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Simple Downflow Water Filtration System in Sasake Village

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Abstract: The availability of clean water needs to be a special concern in the community, because there are several cases in various regions in Indonesia where the availability of clean water sources becomes difficult to obtain during the long dry season, one of which is in the West Nusa Tenggara region, specifically in Sasake Village, Praya Tengah District, Central Lombok Regency. The main water source used in Sasake Village is PDAM water. However, in recent years, several villages in Central Lombok Regency have experienced drought, making it difficult to obtain clean water. The BPBD of Central Lombok Regency must prepare clean water at the peak of the dry season for several villages, including Sasake Village. Alternative water sources in Sasake Village are wells and the Batujai Reservoir. However, at the peak of the dry season, the water in several wells becomes cloudy and smelly, so residents cannot use it as clean water. This community service initiative seeks to implement a user-friendly downflow water filtration system designed for community-level ownership, operation, and maintenance. The design of this filter uses a 4" PVC pipe containing filter media, including sand, palm fiber, charcoal (activated carbon), and cotton. This physical water purification process excludes chemical and biological reactions, relying instead on gravity-driven separation of suspended solids from the fluid phase. Based on the filtering results, it is known that this tool can reduce turbidity concentration by 69.3% and eliminate odors. According to the evaluation results of the counseling participants, there has been a significant increase in understanding of simple water filtration methods. Counseling regarding this water filtration tool is crucial so that the community can overcome clean water problems independently.

Keywords: Down Flow Water Filtration, Sand, Palm Fiber, Charcoal, Cotton.

Introduction

Water is the most important compound for the survival of living things known today. Nearly 71% of the Earth's surface is covered by water, while an adult human body contains approximately 60-70%. Water serves a wide range of human needs, including consumption, hygiene, domestic use, food preparation, and irrigation. This is the reason why water is so important for the survival of living things on Earth. Clean water is water that is colorless, tasteless, odorless, clear, and has a temperature preferably below the air temperature to create a comfortable feeling. Clean water refers to water that is safe for consumption, typically rendered potable through boiling or other purification methods (Peraturan Menteri Kesehatan Republik Indonesia No.416 Tahun 1990). An alternative definition of clean water refers to water that meets established health standards, including being odorless and tasteless, having a pH between 6.5 and 8.5, and a temperature within ±3°C, free from Escherichia coli contamination (Kepmenkes RI, 2022) . Theoretically, clean water should be free from potential contamination by bacteria and from chemical substances that pose risks to human health (Salilama et al., 2018).

The definition of clean water is water used for daily needs whose quality meets health requirements and can be drunk after being cooked (Peraturan Menteri Kesehatan No. 416 Tahun 1990). Drinking water is defined as water that meets established health standards and is safe for direct human consumption. However, the new definition no longer differentiates between the

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definitions of clean water and drinking water (Peraturan Menteri Kesehatan Republik Indonesia No.492 Tahun 2010). The provided definition pertains solely to drinking water, characterized as water that complies with health standards and is safe for direct consumption. A good clean/drinking water supply system must aim to 1. Provide water of safe and healthy quality for its users, both individuals and communities; 2. Provide water in adequate quantities; 3. Provide water continuously, easily, and cheaply to support the health of individuals and the general public. Water quality is the suitability of water for various uses or specific processes (Yuliani & Rahdriawan, 2014). "Access to clean water warrants particular attention within communities, as several regions across Indonesia face challenges related to the availability of safe and ready-to-use water sources—such as in Sasake Village, Praya Tengah District, Central Lombok Regency, West Nusa Tenggara. Due to dense settlements, the Batujai Reservoir, and Zainul Abdul Madjid International Airport, river water has become yellow, cloudy, and thick, making it unsuitable for use. Meanwhile, river water is the primary source of water for residents, including bathing, washing clothes, cooking utensils, and other purposes.

The availability of clean water remains a critical concern for communities, particularly in countries like Indonesia, where numerous regions face persistent challenges in accessing reliable and safe water sources (Rosidi, 2022). One example is Sasake Village, Praya Tengah District, Central Lombok Regency, West Nusa Tenggara (Figure 1).

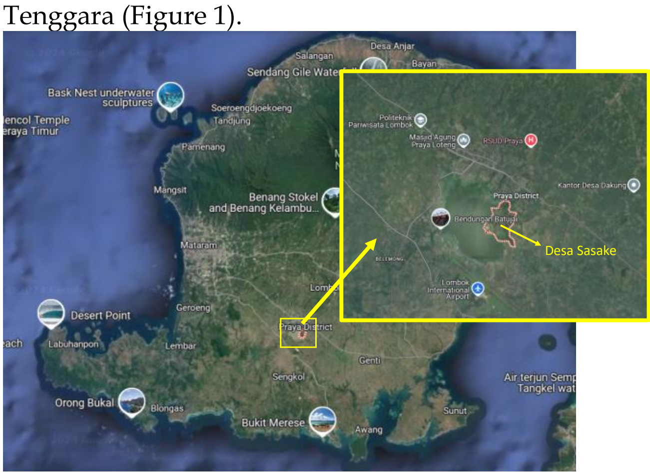

Figure 1. Location of Sasake Village

In this village, dense settlements, along with the presence of the Batujai Reservoir and Zainul Abdul Madjid International Airport, have caused the river water to become yellow, cloudy, and thick, making it unsuitable for use. However, river water is the primary source for residents for daily activities such as bathing, washing clothes, and washing kitchen utensils.

To support the residents of Sasake Village in addressing clean water challenges, several alternative solutions are available. One of them implements water filtration systems. This method is often used both with traditional and modern systems. Filtration systems work by separating or retaining solids and other unnecessary chemicals. The filtration system itself comprises several techniques, one of which is the Downflow technique. Downflow filtration is a filtration process in which water flows vertically from the bottom to the top of the filter media, resulting in the filtered water remaining above the filter media.

In response to challenges related to clean water support and prevailing economic conditions, the author initiated a community service project titled Simple Downflow Water Filtration in Sasake Village. The initiative focused on developing a portable, cost-effective, and user-friendly water treatment system that can be relocated as needed to serve other areas. This project aims to introduce the simple Downflow water purifier to the Sasake Village community and train them in the construction, operation, and maintenance of the device.

This initiative equips the community with practical knowledge and strategies for addressing clean water challenges.

Method

The Downflow system is a simple water filtration system used to filter cloudy and odorous well or river water that cannot be removed by simply boiling. This physical water purification process excludes chemical and biological reactions, relying instead on gravity-driven separation of suspended solids from the fluid phase. Water is fed into the filter with a top-to-bottom flow, utilizing the force of gravity. Generally, the wastewater treatment process with the Downflow system consists of a process unit, namely a wastewater storage tank. A water treatment unit with a Downflow slow sand filter is a complete package, where the processing capacity can be designed in various sizes according to the required needs. Typically, this filter only consists of a tank to hold water and sand filter media. This tank is equipped with a bottom channel system, inlet, outlet, and control equipment. A downflow water purification system is shown in Figure 2. This system utilizes gravity, so an adequate water column height is required to ensure a steady and smooth water flow during the filtration process. This ensures optimal water flow.

Figure 2 shows a downflow water purification system, made from an 8-inch diameter PVC pipe and equipped with four layers of filter media:

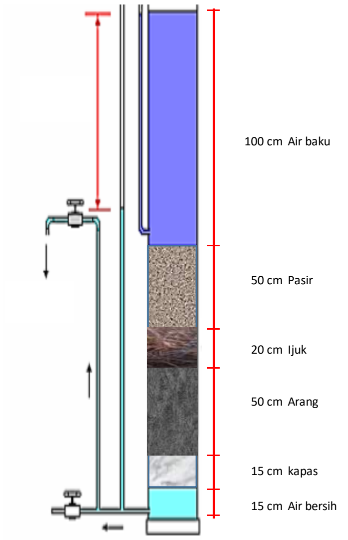

Figure 2: Downflow Water Purification

- A 50 cm thick layer of coarse sand
- A 20 cm thick layer of palm fiber
- A 50 cm thick layer of charcoal
- A 15 cm thick layer of cotton

Filter Media Materials:

1. Silica sand, or quartz sand, is a mining material consisting of silica crystals (SiO_2), usually mixed with compounds such as SiO_2, Fe_2O_3, Al_2O_3, TiO_2, CaO, MgO, and K_2O. The color of silica sand is generally clear white, but it can vary. Silica sand is often used in the wastewater treatment process to produce clean water (Mahyuddin and Nursetiawan, 2016). This sand has high resistance to weathering. During the filtration process, this sand filters out dirt particles through the cavities between the sand grains. The filtering capacity of silica sand is quite high, allowing it to remove physical properties of dirty water, such as turbidity, mud, and odor. Figure 3 shows silica sand.

Figure 3: Silica sand

2. Palm fiber is a black, hard natural fiber derived from the stem of the sugar palm. Palm fiber functions as a filter medium in the water purification process. In water filtration, palm fiber can remove fine particles when combined with other media such as sand, stones, and activated charcoal. Palm fiber also acts as a sand retainer, preventing it from passing through to the bottom layer of the filter (Sadaruddin and Nour, 2020). Additionally, due to its flexible and densely structured composition, palm fiber serves as an effective filtration medium for large particulate matter in water, efficiently capturing debris while maintaining adequate permeability for fluid flow. Usually, palm fiber is used as an additional filter medium after the dirt has been filtered and the water is free from microorganisms (Susanti, 2014). Combining palm fiber with media such as sand and gravel in a filtration system can reduce the Biological Oxygen Demand (BOD) level in slaughterhouse wastewater by up to 81.62% (Yuliani, 2018). Figure 4 shows palm fiber.

Figure 4: Palm fiber

3. Charcoal, or activated carbon, is a black, porous form of carbon obtained by burning raw materials such as coconut shells, animal bones, sawdust, and coke or coal in the absence of oxygen. Activated carbon has an amorphous structure with specific crystalline properties and large pores, which allows it to adsorb unpleasant-smelling organic compounds, colors, flavors, and non-biodegradable compounds. Activated carbon is made through a special process that opens the pores of the carbon, thereby increasing its absorption capacity. This activated carbon is known for its ability to absorb metals, gases, bleaching agents, and remove organic materials, surfactants, and odors. The absorption capacity of activated carbon is highly dependent on the amount of free carbon compounds, which ranges from 85% to 95%. In the filtration process, activated carbon works by adsorption, namely, removing pollutants through

the surface of its pores (Mifbakhuddin, 2010). Activated carbon derived from carbon-rich materials through high-temperature processing contains constituents such as ash, sulfur, bound carbon, nitrogen, and residual moisture (Khuluk, 2016). The advantages of using activated carbon as a filter medium include ease of operation because water flows well through the carbon medium, fast processing due to the larger carbon grain size, and its ability to be regenerated without sludge contamination (Asadiya and Karmaningroem, 2018). Activated carbon has a wide range of applications due to its large surface area, ease of use, and relatively affordable price. In addition to being used as a fuel, activated carbon is often used as an adsorbent or absorbent in various industries, including water treatment and waste treatment. Figure 5 shows charcoals.

Figure 5: Charcoals

4. Cotton is a vital natural fiber extensively utilized across various industries, particularly textiles, due to its biodegradability, which minimizes environmental pollution following disposal. Cotton serves as an effective water filtration medium due to its fine and densely packed fibers, which enable the capture of small particulate matter suspended in water. When water flows through a layer of cotton, dirt and particles are filtered and retained between the cotton fibers. Cotton fibers possess water-absorptive properties that enable them to attract and retain organic contaminants and microorganisms present in water. Cotton can absorb oil, chemicals, and other harmful substances, improving the quality of the resulting water. "Cotton is frequently combined with complementary filter media, such as sand, activated charcoal, and gravel, to enhance overall filtration efficiency. Cotton is a cheap and readily available material, making it an economical choice for small-scale water purification systems. The application of cotton as a filtration medium is straightforward and does not rely on advanced technology, making it well-suited for diverse settings, including resource-limited rural areas (Taufik, 2024). Figure 6 shows cotton.

Figure 6: Cotton

Implementation Stages for Addressing Clean Water Shortages in Sasake Village through the Downflow Purification System to mitigate the clean water crisis in Sasake Village, a structured approach utilizing a simple Downflow filtration system is proposed. The implementation comprises five key stages:

1) Community Engagement and Socialization

   This initial phase aims to introduce the program to the local community and foster collective support.

   Stakeholder Meetings: Convene sessions with village leaders, community representatives, and residents to communicate the program's objectives, expected outcomes, and community roles.

   Information Dissemination: Distribute educational materials—such as brochures and posters—highlighting water quality challenges and the proposed Downflow solution.

   Awareness Campaigns: Launch environmental awareness initiatives through local media channels to emphasize the importance of clean water and community participation.

2) Capacity Building and Training

   This phase focuses on equipping the community with the knowledge and skills necessary to operate and maintain the purification system.

   Technical Instruction: Deliver structured training on the Downflow system's principles, including installation procedures, operational protocols, and routine maintenance.

   Hands-On Demonstration: Facilitate live demonstrations to illustrate the purification process and reinforce practical understanding.

Training Materials: Provide comprehensive training modules as reference guides for participants, ensuring clarity and accessibility.

3) Technology Deployment
This stage involves the physical implementation of the Downflow purification system at selected locations.
Site Assessment and Selection: Identify optimal installation sites near water sources and residential clusters to maximize accessibility and impact.
System Installation: Execute the installation process with technical support from experts and active involvement of community members.
System Testing and Calibration: Conduct initial trials and calibrations to verify system performance and ensure water purification.
4) Technical Support and Performance Evaluation
Ongoing monitoring and evaluation are essential to ensure system reliability and continuous improvement.
Operational Support: Provide periodic technical assistance to guide the community in system operation and troubleshooting.
Water Quality Monitoring: Water samples shall be collected and analyzed both before and after the filtration to evaluate the effectiveness of the purification process.
Evaluation and Reporting: Perform scheduled evaluations and compile findings into reports to inform future program enhancements.
5) Program Sustainability and Institutionalization
This final phase ensures long-term functionality and community ownership of the purification system.
Formation of Local Working Group: Establish a dedicated community-based team responsible for system oversight, maintenance, and coordination.
Ongoing Capacity Development: Offer advanced and refresher training sessions to reinforce technical competencies and adapt to evolving needs.
Long-Term Monitoring Framework: Develop and implement a monitoring system to track performance, address emerging issues, and ensure sustained access to clean water.
Through this integrated and participatory approach, the clean water shortage in Sasake Village is expected to be effectively addressed. The community will benefit from improved access to safe, reliable water for daily use, fostering health, resilience, and environmental stewardship.
Steps to Addressing Clean Water Problems with a Downflow System:

a) For Economically Productive Partners
   - Production Problem Analysis: Partners are encouraged to identify constraints on clean water availability, such as declining product quality or inefficient production.
   - Downflow System Implementation: Partners are encouraged to build and explain how to build a downflow water purifier.
   - Technical Training: Partners are shown how to use and maintain the water purification system.
   - Monitoring and Evaluation: Partners are taught how to monitor system performance and evaluate its impact on production efficiency and product quality.

b) For Economically/Socially Unproductive Partners
   - Needs Identification: Partners are shown the impact of clean water shortages on public health.
   - Health Outreach: Partners are encouraged to conduct health campaigns on the importance of clean water for disease prevention.
   - Downflow System Installation: Partners are shown how to install water purifiers in various strategic locations such as homes, schools, and health facilities.
   - Education and Training: Partners are trained on how to use and maintain water purifiers.

c) Partner Participation in Program Implementation
   - Active Participation: Partners actively participate in every stage of the program, from outreach to technology implementation.
   - Working Groups: Partners form local working groups responsible for the duplication, operation, and maintenance of the water purification systems.
   - Feedback: Involve partners in providing feedback and suggestions for program improvement.

d) Evaluation of Program Implementation and Sustainability
   - Periodic Evaluation: Conduct regular evaluations of the performance of the water purification system and its impact on the community's quality of life.
   - Sustainability: Develop a sustainability plan to ensure the continued functioning of the water purifiers, including follow-up training and routine maintenance.
   - Evaluation Reports: Prepare comprehensive evaluation reports to refine and develop the program.

Result and Discussion

Community service activities regarding “Simple Down Flow System Water Filtration in Sasake Village” were carried out at State Elementary School No. 1 of

Sasake Village and were attended by the Head of Sasake Village, the Head of the Village Deliberative Body, the Head of the Environment, Babinsa, Members of the Youth Organization, and Community Representatives. Furthermore, the program engaged university students participating in the Community Service (KKN) initiative, enabling them to contribute directly to disaster mitigation efforts through active field involvement. When delivering community service materials, related matters conveyed included (1). Causes of cloudy and smelly water, (2) How to make a simple Down Flow system water filter; (3). Demonstration of water filtration. Following the presentation, the session proceeded with a facilitated discussion and a question-and-answer segment to engage participants and clarify key points (Figure 7).

Figure 7: Activity Implementation

Throughout the activity, participants demonstrated strong engagement by raising a range of issues and inquiries—particularly concerning appropriate measures to take before, during, and after clean water shortages in the dry season, as well as responses to water conditions that become turbid and malodorous. The community service activity concluded with an experiment to filter cloudy water from the Batujai reservoir. The success of this activity was demonstrated by participants' increased understanding of simple water filtration and the benefits of clean water and sanitation. This simple water education emphasized that the filtered water must be boiled at 100°C for several minutes to ensure it is free of disease-causing bacteria. It is hoped that the availability of this simple water filtration device in the community will enable them to address the problem of clean water shortages caused by cloudy and smelly water sources in their area.

To determine the success of the community service activity, initial and final tests were conducted. The results of this analysis are shown in Table 1 and Figure 8.

Table 1. Results of the comprehension test analysis

Indicators	Percentage of Comprehension Level			
	Initial Test	Percentage	Final Test	Percentage
Does Not Understand	22	65%	5	15%
Understands	12	35%	29	88%
Total	34	100%	34	100%

Table 1 indicates that a total of 34 participants took part in the comprehension assessment. Initial test results revealed that 22 participants (65%) demonstrated a lack of understanding regarding water filtration, while only 12 participants (35%) showed adequate comprehension. Following targeted interventions, including socialization, counseling, and explanatory sessions, a post-test was administered. The final results showed a marked improvement: only 5 participants (15%) remained without understanding, whereas 29 participants (88%) demonstrated clear comprehension of the water filtration concept.

Figure 8 shows a clear change in participant understanding between the initial and final assessments. In the first test, most participants lacked understanding, with fewer demonstrating adequate comprehension. However, the final test results showed a notable improvement, with more participants understanding the material compared to those who did not.

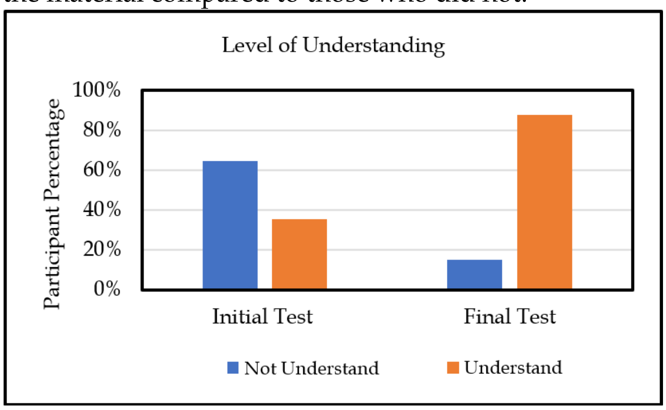

Figure 8: Activity Implementation

Conclusion

Based on the test results, the following conclusions can be drawn:

A simple downstream water filtration system, using sand, palm fiber, charcoal, and cotton, has been proven to improve river water quality in Sasake Village. Test results showed that well water, which was initially cloudy and smelled of dirty mud and therefore unfit for consumption, is now clearer and odorless. It is important to note that filtered water intended for consumption must be boiled at 100°C for a minimum of 10 minutes, in accordance with Government Regulation of the Republic of Indonesia No. 22 of 2021 on the Implementation of Environmental Protection and Management. The following water filtration media configurations and thicknesses: 50 cm of sand, 20 cm of palm fiber, 50 cm of charcoal, and 15 cm of cotton, reduced turbidity by 69.3%; TSS by 84.536%; pH by 6.51; and DO by 6.11 mg/L.

Initial assessments revealed that participants had a limited understanding of the simple filtration system, as evidenced by low performance in the initial test results. However, following a series of targeted outreach and educational activities focused on the Downflow water filtration method, community comprehension improved significantly. Overall, this community service initiative has successfully enhanced local awareness and understanding of basic water filtration practices in Sasake Village.

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