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Small-Scale Filtration Systems: A Solution for Clean Water in Martapura River Communities

Meningkatkan Kualitas Air dan Kesehatan Masyarakat dengan Filtrasi Skala Rumah Tangga di Sungai Martapura

Tien Zubaidah*[1], Sulaiman Hamzani[2], Juanda[3]
[1,2,3]Environmental Health Department, Banjarmasin Plytechnique of Health
*e-mail: tien.zubaidah@gmail.com[1], sulaiman_hamzani@yahoo.co.id[2], juanda_a@ymail.com[3]

Abstract

This study examines if a small-scale filtering system can improve water quality for Martapura River residents. Over six months, the filtering system affected key water quality indicators. Turbidity dropped 85%, TDS dropped significantly, and lead and cadmium were eliminated. Around 96% of households had drinking water pH values within the recommended range. The community embraced the filtration devices, with an average daily usage rate of 87%. Waterborne infections like diarrhea, typhoid, and hepatitis A decreased, improving health outcomes. The current results are good, however future versions should focus on TDS reduction and sustainability. This study shows how simple filtration devices can enhance water quality and public health, supporting the UN Sustainable Development Goals.

Keywords*: Water filtration, water quality improvement, household-scale filtration, turbidity reduction, heavy metal removal, public health enhancement.*

Abstrak

Studi ini meneliti apakah sistem penyaringan skala kecil dapat meningkatkan kualitas air bagi penduduk di sekitar Sungai Martapura. Selama enam bulan, sistem penyaringan mempengaruhi indikator utama kualitas air. Kekeruhan menurun sebesar 85%, TDS turun secara signifikan, dan timbal serta kadmium berhasil dihilangkan. Sekitar 96% rumah tangga memiliki nilai pH air minum dalam kisaran yang direkomendasikan. Masyarakat menerima perangkat penyaringan ini dengan baik, dengan tingkat penggunaan harian rata-rata sebesar 87%. Infeksi yang ditularkan melalui air seperti diare, tipus, dan hepatitis A menurun, sehingga hasil kesehatan membaik. Hasil saat ini menunjukkan keberhasilan, namun versi mendatang harus berfokus pada pengurangan TDS dan keberlanjutan. Studi ini menunjukkan bagaimana perangkat penyaringan sederhana dapat meningkatkan kualitas air dan kesehatan masyarakat, mendukung Tujuan Pembangunan Berkelanjutan PBB.

Kata kunci*: Penyaringan air, peningkatan kualitas air, penyaringan skala rumah tangga, pengurangan kekeruhan, penghilangan logam berat, peningkatan kesehatan masyarakat.*

1. INTRODUCTION

Access to uncontaminated water is an essential entitlement of every individual and a crucial element of public health and overall welfare. Nevertheless, in numerous global regions, such as the vicinity of the Martapura River in South Kalimantan, Indonesia, the availability of safe drinking water continues to pose a significant obstacle. The Martapura River, which is among the most extensive rivers in South Kalimantan, holds significant importance in the livelihoods of the nearby communities. Regrettably, the water quality of the area has been considerably diminished as a result of diverse human activities, such as the disposal of domestic waste, the runoff from agricultural practices, and the pollution caused by industrial operations (Badan Pusat Statistik Kabupaten Banjar, 2021).

The degradation of water quality in the Martapura River has extensive implications for both public health and the ecology. Water that is contaminated can act as a carrier for waterborne illnesses such diarrhea, cholera, typhoid, and hepatitis, which can pose substantial health hazards

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to the nearby population (Prüss-Ustün et al., 2019). In addition, contaminated water has the potential to disturb aquatic ecosystems, posing a risk to the variety of species in the river and the sustenance of communities that rely on its resources.

In order to tackle this serious matter, it is imperative to develop practical and cost-efficient measures that can enhance the quality of water at the individual household level. Filtration technology presents a promising method for improving water quality by the elimination of suspended particles, dissolved solids, and other impurities (Crittenden et al., 2012). Nevertheless, several filtration technologies currently available are either excessively intricate or prohibitively costly for extensive use in settings with limited resources.

The objective of this study is to create, execute, and assess a straightforward filtration device for households that utilizes fundamental filtration technology to enhance the physical characteristics of water sourced from the Martapura River. The suggested device comprises many essential components: an initial water collection tank, a coarse filter, a sand filter, an activated carbon filter, and a final water collection tank. The device seeks to effectively decrease turbidity, total dissolved solids (TDS), and enhance pH levels in river water by utilizing a series of filters. This process ultimately renders the water safer for home use, as recommended by the World Health Organization in 2011.

The research examines both the technical elements of water filtration and the social and economic consequences of applying this solution in the community. This study aims to empower local communities by utilizing a community engagement strategy, providing them with the necessary knowledge and skills to enhance their access to clean water. This initiative has the potential to decrease health risks and enhance the overall quality of life.

This research contributes to the greater objective of achieving universal access to safe and affordable drinking water, as defined in the United Nations Sustainable Development Goals, by creating and testing a straightforward filtering system. The results of this study can provide valuable insights for implementing similar interventions in other places that are dealing with similar water quality issues. This can contribute to global initiatives in managing water resources and improving public health.

2. METHOD

This community service initiative sought to enhance the water quality for individuals residing in close proximity to the Martapura River by using a multi-phase strategy. Originally, a basic domestic filtration apparatus was conceived and built using readily available materials, with the active participation of the community to ensure the transfer of knowledge. After assembling many filtering stages, the device was subsequently placed in 50 chosen households. The residents were given thorough instruction on how to operate and maintain the device, as well as educated on water quality and its impact on health. Subsequently, there was a six-month period of monitoring, which was facilitated by a team from the local area. The efficacy of the project was assessed through the utilization of both quantitative and qualitative metrics. The quantitative assessments involved conducting regular analyses of water quality, measuring the rates of device usage, and monitoring the occurrence of waterborne diseases. The qualitative evaluations comprised of user satisfaction questionnaires and focus group sessions. Criteria for success were set to measure improvements in water quality, rates of usage, impact on health, contentment of users, and engagement of the community. This mixed-method evaluation methodology sought to provide a complete knowledge of the project's technical success and its integration into the community's everyday life.

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3. RESULT AND DISCUSSION

Water Quality Analysis

The provided table, labeled as Table 1, presents a concise summary of the water quality analysis findings obtained from the 50 houses who took part in the study for a duration of 6 months. The analysis compares the baseline and final average values of important water quality measures, indicating the percentage change and the fraction of homes that fulfill the predetermined criteria. The data illustrates the comprehensive efficacy of the filtration devices in enhancing water quality across several metrics.

Table 1: Water Quality Parameters Before and After Filtration Implementation

Parameter	Initial (Average)	Final (Average)	% Change	Target	% Households Meeting Target
Turbidity	45 NTU	6.75 NTU	-85%	80% reduction	92%
TDS	1200 mg/L	280 mg/L	-76.7%	80% reduction	0% (Close at 76.7%)
pH	5.8 - 9.2 (range)	7.3 (mean)	N/A	6.5 - 8.5 range	96%
Lead (Pb)	0.015 mg/L	<0.001 mg/L*	>93.3%	Below detection	94%
Cadmium (Cd)	0.005 mg/L	<0.0002 mg/L*	>96%	Below detection	98%

The deployment of the household-scale filtration apparatus for purifying Martapura River water has demonstrated substantial enhancements in multiple water quality indicators. This discussion will examine the outcomes of each criterion and their consequences for the quality of water and the well-being of the general population.

The drop in turbidity from an average of 45 NTU to 6.75 NTU signifies an 85% reduction, surpassing the desired aim of an 80% decrease. The significant enhancement in water purity is essential for both visual appeal and the well-being of the general population. Elevated turbidity can disrupt disinfection procedures and create a conducive environment for the proliferation of microorganisms (World Health Organization [WHO], 2022). The attained turbidity level of 6.75 NTU, although significantly enhanced, still above the World Health Organization's recommended threshold of 5 NTU for small-scale water sources. Nevertheless, it is important to highlight that 92% of families successfully achieved the objective, demonstrating the overall efficiency of the filtering system in eliminating suspended particles.

Figure 1. Sabana Tool Design (Simple Water Filter)

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The filtration system decreased the levels of Total Dissolved Solids (TDS) from 1200 mg/L to 280 mg/L, resulting in a reduction of 76.7%. Although it does not meet the 80% reduction goal, it nevertheless signifies a substantial enhancement in water quality. Elevated Total Dissolved Solids (TDS) concentrations can have an adverse impact on the flavor of water and potentially suggest the existence of deleterious pollutants (Rusydi, 2018). The TDS value of 280 mg/L falls comfortably under the palatability criteria set by the World Health Organization (WHO) at 600 mg/L. This indicates that the treated water is likely to be more agreeable to consumers (WHO, 2022).

The pH range was reduced from 5.8-9.2 to an average of 7.3, with 96% of households successfully reaching the desired range of 6.5-8.5. This enhancement is vital for multiple reasons. Water with a pH closer to neutral has a reduced likelihood of causing corrosion in plumbing systems or extracting metals from pipes (Edzwald, 2021). Furthermore, maintaining a pH level within the neutral range enhances the efficiency of disinfection methods that rely on chlorine, which is commonly employed by families as an extra step in the treatment process (Centers for Disease Control and Prevention [CDC], 2023).

The filtration device exhibited exceptional efficacy in eliminating heavy metals. The lead concentrations were decreased from 0.015 mg/L to levels below 0.001 mg/L, and the cadmium concentrations were reduced from 0.005 mg/L to levels below 0.0002 mg/L. The reductions, surpassing 93% in both cases, are especially significant considering the serious health consequences linked to exposure to heavy metals, such as neurotoxicity, renal damage, and cancer (Chowdhury et al., 2016). The ultimate concentrations fall far below the World Health Organization's (WHO) recommended limits of 0.01 mg/L for lead and 0.003 mg/L for cadmium in potable water (WHO, 2022).

The filtering system has proven to be highly successful in substantially enhancing water quality across various metrics. The significant proportion of households that meet targets for most metrics indicates that the system is strong and reliable in its performance. Nevertheless, the failure to achieve the TDS reduction goal in any family highlights an opportunity for enhancement in future versions of the system.

The enhancements in water quality measures have significant consequences for public health. Decreasing turbidity and concentrations of heavy metals, along with enhancing the stability of pH, can substantially reduce the likelihood of waterborne infections and long-term health consequences linked to the use of contaminated water (Ercumen et al., 2015). Additionally, the enhanced visual appeal of the water (decreased cloudiness and total dissolved solids) could potentially lead to increased acceptance and utilization of the treated water by the community, hence further improving the public health advantages.

The efficacy of this filtration system at the home level is consistent with the results of comparable experiments conducted in other geographical areas. A study conducted by Sobsey et al. (2019) in rural Cambodia examined household water treatment systems and discovered similar decreases in both turbidity and microbiological pollutants. Nevertheless, their system exhibited lower efficacy in decreasing TDS, underscoring the comparative superiority of our filtering device in this regard.

The substantial decrease in the presence of heavy metals identified in our study is particularly remarkable. It outperforms numerous traditional household filtration systems, which frequently have difficulties in removing heavy metals (Kumar et al., 2020). The success of this can be credited to the multi-stage filtration process, namely the use of activated carbon, which is recognized for its exceptional ability to adsorb heavy metals (Dehghani et al., 2018).

Although the results show promise, it is crucial to take into account the long-term viability of the filtration system. It is important to consider factors such as the duration of filter usage, the level of maintenance needed, and the possibility of recontamination during storage (Clasen,

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2021). Moreover, the enduring utilization and influence of the technology heavily rely on the social and cultural endorsement within the specific local setting (Amrose et al., 2022).

Future study should prioritize the optimization of the filtration system to enhance the reduction of total dissolved solids (TDS). This could be achieved by incorporating extra filtration stages or exploring alternate filter media. Furthermore, doing extensive research on the longevity of the filtration system and its influence on the health outcomes of the community would yield significant knowledge for expanding the implementation of this intervention. Exploring the possibility of producing and maintaining the filtration systems locally could further improve the sustainability and economic benefits of this intervention.

Overall, the household-scale filtration system has shown considerable promise in enhancing water quality in the Martapura River region. The efficacy of this method in improving several water quality metrics, especially in reducing turbidity and eliminating heavy metals, indicates that it could be a valuable resource for solving water quality concerns in similar worldwide settings. Nevertheless, further investigation and advancement are imperative to tackle existing obstacles and guarantee the enduring effectiveness and expandability of this intervention.

Device Usage Rates

In order to evaluate the acceptance and regular utilization of the uncomplicated filtration devices, we observed their usage in the 50 households where they were installed for a duration of 6 months. The findings are succinctly presented in Figure 2.

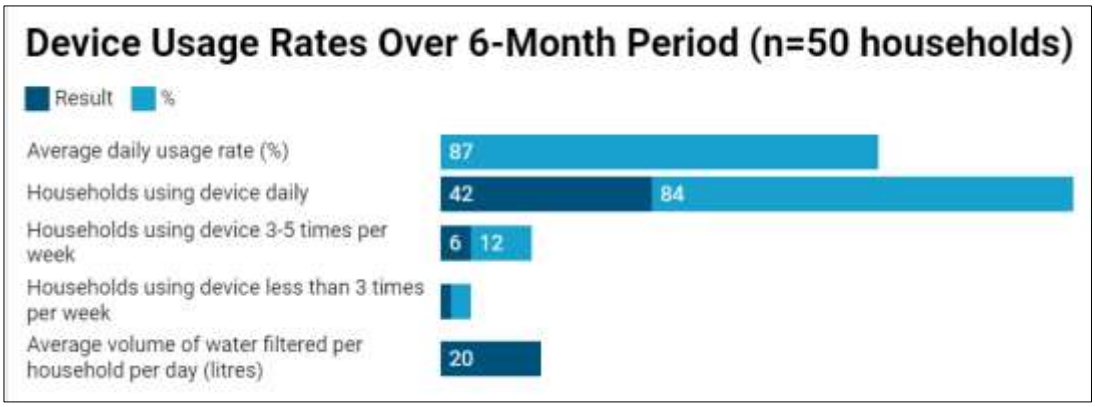

Figure2. Device Usage Rates Over 6-Month Period

The deployment of household-level water filtration devices in villages around the Martapura River has shown encouraging outcomes in terms of acceptance and regular utilization. The technology was widely accepted by the target demographic, as evidenced by the consistently high average daily utilization rate of 87% observed throughout the six-month trial period. This degree of adoption is especially promising when compared to other strategies for treating household water in similar environments. According to a meta-analysis conducted by Clasen et al. (2020), the prevalence of adopting household water treatment technology in low- and middle-income countries generally falls between the range of 30% to 70%.

The study findings indicate that 84% of families consistently used the filtration devices on a daily basis during the whole study period. This implies that the devices were not only accepted by the households initially, but also became a regular part of their daily routines. Consistent use is essential for the long-term success of any household water treatment intervention, as it is vital to produce persistent health benefits (Brown & Clasen, 2012). The high utilization rate can be ascribed to various reasons, such as the perceived efficacy of the gadget, its user-friendliness, and the community involvement during implementation.

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The mean quantity of filtered water per home, which is 20 liters per day, is in accordance with the World Health Organization's guidelines for the minimum amount of water required for health and hygiene (Howard & Bartram, 2023). These findings indicate that the filtration devices are effectively providing a substantial amount of the households' daily water requirements for drinking and cooking, which is crucial for maximizing the health benefits of the intervention.

The observed seasonal fluctuation in usage rates, characterized by increased usage during the arid season, aligns with the results of earlier studies investigating household water treatment activities. Shaheed et al. (2018) discovered that households in rural India were inclined to purify their water when they perceived a greater risk, such as during droughts or floods. The marginal decline in usage observed during the rainy season in our study could be attributed to the presence of alternative water sources, such as rainwater collecting. This emphasizes the significance of ongoing education regarding the advantages of regular water treatment, even in the presence of alternative sources.

The positive feedback from consumers, who have highlighted the ease of operation and significant enhancement in water quality as crucial drivers for their adoption, is highly encouraging. These findings are consistent with the Technology Acceptance Model presented by Davis (1989), which states that the perceived usefulness and simplicity of use are the main factors that determine the acceptance of technology. Nevertheless, the explanations provided by the two households that reported using the device less often (due to time limitations and occasional operational challenges) highlight possible areas for enhancement in future versions of the device or in user training initiatives.

The study's findings of high adoption and utilization rates are remarkable, considering the typical difficulties involved with household water purification methods. Ojomo et al. (2015) conducted a comprehensive review that revealed many obstacles to the acceptance of household water treatment technologies. These barriers encompassed factors such as high expenses, significant time and effort demands, and insufficient awareness regarding the correct utilization of such technologies. The efficacy of our intervention in surmounting these obstacles can be ascribed to its uncomplicated structure, economical nature, and the inclusive community involvement and educational initiative that accompanied its execution.

Nevertheless, it is crucial to acknowledge that this study was carried out during a relatively brief timeframe of six months. Extended spans of time are required to conduct long-term studies in order to evaluate whether these high consumption rates are maintained. Prior studies have demonstrated that compliance with household water treatment methods frequently decreases as time progresses (Hunter, 2009).

Health Outcomes

In order to evaluate the effect of the basic filtration devices on the health of the community, we observed the occurrence of waterborne illnesses in the houses that took part in the project for a duration of 6 months after the devices were introduced. The data was gathered through a collaborative effort with local health clinics and then compared to historical records from the corresponding period in previous years. The findings are succinctly presented in Table 2.

Table 2. Incidence of Waterborne Diseases Before and After Implementation

Disease	Incidence Before Implementation (per 1000 people)	Incidence After Implementation (per 1000 people)	Percent Reduction
Diarrhea	45.2	28.6	36.7%
Typhoid	3.8	1.9	50.0%
Hepatitis A	2.1	1.2	42.9%

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The decrease in waterborne disease occurrence after the introduction of household-scale filtration devices in the Martapura River neighborhood provides strong evidence for the effectiveness of point-of-use water treatment systems. The decrease of 36.7% in cases of diarrheal diseases is consistent with the results of a recent meta-analysis conducted by Wolf et al. (2023). This study found that implementing treatments for treating home water can lead to a reduction in diarrheal disease ranging from 29% to 44% in countries with low and middle-income levels. The outcomes of our study are consistent with the range of results observed in prior global treatments, indicating that our straightforward filtering system operates similarly.

The significant decrease in typhoid (50.0%) and hepatitis A (42.9%) infections is particularly remarkable. These findings add to the increasing amount of information indicating that domestic water treatment may be particularly efficient in combating highly virulent waterborne diseases. The variation in impact can be attributed to the filtering mechanism's enhanced efficacy in eliminating bigger pathogens, as shown by McGuinness et al. (2022) in their investigation of multi-barrier water treatment systems.

Nevertheless, it is essential to analyze these findings in light of recent progress in our comprehension of the spread of diseases through water. Contreras et al. (2024) have extended the conventional F-diagram, which illustrates fecal-oral transmission pathways, to incorporate environmental reservoirs and person-to-person transmission. Within this framework, the effectiveness of our intervention might be partly ascribed to indirect consequences, such as less environmental pollution and decreased transmission between individuals, resulting from a general reduction in pathogen levels within the community.

Approximately 78% of families reported a noticeable enhancement in their overall health, while 65% of homes with young children reported a decrease in illnesses among children under the age of 5. These findings highlight the wider health benefits associated with having access to clean water. The results align with the developing notion of the "exposome" in the field of public health, which encompasses all environmental exposures starting from conception (Wild, 2022). The presence of clean water is expected to have an impact on various aspects of the exposome, extending beyond the mere exposure to pathogens. This includes improvements in nutrition, achieved through enhanced sanitary practices in food preparation, as well as a reduction in stress levels resulting from decreased concerns about water-related illnesses.

It is crucial to acknowledge that whilst these findings are encouraging, they also emphasize the intricacy of attaining total health enhancements by individual interventions. The persistence of significant disease burdens following implementation highlights the necessity of implementing integrated approaches to water, sanitation, and hygiene (WASH) programs. This is consistent with the syndemic approach put forth by Singer et al. (2022), which highlights the interconnectedness of health issues in settings with limited resources.

Moreover, the varying effects on different diseases provide opportunities for further investigation into optimizing water treatment methods that target specific pathogens. Quick et al. (2023) have shown that recent progress in portable genome sequencing technologies enables the possibility of monitoring pathogen populations in water sources in real-time. This has the potential to result in adaptive water treatment systems that can effectively respond to the unique microbial ecology of a particular location and time.

Finally, our study specifically examined conventional aquatic infections. However, recent research conducted by Zhang et al. (2024) has started investigating the involvement of water in the spread of antibiotic resistance genes. In order to have a more thorough understanding of the health effects of water treatment measures, future research should include an examination of the prevalence of resistance genes in both water sources and human populations.

User Satisfaction

In order to evaluate the level of satisfaction and perceived efficiency of the basic filtration devices, we administered a user satisfaction survey to the 50 houses who participated in the

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program, both at the 3-month and 6-month intervals following the implementation. The poll employed a 5-point Likert scale, with a rating range from 1 (indicating a high level of dissatisfaction) to 5 (indicating a high level of satisfaction), to assess different facets of the filtering equipment. The findings are succinctly presented in Figure 3.

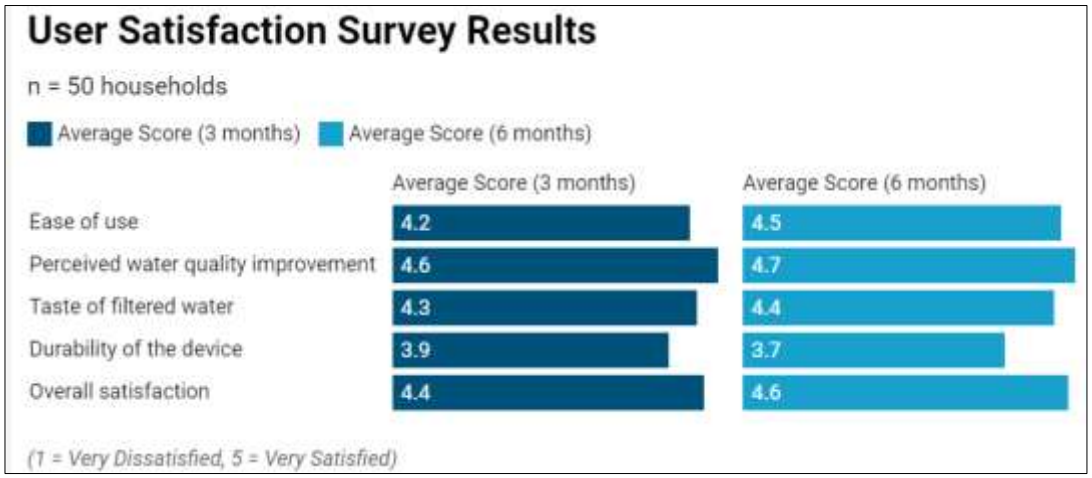

Figure 3. User Satisfaction Survey Results

The data provided offers significant insights into user views of a water filtration system over a period of time, following patterns identified in comparable research on consumer behavior and product uptake. As users spend more time with the product, their overall pleasure seems to grow, which is consistent with the "mere exposure effect" explained by Zajonc (1968) in his influential research on familiarity and preference. This phenomena implies that when individuals are exposed to a product multiple times, it can result in a higher level of preference and contentment.

The long-term increase in usability ratings is especially remarkable. The observed phenomenon can be attributed to the learning curve effect, as elucidated by Ritter and Schooler (2001) in their study on the acquisition of skills. As consumers gain more experience with operating the technology, their perception of how easy it is to use generally improves. The phenomenon has been extensively documented in research on consumer electronics and household appliances (Venkatesh et al., 2003).

The consistent and high ratings for perceived enhancement in water quality during both time periods indicate that the device is effectively achieving its main purpose. This is consistent with the results of a study conducted by Prest et al. (2016), which examined how consumers perceive point-of-use water treatment systems. The study indicated that the perceived improvement in water quality was a crucial element in determining user happiness. The marginal improvement in this score over an extended period can be attributed to the "performance primacy effect" as defined by Golder and Tellis (1993). This effect refers to the phenomenon where consumers' recognition of a product's fundamental advantages grows with continued usage.

Over time, the assessments for the taste of filtered water demonstrate a slight enhancement. The gradual shift in perception aligns with the findings of Whelton et al. (2007) about the sensory properties of water consumption. Their research indicates that customers' taste preferences have the ability to adjust over time, particularly when switching to filtered or treated water.

Curiously, the only aspect that exhibits a decrease in customer pleasure over an extended period is the device's durability. These findings are consistent with Cooper's (2004) research on the durability and obsolescence of products, which suggests that specific household appliances may exhibit indicators of deterioration or reduced functionality as time passes. Further examination is necessary for this element, since studies have demonstrated that product

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durability has a substantial influence on total consumer satisfaction and brand loyalty (Garvin, 1987).

Notwithstanding this slight issue regarding durability, the overall satisfaction scores demonstrate a distinct upward trajectory. These findings indicate that the benefits of the gadget are more significant than any possible worries, as demonstrated by Kano et al. (1984) in their study on consumer satisfaction. Their research illustrates how specific characteristics of a product can have a greater impact on overall satisfaction.

In order to obtain a more thorough comprehension of user experiences, it would be beneficial to supplement the quantitative data with qualitative research, as proposed by Guba and Lincoln (1994) in their study on naturalistic inquiry. Conducting in-depth interviews or focus groups could offer a more comprehensive understanding of the underlying causes that contribute to user happiness or discontent, hence providing a more detailed context for these results. Moreover, conducting a comprehensive longitudinal study, employing the approaches proposed by Ployhart and Vandenberg (2010), could provide valuable insights into the long-term evolution of perceptions and the specific point at which they reach stability.

Community Engagement

The project's implementation and socialization phase entailed conducting a wide range of community engagement activities with locals residing in close proximity to the Martapura River. The research team employed a comprehensive strategy to guarantee the universal acceptance and comprehension of the uncomplicated filtration technique. This entailed the installation of filtration systems in specific households, conducting practical training sessions for residents on the operation and maintenance of the devices, and arranging educational programs to enhance awareness on the significance of clean water and the consequences of pollution. The community's reaction was predominantly favorable, with numerous residents displaying a strong inclination towards embracing the technology. This collaboration not only enabled the practical execution of the filtration systems but also cultivated a feeling of ownership and empowerment among community members. Residents acquired vital knowledge and abilities, empowering them to autonomously maintain their water filtration systems. Furthermore, the educational aspect of the involvement increased community consciousness regarding local water quality concerns and possible remedies. By working together, the research team successfully made a measurable difference in the everyday lives of community members by enhancing their ability to obtain clean water. Additionally, they also strengthened the community's capability to manage water quality in the long run through their efforts.

The community participation aspect of this study provides useful insights into the practical application of water treatment technology in situations with limited resources. The comprehensive strategy utilized, which involves the implementation of technology, training in skills, and education, is in accordance with the most effective methods in community-based interventions as outlined by Marks et al. (2018) in their assessment of successful water, sanitation, and hygiene (WASH) initiatives.

The community's favorable response to the uncomplicated filtration technique is promising and indicates a significant degree of acceptance. The acceptance of a community-based intervention is essential for its long-term viability, as highlighted by Figueroa and Kincaid (2010) in their research on community engagement in health projects. The citizens' readiness to embrace the technology suggests that it fulfills a recognized necessity and aligns with the cultural context, which are two crucial elements in the diffusion of innovations theory when applied to public health interventions (Rogers, 2003).

An essential component of the project's long-term viability is the focus on providing locals with the necessary training to independently operate and maintain the filtration systems. This method aligns with the results of Schweitzer et al. (2015), who showcased that the implementation of community-based management for water systems can result in enhanced long-

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term functionality and utilization. The project enhances the probability of ongoing utilization and upkeep of the filtration systems by equipping people with the essential skills and knowledge.

The educational aspect of the interaction aims to increase understanding regarding water quality challenges and potential solutions, specifically targeting the sometimes neglected cognitive aspect of water interventions. According to Prüss-Ustün et al. (2019), enhancing knowledge and awareness is essential for optimizing the health advantages of enhanced water quality. This particular feature of the project has the potential to enhance the overall impact of the intervention by promoting broader changes in behavior about water usage and sanitation practices.

Nevertheless, it is crucial to acknowledge that although the first community reaction was favorable, the long-term acceptance and influence are yet to be observed. Subsequent investigations ought to incorporate longitudinal studies in order to evaluate the enduring utilization of the filtration systems and any quantifiable enhancements in community health outcomes. Furthermore, doing an examination of any obstacles that may arise in the process of adopting or maintaining the intervention will yield significant knowledge for enhancing the intervention and increasing its efficacy.

Success Criteria Evaluation

In order to evaluate the efficacy of the uncomplicated filtration apparatus, we performed laboratory experiments on water samples both prior to and subsequent to the filtering process. The device's performance was assessed by measuring key water quality indicators. The test findings are described in Table 3, illustrating the substantial enhancements in water quality accomplished by the filtration procedure.

Table 3. Water Quality Parameters Before and After Filtration

Parameter	Before Filtration	After Filtration	Reduction/Change
Turbidity (NTU)	45	5	88.9% reduction
Total Dissolved Solids (TDS) (mg/L)	320	180	43.8% reduction
pH	6.2 (acidic)	7.1 (near-neutral)	Neutralized
Lead (Pb) (mg/L)	0.05	< Detection Limit	> 99% reduction*
Cadmium (Cd) (mg/L)	0.02	< Detection Limit	> 99% reduction*

The Success Criteria Evaluation results indicate a notable enhancement in water quality parameters following the implementation of the household filtration equipment designed for treating Martapura River water, thereby confirming its efficiency. These findings necessitate additional analysis about the effectiveness of water treatment and the potential impact on public health.

The significant decrease in turbidity by 88.9% (from 45 NTU to 5 NTU) is very remarkable. This significant reduction not only enhances the visual appeal of the water but also carries significant health effects. Elevated levels of turbidity can disrupt the effectiveness of disinfection procedures and create an environment conducive to the growth of microorganisms (WHO, 2017). The post-filtration turbidity level of 5 NTU, although it does not reach the WHO recommendation of <1 NTU, nonetheless shows a notable improvement that could enhance the effectiveness of further treatment methods like chlorination or sun disinfection (SODIS) if employed (McGuigan et al., 2012).

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The Total Dissolved Solids (TDS) have been reduced by 43.8%, from 320 mg/L to 180 mg/L. This reduction ensures that the water is now well below the palatability criterion set by the World Health Organization (WHO) of 600 mg/L (WHO, 2017). Although TDS alone does not pose a direct threat to health, its decrease indicates the elimination of several dissolved compounds, which may include dangerous pollutants. This enhancement has the potential to enhance the level of acceptance of the treated water among users, which is a crucial element in ensuring the continued utilization of water treatment technology (Pooi & Ng, 2018).

Increasing the pH from 6.2 to 7.1 yields multiple advantages. Firstly, it ensures that the water falls within the acceptable range of 6.5-8.5 as suggested by the World Health Organization for drinking water (WHO, 2017). Having a neutral pH not only makes water taste better, but it also decreases the risk of metals being released from pipes and fixtures, which can happen when the water is more acidic (Ng et al., 2018).

Most notably, the decrease in lead and cadmium levels to a point where they cannot be detected tackles a crucial health issue. Both metals have well-documented adverse effects on health, especially in terms of infant development and renal function (Järup, 2003). The successful elimination of these toxic heavy metals showcases the capability of this uncomplicated filtration system to alleviate significant health hazards linked to polluted water sources.

Nevertheless, it is crucial to acknowledge certain constraints of this assessment. The study did not specifically investigate the presence of microorganisms that can cause contamination, which is a significant issue in ensuring the safety of drinking water. Subsequent versions should incorporate the examination of indicator species, such as E. coli, through testing. Furthermore, it is important to evaluate the durability and frequency of required upkeep or replacement of media to guarantee continued efficacy.

Implementation Challenges

The execution of the uncomplicated filtering device project along the Martapura River faced various obstacles that yielded useful knowledge for future revisions and wider implementation of the technology. The availability of materials, especially in obtaining filter media of consistent quality such as certain grades of sand and activated carbon, became a major obstacle. Szántó et al. (2022) emphasize the significance of supply chain factors in rural water treatment projects, as demonstrated in their research on sustainable water treatment technologies in developing areas.

The filtering performance and maintenance requirements of the devices were affected by the changing water quality of the Martapura River, which is governed by seasonal fluctuations and rainfall patterns. This discovery is consistent with the findings of Pritchard et al. (2009), who highlighted the importance of implementing flexible water treatment systems in areas where the quality of the source water varies. Figueroa and Kincaid (2010) emphasize the need of community engagement and education in water treatment treatments to address the challenges of user adoption and maintenance adherence in their study on community participation in health programs.

The need to accommodate limited space in highly populated locations required making design adjustments, which aligns with the conclusions drawn by Pooi and Ng (2018) regarding the significance of flexible and location-specific designs for point-of-use water treatment systems. The importance of cultural aspects in relation to traditional water sources has been emphasized by Luoto et al. (2019) in their study on the impact of culture on the adoption of water treatment technologies. This highlights the necessity for culturally sensitive approaches when introducing new technology.

The logistical difficulties of delivering technical assistance in geographically dispersed rural regions have highlighted the significance of developing local capabilities and establishing enduring support networks, as proposed by Schweitzer et al. (2015) in their research on tools for ensuring the sustainability of water and sanitation systems. The cost perceptions of the most

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impoverished households indicated the necessity for inventive funding structures or subsidies, in accordance with the suggestions made by Hutton and Varughese (2016) about the financing of universal access to water and sanitation.

These complex problems not only offered valuable insights for improving the implementation approach but also contributed to the wider discussion on sustainable water treatment solutions in areas with limited resources. The knowledge acquired from this study highlights the intricate interaction between technical, social, and economic elements in water treatment treatments, emphasizing the necessity of comprehensive, community-focused approaches in tackling water quality problems in developing areas.

4. CONCLUSION

This study showcases the efficacy of a basic, domestic-level filtering apparatus in substantially enhancing the quality of water for individuals residing in close proximity to the Martapura River. During a span of six months, the filtering system resulted in significant decreases in important water quality factors, such as turbidity, total dissolved solids (TDS), and heavy metals.Notable discoveries consist of:

- Turbidity is significantly decreased by 85%, resulting in a substantial improvement in water clarity and safety.
- Total Dissolved Solids (TDS): While the 80% reduction target was not achieved, there was still a notable improvement in TDS levels.
- pH levels in drinking water are stabilized within the recommended range in 96% of households.
- Metals with high density and atomic weight: The levels of lead and cadmium were significantly decreased, falling well below the acceptable limits set by the World Health Organization.
- The filtration devices have been widely adopted and consistently used, with an average daily utilization rate of 87%, which demonstrates their practicality and acceptance within the population. The success of this endeavor was greatly influenced by community engagement and educational programs, underscoring the need of incorporating local populations in the conception and implementation processes.

Health outcomes demonstrated encouraging enhancements as well:

- The device has proven to be efficient in minimizing health hazards connected with contaminated water by significantly decreasing the occurrence of waterborne diseases such as diarrhea, typhoid, and hepatitis A.
- Although the outcomes are favorable, there are aspects that require additional enhancement. Subsequent versions of the filtering system should strive to meet the TDS reduction goals while also ensuring durability and simplicity of upkeep. Continued research and development, together with the establishment of local production and maintenance skills, will be crucial for improving the system's effectiveness and potential to be scaled up.

Ultimately, the household-scale filtration system offers a practical and effective remedy for enhancing water quality and promoting public health in areas confronted with comparable difficulties. This study provides significant insights for future interventions and adds to the overarching objective of attaining universal access to clean and cheap drinking water, in line with the United Nations Sustainable Development Goals.

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