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EMPOWERING SCHOOL SANITATION POST-DISASTER: WATER FILTER DEVELOPMENT AND THE ECONOMIC VALUE OF LEMONGRASS SOAP PRODUCTION IN MIS BI AL-NAZHAR, LANGKAT REGENCY

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Abstract

MIS BI Al-Nazhar, a primary school in Kecamatan Tanjung Pura, Kabupaten Langkat, North Sumatra, faces persistent water and sanitation challenges in the aftermath of local disaster events, as its groundwater source is contaminated by salt intrusion and bacterial contamination originating from brackish soil. This community service program, entitled "Empowering School Sanitation Post-Disaster: Development of Water Filters and Soap Production in MIS BI Al-Nazhar, Langkat Regency," was designed to strengthen the school's sanitation resilience through the development of a simple household-scale water filtration system and training in lemongrass (sereh) soap production. The program was implemented in four stages: introduction and socialization, technology transfer and installation, hands-on training and mentoring, and monitoring and evaluation. A two-tank filtration system equipped with silica sand, manganese greensand, and activated carbon media, supported by a 3-way valve and a bypass line, was installed to reduce turbidity, iron and manganese content, odor, and taste in the school's water supply. In parallel, teachers and students were trained to produce lemongrass soap from palm oil, soybean oil, and citronella extract through the saponification process using NaOH. A production feasibility analysis showed that the cost of goods sold (Harga Pokok Produksi/HPP) of the soap was Rp4,056.89 per bar, generating a profit of Rp943.11 per bar at a selling price of Rp5,000, with a break-even point (BEP) of approximately 559 bars per month. The program is expected to improve access to safe water, strengthen hygiene behavior among students and teachers, and open an economically sustainable micro-enterprise opportunity for the school community.

Keywords: water filter; school sanitation; lemongrass soap; post-disaster recovery.

1. Introduction

Access to clean water and adequate sanitation is a basic human right and one of the primary determinants of public health, yet many regions in Indonesia, particularly those affected by disaster, continue to struggle in securing reliable access to safe water sources. The World Health Organization reports that inadequate water, sanitation, and hygiene contribute to a substantial global burden of disease, with children in developing countries disproportionately affected (World Health Organization, 2020). Contaminated water sources are strongly associated with diarrheal disease, cholera, dysentery, hepatitis A, and typhoid, underscoring the urgency of household- and institution-level water treatment interventions.

In Kabupaten Langkat, this challenge is particularly evident in the vicinity of MIS BI Al-Nazhar. The school is located in an area with a distinctive geographical characteristic: its groundwater is frequently contaminated by salt and bacteria originating from brackish soil. Although boreholes have been drilled as an alternative water source, not every borehole yields water of acceptable quality, forcing students and staff to rely on water whose safety cannot be guaranteed (Bennett & Arifin, 2022). Evidence from post-disaster settings shows that exposure to poor-quality water increases the incidence of skin irritation, dermatitis, and other dermatological conditions among school-age children, in addition to gastrointestinal illness (Bennett & Arifin, 2022).

Beyond the physical health implications, inadequate sanitation infrastructure also affects the learning environment. Prior studies indicate that students exposed to unhealthy school environments tend to have lower academic performance and higher rates of absenteeism (Mahmud & Sari, 2021; Husnain et al., 2020). A systematic review of household water treatment technologies further emphasizes that the effectiveness of any water treatment method in removing microorganisms varies considerably depending on the technology used, the initial water quality, the type of microorganism present, and how consistently the technology is used and maintained (Rao et al., 2025). This finding highlights that a clear, visually appealing glass of water is not, by itself, evidence of microbiological safety, and that appropriate technology must be paired with correct usage and routine maintenance to be effective.
Simple multi-stage filtration systems combining sedimentation, iron/manganese removal, and activated carbon adsorption have been widely documented as a cost-effective option for rural and disaster-affected communities where centralized water treatment infrastructure is unavailable (Kumar & Singh, 2021; Yusuf, 2021; Rizky & Saleh, 2023). In parallel, soap production training has been recognized as an effective vehicle for reinforcing hygiene education in schools while simultaneously introducing a marketable skill with income-generating potential for the surrounding community (Sari & Rini, 2020). Citronella (sereh wangi/Cymbopogon nardus) oil, in particular, contains bioactive compounds such as citronellal, geraniol, and citronellol that provide antiseptic, antifungal, and antibacterial properties, making it a suitable natural additive for hygiene soap intended to counter body odor, excess oil, and acne-causing bacteria.

Building on these considerations, this community service program was designed to provide an integrated response to both the water-access and sanitation-education needs of MIS BI Al-Nazhar. The program combined (1) the design, installation, and operational training of a simple two-tank water filtration system, and (2) hands-on training in lemongrass soap production, including a cost-of-production (HPP) and break-even point (BEP) analysis so that the resulting soap could be developed into a small, sustainable school- or community-based enterprise. The program also supports the achievement of several Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-Being), SDG 4 (Quality Education), and SDG 6 (Clean Water and Sanitation).

2. Methods

This community service activity was implemented at MIS BI Al-Nazhar, located at Jl. Pembangunan, Desa Pekubuan, Kecamatan Tanjung Pura, Kabupaten Langkat, Sumatera Utara, over a period of approximately six months, as an international collaboration between the Faculty of Vocational, Universitas Sumatera Utara and the Faculty of Hotel and Tourism Management, Universiti Teknologi MARA (UiTM) Cawangan Pulau Pinang, Malaysia. The implementation followed four main stages, as summarized below.

2.1 Introduction, Socialization, and Focus Group Discussion

The activity began with an introductory session and Focus Group Discussion (FGD) involving the school principal, teachers, and the community service team (Figure 1). This stage was used to explain the objectives and expected benefits of the program, to observe first-hand the condition of the school's existing water source, and to gather input from the school regarding the specific sanitation challenges it faced, including the salinity and bacterial contamination of its groundwater.



Figure 1. Initial visit and Focus Group Discussion of the community service team with the principal and teachers of MIS BI Al-Nazhar

2.2 Water Filter Technology Transfer and Installation

A simple two-tank water filtration system was designed, procured, and installed at the school. The design, specifications, and materials used are described in detail in Section 3.2. The team also delivered a technical explanation of the function of each component to ensure that school staff could operate and maintain the system independently.

2.3 Soap Production Training

Teachers and students participated in hands-on training on the production of lemongrass (sereh) soap using the cold-process saponification method. The training covered the preparation of raw materials, the safe handling of sodium hydroxide (NaOH), the mixing procedure, molding, and curing, as detailed in Section 3.4. This stage also included a short seminar on determining the cost of goods sold (HPP), selling price, and break-even point (BEP) so that participants could evaluate the economic feasibility of continuing production as a small enterprise.

2.4 Sanitation and Clean and Healthy Living Behavior (PHBS) Education

Interactive sessions on sanitation and Perilaku Hidup Bersih dan Sehat (PHBS) were delivered to students to reinforce the link between water quality, handwashing practices, and disease prevention, using the newly installed filter and the soap produced by participants as concrete teaching aids.

2.5 Monitoring and Evaluation

The team conducted monitoring of the filter system's operation and the participants' soap-making practice, supplemented by pre- and post-training questionnaires to measure changes in participants' understanding of sanitation and hygienic soap production. Results from this stage informed the recommendations presented in Section 4.

3. Results and Discussion

3.1 Water Quality Condition at MIS BI Al-Nazhar

Field observation confirmed that the school's groundwater source is affected by salt intrusion and bacterial contamination associated with the brackish characteristics of the local soil. Clarity alone was found to be an unreliable indicator of safety: water that appeared visually clear was not necessarily free of harmful microorganisms, consistent with findings that the effectiveness of water treatment against bacteria, viruses, and protozoa varies according to technology type, source water quality, and usage practice (Rao et al., 2025). This condition directly affected students' access to water for drinking, ablution, and general hygiene, and was compounded by the school's limited prior understanding of sanitation and PHBS.

3.2 Design and Installation of the Water Filter System

The water filtration system installed at MIS BI Al-Nazhar consists of two filter tanks arranged in series, equipped with a 3-way valve and a bypass line to simplify operation and maintenance (Figure 2). Tank 1 contains silica sand media that filters coarse particles and sediment, while Tank 2 contains manganese greensand to remove iron (Fe) and manganese (Mn), layered with activated carbon to remove odor and taste. The bypass line allows water to continue flowing to the school without passing through the filter tanks whenever the system requires servicing. The main components of the system are summarized in Table 1.

Table 1. Main components of the two-tank water filtration system

No.	Component	Function
1	Tank 1 — Silica Sand	Filters coarse particles and sediment from raw water.
2	Tank 2 — Manganese Greensand	Removes dissolved iron (Fe) and manganese (Mn).
3	Tank 2 — Activated Carbon	Removes odor, taste, and residual organic compounds.
4	3-Way Valve	Switches the system between Filter, Backwash, and Fast Rinse modes.
5	Bypass Line	Allows water use without passing through the filter tanks during maintenance.

The 3-way valve provides three operating modes. In Filter mode, water flows sequentially through both tanks under normal daily use, with particles, iron, manganese, odor, and taste removed in stages to produce water suitable for

everyday needs. In Backwash mode, the flow direction is reversed to lift and flush accumulated dirt out of the filter media, which should be performed at least once every one to two weeks, or sooner if water flow weakens or the filter feels clogged. Fast Rinse mode is used immediately after backwashing to rinse residual fine particles from the media until the rinse water runs clear, after which the valve is returned to Filter mode for normal use. This operational logic is consistent with best practice for household-scale iron/manganese removal filters reported in the literature (Kumar & Singh, 2021; Yusuf, 2021).



Figure 2. Installation of the two-tank water filtration system at MIS BI Al-Nazhar

3.3 Operation and Maintenance Guidance

To support the long-term sustainability of the filter system, the team compiled a set of maintenance guidelines for the school, summarized in Table 2. Regular maintenance is critical, since a systematic review of 396 studies on household water treatment technologies found that even effective filtration technologies can lose their microbiological performance if not properly used and maintained (Rao et al., 2025).

Table 2. Recommended maintenance schedule for the water filter system

No.	Maintenance Action	Recommended Frequency
1	Backwash the filter media	Every 1–2 weeks, or when flow weakens/media appears dirty
2	Fast rinse after backwashing	Every time after a backwash cycle, until rinse water is clear
3	Check valves and pipe connections	Periodically, to ensure no leaks
4	Monitor filter media condition (silica sand, manganese greensand, activated carbon)	Periodically; replace media when saturated or when turbidity/odor removal declines
5	Monitor water pressure via manometer	Periodically, to detect early clogging
6	Keep the installation area clean and dry	Ongoing

3.4 Lemongrass (Sereh) Soap Production Training

Soap production training was conducted using palm oil and soybean oil as the base fats, saponified with sodium hydroxide (NaOH) dissolved in distilled water (aquadest), with citronella extract added for its antiseptic and aromatic properties. The tools and materials used in the training are listed in Table 3.

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Table 3. Tools and materials for lemongrass soap production

Tools	Materials	Quantity
Beaker glass	Distilled water (aquadest)	300 mL
Measuring cylinder	Sodium hydroxide (NaOH)	90 g
Hand blender	Palm oil	280 mL
Plastic container	Soybean oil	200 mL
Spatula	Citronella (lemongrass) extract	60 mL

The production procedure followed ten sequential steps: (1) preparing all tools and materials; (2) dissolving NaOH into the distilled water to form the lye solution; (3) combining the palm oil and soybean oil in a mixing container; (4) blending the oils thoroughly using a hand blender; (5) gradually adding the NaOH solution into the oil mixture; (6) mixing continuously until evenly combined; (7) adding the citronella extract; (8) blending all ingredients until the mixture reaches a thickened, trace consistency; (9) pouring the mixture into soap molds; and (10) allowing the soap to cure and harden before unmolding and curing further for use (Figure 3). Participants were guided through each step and were able to produce their own soap bars, which strengthened both their technical confidence and their understanding of how citronella oil's antiseptic, antifungal, and antibacterial properties contribute to body-odor control, oil control, and acne prevention when incorporated into a bath soap.



Figure 3. Hands-on lemongrass soap production training with students and student assistants

3.5 Production Cost and Business Feasibility Analysis

To support the sustainability of the soap-making activity as a potential micro-enterprise for the school community, the team calculated the cost of goods sold (Harga Pokok Produksi/HPP) and the break-even point (BEP) for the lemongrass soap. Based on an assumed production volume of 50 bars per day (1,500 bars per month), the fixed cost per bar was calculated by dividing the total monthly fixed cost of Rp839,542 — comprising equipment depreciation, utilities, and labor — by the monthly production volume, resulting in a fixed cost of Rp559.69 per bar. The variable cost per bar, consisting of raw materials and packaging, is summarized in Table 4.

Table 4. Variable cost per bar of lemongrass soap

Raw Material / Component	Cost per Bar (Rp)
Palm oil	641.20
Soybean oil	896.00
NaOH	270.00
Citronella (lemongrass) oil	1,140.00
Distilled water	150.00
Total raw material cost	3,097.20
Packaging	400.00
Total variable cost	3,497.20

The results of this cost analysis, along with the recommended selling price, were presented back to the school community in a dedicated socialization session (Figure 4) to ensure that teachers and prospective soap producers understood how the numbers were derived and how they could be used to set a fair and sustainable price. Combining the fixed and variable costs, the cost of goods sold (HPP) was calculated as Rp3,497.20 + Rp559.69 = Rp4,056.89 per bar. At a proposed retail price of Rp5,000 per bar, this yields a profit of Rp943.11 per bar, or a profit margin of approximately 18.86%. If the full monthly production of 1,500 bars were sold, the potential monthly profit would reach approximately Rp1,414,665. The break-even point (BEP), calculated as fixed cost divided by the difference between selling price and variable cost per bar (Rp839,542 ÷ (Rp5,000 − Rp3,497.20)), was found to be approximately 559 bars per month, or roughly 56 mold-batches per month at 10 bars per mold. These figures, summarized in Table 5, indicate that the lemongrass soap enterprise is financially feasible at a realistic production scale, consistent with prior findings that soap-making training in schools can generate both hygiene benefits and household income (Sari & Rini, 2020).

Table 5. Summary of HPP, selling price, and break-even point for lemongrass soap

Component	Value
Fixed cost	Rp839,542 / month
Selling price	Rp5,000 / bar
Variable cost	Rp3,497.20 / bar
Contribution margin	Rp1,502.80 / bar
Cost of goods sold (HPP)	Rp4,056.89 / bar
Profit per bar	Rp943.11 / bar (≈18.86% margin)
Break-even point (BEP)	≈559 bars / month



Figure 4. Socialization session with the school community, including the presentation on cost of goods sold (HPP) and business feasibility of the soap enterprise

3.6 Business Model Overview

To help the school community translate the training into a sustainable venture, a simple Business Model Canvas was developed together with participants. The target customer segments identified were students, teachers, parents, and the surrounding community; the value proposition centered on a hygienic, practical, and affordably priced soap with added economic value; and the primary distribution channels identified were direct sales at school, community networks, and WhatsApp/social media promotion. Revenue was projected to come from unit and bundled-package sales, with key resources comprising raw materials, production equipment, packaging, labor, and working capital, and key partnerships including the school, the local women's community group (PKK), suppliers, and sales partners. Profits from initial sales were recommended to be reinvested as production capital to sustain and gradually expand the enterprise.

3.7 Discussion

The results of this program demonstrate that a relatively low-cost, two-stage filtration system can be a practical solution for schools situated in areas with saline or bacterially contaminated groundwater, provided that operation and maintenance are properly understood by school staff (Kumar & Singh, 2021; Rizky & Saleh, 2023). At the same time, the program reinforces the point that a filter is not a one-time fix but requires consistent operational discipline — regular backwashing, rinsing, and media monitoring — to sustain its performance over time, echoing the broader finding that treatment effectiveness depends heavily on correct and consistent use (Rao et al., 2025). The integration of soap production training with a concrete cost and break-even analysis further extends the program's benefit beyond hygiene education alone, giving participants a replicable pathway to convert a health-oriented skill into household income, consistent with previous school-based soap training initiatives (Sari & Rini, 2020). Taken together, the water filter and soap-production components complement one another: the filter secures a safer water source for daily use and soap production, while the soap itself, made partly from the same clean water, becomes both a hygiene tool and a small income-generating product for the school community. Improved water access and sanitation practices of this kind are also expected to reduce water-related illness and school absenteeism, in line with earlier evidence linking clean water and sanitation access to better health and educational outcomes (Mahmud & Sari, 2021; Husnain et al., 2020; Wolf et al., 2014).

4. Conclusion

The Empowering School Sanitation Post-Disaster program successfully introduced a simple, low-cost two-tank water filtration system and a lemongrass soap production enterprise at MIS BI Al-Nazhar, Kabupaten Langkat. The filtration system, consisting of silica sand and manganese greensand/activated carbon media supported by a 3-way valve and bypass line, was shown to be a feasible solution for improving water quality in an area affected by saline and bacterial groundwater contamination, provided that routine backwashing, rinsing, and media monitoring are maintained. The lemongrass soap production training not only strengthened participants' hygiene practices but was also shown, through HPP and BEP analysis, to be economically viable, with a selling price of Rp5,000 per bar yielding a profit margin of approximately 18.86% and a break-even point of around 559 bars per month. Overall, the program contributes to improved school sanitation, healthier learning environments, and a pathway toward

sustainable, community-driven economic empowerment, and may serve as a replicable model for other post-disaster school communities facing similar water and sanitation challenges.

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