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Utilizing Blood Clam and Green Mussel Shell-Derived CaO Biocoagulants for Acid Correction Testing in GCV Analysis

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ABSTRACT

Proper management of company-generated wastewater, specifically wastewater generated from acid correction testing in GCV analysis conducted by service providers and consulting firms, is crucial. Coagulation-flocculation emerges as an effective treatment method, utilizing biocoagulants derived from abundant blood clam and green mussel shells in Cilacap Regency. This study aims to identify the optimal calcination temperature for CaCO3 to CaO decomposition, assess the effectiveness of CaO biocoagulants in treating acid correction testing wastewater, and evaluate the impact of CaO biocoagulant dosage on pH, TDS, TSS, Turbidity, COD, and BOD5 parameters. Results indicate 1000°C as the best calcination temperature, with elemental compositions of Ca at 55.3% for blood clam shells and 58.7% for green mussel shells. The CaO coagulant's efficacy, derived from these shells, demonstrated significant pH increase (5 to 12.10), and substantial reductions in TDS (60%), TSS (79%), Turbidity (91%), BOD5 (93.71%), and COD (88%). The study reveals a dose-dependent relationship, with higher doses elevating pH and decreasing TSS, BOD5, and COD, while lower doses exhibit greater efficacy in reducing TDS and Turbidity values. This research underscores the potential of blood clam and green mussel shell-derived CaO biocoagulants in wastewater treatment, promoting environmental sustainability.

Keywords: *biocoagulant, blood mussels, green mussels.*

1. INTRODUCTION

The coal consulting and analysis services company, located in Cilacap Regency, specializes in various analyses, including Gross Calorific Value (GCV) to determine the calorific value of coal. In GCV analysis, an acid correction test is conducted by titrating the water from washing bombs and vessels used in the process. The titration involves Methyl Orange as a titration indicator and sodium carbonate as a titrant. However, the resulting acid correction testing wastewater is currently stored in a container without processing, leading to potential environmental issues such as soil structure degradation, threats to air and land ecosystems, and potential impacts on human health [1].

To address this, one effective treatment for processing acid correction testing waste in GCV analysis is the coagulation method. This method is chosen for its effectiveness, affordability, and efficiency [2]. While chemical coagulants are more effective, high doses can lead to challenging precipitates. Hence, natural coagulants, or biocoagulants, are considered as an alternative [3].

Various types of biocoagulants, such as rice snail shells [4], lokan clam shells [5], crab shells [6], mussel shells [7], and tamarind seeds [8], can be used for air waste treatment. In this research, the selected biocoagulant is calcium oxide (CaO) derived from clam shells (Andara Granosa) and green blood shells (Perna Viridis). Blood shells and green mussel shells were chosen as raw materials due to their abundance on beaches and fish

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markets in Cilacap Regency. Considering these conditions, the waste shells of blood cockles and green mussels will be utilized as raw materials to develop a natural biocoagulant for wastewater treatment, specifically for testing acid correction in GCV analysis. Shellfish shells, known for their hardness, contain higher levels of calcium carbonate (CaCO3) compared to limestone, eggshells, and ceramics. This choice is guided by the principle that the harder the shell, the higher the calcium carbonate content [9].

2. RESEARCH METHODS

2.1. Tools and Materials

In this research, a range of instruments and materials were utilized, including a pH meter, TDS meter, turbidimeter, furnace, porcelain cup, analytical balance, mortar and pestle, 200 mesh sieve, watch glass, glass funnel, filter paper, and beakers of various sizes (100 mL, 500 mL, 1000 mL). Additionally, the jar test and XRF (X-Ray Fluorescence) were employed. The materials involved in the study comprised blood cockle shells, green cockle shells, distilled water, and acid correction testing wastewater for GCV analysis.

2.2. Preparation Of Blood Mussel Shells And Green Mussel Shells

The preparation process involved cleaning blood cockle and green mussel shells under running water to eliminate dirt and sand adhering to the shells. Subsequently, the shells were sun-dried for 3 to 4 hours. Once dry, they were coarsely crushed using a mortar and pestle [10].

2.3. Calcination Blood Clam Shells And Green Clam Shells

Calcination procedures were carried out at temperatures of 800ºC, 900ºC, and 1000°C for a duration of 4 hours in a furnace, followed by cooling in a desiccator for 15 minutes. As per previous research by Srichanachaichok and Pissuwan [10], the post-calcination process involved crushing and sifting the shells through a 200 mesh sieve. XRF (X-ray fluorescence) analysis was then performed to identify the compound composition of CaO derived from blood cockles and green mussels.

2.4. Application of Biocoagulant from Blood Mussel Shells and Green Mussels in Wastewater for Acid Correction Testing in GCV Analysis

Referring to prior studies by Herlina et al. [11], the wastewater from the GCV test analysis underwent processing using the coagulation method. The process commenced by preparing 500 mL of wastewater in a glass beaker. Subsequently, based on research by Prastowo et al. [12], variations in biocoagulant doses (ranging from 0.4 gr to 1.9 gr) were introduced, derived from both blood clam shells and green clam shells. The solution was then stirred using a Jar Test apparatus at 125 rpm for 2 minutes, followed by slow stirring at 30 rpm for 30 minutes. Finally, the mixture was left to settle for 60 minutes [4].

3. RESULTS AND DISCUSSION

3.1. Results of Calcination of Blood Clam Shells and Green Clam Shells for Biocoagulant Production

The outcomes of the calcination process applied to blood cockle shells and green cockle shells at temperatures of 800°C, 900°C, and 1000°C are summarized in Table 1.

Table 1. Data on Sample Yield Percentage Results After the Calcination Process.

Temperature Variations	Blood Clam Shells (%)	Green Mussel Shells (%)
800°C	87.2 %	83.2 %
900°C	60.8%	62.4 %
1000°C	55.6%	53.2 %

From the data presented in Table 1, it is evident that a smaller yield percentage correlates with more optimal results. Remarkably, the most favorable yield outcomes were achieved at a temperature variation of 1000°C, yielding 55.6% for blood clam shells and 53.2% for green clam shells. These results signify a promising efficiency in the biocoagulant production process, particularly at the higher temperature range. The attained yield percentages align well with the Ca percentage results obtained from prior research [13].

3.2. Ca Elemental Composition in Blood and Green Clam Shell Biocoagulant Samples

The Ca elemental composition in biocoagulant samples derived from six variations of blood and green cockle shells was assessed through XRF (X-ray fluorescence) analysis. The results are detailed in Table 2.

Table 2. XRF Test Results Data.

Raw Material	Temperature	% Ca
Blood Clam Shell	800°C	38.9%
	900°C	50.4%
	1000°C	55.3%
Green Mussel Shells	800°C	37.8%
	900°C	47.2%
	1000°C	58.7%

Analysis of the XRF test results in Table 2 reveals that the highest Ca content was observed at 1000°C. This is attributed to the more complete decomposition of the shells during the 4-hour calcination process at this elevated temperature, leading to a higher composition of Ca compounds [10]. The temperature-dependent variations in Ca content offer valuable insights into the optimal conditions for biocoagulant production. Furthermore, the Ca content in green mussel shells surpasses that in blood cockle shells, with values of 58.7% for green mussel shells and 55.3% for blood cockle shells. This discrepancy suggests that the choice of shell material significantly influences the Ca composition of the biocoagulant. The higher Ca content in green mussel shells may be attributed to the inherent characteristics of the shells, emphasizing the importance of raw material selection in biocoagulant production.

These findings underscore the impact of calcination temperature and shell type on the resulting Ca composition, providing essential information for optimizing the biocoagulant production process and tailoring it to specific material characteristics.

3.3. Wastewater Treatment Testing Acid Correction in GCV Analysis Using Biocoagulant Blood Clam Shells and Green Clam Shells

To evaluate the effectiveness of wastewater treatment from the GCV test analysis, initial parameter testing was conducted. The results of these tests are presented in Table 3.

Table 3. Initial Waste Water Content Data for Acid Correction Testing in GCV Analysis.

Parameter	Test Results	Quality Standards*	Unit
pH	5	6-9	-
TSS	180	30	mg/L
BOD_5	155.59	30	mg/L
COD	315	100	mg/L

** Quality Standards: Minister of Environment and Forestry Regulation No.68 of 2016.*

Following the addition of biocoagulant derived from blood cockle shells and green mussels to the wastewater, the acid correction test in GCV analysis was conducted. The results of this test, considering six different doses of biocoagulant, are detailed in Tables 4 and 5.

Table 4. Final Test Results Data Using Blood Clam Shell Biocoagulant.

Dosage Variations	pH	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)	BOD_5 (mg/L)	COD (mg/L)
KD 1 (0.4 gr)	12.10	138	48	0.35	10.21	59
KD 2 (0.7 gr)	12.12	172	47	0.49	10.19	50
KD 3 (1 gr)	12.39	173	44	0.57	10.11	47
KD 4 (1.3 gr)	12.42	207	41	2.03	9.89	47
KD 5 (1.6 gr)	12.45	253	39	2.61	9.82	44
KD 6 (1.9 gr)	12.47	276	37	2.92	9.79	39

Table 5. Final Test Results Data Using Green Mussel Shell Biocoagulant.

Dosage Variations	pH	TDS (mg/L)	TSS (mg/L)	Turbidity NTU	BOD_5 (mg/L)	COD (mg/L)
KD 1 (0.4 gr)	12.11	138	63	0.35	34.21	134
KD 2 (0.7 gr)	12.28	172	59	0.49	33.79	127
KD 3 (1 gr)	12.41	173	58	0.57	33.21	125
KD 4 (1.3 gr)	12.42	207	56	2.03	32.89	118
KD 5 (1.6 gr)	12.43	253	53	2.61	32.69	115
KD 6 (1.9 gr)	12.45	276	51	2.92	31.79	111

Tables 4 and 5 depict the outcomes of the acid correction testing in Gross Calorific Value (GCV) analysis, following the application of biocoagulants obtained from blood cockle shells and green mussel shells. The subsequent paragraphs delve into the specific parameters, such as TDS, TSS, turbidity, BOD5, and COD values, providing a detailed examination of the effectiveness of the biocoagulants across varying doses. The findings underscore the intricate relationship between biocoagulant dosages and the resulting impact on wastewater characteristics, offering valuable insights for potential applications in environmental and waste management practices.

pH Parameters:

Based on Table 5, the initial pH level before adding biocoagulant from blood cockle shells and green mussel shells was 5, not meeting the quality standards of 6 to 9. This discrepancy is attributed to the chemicals in the wastewater. The research findings indicate a consistent pH increase for each additional variation in biocoagulant dose. Notably, a dose of 0.4 gr from blood cockle shells approached the quality standard limit of 12.10 compared to other variations. However, excessive pH increases beyond the quality standard are observed due to the calcium carbonate content in the shells, which is commonly used in wastewater treatment.

According to research by Prastowo et al. [12], when Calcium Oxide (CaO) is reacted with water (H2O), it forms Ca(OH)2 and increases the concentration of hydroxide ions (OH-), which are carriers of alkaline properties, causing the pH of the water to rise from the initial level. This aligns with the statement that the higher the variation in the dose of biocoagulant used, the more the pH level increases.

Total Dissolved Solid (TDS):

Initially, the TDS level was 343 mg/L, which falls within the safe range. The most significant reduction, observed with a 0.4-gram dose, showed 62% effectiveness for green mussel shells and 60% for blood cockle shells. Interestingly, higher doses exhibited reduced efficacy in lowering TDS levels, highlighting a correlation with pH increase.Based on the results of the research carried out, it was found that there was a different increase in TDS for each additional dose of biocoagulant. The larger the dose added, the higher the TDS value because the CaO content cannot bind pollutants in water and the higher the TDS value, the greater the pH value [14].

Total Suspended Solid (TSS):

Before introducing biocoagulants, the TSS concentration surpassed the quality standard at 180 mg/L. The most substantial decrease was noted at a 1.9 gr dose, with blood cockle shells proving more efficient (79%) than green cockle shells (72%). Although successful in TSS reduction, the levels remained insufficient to meet quality standards.

Biocoagulant of blood cockle shells and green cockle shells in reducing the TSS amount, where the positive charge due to amine ions contained in the biocoagulant has the right ratio with the amount of negative charge contained in the acid correction test wastewater in GCV analysis, so that the colloidal particle neutralization process takes place well [7].

Turbidity Test:

Initiating at 3.93 NTU, the initial turbidity level fell within the safe category. At a 0.4 gr dose, blood cockle shells exhibited higher efficacy (91%) compared to green cockle shells (87%). Notably, larger doses displayed diminished effectiveness in reducing turbidity levels.

The biocoagulant ability of blood cockle shells and green mussels to reduce turbidity levels is due to the calcium carbonate ($CaCO_3$) contained in clam shells, which can bind organic materials found in wastewater [15].

Biological Oxygen Demand (BOD):

Commencing with an initial value exceeding the quality standard at 155.59 mg/L, the most substantial reduction occurred at a 1.9 gr dose from blood cockle shells (93.71%), meeting quality standards. Green mussel shells exhibited a 72% reduction, yet none of the variations conformed to the standards.

This occurs because it is caused by high or low organic material content in wastewater from acid correction testing in GCV analysis of the performance of blood cockle calcium oxide biocoagulant capabilities which results in a decrease in dissolved oxygen levels in the water because it is used for the oxidation process of organic material [12].

Chemical Oxygen Demand (COD):

The initial COD level exceeding the quality standard at 315 mg/L saw the most significant reduction at a 1.9 gr dose from blood cockle shells (88%), aligning with quality standards. Green mussel shells showed a 5% reduction, with none of the variations meeting the standards. The varied reduction in COD levels emphasized the impact of each biocoagulant dose.

This is in accordance with the statement by Aulia et al. [6] that the effectiveness of reducing levels of COD parameters tends to decrease due to the excessive positive charge of the biocoagulant material causing the binding of colloids, which contain less than optimal organic substances. Conversely, the removal of COD parameter levels is less than optimal due to the lack of positive charge on coagulants, which prevents the formation of floc containing organic substances that can bind colloids. Therefore, this influences the effectiveness of reducing COD parameter levels in acid correction testing wastewater in GCV analysis.

The study highlights the potential use of waste blood cockle shells and green mussel shells as natural biocoagulants. The results provide insights into their effectiveness in wastewater treatment, and further innovations can be explored to optimize their use.

4. CONCLUSION

In conclusion, the optimal calcination temperature for producing biocoagulants from blood and green cockle shells is determined to be 1000 °C, showcasing favorable Ca element compositions of 55.3% and 58.7% in blood cockle and green cockle shells, respectively.

The effectiveness of CaO biocoagulant, derived from these shells, is demonstrated through acid correction testing in GCV analysis. The addition of blood cockle shell biocoagulant results in a significant pH increase from 5 to 12.10, coupled with notable reductions in TDS (60%), TSS (79%), turbidity (91%), BOD5 (93.71%), and COD (88%). Similarly, the introduction of green mussel shell biocoagulant elevates pH from 5 to 12.11, exhibiting efficacy in decreasing TDS (62%), TSS (72%), turbidity (87%), BOD5 (72%), and COD (65%).

Furthermore, the impact of biocoagulant dosage on acid correction testing wastewater in GCV reveals a dose-dependent relationship. Higher doses contribute to elevated pH levels and reduced TSS, BOD5, and COD values, while lower doses exhibit greater efficacy in decreasing TDS and turbidity. These findings collectively highlight the potential of CaO biocoagulants from blood cockle shells and green mussel shells in wastewater treatment, emphasizing their role in environmental remediation practices.

REFERENCES

[1] M. Audiana, I. Apriani, U. Kadaria, Pengolahan Limbah Cair Laboratorium Teknik Lingkungan, *Jurnal Teknologi Lingkungan Lahan Basah*, vol. 5, no. 1, pp. 1–10, 2014.

[2] R. D. Kusumaningrum, Efektifitas CaO dan CaCO3 Sebagai Koagulan Pada Pengolahan Limbah Cair PT. Perkebunan Nusantara X Industri Bobbin Jember, Bachelor Teshis, Dept. of Chemistry, University of Jember, 2020.

[3] P. Coniwanti, I. D. Mertha, D. Eprianie, Pengolahan Limbah Cair Industri Tahu dalam Tinjauannya Terhadap *Turbidity*, TSS dan COD, *Jurnal Teknik Kimia*, vol. 19, no. 3, pp. 22–30, 2013.

[4] D. Sriwahyuni, Penggunaan Cangkang Keong Sawah (*Pila ampullacea*) sebagai Biokoagulan pada Pengolahan Limbah Domestik (*Grey Water*), Bachelor Thesis, Dept. Of Enviromental Engineering, UIN Ar-Raniry, Indonesia, 2020.

[5] R. Samsuarni, Pemanfaatan Cangkang Kerang Lokan (*Geloina erosa*) sebagai Biokoagulan pada Pengolahan Limbah Cair UPTD Rumah Pemotongan Hewan, Bachelor Thesis, Dept. of Environmental Engineering, UIN Ar-Raniry, Indonesia, 2022.

[6] Z. Aulia, S. Endro, M. Hadiwidodo, Pemanfaatan Limbah Cangkang Kepiting sebagai Biokoagulan untuk Menurunkan Parameter Pencemar COD dan TSS pada Limbah Industri Tahu, *Teknik Lingkungan*, vol. 5, no. 2, pp. 1–12, 2016.

[7] R. Sofiyani, Pemanfaatan Cangkang Kerang Kijing (*Pilsbryoconcha exilis*) sebagai Biokoagulan pada Pengolahan Limbah Cair RPH, Bachelor Thesis, Dept. of Environmental Engineering, UIN Ar-Raniry, Indonesia 2022.

[8] C. Rosyidah, Uji Dosis Serbuk Aam Jawa (*Tamarindus indica*) sebagai Biokoagulan Terhadap Kualitas Air Ditinjau dari Aspek Fisik, Kimia dan Bakteriologi, Bachelor Thesis, Dept. of Biology, UIN Malang, Indonesia, 2008.

[9] M. Setyowati, C. Chairudin, Kajian Limbah Cangkang Kerang sebagai Alternatif Bahan Amelioran di Lahan

Gambut, *Jurnal Agrotek Lestari*, vol. 2, no. 1, pp. 59–64, 2016.

[10] W. Srichanachaichok, D. Pissuwan, Micro/Nano Structural Investigation and Characterization of Mussel Shell Waste in Thailand as a Feasible Bioresource of CaO, *Materials,* vol. 16, no. 2, pp. 805, 2023.

[11] A. Herlina, H. E. Handayani, H. Iskandar, Pengaruh *Fly Ash* dan Kapur Tohor pada Netralisasi Air Asam Tambang Terhadap Kualitas Air Asam Tambang (pH, Fe & Mn) Di IUP Tambang Air Laya PT. Bukit Asam (Persero), Tbk, *Jurnal Ilmu Teknik*, vol. 2, no. 2, pp. 1–7, 2014.

[12] P. Prastowo, L. Destiarti, T. A. Zaharah, Penggunaan Kulit Kerang Darah sebagai Koagulan Air Gambut, *Jurnal Tilapia*, vol. 6, no. 4, pp. 4–7, 2017.

[13] L. Handayani, R. Zuhrayani, N. Putri, R. Nanda, Pengaruh Suhu Kalsinasi Terhadap Nilai Rendemen CaO Cangkang Tiram (*Crassostrea gigas*), *Jurnal Tilapia*, vol. 1, no. 1, pp. 1–6, 2020.

[14] J. Evi, M. Mustari, F. Afriani, R. A. Rafsanjani, Y. Tiandho, Pemanfaatan Limbah Cangkang Kerang Darah sebagai Bio-Koagulan untuk Penjernihan Air Tanah Terpolusi (Studi Kasus : Selindung), *Prosiding Seminar Penelitian dan Pengabdian Masyarakat*, pp. 92–94, 2020.

[15] R. M. Rachman, A. R. Syaban, Efektifitas Penggunaan Dosis Kalsium Karbonat ($CaCO_3$) dan PAC (*Poly Alumunium Cloride*) dalam Menjernihkan Air Sumur Gali di Kelurahan Lalolara Kecamatan Kambu, *Jurnal Teknik Lingkungan*, vol. 6, no. 1, Pp. 17–24, 2020.