Alternative Strategies for heavy metal removal from water

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Abstract

Water is an important natural resource for humans. However, some water sources may contain heavy metals, which may cause many environmental and health problems. Many method strategies have been used at this point to clear the climate of the unfriendly influence, but a largeportion of the techniques used are more expensive and far from the most effective purpose.

However, one of the strategies used to purify and treat water is Membranes Adsorption (MAs). This research paper addresses a bibliographic review of what has been accomplished globally and domestically of all peer-reviewed publications such as environmental organization reports, journal articles, and books. In this audit, a brief outline of the adsorptive membranes and their high effectiveness in removing heavy metals from water. this article reviewed the adsorptions membranes such as Ceramic Polymer Membranes, Polymeric Membranes, Electrospinning Nanofiber membranes, and Nano Enhanced Membranes. for high-quality absorption and removal of heavy metals from water. this work will be useful to the reader in understanding the present applications of various Membranes Adsorption (MAs) and their mechanisms in heavy metals ionadsorption.

Keywords: Heavy Metals, Adsorption, Membranes, Water, Polymeric

Introduction

As the modern world developed, the natural challenges likewise increased. A typical type of pollution that the world suffers from nowadays is water pollution. Water pollution can be due to many different causes such as agriculture, wastewater, waste water, oil pollution, and radioactivematerials. Heavy metals can be found in wastewater, especially that discarded by industries.

Heavy metals are a common cause of water pollution. Heavy metals are non-degradable and canbuild up in the environment. Heavy metal pollution in streams, lakes and oceans the waters in which marine organisms live, for example fish that are consumed by humans, not only are aquatic life endangered, but human health is also endangered as these heavy metals accumulate biologically through the food chain. Arsenic, cadmium, chromium, copper, lead, nickel, and zinc are important water impurities (Jaishankar, Tseten, Anbalagan, Mathew, Beeregowda, 2014).

Heavy metals are removed from modern wastewater through conventional strategies such as chemical precipitation, reverse absorption, industrial ion exchange process, electrophoresis, and ultrafiltration (SAO, 2014). These common industrial methods of removing heavy metals have few disadvantages, for example, being expensive, requiring large amounts of energy, not suitablefor expelling heavy metals at low concentration (1-50 mg / L), and high amount of reagents requirements, which causes Secondary pollution from chemical sludge formation and sediment removal rendering these technologies unsustainable in the long term (Wei et al., 2016). The adsorption method is a simple design and implementation method with cost-effective, reliable, and flexible properties. Furthermore, the findings of different investigators' adsorption processes indicate that heavy metals are successfully removed.

Membranes may also be considered as efficient adsorbents to be called adsorptive membrane (AM) owing to unique adsorption groups and exclusive morphological properties on the membranes to contribute support adsorption removal of heavy metal ions from wastewater, in addition to low-cost adsorbents (i.e. natural materials, bio-materials, and waste materials. AMs are an excellent candidate for wastewater purification using the adsorption process to protect theecosystem. In light of this positive effect, the advantages and disadvantages of polymeric membranes (PMs), polymer-ceramic membranes (PCMs), electrospinning nanofiber membranes (ENMs), and Nano enhanced membranes (NEMs) are discussed in this review article. However,in order to assess the consistency of Adsorption Membranes for practical use, they must be chemically stable and reusable. As a result, one of the necessary benefits that makes this methodmore cost-effective and environmentally sustainable is the regeneration and reuse of adsorbents.

1. Sources of heavy metals

Hazardous metals and minerals can pollute the environment from both natural and anthropogenic sources. Seepage from rocks into water, volcanic activity, forest fires, and other natural sources are examples. Pollution occurs when polluting elements (which are concentrated in clay minerals with high absorption capacities) are partitioned between sedimentary rocks and their predecessor sediments and water with rapid environmental pollution has risen as a result of industrialization and a consumerist lifestyle. Pollution occurs at several levels, including industrial development, product end-use, and run-off. Toxic elements reach the human body primarily through food and water, but also through inhalation of polluted air, cosmetics, medications, low quality herbal formulations (herbo-mineral preparations) and Unani formulations, and even products such as toys that have been contaminated paints containing lead.

- Leather tanning, chromium (Cr) mining, industrial coolants, chromium salts manufacturing.
- Lead (Pb) lead acid batteries, paints, e-waste, smelting operations, coal-fired power plants,ceramics, and the bangle industry.
- Mercury (Hg) Chlor-alkali plants, thermal power plants, fluorescent lamps, hospital waste (damaged

thermometers, barometers, sphygmomanometers), electrical equipment, and othersources of mercury (Hg).

Table 1. The different types of heavy metals and how they affect human health

Pollutants	Major Sources	Effect on Human Health	Permissible Level (ppm)
Cd	Welding, electroplating, pesticides, and fertilizer are only a few examples.	Harm to the kidneys, bronchitis, stomach problems, bone marrow, andcancer	0.06
As	Metal smelters, pesticides, and fungicides	Bronchitis, dermatitis, and bronchitis	0.02
Pb	Paint, pesticides, tobacco, vehicle emissions, mining, and coal combustion are all examples of pollutants.	Harm to the liver, kidneys, and gastrointestinal tract, as well as mental retardation in children	0.1
Mn	Welding, fuel addition, and ferromanganese processing are all examples of ferromanganese production.	The central nervous system is harmedby inhalation or touch.	0.26
Hg	Pesticides, batteries, and the paper industry are all examples of industries that use pesticides.	Tremors, gingivitis, protoplasm poisoning, damage to nervous system, spontaneous abortion	0.01
Zn	Metal plating, refineries, and brass manufacturing	Nervous system damage, dermatitis	15
Cu	Mining, pesticide manufacturing, and the chemical industry	Anemia, liver and kidney damage, and stomach irritation are all symptoms of anemias.	0.1
Cr	mineral sources, mine.	Nervous system damage, irritability	0.05

2. Problem statement

Although there is no specific definition of a heavy metal, the literature has defined it as a natural element with a high atomic weight and high density five times greater than water. Heavy metals,among all contaminants, have gotten a lot of attention from environmental chemists because of their toxicity. It is worth noting that heavy metal removal services are essential services that mustbe provided everywhere, yet very little is known about heavy metal removal to protect the environment and humanity from metals. Poisonous and lethal. Even at very low concentrations, many of them are toxic. Even in small quantities, minerals like arsenic, lead, cadmium, nickel, mercury, chromium, cobalt, zinc, and selenium are extremely toxic. Increasing the amount of heavy metalsin our resources is currently one of the areas of greater concern, especially since a large number of industries are discharging their liquid waste-containing minerals into fresh water without any adequate treatment. It is important to have a clear guide on how to classify heavy metals based on their sources, environmental issues and the technology available to address them. Therefore, the current research examines the concept of removing heavy metals by adsorption by biomass inorder to purify water from heavy minerals and reduce their damages.

3. Methodology

This paper is a literature review based on secondary data as is the case with most office studies where the information is used for analysis and drawing vital conclusions. Some of the data sources identified for study include books, newspaper articles, unpublished papers, and organizational and private web pages. This research approach is used when the intent of the study is to answer specific questions based on previous work. For these reasons, this paper used this approach to examine what different researchers have said about removing heavy metals fromwater with adsorption membranes.

Adsorption Membranes are available with a count of industrial geometries or laboratory- prepared geometries. Single AMs with thin sheets and hollow fibers are surprisingly flexible, cheap, convenient, quickly adsorb at low pressure, and recycle continuously. To achieve the necessary adsorption, these single AMs are stacked in series and housed in a rigid cylindrical shell capacity due to the single AMs' reduced recovery potential, which are referred to as spiral wound and membrane stack. There are spiral-wound and membrane stack options. several advantages including high compatible ability, and the cross-sectional dimension is perpendicularto the direction of the flow Significantly longer than the flow direction, with frictional support inthe column wall, and resistance to settling and cracking. As a result, the residence times and backpressures of these membrane-based columns are shorter than those of single AMs with highvolumetric potential in the large-scale.

Adsorption occurs on the solid surface to remove heavy metals, and equilibrium is achieved bymaintaining steady concentrations of adsorbed heavy metals in water. To achieve higher adsorption power, chemical adsorption interactions are more common than physical adsorption interactions for heavy metal removal.

4. Applications of Adsorption Membranes in heavy metal removal

4.1. Applications of Polymeric Membranes

In the 1960s, the use of adsorbents made of polymer materials was increased. Pollutants are adsorbed into the important functional groups on AMs during the adsorption process, which occurs when wastewater passes through the membrane. Significant functional groups in synthesized polymers include amine, carboxyl, and sulfonic acid (or biopolymers), ensure that their heavy metal adsorption capacities are efficient. Because of the amino and hydroxyl groups on CTS, chitosan (CTS)-based AMs have been widely used to extract various pollutants from wastewater. As a result, metal ion adsorption on CTS may be attributed to a variety of processes, such as chelation, electrostatic attraction, ion exchange, and so on.

Because of its high affinity for different metal ions, poly(ethyleneimine) (PEI) is considered achelating agent and is useful for heavy metal removal from wastewater. For example, a semi- interpenetrating polymer network of crosslinked poly (vinyl alcohol) (PVA)-matrix and PEI- complexing polymer was employed for the removal of Cu2+, Pb2+, and Cd2+ from aqueous solution, Pb2+ > Cu2+ > Cd2+ was the affinity order for this membrane, which was close to theoverall adsorption potential of the ions per gramme of membrane, which was 0.59, 0.47, and
0.33 m mol g1, respectively.

4.2. Applications of Electrospinning Nanofiber Membranes

Electrospinning is a well-known process for forming nanometer to micron diameter fibers intolong polymeric fibers in order to produce nanofiber membranes (nanostructure membranes) High porosity (> 90.0 percent) and a high surface-to-volume ratio (10.0–40.0 m2 g1)
Electrospinning has a number of benefits, including the ability to work with a wide range of materials; (ii) precise control over nanofiber diameter, microstructure, and arrangement; (iii) easeof incorporating additives into nanofibers; (iv) a one-step and visible process; (v) high porosity membranes (> 90.0 percent) and a high surface-to-volume ratio; and (vi) practicability in producing nanostructures.

4.3. Applications of Nano-Enhanced Membranes

The unique structure and surface characteristics of nanomaterials (carbonaceous materials, nanometal or nanometal oxides, and other organics) enable use as adsorbents for heavy metalremoval for example larger surface contact, higher reactivity, and better disposal ability).
Because of their high aspect ratio, mechanical strength, compatibility of the carbon matrix with the polymeric structure, and strong interactions and adhesion, carbonaceous materials (carbon nanotubes (CNTs), active carbon (AC), and graphene) are considered as possible counterparts inpolymer-based composites.

4.1. Applications of Ceramic Polymer Membranes

Ceramic Polymer Membranes have some drawbacks over Polymeric Membranes, such as foul, slower, and more severe recovery methods, whereas Polymeric Membranes are limited by their thermal stability. Natural clay materials (bentonite, kaolinite, and montmorillonite) are, however,more effective for heavy metal removal due to their lamellar structure, nontoxicity, low cost, high cation exchangeability, and mechanical and chemical stability.

5. Conclusion and Outlook of Future Research

Fabrication costs are a critical consideration in the production of Adsorption Membranes. It can be reduced to the desired level by low cost synthesis process, reusing the Adsorption Membranes and improving the Adsorption Membranes' heavy metal ion removal efficiency. To regenerate and reuse AMs, chemical factors must be stable, and recycling efficiency must be comparable tothe first cycles. As a result, to preserve the adsorption potential of the adsorbents during repeateduse in wastewater treatment or purification. One of the most important aspects of the adsorption process is recycling efficiency. The heavy metal ions from the spent Adsorption Membranes are desorbed in general recycling techniques.

The evolution of Adsorption Membranes (Nano-Enhanced Membranes, Polymeric Membranes, Electrospinning Nanofiber Membranes, and Ceramic Polymer Membranes) is discussed, as well as recent advances in advanced adsorbents (nanoparticles). Because of their unique morphological surface and chemical structure features, the prepared Adsorption Membranes were able to effectively extract heavy metal ions from water, as well as regenerate and reuse them, according to the findings. Advanced research on the recycling of Adsorption Membranes for large numbers of cycles with excellent adsorption and desorption efficiency without the use of costly desorbing chemicals is needed for further development. In order to preserve the surfacearea and active site of Adsorption Membranes, fabrication processes must be developed, as well as the use of multiligand or multifunctional materials that act as heavy metal ions adsorbing antennas in a variety of environments. Although the addition of nanoparticles to the nanofiber membrane resulted in increased surface area, porosity, and adsorption capability, further research and development into Adsorption Membrane fabrication will be needed to produce promising Adsorption Membranes that are both environmentally friendly and cost effective.

References

(1)Salmons W, Forstner U, Mader P. Heavy Metals: Problems and Solutions. Berlin, Germany: Springer-Verlag; 1995.

(2)F. R. Espinoza-Quiñones, C. E. Zacarkim, S. M. Palacio et al., "Removal of heavy metal from polluted river water using aquatic macrophytes Salvinia sp.," *Brazilian Journal of Physics*, vol. 35, no. 3, pp. 744–746, 2005.

(3)G. Crini, Prog. Polym. Sci.30, 38 (2005).

(4)Abbas Ali, A., Mohamed Sihabudeen, M., & Zahir Hussain, A. (2016). Biosorption of Heavy Metals by Pseudomonas Bacteria. International Research Journal of Engineering and Technology, 3(8), 1446–1450.

(5) Georgieva VG, Tavlieva MP, Genieva SD, Vlaev LT. Adsorption kinetics of Cr (VI) ions from aqueous solutions onto black rice husk ash. J Mol Liq 2015; 208:219–26.

(6)Hubadillah SK, Othman MHD, Harun Z, Ismail AF, Rahman MA, Jaafar J. A novel green ceramic hollow fiber membrane (CHFM) derived from rice husk ash as combined adsorbent-separator for efficient heavy metals removal. Ceram Int 2017;43(5): 4716–20.

(7)Reneker DH, Chun I: Nanometer diameter fibers of polymer, produced by electrospinning. Nanotechnology 1996, 7: 216-223.

(8)Martin CR: Membrane-based synthesis of nanomaterials. Chem Mater 1996, 8:1739-1746.

(9)Feng C, Khulbe K.C, Matsuura T, Tabe S, Ismail AF: Preparation and characterization of electro-spun nanofiber membranes and their possible applications in water treatment. Sep Purif Technol 2013, 102:118-135.

(10) Kaur S, Sundarrajan S, Rana D, Sridhar R, Gopal R, Matsuura T, Ramakrishna S: Review: the characterization of electrospun nanofibrous liquid filtration membranes. J Mater Sci 2014, 49:6143-6159.

(11) Liu Y, Ma H, Liu B, Hsiao BS, Chu B (2015) High-performance nanofbrous membrane for removal of Cr (VI) from contaminated water. J Plast Film Sheet 31(4):379–400 Ma H, Hsiao BS, Chu B (2013) Electrospun nanofbrous.