論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Ball-milled Indonesian natural bentonite application for manganese removal on acid mine drainage: batch and column study
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出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第11016号, 授与年月日:2018年12月31日, 学位の種別:課程博士, 審査員:日野出 洋文,MARIQUIT EDEN GAN,江頭 竜一,高橋 史武,竹村 次朗,KURNIAWAN WINARTO
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第11016号, Conferred date:2018/12/31, Degree Type:Course doctor, Examiner:,,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

専攻： Department of	International Development Engineering 専攻	申請学位（専攻分野）： Academic Degree Requested	博士 (Engineering) Doctor of
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要旨（英文 800 語程度）
Thesis Summary (approx.800 English Words)

Most Indonesian coal mining company apply open-pit mining method for excavation due to its effectiveness, safety, and low cost. However, open pit mining causes several environmental problems such as acid mine drainage (AMD), land movement, soil erosion, sedimentation, and toxicity. Acid mine drainage (AMD) is wastewater generated when the sulfide minerals are exposed with oxygen and water. The sulfide minerals are commonly present in coal bed formation as impurities. Acid mine drainage (AMD) typically has low or near neutral pH. Some metals such as iron (Fe), manganese (Mn), aluminum (Al), and also other heavy metals with elevated concentration are possibly containing in AMD. One of Indonesian coal mining company which is located in Jorong, Tanah Laut district, province of South Kalimantan, Indonesia, reported containing two metal types Mn and Fe in the AMD. The manganese concentration reported exceeded the quality standard of Indonesian government regulation for mining wastewater. The treatment of AMD is mainly divided into two types "active" and "passive" method. Both methods have the same main purposes to decrease the metal toxic and raise the pH. The active method refers to continuous reagent addition to neutralize the pH and remove the metal which involves human assistance for continued operation. In the active system, a fixed plant is required. Conversely, the passive system does not require continuous reagent addition and only needs occasional human assistance. Principally, the passive method only passes the AMD through the passive treatment installation such as limestone channel. Passive treatment is more economical compared to active treatment. However, a problem arises is that most passive treatment utilizes the carbonate-based system to increase the pH and to precipitate the metal. Hence, not all metals can be removed due to maximum pH limitations that can be reached.

Bentonite, a natural clay that mostly contains montmorillonite mineral, has been widely utilized as a sorbent because of its large specific surface area (SSA) and high cation exchange capacity (CEC). Milling is one of modification to improve the sorption performance of bentonite. Milling treatment on bentonite affects to morphological change, particle size reduction, exfoliation, and brings the increase of SSA and CEC. Several previous studies reported milling-activated bentonite had given better improvement for metals removal from aqueous solution.

Even though milling on bentonite has improved the metal removal from aqueous solution, however, the optimization of milling investigation and its character identification to achieve the maximum sorption performance never investigated before. Previous studies only performed one milling time condition and directly applied as a sorbent. As the milling modified bentonite has significant potential for metal removal, an application of milling modified bentonite for bed sorbent as passive treatment of AMD never conducted before. In the low-cost passive treatment system that utilizes the carbonate-based system, Mn is still a problem since it requires higher pH to be precipitated.

The primary goal of this research is to investigate the significant improvement of optimally ball-milled bentonite on column sorption test as AMD passive treatment approach. This work utilizes Indonesian natural bentonite (INB), located in Wonosegoro, province of central Java, Indonesia. This area has a hypothetical resource 58 million tons of natural bentonite with a calcium-bentonite type. The AMD is simulated from the coal company located in Jorong with Mn as targeted metal to be removed. The work is divided into three parts. The first part focuses on the characteristic change investigation of INB during continuous milling. The results show that the cation exchange capacity (CEC) increases and reaches the peak which is then followed by a decrease due to further milling. The trend of increase and decrease of CEC was not affected by the change of specific surface area (SSA) and particle size during the milling but corresponding to

the microstructural deformation of montmorillonite mineral.

In the second part, Mn batch sorption tests are carried out on the unmilled and the milled INB samples that have a significant change of character during continuous milling. The results of the Mn batch sorption test also show the trend of sorption capacity increase and reach the peak, followed by a decline in further milling. The trend of increase and decrease in sorption capacity is in line with the trend of increase and decrease in CEC during the milling. In equilibrium condition, the pHs of both unmilled and milled INB increase become neutral.

The last part focuses on the application of milled INB on column sorption test. The column sorption test results show the effect of ball milling on INB brought significant improvement by showing longer breakthrough time, higher maximum manganese removal, and shorter length of unused bed (LUB). The pHs also show the desired values since the service time until the saturation time.

In conclusion, milling time optimization on INB for Mn removal from AMD has reached the highest sorption capacity. The highest sorption capacity was achieved due to the loss of all cations in the octahedral sheet that affected the maximum increase of the negative surface charge of montmorillonite. The application of optimally ball-milled INB on column sorbent as the passive treatment system approach has successfully removed the Mn from the AMD and improved the pH. The milled INB becomes more efficient bed sorbent than the unmilled.