

SUSTAINABLE DEVELOPMENT THROUGH RAW MATERIAL DIVERSIFICATION IN THE BANYUMULEK POTTERY INDUSTRY COMMUNITY ON LOMBOK ISLAND

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Abstrak: Gerabah merupakan salah satu produk unggulan daerah di Desa Banyumulek Kabupaten Lombok Barat, Provinsi Nusa Tenggara Barat. Industri ini telah berlangsung lebih dari setengah abad, dan menjadi mata pencaharian pokok hampir 80% masyarakat di Desa Banyumulek. Kegiatan pengabdian ini bertujuan untuk sosialisasi dan praktek penerapan teknologi material komposit menggunakan bahan alternatif untuk pembuatan gerabah. Bahan alternatif yang digunakan berasal dari limbah abu pembakaran gerabah. Tim pengabdian bermitra dengan KIAT Gerabah Lombok, yang merupakan kelompok pengrajin gerabah beranggotakan 25 orang. Selain itu, kegiatan ini bertujuan untuk mengurangi dampak negatif dari limbah abu dan meningkatkan nilai ekonomisnya. Pengabdian dilakukan dengan metode Participatory Action Research (PAR) dan Focus Group Discussion (FGD). Penerapan kedua metode dapat meningkatkan pemahaman dan pengetahuan para peserta pengabdian tentang diversifikasi dan teknik pembuatan gerabah dengan teknologi komposit sebanyak 30-80%. Sedangkan indeks kepuasan peserta pengabdian menunjukkan sebanyak 76% peserta pengabdian merasa puas dan sangat puas terhadap pelaksanaan kegiatan. Diversifikasi bahan baku dalam pembuatan gerabah, diharapkan dapat menjaga keberlangsungan industri gerabah di Desa Banyumulek sebagai menjadi salah satu warisan budaya dan produk unggulan daerah yang perlu dilestarikan.

Kata Kunci: gerabah, diversifikasi, limbah abu pembakaran, Banyumulek, teknologi komposit

Abstract: Pottery is a leading regional product in Banyumulek Village, West Lombok Regency, West Nusa Tenggara Province. The industry, which has existed for over half a century, serves as the primary livelihood for nearly 80% of Banyumulek's population. This community service activity aimed to introduce and practice composite material technology using alternative materials derived from pottery firing ash waste. The service partnered with KIAT Gerabah Lombok, a pottery artisans' group with 25 members. The objectives included mitigating the negative impacts of firing ash waste and enhancing its economic value. Employing Participatory Action Research (PAR) and Focus Group Discussion (FGD) methods, the activities improved participants' understanding of diversification and composite technology pottery techniques by 30-80%. The participant satisfaction index revealed that 76% were satisfied or very satisfied with the activity. Diversifying raw materials in pottery making is expected to sustain the pottery industry in Banyumulek Village, preserving it as a cultural heritage and regional hallmark.

Keywords: pottery, diversification, firing ash waste, Banyumulek, composite technology

Introduction

Pottery is one of the flagship regional products of West Nusa Tenggara Province, as stated in the Regional Medium-Term Development Plan (RPJMD) of West Lombok Regency for 2019–2024. The document highlights Banyumulek Village in Kediri Subdistrict as one of the prioritized and leading cultural tourism centres in the regency (RPJMD, 2019). The traditional pottery industry in Banyumulek Village has been thriving since the 1960s and remains the largest pottery

production centre in the province. According to the Central Bureau of Statistics (BPS) of West Lombok Regency in 2015, there were 2,227 small and medium enterprises (SMEs) in Kediri Subdistrict, 80% of which were pottery SMEs located in Banyumulek Village (Kediri in Figures, 2023).

The pottery industry in Banyumulek Village began with the production of basic household utensils, such as cooking pots, water storage containers, clay frying pans, and other simple kitchenware. Over time, nearly 95% of these crafts have evolved into decorative accessories and artistic ornaments (Ria, 2021). The Banyumulek pottery industry has successfully penetrated not only local markets, such as Bali, Java, and Kalimantan, but also international markets in Asia, including Malaysia, Thailand, and Singapore. This achievement is supported by the availability of high-quality clay around Banyumulek Village (Hamdiani, Zuryati, and Ariessaputra, 2017). Besides clay, fine sand is also required to strengthen the pottery structure. It requires some efforts to ensure the availability of raw materials and sustain this flagship industry.

One of the main challenges artisans face is the increasing scarcity and rising cost of fine sand, which is essential as a structural filler in pottery-making. The depletion of fine sand reserves is primarily caused by its extensive use in construction and the tile and brick industries (Daniswara and Walujodjati, 2022; Shalahuddin, 2010). Based on composite technology, clay serves as the matrix in pottery-making, while fine sand acts as the filler (Hamdiani, Ariessaputra, and Hadisaputra, 2019). The use of filler can be substituted by seeking alternative renewable natural materials. One potential material is firing ash waste generated from pottery production. Traditionally, pottery in Banyumulek is fired using fuel sources such as wood, straw, coconut shells, and rice husks. The accumulation of firing ash waste becomes an unutilized by-product, posing health risks. Additionally, the proximity of firing sites to residential areas creates new environmental issues. Airborne ash particles can cause respiratory problems and degrade air quality (Suswati and Taneo, 2004; Putri, Kinasti, and Lestari, 2018).

According to research conducted by Hamdiani et al. (2019), the fine sand used in pottery contains silicate (SiO_2) and iron oxide (Fe_2O_3) at 40.9% and 28.6% by weight, respectively. Silicate acts as a binder and forms a silica network to produce a stronger structure capable of withstanding high firing temperatures. The high iron content contributes to the strength and heaviness of Banyumulek pottery. Conversely, rice husk ash has been identified as a potential reinforcing material, containing 86.9% SiO_2 and 0.54% Fe_2O_3 by weight. These compositions, derived from the material's organic makeup, include 70-90% silicate content in rice husks (Hamdiani, Nuryono, and Rusdiarso, 2015). Its high silica and low iron content make it suitable for producing strong and lightweight pottery. Thus, this community service program aimed to provide an alternative raw material to replace fine sand and train artisans to apply rice husk ash waste in pottery-making using composite technology. The program was expected to reduce environmental pollution from firing ash waste and sustain the pottery industry in Banyumulek Village, West Lombok Regency, West Nusa Tenggara Province.

Method

The implementation steps for this community service activity adopted the Participatory Action Research (PAR) method (Afandi, 2020; Muhtarom, 2019) to address the challenges faced by pottery SMEs in Banyumulek Village. The participants included four speakers, 25 KIAT Gerabah Lombok Group members, and six students. The speakers presented the activity and provided materials on prospects and innovations to support product diversification. They also guided the training on composite technology transfer. KIAT Gerabah Lombok members actively participated as attendees provided the venue and joined the training alongside students. The students actively facilitated the event, distributed questionnaires during the socialization and training sessions, and evaluated the program's execution. The program was conducted in several stages as follows.

Socialization

The socialization stage involved inviting the entire community service team and 25 representatives from pottery SMEs. Socialization and lectures were conducted using Focus Group Discussion (FGD) techniques (Afiyanti, 2008; Mishra, 2016). This process began with distributing questionnaires to assess the participants' initial understanding of alternative materials and composite technology in pottery-making. After this, the community service team members conducted interviews, lectures, and small group mentoring sessions.

Training on Composite Nanotechnology Application for Improving Pottery Quality

The training was held over six sessions and was attended by SME members, the community service team, and students. The training used the Small Group Discussion method (Ahmad and Nurma, 2020; Muzayin et al., 2022), with 25 SME members divided into five smaller groups. Each group received intensive guidance from the community service team and students for 3x45-minute sessions. The training covered preparing substitute materials for fine sand, mixing techniques, and pottery-making processes.

Technology Implementation

The applied technology used composite material concepts to integrate ash waste as an alternative filler in pottery-making. This technology is widely used in various fields, such as transportation, construction, and commercial products (Tabassum et al., 2023). Composite technology combines different materials to create a new material with improved properties, such as lightness, strength, stiffness, permeability, electrical properties, biodegradability, and unique optical characteristics, compared to the properties of individual components (Dolz et al., 2023).

Composites have two main components: the matrix (host material) and the filler. The matrix can be organic or inorganic materials. Organic matrices typically consist of larger polymers, such as carbohydrates, lipids, or proteins (Aguero et al., 2019; Alswat, Ahmad, and Saleh, 2017; Sharma et al., 2020; Bee et al., 2021). Inorganic matrices often originate from porous materials like clay (Elsanadedy et al., 2019). Fillers can also be organic materials, particularly those with high cellulose and silicate content, which enhance the material's strength

and plasticity. An illustration of composite pottery formation using clay matrix and firing ash waste filler is shown in Figure 1.

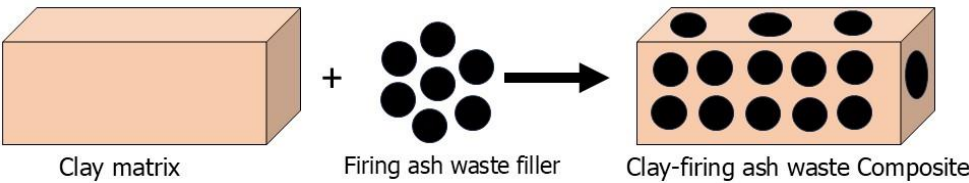


Figure 1. Illustration of the Formation of Composite Pottery from a Clay Matrix and Firing Ash Waste Filler

Composite technology was implemented by varying the composition of clay and firing ash waste mixtures as shown in Table 1.

Table 1. Composition of Composite Pottery

No.	Material Composition (%w/w)		
	Clay	Sand	Firing Ash Waste
1.	4	-	2
2.	4	1	2
3.	4	2	1
4.	4	2	2

Table 1 displays different compositions of materials used to create composite pottery. The proportions of clay, fine sand, and firing ash waste are adjusted to evaluate the resulting quality and characteristics of the pottery.

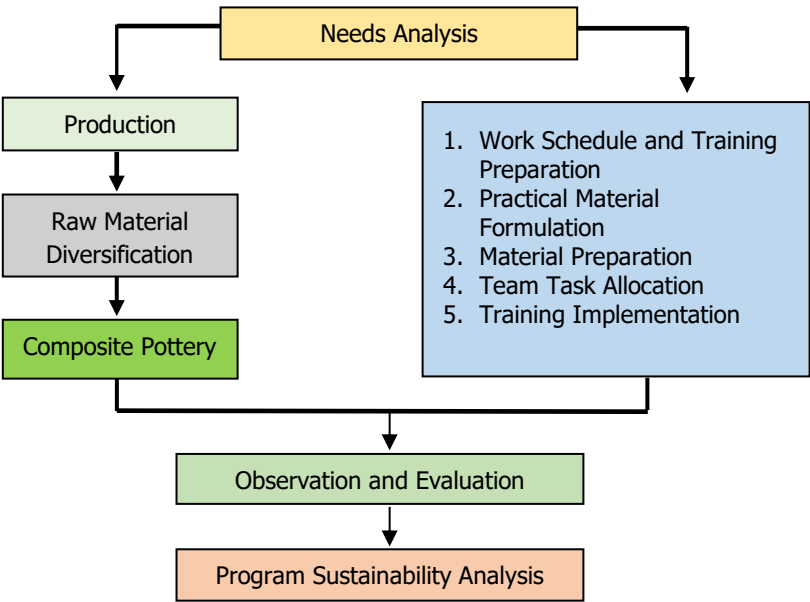


Figure 2. Flowchart of Community Service Activities

Mentoring and Evaluation

Mentoring activities covered the socialization of raw material diversification and the practical application of composite technology. These activities were evaluated at the beginning

and end of the program by distributing questionnaires to measure participants' understanding of the material and practical sessions. A satisfaction survey was also conducted to assess participants' overall impressions of the program. The activity flowchart is presented in [Figure 2](#).

Results and Discussion

Community Service Socialization Activities

The community service program was attended by 25 participants, who were representatives of the KIAT Gerabah Lombok group, chaired by Mr. Sahibudin. The profile of the participants is summarized in [Table 2](#).

Table 2. Characteristics of Participants in the Community Service Program

No.	Description	Number of Participants (People)	Percentage (%)
1.	Gender		
	• Male	1	4.00
	• Female	24	96.00
	Total	25	100.00
2.	Age		
	• 22-30 years	2	8.00
	• 31-40 years	7	28.00
	• 41-50 years	10	40.00
	• 51-60 years	4	16.00
	• 61-69 years	2	8.00
	Total	25	100.00
3.	Education		
	• No formal schooling	3	12.00
	• Primary school graduate	5	20.00
	• Junior high school graduate	12	48.00
	• High school graduate	5	20.00
	Total	25	100.00
4.	Occupation		
	• Pottery artisans	23	92.00
	• Entrepreneurs	2	8.00
	Total	25	100.00
5.	Role in the Community		
	• KIAT Gerabah Lombok Leader	3	12.00
	• Members	22	88.00
	Total	25	100.00

Data source: The result of data tabulation collected from KIAT Gerabah Lombok members

Based on [Table 2](#), 96% of the participants were women, with 92% working in the informal sector as pottery artisans. It reflects a cultural norm where women traditionally worked in kitchens, producing household items such as pots and cooking tools, which later expanded into pottery production. Today, 90% of the pottery production in Banyumulek is dominated by women.

During the program, the women participants were introduced to sustainable pottery production, particularly using composite technology in manufacturing. The knowledge improvement achieved

during the socialization session is summarized in [Table 3](#), and the percentage of understanding improvement is illustrated in [Figure 3](#).

Table 3. Summary of Questionnaire Results Before and After Socialization

No.	Indicator	Understanding	
		Before (%)	After (%)
1.	Familiarity with composite technology concepts	10	80
2.	Knowledge of sand function in pottery-making	50	100
3.	Knowledge of clay function in pottery-making	70	100
4.	Awareness of alternative materials for pottery-making	15	75
5.	Knowledge of alternative material characteristics	10	80
6.	Awareness of health risks from unmanaged firing ash waste	35	80
7.	Knowledge of processing ash waste before application	25	75
8.	The economic value of firing ash waste in pottery-making	10	80
9.	Techniques for applying ash waste in pottery production	15	85
10.	Understanding the advantages of composite pottery	10	90

Data Source: The data Tabulation questionnaire was collected after the socialization session

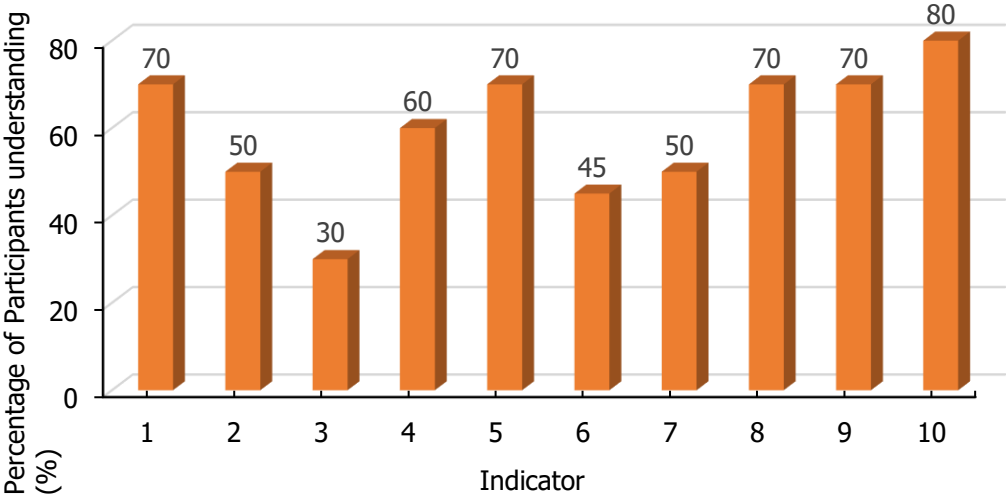


Figure 3. Percentage Increase in Participants' Understanding Before and After Socialization

The percentage increase in the participants' understanding before and after the socialization sessions is illustrated in [Figure 3](#). The highest increase in understanding was observed in Indicator 10, which showed an 80.0% improvement. Indicator 10 measures the participants' comprehension of the advantages of composite pottery using firing ash waste compared to similar products. Considering the educational profile of the respondents, where nearly 88% had only completed basic education, and 12% had no formal schooling, an 80% improvement in understanding among artisans on indicator 10 highlights the success of the technology transfer process. The technology transfer was carried out using simple, comprehensible language, and the technology introduced was highly relevant to the daily activities of the artisans. The community service team also identified a key economic advantage of composite pottery from the socialisation sessions, as shown in [Table 4](#). Composite technology

can increase artisans' profit margins by up to twice as much as conventional pottery made from clay and fine sand. Photos of the socialization activities are displayed in Figure 4. The economic benefits of using ash waste as a substitute for fine sand in pottery-making are summarized in Table 4.

Table 4. Cost Comparison Between Pottery Using Sand and Composite Pottery Using Firing Ash Waste

No.	Material	Pottery with sand filler (IDR)	Composite pottery with ash (IDR)	Results
1.	Clay	500.000	500.000	100 pottery pieces (80 cm height)
2.	Sand	500.000	-	
3.	Coconut shells	250.000	250.000	
4.	Straw	150.000	150.000	
5.	Fuel (Diesel)	100.000	100.000	
6.	Transportation cost	200.000	200.000	
7.	Labor cost	800.000	800.000	
8.	Clay milling	150.000	150.000	
Initial Capital (A)		2.650.000	2.150.000	
Estimated (B)		4.000.000*	5.000.000**	
Revenue		1.350.000	2.850.000	
Profit (B-A)				

* Pottery with sand filler is sold at Rp. 20,000/piece (80 cm high)

* * Improving the quality of pottery with nanocomposite technology produces lightweight and structurally strong pottery at Rp 25,000/piece (80 cm high)

Data source: Data obtained from interviews with members of pottery MSMEs in Banyumulek Village, West Lombok Regency.

Explanation: Using ash waste reduces production costs by eliminating the need for sand, resulting in an estimated profit increase of over 100%.



Figure 4. Socialization Activities on Raw Material Diversification in Banyumulek Village

Training on the Application of Nanocomposite Technology in Pottery

The training sessions were conducted using pottery compositions as outlined in Table 1. Each participant was divided into five groups. Photos of the training activities are shown in Figure 5. The practice of mixing clay with firing ash waste filler was carried out directly by the women artisans under the guidance of the community service team. After creating pottery with various shapes and compositions (a, b, c, d, e), the pottery was fired using traditional methods involving

wood pieces, straw, and coconut shells as fuel. The firing results are displayed in **Figures f, g, and h**. The pottery outcomes shown in **Figure 5** represent the results of six mentoring sessions conducted for the artisans.



Figure 5. Training Activities: (a) Training session, (b) Mixing clay with firing ash waste filler, (c) Firing ash waste material, (d) Pottery-making practice using clay and ash compositions, (e) Formed pottery, (f) Fired pottery with Composition 1, (g) Fired pottery with Composition 2, (h) Fired pottery with Compositions 3 and 4

The results of the firing process are shown in Figure 5 (f, g, h). The analysis revealed that pottery made exclusively with clay and ash waste (Composition 1) exhibited cracking after firing, whereas pottery made with clay, ash waste, and sand (Compositions 2, 3, and 4) displayed better quality, with no cracking after firing. Based on the compositions in Table 1, firing ash waste can be applied as a substitute for fine sand in pottery-making, with a substitution rate of 14.3% to 28.6%. This finding demonstrates that fine sand is still necessary as a filler in the clay matrix, but its usage can be reduced by up to 28.6% when replaced with firing ash waste.

Mentoring and Evaluation of the Community Service Program

Mentoring was conducted throughout the activity, encompassing socialization about raw material diversification in pottery-making and practical sessions on composite technology application. Evaluations were performed at the beginning and the end of the community service program to measure participants' understanding of the presented material and practical sessions. It was achieved by distributing questionnaires to gauge participants' knowledge and satisfaction levels regarding the implementation of the program. The mentoring process included six training sessions. During each session, the community service team assessed shortcomings in the production process to improve the quality of the pottery. The intensity of the mentoring and training activities is shown in Table 5.

Table 5. Intensity of Training and Mentoring Activities for Composite Technology Application in Pottery

No.	Training session	The number of participants	Attendance (%)
1.	Session-1	25	100
2.	Session-2	23	92
3.	Session-3	21	84
4.	Session-4	19	76
5.	Session-5	24	96
6.	Session-6	23	92
Average			90

Data source: Recapitulation of participants attendance

Table 6. Participant Feedback on Training Activities for Raw Material Diversification

No	Variable	Category				Total (%)
		Not Satisfied (%)	Moderately Satisfied (%)	Satisfied (%)	Very Satisfied (%)	
1.	Feedback on Composite Pottery Innovation	-	5 (20,0%)	11 (44,0%)	9 (36,0%)	25 (100%)
2.	Motivation to use and apply composite technology	-	6 (24,0%)	19 (76,0%)	-	25 (100%)
3.	Motivation to continue composite pottery production	-	7 (28,0%)	8 (32,0%)	10 (40,0%)	25 (100%)
4.	Feedback on the need for further training sessions	-	5 (20,0%)	8 (32,0%)	12 (48,0%)	25 (100%)

Data Source: Tabulated results of questionnaires/surveys distributed to participants after training sessions

The program was evaluated through a participant satisfaction survey and an analysis of the program’s benefits in supporting the sustainability of pottery businesses led by the KIAT Gerabah Lombok Group. The recapitulated results of participant feedback are presented in [Table 6](#) and [Table 7](#).

Table 7. Benefits of the Community Service Program

Indicator	Distribution of Scores					Score Range	Average Score	Category
	1	2	3	4	5			
Program Benefits	0	0	1	9	15	1-5	4,56	Very Beneficial

(*1= very unbeneficial (1,00-1,80), 2= unbeneficial (1,81-2,60), 3= moderately beneficial (2,61-3,40), 4= beneficial (3,41-4,20), 5= very beneficial (4,21-5,00))

Data Source: Results of Questionnaire Data Tabulation after training and mentoring activities

Survey results from [Table 6](#) and [Table 7](#), completed by 25 participants, indicate the highest satisfaction index was achieved in indicator 3, with 76% of participants expressing satisfaction and high motivation to apply composite technology using other alternative materials. The satisfaction index fell within the "good" range, which spans from 62.51% to 81.25% (LPM Universitas Islam Negeri Ar-Raniry Banda Aceh, [2021](#)). The high satisfaction scores were influenced by factors such as engaging material presentations, effective communication by the community service team, and the practicality, affordability, and applicability of the technology solutions provided. Additionally, the analysis of program benefits showed that 15 respondents found the program "very beneficial," and nine respondents rated it as "beneficial." The hands-on and practical nature of the training, combined with socialization and material explanations, improved participants’ understanding, creativity, and innovativeness (Sucilestari & Arizona, [2019](#)).

Conclusion

The community service activities were carried out successfully, with participants showing great enthusiasm throughout each implementation stage. Participants' understanding of composite technology using ash waste for pottery-making increased by 30–80%. This technology is practical, applicable, simple, and cost-effective, as reflected in the 89% of participants who expressed interest in participating in similar future activities. The activities significantly impacted the use of alternative materials for pottery-making, with up to 28.6% of firing ash waste being utilized as a replacement for fine sand, thereby increasing the artisans' economic returns. Additionally, the program inspired the participants and the community service team to continue innovating to produce high-quality, durable products with environmentally friendly characteristics, creating unique regional products. The community service program is planned to run for three years and has successfully completed its first year. In the coming years, the focus will be on expanding and increasing the production capacity of the KIAT Gerabah Lombok group. The community service team will continue mentoring to ensure the sustainability of the pottery industry in Banyumulek Village, West Lombok Regency, West Nusa Tenggara Province.

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