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# Preface

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# PREFACE

The **1st International Seminar on Mineral and Coal Technology (ISMCT 2021)** was held for the first time in Bandung, Indonesia on the 23rd–24th June 2021. The seminar theme is "*Sustainable Development on Mining, Processing, and Environment*" and presented four distinguished keynote speakers, namely Dr. Ir. Ridwan Djamaluddin, M.Sc. as Directorate General of Mineral and Coal, Ministry of Energy and Mineral Resources Republic of Indonesia (MEMR); Prof. Dr. Aleksandar Nikoloski from Murdoch University, Australia; Dr. Kazuyuki Murakami from JCOAL, Japan; and Cristian Bolda, BCSEng (Mech) from Leigh Creek Energy, Australia. The seminar also performed 10 Invited speakers from institutions, namely the Research Institute of Soil Science and Agrochemistry, Uzbekistan; GOLD ISMIA-UNDP; Mine Reclamation Corporation, South Korea; TNB Fuel, Malaysia; Research and Development Center for Mineral and Coal Technology (*tek*MIRA); PT. Vale Indonesia; PT. Amman Mineral Nusa Tenggara; PT. Indo Tambang Megah; PT PLN (Persero); and PT. Timah Tbk.

The participant of the seminar included academics, researchers, practitioners, professionals, and government personnel that came from Murdoch University, Australia; Center for Ceramics; Ministry of Industry Republic of Indonesia; Indonesia Institute of Sciences (LIPI); *tek*MIRA-MEMR; Center for Applied Nuclear Science and Technology (PSTNT)- BATAN; The Laboratory of Fuel and Engineering Design (BTBRD-BPPT); Centre for Pulp and Paper-Ministry of Industry; PT. PLN (Persero); Research Center for Maritime Affairs Republic of Indonesia; PT Multi Nitrotama Kimia; University of Indonesia (UI), Universitas Pembangunan Nasional Veteran Jakarta (UPN Jakarta), Universitas Pembangunan Nasional Veteran Jogjakarta (UPN Jogjakarta), University of Gadjah Mada (UGM), University of Padjadjaran (UNPAD), University of Trisakti (USAKTI), University of Jenderal Achmad Yani (UNJANI), Polytechnic of Energy and Mining (PEP), and Technology Institute of Sumatera (ITERA).

Due to pandemic Covid-19, the seminar was held virtually and was conducted within two days. The first day seminar was divided into three sessions, the first session was the opening ceremony which began with the ISMCT report from Head of Research and Development Agency of Energy and Mineral Resources, and opening remarks from the Minister of Energy and Mineral Resources that belongs to the first session. The second session came from two keynote speakers and the third session was a parallel oral presentation which was divided into five virtual rooms based on the presentation theme, i.e., room A (Mineral); Room B (Coal); Room C (Mining); Room D (Environment) and Room E (Techno-economics and Policy). Each room was guided by a moderator and operator. Parallel session in each room was initiated with the speak from the invited speaker, followed by the oral presentation from an average of 10 presenters per room with assigned time for 15 minutes per presenter (10 minutes presentation and 5 minutes discussion). The second day was divided into three sessions, the first session was a keynote speech served by two keynote speakers, and the second session was the parallel session. The third session was the closing speech from the chairman of the committee and ended with the announcement the of the best presenter.

Around 103 selected manuscripts were presented in the seminar. Such an amount was chosen from 137 manuscripts that had been received by the committee and screened by the ISMCT editorial team. All manuscripts have been peer-reviewed with triple-blind review by three reviewers for each manuscript. Of 103 presented manuscripts around 88 papers have been accepted by the editorial team and submitted to IOP Conference Series: Earth and Environmental Science (EES) for further processing prior to publishing them.

The ISMCT 2021 has been successfully organized by R&D Centre for Mineral and Coal Technology (tekMIRA) and has brought together practitioners, researchers, academics, regulators, professionals and civil society to meet and collaborate on sustainable development and technology innovation in the fields of mineral, coal and mining industry, processing, environment and techno-economics and policy.

Thanks to the Minister of Energy and Mineral Resources, the Research and Development Agency of Energy and Mineral Resources and the directorate General of Mineral and Coal - Ministry of Energy and Mineral Resources Republic of Indonesia for the support. Special appreciations to the organizing committee and the editor team who have well coordination, and has given effort in organizing the seminar and the process of papers publishing.

Editors Team,

**1. Prof. Dr. Datin Fatia Umar**
**2. Ir. Tatang Wahyudi, MSc**
**3. Dra. Sri Handayani, MSc**
**4. Dr. M. Ikhlasul Amal**
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All papers published in this volume of IOP Conference Series: Earth and Environmental Science have been peer reviewed through processes administered by the Editors. Reviews were conducted by expert referees to the professional and scientific standards expected of a proceedings journal published by IOP Publishing.

- **Type of peer review: Single-blind / Double-blind / Triple-blind / Open / Other (please describe)**

  All accepted papers from ISMCT 2021 conference have been peer reviewed with triple-blind review type through processes administered by the proceedings Editors. Reviews were conducted by expert referees to the professional and scientific standards expected of a proceedings journal published by IOP Publishing.

- **Conference submission management system:**

  We use conference submission management system electronically with link https://seminar.tekmira.esdm.go.id/index.php/registration. This management system was affiliated with https://edas.info.

- **Number of submissions received: 137 papers**

- **Number of submissions sent for review: 103 papers**

- **Number of submissions accepted: 86 papers**

- **Acceptance Rate (Number of Submissions Accepted / Number of Submissions Received X 100): 62.77%**

- **Average number of reviews per paper: three reviewers**

- **Total number of reviewers involved: 97 reviewers**

- **Any additional info on review process:** Review description need to check:

  1. Paper template (Title, affiliation, abstract, paper content, figure and table format, equation, references)
  2. Originality
  3. Novelty
  4. Paper quality
  5. Language quality (structure and grammar)

- **Contact person for queries:**
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  E-mail : a.wahyudi80@esdm.go.id

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# The Fe (II) and Mn (II) adsorption in acid mine drainage using various granular sizes of activated carbon and temperatures

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# The Fe (II) and Mn (II) adsorption in acid mine drainage using various granular sizes of activated carbon and temperatures

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**Abstract**. Acid mine drainage (AMD) from coal mining activities contains Fe and Mn concentrations that often exceed environmental quality requirements. This study aims to determine the effect of the coal material size and temperature on the adsorption process of Fe and Mn metals contained in AMD using activated carbon made with a composition of 60% coal and 40% $ZnCl_2$. For characterizing activated carbon, surface morphological was analyzed using SEM method, and surface area was analyzed using BET method. Meanwhile, for measuring Fe and Mn concentrations, the researchers used atomic absorption spectrophotometry. The adsorption process was carried out with various granular sizes of activated carbon (20, 28, 35, 48 and 60 mesh) and temperature (25, 35, 40, 45 and 50°C). The results showed that the maximum adsorption of Fe was 100% occurred in the treatment with an activated carbon size of 60 mesh and a temperature of 45°C, while the maximum adsorption of Mn was 11.91% in the treatment with an activated carbon size of 60 mesh and a temperature of 50°C. Furthermore, the activated carbon of coal is highly effective as an adsorbent for Fe in AMD waste but less effective for Mn.

## 1. Introduction

Mining exploitation activities have an impact on the environment, specifically in mining using the open-pit method. This mining method can expose rock from the ground to the surface. If the rock contains sulfide minerals and reacts with water and air, it can form an acid mine drainage (AMD) with a pH of < 4. AMD can cause an increase in the solubility of heavy metals in water, which potentially become a source of environmental pollution [1-4].

Active and passive methods are generally used to treat AMD in mining areas. In the active methods, calcium oxide was used to increase the pH, reduce the total suspended solids (TSS), and reduce Fe and Mn content. While in the passive method, plants were used as media to reduce metal content in the AMD, mainly Fe and Mn. Studies on the adsorption of Fe and Mn in acid mine drainage continue to be developed to find alternatives to the use of calcium oxide [5-6].

One of the materials that are used to reduce levels of Fe and Mn metals is activated carbon [7-9]. Activated carbon is a processed material with a high adsorption capacity against materials in the form of solutions or gases. Activated carbon can adsorb anions, cations, and molecules in the form of organic and inorganic compounds, solutions, and gases. Activated carbon can be differentiated based on its adsorption capacity and characteristics [10]. Besides being made from natural materials, such as coconut shells, bagasse, wood charcoal, corn cobs, and grape stalks, activated carbon can also be made from coal. Activated carbon from coal has a high iodine number and a large surface area compared to activated carbon from other materials [11-13].

Therefore, in this study, activated carbon from coal with medium rank and sub-bituminous A was used. The composition of activated carbon was 60% coal and 40% $ZnCl_2$. The variations of granular size of activated carbon observed in this study were 20, 28, 35, 48 and 60 mesh. Meanwhile, the variations of temperatures observed in this study were 25, 35, 40, 45 and 50°C. The purpose of this study is to determine the optimal granular size of activated carbon and temperature in adsorption of Fe and Mn in AMD.

## 2. Methods

### *2.1. Preparation of activated carbon and AMD*

Coal samples that have been reduced in size dried in a dry oven at 105°C for 1 hour to remove moisture that may be contained during the storage process. The samples were chemically activated using 40% $ZnCl_2$. After that, carbonization was carried out by heating the samples at 500°C in an airtight reactor flowing with nitrogen for 1 hour. Next, the activated carbon is soaked in HCl solution, washed with hot water, and then dried.

### *2.2. Characterizing activated carbon*

The characterization process of activated carbon includes analysis of surface morphology using the scanning electron microscope (SEM) and analysis of the surface area, pore-volume, and pore-diameter using the Brunauer–Emmett–Teller (BET) method.

### *2.3. Processing AMD using activated carbon with various granular sizes*

The dried activated carbon was weighed ± 1800 mg for each granular size, 20, 28, 35, 48 and 60 mesh, and put into a 250 ml erlenmeyer flask. 150 ml of AMD sample were added to those five erlenmeyer flasks, then covered with aluminum foil to prevent contamination. The AMD treatment process was carried out in a shaker incubator at a speed of 150 rpm and a temperature of 25°C for 3 hours. Furthermore, AMD was filtered. The obtained filtrate was analyzed using the atomic absorption spectrophotometry (AAS) method to determine the amount of Fe and Mn adsorption.

### *2.4. Processing AMD for temperature variations during the adsorption process*

The next step was conducting the AMD treatment process using a 60-mesh granular size of activated carbon with various temperatures. 60 mesh of dried activated carbon samples were weighed ± 1800 mg for each temperature variation and put into an erlenmeyer flask. They were added with 150 ml of AMD samples, covered with aluminum foil, and put into a shaker incubator with a speed of 150 rpm and set at 25°C, 35°C, 40°C, 45°C, and 50°C for 3 hours. After 3 hours, the solution was filtered. The obtained filtrate was analyzed using the AAS method to determine the amount of Fe and Mn adsorption.

## 3. Results and Discussion

The AMD samples were obtained from a mining company located in the East Kutai Regency, South Kalimantan. The initial pH of the sample was measured using a pH meter, while the initial levels of Fe and Mn metals were analyzed using AAS method.

In Table 1, it can be seen that the levels of Fe and Mn exceed the quality standards for wastewater for coal mining activities based on the Decree of the Minister of Environment No. 113/2003. The results of surface characterization of activated carbon using SEM can be seen in Figure 1.

**Table 1.** Initial concentrations of Fe and Mn in the AMD.

| Parameters | Levels (mg/L) | Wastewater standards for coal mining activities (mg/L) |
|---|---|---|
| Fe | | 7 |
| Mn | 7.22 | 4 |

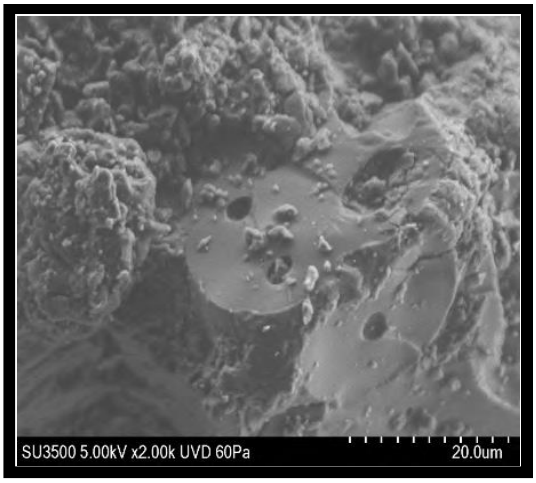


**Figure 1.** The result of the Scanning electron microscope (SEM) towards raw coal.

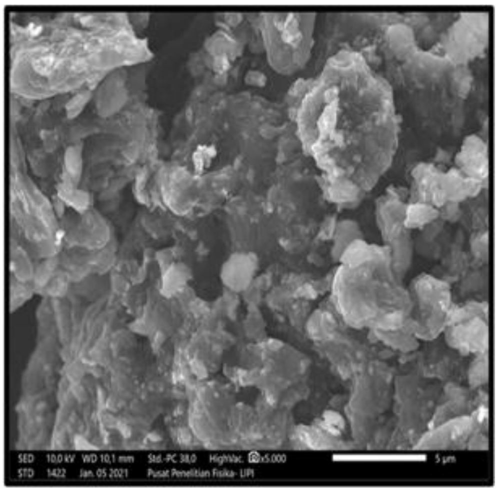

**Figure 2.** The result of the Scanning electron microscope (SEM) towards coal activated carbon.

Figure 1 shows the raw coal surface before being synthesized into activated carbon, which appears to have few cracks and pore cavities. Figure 2 shows the surface of activated carbon made from 60 mesh coal. It appears that there are cracks, openings, and pore holes that look bigger so that they can support the adsorption process. The activation and carbonization processes of coal can adsorb macromolecules in coal, form pores, and increase its surface area [14]. The results of surface characterization using the BET method are 526.6 $m^2/g$ of surface area, 0.29 cc/g of total pore volume, and 2.228 nm of pore diameter.

After conducting the AMD treatment process using activated carbon with size variations of 20, 28, 35, 48 and 60 mesh at a temperature of 25°C, the results of adsorption of activated carbon against Fe and Mn metals can be seen in Table 2 and Table 3.

**Table 2.** Fe metal concentration before and after conducting the treatment with variations in the granular sizes of activated carbon.

| Mesh Sizes | Fe Concentration | |
|---|---|---|
| | Before (mg/L) | Remaining (mg/L) |
| 20 | 45.2 | 23.9 |
| 28 | 45.2 | 25.5 |
| 35 | 45.2 | 16.0 |
| 48 | 45.2 | 7.2 |
| 60 | 45.2 | 0.8 |

**Table 3**. Mn metal concentration before and after conducting the treatment with variations in the granular sizes of activated carbon.

| Mesh Sizes | Mn Concentration | |
|---|---|---|
| | Before (mg/L) | Remaining (mg/L) |
| 20 | 7.22 | 7.22 |
| 28 | 7.22 | 7.1 |
| 35 | 7.22 | 7.0 |
| 48 | 7.22 | 6.8 |
| 60 | 7.22 | 6.5 |

The relationship between the granular size of activated carbon and the adsorption of Fe and Mn listed in Table 2 and Table 3 can be seen in Figure 3.

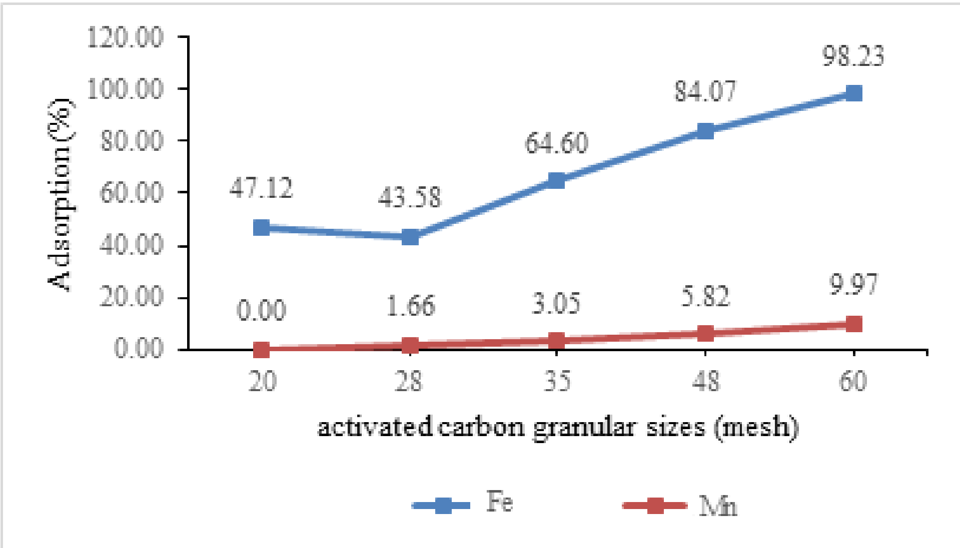


**Figure 3**. The effect of activated carbon granular sizes on the Fe and Mn adsorption.

Table 2 shows the amount of Fe metal before and after the treatment process was conducted. The maximum adsorption of Fe occurred at 60 mesh activated carbon. The initial concentration was 45.2 mg/L, then reduced to 0.8 mg/L, which has met the environmental quality standard requirements. In Figure 3, it can be seen that in 60 mesh activated carbon, the adsorption capacity against Fe metal was 98.23%. Furthermore, Table 3 shows the amount of Mn metal before and after the treatment process was conducted. The maximum adsorption of Fe also occurred at 60 mesh of activated carbon. Its initial concentration was 7.22 mg/L, and then reduced to 6.5 mg/L. However, it has not met the environmental quality standard requirements. In Figure 3, it can be seen that, in 60 mesh of activated carbon, the adsorption capacity against Mn metal was 9.97%.

The granular sizes of activated carbon have influenced metal adsorption. The smaller the granular size is, the larger the surface area will be. Therefore, it can increase the interaction between metal ions and functional groups on the surface of the activated carbon [15]. After conducting the AMD treatment process with the temperature variations of 25°C, 35°C, 40°C, 45°C, and 50°C, the results of adsorption of activated carbon against Fe and Mn metals can be seen in Table 4 and Table 5.

**Table 4**. Fe metal concentration before and after conducting the treatment with variations in temperature.

| Temperature (°C) | Fe Concentration | |
|---|---|---|
| | Before (mg/L) | Remaining (mg/L) |
| 25 | 45.2 | 2.63 |
| 35 | 45.2 | 2.81 |
| 40 | 45.2 | 3.02 |
| 45 | 45.2 | 0 |
| 50 | 45.2 | 0 |

**Table 5**. Mn metal concentration before and after conducting the treatment with variations in temperature.

| Temperature (°C) | Mn Concentration | |
|---|---|---|
| | Before (mg/L) | Remaining (mg/L) |
| 25 | 7.22 | 7.15 |
| 35 | 7.22 | 7.16 |
| 40 | 7.22 | 7.12 |
| 45 | 7.22 | 6.43 |
| 50 | 7.22 | 6.36 |

Table 4 and table 5 show changes in Fe and Mn concentrations before and after the AMD treatment was conducted using 60 mesh of activated carbon at temperature variations of 25, 35, 40, 45 and 50°C. Table 4 shows Fe concentration before and after the treatment process.The maximum adsorption of Fe metal occurred at temperatures of 45°C. Its initial concentration was 45.2 mg/L, and then decreased to 0, which indicates that the adsorption capacity against Fe metal is 100%. At the temperature variation between 25°C and 50°C, the concentration of Fe has met the environmental quality standard requirements. Table 5 shows the amount of Mn metal before and after the treatment process was conducted. The maximum adsorption of Mn metal occurred at temperatures of 50°C. Its initial concentration was 7.22 mg/L, and then reduced to 6.36 mg/L. This concentration doesnot meet the environmental quality standard requirements. In Figure 5, it can be seen that, at a temperature of 50°C, the adsorption capacity against Mn metal was 11.91%. Figure 4 shows the effect of temperature on the adsorption of Fe and Mn. The higher the temperature on the AMD treatment process is, the greater the adsorption capacity will be. The increase in temperature can increase adsorption capacity and adsorption rate. The increase in the adsorption rate can cause a strong adsorptionforce between the active groups of the adsorbent and the molecules on the adsorbate [16].

In the AMD treatment processes with various granular sizes of activated carbon and temperatures, the adsorption capacity against Fe metal was greater than that against Mn metal. The decrease in Mn metal content was not too significant due to the influence of differences in electronegativity and ionic radii between Fe metal and Mn metal. The higher the electronegativity is, the greater the adsorption capacity will be. The ionic radius of $Fe^{2+}$ is smaller than $Mn^{2+}$ because, in the electron orbital, the charge on the $Fe^{2+}$ ion pulled more strongly towards the atomic nucleus than the $Mn^{2+}$ ion. Because the activated carbon used is microporous, the small metal ions are more easily trapped into the pores of the activated carbon surface [17].

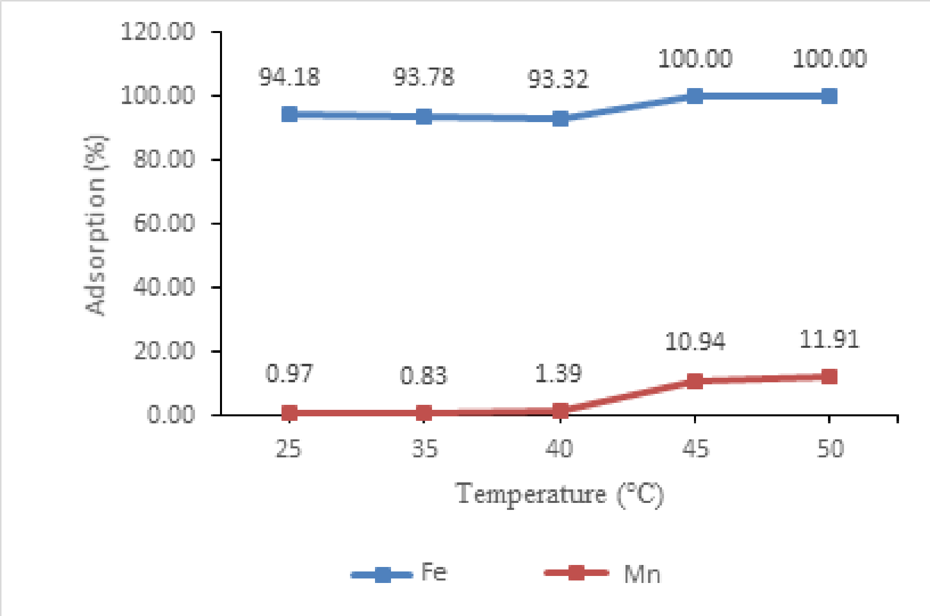


**Figure 4.** The effect of temperature on the Fe and Mn adsorption.

## 4. Conclusion

The smaller the granular size of the activated carbon is, the more the adsorbed metal content will be. At a granular size of 60 mesh, the maximum adsorption capacity against Fe metal is 98.23%, whilethat against Mn metal is 9.97%. The higher the temperature during the AMD treatment process using activated carbon is, the more the adsorbed metal will be. The maximum adsorption against Fe metal (100%) occurred at a temperature of 45°C, while that against Mn metal (11.91%) occurred at a temperature of 50°C. The granular sizes of the activated carbon affect the amount of adsorption capacity. The smaller the granular size of activated carbon is, the larger the surface area will be. Therefore, it can increase the interaction between metal ions and the surface of the activated carbon. The temperature during the treatment process also affects the amount of adsorption capacity. The higher the temperature is, the higher the adsorption rate and adsorption capacity will be. The results of this study showed that the activated carbon of coal is highly effective as an adsorbent for Fe metal so that it is possible to reduce Fe content to meet environmental quality standards. However, it is less effective for Mn metal.

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