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Comparison of Bentonite Characteristics Before and After Be Used as Coagulan of Liquid Tofu Waste

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ABSTRACT

The study aims to examine Bentonite characteristics before and after be used as coagulan of liquid tofu waste. This research was conducted at the Quality Control. Bentonite obtained from East Java is a Ca-Bentonite type which has been activated with H_2SO_4 20% based on the XRF results which showed CaO level of 4.15%. Bentonite can be reused after being applied as a coagulant and it's based on the results of the Bentonite XRD diffractogram pattern before and after being applied as a coagulant that doesn't have a significant change of 2q, including the 2q montmorillonite at 21,98^0 (516,42 cps), 35,47^0 (384,43 cps), 62,26^0 (100,66 cps) to 22^0 (436,22 cps), 35,47^0 (326,46 cps), 62,79^0 (65,79 cps) and 2q of quartz (SiO_2) at 26,5^0 (607,56 cps) to 26,53^0 (537,65 cps). The optimum coagulation conditionsis when height of bentonite is 900 mg in 50 mL of liquid tofu waste pH 2, its can remove turbidity by 98% and TSS by 84.6%.

INTRODUCTION

Bentonite is one of the abundant montmorillonite mineral resources in Indonesia. The structure and content of bentonite includes hydrated alumina-silicate crystals which have interlayers between layers and contain alkaline or alkaline earth cations (Sakinah, 2020; Siregar & Irma, 2016). Bentonite is widely used as an adsorbent in reducing the concentration of dyes and heavy metals. Research result (Nugraha et al., 2017) wrote that bentonite has the potential as an adsorbent in the adsorption process of heavy metal ions Cd (II) and bentonite activated with acidic compounds has a higher absorption rate. However, in his journal (Juhra & Notodarmojo, 2016) stated that the use of the adsorption method was considered less effective in waste treatment because the adsorbed waste could accumulate with the adsorbent, causing new problems.

Therefore, (Suryadiputra, 1995) write down the waste treatment process with the coagulation process believed to be a fast, effective, and efficient process in reducing the concentration of waste by precipitating it with coagulants. The coagulation process is a waste treatment technique that adds chemicals to wastewater with the aim of making the impurity particles more easily settle and bond with the coagulant to form larger flocs. Bentonite has the ability to precipitate impurities because it contains Aluminum Oxide (Al2O3) and Al cations in its interlayer which are the content of coagulants in general such as alum (Husaini et al., 2018). According to Ruskandi (2020) bentonite has 2 types, including Na-Bentonite and Ca-Bentonite. Na-bentonite has a higher swelling ability than Ca-bentonite. However, the swelling ability of Ca-bentonite can be increased by activating Ca-bentonite

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using sulfuric acid. The alkaline or alkaline earth group cations that are in the bentonite interlayer can be replaced with H+ ions from sulfuric acid so that the active site of bentonite increases. Maulani (2021) wrote that liquid tofu waste originating from the process of soaking, washing soybeans, washing tools, and filtering when printing tofu has a negative impact on the surrounding environment, so it must be processed first.

Ginting (2021) has conducted a study on the use of bentonite in measuring TDS and pH in his journal stated that bentonite can reduce TDS by 98% and does not change the pH of the water remains at pH 9 in formation water. Bentonite has also been used to reduce turbidity by 94% and TSS by 83% in river water (Syafalni & Pujiindayati, 2016). Bentonite clay can be a coagulant because it contains aluminum and iron oxides (Bahri et al., 2013). In this study, bentonite activation was carried out whose success was measured by characteristics using XRF and XRD. The resulting bentonite will be used as a coagulant in tofu factory wastewater. After being used as a coagulant, bentonite that has been used will be re-characterized by XRD to see how much the intensity changes in the bentonite crystal structure.

METHODS

This research was conducted at the Quality Control (QC) Laboratory of PT. Semen Baturaja in August 2022. XRD characterization was carried out at the Physics Laboratory of Sriwijaya University. The tools used in this study included a set of laboratory glassware, magnetic stirrer, pH meter, turbidimeter (Hach 2100Q), TSS meter (Partech), TDS meter with portable meter HQ40D, XRF (ARL 9900 Series), and XRD (Rigaku Miniflex-600).

Research procedure

Bentonite activation

Activated bentonite was mixed with 500 mL 20% H_2SO_4 with a magnetic stirrer for 30 minutes. The mixture was allowed to stand for 5 hours until the filtrate and precipitate separated which were then filtered using Whatman No. filter paper. 42. The resulting precipitate is then washed with distilled water at 70℃ so that the sulfate ions from H_2SO_4 are completely removed and baked at 150℃ for 5 hours to remove the water content. The precipitated powder obtained was in the form of 20% H_2SO_4 activated bentonite which was then characterized using XRD and XRF.

Performance of Bentonite as a Coagulant of Tofu Waste based on Turbidity and pH Parameters

Bentonite Weight Variation

The initial turbidity of tofu waste was measured with a turbidimeter. 50 mL of tofu waste in a beaker added 100, 300, 500, 700 and 900 mg of bentonite respectively. The mixture was stirred using a magnetic stirrer at a high speed of 1000 rpm. The mixture was allowed to stand for 5 hours until the filtrate and precipitate separated. After standing, the mixture is separated by filtration with filter paper. The resulting filtrate was measured for turbidity while the precipitate in the form of bentonite which had been used in the application was prepared again. The precipitate is washed with distilled water until clean and oven at 150℃. Then bentonite powder was characterized using XRD.

Tofu Waste pH Variation

The initial pH of tofu waste was measured with a pH meter. 50 mL of tofu waste was mixed with 900 mg of bentonite in a beaker glass for each tofu waste conditioned at acidic pH (pH 2), neutral pH (pH 6), and alkaline pH (pH 8) with the addition of 0.1 M NaOH and 0.1 M HCl. The next procedure follows the procedure for Bentonite Weight Variation.

Measurement of Total Suspended Solid (TSS) and Total Disolved Solid (TDS) Levels

TSS and TDS levels were measured when bentonite weight and pH were optimum in the deposition of tofu waste, namely 900 mg and pH 6.

RESULTS

Bentonite XRF

Based on the results of the XRF measurements, the contents contained in the prepared and activated bentonite are presented in Table 1 below.

Table 1
Bentonite XRF Measurement Results

elements	% content
SiO_2	61,23
Al_2O_3	8.56
Fe_2O_3	2,8
K_2O	0.44
CaO	4,15
MgO	0.72
Na_2O	0.00

Table 1 shows the highest content in the prepared bentonite, namely SiO_2 of 61.23%. The bentonite used is known to be of Ca-bentonite type because of the CaO content of 4.15% while the Na_2O content is 0%.

XRD Activated Bentonite H_2SO_4 20%

In their journal, Zaher et al. (2018) wrote that the diffraction angle for montmorillonite is at an angle of around 20^0-22^0 which indicates Na/Ca-Montmorillonite, the diffraction angles of 35^0 and 60^0 also show other typical diffraction angles of montmorillonite, and at an angle of 25^0-28^0 is the diffraction angle of quartz. The diffractogram pattern of 20% H_2SO_4 activated bentonite is shown in Figure 1 below.

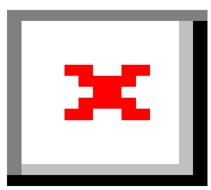

Figure 1. Activated Bentonite XRD Diffractogram Pattern

Figure 1 above shows the typical diffraction angles of bentonite. The results of observing the bentonite XRD diffractogram pattern can be seen in Table 2 below.

Table 2
Analysis of the Diffraction Angle of the Bentonite Diffractogram Pattern.

Compound Type	Angle 2θ	Intensity (cps)
Montmorillonite	21.98^0	516,42
	35.47^0	384,43
	62.26^0	100.66
Quartz (SiO_2)	26.53^0	607.56

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The results of the XRD analysis show that the highest intensity of bentonite is at the diffraction angle of 26.53^0 which is the angle of quartz (SiO2), this is in accordance with the results obtained in the XRF analysis where the highest content in bentonite is SiO2. The diffraction angles of 21.98^0, 35.47^0 and 62.26^0 are typical angles of the montmorillonite mineral where Ca, Al, Fe, Mg and K are contained in the interlayer.

Bentonite Weight Variation As Coagulant

The initial turbidity measured in tofu waste was 428 NTU. The turbidity measurement results from variations in the weight of bentonite as a coagulant for tofu waste can be seen in Figure 3 below. Figure 3 shows that the most effective precipitation occurred in coaglulant weighing 900 mg with 24 NTU remaining. The percentage of turbidity deposition of tofu waste can be calculated using the following formula (Bangun et al, 2013).

% Precipitation = 

Information :
A = Initial Turbidity (NTU)
B = Residual Turbidity (NTU)

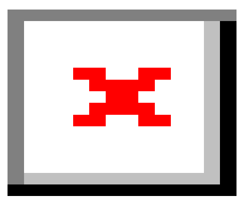

Figure 2. Value of Residual Turbidity (Settlement Percentage) on Bentonite Weight Variations

Figure 2 shows that the increasing the coagulant weight, the greater the percentage of tofu waste deposition that can be precipitated together with bentonite. This is in accordance with the statement of Rahimah et al. (2016) that the more coagulant, the better the deposition of turbidity can occur. Heavy doses of coagulants greatly affect the deposition process because if it is not appropriate, then precipitation is less effective.

Tofu Waste pH Variation

The initial pH measured in tofu waste was pH 3. Tofu waste was conditioned at pH 2, 6 and 8 with the addition of NaOH and HCl. The amount of turbidity reduction (NTU) can be seen in Figure 4 below. Figure 4 shows that the most effective turbidity deposition occurs at an acidic pH, namely pH 2, with a remaining 9 NTU.

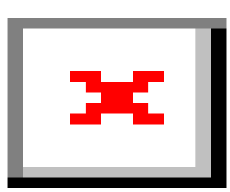

Figure 3. Value of Residual Turbidity (Settlement Percentage) at Variations in pH of Tofu Waste

The figure above shows the largest percentage of deposition in the condition of tofu waste at pH 2. This is possible because bentonite is more active and expands in acidic conditions where the surface of the adsorbent will have an excess of H+ protons so that the sides of the bentonite will be positively charged and have the potential to bind impurities to the tofu waste. anionic. The second highest percentage is in alkaline conditions, namely pH 8. This is possible because the bentonite surface in alkaline conditions will be negatively charged and has the potential to bind impurities in tofu waste which are cationic (Dardinata et al., 2019). The pH of tofu waste after the coagulation process can be seen in Figure 5 below.

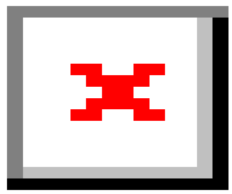

Figure 4. The pH of Tofu Waste After the Coagulation Process

Figure 5 shows that after the coagulation process with bentonite coagulant, the pH of the tofu waste is close to the normal pH, namely pH 6.5, which was previously pH 2. Likewise, the tofu waste, which initially had a pH of 8, is close to the normal pH, namely pH 7. This is in accordance with the Wastewater Quality Standards Tofu Industry based on Regulation of the Minister of Environment of the Republic of Indonesia No. 5 of 2014 concerning Wastewater Quality Standards, namely the pH of tofu wastewater must be in the range of 6-9 (Sayow et al., 2020). In this case, bentonite is good at improving the pH of tofu waste close to normal pH.

TSS measurement

The TSS measurement of tofu waste was carried out at the optimum bentonite weight variation of 900 mg and the optimum pH variation of tofu waste was pH 2. The TSS value of tofu waste before being deposited was 598 mg/L, after being precipitated with bentonite the remaining TSS of tofu waste was 92 mg/L shown by Figure 6. This shows that bentonite can reduce the TSS of tofu waste by 506 mg/L with a TSS reduction percentage of 84.6%.

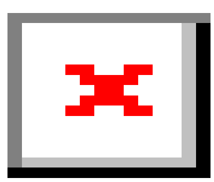

Figure 5. TSS Value of Residual Tofu Waste After Coagulation Process

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This is in accordance with the Tofu Industry Wastewater Quality Standards based on the Regulation of the Minister of Environment of the Republic of Indonesia No. 5 of 2014 concerning Wastewater Quality Standards, namely TSS of tofu wastewater with a maximum of 200 mg/L (Sayow et al., 2020).

XRD Bentonite After Liquid Tofu Waste Coagulation Application

Bentonite that has been used in each coagulation process is taken from the filtration process and washed using distilled water until clean. Then the bentonite was dried again using an oven at 150°C to remove the water content and then measured using XRD. The bentonite diffractogram pattern that has been applied as a coagulant can be seen in Figure 6.

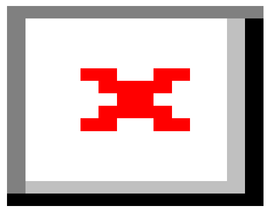

Figure 6. Diffractogram pattern of (a) Bentonite and (b) Bentonite that has been applied as a coagulant

Figure 6 shows that there is no change in the bentonite diffraction angle. The results of the diffractogram pattern analysis after being applied as a coagulant (Figure 9b) are presented in Table 3 below.

Table 3
Analysis of the diffraction angle of the bentonite diffractogram pattern after being applied as a coagulant

Compound Type	Angle 2θ	Intensity (cps)
Montmorillonite	22^0	436,22
	35.47^0	326,46
	62.79^0	65,79
Quartz (SiO2)	26.53^0	537.65

Table 3 shows that there was no significant change in the XRD diffraction angle of bentonite after being applied as a coagulant compared to benonite before being applied as a coagulant as shown in Table 2 previously. However, the intensity of each diffraction angle decreases. This may be caused by the reduced active side of bentonite after depositing impurities in tofu waste so that the intensity of the diffraction angle also decreases. Thus, bentonite that has been applied as a coagulant can be processed and reused for the next coagulation process.

CONCLUSION

Bentonite from East Java was successfully activated using sulfuric acid based on the results of XRF and XRD characterization. Bentonite which has been successfully synthesized has been used as a coagulant for tofu wastewater. Based on variations in weight of bentonite and variations in pH of liquid tofu waste, the best turbidity deposition occurs in 50 mL of liquid tofu waste with a coagulant weight of bentonite 900 mg and pH of tofu waste in acid (pH 2) which can reduce turbidity by 98%

and TSS by 84. 6%. The pH condition of tofu waste after being precipitated is close to normal pH, namely pH 6.5 (acid condition) and pH 7 (alkaline condition). The XRD characteristics of bentonite before and after its application as a coagulant did not experience a significant shift in the diffraction angle, but experienced a decrease in intensity at each angle.

REFERENCES

Bahri, S., Amri, T. A., & Hamid, A. (2013). Sintesis Koagulan Cair Berbasis Lempung Alam Cengar. *Prosiding SEMIRATA 2013*, *1*(1).

Darmadinata, M., Jumaeri, J., & Sulistyaningsih, T. (2019). Pemanfaatan Bentonit Teraktivasi Asam Sulfat sebagai Adsorben Anion Fosfat dalam Air. *Indonesian Journal of Chemical Science*, *8*(1), 1–8.

El-Mahalaway, A. M., El-Azab, N. E. E., Abdrabbo, M., Said, O. M., & Sabry, D. (2018). Sorption characteristics of iron, fluoride and phosphate from wastewater of phosphate fertilizer plant using natural sodium bentonite. *Journal of Membrane Science and Technology*, *8*(2).

Ginting, M., Wijayanti, P., & Riady, M. A. (2021). Studi Laboratorium Pengaruh Penambahan Bentonit Terhadap Total Dissolved Solid Dan Ph Air Formasi. *Petro: Jurnal Ilmiah Teknik Perminyakan*, *10*(3), 117–121.

Husaini, H., Cahyono, S. S., Suganal, S., & Hidayat, K. N. (2018). Perbandingan koagulan hasil percobaan dengan koagulan komersial menggunakan metode jar test. *Jurnal Teknologi Mineral Dan Batubara*, *14*(1), 31–45.

Juhra, F., & Notodarmojo, S. (2016). Degradasi Zat Warna Pada Air Gambut Menggunakan Metode Fotokatalitik ZnO DEGRADATION COLOR SUBSTANCES IN PEAT WATER USING PHOTOCATALYTIC ZnO. *Jukung (Jurnal Teknik Lingkungan)*, *2*(2).

Maulani, M., Satiyawira, B., Nugrahanti, A., Apriniyadi, M., Nurfajrin, Z. D., Young, H., & Disaputra, M. K. (2021). Pemanfaatan pengolahan limbah industri tahu menggunakan bentonite. *Community Empowerment*, *6*(10), 1892–1898.

Nugraha, M. S., Mahatmanti, F. W., & Sulistyaningsih, T. (2017). Pemanfaatan Bentonit Teraktivasi HCl sebagai Adsorben Ion Logam Cd (II). *Indonesian Journal of Chemical Science*, *6*(3), 196–201.

Rahimah, Z., Heldawati, H., & Syauqiah, I. (2016). Pengolahan limbah deterjen dengan metode koagulasi-flokulasi menggunakan koagulan kapur dan PAC. *Konversi*, *5*(2), 52–59.

Ruskandi, C., Siswanto, A., & Widodo, R. (2020). Karakterisasi fisik dan kimiawi bentonite untuk membedakan natural sodium bentonite dengan sodium bentonite hasil aktivasi. *Jurnal Polimesin*, *18*(1), 53–60.

Sakinah, F. (2020). Peningkatan Kualitas Biopolimer (Pla) Nanokomposit Modifikasi Filler Bentonit Dan Kitosan Anti-Bakteri. *Jurnal Sains Dan Teknologi Reaksi*, *18*(01).

Sayow, F., Polii, B. V. J., Tilaar, W., & Augustine, K. D. (2020). Analisis kandungan limbah industri tahu dan tempe rahayu di Kelurahan Uner Kecamatan Kawangkoan Kabupaten Minahasa. *Agri-Sosioekonomi*, *16*(2), 245–252.

Siregar, S. H., & Irma, W. (2016). Sintesis Dan Perbandingan Struktur, Tekstur Bentonit Alam Dan Bentonit Teraktivasi Asam. *Photon: Jurnal Sain Dan Kesehatan*, *7*(01), 137–140.

Suryadiputra, I. N. N. (1995). Pengantar Kuliah Pengolahan Air Limbah: Pengolahan Air Limbah dengan Metode Kimia (Koagulasi dan Flokulasi). *Fakultas Perikanan, Institut Pertanian Bogor*.

Syafalni, S., & Pujiindayati, E. R. (2016). Aplikasi Bentonit dan Besi (III) Klorida pada Zeolite yang Dimodifikasi untuk Pengolahan Air Sungai. *Jurnal Teknologi Lingkungan*, *17*(1), 15–20.

https://doi.org/10.46799/ijssr.v3i2.251.