Comparing the performance of chitosan in two different solvents for coagulation of peat water

by Utami Irawati

Comparing The Performance of Chitosan in Two Different Solvents for Coagulation of Peat Water

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Abstract. Chitosan is a natural material that possesses great potentials as an alternative coagulant. In this research, chitosan was used for peat water treatment. As the efficiency of chitosan is also determined by the solvent used, this research investigated the effect of different solvents, i.e., acetic acid (CH_3COOH) and hydrochloric acid (HCl) towards the efficiency of chitosan as a coagulant to treat peat water. The parameters being studied comprised turbidity, TDS, and total iron concentration in the sample before and after coagulation using chitosan. Optimum dose and pH for chitosan in each solvent were determined using a standard jar test apparatus. The results showed that both chitosan dissolved in acetic acid (chitosan-CH_3COOH) and hydrochloric acid (chitosan-HCl) had given an optimum result at 10 mg/L dosages the decrease in turbidity reached up to 95.38% for chitosan-CH_3COOH and 92.39% for chitosan-HCl. A dosage above this optimum value leads to deflocculation, lowering the coagulation efficiency. Both of the chitosan coagulants gave optimum results at pH 6. However, chitosan-HCl seemed to work in a wider pH range than chitosan- CH_3COOH. Both solvents used increased TDS than the initial values due to the solvent being ionic compounds themselves.

INTRODUCTION

Peat water is surface water that can be used as raw water due to the extensive distribution of peatlands. However, peat water has several characteristics, such as including a dark brown to black color (124-850 PtCo), acidic (pH 3.7-5.3), and high organic content (138-1560 mg/L $KMnO_4$) [1]. Peat water also contains a high level of iron (Fe), causing the water to turn brownish-red [2]. As a result of these characteristics peat water generally does not meet the requirements to be used as clean water. Peat water can be turned into clean water suitable for consumption if it is treated properly. Peat water treatment is generally carried out using the coagulation method [3]. So far, the coagulants commonly used are synthetic coagulants such as alum, PAC, or aluminum salts such as aluminum sulfate. However, the use of synthetic coagulants, if done continuously in large quantities, can negatively impact living things and the environment. Several studies have reported that aluminum can trigger Alzheimer's disease [4]. Therefore, studying alternative coagulants in the peat water treatment process is necessary to make it more environmentally friendly. In this paper, chitosan is used as a natural coagulant to treat peat water. It is important to be noted one of the factors affecting the performance of chitosan in its application is the type of solvent used [5,6]. Thus, in this study, the dosage ratio needed to get optimal results in reducing turbidity, Total Dissolved Solid (TDS), iron content between chitosan dissolved using acetic acid and chitosan dissolved using hydrochloric acid has been investigated. The effect of pH on the effectiveness of each chitosan dissolved with two different solvents in reducing the turbidity, TDS and iron levels was also studied.

The 4th International Conference on Life Science and Technology (ICoLiST)
AIP Conf. Proc. 2634, 020071-1–020071-5; https://doi.org/10.1063/5.0111284
Published by AIP Publishing. 978-0-7354-4313-6/$30.00

MATERIALS AND METHODS

Materials

The materials used in this study were peat water samples taken in front of SMA Banua, South Kalimantan, chitosan (87.5% of deacetylation degree), 2% acetic acid (CH_3COOH), 2% hydrochloric acid (HCl), nitric acid (HNO_3), 1 M sodium hydroxide (NaOH), and distilled water. All the working solutions were prepared from reagents of analytical grade (p.a. Merck). To make 2% (w/v) chitosan solution, as much as 0.5 grams of chitosan powder was dissolved in 25 mL of 2% CH_3COOH and 2% HCl and then labeled Chit-AA and Chit-HCl, respectively.

Experimental Setup

A standard jar test apparatus with six 1-L beakers were used in this experiment. To determine the optimum dose, 1 L of peat water sample was poured into the beaker glass, then a certain amount of chitosan coagulant solution was added into each glass to have various doses. The mixture was stirred rapidly at a speed of 100 rpm for 1 minute, followed by slow stirring at a speed of 45 rpm for 20 minutes. After that, the mixture was let to settle for 30 minutes. The top portion of the solution was taken, and the turbidity, TDS and iron content of it was then analyzed. The effect of pH on the coagulation process was investigated by adjusting the pH of each sample using 1.0 NaOH or 1.0 HCl. After the desired pH was reached, a chitosan coagulant was added. The amount added was the same as the optimal dose that was obtained from the previous step. The sample was then stirred at 100 rpm for 1 minute then stirred at 45 rpm for 20 minutes. After the stirring, the samples were let to settle for 30 minutes. The top portion of the sample was then taken to be analyzed for its turbidity value, TDS, and Fe content. All of the analysis procedures were conducted based on the steps outlined in Indonesian National Standard (*Standar Nasional Indonesia*, SNI)

RESULTS AND DISCUSSION

Determination of Optimum Dose

Dosage is a very important parameter in coagulation-flocculation as an excessive dose of coagulant to water or wastewater can cause deflocculation, reducing the coagulation-flocculation efficiency [7]. Figures 1, 2, and 3 compare the reduction in turbidity, TDS and iron content of peat water samples that took place when treated using chitosan coagulant with two different solvents for each dose variation being examined.

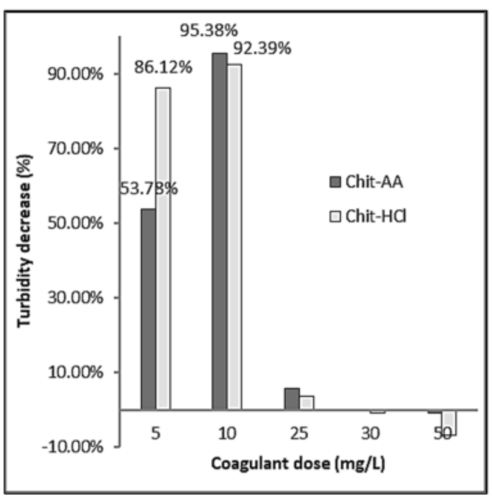

FIGURE 1. Decrease in turbidity for each dose

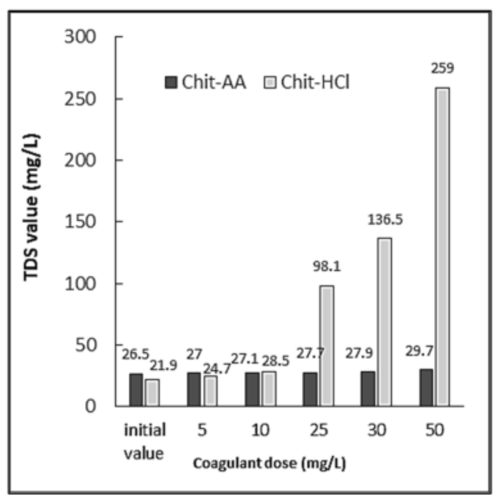

FIGURE 2. TDS value after treatment for each dose

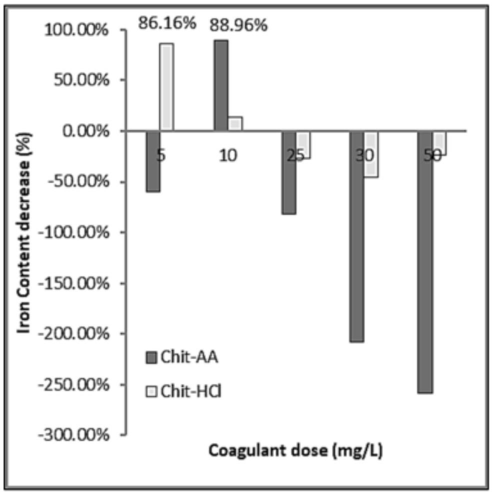

FIGURE 3. Decrease in iron content for each dose

As seen in Figure 1, the optimal dose for coagulation of peat water for both Chit-AA and Chit-HCl is 10 mg/L, where the turbidity reduction was up to 95.38% and 92.39%, respectively. However, it can also be observed that at a dose of 5 mg/L, Chit-HCl gave a more effective result than Chit-AA where the decrease in turbidity was 86.12% compared to 53.78%. This is very likely because the use of acetic acid, an organic solvent, as a solvent for chitosan can simultaneously increase the total organic carbon (TOC) value in the solution, thus reducing the effectivity of the coagulation-flocculation process [6].

Another thing that should be noted about the result is how the reduction in turbidity in the sample decreased after the amount of coagulant added exceeded the optimal doses. This indicates the occurrence of deflocculation in the samples, which decreases turbidity removal efficiency. An excessive amount of coagulant in the solution added is too large. The polymers in the natural coagulant will cover the entire surface of the colloid particles, leading to an excess in positive charges. Thus, the already formed flocs will break down - a phenomenon known as deflocculation - and particles will restabilize [8]. Figure 4 below shows the peat water samples before (a) and after coagulation (b) at the optimal dose.

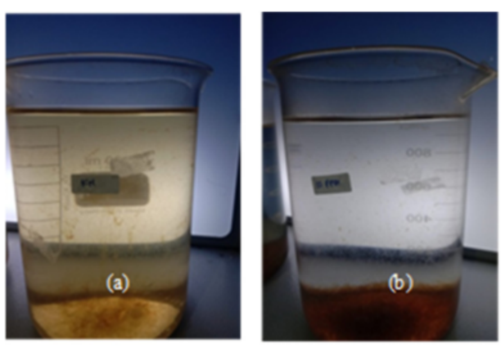

FIGURE 4. Peat water sample (a) before treatment and (b) after treatment

In Figure 2, it can be observed that adding higher coagulant doses leads to an increase in the TDS value of the samples. This is because the compounds in the coagulant itself were ionized, increasing the TDS value. However, HCl's use clearly leads to a higher increase in TDS as the dose of the coagulant was increased. This is likely due to the nature of HCl being a strong acid, which enables more dissociation reactions to take place in the system.

Figure 3 shows the iron content in peat water samples for each dose variation. The optimal dose for Chit-AA was 10 mg/L which gave an 88.96% reduction of Fe content, while the optimal dose for Chit-HCl was 5 mg/L where the Fe reduction was 86.16%. This result implies that when dissolved in HCl, chitosan is more effective in reducing Fe content. This is probably because even in a lower dose, chitosan dissolved in HCl formed firmer flocs more efficiently, entrapping the iron in those flocs. In samples treated with coagulant in doses higher than 10 ppm, iron content showed an increase compared to the initial Fe concentration detected in pre-treated samples. This was likely because the pre-treated samples were filtered before being analyzed for their iron content, and thus, iron trapped in suspended particles was filtered out. On the other hand, treated samples were coagulated first before being filtered. The coagulation treatment might have broken down the trapped irons from the suspended particles and released them into free ions, leading to higher iron content.

Influence of pH

In coagulation, pH holds an important role as it directly affects the speciation of the coagulant and the compounds found in the system. For chitosan in particular, in an acidic solution, the amine groups in chitosan would be protonated into $-NH_3^+$, giving it a polycationic property. The reduction in turbidity, final TDS value, and the decrease in iron content for samples treated with chitosan on different pH are presented in Figures 5, 6 and 7, respectively.

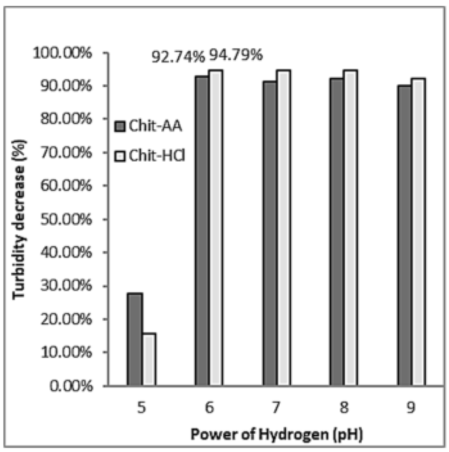

FIGURE 5. Decrease of turbidity in different pH

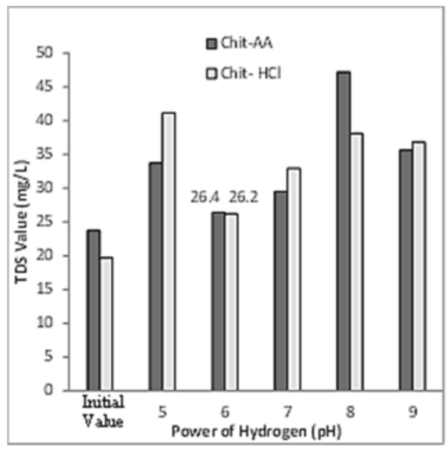

FIGURE 6. TDS value of each sample after treatment in different pH

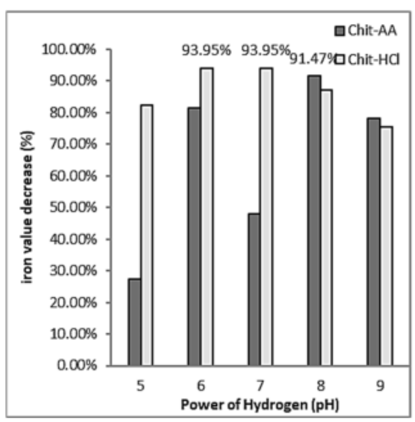

FIGURE 7. Decrease of iron content in each sample in different pH

Those figures showed that pH affects the coagulation process. As can be seen in Figure 5, coagulation by chitosan, both for Chit-AA and Chit-HCl, showed a much better performance in near-neutral pH to a basic pH. This result comes in line with what has been reported by Jadhav and Mahajan [9], where chitosan showed a better performance in a near-neutral pH when used as a coagulant for clay suspension. Similar to what they have observed, in this study, chitosan coagulation did not work effectively in acidic pH. This indicates that instead of charge neutralization, the coagulation mechanism by chitosan occurs through bridging formation, as suggested by Chen *et al.* [10]. Another possible reason for this is in acidic pH. Most of the humic substances in the peat water were protonated. Thus, only a few suspended humic particles in the peat water can interact with the protonated amine groups in chitosan, forming the desired floc.

Figure 6 shows the TDS value of each sample after being treated with chitosan coagulant for each pH being observed. The absence of a pattern from that figure implies no direct correlation between TDS values and pH. The same result was also obtained regarding the decrease in iron content, as shown in Figure 7, which shows no particular pattern between the decrease of iron content and pH. Based on that result, it appears that there is not any direct correlation either between pH and the decrease of iron content through coagulation.

CONCLUSION

The present study proposed that when chitosan is used to treat peat water, hydrochloric acid is a more effective solvent for chitosan than acetic acid to be used in coagulation in terms of turbidity reduction of peat water samples being treated. The optimum dose of chitosan as a coagulant for both chitosan dissolved in acetic acid (Chit-AA) and hydrochloric acid (Chit-HCl) is 10 mg/L. Coagulation by chitosan is influenced by pH, where both Chit-AA and Chit-HCl gave optimum results at a near-neutral pH. This indicates that chitosan coagulation of suspended particles in peat water occurs mainly through bridging formation.

REFERENCES

1. A. Parabi, R. Christiana, D. Octaviani, M. Zalviwan, E. Noerhartati, and L.T. Muharlisiani, in *J. Phys Conf Ser* (IOP Publishing, 2019), p. 33019.
2. M. Apriani, A. Masduqi, and W. Hadi, ARPN J Eng Appl Sci **11**, 8132 (2016).
3. I.D.A. Sutapa and R.L. Toruan, Teknol Indones **37**, (2015).
4. A. Campbell, Nephrol Dial Transplant **17**, 17 (2002).
5. H. Altaher, J Hazard Mater **233**, 97 (2012).
6. C. Huang, S. Chen, and J.R. Pan, Water Res **34**, 1057 (2000).
7. H. Wei, B. Gao, J. Ren, A. Li, and H. Yang, Water Res **143**, 608 (2018).
8. M.A.A. Hassan, T.P. Li, and Z.Z. Noor, J Chem Nat Resour Eng **4**, 43 (2009).
9. M. V Jadhav and Y.S. Mahajan, KSCE J Civ Eng **17**, 328 (2013).
10. L. Chen, D. Chen, and C. Wu, J Polym Environ **11**, 87 (2003).

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