CHAPTER I
INTRODUCTION

1.1. Background of the Study

Indonesia has many sources of biomass spread across various locations in its territory. The main sources of biomass come from plantations, agriculture, and forestry. Several types of biomasses have shown abundance and good utilization, especially as alternative energy sources and bio-products. The amount of biomass used as an energy source is very large in Indonesia, with the annual biomass amounting to 146.7 million tons, while the biomass generated from waste in 2020 is estimated to reach 57.7 million tons[1]. However, there are still some biomass resources that cannot be utilized optimally. One of the obstacles that can cause the inefficiency of renewable energy is the variability of biomass, which results in the inconsistency of its characteristics and composition[2]. Therefore, to ensure the efficiency and sustainability of alternative biomass energy, it is necessary to determine the appropriate type of material and conversion technology.

Another abundant biomass source that has not yet been maximally utilized is bamboo. Bamboo is a plant that belongs to the Gramineae family with efficient photosynthesis capabilities, with national production reaching 17 million stems each year[3] that make Indonesia as the 3rd largest bamboo producer in the world[4]. Bamboo has the advantage of rapid growth and a high strength-to-weight ratio[5]. Ponorogo has a high bamboo production rate, which can be seen from the large number of bamboo weaving industries in the area, totaling 2,088 business units[6]. With the many bamboo craftsman industries, this has resulted in the accumulation of bamboo waste in several shops selling and processing bamboo weavings scattered throughout Ponorogo. The

[1] Sulasminingsih et al., "Penggunaan Biomassa Sebagai Energi Alternatif Pembangkit Listrik Di Wilayah Pedesaan."
[2] Fitriasari, Teknologi Konversi Biomassa Untuk Pengembangan Bioproduk Berbasis Selulosa Dan Lignin Sebagai Sumber Energi Terbarukan Dan Material Berkelanjutan.
[3] Fitriasari, Teknologi Konversi Biomassa Untuk Pengembangan Bioproduk Berbasis Selulosa Dan Lignin Sebagai Sumber Energi Terbarukan Dan Material Berkelanjutan.
[4] Nunu Anugrah, "Pemerintah Kembangkan Strategi Nasional Industri Bambu Rakyat."
[5] Chen et al., "Effect of Pyrolysis Temperature on the Chemical Oxidation Stability of Bamboo Biochar."
[6] Badan Statistik Kabupaten Ponorogo, "Jumlah Industri Dan Kerajinan Rakyat Non Formal Menurut Jenisnya."

bamboo waste consists of parts of the bamboo stalk that have been scraped or split. From that waste, further processing to reduce and prevent waste from being discarded is still considered less innovative. In this case, many people still see bamboo waste pieces as having low economic value, resulting in a lot of bamboo waste being discarded unnecessarily[7]. However, if we look deeper, there is still a lot of potential for utilizing bamboo waste, such as converting it into renewable energy or other bio-products that have benefits like pollutant or heavy metal absorption.

To convert biomass such as bamboo waste into simple biochemical components, various types of application technologies have been implemented, including physical, chemical, mechanical, and biological conversion technologies, among which is pyrolysis[8]. Pyrolysis has been considered a leading and promising biomass conversion technology because it offers many valuable advantages such as low operational costs, high efficiency[9], and relatively wide adaptability[10]. Pyrolysis is a widely used technical term to describe the thermal decomposition of organic materials with little or no oxygen assistance, resulting in the conversion of biomass into several components such as bio-oil, syngas, and primarily biochar[11].

From previous research, it has been stated that pyrolysis conditions, particularly pyrolysis temperature, can significantly affect the elemental composition, chemical structure, and stability of the pyrolysis products[12]. Low pyrolysis temperatures (around 300 °C) yield high biochar yields. As the pyrolysis temperature increases, the volume of biochar produced tends to decrease[13]. At higher temperatures, biochar has higher total nitrogen content and pH, as well as larger surface area and pore volume[14] and also tends to increase the volume of synthetic gas produced. The

[7] Arsallya, "Pengolahan Limbah Bambu Menjadi Trimmings Dan Aksesoris Fesyen."
[8] Qiu et al., "Biochar as a Low-Cost Adsorbent for Aqueous Heavy Metal Removal: A Review."
[9] Monteil-Rivera et al., "Isolation and Characterization of Herbaceous Lignins for Applications in Biomaterials."
[10] Das et al., "Multiband Fluorescent Graphitic Carbon Nanoparticles from Queen of Oils."
[11] Yuan et al., "Comparison of Bio-Chars Formation Derived from Fast and Slow Pyrolysis of Walnut Shell."
[12] Park et al., "Slow Pyrolysis of Rice Straw: Analysis of Products Properties, Carbon and Energy Yields."
[13] Wulandari Et Al., "Pengaruh Suhu Pirolisis Jerami Padi Terhadap Variabel Komposisi Pirolisis Menggunakan Reaktor Batch."
[14] Evizal, Fembriarti, And Prasmatiwi, "Biochar: Pemanfaatan Dan Aplikasi Praktis Biochar: Beneficial And Best Practices."

gas produced usually consists of hydrogen, carbon monoxide, and methane[15]. However, it is important to pay attention to the type of biomass used and the pyrolysis conditions, as they can affect the composition and volume of the pyrolysis products.

Bamboo as biomass to be converted through pyrolysis conversion technology was chosen by researchers due to several advantages such as its rapid cultivation and high lignocellulosic composition. Generally, bamboo in Indonesia has a cellulose component reaching 44%, lignin 28-30%, and hemicellulose 18%. From the research conducted by Widyasari[16], the lignin component in bamboo tends to be higher compared to another biomass. Lignin is a component that is more resistant to thermal decomposition compared to other compositions, so bamboo has stability at high temperatures[17]. This also makes bamboo potentially capable of producing biochar in very large quantities[18]. With the biochar produced, it is also expected that the resulting quality will be consistent in its effectiveness as a pollutant-absorbing material that can reduce environmental damage caused by waste or heavy metals. In this study, bamboo was chosen to analyze the biochar content produced and its ability as an adsorbent for heavy metals.

1.2. Problem Statement

This research is based on several problem formulations, they are; How does temperature affect the yield of bamboo waste pyrolysis? How are the physical and chemical characteristics of biochar from bamboo waste? and What is the effect of biochar as an adsorbent in reducing heavy metals?

1.3. Scope and Limitations

Based on the problem formulation that has been presented above, the researcher has limited the scope of the study by focusing on the research variables in

[15] Kajaste, "Chemicals From Biomass - Managing Greenhouse Gas Emissions In Biorefinery Production Chains - A Review."
[16] Fitriasari, *Teknologi Konversi Biomassa Untuk Pengembangan Bioproduk Berbasis Selulosa Dan Lignin Sebagai Sumber Energi Terbarukan Dan Material Berkelanjutan*.
[17] Jamilatun Et Al., "Experimental Study On The Characterization Of Pyrolysis Products From Bagasse (Saccharum Officinarum L.): Bio-Oil, Biochar, And Gas Products"; Iskandar And Rofiatin, "Biochar Characteristics Based On Biomass Type And Pyrolysis Process Parameters Biochar Characteristics Based On Biomass Type And Pyrolysis Process Parameters."
[18] Chen et al., "Effect of Pyrolysis Temperature on the Chemical Oxidation Stability of Bamboo Biochar."

the pyrolysis process, the effect of pyrolysis temperature on the pyrolysis process, and its impact on the characteristics of biochar, as well as observing the effects of the produced biochar by using it as an adsorbent for heavy metals.

1.4. Objectives of the Study

From the existing problem formulation, the researcher determines the objectives of the research, they are; Knowing the effect of temperature on the yield of bamboo waste pyrolysis. Knowing the physical and chemical characteristics of biochar from bamboo waste. Knowing the influence of biochar implementation as an adsorbent in reducing heavy metals.

1.5. Significances of the Study

The contribution of this research is that it can provide scientific data on the pyrolysis process through several temperature variations based on bamboo waste, which will be used as sustainable energy and bio-products, helping to reduce pollutants that have contaminated the environment such as heavy metals, and maximizing the utilization of bamboo waste without causing negative ecological impacts.