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Utilization of natural zeolite as sorbent material for seawater desalination

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Abstract

Natural zeolite obtained from Sukabumi, Bandung, Indonesia was used as sorbent material for reducing salinity of seawater. The sorption ability of zeolite was enhanced through thermal activation by using furnace. In this study we obtained the optimum condition of activation is 225 ˚C for 3 h. The sorption effectiveness was determined through measurement the reduction of salinity (R_s) and efficiency of reduction (η). The highest value of R_s and η are 3.2 ppt and 9.14%, respectively at 7.5 g of sorbent dose. Effectiveness of desalination process can be enhanced through the increase of zeolite dose. Natural zeolite from Sukabumi possess great potential as low cost sorbent material for seawater desalination.

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Keywords: natural zeolite; sorbent; salinity; seawater; desalination.

1. Introduction

Fresh water is one of the most important human needs. Preservation and availability of fresh water are demanded to ensure the human life. To address the threat of water shortages and ensure the continuous availability of fresh water, it is needed the right strategy that should be tailored to the local potential and characteristics of each country. Indonesia possess abundant seawater resources. Two-thirds area of Indonesia is sea. Therefore, seawater desalination becomes one of potential method to overcome the water crisis in the future [1].

Seawater desalination refers to the removal of salts and minerals to produce fresh water [2, 3]. Various desalination technologies have been developed such as multi-stage flash distillation (MSF), multiple effect distillation (MED), vapor compression distillation (VCD), reverse osmosis (RO), and electro dialysis (ED) [4-6]. This technologies were able to produce fresh water with high level of pureness. However, the operation cost of this technologies are still considered expensive, so it is necessary to find a cheaper alternative methods.

Sorption method is supposed as prospective technique for use in seawater desalination. Sorption method is interesting due to its simplicity and high efficiency [7]. Furthermore, the availability of a wide range of sorbent materials make sorption method is potential developed as cost-effective model [8]. A number of sorbent material such as carbon active [7], fly ash [9], clay [10] and natural zeolites [11] have been used in sorption systems for wide range application. Natural zeolites are considered as low-cost sorbent material with abundant availability [12]. In addition, it gained a significant interest due to their valuable properties such as ion-exchange [13], high sorpsibility for inorganic and organic ions, ease of activation and regeneration as well as non-toxic material [14].

Indonesia has abundant natural zeolite, one of them is located in Sukabumi, West Java. Numerous authors have reported the use of natural zeolites for various applications. Al-Anber et al. have reported utilization of natural zeolite as ion-exchange and

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sorbent material in the removal of iron [15]. Removal of ammonium from grey water using natural zeolite was reported by Widiastuti et al. [16]. Adsorption of Cu(II) ions from solution by natural zeolite has been reported by Kyziol-Komosinska et al. [14]. Removal of phenol from aqueous solution by natural zeolite was reported by Yousef et al. [17]. Removal of Mn^{2+}, Zn^{2+}, and Cr^{3+} from solution by clinoptilolite was reported by Inglezakis et al. [13]. Doula reported the use of clinoptilolite for simultaneous removal of Cu, Mn and Zn from drinking water [18]. Nevertheless, the use of natural zeolite for seawater desalination has not been extensively studied. Wajima [19] investigated ion exchange properties of five different Japanese natural zeolites in seawater and found that sodium ions could be reduced by all zeolites, although anions, Cl^- and SO_4^{2-}, in seawater showed barely changes. Swison [20] reported desalination by natural zeolite membranes offers a robust alternative to the thin film membranes currently used in the desalination industry. The natural zeolite that was used in the study is clinoptilolite from British Columbia, Canada.

Continuing our work [12, 21] to find out cost-effective sorbent material for used in seawater desalination, in this study we investigate the possibility of natural zeolite from Sukabumi, Bandung for reducing the salinity (concentration of salt ion) of seawater. Effect of treatment parameters, particle size and zeolite dose to the effectiveness of desalination were investigated. The sorption kinetic of salt ions onto zeolite particles was also studied.

2. Methods

We used natural zeolite from Sukabumi, Bandung, West Java, Indonesia. The zeolites were prepared into a fine powder by using mechanical mortar to increase the surface area as well as to promote the activation process. The zeolite powders then put in alumina crucibles and heated by using furnace in atmospheric condition. The ranges of activation temperature are 100 to 600 ˚C with activation duration are 2 to 4 h. The morphology of zeolite powder was studied by Scanning Electron Microscopy (Jeol JSM-6510LA). The schematic diagram of activation process is shown in Fig.1. The detail of activation steps were reported in reference [12].

We used seawater from Java Sea with average salinity of 35.0 ppt. The desalination process was conducted by inserting powder zeolite into 100 ml of seawater. The zeolite dose was varied at 1.5, 3.5, 5.0 and 7.5 g. Each sample was shaken mechanically so that the powders zeolite can disperse homogeneously in the seawater. The seawater salinity after treated by zeolite powder was measured by Salinometer (Mettler Toledo SG7-FK2). Effectiveness of desalination was quantitatively expressed by reduction of salinity and efficiency of reduction values. The reduction of salinity (R_s) and efficiency of reduction (η) can be determined by Eq. 1 and Eq. 2, respectively.

$$R_s = C_i - C_e \tag{1}$$

$$\eta = \frac{(C_i - C_e)}{C_i} x\, 100\% \tag{2}$$

with C_i and C_e refer to initial salinity and equilibrium salinity, respectively.

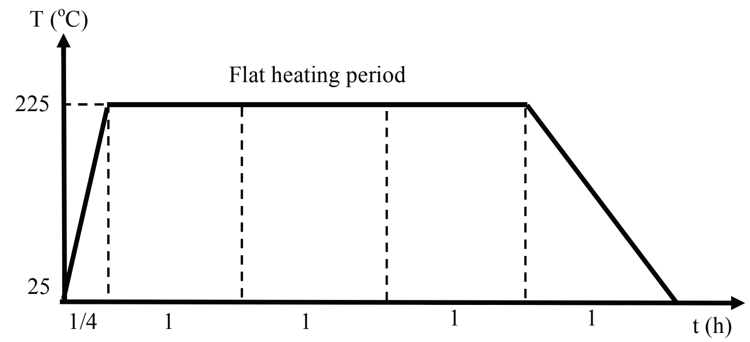

Fig. 1. The schematic diagram of thermal activation process.