LINGKAR
Journal of Environmental Engineering
E-ISSN: 2986-8807, P-ISSN: 2746-2498
https://journal.ar-raniry.ac.id/index.php/lingkar

Published by
Dept. of Environmental Engineering
UIN Ar-raniry Banda Aceh, Indonesia

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ALKALINE-EXTRACTED SUGARCANE BAGASSE AS A PLANT-BASED COAGULANT FOR CATTLE SLAUGHTERHOUSE WASTEWATER

A Jar-Test Screening of Stock Concentration and Dose

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DOI: 10.22373/ljee.v6i2.10879

Abstract

Effluent from the Banda Aceh municipal slaughterhouse, Indonesia, receives only bar screening, and a single grab sample exceeded the national chemical oxygen demand (COD) limit. Plant-based coagulants are proposed alternatives to metal salts; sugarcane bagasse has been studied as an adsorbent and activated-carbon precursor but, to our knowledge, not as a coagulant for slaughterhouse effluent. We screened a crude alkaline bagasse extract (2% NaOH, hotplate set to 120 °C, 2 h, open beaker) as a coagulant for cattle slaughterhouse wastewater. Three stock concentrations (0.1–0.3% w/v) were each dosed at four volumes (5–20 mL; nominal doses 5–60 mg/L) in single-run jar tests, with a settling-only control. Raw COD was 1,422 mg/L, and settling alone reduced it by 53.3%. The lowest COD (155 mg/L; 0.2% stock, 20 mg/L nominal dose) was 76.7% lower than the control and below the 200 mg/L COD limit; pH stayed within 6.5–6.8, but other regulated parameters were not measured. Over-dosing increased COD, and in one treatment (0.3% stock, 60 mg/L) it exceeded the control. Three conditions met the COD limit (0.2% stock at 20 and 30 mg/L; 0.3% stock at 15 mg/L). Because equal nominal doses from different stock concentrations gave inconsistent results and each treatment was run once, these results identify conditions for further testing rather than an optimum. Replicated jar tests with a control in every batch, and characterisation of the extract, are needed.

Keywords: *slaughterhouse wastewater; sugarcane bagasse; natural coagulant; coagulation–flocculation; jar test*

How to cite this article: *Tambunan, Lakhana Zahra, Arief Rahman, and Bhayu Gita Bhernama. 2026. "Alkaline-Extracted Sugarcane Bagasse as a Plant-Based Coagulant for Cattle Slaughterhouse Wastewater." Lingkar: Journal of Environmental Engineering. 7 (1): 50-62. https://doi.org/10.22373/ljee.v6i2.10879*

1. Introduction

Slaughterhouse wastewater is a high-strength effluent of the food industry. Its organic load comes from blood, fat, rumen and intestinal contents, and the water used

Manuscript received 17 October 2026; revised 31 October 2026; accepted 2 November 2026

to clean carcasses and floors (Philipp et al 2021; Ng et al 2022). Its composition varies widely between facilities, depending largely on cleaning practice and water use (Al-Najar and Abdelmajed 2019). Without adequate treatment, its discharge raises organic loading and can cause oxygen depletion in receiving waters. In Indonesia, effluent from slaughterhouse operations must meet the limits set in Annex XLV of Minister of Environment Regulation No. 5 of 2014, including 200 mg/L for chemical oxygen demand (COD) and a pH of 6-9 (Kementerian Lingkungan Hidup 2014). The municipal slaughterhouse of Banda Aceh (UPTD RPH, Gampong Pande) currently provides only bar screening before discharge, and a preliminary characterisation found its final-tank effluent above the COD limit (Table 1).

Coagulation–flocculation is widely used as a physicochemical stage in slaughterhouse wastewater treatment because it removes colloidal and suspended material that settles poorly on its own. Metal-based coagulants nevertheless leave behind large volumes of metal-bearing, poorly biodegradable sludge, and their residues in treated water raise health and environmental concerns (Kurniawan et al 2020). These drawbacks have motivated work on biocoagulants: plant-, animal- or microbe-derived materials that destabilise particles through charge neutralisation and polymer bridging and produce more biodegradable sludge (Kurniawan et al 2020; El Bouaidi et al 2022).

Several biocoagulants have already been tested on abattoir wastewater. *Moringa oleifera* seed combined with snail shell (Anele et al 2023), chito-protein derived from crab shell (Okey-Onyesolu et al 2020), and guava-leaf powder applied at pilot scale (Abouelenien et al 2022) all achieved measurable removal of organic and particulate parameters. Kurniawan et al (2020) point out, however, that raw-material selection, extraction procedure, and wastewater-specific performance remain the main obstacles to wider application. A coagulant that works on low-turbidity raw water cannot be assumed to perform equally on a protein- and fat-rich effluent.

Agricultural residues contain cellulose, protein, tannin, and lignin, and have been widely explored as raw materials for wastewater treatment, mainly as adsorbents (Elshabrawy et al 2023). Their disposal is costly and often involves open burning, which releases harmful gases (Duque-Acevedo et al 2020, quoted in Elshabrawy et al 2023). Sugarcane bagasse is a major example, with an estimated 540 million tonnes generated worldwide each year (Zhao et al 2015, quoted in Elshabrawy et al 2023). Beyond its use as an adsorbent and activated-carbon precursor, its potential as a bio-coagulant precursor has been reviewed (Iwuozor et al 2023). Powdered bagasse achieved 97.3% turbidity removal from raw water at 90 mg/L and pH 7.5 (Zaidi et al 2019). Bahrodin et al (2022) compared acid and alkaline extraction and found that 2% NaOH at 120 °C for 2 h gave the highest polysaccharide yield; the resulting extract removed up to 95.9% of suspended solids from synthetic wastewater.

This study screened an alkaline sugarcane-bagasse extract, prepared by an adapted protocol of Bahrodin et al (2022), as a coagulant for real effluent from the Banda Aceh municipal slaughterhouse. Slaughterhouse effluent is rich in proteins and fats, and the performance of a biocoagulant on such effluent cannot be inferred from tests on low-turbidity water (Kurniawan et al 2020). Alkaline extraction of bagasse recovers a polysaccharide-rich fraction (Bahrodin et al 2022), and biocoagulants are generally considered to act through charge neutralisation and polymer bridging

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(Kurniawan et al 2020; El Bouaidi et al 2022). We therefore hypothesised that the alkaline extract would lower COD in real slaughterhouse effluent beyond plain sedimentation. Three stock concentrations (0.1, 0.2 and 0.3% w/v) were each dosed at four volumes (5–20 mL per litre; nominal doses 5–60 mg/L). The effect on COD and pH was evaluated against both the raw effluent and a no-coagulant settling control, and the treated effluent was compared with the COD limit and pH range of Minister of Environment Regulation No. 5 of 2014. The control separates removal attributable to the extract from removal by plain sedimentation. To our knowledge, no study has tested sugarcane bagasse extract as a coagulant for slaughterhouse wastewater. Section 2 describes sampling, coagulant preparation and the jar-test design. Section 3 reports and discusses the COD and pH responses, including the limits of a single-run screening design, and Section 4 summarises the implications for further testing.

2. Methods

2.1 Sampling site and wastewater collection

Wastewater was collected from the municipal slaughterhouse of Banda Aceh (UPTD Rumah Potong Hewan, Gampong Pande, Kuta Raja District), which supplies fresh beef to local markets (Figure 1). The facility's only treatment is bar screening; effluent then flows to a final holding tank before discharge. A single grab sample (20 L) was taken from that tank in the morning of 14 May 2025 with a long-handled dipper, following SNI 6989.59:2008 (Badan Standardisasi Nasional 2008), and transported in a jerrycan to a university environmental engineering laboratory, where all analyses were carried out. The sample was analysed and used in the jar tests on the day of collection. Experimental work took place between November 2024 and June 2025. The jar tests were run on 14 May 2025, on the day the wastewater sample was collected. Sampling was carried out with permission from the head of the facility (UPTD RPH).

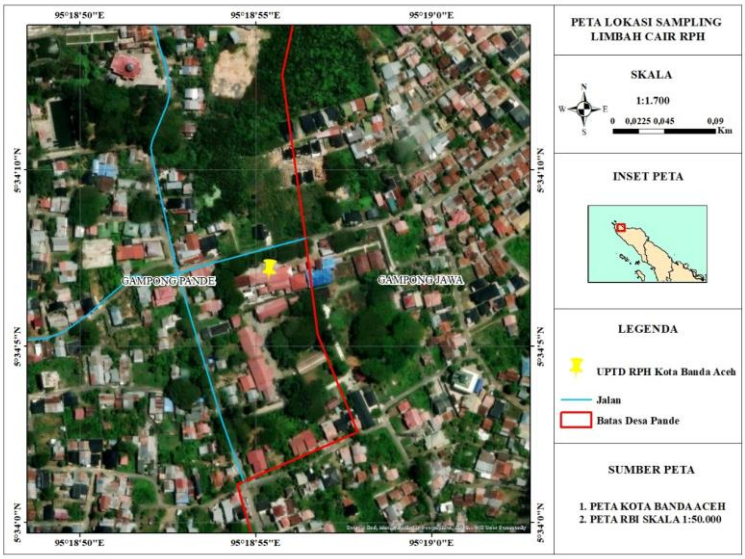


Figure 1. Location of the sampling point (yellow marker) at the Banda Aceh municipal slaughterhouse, Gampong Pande

Manuscript received 17 October 2026; revised 31 October 2026; accepted 2 November 2026

2.2 Preparation of the bagasse coagulant

Sugarcane bagasse was collected from sugarcane juice vendors in Rukoh, Syiah Kuala District, Banda Aceh, Indonesia. The bagasse was washed with tap water, rinsed with distilled water, sun-dried for two days, and oven-dried at 105 °C for 1 h. The dried material was ground using a blender and passed through a 100-mesh sieve. Alkaline extraction was adapted from Bahrodin et al (2022), who reported 2% NaOH at 120 °C for 2 h as optimal for polysaccharide recovery. Briefly, 33 g of bagasse powder was mixed with 1 L of 2% (w/v) NaOH solution and heated for 2 h in an open beaker on a hotplate set to 120 °C. The temperature of the extraction liquid was not measured; at atmospheric pressure, it is limited by the boiling point of the solution, so 120 °C refers to the hotplate setting. Evaporated water was not replenished during heating. Therefore, the extraction conditions may have differed from those reported by Bahrodin et al (2022). After heating, the mixture was cooled to approximately 28 °C and filtered through Whatman No. 42 filter paper. The filtrate was concentrated using a rotary evaporator to obtain a viscous crude extract.

The concentrated extract was a crude alkaline preparation containing extracted organic compounds, potentially including polysaccharides, together with residual alkali and sodium-containing compounds. The polysaccharide content, extraction yield, and pH of the concentrated extract were not determined. The extract was stored in sealed bottles in a refrigerator for two weeks until use. Stock solutions with nominal concentrations of 0.1, 0.2, and 0.3% (w/v) were freshly prepared on the day of each experiment by dissolving 0.1, 0.2, and 0.3 g of the concentrated crude extract, respectively, in distilled water to a final volume of 100 mL. These concentrations correspond to 1, 2, and 3 g of crude extract per litre, respectively, and do not represent the actual polysaccharide concentrations. The pH of the stock solutions was not measured.

2.3 FTIR characterisation

The functional groups of the crude extract were examined by Fourier-transform infrared (FTIR) spectroscopy. The spectrum of the concentrated extract was recorded over 4,000–400 cm^{-1} on 28 May 2025 on a PerkinElmer spectrometer (Spectrum IR software, version 10.6.2). Sample accessory, resolution and number of scans were not recorded. Only one sample was analysed, and no spectrum of raw bagasse was recorded for comparison, so the spectrum is used only to indicate the functional groups present.

2.4 Jar-test design

Coagulation–flocculation tests followed SNI 19-6449:2000 (Badan Standardisasi Nasional 2000) on a four-paddle jar tester. Each 1,000 mL beaker held 1 L of raw wastewater. Coagulant was added at 5, 10, 15 or 20 mL from each of the three stock solutions (1, 2 and 3 g/L), giving 12 treatments with nominal doses of 5–60 mg/L of concentrated extract. One further beaker received no coagulant and served as a plain-settling control shared by all three series, so 13 beakers were tested in total. Because 13 beakers exceeded the capacity of a single run, the tests were conducted in four batches. Batch 1 included the control and the 0.1% stock solution at doses of 5, 10, and 15 mL. Batch 2 included the 0.1% stock solution at 20 mL and the 0.2% stock solution at doses

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of 5, 10, and 15 mL. Batch 3 included the 0.2% stock solution at 20 mL and the 0.3% stock solution at doses of 5, 10, and 15 mL. Batch 4 included the 0.3% stock solution at 20 mL. Each jar was mixed rapidly at 120 rpm for 1 min, then slowly at 30 rpm for 30 min, and allowed to settle for 60 min. The supernatant was then withdrawn from the middle part of each beaker for pH and COD analysis. Initial pH was not adjusted, and temperature was not controlled or recorded. Each treatment was run once, without replication.

2.5 Analytical methods

The pH was measured using a multiparameter meter calibrated against pH 4, 7, and 10 buffer solutions (SNI 6989.11:2019; Badan Standardisasi Nasional 2019b). COD was determined using the closed-reflux dichromate method with spectrophotometric measurement (SNI 6989.2:2019; Badan Standardisasi Nasional 2019a). A homogenised 2.5 mL aliquot of the supernatant was digested with 1.5 mL of potassium dichromate digestion solution and 3.5 mL of sulfuric acid reagent at 150 °C for 2 h. After cooling, the samples were measured using a COD meter zeroed against distilled water. A reagent blank was used, but the calibration standard and calibration range were not documented. Samples were not diluted, and each treatment was analysed once without analytical duplicates. The supernatant was collected from the middle part of each beaker without a specified sampling depth or prior filtration. Therefore, the COD results represent the COD of the unfiltered supernatant after settling.

2.6 Data treatment

Because both stock concentration and added volume were varied, each treatment was converted to a nominal mass dose (mg of crude extract per litre of wastewater):

$$D\ (\text{mg/L}) = 10 \times s\ (\%) \times V\ (\text{mL}) \qquad (1)$$

where s is the stock concentration (% w/v) and V is the volume added to 1 L of wastewater. Doses are expressed as mg of crude concentrated extract (wet basis) per litre of wastewater and are not corrected for moisture or polysaccharide content; they are therefore nominal doses, not doses of active agent. The tested doses ranged from 5 mg/L (0.1%, 5 mL) to 60 mg/L (0.3%, 20 mL). Dilution from the added volume (at most 2%) was not corrected for in the measured concentrations.

Removal was calculated in two ways. Removal relative to the raw wastewater is $R0 = (C0 - Ct)/C0 \times 100$. Removal attributable to the coagulant beyond plain settling is $Rc = (Cc - Ct)/Cc \times 100$. Here C0 is the raw-wastewater concentration, Cc is the concentration in the no-coagulant control after the same mixing and settling, and Ct is the concentration after treatment. Because each treatment was tested once, results are reported descriptively and no inferential statistics were applied. Treated values were compared with the discharge limits for slaughterhouse effluent (COD ≤ 200 mg/L and pH 6–9; Kementerian Lingkungan Hidup 2014). The "best-performing condition" is the treatment with the lowest COD among those tested. It is not a statistically determined optimum.

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3. Results and Discussion

3.1 Initial pH and COD of the wastewater

Table 1 compares the raw effluent with the discharge limits. pH was 6.8, inside the permitted range. COD (1,422 mg/L) exceeded its limit by a factor of about 7.

Table 1. Characteristics of the raw slaughterhouse wastewater and the applicable discharge limits

Parameter	Unit	Raw wastewater	Limit (Kementerian Lingkungan Hidup 2014)
pH	–	6.8	6–9
COD	mg/L	1,422	200

Values are single measurements.

The measured COD (1,422 mg/L) is at the low end of the range reported for slaughterhouse effluents. Al-Najar and Abdelmajed (2019) compiled studies in which COD values are commonly in the thousands of mg/L, and composition varies widely between facilities depending on cleaning practice and water use (Al-Najar and Abdelmajed 2019; Ng et al 2022). For comparison, wastewater from the Al-Hoceima slaughterhouse in Morocco had a COD of 1,280 mg/L at pH 7.47 (El Abdouni et al 2021), a similar COD but a slightly higher pH than in the present study. The relatively low COD may reflect the sampling point, which was the final storage tank after bar screening. However, this possibility was not tested, and the characteristics of the sampled wastewater may differ from those of the wastewater before screening.

The no-coagulant control, after the same mixing and 60 min of settling, had a COD of 664 mg/L, a reduction of 53.3% relative to the raw effluent (1,422 mg/L). This reduction is presumably due to sedimentation of settleable particles with attached organic matter; this was not verified because suspended solids, turbidity, and settleable solids were not measured. The control therefore shows that roughly half of the COD reduction reported against the raw effluent would have occurred without the coagulant. For this reason, removal relative to the control (R_c) is reported alongside R_0 below.

3.2 Functional groups of the bagasse extract

The FTIR spectrum of the crude extract (Figure 2) showed labelled absorption bands at 3,258, 1,576, 1,499, 1,384, and 1,036 cm^{-1}, while additional bands at approximately 407–441 cm^{-1} (labelled at 407, 419, and 441 cm^{-1}) were not interpreted because their assignments remain uncertain. The broad band at 3,258 cm^{-1} is attributed to O–H stretching vibrations of hydroxyl groups, whereas the band at 1,036 cm^{-1} is associated with C–O stretching vibrations of ethers, both of which are consistent with polysaccharide structures (Sari 2021). Similar bands at 3,255.84 and 1,033 cm^{-1} were reported for sugarcane bagasse by Karn et al (2022). The bands at 1,576 and 1,499 cm^{-1} fall within or near the C=C stretching region and may be associated with aromatic skeletal vibrations of lignin, commonly reported near 1,600 and 1,510 cm^{-1} (Sari 2021; Braga and Poletto 2020; Yang et al 2022). Their presence is consistent with the possible co-extraction of lignin during alkaline extraction. However, the bands at 1,576 and 1,384 cm^{-1} may also arise from asymmetric and symmetric stretching of carboxylate groups (including those of uronic acids), which would be expected in a sodium-containing

Manuscript received 17 October 2026; revised 31 October 2026; accepted 2 November 2026

alkaline extract, and 1,384 cm^{-1} also falls within the C–H bending region (Sari 2021); the spectrum alone cannot distinguish these assignments. Overall, the FTIR spectrum indicates functional groups consistent with polysaccharides and potentially other biomass constituents in the crude extract. In the absence of a spectrum of untreated sugarcane bagasse, the results cannot establish which functional groups were enriched during extraction, nor can they confirm that any specific functional group was responsible for coagulation.

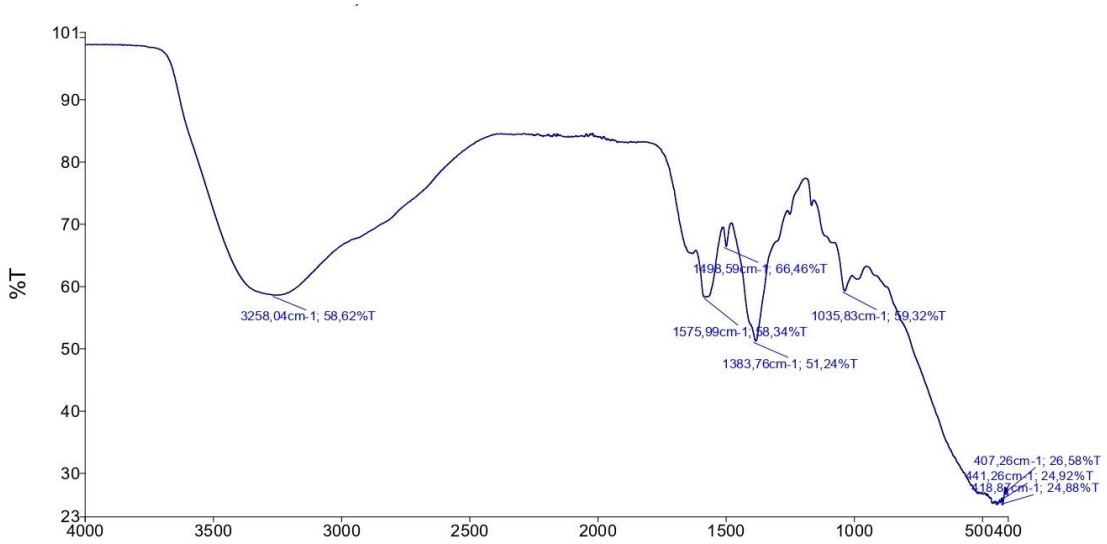


Figure 2. FTIR spectrum of the concentrated alkaline sugarcane-bagasse extract (4,000–400 cm^{-1}, transmittance). Labelled bands: 3,258, 1,576, 1,499, 1,384, and 1,036 cm^{-1}.

3.3 Effect of concentration and dose on pH and COD

Table 2 lists all 12 treatments with their nominal mass dose. Figure 3 plots COD against that dose.

Table 2. pH and COD after coagulation–flocculation and 60 min settling. R_0: removal relative to raw wastewater; R_c: removal relative to the no-coagulant control. Single run per treatment. Values in bold meet the discharge limit

Stock (% w/v)	Volume (mL/L)	Dose (mg/L)	pH	COD (mg/L)	COD R_0 (%)	COD R_c (%)
Raw wastewater	–	–	6.8	1,422	–	–
Control	0	0	6.8	664	53.31	–
0.1	5	5	6.7	502	64.70	24.4
0.1	10	10	6.6	496	65.12	25.3
0.1	15	15	6.6	593	58.30	10.7
0.1	20	20	6.6	642	54.85	3.3
0.2	5	10	6.8	270	81.01	59.3
0.2	10	20	6.7	**155**	89.10	76.7
0.2	15	30	6.6	**157**	88.96	76.4
0.2	20	40	6.6	307	78.41	53.8

Manuscript received 17 October 2026; revised 31 October 2026; accepted 2 November 2026

Stock (% w/v)	Volume (mL/L)	Dose (mg/L)	pH	COD (mg/L)	COD R_0 (%)	COD R_c (%)
0.3	5	15	6.7	**191**	86.57	71.2
0.3	10	30	6.6	332	76.65	50.0
0.3	15	45	6.6	385	72.93	42.0
0.3	20	60	6.5	829	41.70	−24.8

Negative R_c: concentration higher than in the no-coagulant control.

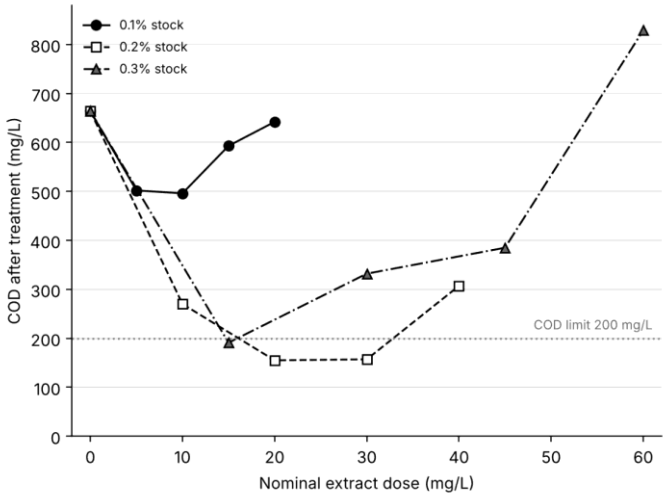


Figure 3. COD after treatment as a function of nominal extract dose for the three stock concentrations. The point at 0 mg/L is the shared no-coagulant control; the dotted line marks the COD discharge limit (200 mg/L). Single run per treatment.

pH. The pH values after treatment ranged from 6.5 to 6.8 across all jars, remaining within the permitted discharge range, as shown in Table 2. The maximum difference between treatments was only 0.3 pH units. pH decreased slightly with the volume of stock added (6.8 to 6.5 in the 0.3% series), which does not indicate a strongly alkaline residue; the cause was not investigated. Since each treatment was measured only once, these results do not establish a dose-dependent effect of the extract on pH. Nevertheless, the observed values indicate that the extract did not shift the pH outside the permitted range under the tested conditions. Bahrodin et al (2022) reported less than 60% turbidity removal at near-neutral pH using sugarcane bagasse extract in synthetic wastewater, with higher removal achieved under their optimum conditions. However, differences in wastewater characteristics and experimental conditions limit direct comparison with the present study. Since the pH was not deliberately varied, its influence on the coagulation performance of the extract, including whether pH 6.8 was optimal, remains undetermined.

COD. All treatments reduced COD relative to the control, except the 0.3% stock concentration at a dose of 60 mg/L. The lowest COD concentration was obtained using the 0.2% stock concentration at a dose of 20 mg/L, reaching 155 mg/L. This corresponds to a COD removal efficiency of 89.1% relative to the raw effluent and 76.7% relative to the control, as shown in Table 2. Three treatments achieved the applicable COD discharge limit: the 0.2% stock concentration at doses of 20 and 30 mg/L, and the 0.3% stock concentration at a dose of 15 mg/L. With the control included as the 0 mg/L point,

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COD first decreased and then increased in all three series (Figure 3). The minimum was reached at 10 mL in the 0.1% series (496 mg/L; 502 mg/L at 5 mL), at 10–15 mL in the 0.2% series (155 and 157 mg/L), and at the smallest volume tested, 5 mL, in the 0.3% series (191 mg/L), so the optimum for the 0.3% stock may lie below the tested range. The difference between 502 and 496 mg/L in the 0.1% series is too small to be read as a trend in single runs. A decrease followed by an increase in performance with increasing coagulant dose has been reported for natural coagulants (Teixeira et al 2024).

3.4 Interpretation and comparison with other studies

COD initially decreased with increasing extract dose but increased again at higher doses, indicating that treatment performance depended on the dosage and stock concentration. The lowest COD concentration (155 mg/L) was obtained using the 0.2% (w/v) stock at 20 mg/L, corresponding to an 89.1% reduction relative to the raw effluent. However, COD increased to 829 mg/L at 60 mg/L using the 0.3% (w/v) stock, exceeding the control value of 664 mg/L. This increase may be associated with the re-suspension of settled particles or the contribution of organic matter from the extract, although these mechanisms were not directly investigated; the COD of the extract itself was not measured.

Equal nominal doses delivered with different stock volumes gave different COD (e.g., at 20 mg/L, 642 mg/L from the 0.1% stock at 20 mL versus 155 mg/L from the 0.2% stock at 10 mL), so nominal mass dose alone does not explain the response. The volume of stock added and the sodium and residual alkalinity it carries were not examined, and because the treatments were not replicated, the best-performing condition should be interpreted cautiously.

Previous studies reported optimum doses of 50 mg/L for turbidity removal in synthetic wastewater (Bahrodin et al 2022) and 90 mg/L for raw water treatment (Zaidi et al 2019). These values are not directly comparable with the present results because the dose bases (here, the wet mass of a crude concentrated extract) and the measured parameters (turbidity or suspended solids versus COD) differ. For abattoir wastewater, Anele et al (2023) reported COD removal efficiencies of 94.4–95.3% using *Moringa oleifera* seed and snail-shell-based biocoagulants at doses of 5, 15, and 25 g. Okey-Onyesolu et al (2020) reported a maximum COD removal of 85.23% using chito-protein at an optimum dose of 3.616 g. Abouelenien et al (2022) reported 83.47% COD removal in a pilot-scale treatment system combining natural zeolite at 1,200 mg/L with physically processed rice-straw filtration. In the present study, the maximum COD removal was 89.10% at a nominal dose of 20 mg/L of crude sugarcane bagasse extract. Although these results provide a useful context for comparison, direct comparison should be made cautiously because the coagulant compositions, dose bases, treatment configurations, and experimental conditions differed. In particular, the dose in the present study was expressed as the mass of crude concentrated extract, which is not equivalent to the doses of the other coagulants.

The data show a reduction in supernatant COD after treatment with the extract; they do not identify the mechanism. Charge neutralisation and polymer bridging, as described for biocoagulants in the Introduction, are plausible, but no zeta potential,

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turbidity, or floc observations were made here, and the possible advantage of a more biodegradable sludge was not examined.

3.5 Limitations

This study has several limitations. Each treatment was conducted once using a single grab sample from one facility, limiting the assessment of experimental variability and the reproducibility of the results. Because the control was run once, in the first batch, differences between treatments and the control may partly reflect batch effects and sample ageing; R_c values are therefore descriptive. The coagulant was a crude alkaline extract with unknown polysaccharide content, dry-solids content, extraction yield, and residual alkalinity, and its own COD contribution was not measured. In addition, pH, temperature, and mixing intensity were not systematically varied, and no conventional coagulant was tested under the same conditions for comparison. Suspended solids and turbidity were not measured; other regulated wastewater parameters, including BOD, oil and grease, and NH_3-N, were also not measured, and sludge volume and settleability were not evaluated. The COD of the sampled wastewater (1,422 mg/L) is at the low end of reported values, so the results may not transfer to more concentrated effluent. The advantages often attributed to biocoagulants (more biodegradable sludge, no metal residues) were not tested, and the cost and environmental burden of the extraction (NaOH, 2 h heating, rotary evaporation) were not assessed. These limitations should be considered when interpreting the findings.

4. Conclusion

In this single-run screening, COD was lower than in the settling-only control in 11 of 12 treatments. The lowest COD (155 mg/L; 0.2% stock, 20 mg/L nominal dose) was 76.7% below the control and 89.1% below the raw effluent, and below the applicable COD discharge limit of 200 mg/L; whether this difference exceeds experimental variability could not be assessed. However, COD increased at higher doses under some treatment conditions, indicating that increasing the extract dose did not consistently improve treatment performance. The pH remained between 6.5 and 6.8 across all treatments, within the applicable discharge range. For the Banda Aceh slaughterhouse, the results identify the alkaline bagasse extract as a candidate for replicated testing; they do not demonstrate compliance with all discharge parameters.

These findings represent preliminary screening rather than dose optimization. Because each treatment was conducted once and results differed between stock concentrations at the same nominal dose, an optimum stock concentration cannot be established. Further studies should use replicated jar tests ($n \geq 3$) with a control in every batch and should separate nominal mass dose from added stock volume, for example by holding the added volume constant while varying stock concentration, together with systematic pH variation and comparison with alum or polyaluminium chloride (PAC) under identical conditions. Additional measurements of BOD, oil and grease, NH_3-N, suspended solids, turbidity, dissolved COD, and sludge volume, together with characterization of the extract's polysaccharide content, dry-solids content, residual alkalinity, sodium content, stock pH, and its own COD, are recommended. FTIR analysis

Manuscript received 17 October 2026; revised 31 October 2026; accepted 2 November 2026

of untreated sugarcane bagasse would also help distinguish the functional groups present in the raw material from those detected in the extract.

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