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# Aplication Of Adsorption Methods For Mining Wastewater Remediation : A Literature Review

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ARTICLEINFO ABSTRACT

**Keywords:** wastewater, natural biomass, heavy metals, adsorption

Small-scale gold mining is a significant economic sector in many developing countries, but it often produces wastewater containing hazardous substances such as mercury (Hg), cyanide (CN), and other heavy metals. One of the effective and sustainable technologies for remediation of mining wastewater is the adsorption method. This article presents a literature review related to the application of adsorption methods for the removal of heavy metals in small-scale gold mining wastewater. The main focus of this study is to evaluate the effectiveness of different types of natural adsorbents such as agricultural waste biomass and wood waste in batch systems and continuous systems. In addition, the study also discusses important parameters that affect adsorption efficiency, such as pH, contact time, adsorbent dose, and initial concentration of heavy metals. The results of the literature review show that natural biomass has great potential as a cheap and environmentally friendly adsorbent in small-scale gold mining wastewater treatment. However, further research is needed to optimize operational conditions and increase adsorption efficiency through modification and activation of adsorbents. With a better understanding, natural biomass-based adsorption methods can be a sustainable solution in mitigating the environmental impact of small-scale gold mining

## INTRODUCTION

Particularly in rural areas, small-scale gold mining (PESK) plays a significant role in the local economy. However, this process frequently results in liquid waste that contains dangerous elements such cyanide (CN), iron (Fe), manganese (Mn), and mercury (Hg). Mercury-containing gold processing has the potential to pollute the environment, harm aquatic ecosystems, and jeopardize local residents' health. Anthropogenic and geological sources are among the many sources of mercury's ecotoxicity (Marrugo et al., 2015). Many techniques, such as flotation, cyanide (CN) fixing, and gravity concentration, can be used to extract and process gold ore.

Conventional miners continue to employ mercury (Hg) as a component in the gold extraction process, either by amalgamation or by mixing it in a bubble. In amalgamation, mercury (Hg) binds gold to create a residue known as tailings (Kusuma, 2017). Water pollution, as defined by Government Regulation No. 82 of 2001, is the introduction of live organisms, materials, energy, or other factors into water as a result of human activity that lowers the water's quality to the point that it is unfit for its intended use.

By preventing and reducing pollution, water pollution control aims to guarantee that water quality satisfies established criteria. Chemical, physical, and biological techniques are a few ways to stop heavy metal pollution in wastewater. Adsorption is the most widely utilized technique among the others since it is thought to be efficient and

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simple to employ. Adsorbents that are often utilized, such activated carbon, have a high capacity to extract impurities from water. To eliminate heavy metal ions from water, it is crucial to employ a different strategy that makes advantage of the many natural resources found in the environment. (Muleta et al., 2024).

## MATERIALS AND METHODS

The research procedure is presented through a scheme (**Figure 1**). This study relies a literature review encompassing both national and internasional journals. Through this research, it is hoped that the right adsorption system for wastewater treatment can be found.

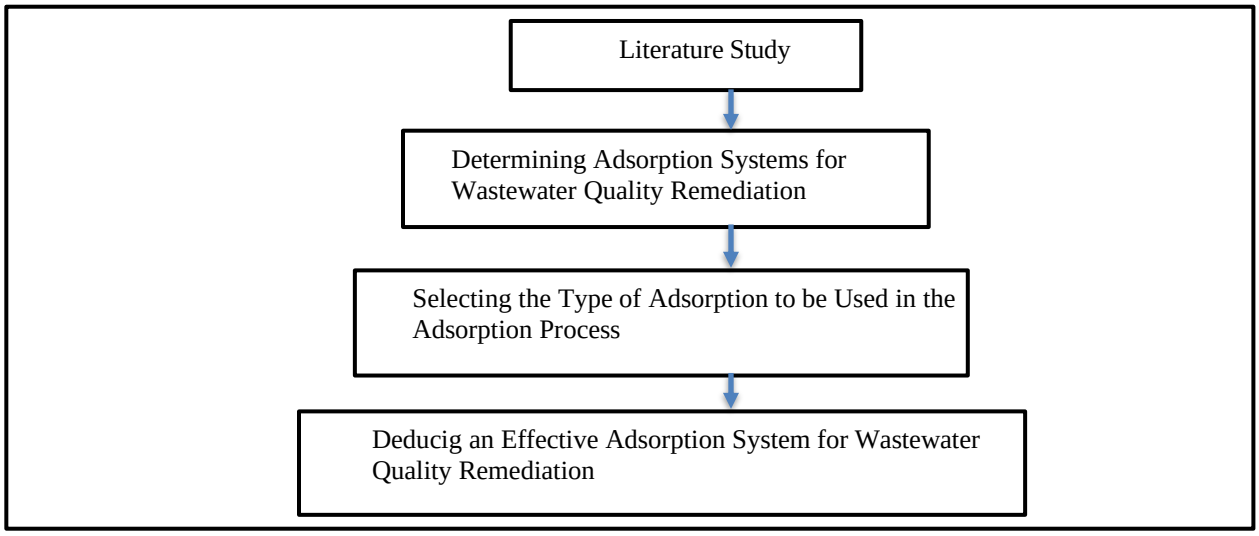


**Figure 1.** Research Scheme

## RESULTS DAN DISCUSSIONS

Adsorption is the process by which specific metals are separated by the adsorbent surface after being absorbed from a combination of gasses and liquids. The adsorption rate of an adsorbend increases with its surface area (Astuti, 2018). Solid materials known as adsorbents have the ability to absorb specific liquid phase constituents (Widayanto.T, 2017). Because they can aid in the process of filtering, separating, or eliminating impurities from solutions and gases, adsorbents are frequently utilized in the chemical industry, medicines, and wastewater treatment. The many kinds of biomass adsorbents listed in **Table 1** that can be employed to adsorb heavy metals are as follows.

**Table 1.** Types of Biomass Waste

| Research Name | Type of Biomass | Benefit | Method | Effectiveness |
|---|---|---|---|---|
| Kusumawardani, R., et al. (2018) | Bagasse | Waste from the sugar industry which has a good pore structure and high lignocellulosic content. Effective in adsorbing various heavy metals and organic matter from wastewater. | • Adsorbent activation using nitric acid (HNO3) solution.<br>• Adsorption Experiment of batch system pH determination and time analysis. | At pH 7, with ion concentration of 10 ppm and contact period of 120 minutes, the measured Cd adsorption capacity was 2,215 mg/g. The optimum pH for Cd adsorption is 7 with an optimum contact time of 120 minutes. This study shows that nitric acid-activated cellulose from bagasse can be an efficient |

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| | | | • Cd adsorption capacity using AAS devices | alternative to the adsorption of metals such as Cd. |
| Rahayu, A., N. (2014) | Corn Cobb | Lognocellulosic, a naturally occurring adsorbent found in corn stalks and cobs, can be altered to enhance the adsorption capacity of heavy metals. | • Activated carbon activation from corn cob adsorbents.<br>• Batch System Experiment.<br>• The determination of the optimum condition is based on the contact time. | Activated carbon from corn cobs has high effectiveness in adsorbing ferrous metals. At an optimum mass of 1.75 grams, the adsorption efficiency reached 97.8%, able to reduce iron content from 1.5236 ppm to 0.0332 ppm within 30 minutes. |
| Kasirajan, R., et. al. (2022) | Eggshell | Eggshell waste has excellent potential as an adsorbent to remove ions (Pb) from water solutions | • Nanosynthesis of calcium oxide (CaO nps) particles from chicken egg shells.<br>• Batch System Adsorption Experiment.<br>• X-ray diffraction test, electron microscope (SEM) to analyze the properties of synthesized nanoparticles. | Chicken egg shell waste was effective in adsorbing lead ions (Pb) reaching an optimum percentage of 99.07% with the following initial conditions: pH 6.94, adsorbent dose of 0.838 grams, concentration of 75.46 parts per million, and contact time of 101.97 minutes. The experimental allowance's efficiency was 98.86%. |
| Ifa, L., et al. (2020) | Coconut Coir | Able to remove heavy metals cadmium (Cd) and lead (Pb) from wastewater. | • Laboratory experimental.<br>• Drying of coconut coir.<br>• Initial testing with methylene blue solution.<br>• Pb concentration analysis using Atomic Absorption Spectrophotometer (AAS). | Coconut coir bioadsorbents are able to absorb Pb metal with high efficiency. The best pH effect in reducing lead concentration occurred at pH 7, with an absorption rate of 96.25%. The optimum contact time for absorption was 4 hours which resulted in a decrease in Pb concentration by 94.66% |
| Halim, A., et al. (2021) | Rice Husk | This biosorbent is effective in removing heavy metals and organic matter due to | • The process of chemical carbon activation. | With 2 grams of adsorbent and 180 minutes of stirring, the best adsorption of Cu and Pb was accomplished, with |

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| | | the content of cellulose, hemicellulose, and lignin. | • Preparation of standard solutions of Cu and Pb.<br>• Adsorption tests using Atomic Absorption Spectrophotometer (AAS). | an efficiency of 98.63% for Cu and 99.39% for Pb. Activated carbon in rice husks had an adsorption capacity of 0.1377 mg/g for Pb and 0.3205 mg/g for Cu. |
| Harnowo, A., et al. (2019) | Peanut Shell | Economical and lignocellulose-rich agricultural waste can be utilized to remove contaminants, such as heavy metals and dyes, from water. | • Adsorbent activation.<br>• Prepare the NaOH solution.<br>• Continuous system adsorption testing. | The highest adsorption capacity at the 120th minute, from the initial concentration of 100 ppm reached 97.02 ppm. Peanut shells have been proven to be efficient so they can be used as adsorbents. |
| Nuryanti, S., et al. (2021) | Cassava Peels | Cassava peels that contain high lignocellulose can be modified to increase their adsorption ability against heavy metals such as Cu, Cd, Zn, and Pb. | • Preparation of cassava peel waste.<br>• Determination of optimal dosage of carbon mass, ph, and contact time.<br>• Adsorbent measurement with atomic absorption spectrometer (ASS) | The optimal condition of Cu adsorption using cassava peel increased at an activated carbon mass of 0.5 grams. Under these conditions, the percentage of Cu adsorption reached 97.72%. Activated carbon derived from cassava peel waste is able to remove the concentration of Cu ions in wastewater. |
| Arifiyana, D., & Devianti, V. A. (2020) | Banana Peels | Contains fiber and lignocellulose compounds that can adsorb metals in wastewater such as Pb, Fe, Cd, Cu. | • Banana peel adsorbent preparation.<br>• Preparation of Fe solution.<br>• Contact Time Caretaker Analytics.<br>• Adsorbent analysis with atomic absorption spectrometer (ASS) | Banana peel can be used as a biosorbent for iron metals. The optimal contact time was 30 minutes, pH of solution 6, with an adsorption rate of 86.387% with a capacity of 1.44 mg/g. |
| Masruhin, M. et al. (2018) | Rice Straw | Rice straw has a higher adsorption capability since it contains cellulose and silica. This kind of biomass is frequently employed for the adsorption of heavy metals, including | • Adsorbent activation.<br>• Optimization of lead metal absorption based on contact time, pH, and NaOH solution. | The optimal adsorption of lignin from rice straw occurred at a contact time of 30 minutes, pH 5, and adsorbent concentration of 10 ppm, with an adsorption efficiency of 88.765%. |

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| | mercury (Hg) and cadmium (Cd). | • Atomic absorption spectrometer (ASS) test | |
| Maharani, D. F. & Wood Sawdust Sa'diyah, K. (2021) | Wood-derived linocellulose is inexpensive and readily available. It can be altered chemically or mechanically to improve its ability to adsorb organic molecules and heavy metals. | • Activation of wood sawdust adsorbents.<br>• Adsorption testing based on adsorbent mass and contact time.<br>• Test (SEM) to determine the characteristics of surface pores.<br>• The adsorption efficiency is calculated theoretically using the Freundlich and Langmuir equations | The maximum conditions of adsorption with wood sawdust reach about 96%. The adsorption process causes the adsorbent to attract the nickel metal to its surface and reduce the size of its pores. The adsorption equilibrium model obtained is the Freundlich equation model. |

The research generally demonstrates that using biomass as an adsorbent to treat wastewater from gold mines has benefits in terms of affordability, usability, and environmental benefits. Although the effectiveness of different biomass types in adsorbing certain heavy metals can vary depending on the process, the fundamental idea behind its utilization is to offer a cost-effective, sustainable, and efficient adsorption solution. Biomass has the potential to develop into a waste treatment technology that presents chances for a more ecologically friendly method of managing mining waste, provided that the proper kind of biomass is chosen and the relevant process parameters are properly configured.

The two types of adsorption methods are the continuous system and the batch system. Continuous system adsorption involves passing the adsorbate solution in a container filled with adsorbents at a specific flow rate so that the solution can be absorbed, whereas batch system adsorption involves soaking the adsorbent in a solution that will be absorbed by heavy metals while monitoring changes in its effectiveness at specific intervals. Table 2 presents a comparison of the advantages and limitations of adsorption methods in their application.

**Table 2.** Comparison of Advantages and Limitations of Adsorpstion Methods

| Research Name | Method | Advantages | Limitations |
|---|---|---|---|
| Grini, G. & Badot, P. M. (2008) | Batch Adsorption System | • Better control of process variables contact time and adsorbent concentration).<br>• Suitable for initial research and testing before large-scale implementation.<br>• Relatively easy to operate with lower capital costs | • Less efficient for large volume processing.<br>• Longer processing time compared to continuous systems |
| Nguyen, et. al. (2015) | Continue Adsorption System | • Efficient for the treatment of large quantities of wastewater. | • Capital and operational costs are higher. |

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| | • It can be automated and integrated in industrial wastewater treatment systems.<br>• Shorter Provides a shorter turnaround time than batch systems. | • Less flexibility in controlling process variables |

## CONCLUSION

The use of natural biomass-based adsorbents made from waste materials, which were previously thought to be of little or no value, holds significant potential in reducing heavy metal concentrations through both batch and continuous system approaches, according to a review of numerous journal studies on the topic. Based on the analysis results,

a. Parameters such as pH
b. Contact time
c. Adsorbent dosage

This study provides perspectives on the proper selection of adsorbents and optimization of parameters to support the development of more efficient and sustainable waste remediation methods.

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