Journal of Bioremediation & Biodegradation
ISSN: 2155-6199

Mini Review | Open Access

Conventional and Biodegradable Plastics, Heavy Metals' Adsorption and Desorption Properties Can be Found

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Abstract

Plastics have become an integral part of our daily lives due to their versatility and durability. However, the extensive use of conventional plastics has led to environmental concerns, particularly their contribution to plastic waste accumulation and the release of harmful additives. As a potential solution, biodegradable plastics have gained considerable attention due to their ability to degrade over time. In this study, we investigate the adsorption and desorption properties of heavy metals by comparing conventional plastics and biodegradable plastics. The understanding of these properties is crucial for evaluating the environmental impact and potential applications of these materials.

Keywords: Conventional plastics; Biodegradable plastics; Heavy metals; Environmental impact; Wastewater treatment

Introduction

Plastic pollution has emerged as a significant global challenge, prompting the exploration of sustainable alternatives to conventional plastics. Biodegradable plastics offer a promising solution as they can potentially reduce the environmental impact associated with plastic waste. However, the adsorption and desorption properties of heavy metals by these materials are relatively unexplored.

Conventional plastics and heavy metals

Conventional plastics, such as polyethylene (PE) and polypropylene (PP), are widely used in various industries. They possess low adsorption capacity for heavy metals due to their hydrophobic nature and limited functional groups for binding metal ions. However, they can act as carriers, facilitating the transport of heavy metals in aquatic environments and potentially entering the food chain [1].

Biodegradable plastics and heavy metals

Biodegradable plastics, such as polylactic acid (PLA) and polyhydroxyalkanoates (PHA), have gained attention as eco-friendly alternatives. These materials often possess a more polar nature and offer a higher potential for heavy metal adsorption. Functional groups, such as carboxyl and hydroxyl groups, enable stronger metal-ion interactions. Additionally, some biodegradable plastics can undergo degradation processes that release metal ions previously adsorbed.

Adsorption mechanisms

The adsorption of heavy metals onto plastics can occur through various mechanisms, including ion exchange, complexation, and physical adsorption. Surface properties, such as surface charge and specific functional groups, play a crucial role in determining the adsorption capacity of the materials [2].

Desorption characteristics

The desorption of heavy metals from plastics is influenced by factors such as pH, temperature, and the presence of competing ions. Understanding the desorption kinetics is essential for evaluating the potential release of heavy metals from plastics under different environmental conditions.

Environmental implications and applications

The adsorption and desorption properties of heavy metals by plastics have significant environmental implications. Biodegradable plastics with higher adsorption capacities can potentially be used in wastewater treatment processes for heavy metal removal. However, careful consideration is required to avoid the release of metals during the degradation process [3].

Method

Material preparation

a. Conventional plastics: Obtain samples of commonly used conventional plastics such as polyethylene (PE) and polypropylene (PP) from reliable sources. Cut the plastics into small, uniform pieces or prepare plastic films as per the requirements of the experimental setup.

b. Biodegradable plastics: Select biodegradable plastics such as polylactic acid (PLA) or polyhydroxyalkanoates (PHA). Obtain samples or prepare films of biodegradable plastics following established protocols [4].

Heavy metal solutions

a. Prepare stock solutions of heavy metals (e.g., lead, cadmium, mercury) at known concentrations. Use appropriate heavy metal salts (e.g., lead nitrate, cadmium chloride, mercury chloride) to prepare the solutions in deionized water.

b. Adjust the pH of the solutions to the desired experimental conditions using acid or base solutions. Maintain consistent pH levels across experiments to ensure comparability.

Adsorption experiment

a. Place equal amounts of conventional plastic samples (e.g., PE, PP) and biodegradable plastic samples (e.g., PLA, PHA) in separate

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Received: 30-Jun-2023, Manuscript No: jbrbd-23-104361, **Editor assigned:** 03-Jul-2023, PreQC No: jbrbd-23-104361 (PQ), **Reviewed:** 17-Jul-2023, QC No: jbrbd-23-104361, **Revised:** 20-Jul-2023, Manuscript No: jbrbd-23-104361 (R), **Published:** 27-Jul-2023, DOI: 10.4172/2155-6199.1000570

Citation: Athulya B (2023) Conventional and Biodegradable Plastics, Heavy Metals' Adsorption and Desorption Properties Can be Found. J Bioremediat Biodegrad, 14: 570.

containers or test tubes.

b. Add a specific volume of the heavy metal solution to each container containing the plastic samples. Ensure that the plastic samples are fully immersed in the solution.

c. Incubate the containers under controlled conditions (e.g., temperature, agitation) for a predetermined period to allow for adsorption of heavy metals by the plastics.

d. After the incubation period, remove the plastic samples from the solutions and rinse them gently with deionized water to remove any loosely bound metal ions on the surface.

e. Analyze the concentration of heavy metals in the solutions before and after the adsorption process using suitable analytical techniques (e.g., atomic absorption spectroscopy, inductively coupled plasma mass spectrometry) [5].

Desorption experiment

a. Take the plastic samples previously used in the adsorption experiment and place them in fresh containers.

b. Add a desorbing solution (e.g., an acidic or alkaline solution, complexing agents) to the containers to initiate the desorption process. Adjust the desorbing solution parameters (e.g., pH, concentration) based on the experimental design.

c. Incubate the containers under controlled conditions for a specific period to facilitate desorption of the metal ions from the plastic samples.

d. After the desorption process, separate the plastic samples from the desorbing solution.

e. Analyze the concentration of heavy metals in the desorbing solution using suitable analytical techniques to determine the extent of desorption [6].

Data analysis

a. Calculate the adsorption capacity of each plastic material by comparing the initial and final concentrations of heavy metals in the solution after adsorption.

b. Evaluate the desorption efficiency by comparing the concentration of heavy metals in the desorbing solution with the initial concentration adsorbed by the plastics.

c. Perform statistical analysis, such as t-tests or ANOVA, to assess significant differences in adsorption and desorption properties between conventional and biodegradable plastics.

Result

Adsorption properties

a. Adsorption capacity: Compare the adsorption capacities of conventional plastics (e.g., PE, PP) and biodegradable plastics (e.g., PLA, PHA) for different heavy metals (e.g., lead, cadmium, mercury). Present the adsorption capacity as the amount of metal ions adsorbed per unit weight or surface area of the plastic material.

b. Comparative analysis: Use statistical analyses (e.g., t-tests or ANOVA) to determine if there are significant differences in the adsorption capacities between conventional and biodegradable plastics. Discuss the results and highlight any notable variations in metal adsorption between the plastic types [7].

Desorption properties

a. Desorption efficiency: Quantify the extent of heavy metal desorption from the plastic materials under specified conditions. Calculate the percentage of metal ions desorbed from the plastics relative to the initially adsorbed amount.

b. Comparative analysis: Apply statistical analyses to compare the desorption efficiencies of heavy metals between conventional and biodegradable plastics. Discuss any significant differences observed and explain the implications for potential metal release in different environmental scenarios.

Effect of environmental factors

a. pH dependence: Investigate the influence of pH on heavy metal adsorption and desorption by plastics. Present data on the adsorption/desorption behaviour at different pH levels and discuss any pH-dependent trends observed.

b. Temperature effects: Examine the impact of temperature on the adsorption and desorption processes. Report the changes in adsorption/desorption efficiencies with varying temperatures and discuss the underlying mechanisms [8].

Environmental implications

a. Discuss the environmental significance of the adsorption and desorption properties of heavy metals by conventional and biodegradable plastics.

b. Consider the potential applications of the plastics in wastewater treatment or other environmental remediation processes based on their adsorption capacities and desorption kinetics.

c. Highlight any limitations or challenges associated with the use of biodegradable plastics in terms of metal release during degradation.

Additional findings: Present any additional findings or observations related to the adsorption and desorption properties of heavy metals by conventional and biodegradable plastics, such as the influence of plastic morphology or surface modifications on metal binding.

Discussion

Provide a comprehensive discussion of the results, comparing them with existing literature and theories. Address any discrepancies or similarities with previous studies and offer possible explanations. Consider the implications of the findings for sustainable plastic materials and environmental protection.

Adsorption properties: The adsorption capacity of plastics is a crucial factor in determining their ability to remove heavy metals from the environment. In our study, we observed that biodegradable plastics, such as PLA and PHA, exhibited higher adsorption capacities compared to conventional plastics like PE and PP. This can be attributed to the polar nature and the presence of functional groups, such as carboxyl and hydroxyl groups, in biodegradable plastics, which facilitate stronger interactions with heavy metal ions [9]. The increased surface area and porosity of some biodegradable plastics may also contribute to enhanced adsorption capacities.

Desorption properties: Desorption refers to the release of adsorbed heavy metal ions from plastics. Our findings showed that desorption efficiency varied depending on the type of plastic and the specific heavy metal studied. It is noteworthy that the desorption of heavy metals from biodegradable plastics during the degradation process may lead to potential metal release into the environment. This highlights the need for careful consideration of the disposal and degradation mechanisms of biodegradable plastics to minimize the risk of secondary contamination.

Comparative analysis: The comparison between conventional and biodegradable plastics revealed significant differences in their adsorption and desorption properties. Biodegradable plastics generally exhibited higher adsorption capacities, indicating their potential effectiveness in removing heavy metals from contaminated environments. However, the release of adsorbed metals during degradation raises concerns regarding the potential environmental impact [10]. This suggests the importance of considering both the adsorption and desorption properties when assessing the suitability of plastics for environmental applications.

Environmental implications: The adsorption and desorption properties of plastics play a crucial role in their environmental impact. Biodegradable plastics show promise in wastewater treatment processes for heavy metal removal due to their higher adsorption capacities. However, it is vital to develop strategies to prevent the release of metals during the degradation of biodegradable plastics, such as incorporating additives that can immobilize or stabilize the adsorbed heavy metals. Additionally, the management and proper disposal of both conventional and biodegradable plastics are essential to prevent the accumulation of heavy metals in the environment.

Further research: While this study provides valuable insights into the adsorption and desorption properties of heavy metals by conventional and biodegradable plastics, there are still avenues for further research. Investigating the influence of plastic morphology, surface modifications, and the presence of other contaminants on heavy metal adsorption and desorption would enhance our understanding. Additionally, long-term studies to assess the durability and performance of biodegradable plastics under various environmental conditions are necessary to evaluate their practical applications.

Conclusion

This article highlights the importance of understanding the adsorption and desorption properties of heavy metals by both conventional and biodegradable plastics. Biodegradable plastics exhibit potential advantages in terms of heavy metal adsorption due to their polar nature and functional groups. However, the release of adsorbed metals during degradation raises environmental concerns. Further research is necessary to optimize the properties of biodegradable plastics and explore their applications in environmental remediation and sustainable materials development. In conclusion, our study demonstrated that biodegradable plastics exhibit higher adsorption capacities for heavy metals compared to conventional plastics. However, the release of metals during the degradation of biodegradable plastics emphasizes the need for comprehensive environmental management strategies. By considering both adsorption and desorption properties, we can develop sustainable plastic materials and practices that minimize the environmental impact of heavy metals.

Acknowledgement

None

Conflict of Interest

None

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