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Innovative Ceramic Filtration System for Drinking Water in Underserved Areas Using Locally Available Resources

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Abstract

One of the primary obstacles remains the provision of clean, safe drinking water in remote and developing areas, where existing filtration methods are often not feasible or accessible. This study adapts a design of a portable ceramic water filtration system using locally available Caniangan clay (95%) and RHA (5%). The best formulation produced a functional ceramic water filter (CWF) with 33.47% water absorption and a flow rate of approximately 0.45 L in 30 minutes (0.9 L/h). When tested with tap water, the system reduced total dissolved solids from 1543.8 mg/L (influent) to 67.1 mg/L (effluent), achieving 95.6% removal while maintaining approximately constant pH within the acceptable drinking water range of 6.5–9.5. Expert assessments yielded a mean acceptability rating of 2.53 ("Very Acceptable"), indicating practical suitability for developing communities. Compared with previously reported ceramic water filters, the present system exhibits comparable water absorption and flow rate despite being fabricated under uncontrolled, traditional firing conditions. While the achieved flow rate lies toward the lower end of reported ranges, it remains suitable for point-of-use applications in community settings. The absence of microbiological testing distinguishes this study from others and is explicitly acknowledged as a limitation rather than a performance claim.

Keywords: Caniangan clay, ceramic water filtration system, community-based water treatment, portable water filtration, rice husk ash

1. Introduction

Access to portable and potable drinking water is a fundamental issue for developing and rural populations across the globe (Ray & Smith, 2021;

Thomas *et al*., 2022; Aman *et al*., 2024). Infection through contaminated water is the primary cause of illness, and there are vast outbreaks of waterborne diseases, including diarrhea, cholera, and dysentery, which target children and other vulnerable groups disproportionately (Tetteh & Tettey, 2025; Krishan & Srivastava, 2023). The increase in water pollution, fueled by industrialization and population growth, has been responsible for the growing shortage of fresh water and the occurrence of hazardous and polluted substances such as heavy metals and pathogenic microorganisms (Madhav *et al*., 2019; Chaudhry & Malik, 2017; Sarker *et al*., 2021; Akpor *et al*., 2014; Schweitzer & Noblet, 2018). One of the most significant of these pollutants is *Escherichia coli*, a bacterium that can cause severe infections when present in potable water. As one of the most researched microbes, it continues to develop resistance and induce extra- intestinal infections, which remain a continuous public health concern (Vila *et al*., 2016; Odonkor & Mahami, 2020; Mohan & Lyons, 2022).

Recent research has investigated various solutions to the ongoing problem of ensuring safe drinking water to developing communities, with an emphasis on decentralized, portable, and sustainable systems. Harvesting rainwater with basic filtration has been successfully used in rural settings to utilize readily available sources (Ross *et al*., 2025; Gomes *et al*., 2024), and recycled aggregates have been used as filter support media to reduce material costs and environmental burden (Verma *et al*., 2025). Systems based on renewable energy, such as solar-powered and hybrid solar–wind-driven filtration systems, have shown potential for round-the-clock water purification in off-grid settings (Arifin *et al*., 2024). Some studies have developed multi-stage, high-rate filtration systems to enhance contaminant removal and automate disinfection at the domestic level (García-Ávila *et al*., 2024; Hincapié *et al*., 2025). Portable designs have been developed for emergency or mobile applications, often powered by solar energy or natural and waste materials to lower costs (Shayo *et al*., 2025; Zubaidah *et al*., 2024; Ray *et al*., 2024; Afreen *et al*., 2024). These solutions are like the current study in that they prioritize portability, point-of-use treatment, and affordability, and in their function to eliminate pathogenic microorganisms, such as *Escherichia coli*. Nevertheless, the majority are based on imported parts, solar or wind power systems, or composite materials that are not necessarily available or economically viable in every rural Philippine environment. Additionally, few combine a filtering medium that achieves optimal porosity for flow rate, provides strong bacterial removal, and is based solely on indigenous, low-cost resources (Ajibade *et al*., 2019; Diana *et al*., 2019). This gap highlights the need for designs, such as the locally sourced ceramic water filter (CWF) suggested in this research, that are scalable, sustainable, and adapted to the infrastructural and material conditions of target communities. Classical systems for water purification, although efficient, are not readily accessible to isolated communities because of cost, space requirements, and maintenance needs (Malik *et al*., 2024; Duggireddy & Pisharody, 2024; Gomes *et al*., 2024; Chaurasia & Tiwari, 2016).

To overcome these issues, this research introduces a novel, lightweight, and portable ceramic water purification (CWP) system constructed from locally sourced materials such as Caniangan clay, eggshells, and rice husk ash (RHA). These resources are not only cheap and readily available but also rich in important compounds such as silica (SiO_2) and calcium oxide (CaO) (Kumari & Mohan, 2021; Tangboriboon *et al*., 2012; Hamidu *et al*., 2025; Yang *et al*., 2020) which are useful in ceramic manufacturing.

2. Methodology

2.1 Research Design

This research used a developmental-experimental design, with Caniangan clay and commonly available materials such as RHA and eggshells as the main raw materials. The objective was to produce a transportable CWF that could be used at any time and place, particularly in communities with very limited access to clean water.

The study flow, as presented in Figure 1, depicts the fabrication process of a handheld ceramic water filtration system (CWFS). It begins by collecting all materials to ensure the research team is adequately prepared for the fabrication process. After the materials have been obtained, the subsequent stage includes the fabrication of the ceramic filter that forms the major component of the filtration system.

Once the filter is designed, the materials are put together to build the entire filtration unit, and then the installation process follows. Once installed, the system goes through extensive tests to assess its performance and efficacy in filtering water. This step is important in ensuring that the system is working as designed and that it is up to standard in water purification.

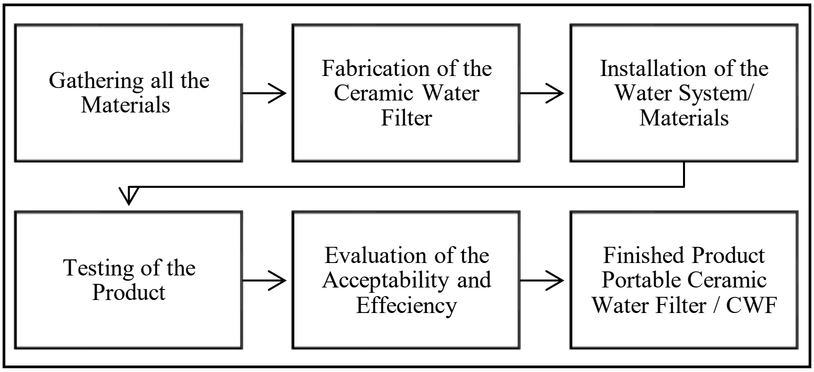


Figure 1. The flowchart diagram of the study

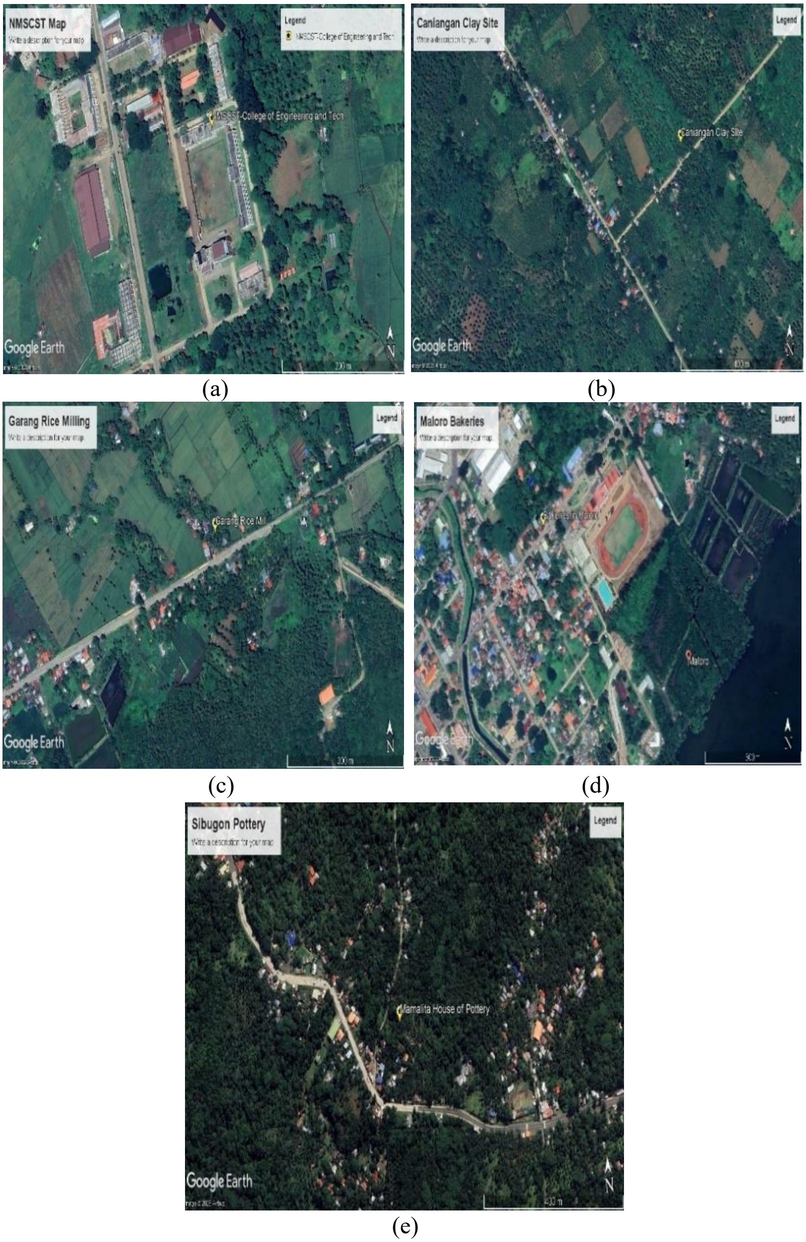
Then, the product is evaluated to determine whether it is acceptable and efficient, both in filtration efficiency and practical functionality. The final process is the manufacture of the portable CWFS, making it available for use in needy communities that require clean drinking water.

This systematic methodology ensures research advances with specific goals and quantifiable results, from material acquisition to product assessment, ultimately toward sustainable solutions for water access.

2.2 Research Environment

The study site, as demonstrated in the components in Figure 2, illustrates the fabrication facility, as seen in Figure 2a, where all activities involved in molding, mixing of materials, flow rate testing, and fabrication of the system were conducted. This facility also hosted the testing of the completed product.

Figure 2b illustrates the site of the Caniangan clay source in Caniangan, Tangub City. The clay utilized for the production of the portable CWFS was specifically obtained from the house of Mr./Mrs. Lumbatan. This location was selected for legal reasons and because of the accessibility of the clay. Before the sample was gathered, permission was secured from the Barangay of Caniangan to adhere to local laws. The choice of Caniangan clay is also intended to mitigate the problem of surplus backfilling from landfill excavation by providing a green solution using available local materials.



(a) (b) (c) (d) (e)

Figure 2. Google site: fabrication site (a), Caniangan clay source (b), RHA (c), eggshell (d); firing site (e)

Figure 2c illustrates the location where rice husks were gathered, which were subsequently transformed into ash. The RHA used in the manufacturing process came from Garang, Tangub City, an area well known for large-scale rice cultivation. Rice husk, a byproduct of rice milling, is readily available due to the enormous volume of rice produced. Silica-rich RHA plays an important position in enhancing the strength and durability of the ceramic filter. The use of such a local by-product not only ensures material availability but also supports sustainability by promoting the reuse of agricultural waste.

As indicated in Figure 2d, eggshells used in the filtration system were sourced from Maloro, Tangub City, obtained from local residents and nearby bakeries. The collection was facilitated by the residence of one team member in the area, making the process more efficient. Eggshells are rich in calcium carbonate, a key component that enhances the structural strength of ceramic materials. Utilizing locally available eggshells contributes to recycling food and farm waste and supports environmental sustainability.

Mamalita's House of Pottery in Sibugon, Lopez Jaena, Misamis Occidental, was the firing facility for ceramic filters produced under this project. This site was chosen because of its proximity and availability of a conventional firing kiln for handling ceramic materials. It is known for its repetitive pottery output, and Mamalita's House of Pottery frequently employs kiln firing for molding and curing ceramic products. The samples were fired for approximately 1 full day, followed by natural cooling for about 24 hours. Based on local pottery practice, the peak firing temperature was estimated to be 900–1000 °C, although the exact temperature profile could not be recorded because no monitoring equipment was available.

The ceramic filter samples were transported to the plant one day prior to the planned firing, allowing sufficient time to undergo the same firing process as the pottery products produced at the facility. By collaborating with a local pottery workshop, the project benefited from a proven, trusted firing method, ensuring the ceramic filters received appropriate heat treatment to enhance their structural strength and filtration efficiency. This partnership also promoted local craftsmanship and contributed to the successful completion of the experimental phase.

2.3 Experimental Procedure

Figure 3 shows how raw materials such as Caniangan clay are prepared by soaking in water, mixing, and filtering to produce a fine liquid mixture. RHA and eggshells, on the other hand, are sun-dried, crushed, and filtered to yield powders. These powders are then blended with the liquid clay mixture. The final formulations consist of different proportions of Caniangan clay, RHA, eggshells, and water, namely 100:0:0, 95:5:0, and 85:10:5, respectively. The blends are cast into molds through slip casting, allowed to settle for 24 hours, and demolded afterward. After sun-drying for half a day, the demolded samples are oven-dried for 30 minutes at 50°C, 10 minutes at 80°C, and 30 minutes at 100°C. The dried products are then fired in a conventional pottery kiln for at least one day, though no temperature was recorded because no monitoring equipment was available at the local pottery facility. After firing, the ceramics are allowed to cool naturally for a day before collection and testing for several physical properties. The fired ceramic body is subsequently assembled with a coupling and cap and sealed with a sealant solution before incorporation into the filtration system. The filtration container was modified according to the given layout. A collapsible tank was used for influent water to add mobility during transport, whereas a gallon tank was used to store filtered (effluent) drinking water. The device was well attached to prevent leakage. A filtration medium, along with the coupling, was placed over the hole in the collapsible tank so that influent (tainted) water could be filtered. The filtration unit was subsequently tested for flow rate, and both influent and effluent water samples were analyzed for bacterial content (*Escherichia coli*) to detect potentially dangerous bacteria. School tap water was used in the testing process. The entire process is illustrated in Figure 3.

2.4 Research Respondents

The respondents were purposively selected for their professional expertise relevant to the design and evaluation of the portable CWFS. The panel consisted of licensed Civil Engineers and Civil Technology instructors with practical experience in water-related infrastructure and instructional backgrounds in construction materials and systems. These experts, primarily faculty members of NMSCST, were chosen to ensure that both the technical performance and the practical applicability of the system could be rigorously assessed from an engineering and pedagogical perspective.

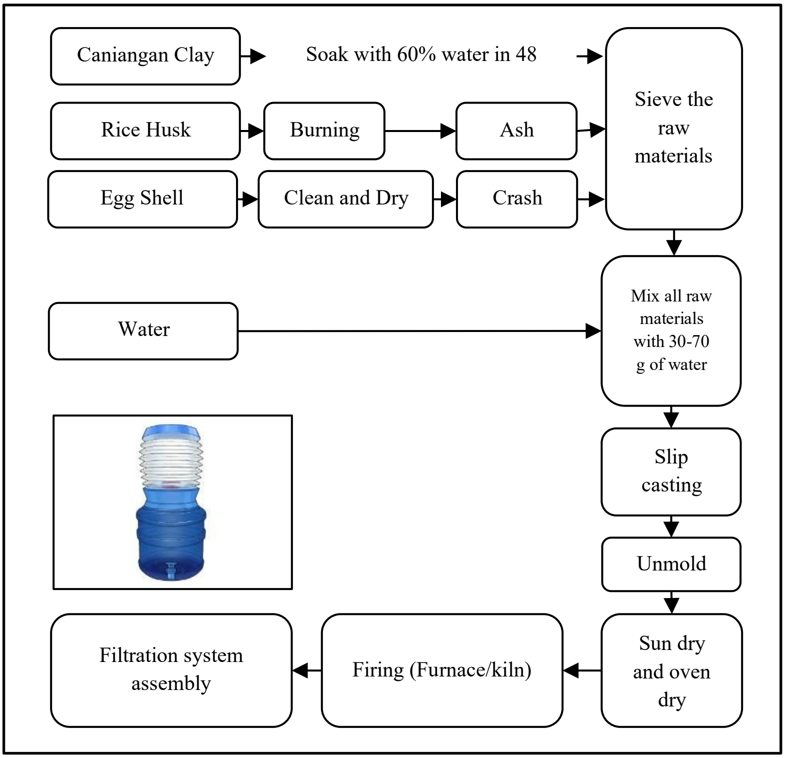


Figure 3. Process flow chart of the fabrication of CWFS

2.5 Research Instrument

A designated questionnaire served as the primary instrument for collecting expert feedback on the design and acceptability of the product. For each ceramic formulation, three replicate specimens were prepared and tested for shrinkage, weight loss, and water absorption to obtain representative values and basic statistical summaries. For flow-rate measurements, repeated tests were conducted at different times to observe the evolution of volume and instantaneous flow.

The results of all physical tests (percent shrinkage, weight loss, and water absorption) are to be solved. Equation 1 below shows the volumetric shrinkage calculation.

$$S = \frac{V_m - V_s}{V_m}\, x\, 100 \qquad (1)$$

where V_m = volume of mold or initial volume (cm^3); V_s = volume of shrinked body or final volume(cm^3); S is the volumetric shrinkage (%).

Equation 2 shows the calculation of weight loss. The weight loss is computed as the weight of green pavement bricks minus the weight of fired pavement bricks.

$$WL = M_g - M_f \tag{2}$$

where M_g = mass of green body (grams); M_f = mass of fired body (grams); WL is the weight loss (grams).

Water absorption is computed for boiled bodies, which are then subtracted from the unboiled bodies after 30 minutes of boiling. This is shown in Equation 3.

$$WA = \frac{W_W - D_W}{D_W} x\ 100 \tag{3}$$

where w_w = mass after boiled (grams); D_w = mass before boiled (grams); WA is the water absorption (%).

The questionnaires, which had been reviewed and cleared by ethics experts, were administered to the designated specialists along with the sample project to facilitate informed evaluations of the study. Data interpretation and response recording were then carried out using the criteria specified in the operational performance rubric.

2.6 Scoring Procedure and Statistical Tool

Quality assessment adapted a 3-point Likert scale to evaluate design and system acceptability (Van de Verg *et al.*, 2021). Data analysis applied the average weighted mean for the expert ratings and basic descriptive statistics (means and ranges, and, where possible, standard deviations) for physical properties, flow rate, and water-quality measurements to support data reliability. The computation for the range is shown in Equation 4.

$$R_v = \frac{H_S - L_S}{H_S} \tag{4}$$

where H_S = highest scale value; L_S = lowest scale value; R_v is the range value.

Data analysis used average weighted mean and a 3-point Likert scale to confirm the project and determine acceptability. The verbal interpretation based on the range values is shown in Table 1.

Table 1. Interpretation and range of verbal scores

Score	Range Value	Verbal Interpretation
3	2.34-3.00	Very Acceptable
2	1.67-2.33	Acceptable
1	1.00-1.66	Not Acceptable

$$\bar{x} = \frac{\Sigma f_w}{N} \tag{5}$$

where Σf_w = total weighted point; N= total number of cases; $\bar{x}$ is the average weighted mean.

The information was cataloged, statistically analyzed, and interpreted in relation to the study's objectives and the identified problem. The analysis employed the average weighted mean and a three-point Likert scale, with calculations based on Equation 5. The weighted mean was used to justify the project's design and application, and the same statistical measure was employed to assess acceptability.

2.7 Design Requirements

The design was inspired and adapted from a famous design of CWF in Mindanao known as Hydria from MSU-IIT (Ibarra & Roda, 2015). Figure 4a below is a drawing of the front view of the final water filter. The experiment uses an expandable plastic container, commercially available, to store the influent (unfiltered) water. The container is 24 centimeters tall when fully expanded and has a capacity of 8 liters of water. The ceramic filter media is constructed as per Figure 4b. The filter medium is fixed on the unthreaded end of a coupling with epoxy. The other threaded end of the coupling has a lock and a gasket. This threaded end is screwed into a hole drilled at the bottom of the expandable container and tightened to ensure leak-proof alignment of water flow.

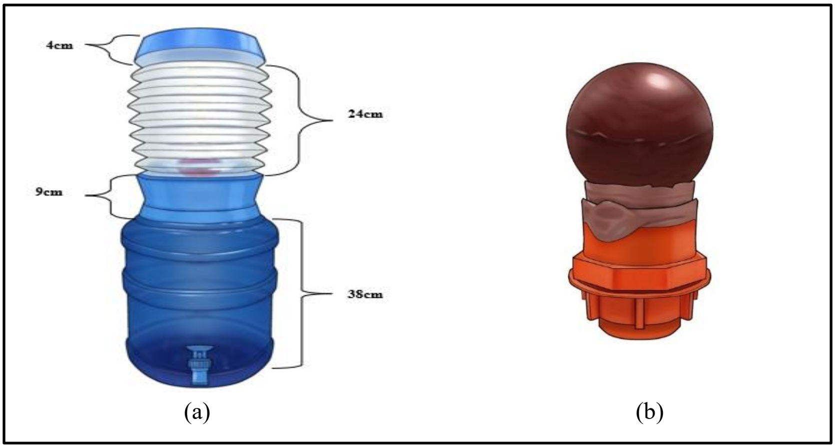


Figure 4. Frontal views: portable water filtration system (a); CWF media (b)

The filtered effluent water is stored in a 5-gallon (about 18-liter) hard plastic tank, commonly employed in water refilling stations. The tank was modified by installing a faucet to facilitate easy drinking and dispensing.

3. Results and Discussion

3.1 Preparation of CWF Media

3.1.1 Result of Oxide\Elemental Analysis Using XRF

The CWF in this study was prepared by first formulating the base composition according to the oxide analysis of the raw materials used, with the analysis performed by the third-party industry HTI Pte. Ltd. Three specific formulations were then developed and processed following the procedure outlined in the established process flow chart for this work.

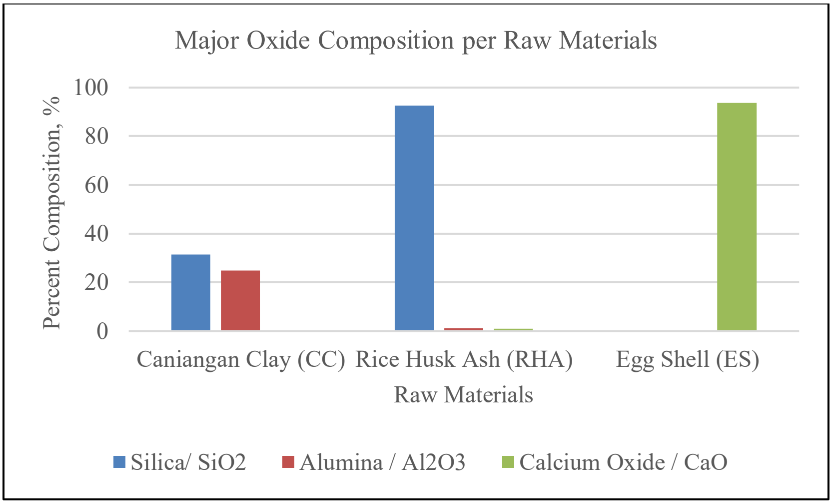


Figure 5. Graphical illustration of the main oxide constituents (SiO_2, Al_2O_3, CaO) of each raw material utilized

The material composition of the CWF materials are the main elements listed in Figure 5. The Caniangan clay was found to consist of 31.36% silica, 24.85% alumina (Al_2O_3), and 0.20% calcium oxide through analysis. These elements serve important functions in the structural characteristics of the clay: silica increases strength, alumina gives plasticity, and calcium oxide enhances sintering during firing.

RHA, another major component, has a much higher silica content (92.5%), with 1.28% alumina and 0.89% calcium oxide. The high silica content of RHA is especially needed to enhance the performance of the filter, as it helps increase porosity and enhance the total filtration capacity of the ceramic material. The content of alumina also helps in structural strength, whereas calcium oxide helps during the binding firing process.

Eggshells, as a source of calcium, have no silica or alumina but have high calcium oxide (93.7%). High calcium oxide is important in creating fluxes within the ceramic framework. The fluxes reduce the firing temperature and enhance material bonding, making the final ceramic filter more durable and efficient.

All these ingredients, silica, alumina, and calcium oxide are fundamental constituents in producing the CWF (Grema *et al.*, 2021). The synergy of these constituents provides the ceramic material with the appropriate strength, porosity, and filtration characteristics required for efficient water purification. The Caniangan Clay serves as the base material, while RHA and Egg Shell augment each other through their contribution of silica and calcium oxide content to create a balanced and effective ceramic filter.

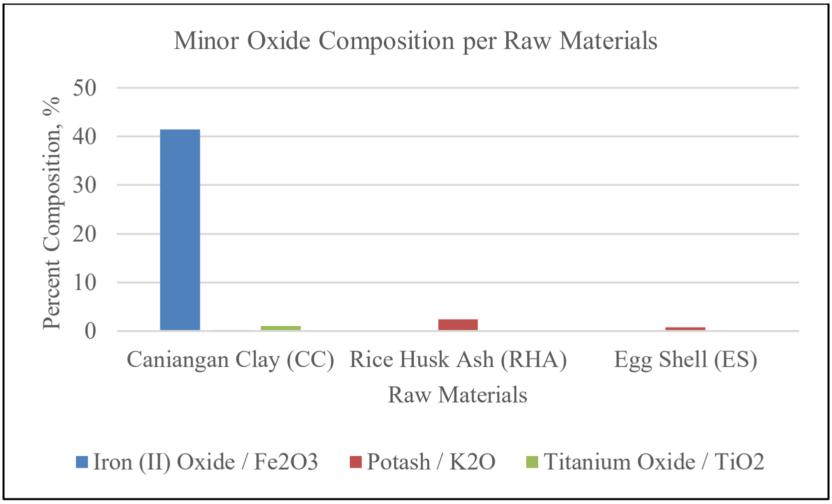


Figure 6. Graphical illustration of the minor oxide components (Fe_2O_3, K_2O, TiO_2) of each raw material used

The trace elements presented in Figure 6, being part of elemental analysis by using XRF, are depicted in the above graph and do not necessarily have to be combined with the composition to form a CWF. Some of these trace elements are Iron oxide, Potash, and Titanium IV oxide.

3.1.2 Formulation through Oxide Analysis using XRF Results

Table 2. Different mixture composition

Mixture No.	Code	Percent Composition		
		Caniangan Clay	RHA	Eggshell
1	F1	100	0	0
2	F2	95	5	0
3	F3	85	10	5

Note: The water percentage will be based on the total solid loading.

Three different formulations or mixtures, as presented in Table 2, are used in the filtration system by the study, each being formulated with different percentages of component materials with same amount of water of 40% of the total loading. The percentages were calculated based on the principles of proximate and ultimate analysis, traditionally applied to assess the composition of materials.

3.2 Determining the Physical Properties of Ceramic Filter Media

In this study, the formulations for the ceramic filter media were developed through a trial-and-error approach using the oxide analysis data, converting ultimate to proximate values to guide the proportioning of raw materials. All three formulations were fabricated by slip casting to shape the filter media, producing cast ceramic bodies that were initially air-dried for one day to remove surface moisture and then oven-dried at 80°C for one hour to reduce internal moisture content before firing. Initial volume and mass measurements were recorded as baseline data, after which the dried specimens were carefully packed and transported to Lopez Jaena, where firing was carried out by the third-party service provider Mamalita House of Pottery using traditional pottery practices without controlled firing parameters or documented firing curves. The ceramics were fired for one day and then left to cool on its own for another day. After cooling, the fired ceramic bodies were shipped back to the Northwestern Mindanao State College of Science and Technology (NMSCST) for fired property measurement and additional testing.

The fired samples were then evaluated for physical properties (shrinkage, water absorption, and weight loss) and their structural integrity was assessed by checking whether the specimens remained intact after firing, and based on the combined results for physical performance and structural soundness, the most suitable formulation was selected for subsequent filtration experiments, including flow-rate measurement and water-quality testing.

Three formulations (F1: 100% Caniangan clay; F2: 95% clay and 5% RHA; F3: 85% clay, 10% RHA, and 5% eggshell) were evaluated for shrinkage, weight loss, and water absorption using three specimens per mixture. F2 showed the highest shrinkage at about 20%, indicating a dense, clay-rich body that experienced significant contraction during drying and firing. F3 displayed slightly lower shrinkage at about 18%, likely moderated by the burning of organic components that generated pore spaces, while F1 exhibited shrinkage but ultimately cracked during firing and was deemed unsuitable.

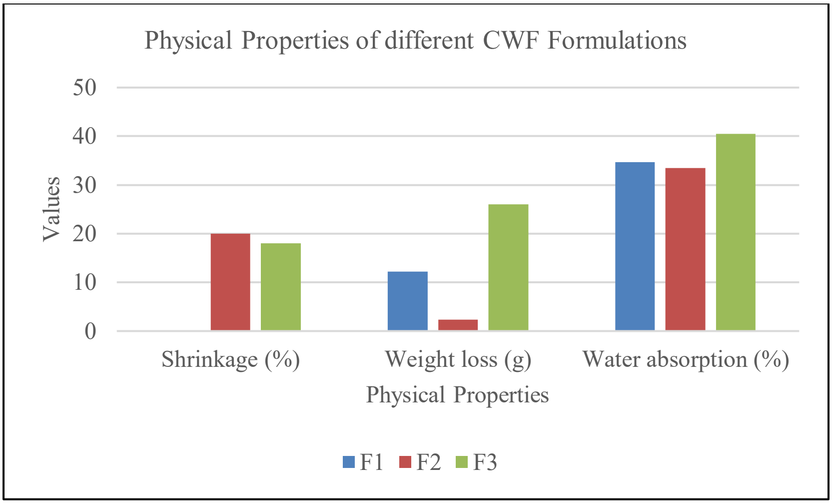


Figure 7. Physical properties of different formulations

Weight loss upon firing reflected removal of moisture and combustion of organic matter. As presented in the Figure 7, F3 had the greatest weight loss (about 26 g), consistent with its higher content of organic-derived additives and the development of a highly porous structure. F2 showed the lowest weight loss (about 2.36 g), indicating relatively limited burnout and a more compact matrix, whereas F1 had moderate weight loss (about 12.2 g) but failed due to cracking. Water absorption ranged from about 33.47% for F2 to 40.45% for F3, with F1 exhibiting intermediate absorption (34.66%) but poor structural stability. These values lie within the 25–45% range often reported for porous ceramic filters, suggesting that the mixtures achieved porosity suitable for filtration applications while highlighting the trade-off between strength and permeability.

From the Table 3 below, among the three formulations, F2 offered the most favorable balance of shrinkage, weight loss, and water absorption, making it the most promising candidate for use as a CWF. This finding is consistent with earlier studies that reported improved performance for clay-based filters when silica-rich agricultural residues were blended in moderate amounts to control porosity and avoid excessive weakening of the ceramic body.

Table 3. Summary of the physical properties

Mixture code	Sample No.	Composition (Clay:RHA: eggshell, %)	Shrinkage (%)	Weight loss (g)	Water absorption (%)
F1	S1	100:0:0	N/A	11.8	34.3
F1	S2	100:0:0	N/A	12.2	34.7
F1	S3	100:0:0	N/A	12.6	35
Average			N/A	12.20	34.66
Std. Dev.			N/A	0.40	0.35
Range			N/A	0.8	0.7
F2	S1	95:5:0	19.43	2.01	32.98
F2	S2	95:5:0	20.87	2.78	33.89
F2	S3	95:5:0	19.70	2.29	33.54
Average			20.0	2.36	33.47
Std. Dev.			0.77	0.39	0.46
Range			1.44	0.77	0.91
F3	S1	85:10:5	17.21	24.83	39.72
F3	S2	85:10:5	18.96	27.12	40.91
F3	S3	85:10:5	17.83	26.05	40.72
Average			18.0	26.00	40.45
Std. Dev.			0.89	1.15	0.64
Range			1.75	2.29	1.19

3.3 Filtration System and Water Test

3.3.1 Flow Rate and Water Quality

Flow rate testing was performed using tap water from the NMSC campus as influent, with the Mixture 2 filter (F2) installed in the collapsible container. Effluent volume was recorded at selected time intervals, and instantaneous flow rate was estimated from the change in volume over time. At 10 minutes, the collected effluent volume was about 100 mL, corresponding to an initial flow of approximately 10 mL/min. At 30 minutes, the effluent volume increased to around 450 mL, with a flow rate of about 15 mL/min. By 60 minutes, total effluent reached about 850 mL, and the flow rate slightly decreased to around 14 mL/min. Overall, the system delivered roughly 0.45 L in 30 minutes (0.9 L/h) or almost 1 liter an hour under the test conditions. The results depicted in Table 4 and presented in Figure 8.

The measured flow rate lies within the lower part of the range commonly reported for household ceramic filters, which often deliver between 0.5 and 3 L/h depending on pore structure and driving head. This suggests that further optimization of pore size and connectivity could increase throughput without compromising structural integrity. In many community-based applications, a lower but steady flow may still be acceptable if water can be collected over time.

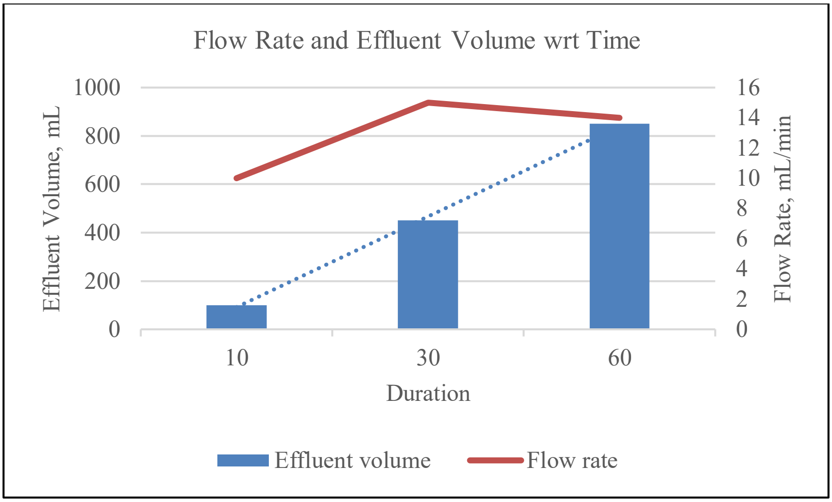


Figure 8. Volumetric flow rate of F2 CWF

Table 4. Summary of the water flow rate

Time (min)	Effluent volume (mL)	Flow rate (mL/min)
10	100	10
30	450	15
60	850	14
Average		13

For water-quality analysis, the influent pH was 7.15 and the effluent pH was 7.09, indicating that the filter did not significantly alter the acidity or alkalinity of the water and both values fell within the acceptable range of 6.5–9.5 for drinking water. Total dissolved solids decreased from 1543.8 mg/L in the influent to 67.1 mg/L in the effluent, corresponding to a reduction of approximately 95.6%. This substantial decrease in TDS demonstrates the filter's ability to remove dissolved species and improve overall water quality, in line with findings from other clay-based ceramic filters developed for household use.

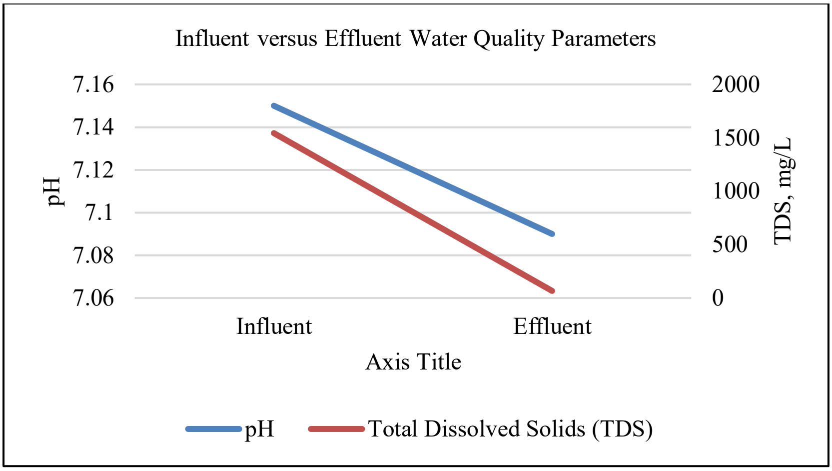


Figure 9. Water quality test results for filtered water in terms of pH and TDS

However, the *Escherichia coli* test, which tests for dangerous bacteria, was not conducted because no equipment was used to test it. Nevertheless, the results of the pH and TDS, shown in Figure 9, indicate that the water filter enhanced the quality of the water and made it safe for consumption. Additional tests, particularly for bacteria, would be required to determine the overall safety of the water. The results indicate improved physicochemical water quality; however, microbiological safety cannot yet be confirmed.

Because testing was conducted using a limited number of specimens and a single influent water source, the reported values represent indicative performance rather than population-level estimates. Variability in firing temperature, raw material heterogeneity, and head pressure may contribute to differences in flow rate and absorption observed across ceramic filters. However, the consistency of measurements across replicate specimens suggests that the reported trends are robust within the scope of this developmental study.

3.4 Responses of Respondents Regarding the Design and Acceptability

The distribution of respondents shown in Table 5 that the expert panel was composed of three Civil Engineers and two Civil Technology instructors, giving a total of five evaluators. This composition indicates that a slight majority of the assessors came from professional civil engineering practice, complemented by specialists in civil technology instruction.

Table 5. Distribution of respondents

Item No. Group	Respondents	No. of Respondents
1	Civil Engineers	3
2	Civil Technology Instructors	2
Total		5

Note: These respondents are mainly made up of NMSCST faculties

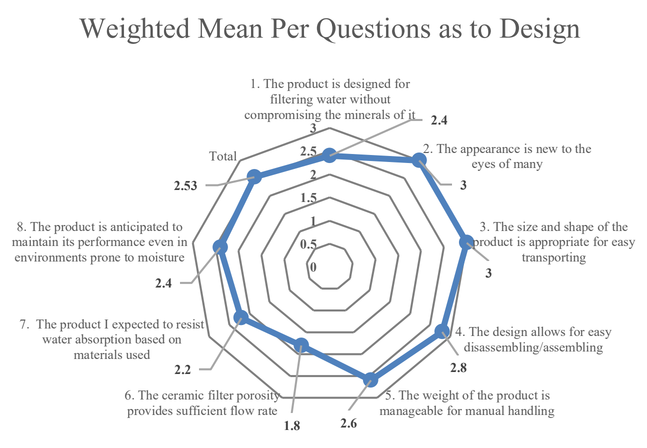


Figure 10. Weighted mean of response on product as to the design

Figure 10 above shows the results of the expert assessment of the CWF we designed against eight parameters. For Parameter 1, regarding the filter's ability to purify water without compromising its mineral content, experts rated it 2.40, interpreted as "very acceptable." Parameter 2, concerning the product's novel appearance, received a perfect score of 3.00, also classified as "very acceptable." Similarly, Parameter 3, which assessed the size and shape for ease of transport, also scored 3.00. In Parameter 4, where the ease of dismantling and assembling the design was considered, the product was scored 2.80. Parameter 5, the weight of the product for manual lifting, was scored 2.60. For Parameter 6, measuring the porosity and flow rate of the ceramic filter, professionals assigned a low rating of 1.80, ranked "acceptable." Parameter 7, which referenced the product's water absorption resistance based on the material, ranked at 2.20, likewise "acceptable." Finally, Parameter 8, which gauged stability in performance at high humidity environments, ranked at 2.40. The total weighted mean of all the parameters was 2.53, which means that the product is "very acceptable." Additionally, it was established that the blend of Caniangan clay and RHA in the ceramic filter is new since no previous studies were identified that utilized both materials.

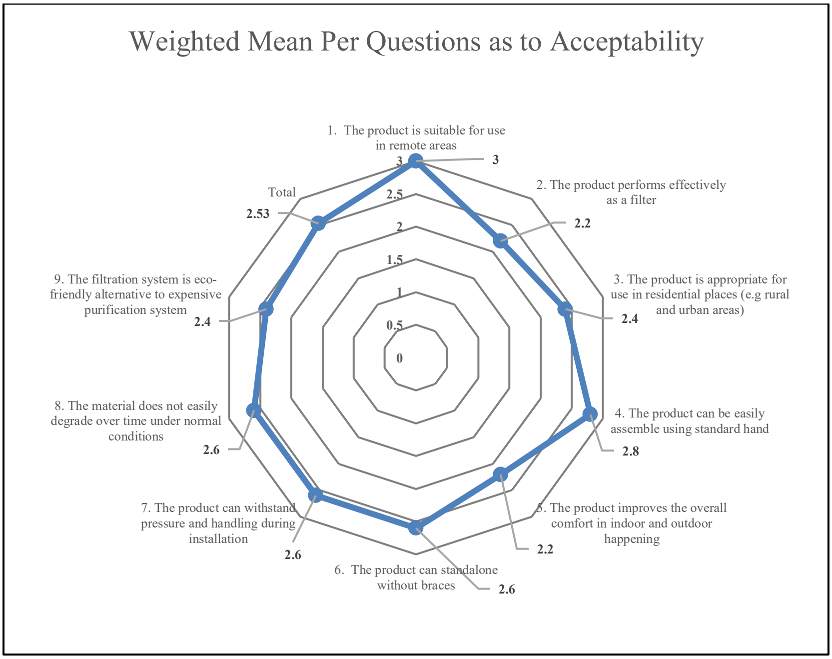


Figure 11. Weighted mean of response on product as to the acceptability

Figure 11 shows the outcome of the expert appraisal of the CWFS on the basis of nine factors. For Parameter 1, determining the product's acceptability to be used in remote locations, the experts assigned a rating of 3.00, or "very acceptable." Parameter 2, which determines the filter's effectiveness, was rated at 2.20 or "acceptable." For Parameter 3, determining appropriateness for residential use both in rural and urban settings, the rating was 2.40, or "very acceptable." Parameter 4, determining ease of assembly with standard tools, was rated at 2.80, or "very acceptable" rating. In Parameter 5, examining the product's effect on general comfort in both indoor and outdoor environments, the rating was 2.20 or "acceptable." For Parameter 6, which tests the product's stand-alone capability without support, experts gave it a rating of 2.60 or "acceptable." Parameter 7, which deals with durability when being handled and installed, also had a rating of 2.60, which is "very acceptable." In Parameter 8, which tests material stability under regular conditions, the experts again rated it 2.60. Finally, Parameter 9, which gauges the system as an environmentally friendly substitute to expensive purification systems, earned a 2.40 or "very acceptable." The weighted mean was estimated to be 2.53, showing that the product is, in general, "very acceptable" according to expert rating.

4. Conclusion and Recommendation

This study demonstrated that locally available Caniangan clay and RHA can be used to produce ceramic filter media suitable for a portable water filtration system through casting method as one of the methods of fabrication explained by Maury Njoya *et al.* (2024). XRF analysis confirmed that the raw materials contained the necessary oxides, with Caniangan clay providing silica and alumina, RHA supplying a high silica content, and eggshells contributing calcium oxide to promote fluxing during firing. Three formulations were prepared, and Mixture 2 (95% clay and 5% RHA) exhibited the most favorable overall performance, combining shrinkage of about 20%, which is comparable to the filter reported by Yanu *et al.* (2023), with a weight loss of 2.36 grams, water absorption of approximately 33.47%, and acceptable structural stability.

This study showed that the Mixture 2 filter, when integrated into a simple, low-cost portable filtration unit, achieved a flow rate of about 0.90 L per hour, a value slightly lower than those reported for similar filters by Zereffa and Zeleke (2020), and nearly within operational range where effective bacterial removal has been demonstrated in ceramic filters as Pérez-Vidal *et al.* (2019) reported; yet it still significantly improved water quality by reducing total dissolved solids from 1543.8 mg/L to 67.1 mg/L while keeping pH within the acceptable range for drinking water. Expert evaluations gave the filter and the overall system an average rating of 2.53 (“very acceptable”), emphasizing strengths in design, portability, and suitability for developing communities, while also indicating that further improvements in flow behavior and long-term performance assessment are needed. By relying on local clay and agricultural residues as key raw materials, the system enhances resource efficiency and waste valorization, supporting broader goals for sustainable, decentralized water purification solutions. This is supported by the effectiveness of ceramic filtration systems in removing microorganisms from water (Goswami & Pugazhenthi, 2020).

Direct evidence of bacterial removal was not obtained in this phase, underscoring the need for future microbiological testing and more controlled firing and formulation optimization. Nevertheless, the present results provide a solid foundation for further development and scaling of a community-based CWFS that can help address drinking water challenges in rural settings.

Future work should address limitations from uncontrolled traditional kiln firing (estimated 900–1000 °C), limited sample sizes, and absence of microbiological testing by implementing temperature-monitored firing, broader formulations with larger samples, and comprehensive bacterial removal validation (e.g., *Escherichia coli*) under field conditions. Long-term studies must also assess durability, cleaning efficacy, biofilm growth, and user behavior impacts. Regular maintenance weekly brushing/rinsing when flow decreases following established ceramic filter protocols (Meierhofer *et al.*, 2018) will ensure sustained performance, positioning this locally-sourced system as a validated, sustainable solution for rural drinking water challenges.

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