to changes in influent composition and flow rate Tran *et al.* (2017).

Micellar Enhanced Ultrafiltration

MEUF is a novel technique for removing heavy metal ions and organic contaminants from the aqueous phase. Surfactants are added to wastewater at concentrations above their critical micelle concentration (CMC), and the monomers aggregate to form micelles, which can then solubilize organic solutes or bind metal ions on the surface of the opposite charged micelle through electrostatic interactions. As a result, using the ultrafiltration method, metal ions and organic contaminants may be removed Huang *et al.* (2017). The primary advantage of MEUF over traditional ultrafiltration is that molecules that would normally be rejected by ultrafiltration membranes will bind to the micelles even at lower concentrations Aryanti *et al.* (2017).

Ion-Exchange in Batch Conical Air Spouted Bed

Spouted bed contactors combine the benefits of fixed and fluidized bed contactors while maintaining excellent hydrodynamic conditions. The removal of $Pb^{2+}$was found to be 99 percent, respectively, under ideal conditions. The major benefits of ion exchange are metal value recovery, selectivity, reduced sludge volume, and strict discharge requirements has described by Zewail and Yousef (2015).

Biological methods

Biological heavy metal removal in wastewater entails the application of biological approaches to the removal of contaminants from wastewater. Microorganisms play a role in this process by settling solids in the solution. Biological therapies are environmentally friendly, efficient, and inexpensive. In nature, there are several bio adsorbents.

Bio filtration

The bio filtration method uses microorganisms attached to a porous medium to break down contaminants in the wastewater stream. The microorganisms form a biofilm on the surface.The particles of the medium are either suspended on the surface of the medium or are suspended in the water phase surrounding the medium particles. The properties and characteristics of the support medium, such as porosity, degree of compaction, water retention capacities, and the capacity to harbour bacteria, determine the overall effectiveness of a biofilter (Chaudhary *et al.,* 2003).

Biosorption

Biosorption is a process for removing heavy metals from wastewater. The sorption process is described as the transfer of ions from the solution phase to the solid phase Babel and Kurniawan (2003). Polysaccharide-based materials have complicated sorption mechanisms that are pH dependent. Chitosan and tannic acid, when mixed, are two effective biopolymers for removing metal ions from wastewater Badawi *et al.* (2017). Taka (2018) stated that using the synthesised pMWCNT-CD/TiO_2-Ag as a biosorbent, lead (Pb^{2+}) metal ions were removed from synthetic and actual wastewater samples. Bio adsorbents made from farm waste would be really attractive. *Hemidesmus indicus*, a plant biomass, was selected as a biomaterial source (Sekhar *et al.,* 2004). Salecan, a microbial polysaccharide, is produced by Agrobacterium strain sp. ZX09. Salecan has a high viscosity and antioxidation properties, as well as biodegradability and biocompatibility Qi *et al.* (2019).

CONCLUSION

Heavy metal removal from effluent is critical in the environmental sector. We've explored numerous chemical, electrochemical, and biological approaches for removing lead from waste water. Chemical treatments have a range of disadvantages, including high operating costs due to the chemicals used, high energy usage, and hazardous sludge disposal handling costs. We've seen electrochemical methods have strong initial solution ph. and current density, as well as high capital and operating costs. As in Batch conical air spouted bed, chemical precipitation creates sludge and is unable to remove species. Poor membrane permeability and difficulty scaling up micellar enhanced ultrafiltration. Biological processes have a lot of potential for removing heavy metals. Biological approaches using a variety of low-cost materials have been shown to be very effective at removing a higher percentage of contaminants. Biological processes, while being low-cost and environmentally sustainable, require vast areas and careful maintenance and operation. In future, new technologies will come overcoming present day technology limitation and they will be more effective and efficient in terms of removal of heavy metals.

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