RESEARCH ARTICLE | MAY 15 2023

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AIP Conference Proceedings 2595, 050010 (2023)
https://doi.org/10.1063/5.0125554

The Use of Papaya Seeds as a Natural Coagulant in the Water Treatment from Tello River

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Abstract. Water from Tello River can be used as a raw water to meet the clean water, addressed the needs of Makassar people. The characteristics of river water are very fluctuate depending on the season especially for its turbidity and Total Suspended Solids (TSS). TSS in water can be reduced through the coagulation process. The aim of this study was to determine the pH and the coagulant concentration of papaya seeds which was a best way in reducing the TSS concentration of sample. Variation in pH was carried out at pH of 1 to 12 by adding 1.0 M HCl or 1.0 M NaOH (with coagulant concentration of 100% from the initial TSS concentration from the sample). After obtaining the optimum initial pH of the coagulation process, the optimization of coagulant concentration was continued. The coagulant concentration variation was carried out at a concentration of 50 to 400% of the initial TSS concentration from the sample at the optimum pH. The coagulation processes used in this study were rapid mixing at 200 rpm for 4 minutes, slow mixing at 50 rpm for 25 minutes, and sedimentation for 60 minutes. The results of this study found that the pH and the coagulant concentration optimal at 3 and 150% of the initial TSS concentration from the sample with percent TSS removal of 99.13%. The results of this study prove that papaya seeds were the best natural coagulants because it could reduce TSS concentrations in the sample approaching 100%.

INTRODUCTION

Water from Tello River can be used as a raw water to meet clean water demands of Makassar people. The characteristics of river water are very fluctuating; it depends on the season especially for its turbidity and Total Suspended Solids (TSS). TSS is the cause of increased turbidity in water. The coagulation-flocculation process can remove TSS in water [1]. The coagulation process usually uses chemicals (coagulants) to help destabilize suspended particles to micro-floc form. Micro-floc particles will bind to form a larger floc using flocculants and settle (flocculation) [2]. The use of coagulants based on Aluminum (Al) such as Alum and PAC for water treatment often causes an increase in the concentration of Al in the water from processing. Al is known as a factor causing neurological disorders such as Alzheimer's disease and dementia [3]. The use of chemical coagulants not only causes health problems, but also the coagulation process produces a large amount of toxic sludge [2] which can harm the environment.

The study aims to examine environmentally friendly coagulants by utilizing fruit waste. Proteins and polysaccharides are natural polymers in fruit waste. The greater the molecular weight of a polymer, the longer the polymer chain, so that there are more active sites available for particle adsorption [4]. Proteins have a positive ion charge in acidic conditions, so that the mechanism of neutralization and adsorption in the coagulation process can be fulfilled [5].

Coagulant concentration and pH are the most important factors in the coagulation process. If the coagulation process was not carried out at the optimum pH, it would generate a low efficiency in TSS removing in water. The pH not only affects the surface charge of the coagulant, but also affects the stability of the suspended particles. In addition, pH variations can affect the solubility of the protein coagulant in solution. Thus, pH studies are needed to determine the optimal pH value of the coagulation process [6]. The appropriate concentration of the coagulant is very important to achieve the desired quality of treated water. Often, the results of the coagulation process are less

Young Scholar Symposium on Science and Mathematics Education, and Environment
AIP Conf. Proc. 2595, 050010-1–050010-5; https://doi.org/10.1063/5.0125554
Published by AIP Publishing. 978-0-7354-4491-1/$30.00

satisfactory due to non-optimal coagulants concentration. Deficient coagulant concentration, optimal coagulant concentration, and excessive coagulant concentration are three possibilities obtained when adding coagulants in the coagulation process [7].

Study about optimization of the pH and the coagulant concentration in TSS removing using natural coagulants previously carried out by Idris et al in 2013. pH optimization was performed using the Dragon Fruit Foliage coagulant with a coagulant concentration of 500 mg/L in the pH range of 2 to11 and obtained an optimal pH of 10. Optimization of the coagulant concentration was carried out at pH 10 with the concentration range used was 200 mg/L to 800 mg/L and the optimal coagulant concentration was obtained at 700 mg/L [5].

Papaya seeds have a high protein content, so papaya seeds can be used as a natural coagulant. The use of papaya seed powder as a natural coagulant was able to reduce turbidity to 93.07% [8], 96.28% [9], and suspended solids 97.09% [9]. Study conducted by George and Arya in 2018 was about the optimization of coagulant concentration without determining optimal pH first. Therefore, in this study optimization of pH and concentration of coagulants using papaya seeds was intended to obtain an optimal coagulation process.

METHODS

Preparation of Samples

The sample from this study was water from Tello River, Makassar City, which was taken in April 2019. Samples were filtered to remove floating impurities, then were deposited by sedimentation process for 30 minutes to precipitate the sand or soil which contained in the sample. The initial pH and initial TSS concentration of the sample were measured.

Preparation of natural coagulant from papaya seeds

Papaya seeds were taken from papaya fruit in Makassar City. Papaya was peeled and then its seeds were taken out. Papaya seed powder was made by means of a few steps that are papaya seeds were washed with clean water, then dried under the sun for 5 days. Dry papaya seeds were ground with blender, then sifted.

Papaya seed powder was stored in an airtight bottle and ready to use. The 5% of papaya seed solution was made by dissolving 5 g of papaya seed powder into 100 mL of 0.05 M NaOH (solvent). The papaya seed solution was stirred with rapid mixing for 5 minutes, rested for 2 hours, then filtered using muslin cloth [10]. The filtrate obtained was used as a coagulant.

Coagulation-Flocculation Process

Condition of coagulation-flocculation process from several studies can be seen in Table 1.

TABLE 1. A summary of the conditions of the coagulation-flocculation process from several studies

Parameter	Range	Reference
Speed of rapid mixing (rpm)	100 - 300	/
Duration of rapid mixing (min)	1 - 4	[5], [11] - [15]
Speed of slow mixing (rpm)	40-60	[5], [11] - [15]
Duration of slow mixing (min)	20 - 30	[5], [11] - [15]
Settling time (min)	30 - 120	[5], [11] - [15]

Based on Table 1 shows a summary of the conditions of coagulation-flocculation process from several studies. In this study, we used rapid mixing at 200 rpm for 4 minutes, slow mixing at 50 rpm for 30 minutes, and then sedimentation for 60 minutes.

The Effect of Initial pH

Study on the effect of the initial pH of the sample was carried out to determine the optimum pH of the coagulation process using papaya seed coagulant. pH variation was carried out in the range pH of 1 to 12 with the initial TSS concentration of the sample that was 229 mg/L and 100% of coagulant concentration of the initial TSS concentration from the sample. pH was adjusted by adding 1 M HCl and 1 M NaOH solution.

The Effect of coagulant concentration

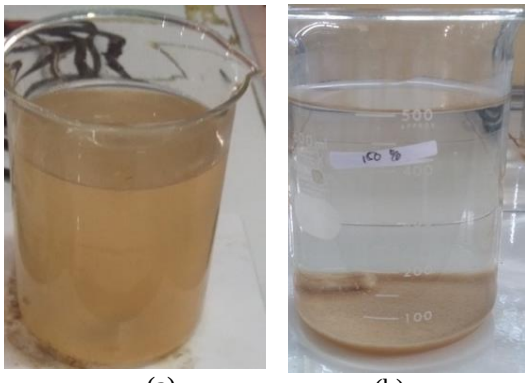
The study on the effect of coagulant concentration from papaya seeds was carried out to determine the optimal coagulant concentration of the coagulation process. The pH of the sample was fixed at pH of 3 (the optimal pH of the previous experiment) with an initial TSS concentration of 229 mg/L. The variation of coagulant concentration was carried out in the range of 50% to 400% of the initial TSS concentration from the sample.

RESULTS AND DISCUSSIONS

The results of this study can be shown in Table 2 and Figures 1 & 2.

TABLE 2. The result of coagulation-flocculation process using papaya seeds coagulant

pH	% TSS removal	Coagulant concentration (% of the initial concentration TSS from the sample)	% TSS removal
1	97.82	50	97.82
2	97.60	100	98.69
3	98.69	150	99.13
4	98.69	200	97.38
5	79.91	250	95.63
6	97.16	300	94.76
7	89.96	350	93.23
8	89.30	400	91.92
9	96.29		
10	95.20		
11	97.82		
12	67.69		



(a) (b)

FIGURE 1. (a) Samples before treatment and (b) after treatment using papaya seeds coagulant.

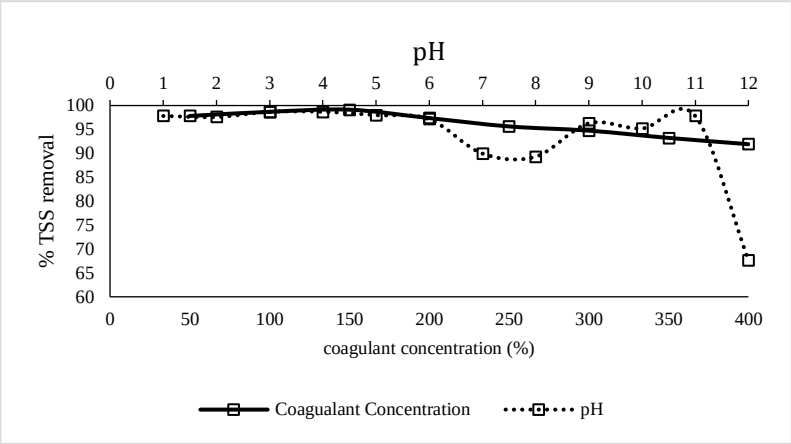


FIGURE 2. Graph of the relationship between percentage of TSS removal both with pH and coagulant concentration.

Study of the coagulation-flocculation process pH had a very significant effect. If the coagulation process did not take place in the optimum pH, it would give a low efficiency of removing TSS in water. The isoelectronic point (pI) and pH of solution could affect the particle charge. pH could reduce the stabilization of suspended particles. If the stability of suspended particles decreased, suspended particles would be easily precipitated. Suspended particles would re-stabilize when there was excessive coagulant concentration. Therefore, pH and coagulant concentration were very important factors in the coagulation-flocculation process.

Determination of the optimum pH coagulation process was carried out in the pH range of 1 to 12. The coagulant concentration was 100% of the initial TSS concentration from the sample. The initial TSS concentration of the sample from this study was 229 mg/L (ppm), therefore the coagulant concentration of papaya seeds was 229 ppm. After knowing the optimum pH, the optimum coagulant concentration for the coagulation-flocculation process was carried out. The coagulant concentration was 50% to 400% of the initial TSS concentration from the sample (114.5 mg/L - 916 mg /L).

Based on the Table 1 and Figure 2, the optimal coagulation-flocculation process conditions were obtained at pH of 3 with TSS removal of 98.69%. The results of this study were in accordance with the research of Abidin et al in 2014 [11] and Abidin et al in 2011 [16] which obtained the optimal pH from the coagulation-flocculation process using natural coagulants of 3. Figure 2 shows that the highest TSS reduction is acidic conditions (pH <3). At pH <3, the largest constituent components of amino acids such as aspartic acid (pI 2.77) and glutamic acid (pI 3.22) were positively charged. The positive charge of this protein was able to neutralize the negative charge from the surface of the suspended particles. In neutral conditions, there was a decrease in performance of the coagulation process. It was possible that amino acid components that had a pI < 3 had been negatively charged, hence it reduced cationic ability of the protein in neutralizing the charge of suspended particles. In the case of alkaline conditions (pH > 7), there was an increase in the performance of the coagulation process. This was probably due to the amino acid component acting in neutralizing the negative charges from the surface of suspended particles which were Lysine and Arginine which had a pI value of 9.74 and 10.76. At pH 12, there was a sharp decrease in the performance of the coagulation process. It was because amino acids from proteins had been positively charged due to the value of pI of the highest amino acid component was 10.76. The amino acid component of papaya seeds [17] has a pI value of 2.77 to 10.76.

Figure 2 shows that the higher concentration of coagulant used, the higher percentage of TSS removal would be. However, after passing through the optimal coagulant concentration, the highest concentration of coagulant decreased TSS removal. It was because an excess of the positive charge from protein would re-stabilize the suspended particles. The papaya seed coagulant concentration was optimal at a concentration of 150% from the initial TSS concentration of the sample or 343.5 mg/L with percentage of TSS removal of 99.13%.

Study on the utilization of papaya seeds as a coagulant was carried out by George and Arya in 2018 [9]. The optimal coagulant concentration and percentage of TSS removal were 600 mg/L and of 97.04% [9]. Figure 3 shows that the percentage of TSS removal from this study was higher and the concentration of coagulant needed is lower

compared to George's study. This was caused by papaya seed powder was immediately applied as a coagulant (without the extraction of protein from papaya seeds) and without process of pH optimization.

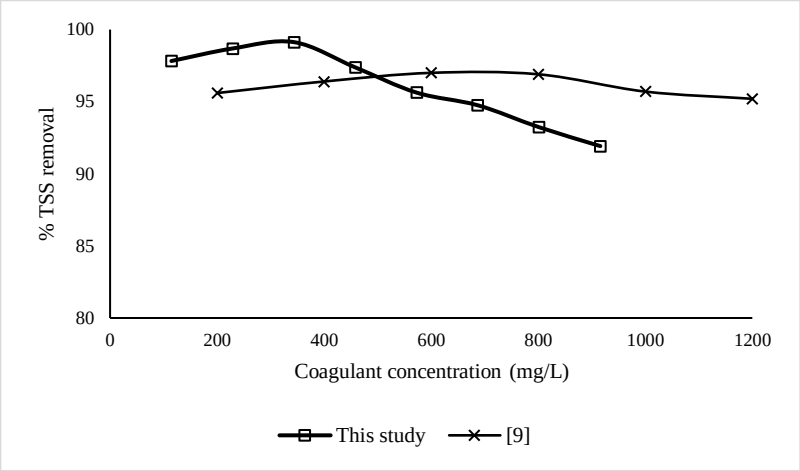


FIGURE 3. Comparison between the results of coagulation-flocculation process from this study with George's research

CONCLUSSION

The results of this study found that pH and coagulant concentration optimal was at 3 and 150% of the initial TSS concentration from the sample with percentage of TSS removal of 99.13%. The use of coagulants based on the concentration of the initial TSS sample was able to overcome the problems in determining the coagulant which must be added due to fluctuation of TSS concentrations in water depending on the season.

REFERENCES

1 H. Zemmouri, M. Drouiche, A. Sayeh, H. Lounici, N. Mameri, Procedia Engineering **33,** 254 – 260 (2012)
2 F. Renault, B. Sancey, P. M. Badot, G. Crini, J. Europ. Polym. **45,** 1332-1348 (2009)
3 Srinivasan, P.T., Viraraghavan, T., and Subramanian, K.S, Aluminium in drinking water: An Overview Water SA **25,** 47-56 (1999)
4 S. Y. Choy, K. M. N Prasad, T. Y. Wu, M.E Raghunandan, and R. N Ramanan, J. Environ. Sci. **26**, 2178-2189 (2014)
5 J. Idris, A. Md Som, M. Musa, K. H. K. Hamid, R. Husen, and M. N. M. Rodhi, J Chemistry 1-7 (2013)
6 S. A. Unnisa and S. Z. Bi, Carica papaya seeds efectiveness as coagulant and solar disinfection in removal of turbidity and coliforms Appl Water Sci **8,** 149 (2018)
7 S.Y.Choy, K.M.N.Prasad, T.Y.Wu, R. N. Ramanan, Int. J. Environ. Sci. Technol **12,** 367–390 (2015)
8 J. Kang, and J. Treviño, Int. J. of Life Sci. Research **5,** 126-131(2017)
9 George, D. and Arya C. J, Int. J.. Latest Technol. Eng. Manag. Appl. Sci. IJLTEMAS **7,** 50-66 (2018)
10 T. Nkurunziza, J. B. Nduwayezu, E. N. Banadda and I. Nhapi, Water Sci. Technol **59,** 1551-1558 (2009)
11 Z. Z. Abidin, M. F. Mohamed and A. G. L. Abdullah, Advanced Materials Research **917,** 96-105 (2014)
12 M. Al-Sameraiy, J. of Water Resource and Protection **4,** 79-92 (2012)
13 Z. Z. Abidin, N. S. M. Shamsudina, N. Madehia, S.Sobria, Industrial Crops and Products **41,** 319– 323 (2013)
14 M. Megersa, A. Beyene, A.Ambelu, D. Asnake, T. Bekele, B. Firdissa, Z. Alebachew, L. Triest, Water Conserv. Sci. Eng. **1,** 95–102 (2016)
15 H. Kristianto, M.A. Kurniawan, J.N.M Soetedjo, Int. J. on Advanc. Sci. Eng. and Information Technol. **8**, 2071-2077 (2018)
16 Z.Z. Abidin, N. Ismail, R. Yunus, I.S. Ahamad and A. Idris, Environ. Technol. **32** 971–977 (2011)
17 C. Passera and P. Spettoli, Plant Foods for Human Nutrition **31,** 77–83 (1981).