


# Chapter 8

## Hydrophytes and Circular Economy for Heavy Metal Remediation

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### ABSTRACT

*Heavy metal pollution poses a significant global environmental challenge, affecting the ecosystem and the health of humans due to different industrial and anthropogenic activities. Traditional remediation methods are ineffective, expensive, and causes secondary pollution. This chapter discusses how hydrophytes, and aquatic plants can be used to provide a sustainable and eco-friendly solution for heavy metal remediation. We explore the variances on how hydrophytes absorb, accumulate and detoxify heavy metals released into water, including phytoextraction, phytostabilization, and rhizofiltration. In addition to what they do in terms of remediation, the chapter points out the importance of integrating the use of hydrophyte-based systems with the philosophy of circular economy.*

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## 1. INTRODUCTION

Heavy metals pollutants are one of the most difficult to treat environmental issues and they are widespread (Xie *et al.*, 2022). Unlike organic pollutants, heavy metals are not biodegradable and thus have long-term detrimental effects to ecosystems and human health due to their potentially high levels of accumulation into the environment (Farid *et al.*, 2023). Current remediation approaches to address heavy metal contamination, including chemical precipitation, ion exchange, and membrane filtration, have the disadvantage of being quite expensive, energy-intensive, and producing secondary wastes, which underlines the fact that they become less sustainable over the long term (Iyyappan *et al.*, 2023). This has encouraged the quest of more environmental friendly and cost-efficient alternatives.

The ability to use plants as a medium of cleaning up polluted environments, known as phytoremediation, has become one of the emerging green technologies. Among the plants that have been being used to do this, the use of the hydrophytes has emerged as a very great potential in removing heavy metals in water (Khan *et al.*, 2024). They are good candidates in purifying water because they can absorb and concentrate the metals that they find around their surroundings. Nonetheless, one of the bottlenecks of phytoremediation has been the issue of management of the metal-laden biomass left after the cleanup process is completed. Otherwise, this biomass may end up providing secondary pollution and ruin all the effectiveness of the entire approach of sustainability.

Here is where the rules of the circular economy are applied. A circular economy does not leave any waste and focuses on the fact that resources can be kept in the merry-go-round, where they can be used all the time, and does not presuppose the traditional straight line of take-make-dispose (Sarah Lee, 2025). By connecting such hydrophyte-based remediation to a sustainable circular economy and assessing its overall health impacts, the possibility of turning the contaminated plant biomass liability into a resource can in fact become a reality. It can be viewed as developing new techniques to produce bioenergy, extract metals, or add value to the harvested biomass (Iyyappan *et al.*, 2023). In addition to addressing the issue of heavy metal pollution, this combination of tactics can support sustainable development and resource efficiency.

This chapter will provide a comprehensive overview on the utilisation of hydrophytes in heavy metals remediation in the aspect of circular economy. We will explore the biochemistry of extreme metal uptake in hydrophytes, how the ensuing biomass can be valorized and potential applications and problems of this coupled strategy. Envisioning the transformation of the environment remediation process to resource recovery, we can offer a comprehensive and sustainable solution to the burning issue of heavy metal pollution.

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