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COCONUT CELL ACTIVATED CARBON AS SEDIMENTATION AGENT IN WATER PURIFICATION SYSTEM

Suparno and W. S. Mumpuni

Faculty of Mathematics and Science, Yogyakarta State University, Indonesia

Clean water is extremely difficult to find in areas destroyed by earthquake, flood and landslide. It takes from days to weeks to clean the water naturally by the process of sedimentation. A research on the use of coconut cell activated carbon as a sedimentation agent has been done in an effort to find a cheaper and quicker way to clean the water. Coconut cell as a waste product is available in a huge amount in most places in Indonesia as a tropical country.

Simulated dirty water was mixed with coconut cell activated carbon as sedimentation agent and the sedimentation velocity of the dirt coagulant was observed. The coconut shell carbon was activated chemically by soaking it in a solution of acid for 24 hours. The coconut cell activated carbon was then rinsed and used as sedimentation agent. Five different acids i.e. phosphoric acid, sulfuric acid, lactic acid, acetic acid, and nitric acid, were used in this research. The result was then activated physically by heating it in an oven at 120°C for 30 minutes before being use as sedimentation agent in this research.

The results of the research show that coconut cell activated carbon as a sedimentation agent is superior compared to the well known sedimentation agents *aluminum sulfate* [$Al_2(SO_4)_3$] and *poly aluminum chloride* [(Al Cl_3)n]. The sedimentation velocity due to activated carbons ranging from $(3.75 \pm 0.22) \times 10^{-3}$m/s to $(4.30 \pm 0.23) \times 10^{-3}$m/s. Whereas those of *aluminum sulfate* [$Al_2(SO_4)_3$] and *poly aluminum chloride* [(Al $Cl_3)_n$] are $(2.48 \pm 0.13) \times 10^{-3}$m/s and $(2.02 \pm 0.13) \times 10^{-3}$m/s respectively.

Keywords: Coconut cell activated carbon, Sedimentation agent, Aluminum sulfate, Poly Aluminum chloride.

Introduction

Indonesia is located in South-east Asia and it has approximately a population of 240 million. It is rich with natural resources. Finding water should not be an issue everywhere throughout the country. However, due to poor water management system, most of populations are still rely on water from the wells. This tropical country is frequently hit by natural disaster such as earthquake, landslide, tsunami, and flood. These disasters cause the well water to be extremely dirty and it takes too long to wait the dirt to sediment naturally. In fact the well water is the main source of drinking water for most of population especially those living in rural areas. Consuming dirty water may cause the spreading of various deceases such as diarrhea and cholera. The spreading of these deceases may endanger many people's life, therefore a cheaper and quicker way to clean the water is urgently needed.

When an area is hit by earthquake the dirt and dust in the bottom of the well are dispersed in the well water. The same thing may occur when the area is hit by flood, tsunami and landslide. The dispersion of dirt and dust belongs to colloidal dispersion which is relatively stable and very

When an area is hit by earthquake the dirt and dust in the bottom of the well are dispersed in the well water. The same thing may occur when the area is hit by flood, tsunami and landslide. The dispersion of dirt and dust belongs to colloidal dispersion which is relatively stable and very difficult to sediment. Charges on minerals in the dirt and dust particles contribute to electrostatic kinetic stability.[1]-[3] Various techniques are available for determination of charges on the surface of particles.[4] Coulomb repulsive force due to surface charges and overlapping electrical double layer force prevent the dirt and dust particles to coagulate, the dispersion is very slow sediment, so that it takes too long to get clean water. Studies on colloidal particle surface charge have been done extensively using Phase Analysis Light Scattering (PALS).[5]-[9]

Most people use *aluminum sulfate*, $Al_2(SO_4)_3$ or *poly aluminum chloride*, $(AlCl_3)_n$ to clean the water by means of sedimentation.[10] These two substances are not only known as coagulating and sedimentation agent but also known as antiperspirant and deodorant.[11] Tens to hundreds grams of *aluminum sulfate* or *poly aluminum chloride* (PAC) are required to be put into the well and it takes few days to get clean water. These substances promote coagulation among the dispersed dirt and dust, which are then sediment to the bottom of the well resulting in relatively clean water. Unfortunately, people living in the disastrous areas cannot wait for too long to get the clean water. Therefore, an alternative substance to promote sedimentation should be found to accelerate sedimentation of the dispersed dirt and dust in the well water.

A research on the use of coconut shell activated carbon as sedimentation agent has been done. Coconut shell was chosen as material for making activated carbon since it is available in large amount throughout Indonesia. Almost every Indonesian consumes coconut or coconut related food on their daily life. Coconut is also used as the main material for making coconut oil which is needed for preparing various Indonesian foods. It is the coconut that they need, not the shell. Therefore, the coconut shell is basically a waste product. People just throw the shells away into the rubbish bin or burn them. Massive use of coconut can be found in coconut oil home industries. These industries produce huge amount of coconut shell waste product every day. A smart step should be taken to make use of this huge amount of by product.

Coconut shell activated carbon has been used in various areas.[12]-[16] This inspired us to make use of coconut shell activated carbon as sedimentation agent. For this reason, an extensive work has been done to make coconut shell activated carbon a better substance for sedimentation of the dirt inside the water. The coconut shell has to be carbonated in an extremely high temperature in a closed tight carbonation chamber. No air is allowed to flow into the chamber to prevent oxidation that results in ashes. The resulting carbon was then being cooled slowly. The coconut shell carbon was then crust and grind into fine pieces of approximately 50 meshes. These fine pieces of coconut shell carbon were then chemically and physically activated before being used as sedimentation agent. The superiority of coconut shell activated carbon as sedimentation agent was shown by measuring the sedimentation velocity of the dirt coagulants and comparing the results with those of commercial sedimentation agents, *aluminum sulfate* and *poly aluminum chloride*. Some of our work on the use of coconut shell activated carbon has also been presented in IJAS Germany conference.

Sample Preparation and Sedimentation Velocity Determination

Coconut shell was firstly put into a carbonation chamber and burnt by means of pyrolysis. The temperature inside the chamber was maintained at 400°C for 2.5 hours. The air was not allowed to get through the chamber to prevent from oxidation that resulting in ashes instead of carbon.

The closed tight chamber was then cooled slowly to make a good carbon. No air was allowed to get into the chamber during the cooling process.

Coconut shell carbon was crust and grind to small pieces and these small size carbons were then sifted to 50 meshes, which is equivalent to approximately 368 micrometers in diameter. The sieve to small size is very essential to enlarge the surface area which is useful to hold more dirt particles onto the surface of activated carbon. Studies on micrometer size colloidal particles may be done using Dynamic Light Scattering.[17]-[19]

The carbon powder was separated into 5 groups and each of them was chemically activated by using different types of acid. These are phosphoric acid, sulfuric acid, lactic acid, acetic acid, and nitric acid. The concentration of all acids was maintained at 60% and the length of activation time of each of them was 24 hours. All the above acids are capable of destroying and decomposing protein and other organic materials that are trapped inside the pores. These trapped materials are potentially reduce the capacity of the pores, therefore they should destroyed and thrown away from the pores. After being destroyed the trapped materials are thrown by way of rinsing the carbon powders using clean water.

Physical activation was done in an oven at 120°C for 30 minutes prior to the research. This was done to ensure maximum capacity of the pores by evaporating water molecules from the carbon pores. It should be noted that the maximum capacity of the pores is very essential, since it represents maximum absorption of the dirt particles in the chamber of pores and maximum adsorption of the dirt particles on the wall of the pores.

This work used simulated sample in various concentrations ranging from 5grams - 45grams of soil powder in a liter of clean water. The dispersion of soil powder in water was then stirred for 30 seconds before being ready to use. In order to observe the sedimentation velocity a gram of sedimentation agent was added into the sample and the mixture of the sample and the sedimentation agent was stirred for 30 seconds. The sample was then placed into a measuring tube and leaved the tube undisturbed for 60seconds before the observation of sedimentation of the dirt coagulant begins.

When an object is put inside the water there are three forces working on it at the same time. These three forces are gravitational force, buoyant force, and viscous force. The gravitational force causes the object to accelerate, so that it falls faster with time to the bottom of the measuring tube. The buoyant force and the viscous force are against the gravitational force, so that these three forces are eventually in balance. On the balance of these three forces the object moves to the bottom of the measuring tube with constant velocity, which is called sedimentation velocity.

In practice the sedimentation velocity, v is determined by using the following equation

$$v = \frac{\Delta x}{\Delta t} \qquad \textbf{Equation 1}$$

Here Δx is the travelling distance of the falling coagulant and Δt the time needed by the dirt coagulant to travel across this distance. The travelling distance was determined as 10 cm and the travelling time across this distance is measured 20 times for each observation to obtain a better average.

Commercial Sedimentation Agents

Two commercial sedimentation agents were observed in this research. These are aluminum sulfate and poly aluminum chloride. These two substances are commonly used to clean water in the pool as well as in the well. A gram of aluminum sulfate or poly aluminum chloride is dissolve in a liter of simulated dirty water sample and stirred for 30 seconds. This dispersion was then left for 60 seconds in a measuring tube before observation begins. The sedimentation time of the dirt coagulants when falling across 10 cm distance in the measuring tube was measured for 20 times using a stopwatch. The sedimentation time is the average of the above 20 measurements. The average sedimentation time was used to calculate the sedimentation velocity using Equation 1. This was done repeatedly for concentrations of the dirt coagulants ranging from 5g/l to 45 g/l for both aluminum sulfate and poly aluminum chloride.

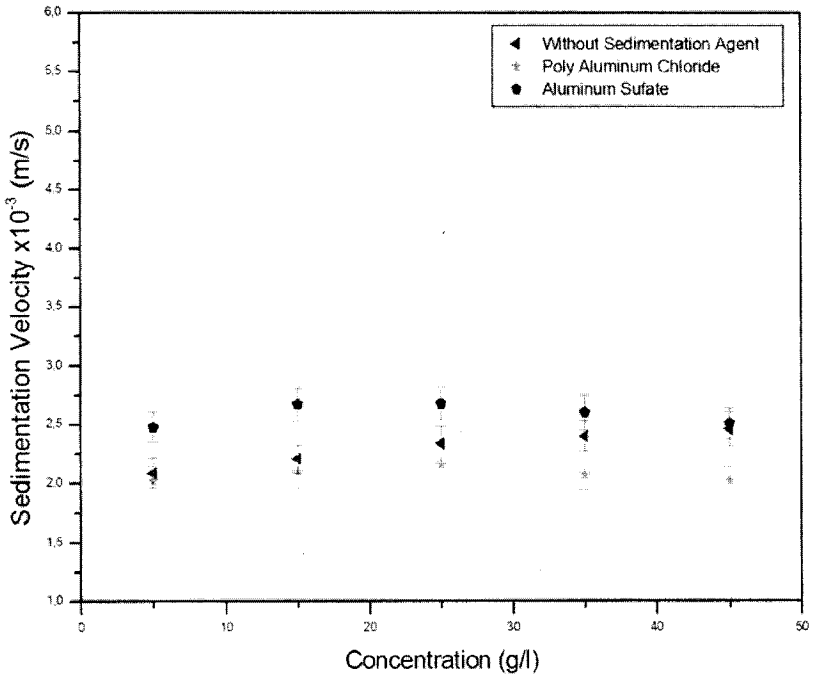

Figure 1. Sedimentation using Aluminum Sulfate and Poly Aluminum Chloride

Figure 1 shows that the sedimentation velocities of the dirt coagulants due to the addition of a gram Aluminum Sulfate in a liter of sample range from $(2.48 \pm 0.14) \times 10^{-3}$m/s to $(2.76 \pm 0.15) \times 10^{-3}$m/s. These are slightly higher compared to those of Poly Aluminum Chloride ranging from $(2.02 \pm 0.13) \times 10^{-3}$m/s to $(2.16 \pm 0.12) \times 10^{-3}$ m/s. This means that in this case the performance of the Aluminum Sulfate as sedimentation agent is better than Poly Aluminum Chloride. Based on the above data it is recommended to use Aluminum Sulfate as sedimentation agent instead of Poly Aluminum Chloride. Coincidently, Aluminum Sulfate as sedimentation agent is more popular compared to Poly Aluminum Chloride in Indonesia. The measurements of sedimentation velocity as a function of dirt coagulant concentrations of the sample without sedimentation agents were also done and presented in Figure 1 all together with the above two sets of measurements using commercial sedimentation agents.

Coconut Shell Activated Carbon Sedimentation Agent

Coconut shell carbon was activated chemically using 5 different acids. These are phosphoric acid (H_3PO_4), sulfuric acid (H_2SO_4), lactic acid ($CH_3CH(OH)COOH$), acetic acid (CH_3COOH), and nitric acid (HNO_3). This was done in an effort to find the best acid suitable for activating the coconut shell carbon.

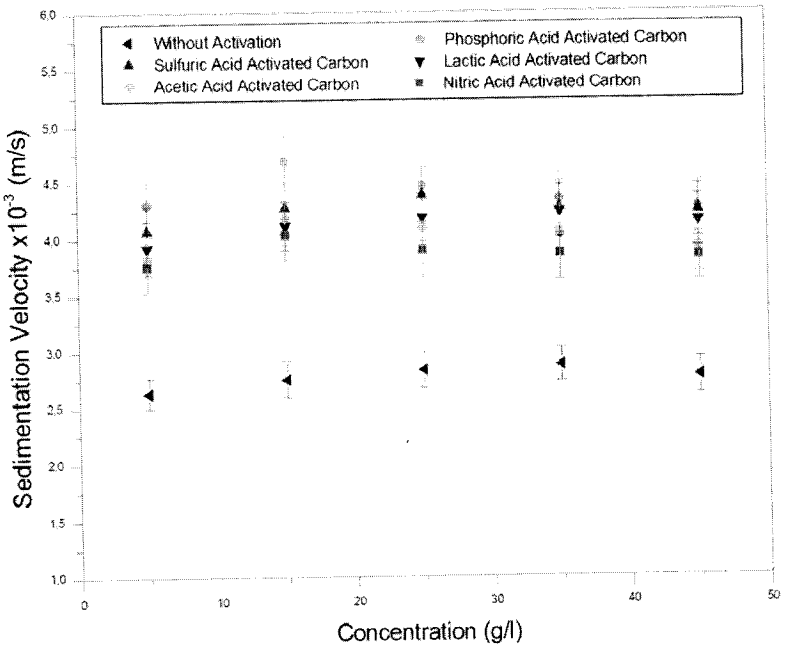

Figure 2. The influence of activation to the sedimentation velocity

Figure 2 shows the performance of the above five acids in increasing the sedimentation velocity of the dirt coagulants. The sedimentation velocity of the dirt coagulant when the dispersions were mixed with coconut shell carbon without being chemically activated ranging from $(2.63 \pm 0.14) \times 10^{-3}$m/s to $(2.87 \pm 0.15) \times 10^{-3}$m/s. When the coconut shell activated carbons were used as sedimentation agents the velocity increases significantly and they are in between $(3.75 \pm 0.22) \times 10^{-3}$m/s (using nitric acid) and $(4.68 \pm 0.26) \times 10^{-3}$m/s (using phosphoric acid). This means that the chemical activation increases the sedimentation velocity very significantly. Moreover the data show that phosphoric acid is superior compared to the other five acids. The sedimentation velocities of the dirt coagulants when they were mixed with coconut shell carbons that have been activated using phosphoric acid were observed to be in between $(4.26 \pm 0.23) \times 10^{-3}$m/s to $(4.68 \pm 0.26) \times 10^{-3}$m/s. This means that phosphoric acid is the most suitable acid for chemical activation of coconut shell carbon for increasing sedimentation velocity among the above five acids.

Comparison of Commercial Sedimentation Agents with Coconut Shell Activated Carbon

According to Figure 1 the commercial sedimentation agents may increase the sedimentation velocity of dirt coagulant. On the other hand, Figure 2 shows that the coconut shell activated

carbon increases the sedimentation velocity very significantly. In order to show the superiority of the performance of coconut shell activated carbon in promoting higher sedimentation velocity, the comparison data of sedimentation velocities of the above two group are presented in Figure 3.

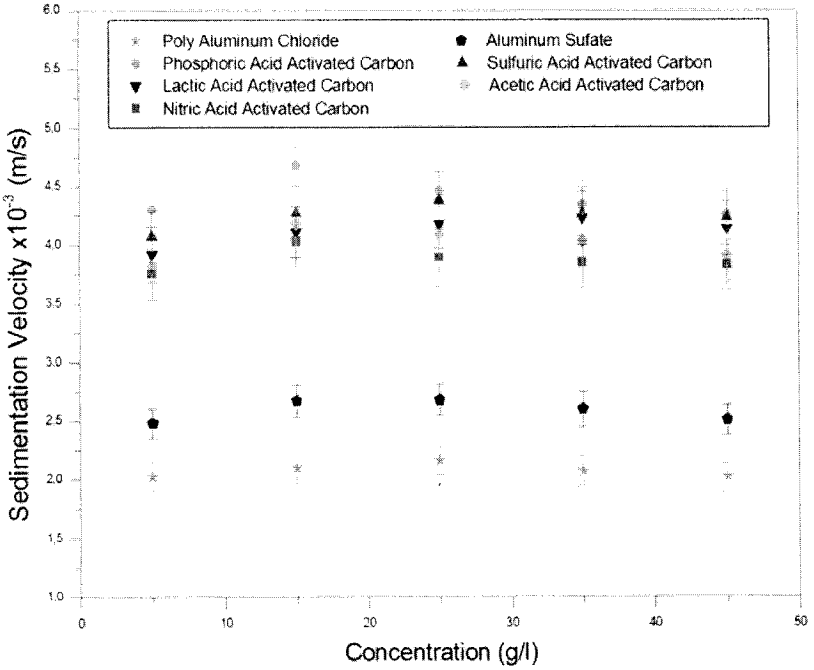

Figure 3. Comparision between activated carbons and commercial sedimentation agents

Figure 3 shows that the sedimentation velocities due to commercial sedimentation agents fall in between (2.02 ± 0.12) x 10^{-3}m/s and (2.76 ± 0.15) x 10^{-3}m/s with Aluminum Sulfate showed better performances compared to Poly Aluminum Chloride. Figure 3 also shows that the sedimentation velocities due to coconut shell activated carbon are in between (3.75 ± 0.22) x 10^{-3}m/s (using nitric acid) and (4.68 ± 0.26) x 10^{-3}m/s (using phosphoric acid). These data show that coconut shell activated carbons in promoting higher sedimentation velocity is much more superior compared the above two commercial sedimentation agents. It should be noted that coconut shell carbons which were activated using phosphoric acids showed the best performance. The sedimentation velocities of all samples due to phosphoric acid fall in between (4.26 ± 0.22) x 10^{-3}m/s and (4.68 ± 0.26) x 10^{-3}m/s. This indicates that coconut shell carbons activated chemically using phosphoric acid makes the best alternative sedimentation agent for the above samples.

Conclusion

Based on the above discussion there is no doubt that coconut shell activated carbon may be used as an alternative sedimentation agent. The performance of coconut shell activated carbon as sedimentation agents are much better compared to those of commercial sedimentation agents. However, an inherent problem arises when carbon is dispersed in the sample that is the carbon

induces black color. It is left to the reader to find solution of this problem. One of the proposed solutions is to put the carbon inside porous packages and submerged these packages in the sample to obtain clean water. This carbon package is somewhat like tea bag.

Acknowledgement

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