Ability of treated kapok (*Ceiba pentandra*) fiber for removal of clay particle from water turbidity

Nurfitri Abdul Gafur[1], Masayuki Sakakibara[1, 2], and Mohamad Jahja[3]

[1] Department of Earth Science, Graduate School of Science and Engineering, Ehime University, Japan
[2] Faculty of Collaborative Regional Innovation, Ehime University, Japan
[3] Department of Physics, Mathematics and Science Faculty, State University of Gorontalo, Indonesia
Email: nurfitri.gafur@ymail.com

Abstract. Kapok (*Ceiba pentandra*, family Bombacaceae) fiber (KF) is a by-product of traditional agriculture in tropical countries and is mainly used as fiberfill in fabric. The aim of this study was to explore the possibility of using KF to remove clay particles from turbid water. Firstly, KF was boiled at 100 ºC in deionized water for 15 min to remove the surface oil. A suspension of montmorillonite powder mixed 1 L of deionized water, divided into volumes of 100, 200, 300, and 400 mL, was used as the turbid water source. The ability of KF to remove clay particles from the water was assessed by filtering the water through 60 g of treated KF in a ~397.9 cm^3 acrylic column. Results showed that the treated KF effectively removed the clay particles from the entire volume of turbid water in this experiment; the results also demonstrate that this KF fiber has value as a simple and inexpensive tool for water treatment, especially in developing countries.
Keywords: Kapok fiber; water turbidity

1. Introduction

In recent years, water management has become a topic of major concern for both scientists and the public worldwide because water, a primary source of life, is now contaminated in many developing countries, including those in Southeast Asia.

There is particular concern about the dumping of industrial waste into rivers as this may compromise the quality of water drawn for human consumption. Wastewater from industries such as metallurgy, leather tanning, metal finishing, steel fabrication, and mining is [1] a major concern because of its potential to produce serious environmental problems. Several approaches and materials have been tested for their capacity to remove heavy metals from industrial wastewater, including chemical precipitation, solvent extraction, adsorption, and resin ion exchange [2]. Surface water, however, is not only contaminated by heavy metals, but also contains various types of suspended materials that cause turbidity in the water [3].

The fibers of many natural plant varieties have been used to absorb heavy metal ions. Because of the high costs and lack of availability of adsorbents traditionally used for reducing the content of heavy metals in wastewater, alternative low-cost regenerated adsorbents such as sand, sepiolite, orange peel, banana peels, and even various kinds of fiber are now being studied [4]. The use of natural materials to reduce water turbidity is not a new idea, and, for example, chestnut, acorn, *Cactus latifaria, Prosopis juliflora,* and crumb rubber have served as natural coagulants in previous studies [5–7].

In 2012, it was found that heavy metal waste particles could be remediated using cotton fibers that had been chemically treated to transform them from hydrophobic to hydrophilic. When treated in this way, cotton fibers can provide effective adsorption of Cr (VI) [1] and heavy metal ions such as lead (Pb), copper (Cu), cadmium (Cd), and zinc (Zn) [8]. Despite their effectiveness, however, chemically treated cotton fibers may be an expensive material for remediating water pollution.

In this study, as an alternative to chemical treatment, a natural fiber obtained from *Ceiba pentandra* pods was first treated by boiling, and the boiled KF was then tested to determine (1) its suitability for use in a filtration process for cleaning turbid water and (2) whether it had potential as a low-cost material for treating turbid water destined for domestic use

2. Material and method

Valve-type kapok fibers (KF) were supplied by the Katsu Takashi Planning Co. Ltd. First, 30 g of KF were placed into pure water and boiled on a hotplate at 100 °C for 15 min. The characteristics of the KF and its composites were then investigated. Various impurities that caused the pure water to turn a light orange colour were discarded. Then, the boiled KF was rinsed thoroughly with high purity water.

The boiled KF was filled into a clear acrylic tube with a diameter of 7 cm to a height of about 20 cm. Once settled into the tube, the boiled KF was rinsed again with pure water until the outflow water from the tube was clear. The turbid water suspension was made by mixing 1 g of bentonite (montmorillonite k-10 sourced from Wako Pure Chemical Industries Ltd.) with 1 l of deionized water. The turbid water was shaken in an ultrasonic bath for 5 min. The turbid water was then divided into four different volumes (100, 200, 300, and 400 mL) for evaluating the filtration ability of the boiled KF. The synthetic water had a turbidity of 240 NTU.

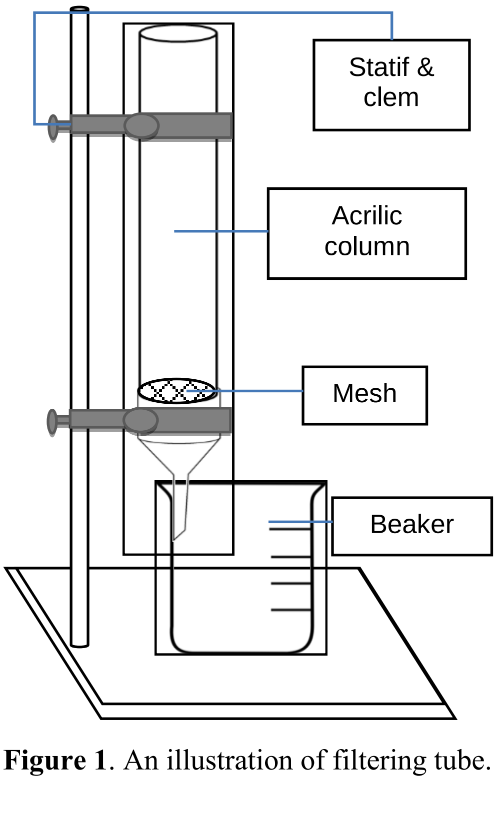

Figure 1. An illustration of filtering tube.

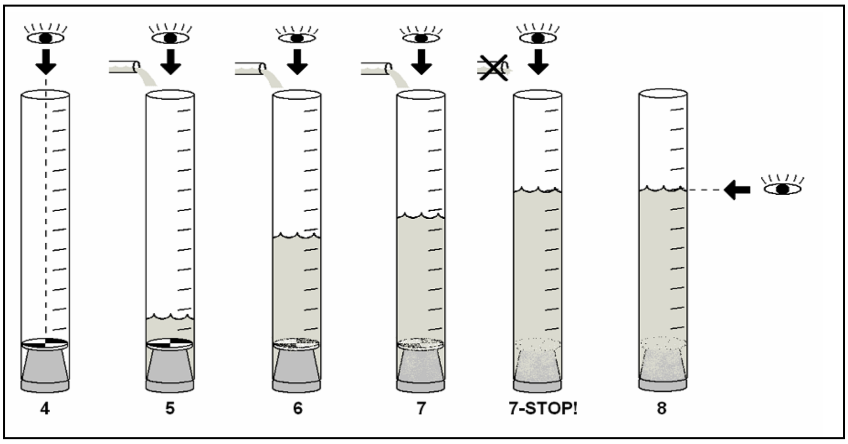

Figure 2. An illustration of processing water turbidity measurement [9].

First, the 100, 200, 300, and 400 mL of turbid water sample was added gradually to the center of the adsorbent using a syringe, respectively. Then measured the pH, turbidity, and electric conductivity of the turbid water before and after filtering to assess the effectiveness of the process. The turbidity of the water was measured with a turbidity tube and a Secchi disk, as shown in the figure below and following the water clarity assessment method. Standard Methods for Tap Water by APHA, 1998 were used for comparing the pH and turbidity of the filtered turbid water. The same procedure was followed for filtering the deionized water as a control.

3. Result and discussion

3.1. pH and electric conductivity effects on the water turbidity

The pH values of the control deionized water and the turbid water are presented in Figure 3. The results shows that pH values of deionized water and turbid water decreased slightly after filtering through the boiled KF. The pH values observed in the deionized water and turbid water were greater than 7 (Figure 3). To be suitable for human consumption, the pH of water should be between 6.5 and 8.5[10,11]. Comparison with the quality standards for tap water indicates that the turbid water was suitable for human activities other than drinking.

Table 1. Quality parameter of tap water

Parameter	Tap water
pH	7.4
Turbidity	0.2 NTU
Calcium (Ca2+)	88 mg/L
Magnesium (Mg2+)	9 mg
Sodium (Na+)	25 mg/L
Alkalinity	225 mg CaCO3/L
KMnO4 demand	6.7 mg KMnO4/L

As with the pH, the electrical conductivity of the turbid water also decreased after filtering, as shown in Figure 4. There was variation in turbidity among the different volumes of filtered turbid water (Table 3). Electrical conductivity is generally used as a measure of ionic processes in water or solutions that enable current transmission [12]. Conductivity is also dependent on water temperature, salinity, and total dissolved solids [13].

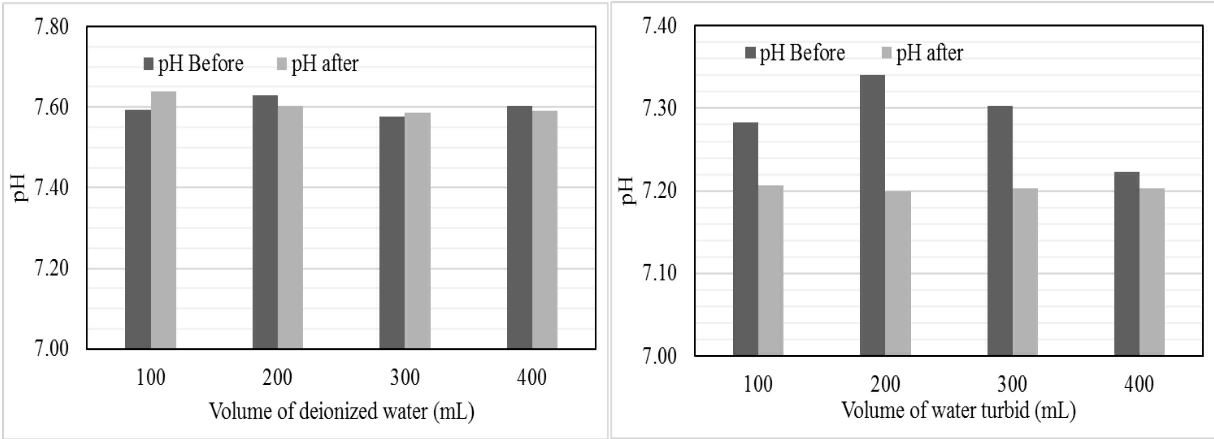

Figure 3. Graph of pH values of pure water and water turbid before and after filtration.

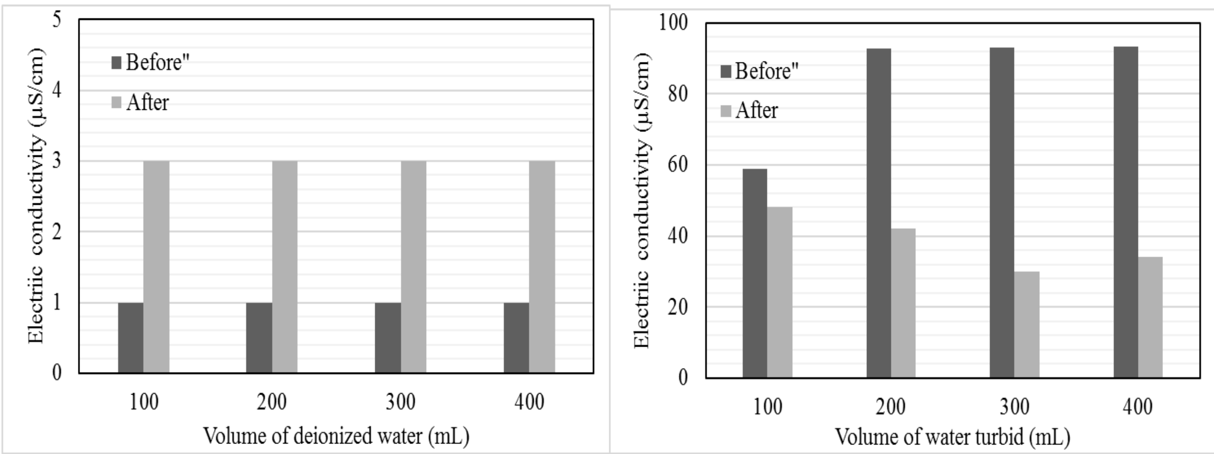

Figure 4. Graph of electric conductivity of pure water and water turbid before and after filtration.

The effectiveness of turbidity removal varied among the different volumes of turbid water. The results indicate that the boiled KF could remove particles from the turbid water. In the caption for Table 2 the term "clear" is not well-defined, because of the turbidity tube with a Secchi disk is also should be considered by the amount of the water volume to measure. The term "clear" shows that the water color is clear. The removal percentages and the figure of comparison initial and final turbidity are presented in Table 2 and Figure 3.

Table 2. Comparison initial and final turbidity after filtering using boiled KF.

Volume of water turbidity (mL)	Initial turbidity (NTU)	Final turbidity (mL)	Removal percentage (%)
100	240	Clear	Clear
200	240	40	16.67
300	240	100	41.67
400	240	200	0

3.2. Initial and final turbidity

Water turbidity removal using natural fiber is difficult directly to applicate in the inhabitant to get the clean water. Compared with the quality parameters of tap water by APHA, 1998 the final turbidity after filtering are not consumable for living things. The flow rate and the media sizes are also important thing to consider the ability of boiled KF for filtering. Comparing with other filtering using crumb rubber, the turbidity removal efficiencies were 92.7 % with the media size about 0.16 mm [7].

Some of the water filtering processess are using the natural plant for water turbidity removal by mixing with other material such as pilot plat mixing with crumb rubber, pilot plant mixing with hollow fiber microfiltration, etc. [7,14]. Water turbidity removal using only fiber is difficult to find, because it has many factors which must be considered such as the porosity, transmembrane area, transmembrane flow, density, permeability, etc. [5,7,14,15]. The percentage turbidity removal values which shown in Table 2 and 3. In this experiment, the best a 100 mL volume of water turbidity removal is using 60 g of boiled KF. Water turbidity level has no big effects the amount of pH in water. However, reducing level of water turbidity has several variation values on the electric conductivity. It is clearly shown in Figure 4. The reducing of electric conductivity related to the reducing of final turbidity. The result clearly indicates that the boiled KF has an ability to remove the water turbidity.

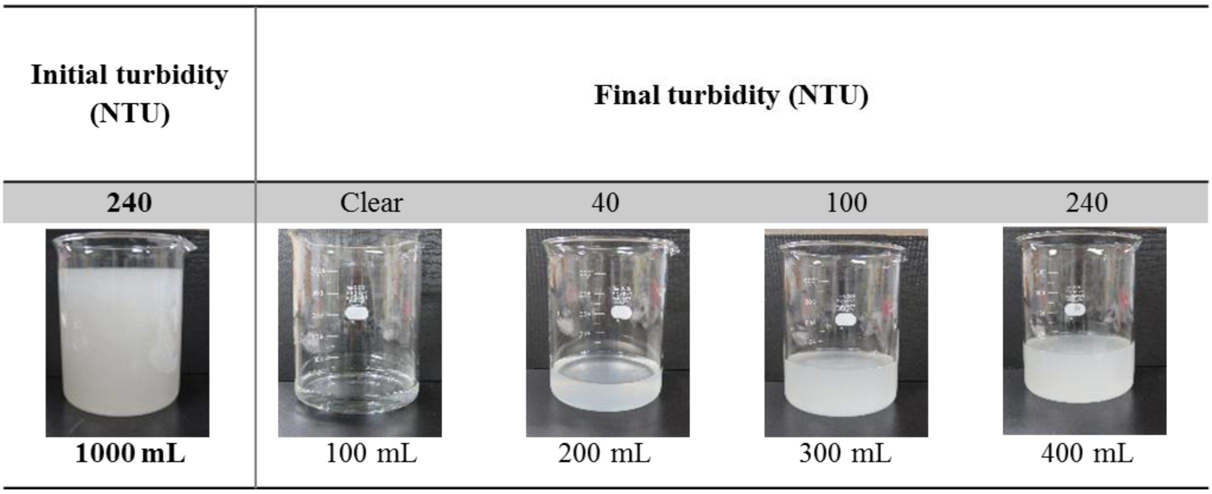

Figure 5. Comparison initial and final of water turbidity for each volume.

4. Conclusion

The experiment conducted to establish the ability of boiled KF for water turbidity removal. This experiment has three parameters to establish the ability of boiled KF such as pH, electric conductivity and turbidity. The initial and final pH of water turbidity is about 7.2. It shows that the final water turbidity levels have no big effects on the amount of pH. However, water turbidity levels have effects on the electric conductivity. Compare with the turbidity level of initial and final turbidity, the 60 g of boiled KF has an ability to remove a 100 mL of water turbidity, which has the best percentage of turbidity removal.

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