1. Introduction
Mining activities gives a negative impact on the environment such as ecology on the local level, although some publications assessed vegetation impacts and animal behaviour also at the regional level [1]. The mining industry will give an impact on a bio-geo-physics aspect such as land, air pollution and wastewater namely acid mine drainage (AMD). AMD is wastewater caused by sulphide as an abundant element on Earth such as sulphur that dangerous for the environment. The largest of sulphur reservoirs are in sediments and rocks (7800 × 1018 g) in the form of iron sulphides, mainly pyrite (FeS2), and gypsum (CaSO4) or as sulphate in seawater (1280 × 1018 g). Sulphur occurs in different oxidation states (from -2 to +6) and chemical forms. These compounds be transformed both chemical and biologically [2].

AMD is also wastewater caused by mining activity and needs to be treated. Acid mine drainage has high heavy metals (Fe, Mn, As, Al, Ca, etc.) content and low pH [3]. The recent study informs that AMD has been treated by adsorption and precipitation [4,5]. Adsorption is a low-cost method to
reduce heavy metals on AMD. Several studies have showed that biochar is a new green carbon material and successfully absorbed the metals ion from aqueous [6,7]. Biochar can produce from all of the carbon materials [8]. Biochar has been successfully reduce more than 40 mg/g Cu from artificial solutions in the competitive study [9]. In several studies, biochar has been utilized in wastewater treatment and soil remediation [10,11]. Biochar has good pores and high surface area, therefore biochar considered as a potential sorbent to reduce metals ion in acid mine drainage. Although biochar has been used to reduce metals ion, however biochar cannot solve the low pH condition in AMD. Meanwhile, clamshell has high CaCO₃, and considered as a potential feedstock to generate CaO by using calcination process.

Although biochar has good pores and high surface area, and clamshell is a potential material to produce CaO; however how to produce biochar and CaO from clamshell in rural areas still being a problem. This might be due to the coal mining area is always in rural areas. Thus, the low cost and simple technology to produce biochar and CaO is still a problem. In this paper, biochar and CaO are generated from coconut shells and clamshells using a low-cost modified reactor. Metals ion removal (Fe and Mn) were measured using Atomic Absorption Spectrophotometry (AAS)

2. Materials and Methods

AMD has been collected from a coal mining company in Batang Hari, Jambi, Indonesia. Clamshell and coconut shells were collected from Tanjung Jabung Barat, Jambi, Indonesia. Low-cost modified reactor was created from a modified pan. The schematic design of biochar production can be seen in Figure 1. Biochar and clamshell were burned for 4 h in the low-cost modified reactor separately.

![Figure 1. Schematic design of biochar production](image)

Biochar and clamshell were added into AMD in beaker glass at room temperature. 100 mg of biochar has been added into 200 mL of AMD and stirred at 500 rpm for 0, 60, 80, 100 and 120 minutes. Then 0, 40, 60, 80, 100 and 120 mg of clamshell were added separately into 100 mL of AMD at room temperature. The samples were stirrer at 500 rpm for 1 h. Biochar and clamshell were characterized by XRD and XRF to identify the structure and elements of samples; the heavy metals and pH measurement were performed by using AAS and pH meter.
3. Results and Discussions

3.1. The Effect of Biochar on The Removal of Heavy Metals
The initial concentration of Fe and Mn in acid mine drainage is 8.9 and 0.5. The different concentrations of heavy metals on acid mine drainage were caused by the geological formation, oxidation process, oxygen, and the weather. The weather will affect the concentration of heavy metals because rain will dilute the acid mine drainage and reduce the heavy metals concentration. The biochar effect of acid mine drainage can be seen in Figure 2. In this study, biochar has successfully reduced Mn from 8 into 0.3 and Fe from 0.5 into 0.1, respectively. This phenomenon informed that low-cost modified pyrolysis has been successfully convert coconut shell into biochar.

The low-cost-modified reactor in this study was able to reduce heavy metals up to 97 % for Mn and 80 % for Fe, respectively. This condition showed that biochar could be considered as a potential adsorbent in competitive study or wastewater application. The possible absorption process in this research is ion exchange adsorption, and recent research also informs that the absorption of heavy metals into biochar is in appropriate with ion exchange and adsorption [12-15]. Biochar utilization on acid mine drainage will give positive impact to reduce waste materials, while biochar sludge is a good material for soil and carbon sequestration [16].

Figure 2. Biochar effect towards Mn and Fe Concentrations in the AMD
3.2. The Effect of Clamshell on The Removal of Heavy Metals

A recent study reported that clamshell has high CaCO₃ concentration [17]. This material is a potential material as an alternative way to neutralize pH of AMD. CaCO₃ is able to synthesis CaO using the calcination process in a modified reactor. In this study, CaO was derived from clamshell and able to neutralize pH on AMD (Figure 3). The possible reaction in this phenomenon can be seen in equation (1). Based on Figure 4, pH of AMD was increased when CaO was added from the clamshell. Clamshell utilization will reduce waste material significantly. The optimum mass of clamshell in 60 mg was successfully increased pH from 2.7 to 7.0. Thus, the best concentration of clamshell in AMD utilization is 60 mg/100 mL AMD.

\[ \text{H}_2\text{O}(l) + \text{CaO} (s) \rightarrow \text{Ca(OH)}_2 \]  

(1)

**Figure 3.** Biochar effect towards percent removal of heavy metals in the AMD

**Figure 4.** Effect of clamshell into pH AMD
4. Conclusion
A simple method using clamshell and biochar could reduce pH and heavy metals content in acid mine drainage. This method involved a low-cost technology in producing biochar and clamshell. Clamshell could neutralize pH from 2.7 to approximately 6-7 and reduce Fe and Mn content from 8.89 to -0.5. This method is suitable to be applied in mining industry at a rural area.

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