CHAPTER

# 7

# CRAYFISH SHELL BIOCHAR FOR DYE ADSORPTION

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## 7.1 INTRODUCTION

Water is a resource without which we cannot survive, sustaining life on earth and driving human progress. Even so, the increasing burden due to pollution threatens the availability of clean and safe water globally. Human activities, namely industrialisation, urbanisation and continual population growth have intensified the discharge of hazardous chemicals, particularly synthetic dyes into water bodies. An estimated 700,000 metric tons of dyes are produced annually across the globe, with 5% to 10% of them being discharged into streams during industrial processes. These pollutants degrade not only water quality but also pose severe health risks to humans, animals, and ecosystems.

While there are many pollutants that contaminate water, synthetic dyes, which are widely used in textiles, printing and plastics, are particularly persistent. Of these, methyl violet, a common triphenylmethane dye, is commonly used in textile manufacturing, biological staining as well as in various industrial applications. Despite this, issues have risen over its improper disposal, which has led to significant environmental concerns. This is extremely alarming because methyl violet is chemically stable, resistant to biodegradation and highly

toxic, causing adverse health effects such as skin irritation, respiratory issues and even carcinogenic risks. In aquatic ecosystem, dye pollution even at low concentrations reduces water transparency and disrupts aquatic photosynthesis. Additionally, dyes increase the biochemical oxygen demand (BOD) and chemical oxygen demand (COD) in water, further endangering aquatic creatures and reducing water quality. Overcoming this challenge requires innovative, cost-effective and sustainable water treatment technologies.

Traditional water treatment methods such as coagulation, flocculation and oxidation have been commonly applied to remove dyes from wastewater. Although they are effective, these conventional methods often suffer from high operational costs, energy-intensive processes and secondary waste generation. Membrane filtration, a more recent method, is costly and needs to be maintained regularly due to fouling issues, making it less feasible for large-scale applications. As the need for cleaner water becomes a pressing global issue, scientists have sought nature-inspired solutions, including the exploration of biochar as a promising alternative for water purification.

Adsorption, the process of trapping pollutants on a solid surface, has proven to be one of the most effective and economically feasible methods for dye removal. Natural and engineered adsorbents, including activated carbon, clay minerals and biochar, have been extensively explored for their ability to capture dyes from wastewater. Nowadays, biochar derived from organic waste materials has gained significant attention due to its low-cost, high adsorption capacity and renewable resource.

Biochar is typically produced from plant-based materials such as wood, crop residues and organic waste, and has been proven effective to remove contaminants from water. However, an unconventional, non-plant, yet highly promising source of biochar has emerged. Crayfish shell is a byproduct of the seafood industry; abundant and is often discarded as waste. Transforming it into biochar opens up a novel way to repurpose the trash that would be otherwise disposed into adsorbent for water purification.

Crayfish shell biochar is rich in calcium carbonate ($CaCO_3$) and chitin, both of which enhance its adsorption properties, making it effective for capturing dyes and heavy metals from wastewater. The unique structural properties of crayfish shell biochar allow it to show superior performance compared to conventional adsorbents, offering an eco-friendly solution to water pollution. This innovation has the potential to revolutionize wastewater treatment, creating a sustainable alternative to alleviate industrial water pollution.

In this chapter, the potential of crayfish shell biochar in dye removal is explored, focusing on its synthesis, adsorption mechanisms and environmental applications. Harnessing this natural resource for water pollution control advances not only current treatment strategies but represents a vital step towards addressing global challenges in achieving environmental sustainability.

## 7.2 TRADITIONAL VERSUS MODERN SOLUTIONS

Water pollution caused by synthetic dyes has led to the development of various treatment techniques to remove these harmful substances from water. Both traditional and modern techniques have been applied throughout the years, and each has its own advantages and limitations. The challenge lies in finding a solution that performs well and also sustainable, affordable and environmentally friendly.

### 7.2.1 Traditional Dye Removal Methods: Strengths and Limitations

Common conventional methods that have been used for decades to treat dye-contaminated water include chemical coagulation and flocculation, oxidation, membrane filtration and biological treatment. In many cases, these methods have proven to be effective, but they often suffer from drawbacks such as high operational and maintenance costs, energy-intensive processes and incurring secondary pollution.