Utilization of activated carbon from coconut shell in remediating heavy metal waste in soil around mining area

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Abstract. Soil contamination by liquid waste that containing heavy metals in Jendi Village, Selogiri Sub-District, Wonogiri Regency has occurred for a long time. This situation is affected by the Traditional Gold Mining activity in that region. To overcome this problem, the authors utilize activated carbon from coconut shell as an easy, effective and environmentally friendly remediation method. In this research, activated carbon is believed can adsorb heavy metal waste around the gold mine area. This research was conducted from August 9, 2017 - December 28, 2017 by taking samples of waste in the gold mine area and applying 200 ml of the waste to a soil miniature. Parameters observed were Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDS). The results show that the existence of heavy metal in soil is decreasing. So, the activated coconut shell carbon effectively in remediating soil that contaminated heavy metal waste.

1. Introduction
Environmental pollution by heavy metals in Indonesia is increasing nowadays. Heavy metals are elements that are not biodegradable, so the accumulates heavy metal waste in the soil will have a negative effect on human life and the environment [1]. The entry of heavy metals into the environment naturally occurs because of the outcrops that appear to the surface or because of the weathering of rocks containing heavy metals. While other causes are human activities such as the use of fertilizers, garbage and factory waste [2].

The traditional gold mining area in Jendi Village, Wonogiri Regency is managed since 1990 by local people. The gold mining activities are carried out in traditional ways without good planning techniques and makeshift equipment [3]. This traditional gold mining process is done by using mercury (Hg) which serves to bind and separate gold ore with sand, mud, and water [4]. Beside that this process also done by using borax. The accumulation of heavy metal waste that discharged into the ditch over a considerable period of time may harm the environment. To overcome the pollution caused by this traditional gold mining process, we try to conduct research aimed at reducing the intensity of the heavy metal in soil. The use of environmentally friendly materials such as activated carbon to adsorb heavy metal that has accumulated beneath the surface is expected to reduce the environmental contamination in the mining area.

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2. Method
This research was conducted from August to December 2017 at the Geology and Mapping Laboratory of Geophysics Department, Universitas Padjadjaran Jatinangor for the sample acquisition and Hydrogeology Laboratory of the Faculty of Mining and Petroleum Engineering, Institut Teknologi Bandung for the analysis of Scanning Electron Microscope (SEM) and Energy Dispersive X-ray Spectroscopy (EDS). The flowchart of the is shown in Figure 1.

Figure 1. Flowchart of the research

2.1. Sample Acquisition
This research was carried out on a small scale using soil miniature which was then injected with mine waste containing heavy metal. Soil miniature was made using a 27.5 cm x 10 cm x 20 cm aquarium which is marked every 5 cm to be nailed. This nail plug aims to provide space and make the absorption of heavy metal waste into the soil easier. Heavy metal waste is injected as much as 5 ml every day until it accumulates as much as 200 ml. Then the soil miniature is divided into two regions: area A and area B. The surface soil of area A is applied activated carbon while area B is left (Figure 2 and Figure 3). The soil miniature is doused with distilled water (Aquades) every day to maintain soil moisture.

Figure 2. Soil miniature injected with heavy metal waste and given Aquades. Figure 3. Area A is applied with activated carbon while area B is left.
2.2. Sample Processing
There are three samples used for SEM-EDS test, ie area A sample, area B sample and original soil sample. These three samples were analyzed using JEOL JSM-6510A. The parameters sought were elements of heavy metal which acted as pollutants. The result of this test shows the percentage mass of elements that exist in the soil.

SEM is a tool for surface observation, with the advantage of the depth of focus greater than the optical microscope with the possibility of direct viewing the complicated surface without replication [5]. The SEM image displayed the morphological state of the sample showing irregular clumps of varying sizes. Meanwhile, EDS analysis is ideal for revealing chemical elements and compounds in the sample [6]. Elemental mapping of EDS will give different colors to each element on the object’s surface and analyze quantitatively the percentage of each element.

3. Result and discussion
Based on SEM-EDS test the elements that present in the original soil sample, area A sample and area B sample are shown in Table 1, Figure 4, Figure 5 and Figure 6.

| Element | Mass % Original Soil | Mass % Area B Soil (contaminated by heavy metal waste) | Mass % Area A Soil (applied with activated carbon) |
|---------|----------------------|------------------------------------------------------|--------------------------------------------------|
| C       | 46.34                | 22.00                                                | 45.10                                            |
| O       | 25.10                | 38.00                                                | 26.38                                            |
| Na      | 0.00                 |                                                      |                                                  |
| Mg      | 0.22                 | 0.36                                                 | 0.43                                             |
| Al      | 12.65                | 9.33                                                 | 12.79                                            |
| Si      | 10.47                | 11.01                                                | 11.86                                            |
| S       | 0.14                 | 9.33                                                 | 0.10                                             |
| Ti      | 0.58                 | 0.40                                                 | 0.41                                             |
| Fe      | 3.68                 | 9.08                                                 | 2.55                                             |
| Cu      | 0.30                 | 0.27                                                 | 0.16                                             |
| Zn      |                      |                                                      |                                                  |
| Ag      |                      |                                                      |                                                  |
| Au      |                      |                                                      |                                                  |
| Hg      | 0.50                 |                                                      | 0.23                                             |
| Pb      |                      |                                                      |                                                  |
| Total   | 100.00               | 100.00                                               | 100.00                                           |

The high number of element O in area B sample known as the impact of oxidation since mercury is easy to oxidize [7]. This shows that the traditional gold mining process in Jendi village does use mercury for the process of separating gold ore with sand and mud.

Heavy metals can be divided into two types, there are essential heavy metals and non-essential heavy metals [8]:

- Essential heavy metal
  Such as Zn, Cu, Fe, Co, Mn and Se is required by living things, but if excessive can be toxic.

- Non-essential heavy metals
  Like Hg, Cd, Pb, Sn, Cr (VI) and As are toxic metals. This heavy metal can have an adverse effect on human health. These compounds cannot be damaged in nature and do not change into other forms.

Based on Table 1, known that the sample contain heavy metal there are Fe, Cu, Zn, Hg and Pb. The composition of Cu in area A is lower than area B, this condition shows that the activated carbon is
adsorbing the metal content in the soil. Meanwhile the content for other heavy metals is not listed in the EDS test results, this is estimated because of the small content of heavy metals compared to other elements contained in the sample. However, the elemental mapping images show that heavy metal content such as Hg and Pb is very high in area B soil samples (Figure 6) then area A soil and original soil sample (Figure 4 and Figure 5).

The area A soil sample (Figure 5) is the area that contaminated by heavy metal waste and applied with activated carbon known that the content of heavy metals are low, even less than the content of the original soil samples. While, the area B soil sample (Figure 6), the area that contaminated by heavy metal waste is known that the content of heavy metals are high, seen from the color indicator of heavy metal element (Fe, Cu, Zn, Hg and Pb) in Figure 6. The more color indicators are detected means the sample contain more elements.

Based on the results of the elemental mapping images, it is known that the content of heavy metals (Fe, Cu, Zn, Hg and Pb) in area A soil sample is less than area B soil samples and original soil samples. This condition shows that the role of activated carbon made from coconut shell is effective in remediating heavy metals content in the soil.

**Figure 4.** Elemental mapping of original soil sample

**Figure 5.** Elemental mapping of area A soil sample (applied with activated carbon)
Figure 6. Elemental mapping of area B soil sample (contaminated by heavy metal waste)

4. Conclusion
Based on the results of the SEM-EDS test and the analysis that has been done it can be concluded that activated carbon from coconut shell is an effective material as an adsorbent for the remediation of heavy metal content in the soil. So that small-scale research can be applied to gold mining areas and the surrounding environment to reduce the negative impact caused by heavy metal waste.

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