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NANOTECHNOLOGY AS AN ADSORBENT FOR THE HEAVY METAL (FE): LITERATURE REVIEW

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ABSTRACT

This research was a literature study that aims to understand the application of nanoparticles as heavy metal adsorbents, explore the role of nanoparticle technology in the context of environmental protection and human health, and identify effective nanotechnology. Industrial waste containing the heavy metal Fe can pose a serious threat to the environment and human health. In this study, we evaluated various literature sources discussing the use of nanoparticles, especially activated carbon, as effective adsorbents for removing heavy metals from water and waste. The results of literature studies show that the application of nanoparticles as adsorbents can increase the efficiency of filtration and heavy metal removal, which in turn contributes to environmental protection and human health. Additionally, this research identifies the important role of nanoparticle technology in various aspects, including water treatment, air pollution control, environmental monitoring, and the development of safer medicines. With proper application, nanoparticle technology can help reduce the risk of exposure to heavy metals and other pollutants, as well as improve water and air quality, which has a positive impact on human health and environmental sustainability. Identification of these most effective nanotechnologies can help guide the development of better solutions in the context of environmental protection and human health. This research provides deeper insight into the positive role of nanoparticle technology in addressing the environmental and health challenges faced by society.

Keywords : Nanoparticles, Heavy Metal Fe, Adsorbents

ABSTRAK

Penelitian ini merupakan studi literatur yang bertujuan untuk memahami aplikasi nanopartikel sebagai adsorben logam berat, mendalami peran teknologi nanopartikel dalam konteks perlindungan lingkungan dan kesehatan manusia, serta mengidentifikasi nanoteknologi yang efektif. Limbah industri yang mengandung logam berat Fe dapat menjadi ancaman serius terhadap lingkungan dan kesehatan manusia. Dalam penelitian ini, kami mengevaluasi berbagai sumber literatur yang membahas penggunaan nanopartikel, terutama karbon aktif, sebagai adsorben yang efektif untuk menghilangkan logam berat dari air dan limbah. Hasil studi literatur menunjukkan bahwa aplikasi nanopartikel sebagai adsorben dapat meningkatkan efisiensi penyaringan dan penghilangan logam berat, yang pada gilirannya berkontribusi pada perlindungan lingkungan dan kesehatan manusia. Selain itu, penelitian ini mengidentifikasi peran penting teknologi nanopartikel dalam berbagai aspek, termasuk pengolahan air, pengendalian pencemaran udara, pemantauan lingkungan, dan pengembangan obat-obatan yang lebih aman. Penelitian ini juga mengidentifikasi beberapa contoh nanoteknologi yang efektif, seperti penggunaan karbon aktif dan nanopartikel logam. Identifikasi nanoteknologi yang paling efektif

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ini dapat membantu panduan pengembangan solusi yang lebih baik dalam konteks perlindungan lingkungan dan kesehatan manusia. Penelitian ini memberikan wawasan yang lebih dalam tentang peran positif teknologi nanopartikel dalam menjawab tantangan lingkungan dan kesehatan yang dihadapi oleh masyarakat.

Kata kunci : *Nanopartikel, Logam Berat Fe, Adsorben*

Introduction

Industrial waste containing the heavy metal Fe, apart from being toxic to plants, can also have a detrimental impact on the human environment. This is related to the properties of heavy metals which tend to be difficult to decompose, so they can accumulate in water resources used by humans. The presence of these heavy metals in the water environment can have an impact on environmental resilience and human health. Heavy metals can accumulate in aquatic organisms, such as fish and shellfish, which can then become part of the human food chain. Therefore, it is important to understand and address the problem of heavy metal pollution to protect the environment and human health.

Research on nanotechnology in the environmental field, especially overcoming heavy metal pollution, has paid great attention to nanoparticle-based adsorbents because nanoparticle-based adsorbents are cheaper in terms of cost, more time efficient, easy to produce and have been proven to be able to overcome water pollution by heavy metals.

Fe metal is an essential metal whose presence in certain amounts is needed by living organisms, but in excess amounts it can cause toxic effects. The high Fe metal content will have an impact on human health, including causing poisoning (vomiting), intestinal damage, premature aging and sudden death, arthritis, birth defects, bleeding gums, cancer, kidney cirrhosis, constipation, diabetes, diarrhea, dizziness, fatigue, hepatitis, hypertension, insomnia (Parulian, 2009). Several water and soil treatment technologies have been applied to remove heavy metal (Fe) waste from water sources, one of which is the adsorption technique. Adsorption is a process in which liquid molecules stick to the surface of a solid (Delaroza, 2018).

This technology is proposed as a solution to overcome the impact of heavy metal waste on humans and the environment. Adsorption is considered an effective technology option in absorbing and reducing heavy metal concentrations in water bodies (Induvesa et al., 2022). Many methods have been reported as efficient ways to remove heavy metal ions from water sources, including chemical precipitation, ion exchange, adsorption, membrane filtration, and electrochemical technologies. Among these methods, adsorption offers flexibility in design and operation because the adsorption process is generally reversible, so that the adsorbent can be regenerated by performing appropriate desorption, allowing a variety of more efficient uses.

Based on the background, the problem formulation can be drawn, namely how the application of nanoparticles as heavy metal adsorbents can increase the efficiency of filtering and removing heavy metals from water or waste, how the role of nanoparticle technology in the context of environmental protection and human health can be explained and assessed, what type of nanotechnology is best effective in the

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context of environmental protection and human health, and what the advantages of each are.

The purpose of this paper is to collect various scientific information regarding the application of nanoparticles as heavy metal adsorbents, explore the role of nanoparticle technology in the context of environmental protection and human health and identify effective nanotechnology. So it is hoped that the research carried out will provide deeper understanding and insight as well as information regarding how nanoparticle technology can be used to clean water and waste contaminated with heavy metals, which in turn can contribute to environmental protection and human health by reducing exposure to heavy metals dangerous.

Methods

The research method used in reviewing this literature study takes data from research results and then reviews it for analysis with data or sources related to a particular topic which can be obtained from various sources such as journals, books, the internet and other libraries. The data or sources used are national and international literature obtained from databases. The literature used is literature obtained from Google Scholar, Pubmed, and ScienceDirect with a journal publication time span of the last 10 years using the keywords "Nanotechnology, heavy metals, adsorbents, activated carbon" so that 8 articles were obtained that met the criteria according to the topic for review. The data collection method used in this research is the documentation method. The documentation method is a data collection method by searching for or digging up data from literature related to what is intended in the problem formulation. This literature review was synthesized using a narrative method by grouping similar extracted data according to the results measured to answer the problems that have been formulated. The data that has been collected will be analyzed. Research articles that meet the inclusion criteria are then collected and a journal summary synthesis is made including the article title, researcher's name, natural materials used, manufacturing methods, and results/findings from the journal. To further clarify the analysis of the abstract and full text of the journal, read and pay close attention. The journal summary is then analyzed regarding the content contained in the research objectives and research results/findings. The data analysis used in this research is content analysis, which is a technique for drawing conclusions through efforts to find message characteristics and is carried out objectively and systematically. This method focuses on obtaining information from several sources.

Results and Discussion

A literature review is a review of scientific articles, books, and other sources that are relevant to a particular problem, research field, or theory, thereby providing a description, summary, and critical evaluation of the work (Ramdhani et al., 2014). Literature review is a systematic, explicit and reproducible method for identifying, evaluating and synthesizing research works and ideas that have been produced by researchers and practitioners comprehensively within its scope including all relevant material, so that it can be continued by other people who will carry out evaluations in reviewing the same topic (Okoli and Schabram, 2010).

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Even though it is research, research using literature studies does not require going into the field and meeting with respondents. The data needed in research can be obtained from library or document sources. According to (Zed, 2014), in library research, library research is not only the first step in preparing a research framework (research design) but also at the same time utilizing library sources to obtain research data.

Nanotechnology is defined as material engineering through chemical or physical processes to produce nano-sized materials, nanoparticles can be easily synthesized using various methods and various approaches. Among these methods, reduction is a relatively easy method because the process is simple (Margaretha et al., 2018). The development of nanotechnology has led to the production of innovative materials, especially environmentally friendly synthetic nanostructure processes for synthesizing metals, with various shapes and sizes (Green et al., 2021).

Nanoparticles have attracted the attention of scientists in various fields because of their ease of synthesis, small size, wide band gap, and semiconductor properties. Using nanotechnology, materials can be made lighter, stronger, more reactive, better electrical conductors and more resistant. long, among many other characteristics. Nanoparticles are materials measuring 10-100 nm nanometers (P.Velavan et al, 2015). The properties of nanoparticles can be modified by changing their size at the nanoscale, allowing them to be used in several scientific fields, including medicine (Uddin et al., 2021).

Adsorption is a process of absorbing atoms, ions or molecules in solution on the surface of an absorbing substance, the process of absorbing a substance onto the surface of another substance due to the molecular attraction that occurs between the adsorbent and the substance being adsorbed (Saputri, 2020). Ion exchange is another form of absorption that is usually used to remove heavy metal ions and other non-metal ions from solution and replace them with less toxic ions. Ion exchange is reversible, and the ion exchange resin can be regenerated by removing unwanted excess ions. This process does not produce significant waste streams of concentrated heavy metals and other ions. (Sutanto 2017). Various adsorption methods tend to be effective for removing pollutants in general, both organic and inorganic. Most adsorption methods use carbon materials to trap pollutant molecules within their pore structure.

Adsorbent is an absorbent substance while adsorbate is a substance that is absorbed. Generally adsorbents can be in the form of solid substances such as alumina, silica gel, cellulose, fine platinum and activated carbon. In this research, the adsorbent used was activated carbon. In activated carbon processing, the carbon material must ultimately be regenerated to remove adsorbed organic compounds. The mass transfer from the liquid to the surface of the grain is the initial process of adsorption, then there is a diffusion process from the surface of the grain into the grain through the pores, the mass of the liquid in the pore moves to the pore walls and finally adsorption on the pore walls. The adsorbent pores are so small that the inner surface area is several times larger than the outer surface. Saturated adsorbents can be renewed so they can be used again in the adsorption process.

Metals can be classified into two categories, namely heavy metals and light metals, heavy metals are metals with a mass of 5 grams or more per cm3, while light metals have a mass of less than 5 grams per cm3 (Delaroza, 2018). Heavy metals are

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essential elements for living things, but not allowed in excess (Afrianti and Irni, 2019). Based on a toxicological point of view, these heavy metals can be divided into two types. The first type is essential heavy metals where their presence in certain amounts is needed by living organisms, but in excessive amounts it can cause toxic effects, an example of this heavy metal is Fe. These heavy metals can cause health effects for humans depending on where the heavy metal is bound in the body. The poison's power will work as a barrier to the work of enzymes, so that the body's metabolic processes are interrupted. Furthermore, these heavy metals will act as allergens, mutagens or carcinogens for humans. The entry route is through the skin, breathing and digestion. Each of these heavy metals has a negative impact on humans if consumed in large quantities over a long time. (Ika et al., 2012)

Activated carbon or often also referred to as activated charcoal is a type of carbon that has a very large surface area and can be achieved by activating the carbon or charcoal. Activated carbon with a large surface area can be used for various applications, including as a color remover, taste remover, odor remover and purifying agent in the food industry. Apart from that, it is also widely used in the water purification process, both in the drinking water production process and in waste handling (Apriani et al., 2013). Just one gram of activated carbon has a surface area of approximately 500 m2 (obtained from nitrogen gas adsorption measurements). (Kamal, 2014). Activated carbon is the best adsorbent in an adsorption system. This is because activated carbon has a large surface area and high adsorption capacity so that its use can be optimal. Good activated carbon must have a large surface area so that its absorption capacity is also large (Prabowo, 2009).

The use of nanoparticles has provided benefits in a variety of applications, but the impact of exposure to nanoparticles on health and the environmental risks associated with the production and use of nanoparticles are still unknown.

Nanoparticle technology has an important role in the context of environmental protection and human health. Following are some of the ways in which nanoparticle technology can make a positive contribution to the health sector:

Nanoparticles can be used in water filtration and purification processes. Nanomaterials such as nanoscale activated carbon, carbon nanotubes, and metal nanoparticles have a large surface area, so they can capture and remove contaminants such as heavy metals, organic compounds, and bacteria in water with higher efficiency.

Nanotechnology can be used in the development of more efficient air filters. Nanoparticles such as nano-fibers can be used in air filters to capture small particles such as fine dust, air pollutants, and even viruses.

Nanotechnology can be used in the development of sensitive and accurate nanoscale sensors for monitoring air, water and soil quality. This allows better monitoring of the environment and rapid action required in response to pollution.

However, it should be remembered that the use of nanoparticles also requires attention to the potential impact on the environment and human health. Therefore, research and development in nanoparticle technology must be carried out carefully to minimize the risks associated with their use.

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Conclusion

From the literature review that we have carried out, it can be concluded that the application of nanoparticles as heavy metal adsorbents is an effective method in overcoming the problem of heavy metal pollution in water and waste. Nanoparticle technology has a significant role in environmental protection and human health through water treatment, air pollution control, environmental monitoring, and the development of safer medicines. Identification of effective nanotechnology will help in optimizing the use of resources and efforts in protecting the environment and human health.

This research provides deeper insight into the use of nanoparticles in the context of environmental protection and human health, and shows great potential in solving the problem of heavy metal pollution. This understanding can be the basis for developing more effective solutions to address the environmental and health challenges faced by society.

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