Ganeshan temple, Komalykudi

REPORT OF DISTRIBUTION OF BIOSAND FILTER TO HOUSEHOLDS & ANGANVADIS FOR THE CONSERVATION OF FRESH WATER HABITAT & THREATENED SPECIES

Conducted as part of:

PROTECTION OF FRESH WATER ECOSYSTEMS FOR THE CONSERVATION OF THREATENED SPECIES IN MUNNAR, WESTERN GHATS, INDIA.
Project Code: 2023A-41

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Disclaimer: The findings and conclusions presented are generalized insights derived from the collective responses of the community members who participated in the survey. The information is used solely for the purpose of understanding and improving community conditions and should not be construed as reflecting the views or conditions of any specific individual or group.

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Figure 1. Filter distributed at Devikulam

1. Introduction

Access to clean and safe drinking water is a fundamental requirement for maintaining public health and well-being and aligns closely with the **United Nations Sustainable Development Goals (SDG)**, particularly **SDG 6 (Clean Water and Sanitation)** and **SDG 3 (Good Health and Well-being)**. Despite Munnar being blessed with abundant natural water resources, the region faces significant challenges in ensuring accessibility to pure and safe drinking water. Factors such as the influence of natural topography, human activities, and changing climatic conditions exacerbate the crisis. To address these issues, the TIES IUCN project conducted a comprehensive water quality analysis in the first quarter and second quarter of 2024, covering 22 locations in and around Munnar. This assessment aimed to identify critical contamination issues and implement targeted interventions to improve water quality and accessibility, thereby contributing to achieving SDG targets and enhancing the well-being of the local community.

The study involved an extensive analysis of 46 water samples collected from a variety of sources, including aquifers, rivers, streams, open wells, ponds, and borewells. Each sample was subjected to a comprehensive evaluation encompassing physical, chemical, and microbiological parameters to provide a holistic understanding of the water quality and its implications for public health. The assessment sought to identify potential health risks, trace sources of contamination, and prioritize regions requiring urgent intervention.

The findings revealed alarming levels of contamination across all sources, with total and fecal coliform bacteria detected in every sample. This widespread presence of coliforms highlights significant pollution from untreated septage and greywater, posing severe risks of waterborne diseases to the local population. The contamination was especially pronounced in areas with poor sanitation infrastructure or high-density human settlements, underscoring the urgent need for improved waste management practices.

In addition to microbiological contamination, the study noted deviations in critical physicochemical parameters in several locations. For instance, pH levels in some samples were either too acidic or too alkaline, making the water unsuitable for consumption and affecting its usability for other purposes. Elevated conductivity and salinity levels were observed in specific sources, likely due to natural mineral leaching, agricultural runoff, or improper wastewater disposal, further limiting access to potable water.

These findings emphasize the critical need for immediate and targeted interventions. Strategies such as enhancing sanitation infrastructure, promoting sustainable water management practices, and implementing community-driven water purification solutions like biosand filters are essential to mitigate these issues. The study also highlights the importance of regular water quality monitoring and public awareness initiatives to ensure the long-term safety and accessibility of drinking water in Munnar.

To address the pressing water quality concerns identified through the study, TIES took proactive measures by strategically installing **TIES Biosand Filters** in over 100 households, anganwadis, schools, and other community spaces across the affected regions. These filters represent a sustainable, low-cost solution tailored to the needs of the local population. They are specifically designed to reduce microbial contamination, including the removal of **E. coli bacteria by up to 99.9%**, a critical intervention given the widespread presence of fecal coliforms in the water sources. Additionally, the filters help optimize key water quality parameters such as turbidity and residual contaminants, ensuring access to potable water for the most vulnerable groups.

The implementation process was carried out in a **phased manner**, prioritizing locations with the poorest water quality, as highlighted by the analysis. Schools and anganwadis were given special attention to protect children, who are particularly vulnerable to waterborne diseases. Households in regions with high population densities and inadequate sanitation infrastructure were also targeted to maximize the impact of the intervention.

The initiative not only improved access to clean drinking water but also fostered community participation and ownership. Training sessions and awareness programs were conducted to educate local residents on the use and maintenance of the filters, ensuring their long-term functionality and effectiveness.

This report provides a detailed overview of the water quality findings and outlines the scope and impact of the **Biosand Filter installations**. It demonstrates how evidence-based strategies, such as targeting high-risk areas, can yield tangible benefits in safeguarding public health. Furthermore, it emphasizes the importance of **community-based solutions** in addressing water quality challenges in ecologically sensitive regions like Munnar.

By combining scientific analysis with practical interventions, the project underscores the critical role of sustainable water management practices in achieving the **Sustainable Development Goals (SDGs)**, particularly **SDG 6 (Clean Water and Sanitation)** and **SDG 3 (Good Health and Well-being)**. These interventions not only mitigate immediate health risks but also contribute to long-term resilience in the face of ongoing challenges such as climate change, population growth, and resource depletion.

The success of this initiative highlights a replicable model that can inspire similar actions in other regions facing water quality issues, demonstrating the power of **collaborative, evidence-driven, and locally adapted solutions.**

Figure 2. Waste filled rivulet at Kadugumudy division Talayar estate

2. Background

Munnar, located in the Western Ghats of Kerala, is a region celebrated for its spectacular landscapes, rich biodiversity, and agricultural prominence, particularly as a global hub for tea and cardamom plantations. This ecologically sensitive area is part of a UNESCO World Heritage Site and plays a pivotal role in supporting both local livelihoods and the broader environmental health of the region. However, despite its natural beauty and ecological importance, Munnar faces significant and persistent challenges related to water quality, which threaten the well-being of its communities and ecosystems alike.

The pressures of rapid urbanization have dramatically altered Munnar's natural water systems. As the population grows and settlements expand, the demand for resources has led to the encroachment of natural habitats and unregulated development, contributing to the contamination and overexploitation of water sources. Simultaneously, increasing tourism, a major economic driver for the region, has placed additional strain on water resources. The influx of tourists has led to higher water consumption, improper waste disposal, and increased pollution, particularly in areas close to popular attractions.

Agricultural practices in Munnar, which are vital to the region's economy, are also a major contributor to water quality issues. The widespread use of chemical fertilizers and pesticides in tea, cardamom, and other crops has resulted in the leaching of harmful chemicals into nearby water sources, contaminating aquifers, rivers, and ponds. Industrial activities, including tea and cardamom processing, further exacerbate the problem by generating wastewater that often finds its way into natural water bodies without adequate treatment.

The water sources in Munnar are diverse, encompassing aquifers, rivers, ponds, open wells, and streams, and they are crucial for meeting the daily needs of local communities. These sources not only provide drinking water but also support agricultural irrigation, industrial processes, and ecological habitats. Despite their critical importance, however, the quality of these water sources remains inconsistent and, in many instances, unsafe for human consumption.

Pollutants such as septage, greywater, and agricultural runoff have severely degraded water quality, leading to the presence of harmful microorganisms, elevated levels of salinity, and the accumulation of heavy metals in some areas. These issues have been compounded by inadequate waste management infrastructure and the lack of comprehensive water treatment facilities in the region.

The degradation of water quality in Munnar underscores the pressing need for sustainable water management practices and integrated conservation efforts. Addressing these challenges requires a multi-pronged approach that includes improving waste treatment systems, regulating agricultural and industrial runoff, and promoting awareness among local communities about the importance of preserving their water resources. By safeguarding its water systems, Munnar can not only ensure the well-being of its residents but also preserve its ecological heritage for future generations.

The Tropical Institute of Ecological Sciences (TIES), in collaboration with the International Union for Conservation of Nature (IUCN), has been actively addressing the critical water quality challenges in Munnar through a dedicated conservation and water quality management initiative. This project is part of a broader effort to safeguard the region's freshwater ecosystems, which are vital for maintaining biodiversity, supporting agriculture, and meeting the daily water needs of local communities. Given the unique ecological and socioeconomic importance of Munnar, the initiative places a strong emphasis on improving access to clean drinking water for rural and vulnerable populations, who are disproportionately affected by water quality and accessibility issues.

A core component of this initiative was a comprehensive water quality analysis conducted in three meticulously planned phases across 2024. This effort aimed to provide a detailed understanding of the current state of drinking water sources in Munnar, identify key contamination issues, and develop targeted interventions to mitigate risks. The study was designed to assess the physical, chemical, and microbiological quality of water from diverse sources, including aquifers, rivers, streams, open wells, borewells, and ponds.

During the analysis, samples were tested for critical parameters such as pH levels, conductivity, salinity, and the presence of harmful contaminants like coliform bacteria, fluoride, and iron. This holistic approach allowed the team to evaluate the overall safety and suitability of water for consumption and identify specific pollution hotspots. Particular attention was paid to microbiological contamination, as pathogens such as E. coli and other coliform bacteria are primary indicators of fecal contamination and pose significant health risks, especially in regions with inadequate sanitation infrastructure.

The findings of the study revealed several alarming trends. Widespread microbial contamination was detected in all water sources, with both total and fecal coliforms present, indicating pollution from untreated septage and greywater. Certain locations also showed deviations in chemical parameters, such as elevated levels of fluoride and iron, which can cause long-term health issues if consumed regularly. Parameters like pH imbalance, high conductivity, and salinity were observed in some areas, further underscoring the vulnerability of the region's water resources.

The analysis also highlighted the impact of local human activities on water quality. Agricultural runoff, industrial effluents from tea and cardamom processing units, and poor waste management were found to be major contributors to the contamination of water sources. Additionally, the survey revealed challenges related to water accessibility, particularly in remote areas where infrastructure and maintenance issues hindered the reliable supply of clean water.

By identifying these critical issues, the water quality analysis laid the foundation for evidence-based interventions. The results directly informed the deployment of TIES Biosand Filters, which were installed in priority locations across the region to address the contamination and provide clean, safe drinking water to affected communities. This systematic approach underscores the importance of combining scientific research with community-based solutions to tackle complex environmental challenges and improve the health and well-being of vulnerable populations.

Through this project, TIES and IUCN are not only addressing immediate water quality concerns but also contributing to the long-term resilience of Munnar's freshwater ecosystems. The initiative aligns with global sustainability priorities, particularly Sustainable Development Goal 6 (Clean Water and Sanitation), by promoting safe and equitable access to water while protecting vital ecological resources in this fragile landscape.

The findings of the analysis highlighted several critical issues, including the presence of high levels of microbial contamination (coliform bacteria), variations in key water quality parameters (such as pH, conductivity, and salinity), and the elevated presence of harmful substances like fluoride and iron in certain areas. These results prompted the installation of TIES Biosand Filters in selected locations across Munnar to mitigate contamination and improve water safety. The filters were designed to remove harmful microorganisms and optimize the quality of water by addressing issues like pH imbalance and high microbial loads, thereby ensuring that the water is safe for consumption.

This report provides a detailed account of the water quality analysis, the rationale behind the installation of the filters, and the progress made in addressing the water contamination challenges in Munnar. It highlights the importance of integrated water management and community-based solutions to ensure long-term water security and public health in this ecologically sensitive region.

3. Methodology

The methodology adopted for the water quality analysis and the subsequent installation of TIES Biosand Filters in selected locations of Munnar was meticulously designed to ensure comprehensive and accurate data collection, followed by effective and sustainable interventions to improve drinking water quality. The approach was divided into two main phases: water quality analysis and the installation of biosand filters. This section elaborates on the key steps involved in each phase to provide a clear understanding of the process.

3.1. Water Quality Analysis

The primary objective of the water quality analysis was to evaluate the status of drinking water sources by assessing a range of physical, chemical, and microbiological parameters. This phase was carried out systematically to ensure reliable data collection and accurate interpretation.

a. Site Selection

To ensure representative sampling, 46 water samples were collected from 22 strategically selected locations across Munnar. These locations included various types of water sources, such as:

- Aquifers: Underground layers of water-bearing rock or sand

Figure 3. One of the drinking Water source of hindu mudhuvan tribal settlement

- Rivers and Streams: Flowing surface water bodies prone to contamination from upstream sources
- Open Wells: Common rural water sources, often exposed to surface pollutants
- Ponds: Static water bodies vulnerable to eutrophication and microbial growth
- Borewells: Deep groundwater sources that may have high mineral content

The selection criteria were based on the significance of these sources to local communities, as well as observable variations in pollution levels across different locations. By covering diverse types of water sources, the analysis aimed to capture a holistic view of water quality in the region.

- Tea estates: Water sources within large agricultural operations
- Government institutions: Schools, healthcare centers, and offices
- Community centers: Shared public water sources

b. Sampling Procedure

To ensure the integrity of the samples, strict protocols were followed during the sampling process. Key steps included:

- Sterilization: All containers used for sample collection were sterilized beforehand to prevent external contamination.
- Transport Conditions: Samples were transported in private vehicles to maintain their original state until laboratory analysis.
- Documentation: Each sample was labeled with a unique identifier, including details of the location, type of water source, date, and time of collection also ensured spot testing.

Sampling locations covered a wide range of environments, including:

- Rural households: Private water sources used for daily consumption

c. Laboratory Analysis

The collected water samples were subjected to rigorous laboratory testing to determine various parameters:

- Physical Parameters:
  - Turbidity: Measured to assess water clarity
  - Color: Evaluated to detect potential contamination
  - Temperature: Monitored to understand its influence on other parameters
- Chemical Parameters:
  - pH: Indicates the acidity or alkalinity of water
  - Total Dissolved Solids (TDS): Reflects the concentration of dissolved substances
  - Salinity: Important for determining suitability for drinking and irrigation
  - Conductivity: Measures the water's ability to conduct electricity, related to ion concentration

Figure 4. Water sample collection for analysis from Muttukadu (household)

Hardness: Total, calcium, and magnesium hardness were measured to assess scaling potential

Chloride, sulphate, fluoride, nitrate, phosphate, and iron levels: Evaluated to detect chemical contaminants and nutrient loads

- **Microbiological Parameters: Total coliforms and fecal coliforms:** Used as indicators of microbial contamination from human and animal waste

All analyses were performed at accredited laboratories, adhering to international standards set by the World Health Organization (WHO) and national standards specified by the Bureau of Indian Standards (BIS).

Figure 5. Water sample collection from the tank of GHSS, Vaguvarrai

d. Data Analysis

The data collected from the laboratory analysis were processed and analyzed using the following approach:

- Water Quality Index (WQI): A composite index was calculated for each water source by aggregating the results of various parameters. The WQI provided a single numerical value representing the overall water quality.
- Comparative Analysis: Results from different sources were compared to identify the most severely affected areas and the primary contaminants. Trends in contamination levels were also noted.
- Mapping: GIS tools were employed to create spatial distribution maps of water quality, highlighting high-risk areas and guiding subsequent interventions.

3.2. Installation of TIES Biosand Filters

Following the analysis, TIES Biosand Filters were identified as a suitable intervention to address the specific water quality issues found in Munnar. This phase involved detailed planning and execution to ensure successful installation and long-term benefits.

a. Filter Selection

The selection of filters was based on the specific contaminants detected during the water quality analysis. Key considerations included:

Figure 6. Installation of filter at Muttukad (Household)

Microbial Contamination: High levels of coliforms and E. coli necessitated the use of filters with effective microbial removal capabilities.

- Chemical Imbalances: Locations with elevated fluoride, iron, or nitrate levels required filters designed to address these specific issues.

TIES Biosand Filters were chosen due to their proven efficiency in removing up to 99.9% of harmful microorganisms, along with their ability to enhance water taste and clarity.

b. Community Engagement and Beneficiary Selection

Community participation was a critical component of this phase to ensure acceptance and proper use of the filters. Key steps included:

- Awareness Programs: Conducted to educate the community about the importance of clean water and the benefits of biosand filters
- Stakeholder Involvement: Local leaders, government officials, healthcare providers, and community groups were involved in identifying suitable beneficiaries and locations for filter installation
- Criteria for Beneficiary Selection:
  - Proximity to contaminated water sources
  - High dependency on unsafe water sources
  - Willingness to adopt and maintain the filters

c. Installation Process

The installation of the filters was carried out in a phased manner to ensure systematic coverage:

- Phase 1: Focused on households, anganwadis, schools, dispensaries, and tea estate offices identified as high-priority locations
- Placement: Filters were installed in areas with the highest water usage, such as kitchens, water storage areas, and community spaces
- Guidelines: The installation team followed detailed guidelines to ensure proper setup and optimal functioning of the filters

d. Monitoring and Maintenance

To ensure the continued effectiveness of the filters, a monitoring and maintenance plan was implemented:

- Regular Monitoring: Water quality was periodically tested to evaluate the performance of the filters
- Training Sessions: Beneficiaries were trained on how to use and maintain the filters correctly
- Follow-Up Visits: Conducted to gather user feedback, address any issues, and provide additional support

Figure 7. Filter monitoring at Munnar Family Care Homestay

3.3. Data Collection and Reporting

Post-installation, data collection continued to assess the improvement in water quality. This phase involved:

- Periodic Sampling: Water samples were collected at regular intervals from locations with installed filters
- Impact Assessment: The post-installation data were compared with the baseline data to measure improvements in key parameters such as microbial contamination, pH, and conductivity

Report Compilation: The findings were compiled into detailed reports, including tables, charts, and graphs for clear presentation

Figure 8. Periodic sample collection at Muttukadu

3.4. Analysis Tools

Descriptive and inferential statistical tools were employed to analyze the data. Key techniques included:

- Descriptive Statistics: Used to summarize the data in terms of mean, median, range, and standard deviation
- Comparative Analysis: Before-and-after comparisons were made using paired sample t-tests and other relevant statistical methods
- Graphical Representation: Results were presented in the form of bar charts, line graphs, and pie charts to facilitate easy interpretation by stakeholders

By integrating rigorous scientific analysis with community-centered interventions, this methodology aimed to ensure sustainable improvements in water quality in Munnar. The approach not only addressed immediate water safety concerns but also fostered community ownership and long-term maintenance of the installed filters, contributing to enhanced public health and well-being in the region.

4. Filter Details

The TIES Biosand Filter was selected as the primary intervention for improving water quality in the Munnar region. This filter system is designed to address key water quality issues identified during the baseline study, including microbial contamination, elevated levels of fluoride, and chemical imbalances in drinking water sources. The following details outline the design, operation, and effectiveness of the filter system.

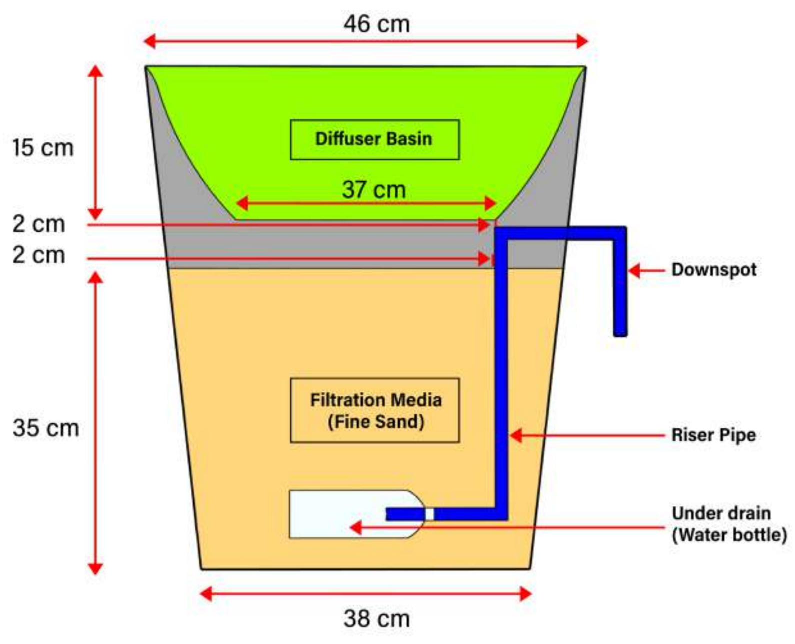

Figure 9. Filter design

4.1. Design and Structure

The TIES Biosand Filter is a simple, cost-effective, and sustainable water treatment system that is particularly suitable for rural and remote areas. The filter operates based on the principle of filtration and biological processes to remove contaminants from water, making it safer for consumption. The design of the filter includes the following components:

- Filter Vessel: The filter vessel is typically made of reinforced concrete or plastic, designed to hold the filtering media and provide space for water storage. It is portable and compact enough to be installed in various locations, including kitchens, sheds, and community spaces.
- Filtering Media: The filter media consists of a layered bed that includes:
- Coarse sand: At the bottom, this layer helps in the initial filtration of large particles.
- Fine sand: This layer traps smaller particles and pollutants.
- Gravel layer: Positioned above the sand layers, this helps in distributing the incoming water evenly across the filter surface.
- Biofilm Layer: A key feature of the biosand filter, this biological layer forms naturally on the surface of the filter media. It contains beneficial microorganisms that assist in breaking down harmful pathogens, including E. coli, fecal coliforms, and other microbial contaminants.

Outlet and Overflow System: The filter has an outlet for collecting the filtered water and an overflow system to prevent flooding of the filter vessel when excess water is added.

Figure 10. Sieving of filter media

4.2. Working Principle

The TIES Biosand Filter works through a combination of physical filtration and biological treatment processes:

- Physical Filtration: The sand and gravel layers physically remove suspended solids, dirt, and large particles from the water. These layers also reduce turbidity by trapping particles as the water passes through.

Biological Filtration: The biofilm that develops on the top layer of sand contains a variety of microorganisms, including bacteria, fungi, and protozoa, which feed on and decompose harmful microorganisms like E. coli, fecal coliforms, and other pathogens. This biological activity is essential for ensuring that the water is microbiologically safe for drinking.

- Absorption: Some contaminants, such as fluoride and iron, are partially absorbed or removed due to the chemical properties of the sand and other media. However, the removal of these substances is not as effective as microbial filtration, and for certain areas with high concentrations of fluoride, additional treatment might be needed.

Figure 12. Filter making

Figure 11. Water bottle placed in the bottom of the filter

4.3. Installation Locations

The TIES Biosand Filters were strategically installed in 100 households, schools, anganwadis, and dispensaries across Munnar. These locations were selected based on the baseline data study, which identified the most vulnerable areas with significant water quality issues.

Figure 13. TIES Bio sand filter (BSF)

The installation sites included:

- Households: Focused on communities with limited access to clean water or where traditional filtration methods were ineffective.
- Schools and Anganwadis: Ensured that children and vulnerable populations had access to clean, safe drinking water.
- Dispensaries and Offices: Provided clean water for healthcare and administrative needs in remote areas.

The filters were installed in easily accessible locations such as kitchens, sheds, verandas, and community spaces. Specific installation locations included places like Muttukad, Kampiline, Thalayar, Mankulam, and Vellathooval.

4.4. Benefits of TIES Biosand Filter

Effective Microbial Contamination Removal: The primary benefit of the biosand filter is its ability to remove harmful microorganisms, including E. coli and fecal coliforms, which are prevalent in the baseline study findings. Studies have shown that biosand filters can reduce microbial contamination by up to 99.9%.

- Improved Water Quality: The filter significantly improves water quality by reducing
- turbidity, suspended solids, and microbial contaminants, making the water safer for consumption and reducing the risk of waterborne diseases.
- Simplicity and Sustainability: The TIES Biosand Filter is low-cost, easy to maintain, and can be locally constructed with available materials, ensuring its long-term sustainability. The filters require minimal maintenance and have a long operational lifespan, making them an ideal solution for remote, rural areas.
- Adaptability: The filter can be adapted to treat water from various sources, including rivers, ponds, wells, and borewells, catering to the specific needs of different communities in Munnar.
- Environmental Impact: By reducing the need for chemical disinfectants, the biosand filter is environmentally friendly and promotes sustainable water treatment practices.

4.5. Monitoring and Maintenance

After installation, regular monitoring is carried out to assess the performance of the filters. Parameters such as water flow rate, turbidity, microbial contamination, and user satisfaction are regularly tracked to ensure that the filters are operating effectively. In case of reduced performance, the filters can be easily cleaned by flushing the sand layers with water to remove accumulated contaminants.

The TIES Biosand Filter represents a significant step toward improving water quality in Munnar, addressing critical issues of microbial contamination and chemical imbalances. Its simple design, combined with its ability to remove harmful pathogens and improve overall water quality, makes it an effective and sustainable solution for rural and underserved communities in the region. The installation of these filters aims to significantly reduce health risks associated with unsafe drinking water, contributing to the overall well-being of local populations.

4.6 User Manual for the TIES Biosand Filter Report

Figure 14. User manual (Malayalam) for the TIES Biosand Filter

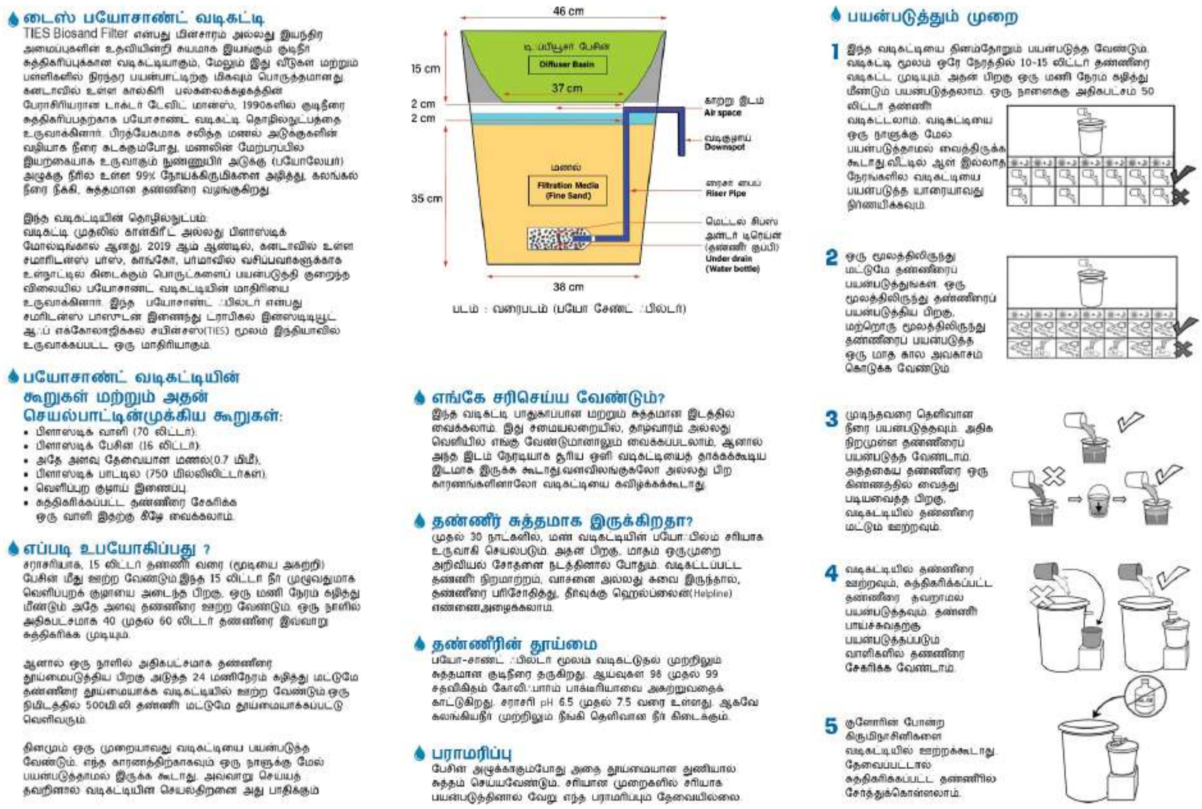

Figure 17. User Manual for the TIES Biosand Filter (Tamil)

4.6.1. Introduction to the TIES Bio-sand Filter

The TIES Biosand Filter is a sustainable water purification solution designed to remove contaminants and pathogens from drinking water, providing communities with clean, safe water. Developed by the Tropical Institute of Ecological Sciences (TIES) in collaboration with Samaritan's Purse and technical expertise from Prof. David Manz (Canada), this filter plays a critical role in improving health and hygiene, particularly in areas with limited access to clean water.

4.6.2. Key Features of the TIES Biosand Filter

- Multi-Layer Filtration: The filter consists of several layers, including fine sand, which effectively removes bacteria and particulate matter from water.
- Low Maintenance: Designed for long-term use, the filter requires minimal maintenance to function efficiently.
- Improved Water Quality: Reduces turbidity and enhances water clarity, making it suitable for human consumption.

4.6.3. How It Works

The filtration process is simple but effective. Water is poured into the top of the filter and flows down through the sand layers. As it passes through, harmful bacteria (ecoli), are trapped in the sand layers, leaving clean water to be collected at the bottom of the filter.

4.6.4. Installation

- The TIES Bio-sand Filter can be installed in a variety of locations, including households, schools, and community centers.
- It is essential to place the filter in a clean, dry environment to ensure optimal performance.
- The filter's position should allow easy access for regular cleaning and water collection.

4.6.5. Maintenance and Cleaning

- Cleaning Schedule: The filter should be cleaned regularly to maintain its effectiveness. The sand should be washed periodi-

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Figure 18. Installation of filter at Thalayar Anganwadi

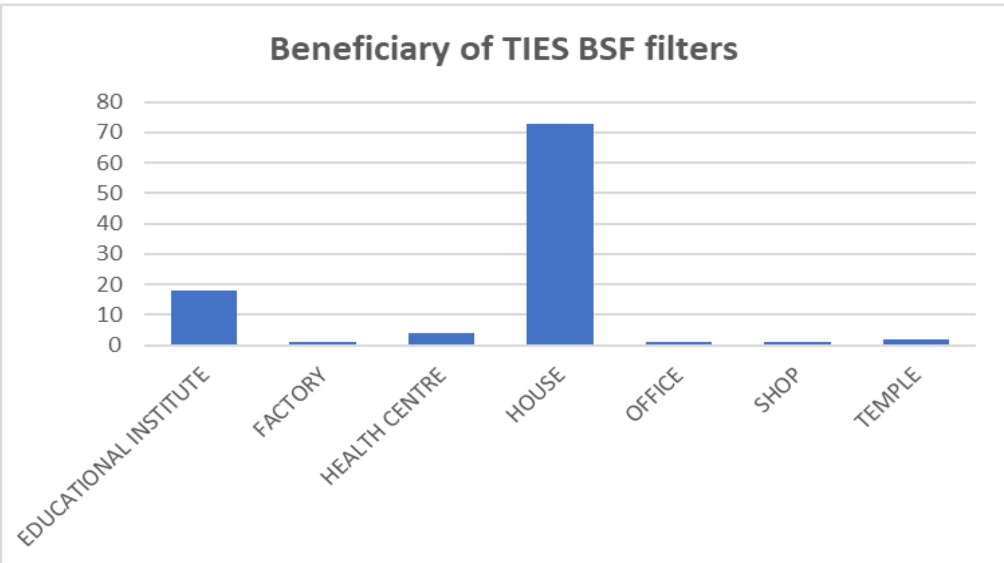
cally to remove trapped debris and contaminants.

- Maintenance Steps: Remove the top cap and wash. Avoid using harsh chemicals or washing the sand, as this may damage the filter.

4.6.6. Important Notes

- The TIES Biosand Filter is part of a community service initiative supported by the IUCN and is not available for commercial purchase.
- The filter is specifically designed to address water contamination issues in the Munnar region, helping to protect local freshwater ecosystems and conserve threatened species.

4.7 Beneficiary List for TIES Biosand Filter Installation



Graph 1. BSF Beneficiaries

The beneficiaries of the project span across different categories, ensuring a diverse reach. The installations include:

- Educational Institutions: 18 Anganwadis and schools received the filters, benefiting children and staff by ensuring clean water for drinking and sanitation.
- Houses: 64 households across multiple locations have been provided with the filters, directly impacting families and improving their quality of life.
- Temples: 2 temples in Komalikudi have been equipped with biosand filters, ensuring access to clean water for devotees and community activities.
- Health Centers: 4 dispensaries in Thalayar, Chattamunnar, and Pampanmalley now have access to filtered water, improving hygiene and health services.
- Offices and Factories: 2 workplaces, including the Thalayar Tea Office and Thalayar Factory, have received biosand filters, enhancing the water quality for employees and staff.
- Shops: 1 commercial establishment has been included in the initiative, demonstrating its outreach to small businesses.

4.7.1.Geographical Distribution

The filters have been installed across various regions, including Komalikudi, Muttukad, Thalayar, Anthoniyar Colony, Mankulam, Kambiline, Thalumkandam, Padikappu, Veliyampara, Munipara, Vellathooval, Kunchithanny, and other locations. This widespread distribution ensures that clean water reaches remote and underserved communities.

Here is a list of beneficiaries who have received the TIES Biosand Filter as part of the Project:

FILTER NUMBER	NAME OF BENEFICIARY	PLACE	GPS COORDINATES	CATEGORY
1	BINDHU	KOMALIKUDI ANGANWADI	10° 0'18.02"N, 77° 7'44.66"E	EDUCATIONAL INSTITUTE
2	GANESHAN	KOMALIKUDI TEMPLE	10° 0'19.62"N, 77° 7'44.18"E	TEMPLE
3	PONNUSWAMI	KOMALIKUDI TEMPLE	10° 0'16.49"N, 77° 7'49.32"E	TEMPLE
4	JIJI KUMARI	MUTTUKAD ANGANWADI	10° 0'35.08"N, 77° 7'55.70"E	EDUCATIONAL INSTITUTE
5	JOMET GEORGE	SOCIETYMEDU CITY	10° 0'39.51"N, 77° 8'4.88"E	SHOP
6	JAYASHREE	SOCIETYMEDU ANGANWADI	10° 0'39.37"N, 77° 8'15.09"E	EDUCATIONAL INSTITUTE
7	AJIMOL	CHANGANASSERI KADA ANGANWADI	10° 0'47.00"N, 77° 7'27.60"E	EDUCATIONAL INSTITUTE
8	AKHIL	MUTTUKAD	10° 0'44.03"N, 77° 8'46.37"E	HOUSE
9	AJITHA RAJAN	MUTTUKAD	10° 0'46.47"N, 77° 8'46.29"E	HOUSE
10	THANKACHAN	MUTTUKAD	10° 0'47.59"N, 77° 8'43.29"E	HOUSE
11	MOHANAN TK	MUTTUKAD	10° 0'38.13"N, 77° 8'44.41"E	HOUSE
12	RENJITH OLICKAL	MUTTUKAD	10° 0'36.72"N, 77° 8'47.10"E	HOUSE
13	PALANISWAMI	THALAYAR TEA OFFICE	10° 9'18.39"N, 77° 6'43.39"E	OFFICE
14	S.SUDHA	THALAYAR DISPENSARY	10° 9'18.20"N, 77° 6'42.24"E	HEALTH CENTRE

15	S.MOHANA KRISHNAN	THALAYAR FACTORY	10° 9'21.91"N, 77° 6'8.38"E	FACTORY
16	MANOJ M	GLPS THALAYAR	10° 9'25.81"N, 77° 6'15.77"E	EDUCATIONAL INSTITUTE
17	MAHALAKSH-MI	KADUKUMUDI ANGANWADI	10° 9'20.31"N, 77° 6'18.38"E	EDUCATIONAL INSTITUTE
18	LAKSHMI C	THALAYAR ANGANWADI	10° 9'22.21"N, 77° 6'28.88"E	EDUCATIONAL INSTITUTE
19	SELVIN RAJ	GHSS VAGUVURRAI	10°10'7.59"N, 77° 6'6.13"E	EDUCATIONAL INSTITUTE
20	ARUNA	GHSS VAGUVURRAI	10°10'7.60"N, 77° 6'5.66"E	EDUCATIONAL INSTITUTE
21	JESSY	CHATTAMUNNAR TOP DIVI-SIION DISPENSARY	10°12'7.60"N, 77° 7'33.18"E	HEALTH CENTRE
22	INDHIRA SAJAN	CHATTAMUNNAR LOWER DIVI-SION DISPENSARY	10°12'35.75"N, 77° 7'54.50"E	HEALTH CENTRE
23	GAYATHRI	PAMAPANMALLEY DISPENSARY	10°12'49.36"N, 77° 8'15.09"E	HEALTH CENTRE
24	BALAKRISH-NAN	PAMPANMALLEY	10°12'49.94"N, 77° 8'15.06"E	HOUSE
25	REENA CHARLES	ANTHONIYAR COLONY	10° 5'24.23"N, 77° 3'23.16"E	HOUSE
26	JAQUALIN MARY	ANTHONIYAR COLONY	10° 5'23.81"N, 77° 3'23.50"E	HOUSE
27	JOSEPHINE	ANTHONIYAR COLONY	10° 5'24.46"N, 77° 3'23.38"E	HOUSE
28	CHINNAPPA RAJAN	ANTHONIYAR COLONY	10° 5'24.57"N, 77° 3'22.89"E	HOUSE
29	S. GEORGE	ANTHONIYAR COLONY	10° 5'24.60"N, 77° 3'23.65"E	HOUSE
30	JOSEPH RAJ	ANTHONIYAR COLONY	10° 5'24.16"N, 77° 3'22.79"E	HOUSE
31	SELVAM	ANTHONIYAR COLONY	10° 5'24.32"N, 77° 3'24.37"E	HOUSE
32	MOHANAN	FAMILY CARE HOMESTAY MUNNAR	10° 5'25.06"N, 77° 3'27.74"E	HOUSE
33	MANOJ JO-SEPH	MUNIPARA	10° 6'8.74"N, 76°56'4.01"E	HOUSE
34	RAJENDRAN DR	MUNIPARA	10° 6'16.07"N, 76°56'4.07"E	HOUSE
35	TAHA MON	MUNIPARA	10° 6'18.38"N, 76°56'3.34"E	HOUSE
36	ROY CHACKO	MUNIPARA	10° 6'4.13"N, 76°56'0.12"E	HOUSE
37	JINTO DEVASYA	MUNIPARA	10° 6'2.67"N, 76°56'1.97"E	HOUSE
38	GIREESH V	MUNIPARA	10° 5'58.61"N, 76°56'4.96"E	HOUSE
39	PRAMOD	MANKULAM	10° 6'25.89"N, 76°55'31.61"E	HOUSE
40	RAGHAVAN PILLAI	MANKULAM	10° 6'24.53"N, 76°55'29.46"E	HOUSE
41	SHAJAN JO-SEPH	MANKULAM, THALUMKANDAM	10° 6'32.63"N, 76°55'29.23"E	HOUSE
42	SUNNY NJ	MANKULAM, THALUMKANDAM	10° 6'33.22"N, 76°55'29.24"E	HOUSE
43	PK MANI	KAMBILINE	10° 1'13.13"N, 77° 0'8.67"E	HOUSE

44	KUNJAPPAN	KAMBILINE	10° 1'10.00"N, 77° 0'8.42"E	HOUSE
45	SCARIA KURIA-KOSE	KAMBILINE	10° 1'11.90"N, 77° 0'7.61"E	HOUSE
46	PUSPA GOPI	KAMBILINE	10° 1'9.92"N, 77° 0'3.05"E	HOUSE
47	DOLLY PARAK-KETHHOTTIL	KAMBILINE	10° 1'13.27"N, 77° 0'5.69"E	HOUSE
48	SHAJI PANAM-BIL	KAMBILINE	10° 1'14.66"N, 77° 0'3.66"E	HOUSE
49	PRASANNAKU-MAR	KAMBILINE	10° 1'11.18"N, 77° 0'2.98"E	HOUSE
50	SIJO GEORGE	THALUMKANDAM	10° 6'24.14"N, 76°55'23.31"E	HOUSE
51	POTTY	PADIKAPPU	10° 3'25.58"N, 76°52'13.35"E	HOUSE
52	SUMESH	PADIKAPPU	10° 3'24.31"N, 76°52'12.79"E	HOUSE
53	VASU	PADIKAPPU	10° 3'23.67"N, 76°52'11.99"E	HOUSE
54	KUTTY	PADIKAPPU	10° 3'23.48"N, 76°52'10.90"E	HOUSE
55	MUTHAIAN	PADIKAPPU	10° 3'23.94"N, 76°52'9.76"E	HOUSE
56	CHINNADI	PADIKAPPU	10° 3'26.97"N, 76°51'56.19"E	HOUSE
57	RATHEESH	PADIKAPPU	10° 3'26.99"N, 76°51'56.95"E	HOUSE
58	ELSON	PADIKAPPU	10° 3'24.21"N, 76°52'2.44"E	HOUSE
59	THANKAPPAN	PADIKAPPU	10° 3'26.31"N, 76°52'1.53"E	HOUSE
60	SAJEEV	PADIKAPPU	10° 3'28.96"N, 76°51'58.71"E	HOUSE
61	SHIVAN	PADIKAPPU	10° 3'29.42"N, 76°51'56.04"E	HOUSE
62	JOJO AUGUS-TINE	VELIYAMPARA	10° 7'6.67"N, 76°55'20.57"E	HOUSE
63	SAVITHRI	VELIYAMPARA	10° 7'5.67"N, 76°55'20.79"E	HOUSE
64	JOMON	VELIYAMPARA	10° 7'7.15"N, 76°55'18.65"E	HOUSE
65	THANKACHAN KM	VELIYAMPARA	10° 7'9.77"N, 76°55'17.49"E	HOUSE
66	SHAJI AUGUS-TINE	VELIYAMPARA	10° 7'12.03"N, 76°55'17.08"E	HOUSE
67	JOSHY THOM-AS	VELIYAMPARA	10° 7'6.73"N, 76°55'17.29"E	HOUSE
68	JOMON CHERI-YAN	VELIYAMPARA	10° 7'3.14"N, 76°55'15.81"E	HOUSE
69	JINESH	VELIYAMPARA	10° 7'1.50"N, 76°55'17.05"E	HOUSE
70	SHIBU	VELIYAMPARA	10° 7'2.42"N, 76°55'14.52"E	HOUSE
71	BIJU GEORGE	VELIYAMPARA	10° 7'1.08"N, 76°55'16.65"E	HOUSE
72	AJIMON OL-ICKAL	VELIYAMPARA	10° 7'2.16"N, 76°55'14.28"E	HOUSE
73	GEORGE JO-SEPH	VELIYAMPARA	10° 6'57.66"N, 76°55'17.91"E	HOUSE
74	ANCY VARKEY	VELIYAMPARA	10° 6'56.83"N, 76°55'16.13"E	HOUSE
75	RAJU AGUSTIN	VELIYAMPARA	10° 7'0.83"N, 76°55'12.84"E	HOUSE
76	GEORGE MJ	THALUMKANDAM	10° 6'38.51"N, 76°54'35.70"E	HOUSE

77	KAVITHA N THOMAS	AMBAZHACHAL ANGANWADI	10° 0′59.54″N, 77° 0′49.81″E	EDUCATIONAL INSTITUTE
78	JOSE UTHUP	AMBAZHACHAL	10° 0′49.20″N, 77° 0′48.33″E	HOUSE
79	SOLLY PHILIP	THOKKUPARA ANGANWADI	10° 1′16.17″N, 77° 1′22.80″E	EDUCATIONAL INSTITUTE
80	MINI CV	PAINADHAN KUNNU ANGAN-WADI	10° 1′14.95″N, 77° 1′25.63″E	EDUCATIONAL INSTITUTE
81	RAJI UG	SENGULAM ANGANWADI	10° 0′32.67″N, 77° 1′35.66″E	EDUCATIONAL INSTITUTE
82	ANNIS MM	ANVIRATTY ANGANWADI	10° 1′1.56″N, 76°59′31.17″E	EDUCATIONAL INSTITUTE
83	LALY MD	KOOMPANPARA ANGANWADI	10° 0′39.61″N, 76°58′37.74″E	EDUCATIONAL INSTITUTE
84	SHEEBA KK	ODAKKACITY ANGANWADI	10° 0′34.09″N, 76°59′1.18″E	EDUCATIONAL INSTITUTE
85	SALMA VM	KOOMPANPARA ANGANWADI	10° 0′30.38″N, 76°59′8.08″E	EDUCATIONAL INSTITUTE
86	LAILA MM	NAIKUNNU ANGANWADI	9°59′29.05″N, 76°59′51.47″E	EDUCATIONAL INSTITUTE
87	KUNJUMON PK	ODAKKACITY	10° 0′23.28″N, 76°59′11.93″E	HOUSE
88	SOMY BABU	VELLATHOOVAL	9°58′44.46″N, 77° 1′25.93″E	HOUSE
89	SHIBU	VELLATHOOVAL	9°58′44.49″N, 77° 1′24.58″E	HOUSE
90	ARUNRAJ	VELLATHOOVAL	9°58′43.12″N, 77° 1′25.09″E	HOUSE
91	SEENA	VELLATHOOVAL	9°58′44.99″N, 77° 1′22.48″E	HOUSE
92	SHAINY	VELLATHOOVAL	9°58′45.48″N, 77° 1′23.73″E	HOUSE
93	RAHUL	VELLATHOOVAL	9°58′43.74″N, 77° 1′20.59″E	HOUSE
94	LEKSHMI	VELLATHOOVAL	9°58′41.99″N, 77° 1′21.01″E	HOUSE
95	SINDHU KAN-NAN	KUNCHITHANNY	10° 0′44.56″N, 77° 4′0.88″E	HOUSE
96	SREEJA	KUNCHITHANNY	10° 0′44.19″N, 77° 4′2.26″E	HOUSE
97	JAYAN	KUNCHITHANNY	10° 0′44.31″N, 77° 4′1.84″E	HOUSE
98	AUGUSTINE JOSEPH	VELIYAMPARA	10° 7′15.85″N, 76°55′17.04″E	HOUSE
99	RAIJU JOSEPH	MANKULAM,MUNIPARA	10° 6′28.13″N, 76°55′58.50″E	HOUSE
100	DEVASSYA MICHEAL	VELIYAMPARA	10° 7′3.78″N, 76°55′7.78″E	HOUSE

Table 1. Beneficiary list of TIES BSF

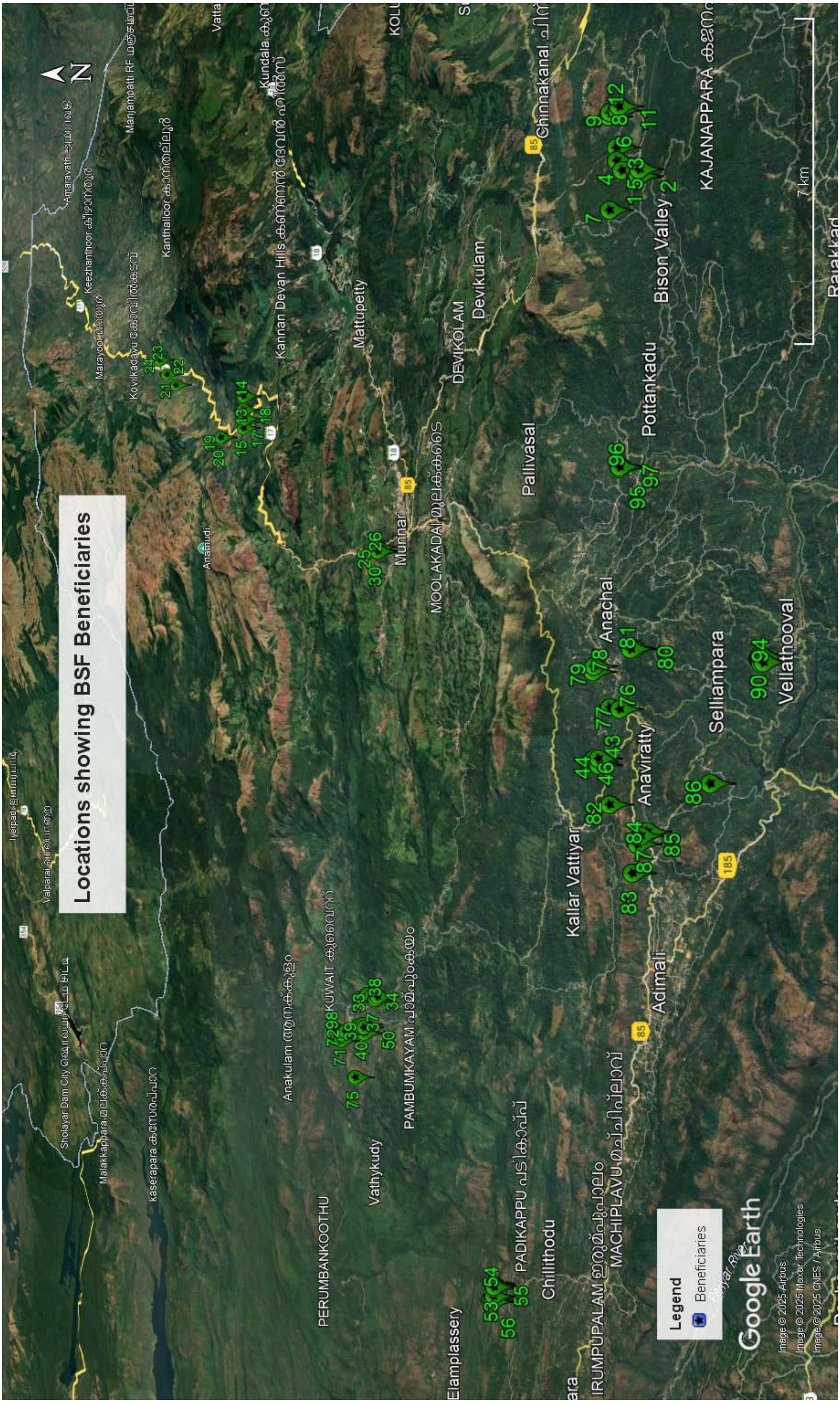


Figure 19. Map Showing locations of BSF Beneficiaries

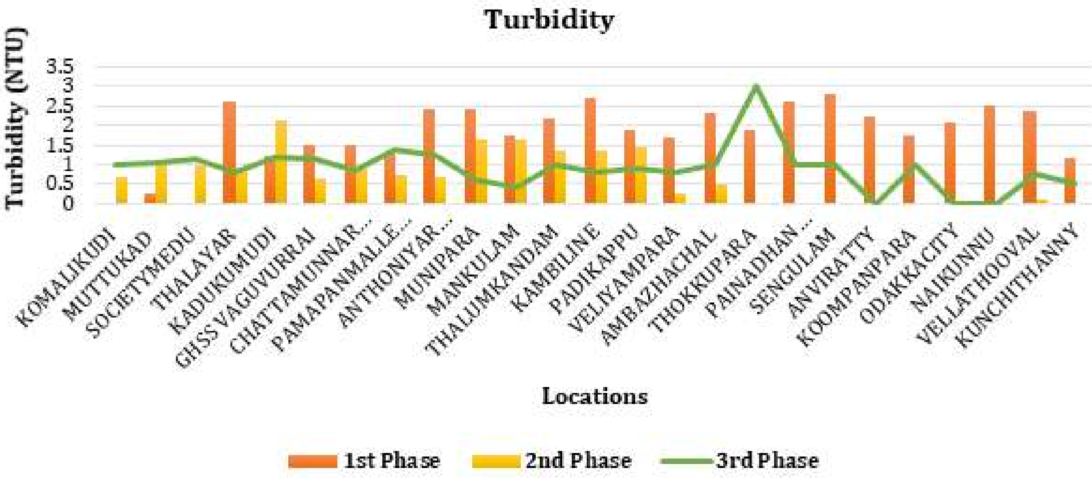
Filter distributed for SHIVAN, PADIKAPPU

The TIES Bio-sand Filter Installation Project has made significant strides in improving water accessibility and quality for a diverse range of beneficiaries. By targeting educational institutions, households, religious centers, health facilities, and workplaces, the project has contributed to enhanced public health and environmental sustainability. Continued monitoring and maintenance of these filters will be essential to ensure long-term benefits for the communities involved

4.8. Water quality assessment studies

4.8.1. Turbidity

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates[1]. In the initial phase, only 21 filters achieved turbidity levels within the prescribed standard of 1 NTU (as per BIS, 2012). During the 2nd phase, a significant improvement was observed, with 65 samples meeting the prescribed limits. This demonstrates the effectiveness of the filters in reducing turbidity overtime. Further improvement was recorded in the 3rd phase, with 74 samples complying with the prescribed turbidity standards. This steady increase suggests that the filters became more efficient overtime, likely due to enhanced community awareness, better maintenance practices, or the gradual maturation of the biosand filter media. The mean turbidity values and ranges for samples collected across different filter locations are summarized in Table 2 (Graph.2). The BSF removes contaminants from water through four mechanisms: mechanical trapping, predation, adsorption and natural death. Mechanical trapping occurs when solids and microbes suspended in the water are retained in the small spaces between sand grains[2].



Graph 2. Phase-wise comparison of turbidity levels in water samples collected from biosand filters across various locations.

S. No	Filter Location	1st Phase		2nd Phase		3rd Phase	
		Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
1	KOMALIKUDI	0 ± 0	0-0	0.7 ± 0.07	0.65-0.8	1 ± 0.26	0.8-1.3
2	MUTTUKAD	0.27 ± 0.52	0-1.3	1.06 ± 0.48	0.45-1.85	1.03 ± 0.2	0.8-1.2
3	SOCIETYMEDU	0 ± 0	0-0	0.95 ± 0.23	0.75-1.2	1.13 ± 0.45	0.7-1.6
4	THALAYAR	2.6 ± 1.04	1.5-4.05	0.9 ± 0.3	0.45-1.2	0.8 ± 0.31	0.5-1.3
5	KADUKUMUDI	1.2 ± 0*	1.2 *	2.15 ± 0*	2.15*	1.2 ± 0*	1.2*
6	GHSS VAGUVURRAI	1.5 ± 0	1.5-1.5	0.65 ± 0.3	0.45-0.85	1.15 ± 0.21	1-1.3
7	CHATTAMUNNAR DISPENSARY	1.5 ± 0.14	1.4-1.6	0.87 ± 0.4	0.6-1.15	0.85 ± 0.07	0.8-0.9
8	PAMAPANMALLEY DISPENSARY	1.3 ± 0	1.3-1.3	0.75 ± 0.42	0.45-1.05	1.4 ± 0.3	1.2-1.6
9	ANTHONIYAR COLONY	2.4 ± 3.8	0.5-11.7	0.67 ± 0.35	0.2-1.3	1.24 ± 0.4	0.8-1.8
10	MUNIPARA	2.4 ± 0.97	1.1-3.6	1.63 ± 0.92	0-2.5	0.63 ± 0.67	0-2
11	MANKULAM	1.75 ± 0.35	1.5-2	1.65 ± 0.35	1.4-1.9	0.4 ± 0.14	0.3-0.5
12	THALUMKANDAM	2.17 ± 0.62	1.8-3.1	1.37 ± 0.45	1-1.9	1.02 ± 0.68	0.5-2
13	KAMBILINE	2.7 ± 1.56	1.8-6.2	1.37 ± 0.31	1-1.9	0.8 ± 0.42	0.3-1.5
14	PADIKAPPU	1.9 ± 1.1	0.6-4.7	1.44 ± 0.36	1-2.3	0.89 ± 0.21	0.6-1.2
15	VELIYAMPARA	1.7 ± 0.5	0.8-2.7	0.25 ± 0.4	0-1	0.8 ± 0.54	0-2
16	AMBAZHACHAL	2.3 ± 0	2.3-2.3	0.5 ± 0.7	0-1	1 ± 0	1-1
17	THOKKUPARA	1.9 ± 0*	1.9*	0 ± 0*	0*	3 ± 0*	3*
18	PAINADHAN KUNNU	2.6 ± 0*	2.6*	0 ± 0*	0*	1 ± 0*	1*
19	SENGULAM	2.8 ± 0*	2.8*	0 ± 0*	0*	1 ± 0*	1*
20	ANVIRATTY	2.2 ±0*	2.2*	0 ± 0*	0*	0 ± 0*	0*
21	KOOMPANPARA	1.75 ± 0.35	1.5-2	0 ± 0	0-0	1 ± 0	1-1
22	ODAKKACITY	2.1 ± 0.56	1.7-2.5	0 ± 0	0-0	0 ± 0	0-0
23	NAIKUNNU	2.5 ± 0*	2.5*	0 ± 0*	0*	0 ± 0*	0*
24	VELLATHOOVAL	2.37 ± 1.82	0.4-5.5	0.12 ± 0.35	0-1	0.75 ± .46	0-1
25	KUNCHITHANNY	1.15 ± 0.78	0.6-1.7	0 ± 0	0-0	0.5 ± 0.7	0-1

Table 2. Turbidity Mean Values (± SD) and Ranges of Drinking Water samples from Biosand Filters Across Different Locations (Phase-wise Analysis).

** For locations with only one measurement, the range is represented as single value, and the mean is shown as value ± 0 to indicate the absence of variability.*

4.8.2. pH

The pH of any water sample is a measure of its acidic or basic property[3]. The pH levels of water samples collected during all three phases were analyzed to assess compliance with the BIS standard of 6.5-8.5. During the initial phase, 50 samples showed pH values within the prescribed limits, indicating that nearly half of the filters maintained an acceptable pH balance. A substantial improvement was observed during 2nd phase with 97 samples achieving pH values within the limits. This increase reflects the positive impact of the biosand filters and better management practices. However, in the 3rd phase, the number of samples meeting the standard slightly decreased to 83. Additionally, deviations from the prescribed limits were noted. 5 samples recorded pH values below 6.5, indicating acidic water, while 12 samples exceeded 8.5, indicating alkalinity. Overall, a total of 17 samples fell outside the acceptable range during the 3rd phase. These results demonstrate that the biosand filters were effective in maintaining pH levels within the acceptable range, particularly during the second phase. Mean values and ranges across locations are presented in Table 3 and Graph 3.

Graph 3. Phase-wise comparison of pH levels in water samples collected from biosand filters across various locations.

S. No	Filter Location	1st Phase		2nd Phase		3rd Phase	
		Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
1	KOMALIKUDI	6.82 ± 0.93	5.9-7.76	7.8 ± 0.1	7.7-7.9	8.69 ± 0.25	8.5-8.98
2	MUTTUKAD	7.07 ± 0.82	6.06-7.9	7.9 ± 0.35	7.6-8.4	8.88 ± 0.4	8.43-9.16
3	SOCIETYMEDU	7.2 ± 0.59	6.87-7.9	7.9 ± 0.5	7.6-8.5	8.8 ± 0.53	8.3-9.35
4	THALAYAR	6.29 ± 0.06	6.2-6.35	7.7 ± 0.2	7.5-8	8.32 ± 0.4	7.8-8.9
5	KADUKUMUDI	6.4 ± 0*	6.4*	7.8 ± 0*	7.8*	8.26 ± 0*	8.26*
6	GHSS VAGUVURRAI	6.3 ± 0	6.3-6.3	7.7 ± 0.44	7.04-8.03	8.76 ± 0.05	8.73-8.8
7	CHATTAMUNNAR DISPENSARY	6.9 ± 0.15	6.8-7.01	7.65 ± 0.07	7.6-7.7	8.15 ± 0.07	8.1-8.2
8	PAMAPANMALLEY DISPENSARY	6.36 ± 0	6.36-6.36	7.75 ± 0.07	7.7-7.8	8.19 ± 0.01	8.18-8.2
9	ANTHONIYAR COLONY	6.4 ± 0.44	5.87-7.04	7.88 ± 0.35	7.35-8.3	7.17 ± 0.7	5.8-7.96
10	MUNIPARA	6.4 ± 0.55	5.53-7.06	7.68 ± 0.72	6.2-8.45	7.54 ± 0.4	6.72-7.9
11	MANKULAM	6.1 ± 0.97	5.43-6.8	8.2 ± 0.07	8.15-8.26	7.55 ± 0.35	7.3-7.8
12	THALUMKANDAM	6.79 ± 1.08	5.83-8.22	8.09 ± 0.65	7.16-8.64	7.04 ± 0.53	6.56-7.5
13	KAMBILINE	5.8 ± 0.6	5.01-6.5	8.02 ± 0.12	7.86-8.16	7.4 ± 0.23	7.1-7.7
14	PADIKAPPU	5.89 ± 0.4	5.34-6.55	8.27 ± 0.2	7.99-8.63	6.83 ± 0.16	6.6-7.1
15	VELIYAMPARA	8.27 ± 0.62	6.6-8.8	7.35 ± 0.43	6.7-8.2	6.83 ± 0.44	6.3-7.9

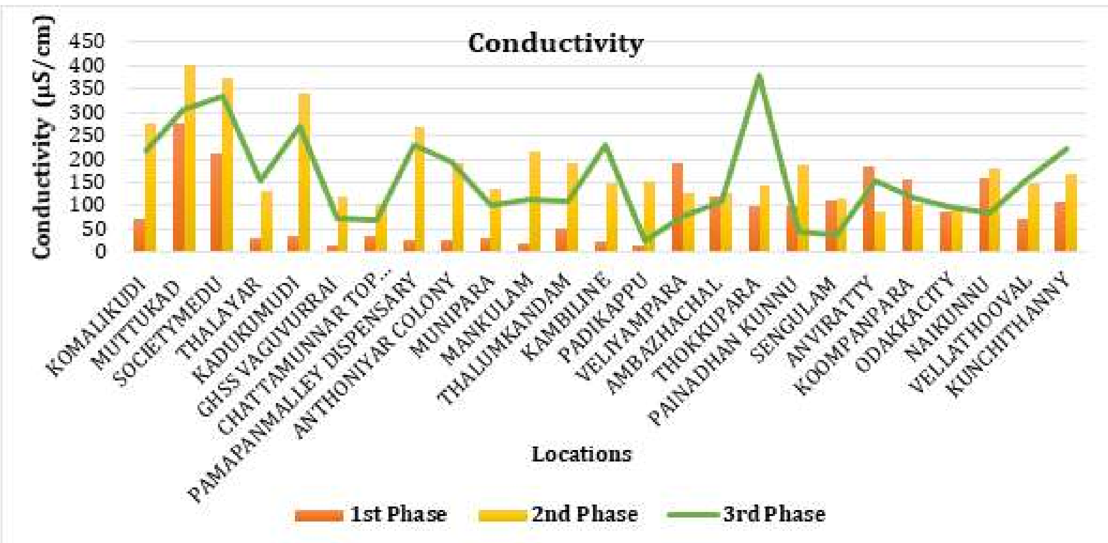
16	AMBAZHACHAL	7.84 ± 0.36	7.59-8.1	8.12 ± 0.25	7.95-8.3	8.18 ± 0.16	8.07-8.3
17	THOKKUPARA	7.97 ± 0*	7.97*	8.2 ± 0*	8.2*	8.6 ± 0*	8.6*
18	PAINADHAN KUNNU	7.86 ± 0*	7.86*	7.85 ± 0*	7.85*	5.3 ± 0*	5.3*
19	SENGULAM	8.17 ± 0*	8.17*	7.9 ± 0*	7.9*	8.3 ± 0*	8.3*
20	ANVIRATTY	8.2 ± 0*	8.2*	7.6 ± 0*	7.6*	8.3 ± 0*	8.3*
21	KOOMPANPARA	8.18 ± 0.04	8.15-8.21	7.94 ± 0.09	7.87-8.01	7.95 ± 0.07	7.9-8.01
22	ODAKKACITY	7.77 ± 0.02	7.76-7.79	8.03 ± 0.08	7.97-8.09	7.65 ± 0.35	7.4-7.9
23	NAIKUNNU	8.1 ± 0*	8.1*	7.7 ± 0*	7.7*	7.7 ± 0*	7.7*
24	VELLATHOOVAL	6.67 ± 0.17	6.5-6.9	7.6 ± 0.53	6.7-8.2	7.37 ± 0.3	7-7.9
25	KUNCHITHANNY	6.2 ± 0.42	5.9-6.5	7.95 ± 0.35	7.7-8.2	7.7 ± 0.3	7.5-7.9

Table 3. pH Mean Values (± SD) and Ranges of Drinking Water samples from Biosand Filters Across Different Locations (Phase-wise Analysis).

** For locations with only one measurement, the range is represented as single value, and the mean is shown as value ± 0 to indicate the absence of variability.*

4.8.3. Conductivity

The ability of water to carry electrical current is measured by its conductivity, which is an essential parameter in assessing water quality. Electrical conductivity usually used for indicating the total concentration of ionized constituents of water[4] (Huq and Alam, 2005). During the 1st phase, the mean values of electrical conductivity (EC) ranged from 15.9 ± 0 to 276.85 ± 119.7 µS/cm. In the 2nd phase, the values ranged from 86 ± 0 to 400 ± 166.1 µS/cm while in the 3rd phase, values varied from 39 ± 0 to 380 ± 0 µS/cm. It is noteworthy that the EC values for all treated water samples across the three phases remained well within the WHO permissible limit of 750 µS/cm for drinking water. This indicates the efficiency of the treatment processes in maintaining acceptable conductivity levels, ensuring the water's suitability for consumption. Detailed data can be



Graph 4. Phase-wise comparison of Conductivity levels in water samples collected from biosand filters across various locations.

found in Table 4 and Graph 4.

S. No	Filter Location	1st Phase		2nd Phase		3rd Phase	
		Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
1	KOMALIKUDI	72.6 ± 59.65	31-141	276 ± 27.84	246-301	217 ± 136	82-354
2	MUTTUKAD	276.85 ± 119.7	74.1-421	400 ± 166.1	156-582	306.8 ± 113.9	132-461
3	SOCIETYMEDU	211.67 ± 186.7	35-407	372.3 ± 194	156-531	333.3 ± 229	70-486
4	THALAYAR	30.5 ± 3	28.5-35.8	131 ± 86.7	58-279	153.98 ± 99.1	37.9-310
5	KADUKUMUDI	34.6 ± 0*	34.6*	342 ± 0*	342*	269 ± 0*	269*
6	GHSS VAGUVURRAI	15.9 ± 0	15.9-15.9	121 ± 8.5	115-127	75.5 ± 16.3	64-87
7	CHATTAMUNNAR DISPENSARY	37.45 ± 18	24.7-50.2	103.5 ± 4.9	100-107	69 ± 1.4	68-70
8	PAMAPANMALLEY DISPENSARY	26.35 ± 0.07	26.3-26.4	270 ± 31.1	248-292	231.5 ± 2.1	230-233
9	ANTHONIYAR COLONY	28.27 ± 22.07	12.9-74.4	190.87±114.7	60-410	196.37 ± 129.3	12.2-362
10	MUNIPARA	29.6 ± 8.06	20-43	135.7 ± 81.5	87-314	103.7 ± 7.04	95-114
11	MANKULAM	20 ± 2.8	18-22	216 ± 154.1	107-325	115 ± 12.7	106-124
12	THALUMKANDAM	52.5 ± 69.7	15-157	194.25 ± 77.7	138-309	110.75 ± 18.5	83-121
13	KAMBILINE	25.3 ± 9	14-37	148 ± 23.4	114-170	230.43 ± 25.6	186-260
14	PADIKAPPU	13.63 ± 4.4	7-20	151.36 ± 27.1	111-186	25.82 ± 4.8	18-36
15	VELIYAMPARA	191.56 ± 71.8	23-316	126.44 ± 36.7	71-187	76.56 ± 23.2	37-112
16	AMBAZHACHAL	119 ± 31.1	97-141	126.5 ± 13.4	117-136	111 ± 41	82-140
17	THOKKUPARA	101 ± 0*	101*	144 ± 0*	144*	380 ± 0*	380*
18	PAINADHAN KUNNU	98 ± 0*	98*	188 ± 0*	188*	45 ± 0*	45*
19	SENGULAM	112 ± 0*	112*	117 ± 0*	117*	39 ± 0*	39*
20	ANVIRATTY	185 ± 0*	185*	86 ± 0*	86*	156 ± 0*	156*
21	KOOMPANPARA	157 ± 5.6	153-161	104.5 ± 89.8	41-168	118.5 ± 31.8	96-141
22	ODAKKACITY	87 ± 2.8	85-89	101.5 ± 0.7	101-102	97.5 ± 7.7	92-103
23	NAIKUNNU	161 ± 0*	161*	182 ± 0*	182*	87 ± 0*	87*
24	VELLATHOOVAL	72.37 ± 18.6	39-89	148.75 ± 33.4	103-189	156.25 ± 85.5	37-328
25	KUNCHITHANNY	109.5 ± 13.4	100-119	169.5 ± 2.1	168-171	223.5 ± 7.7	218-229

Table 4. Conductivity Mean Values (± SD) and Ranges of Drinking Water samples from Biosand Filters Across Different Locations (Phase-wise Analysis).

** For locations with only one measurement, the range is represented as single value, and the mean is shown as value ± 0 to indicate the absence of variability.*

4.8.4. Total Coliform

Coliform bacteria are organisms present in the environment and in the feces of all warm-blooded animals and humans. Total coliform bacteria are commonly found in the environment (e.g., soil or vegetation) and are generally harmless. If only total coliform bacteria are detected in drinking water, the source is likely environmental, and fecal contamination is not probable. Source water samples from 100 beneficiaries were collected (Phase 1) to establish a baseline water quality before bio-sand filter installation. Water samples were tested after the initial installation of the bio-sand filters (Phase 2). The values are compared to WHO guideline of 0 MPN/100 mL. Results revealed that 36 out of 100 filter samples showed a significant reduction in bacterial count, indicating partial effectiveness of the filters in the initial phase. A second round of water testing was conducted after continued use of the filters (Phase 3). Results showed improvement with 47 out of 100 filters exhibiting a reduction in bacterial count. Comparing all three phases, a total of 39 samples demonstrated a reduction in total coliform levels. This improvement signifies that the biosand filters effectively reduced microbial contamination in many households. The MPN index

Figure 20. Total coliform analysis

values for the three phases are provided in Table 5.

Filter Number	Name of Beneficiary	Location	MPN (0/100ml)		
			1st Phase	2nd Phase	3rd Phase
1	BINDHU	KOMALIKUDI ANGANWADI	2400	1100	1100
2	GANESHAN	KOMALIKUDI TEMPLE	2400	460	2400
3	PONNUSWAMI	KOMALIKUDI TEMPLE	2400	2400	460
4	JIJI KUMARI	MUTTUKAD ANGANWADI	1100	2400	2400
5	JOMET GEORGE	SOCIETYMEDU CITY	2400	240	460
6	JAYASHREE	SOCIETYMEDU ANGANWADI	240	2400	93
7	AJIMOL	CHANGANASSERI KADA ANGANWADI	93	240	240
8	AKHIL	MUTTUKAD	150	2400	2400
9	AJITHA RAJAN	MUTTUKAD	2400	2400	2400
10	THANKACHAN	MUTTUKAD	2400	240	2400
11	MOHANAN TK	MUTTUKAD	240	23	1100
12	RENJITH OLICKAL	MUTTUKAD	2400	2400	2400
13	PALANISWAMI	THALAYAR TEA OFFICE	2400	75	43
14	S. SUDHA	THALAYAR DISPENSARY	2400	2400	2400
15	S. MOHANA KRISHNAN	THALAYAR FACTORY	2400	1100	93
16	MANOJ M	GLPS THALAYAR	2400	2400	2400
17	MAHALAKSHMI	KADUKUMUDI ANGANWADI	2400	2400	460
18	LAKSHMI C	THALAYAR ANGANWADI	2400	210	4
19	SELVIN RAJ	GHSS VAGUVURRAI	1100	460	93
20	ARUNA	GHSS VAGUVURRAI	1100	2400	43
21	JESSY	CHATTAMUNNAR TOP DIVISIION DISPENSARY	1100	2400	43
22	INDHIRA SAJAN	CHATTAMUNNAR LOWER DIVISION DISPENSARY	2400	39	240
23	GAYATHRI	PAMAPANMALLEY DISPENSARY	2400	2400	240
24	BALAKRISHNAN	PAMPANMALLEY	2400	2400	93
25	REENA CHARLES	ANTHONIYAR COLONY	2400	2400	23

26	JAQUALIN MARY	ANTHONIYAR COLONY	1100	2400	240
27	JOSEPHINE	ANTHONIYAR COLONY	1100	2400	2400
28	CHINNAPPA RAJAN	ANTHONIYAR COLONY	2400	210	93
29	S. GEORGE	ANTHONIYAR COLONY	2400	2400	43
30	JOSEPH RAJ	ANTHONIYAR COLONY	2400	460	460
31	SELVAM	ANTHONIYAR COLONY	2400	1100	1100
32	MOHANAN	FAMILY CARE HOMESTAY MUNNAR	1100	150	23
33	MANOJ JOSEPH	MUNIPARA	39	2400	460
34	RAJENDRAN DR	MUNIPARA	2400	2400	2400
35	TAHA MON	MUNIPARA	39	2400	2400
36	ROY CHACKO	MUNIPARA	23	150	460
37	JINTO DEVASYA	MUNIPARA	93	2400	460
38	GIREESH V	MUNIPARA	1100	460	43
39	PRAMOD	MANKULAM	150	460	2400
40	RAGHAVAN PILLAI	MANKULAM	2400	1100	460
41	SHAJAN JOSEPH	MANKULAM, THALUMKANDAM	460	150	210
42	SUNNY NJ	MANKULAM, THALUMKANDAM	460	1100	2400
43	PK MANI	KAMBILINE	2400	1100	2400
44	KUNJAPPAN	KAMBILINE	2400	460	150
45	SCARIA KURIAKOSE	KAMBILINE	460	2400	2400
46	PUSPA GOPI	KAMBILINE	460	2400	2400
47	DOLLY PARAKKETH-HOTTIL	KAMBILINE	1100	460	93
48	SHAJI PANAMBIL	KAMBILINE	460	2400	2400
49	PRASANNAKUMAR	KAMBILINE	2400	2400	43
50	SIJO GEORGE	THALUMKANDAM	23	150	240
51	POTTY	PADIKAPPU	460	2400	460
52	SUMESH	PADIKAPPU	2400	2400	2400
53	VASU	PADIKAPPU	1100	1100	240
54	KUTTY	PADIKAPPU	2400	210	150
55	MUTHAIAN	PADIKAPPU	2400	460	1100
56	CHINNADI	PADIKAPPU	2400	1100	2400
57	RATHEESH	PADIKAPPU	2400	460	2400
58	ELSON	PADIKAPPU	2400	1100	2400
59	THANKAPPAN	PADIKAPPU	2400	2400	9
60	SAJEEV	PADIKAPPU	1100	2400	2400
61	SHIVAN	PADIKAPPU	2400	1100	43
62	JOJO AUGUSTINE	VELIYAMPARA	2400	2400	43
63	SAVITHRI	VELIYAMPARA	2400	2400	43
64	JOMON	VELIYAMPARA	2400	2400	43
65	THANKACHAN KM	VELIYAMPARA	2400	23	23
66	SHAJI AUGUSTINE	VELIYAMPARA	2400	2400	150
67	JOSHY THOMAS	VELIYAMPARA	2400	2400	2400
68	JOMON CHERIYAN	VELIYAMPARA	2400	23	2400
69	JINESH	VELIYAMPARA	2400	23	2400
70	SHIBU	VELIYAMPARA	2400	2400	43

71	BIJU GEORGE	VELIYAMPARA	460	460	43
72	AJIMON OLICKAL	VELIYAMPARA	2400	2400	240
73	GEORGE JOSEPH	VELIYAMPARA	2400	2400	43
74	ANCY VARKEY	VELIYAMPARA	2400	2400	43
75	RAJU AGUSTIN	VELIYAMPARA	2400	1100	2400
76	GEORGE MJ	THALUMKANDAM	2400	2400	23
77	KAVITHA N THOMAS	AMBAZHACHAL ANGANWADI	1100	2400	23
78	JOSE UTHUP	AMBAZHACHAL	1100	1100	93
79	SOLLY PHILIP	THOKKUPARA ANGANWADI	460	2400	460
80	MINI CV	PAINADHAN KUNNU ANGANWADI	2400	2400	2400
81	RAJI UG	SENGULAM ANGANWADI	150	2400	2400
82	ANNIS MM	ANVIRATTY ANGANWADI	2400	2400	2400
83	LALY MD	KOOMPANPARA ANGANWADI	460	2400	1100
84	SHEEBA KK	ODAKKACITY ANGANWADI	2400	2400	75
85	SALMA VM	KOOMPANPARA ANGANWADI	2400	2400	1100
86	LAILA MM	NAIKUNNU ANGANWADI	2400	2400	2400
87	KUNJUMON PK	ODAKKACITY	460	2400	2400
88	SOMY BABU	VELLATHOOVAL	210	1100	2400
89	SHIBU	VELLATHOOVAL	460	460	93
90	ARUNRAJ	VELLATHOOVAL	2400	2400	2400
91	SEENA	VELLATHOOVAL	2400	2400	460
92	SHAINY	VELLATHOOVAL	1100	460	2400
93	RAHUL	VELLATHOOVAL	2400	150	2400
94	LEKSHMI	VELLATHOOVAL	2400	1100	2400
95	SINDHU KANNAN	VELLATHOOVAL	2400	1100	2400
96	SREEJA	KUNCHITHANNY	2400	93	1100
97	JAYAN	KUNCHITHANNY	1100	1100	460
98	AUGUSTINE JOSEPH	VELIYAMPARA	2400	2400	2400
99	RAIJU JOSEPH	MANKULAM, MUNIPARA	460	93	2400
100	DEVASSYA MICHEAL	VELIYAMPARA	210	460	240

Table 5. Phase-wise comparison of Total coliform levels in water samples collected from biosand filters across various locations.

4.8.5. Fecal Coliform

Fecal coliform bacteria are a sub-group of total coliform bacteria. They appear in great quantities in the intestines and feces of people and animals. After the installation of biosand filters, 50 out of 100 samples showed a reduction in fecal coliform levels during Phase 2 testing. In Phase 3 testing, 47 out of 100 samples exhibited reduced fecal coliform levels. A total of 25 samples showed consistent improvement in fecal coliform levels across all phases. Despite the observed improvements, a notable proportion of samples did not show bacterial count reduction or improvement because of irregular usage, improper maintenance, or issues with safe storage practices. Table 6 provides a phase-wise

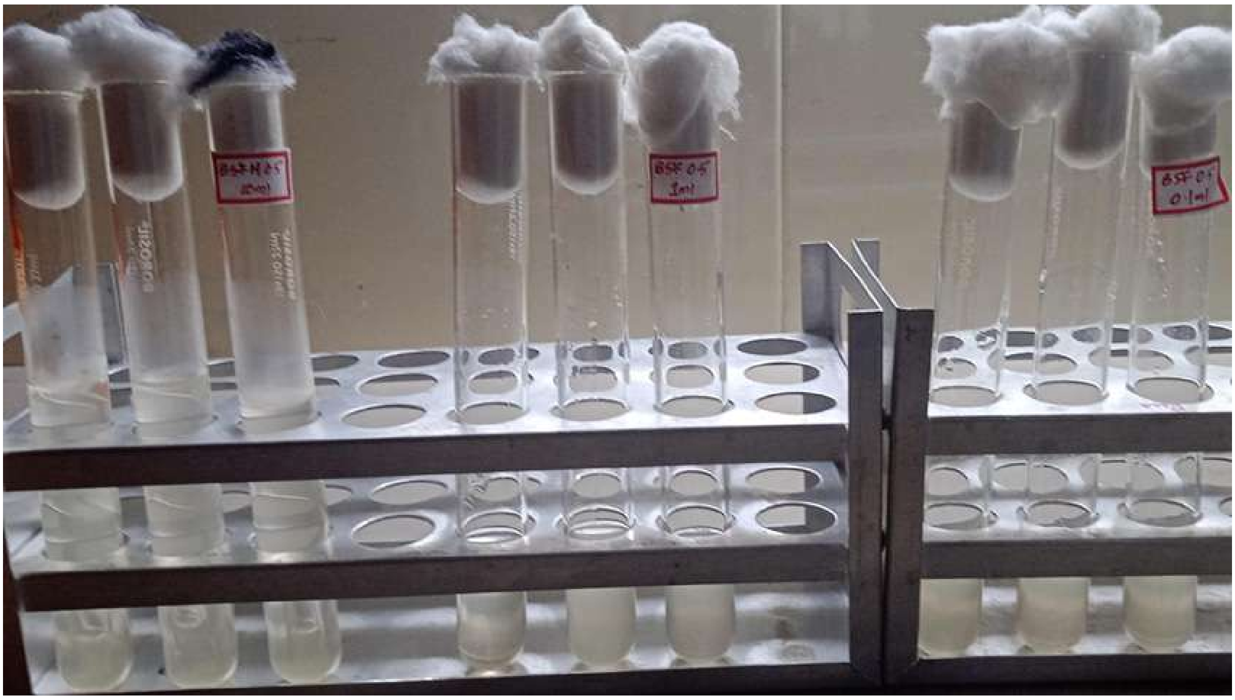


Figure 21. Fecal coliform analysis of samples

comparison of fecal coliform levels.

Filter Number	Name of Beneficiary	Location	MPN (0/100ml)		
			1st Phase	2nd Phase	3rd Phase
1	BINDHU	KOMALIKUDI ANGANWADI	2400	240	460
2	GANESHAN	KOMALIKUDI TEMPLE	2400	240	460
3	PONNUSWAMI	KOMALIKUDI TEMPLE	2400	150	93
4	JIJI KUMARI	MUTTUKAD ANGANWADI	1100	240	1100
5	JOMET GEORGE	SOCIETYMEDU CITY	2400	43	43
6	JAYASHREE	SOCIETYMEDU ANGANWADI	240	2400	43
7	AJIMOL	CHANGANASSERI KADA ANGANWADI	93	93	23
8	AKHIL	MUTTUKAD	150	43	23
9	AJITHA RAJAN	MUTTUKAD	2400	1100	1100
10	THANKACHAN	MUTTUKAD	2400	93	1100
11	MOHANAN TK	MUTTUKAD	240	4	150
12	RENJITH OLICKAL	MUTTUKAD	2400	150	460
13	PALANISWAMI	THALAYAR TEA OFFICE	43	43	23
14	S. SUDHA	THALAYAR DISPENSARY	1100	43	23
15	S. MOHANA KRISHNAN	THALAYAR FACTORY	1100	93	23
16	MANOJ M	GLPS THALAYAR	2400	43	1100
17	MAHALAKSHMI	KADUKUMUDI ANGANWADI	2400	43	43
18	LAKSHMI C	THALAYAR ANGANWADI	43	43	0
19	SELVIN RAJ	GHSS VAGUVURRAI	150	93	7
20	ARUNA	GHSS VAGUVURRAI	150	9	7
21	JESSY	CHATTAMUNNAR TOP DIVISIION DISPENSARY	39	23	0
22	INDHIRA SAJAN	CHATTAMUNNAR LOWER DIVISION DISPENSARY	2400	23	9

23	GAYATHRI	PAMAPANMALLEY DISPENSARY	1100	43	93
24	BALAKRISHNAN	PAMPANMALLEY	2400	93	43
25	REENA CHARLES	ANTHONIYAR COLONY	2400	23	23
26	JAQUALIN MARY	ANTHONIYAR COLONY	39	7	23
27	JOSEPHINE	ANTHONIYAR COLONY	1100	23	460
28	CHINNAPPA RAJAN	ANTHONIYAR COLONY	2400	23	23
29	S. GEORGE	ANTHONIYAR COLONY	2400	9	4
30	JOSEPH RAJ	ANTHONIYAR COLONY	240	93	23
31	SELVAM	ANTHONIYAR COLONY	2400	43	23
32	MOHANAN	FAMILY CARE HOMESTAY MUNNAR	43	9	9
33	MANOJ JOSEPH	MUNIPARA	23	23	460
34	RAJENDRAN DR	MUNIPARA	2400	39	2400
35	TAHA MON	MUNIPARA	23	150	93
36	ROY CHACKO	MUNIPARA	23	43	150
37	JINTO DEVASYA	MUNIPARA	75	2400	210
38	GIREESH V	MUNIPARA	23	93	4
39	PRAMOD	MANKULAM	93	240	2400
40	RAGHAVAN PILLAI	MANKULAM	4	93	240
41	SHAJAN JOSEPH	MANKULAM, THALUMKANDAM	240	93	20
42	SUNNY NJ	MANKULAM, THALUMKANDAM	43	43	2400
43	PK MANI	KAMBILINE	39	240	2400
44	KUNJAPPAN	KAMBILINE	1100	460	43
45	SCARIA KURIAKOSE	KAMBILINE	75	2400	460
46	PUSPA GOPI	KAMBILINE	240	1100	2400
47	DOLLY PARAKKETHHOT-TIL	KAMBILINE	460	240	43
48	SHAJI PANAMBIL	KAMBILINE	93	43	1100
49	PRASANNAKUMAR	KAMBILINE	460	240	21
50	SIJO GEORGE	THALUMKANDAM	23	4	93
51	POTTY	PADIKAPPU	93	75	93
52	SUMESH	PADIKAPPU	460	2400	2400
53	VASU	PADIKAPPU	150	75	240
54	KUTTY	PADIKAPPU	93	75	43
55	MUTHAIAN	PADIKAPPU	43	43	240
56	CHINNADI	PADIKAPPU	150	43	2400
57	RATHEESH	PADIKAPPU	210	43	2400
58	ELSON	PADIKAPPU	93	43	2400
59	THANKAPPAN	PADIKAPPU	39	93	9
60	SAJEEV	PADIKAPPU	39	23	210
61	SHIVAN	PADIKAPPU	43	23	23
62	JOJO AUGUSTINE	VELIYAMPARA	1100	240	23
63	SAVITHRI	VELIYAMPARA	2400	2400	43
64	JOMON	VELIYAMPARA	1100	2400	43
65	THANKACHAN KM	VELIYAMPARA	210	9	23
66	SHAJI AUGUSTINE	VELIYAMPARA	2400	2400	150
67	JOSHY THOMAS	VELIYAMPARA	240	2400	1100
68	JOMON CHERIYAN	VELIYAMPARA	2400	9	2400

69	JINESH	VELIYAMPARA	1100	0	93
70	SHIBU	VELIYAMPARA	23	2400	23
71	BIJU GEORGE	VELIYAMPARA	460	240	43
72	AJIMON OLICKAL	VELIYAMPARA	75	2400	43
73	GEORGE JOSEPH	VELIYAMPARA	120	2400	23
74	ANCY VARKEY	VELIYAMPARA	210	2400	23
75	RAJU AGUSTIN	VELIYAMPARA	93	1100	2400
76	GEORGE MJ	THALUMKANDAM	150	2400	4
77	KAVITHA N THOMAS	AMBAZHACHAL ANGANWADI	23	2400	4
78	JOSE UTHUP	AMBAZHACHAL	4	1100	43
79	SOLLY PHILIP	THOKKUPARA ANGANWADI	23	2400	150
80	MINI CV	PAINADHAN KUNNU ANGANWADI	1100	2400	1100
81	RAJI UG	SENGULAM ANGANWADI	43	2400	2400
82	ANNIS MM	ANVIRATTY ANGANWADI	43	2400	460
83	LALY MD	KOOMPANPARA ANGANWADI	23	2400	150
84	SHEEBA KK	ODAKKACITY ANGANWADI	9	2400	23
85	SALMA VM	KOOMPANPARA ANGANWADI	43	2400	93
86	LAILA MM	NAIKUNNU ANGANWADI	23	2400	210
87	KUNJUMON PK	ODAKKACITY	23	1100	1100
88	SOMY BABU	VELLATHOOVAL	39	93	2400
89	SHIBU	VELLATHOOVAL	75	150	43
90	ARUNRAJ	VELLATHOOVAL	43	43	150
91	SEENA	VELLATHOOVAL	9	460	240
92	SHAINY	VELLATHOOVAL	23	150	210
93	RAHUL	VELLATHOOVAL	2400	43	2400
94	LEKSHMI	VELLATHOOVAL	460	93	2400
95	SINDHU KANNAN	VELLATHOOVAL	43	93	460
96	SREEJA	KUNCHITHANNY	9	43	460
97	JAYAN	KUNCHITHANNY	1100	240	93
98	AUGUSTINE JOSEPH	VELIYAMPARA	43	460	2400
99	RAIJU JOSEPH	MANKULAM, MUNIPARA	43	43	2400
100	DEVASSYA MICHEAL	VELIYAMPARA	93	93	240

Table 6. Phase-wise comparison of Fecal coliform levels in water samples collected from biosand filters across various locations.

4.8.6. E. coli

E. coli is a sub-group of the fecal coliform group. Most E. coli bacteria are harmless and are found in great quantities in the intestines of people and warm-blooded animals. The presence of E. coli in a drinking water sample almost always indicates recent fecal contamination, signifying a greater risk of pathogens being present. Baseline testing (Phase 1) revealed that E. coli was absent in 3 out of 100 samples. After the installation of biosand filters, E. coli was absent in 8 out of 100 samples. In the final testing, E. coli was absent in 15 out of 100 samples. These results demonstrate a progressive improvement in the absence of E. coli across the phases, indicating the positive impact of biosand filters in reducing this specific contaminant. Table 7

Figure 22. A sample showing with E.coli; green shield shows the presence of E.coli

provides a phase-wise comparison of E. coli levels in water collected from biosand filters.

Filter Number	Name of Beneficiary	Location	MPN (0/100ml)		
			1st Phase	2nd Phase	3rd Phase
1	BINDHU	KOMALIKUDI ANGANWADI	Present	Present	Present
2	GANESHAN	KOMALIKUDI TEMPLE	Present	Present	Present
3	PONNUSWAMI	KOMALIKUDI TEMPLE	Present	Present	Present
4	JIJI KUMARI	MUTTUKAD ANGANWADI	Present	Present	Present
5	JOMET GEORGE	SOCIETYMEDU CITY	Present	Present	Present
6	JAYASHREE	SOCIETYMEDU ANGANWADI	Present	Present	Present
7	AJIMOL	CHANGANASSERI KADA ANGANWADI	Present	Present	Present
8	AKHIL	MUTTUKAD	Absent	Absent	Absent
9	AJITHA RAJAN	MUTTUKAD	Present	Present	Present

10	THANKACHAN	MUTTUKAD	Present	Present	Present
11	MOHANAN TK	MUTTUKAD	Absent	Present	Present
12	RENJITH OLICKAL	MUTTUKAD	Present	Present	Present
13	PALANISWAMI	THALAYAR TEA OFFICE	Present	Present	Absent
14	S. SUDHA	THALAYAR DISPENSARY	Present	Present	Present
15	S. MOHANA KRISHNAN	THALAYAR FACTORY	Present	Present	Absent
16	MANOJ M	GLPS THALAYAR	Present	Present	Present
17	MAHALAKSHMI	KADUKUMUDI ANGANWADI	Present	Present	Present
18	LAKSHMI C	THALAYAR ANGANWADI	Present	Present	Absent
19	SELVIN RAJ	GHSS VAGUVURRAI	Present	Present	Present
20	ARUNA	GHSS VAGUVURRAI	Present	Present	Present
21	JESSY	CHATTAMUNNAR TOP DIVISIION DISPENSARY	Present	Present	Absent
22	INDHIRA SAJAN	CHATTAMUNNAR LOWER DIVISION DISPENSARY	Present	Present	Present
23	GAYATHRI	PAMAPANMALLEY DISPENSARY	Present	Present	Present
24	BALAKRISHNAN	PAMPANMALLEY	Present	Present	Present
25	REENA CHARLES	ANTHONIYAR COLONY	Present	Present	Absent
26	JAQUALIN MARY	ANTHONIYAR COLONY	Present	Absent	Absent
27	JOSEPHINE	ANTHONIYAR COLONY	Present	Present	Present
28	CHINNAPPA RAJAN	ANTHONIYAR COLONY	Present	Present	Absent
29	S. GEORGE	ANTHONIYAR COLONY	Present	Present	Absent
30	JOSEPH RAJ	ANTHONIYAR COLONY	Present	Present	Present
31	SELVAM	ANTHONIYAR COLONY	Present	Absent	Absent
32	MOHANAN	FAMILY CARE HOMESTAY MUNNAR	Present	Present	Absent
33	MANOJ JOSEPH	MUNIPARA	Present	Absent	Present
34	RAJENDRAN DR	MUNIPARA	Present	Present	Present
35	TAHA MON	MUNIPARA	Present	Present	Present
36	ROY CHACKO	MUNIPARA	Present	Present	Present
37	JINTO DEVASYA	MUNIPARA	Present	Present	Present
38	GIREESH V	MUNIPARA	Present	Present	Absent
39	PRAMOD	MANKULAM	Present	Present	Present
40	RAGHAVAN PILLAI	MANKULAM	Present	Present	Present
41	SHAJAN JOSEPH	MANKULAM, THALUMKANDAM	Present	Present	Present
42	SUNNY NJ	MANKULAM, THALUMKANDAM	Present	Present	Present
43	PK MANI	KAMBILINE	Present	Absent	Present
44	KUNJAPPAN	KAMBILINE	Present	Present	Present
45	SCARIA KURIAKOSE	KAMBILINE	Present	Present	Present
46	PUSPA GOPI	KAMBILINE	Present	Present	Present
47	DOLLY PARAKKETHHOTTIL	KAMBILINE	Present	Present	Present
48	SHAJI PANAMBIL	KAMBILINE	Present	Present	Present
49	PRASANNAKUMAR	KAMBILINE	Present	Present	Absent
50	SIJO GEORGE	THALUMKANDAM	Absent	Absent	Present
51	POTTY	PADIKAPPU	Present	Present	Present
52	SUMESH	PADIKAPPU	Present	Present	Present
53	VASU	PADIKAPPU	Present	Present	Present

54	KUTTY	PADIKAPPU	Present	Present	Present
55	MUTHAIAN	PADIKAPPU	Present	Present	Present
56	CHINNADI	PADIKAPPU	Present	Present	Present
57	RATHEESH	PADIKAPPU	Present	Present	Present
58	ELSON	PADIKAPPU	Present	Present	Present
59	THANKAPPAN	PADIKAPPU	Present	Present	Absent
60	SAJEEV	PADIKAPPU	Present	Present	Present
61	SHIVAN	PADIKAPPU	Present	Present	Present
62	JOJO AUGUSTINE	VELIYAMPARA	Present	Present	Present
63	SAVITHRI	VELIYAMPARA	Present	Present	Present
64	JOMON	VELIYAMPARA	Present	Present	Present
65	THANKACHAN KM	VELIYAMPARA	Present	Absent	Present
66	SHAJI AUGUSTINE	VELIYAMPARA	Present	Present	Absent
67	JOSHY THOMAS	VELIYAMPARA	Present	Present	Present
68	JOMON CHERIYAN	VELIYAMPARA	Present	Present	Present
69	JINESH	VELIYAMPARA	Present	Absent	Present
70	SHIBU	VELIYAMPARA	Present	Present	Present
71	BIJU GEORGE	VELIYAMPARA	Present	Present	Present
72	AJIMON OLICKAL	VELIYAMPARA	Present	Present	Present
73	GEORGE JOSEPH	VELIYAMPARA	Present	Present	Present
74	ANCY VARKEY	VELIYAMPARA	Present	Present	Present
75	RAJU AGUSTIN	VELIYAMPARA	Present	Present	Present
76	GEORGE MJ	THALUMKANDAM	Present	Present	Present
77	KAVITHA N THOMAS	AMBAZHACHAL ANGANWADI	Present	Present	Present
78	JOSE UTHUP	AMBAZHACHAL	Present	Present	Present
79	SOLLY PHILIP	THOKKUPARA ANGANWADI	Present	Present	Present
80	MINI CV	PAINADHAN KUNNU ANGANWADI	Present	Present	Present
81	RAJI UG	SENGULAM ANGANWADI	Present	Present	Present
82	ANNIS MM	ANVIRATTY ANGANWADI	Present	Present	Present
83	LALY MD	KOOMPANPARA ANGANWADI	Present	Present	Present
84	SHEEBA KK	ODAKKACITY ANGANWADI	Present	Present	Present
85	SALMA VM	KOOMPANPARA ANGANWADI	Present	Present	Present
86	LAILA MM	NAIKUNNU ANGANWADI	Present	Present	Present
87	KUNJUMON PK	ODAKKACITY	Present	Present	Present
88	SOMY BABU	VELLATHOOVAL	Present	Present	Present
89	SHIBU	VELLATHOOVAL	Present	Present	Present
90	ARUNRAJ	VELLATHOOVAL	Present	Present	Present
91	SEENA	VELLATHOOVAL	Present	Present	Present
92	SHAINY	VELLATHOOVAL	Present	Present	Present
93	RAHUL	VELLATHOOVAL	Present	Present	Present
94	LEKSHMI	VELLATHOOVAL	Present	Present	Present
95	SINDHU KANNAN	VELLATHOOVAL	Present	Present	Present
96	SREEJA	KUNCHITHANNY	Present	Present	Present
97	JAYAN	KUNCHITHANNY	Present	Present	Present
98	AUGUSTINE JOSEPH	VELIYAMPARA	Present	Present	Present
99	RAIJU JOSEPH	MANKULAM, MUNIPARA	Present	Present	Present
100	DEVASSYA MICHEAL	VELIYAMPARA	Present	Present	Present

Table 7. Phase-wise comparison of E. coli levels in water samples collected from biosand filters across

various locations.

4.9. The success rate

The installation of biosand filters across various locations in Munnar has shown significant improvements in water quality over the three phases of testing. However, the results also highlight variations in performance based on household usage patterns and location-specific factors. Below is an analysis of some key observations:

4.9.1. Turbidity Improvements in Specific Locations

Komalikudi: In the first phase, all samples from Komalikudi had a turbidity of 0 NTU, indicating excellent initial performance. However, by the third phase, turbidity increased to 1 ± 0.26 NTU, suggesting a slight decline in filter efficiency, possibly due to irregular maintenance or increased sediment load in the source water.

Thalayar: This location showed remarkable improvement, with turbidity decreasing from 2.6 ± 1.04 NTU in the first phase to 0.8 ± 0.31 NTU in the third phase. This indicates that the filters became more effective over time, likely due to better community awareness and proper maintenance.

Muttukad: Turbidity levels remained relatively stable, with values hovering around 1 NTU across all phases. This suggests consistent performance, possibly due to regular usage and maintenance by households in this area.

4.9.2. pH Variations and Household Compliance

Anthoniyar Colony: This location showed significant fluctuations in pH levels. In the first phase, pH ranged from 5.87 to 7.04, with some samples being acidic. By the third phase, pH levels improved but still showed variability (5.8–7.96), indicating that some households struggled to maintain consistent water quality.

Mankulam: pH levels in Mankulam improved significantly, from 5.43–6.8 in the first phase to 7.3–7.8 in the third phase. This improvement reflects better filter performance and possibly increased user awareness about the importance of maintaining pH within acceptable limits.

Veliyampara: This location showed a decline in pH compliance, with values dropping from 6.6–8.8 in the first phase to 6.3–7.9 in the third phase. This could be due to irregular filter usage or contamination from external sources.

4.9.3. Microbial Contamination: Total and Fecal Coliform

Kambiline: Total coliform counts in Kambiline showed a mixed trend. While some households achieved significant reductions (e.g., from 2400 MPN/100mL to 150 MPN/100mL), others saw no improvement. This variability highlights the impact of inconsistent filter usage and maintenance practices.

Padikappu: Fecal coliform counts in Padikappu improved in some households, with reductions from 2400 MPN/100mL to 43 MPN/100mL. However, other households showed no change, indicating that safe storage practices and regular cleaning of filters were not uniformly adopted.

Veliyampara: This location showed a notable reduction in fecal coliform counts, with some households achieving complete elimination (0 MPN/100mL). This success can be attributed to proper filter usage and community education programs.

4.9.4. E. coli Reduction in Households

Chattamunnar Dispensary: E. coli was consistently present in the first two phases but was absent in some samples during the third phase. This improvement suggests that regular filter usage and maintenance can effectively reduce E. coli contamination.

Anthoniyar Colony: While E. coli was present in most samples during the first two phases, some households achieved complete elimination by the third phase. This highlights the importance of consistent filter usage and proper cleaning practices.

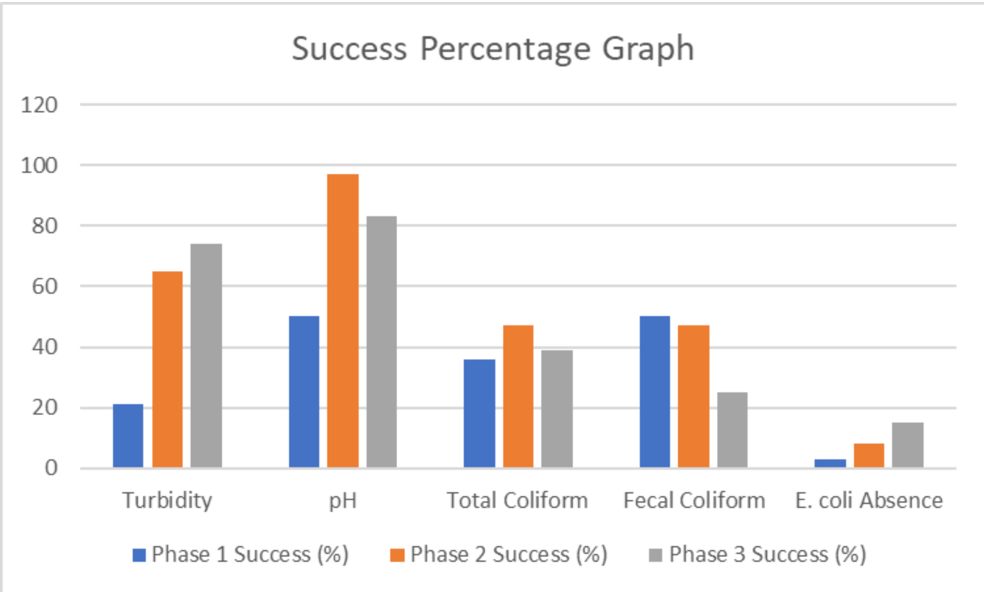
Muttukad: One household in Muttukad maintained E. coli absence across all three phases, demonstrating the effectiveness of biosand filters when used correctly.

4.9.5. Conductivity Trends

Societymedu: Conductivity levels in Societymedu showed a steady increase, from 211.67 ± 186.7 µS/cm in the first phase to 333.3 ± 229 µS/cm in the third phase. This could be due to increased mineral content in the source water or filter media degradation.

Thalayar: Conductivity levels in Thalayar remained relatively stable, with values ranging from 30.5 ± 3 µS/cm in the first phase to 153.98 ± 99.1 µS/cm in the third phase.
This stability indicates consistent filter performance and proper maintenance.

Here's a table (Table 8.) summarizing the success



Graph 5. Success percentage for each parameter

percentage for each parameter (turbidity, pH, total coliform, fecal coliform, and E. coli) across the three phases.

Sl. No.	Parameter	Phase 1 Success (%)	Phase 2 Success (%)	Phase 3 Success (%)
1	Turbidity	21	65	74
2	pH	50	97	83
3	Total Coliform	36	47	39
4	Fecal Coliform	50	47	25

Table 8. Success percentage for each parameter

The overall success and efficiency of the biosand filters across the three phases of testing demonstrate a significant improvement in water quality, particularly in reducing turbidity, maintaining pH levels, and lowering microbial contamination. Turbidity compliance improved from 21% in the first phase to 74% in the third phase, indicating that the filters became more effective over time, likely due to better maintenance and community awareness. pH compliance also saw a substantial increase, peaking at 97% in the second phase before stabilizing at 83% in the third phase, reflecting the filters' ability to maintain water within acceptable limits. Microbial contamination, including total coliform, fecal coliform, and E. coli, showed notable reductions, with 47% of samples achieving lower total coliform counts and E. coli absence increasing to 15% by the third phase.

However, the variability in results across locations and households underscores the importance of consistent usage, proper maintenance, and community education. While the biosand filters have proven to be highly effective in improving water quality, their long-term success depends on addressing challenges such as irregular usage, improper cleaning, and safe storage practices. Overall, the filters have demonstrated their potential to provide safe drinking water, particularly when supported by sustained community engagement and adherence to best practices.

4.10. Benefit Status of TIES BSF Beneficiaries

The installation of TIES Biosand Filters in 100 households has significantly improved water quality and reduced the need for boiling, leading to tangible benefits for the community. Before installation, many households relied on unfiltered water from aquifers, wells, and borewells, which contained dirt, iron content, salt deposits, and other contaminants. Some families resorted to chlorine treatment or boiling water before use, leading to increased fuel and electricity consumption. Post-installation, all households now have access to clear, clean water without additional filtration or boiling, saving kitchen gas and electricity. In cases where water fetching was a challenge, the installation has also reduced the distance required to collect potable water. This initiative not only enhances household water security but also promotes environmental sustainability by reducing energy consumption and dependency on chemical treatments.

4.10.1 Analysis: Benefits for the Stakeholders - Economic

The implementation of the TIES Bio-Sand Filters (BSF) has led to significant economic benefits for stakeholders by reducing energy consumption, cutting household health expenditures, and increasing overall savings. The following key insights are derived from the data collected:

1. Energy Savings

- Households using kitchen gas saved an average of Rs. 26 - 45 per year on fuel consumption.
- Households relying on electricity for water heating saved between Rs. 100 - 113 annually.
- Chlorination users saved a relatively lower amount, ranging from Rs. 2 - 43 annually.

Sl. No.	HOUSEHOLD NAME	DAILY QUANTITY OF WATER (L)	DAILY AVG. ENERGY (g)	MONTHLY AVG. ENERGY (g)	MONTHLY ENERGY SAVED (Rs.)	YEARLY ENERGY SAVED (Rs.)	ENERGY TYPE
1	BINDHU	50	1.65	49.5	2.673	32.076	Kitchen Gas
2	GANESHAN	40	1.32	39.6	2.1384	25.6608	Kitchen Gas
3	PONNUSAMI	35	1.155	34.65	1.8711	22.4532	Kitchen Gas
4	JIJI KUMARI	40	1.32	39.6	2.1384	25.6608	Kitchen Gas
5	JOMET GEORGE	45	1.485	44.55	2.4057	28.8684	Kitchen Gas
6	JAYASHREE	45	1.485	44.55	2.4057	28.8684	Kitchen Gas
7	AJI MOL	40	1.32	39.6	2.1384	25.6608	Kitchen Gas
8	AKHIL	42	1.386	41.58	2.24532	26.94384	Kitchen Gas
9	AJITHA RAJAN	40	1.32	39.6	2.1384	25.6608	Kitchen Gas
10	THANKACHAN	30	5.49	164.7	8.8938	106.7256	Electricity
11	MOHANAN TK	32	5.856	175.68	9.48672	113.8406	Electricity
12	RENJITH OLICKAL	35	1.155	34.65	1.8711	22.4532	Kitchen Gas
13	PALANISWAMI	25	0.125	3.75	0.2025	2.43	Chlorination

14	S. SUDHA	45	0.225	6.75	0.3645	4.374	Chlorination
15	S. MOHANA KRISHNAN	60	0.3	9	0.486	5.832	Chlorination
16	MANOJ M	70	0.35	10.5	0.567	6.804	Chlorination
17	MAHALAKSHMI	45	0.225	6.75	0.3645	4.374	Chlorination
18	LAKSHMI C.	65	0.325	9.75	0.5265	6.318	Chlorination
19	SELVINRAJ	70	2.31	69.3	3.7422	44.9064	Kitchen Gas
20	ARUNA	70	2.31	69.3	3.7422	44.9064	Kitchen Gas
21	JESSY	20	0.1	3	0.162	1.944	Chlorination
22	INDHIRA SAJAN	20	0.1	3	0.162	1.944	Chlorination
23	GAYATHRI	25	0.125	3.75	0.2025	2.43	Chlorination
24	BALAKRISHNAN	25	0.125	3.75	0.2025	2.43	Chlorination
25	REENA CHARLES	45	1.485	44.55	2.4057	28.8684	Kitchen Gas
26	JAQUALIN MARY	40	1.32	39.6	2.1384	25.6608	Kitchen Gas
27	JOSEPHINE	35	1.155	34.65	1.8711	22.4532	Kitchen Gas
28	CHINNAPPA RAJAN	35	1.155	34.65	1.8711	22.4532	Kitchen Gas
29	S. GEORGE	35	1.155	34.65	1.8711	22.4532	Electricity
30	JOSEPH RAJ	35	1.155	34.65	1.8711	22.4532	Electricity
31	SELVAM	35	1.155	34.65	1.8711	22.4532	Kitchen Gas
32	MOHANAN (FCH)	50	1.65	49.5	2.673	32.076	Kitchen Gas
33	MANOJ JOSEPH	55	1.815	54.45	2.9403	35.2836	Kitchen Gas
34	RAJENDRAN DR	38	1.254	37.62	2.03148	24.37776	Kitchen Gas
35	TAHA MON	48	1.584	47.52	2.56608	30.79296	Kitchen Gas
36	ROY CHACKO	42	1.386	41.58	2.24532	26.94384	Kitchen Gas
37	JINTO DEVASYA	37	1.221	36.63	1.97802	23.73624	Kitchen Gas
38	GIREESH V	39	1.287	38.61	2.08494	25.01928	Kitchen Gas
39	PRAMOD	36	1.188	35.64	1.92456	23.09472	Kitchen Gas
40	RAGHAVAN PILLAI	44	1.452	43.56	2.35224	28.22688	Electricity
41	SHAJAN JO-SEPH	47	1.551	46.53	2.51262	30.15144	Kitchen Gas
42	SUNNY NJ	41	1.353	40.59	2.19186	26.30232	Kitchen Gas
43	PK MANI	43	1.419	42.57	2.29878	27.58536	Kitchen Gas
44	KUNJAPPAN	49	1.617	48.51	2.61954	31.43448	Kitchen Gas
45	SCARIA KURIA-KOSE	52	1.716	51.48	2.77992	33.35904	Chlorination
46	PUSPA GOPI	53	1.749	52.47	2.83338	34.00056	Kitchen Gas
47	DOLLY PARAK-KETHHOTTIL	54	1.782	53.46	2.88684	34.64208	Kitchen Gas
48	SHAJI PANAM-BIL	56	1.848	55.44	2.99376	35.92512	Chlorination
49	PRASANNAKU-MAR	58	1.914	57.42	3.10068	37.20816	Kitchen Gas

50	SIJO GEORGE	60	1.98	59.4	3.2076	38.4912	Kitchen Gas
51	POTTY	62	2.046	61.38	3.31452	39.77424	Kitchen Gas
52	SUMESH	64	2.112	63.36	3.42144	41.05728	Kitchen Gas
53	VASU	66	2.178	65.34	3.52836	42.34032	Kitchen Gas
54	KUTTY	68	2.244	67.32	3.63528	43.62336	Kitchen Gas
55	MUTHAIAN	70	2.31	69.3	3.7422	44.9064	Kitchen Gas
56	CHINNADI	50	1.65	49.5	2.673	32.076	Kitchen Gas
57	RATHEESH	45	1.485	44.55	2.4057	28.8684	Electricity
58	ELSON	40	1.32	39.6	2.1384	25.6608	Kitchen Gas
59	THANKAPPAN	38	1.254	37.62	2.03148	24.37776	Kitchen Gas
60	SAJEEV	42	1.386	41.58	2.24532	26.94384	Chlorination
61	SHIVAN	47	1.551	46.53	2.51262	30.15144	Kitchen Gas
62	JOJO AUGUS-TINE	52	1.716	51.48	2.77992	33.35904	Kitchen Gas
63	SAVITHRI	55	1.815	54.45	2.9403	35.2836	Kitchen Gas
64	JOMON	58	1.914	57.42	3.10068	37.20816	Kitchen Gas
65	THANKACHAN KM	60	1.98	59.4	3.2076	38.4912	Kitchen Gas
66	SHAJI AUGUS-TINE	62	2.046	61.38	3.31452	39.77424	Kitchen Gas
67	JOSHY THOMAS	64	2.112	63.36	3.42144	41.05728	Kitchen Gas
68	JOMON CHERI-YAN	66	2.178	65.34	3.52836	42.34032	Kitchen Gas
69	JINESH	68	2.244	67.32	3.63528	43.62336	Kitchen Gas
70	SHIBU	70	2.31	69.3	3.7422	44.9064	Chlorination
71	BIJU GEORGE	50	1.65	49.5	2.673	32.076	Kitchen Gas
72	AJIMON OL-ICKAL	45	1.485	44.55	2.4057	28.8684	Electricity
73	GEORGE JO-SEPH	40	1.32	39.6	2.1384	25.6608	Kitchen Gas
74	ANCY VARKEY	38	1.254	37.62	2.03148	24.37776	Kitchen Gas
75	RAJU AGUSTIN	42	1.386	41.58	2.24532	26.94384	Kitchen Gas
76	GEORGE MJ	47	1.551	46.53	2.51262	30.15144	Kitchen Gas
77	KAVITHA N THOMAS	52	1.716	51.48	2.77992	33.35904	Kitchen Gas
78	JOSE UTHUP	55	1.815	54.45	2.9403	35.2836	Kitchen Gas
79	SOLLY PHILIP	58	1.914	57.42	3.10068	37.20816	Kitchen Gas
80	MINI CV	60	1.98	59.4	3.2076	38.4912	Kitchen Gas
81	RAJI UG	62	2.046	61.38	3.31452	39.77424	Kitchen Gas
82	ANNIS MM	64	2.112	63.36	3.42144	41.05728	Kitchen Gas
83	LALY MD	66	2.178	65.34	3.52836	42.34032	Electricity
84	SHEEBA KK	68	2.244	67.32	3.63528	43.62336	Kitchen Gas
85	SALMA VM	70	2.31	69.3	3.7422	44.9064	Kitchen Gas
86	LAILA MM	50	1.65	49.5	2.673	32.076	Kitchen Gas
87	KUNJUMON PK	45	1.485	44.55	2.4057	28.8684	Chlorination
88	SOMY BABU	40	1.32	39.6	2.1384	25.6608	Kitchen Gas

89	SHIBU	38	1.254	37.62	2.03148	24.37776	Kitchen Gas
90	ARUNRAJ	42	1.386	41.58	2.24532	26.94384	Kitchen Gas
91	SEENA	47	1.551	46.53	2.51262	30.15144	Electricity
92	SHAINY	52	1.716	51.48	2.77992	33.35904	Kitchen Gas
93	RAHUL	55	1.815	54.45	2.9403	35.2836	Kitchen Gas
94	LEKSHMI	58	1.914	57.42	3.10068	37.20816	Kitchen Gas
95	SINDHU KAN-NAN	60	1.98	59.4	3.2076	38.4912	Kitchen Gas
96	SREEJA	62	2.046	61.38	3.31452	39.77424	Kitchen Gas
97	JAYAN	64	2.112	63.36	3.42144	41.05728	Kitchen Gas
98	AUGUSTINE JOSEPH	66	2.178	65.34	3.52836	42.34032	Electricity
99	RAIJU JOSEPH	68	2.244	67.32	3.63528	43.62336	Electricity
100	DEVASSYA MICHEAL	70	2.31	69.3	3.7422	44.9064	Kitchen Gas

Table 9. Energy Savings

2. Reduction in Health Expenditure

- Families experienced a reduction in health-related costs, especially those previously exposed to contaminated water.
- Savings in health expenditures ranged from Rs. 645 to Rs. 129,000 annually, depending on household vulnerability and location.

3. Overall Economic Savings

- The total amount saved annually per household varies, with a range of Rs. 650 - 130,000.
- The percentage of money saved from annual income ranges from 0.16% to 8.66%, highlighting the significant impact of BSF on lower-income families.
- The highest savings were recorded in households with previously high medical expenses, indicating improved health outcomes due to clean water access.

Sl. No.	HOUSEHOLD NAME	AVG. YEARLY HEALTH EXPENDITURE (Rs.)	PLACE	ANNUAL INCOME (Rs.)	TOTAL AMOUNT SAVED ANNUALLY (Rs.)	TOTAL MONEY SAVED FROM ANNUAL INCOME (%)
1	BINDHU	10965	KOMALIKUDI ANGAN-WADI	420000	12000	2.857142857
2	GANESHAN	12900	KOMALIKUDI TEMPLE	360000	13500	3.75
3	PONNUSAMI	9675	KOMALIKUDI TEMPLE	300000	9500	3.166666667
4	JIJI KUMARI	6450	MUTTUKAD ANGAN-WADI	480000	7000	1.458333333
5	JOMET GEORGE	10965	SOCIETYMEDU CITY	420000	11000	2.619047619
6	JAYASHREE	9030	SOCIETYMEDU AN-GANWADI	480000	9200	1.916666667

7	AJI MOL	7095	CHANGANASSERI KADA ANGANWADI	300000	7500	2.5
8	AKHIL	5160	MUTTUKAD	720000	5500	0.763888889
9	AJITHA RAJAN	3225	MUTTUKAD	480000	3500	0.729166667
10	THANKACHAN	1935	MUTTUKAD	1200000	2000	0.166666667
11	MOHANAN TK	2580	MUTTUKAD	1440000	2700	0.1875
12	RENJITH OLICKAL	2580	MUTTUKAD	420000	2600	0.619047619
13	PALANISWAMI	3870	THALAYAR TEA OFFICE	480000	4000	0.833333333
14	S. SUDHA	9675	THALAYAR DISPEN-SARY	240000	9800	4.083333333
15	S. MOHANA KRISHNAN	19350	THALAYAR FACTORY	600000	19500	3.25
16	MANOJ M	30315	GLPS THALAYAR	900000	30500	3.388888889
17	MAHALAKSH-MI	4515	KADUKUMUDI AN-GANWADI	360000	4600	1.277777778
18	LAKSHMI C.	9675	THALAYAR ANGAN-WADI	480000	9700	2.020833333
19	SELVINRAJ	129000	GHSS VAGUVURRAI	1500000	130000	8.666666667
20	ARUNA	129000	GHSS VAGUVURRAI	1500000	128000	8.533333333
21	JESSY	645	CHATTAMUNNAR TOP DIVISIION DISPENSARY	240000	700	0.291666667
22	INDHIRA SAJAN	645	CHATTAMUNNAR LOWER DIVISION DISPENSARY	240000	650	0.270833333
23	GAYATHRI	1290	PAMAPANMALLEY DISPENSARY	240000	1300	0.541666667
24	BALAKRISH-NAN	1290	PAMPANMALLEY	360000	1400	0.388888889
25	REENA CHARLES	4515	ANTHONIYAR COLONY	240000	4600	1.916666667
26	JAQUALIN MARY	3870	ANTHONIYAR COLONY	216000	3900	1.805555556
27	JOSEPHINE	3225	ANTHONIYAR COLONY	180000	3300	1.833333333
28	CHINNAPPA RAJAN	2580	ANTHONIYAR COLONY	210000	2600	1.238095238
29	S. GEORGE	2580	ANTHONIYAR COLONY	240000	2700	1.125
30	JOSEPH RAJ	3225	ANTHONIYAR COLONY	336000	3400	1.011904762
31	SELVAM	2580	ANTHONIYAR COLONY	300000	2600	0.866666667
32	MOHANAN (FCH)	3225	FAMILY CARE HOMESTAY MUNNAR	900000	3300	0.366666667
33	MANOJ JO-SEPH	3870	MUNIPARA	540000	4000	0.740740741
34	RAJENDRAN DR	4515	MUNIPARA	600000	4700	0.783333333
35	TAHA MON	5160	MUNIPARA	720000	5300	0.736111111
36	ROY CHACKO	5160	MUNIPARA	540000	5200	0.962962963

37	JINTO DEVASYA	4515	MUNIPARA	420000	4600	1.095238095
38	GIREESH V	4515	MUNIPARA	480000	4700	0.979166667
39	PRAMOD	3870	MANKULAM	300000	3900	1.3
40	RAGHAVAN PILLAI	5160	MANKULAM	720000	5400	0.75
41	SHAJAN JOSEPH	5160	MANKULAM, THALUM-KANDAM	480000	5300	1.104166667
42	SUNNY NJ	4515	MANKULAM, THALUM-KANDAM	1200000	4600	0.383333333
43	PK MANI	4515	KAMBILINE	1440000	4700	0.326388889
44	KUNJAPPAN	5160	KAMBILINE	420000	5200	1.238095238
45	SCARIA KURIAKOSE	5160	KAMBILINE	540000	5300	0.981481481
46	PUSPA GOPI	5160	KAMBILINE	540000	5400	1
47	DOLLY PARAK-KETHHOTTIL	5160	KAMBILINE	540000	5500	1.018518519
48	SHAJI PAN-AMBIL	5160	KAMBILINE	540000	5600	1.037037037
49	PRASANNA-KUMAR	5160	KAMBILINE	540000	5700	1.055555556
50	SIJO GEORGE	5160	THALUMKANDAM	540000	5800	1.074074074
51	POTTY	5160	PADIKAPPU	540000	5900	1.092592593
52	SUMESH	5160	PADIKAPPU	900000	6000	0.666666667
53	VASU	5160	PADIKAPPU	360000	6100	1.694444444
54	KUTTY	5160	PADIKAPPU	480000	6200	1.291666667
55	MUTHAIAN	5160	PADIKAPPU	1500000	6300	0.42
56	CHINNADI	3225	PADIKAPPU	1500000	3300	0.22
57	RATHEESH	3225	PADIKAPPU	240000	3400	1.416666667
58	ELSON	2580	PADIKAPPU	240000	2600	1.083333333
59	THANKAPPAN	2580	PADIKAPPU	360000	2700	0.75
60	SAJEEV	2580	PADIKAPPU	360000	2800	0.777777778
61	SHIVAN	2580	PADIKAPPU	360000	2900	0.805555556
62	JOJO AUGUS-TINE	2580	VELIYAMPARA	360000	3000	0.833333333
63	SAVITHRI	2580	VELIYAMPARA	360000	3100	0.861111111
64	JOMON	2580	VELIYAMPARA	360000	3200	0.888888889
65	THANKACHAN KM	2580	VELIYAMPARA	360000	3300	0.916666667
66	SHAJI AUGUS-TINE	2580	VELIYAMPARA	360000	3400	0.944444444
67	JOSHY THOM-AS	2580	VELIYAMPARA	360000	3500	0.972222222
68	JOMON CHERIYAN	2580	VELIYAMPARA	900000	3600	0.4
69	JINESH	2580	VELIYAMPARA	360000	3700	1.027777778
70	SHIBU	2580	VELIYAMPARA	480000	3800	0.791666667

71	BIJU GEORGE	3225	VELIYAMPARA	1500000	3900	0.26
72	AJIMON OLICKAL	3225	VELIYAMPARA	1500000	4000	0.266666667
73	GEORGE JOSEPH	2580	VELIYAMPARA	240000	4100	1.708333333
74	ANCY VARKEY	2580	VELIYAMPARA	240000	4200	1.75
75	RAJU AGUS-TIN	2580	VELIYAMPARA	360000	4300	1.194444444
76	GEORGE MJ	2580	THALUMKANDAM	360000	4400	1.222222222
77	KAVITHA N THOMAS	2580	AMBAZHACHAL AN-GANWADI	360000	4500	1.25
78	JOSE UTHUP	2580	AMBAZHACHAL	360000	4600	1.277777778
79	SOLLY PHILIP	2580	THOKKUPARA ANGAN-WADI	360000	4700	1.305555556
80	MINI CV	2580	PAINADHAN KUNNU ANGANWADI	360000	4800	1.333333333
81	RAJI UG	2580	SENGULAM ANGAN-WADI	360000	4900	1.361111111
82	ANNIS MM	2580	ANVIRATTY ANGAN-WADI	360000	5000	1.388888889
83	LALY MD	2580	KOOMPANPARA AN-GANWADI	360000	5100	1.416666667
84	SHEEBA KK	2580	ODAKKACITY ANGAN-WADI	360000	5200	1.444444444
85	SALMA VM	2580	KOOMPANPARA AN-GANWADI	900000	5300	0.588888889
86	LAILA MM	3225	NAIKUNNU ANGAN-WADI	360000	5400	1.5
87	KUNJUMON PK	3225	ODAKKACITY	480000	5500	1.145833333
88	SOMY BABU	2580	VELLATHOOVAL	1500000	5600	0.373333333
89	SHIBU	2580	VELLATHOOVAL	1500000	5700	0.38
90	ARUNRAJ	2580	VELLATHOOVAL	240000	5800	2.416666667
91	SEENA	2580	VELLATHOOVAL	240000	5900	2.458333333
92	SHAINY	2580	VELLATHOOVAL	360000	6000	1.666666667
93	RAHUL	2580	VELLATHOOVAL	360000	6100	1.694444444
94	LEKSHMI	2580	VELLATHOOVAL	360000	6200	1.722222222
95	SINDHU KAN-NAN	2580	KUNCHITHANNY	360000	6300	1.75
96	SREEJA	2580	KUNCHITHANNY	360000	6400	1.777777778
97	JAYAN	2580	KUNCHITHANNY	360000	6500	1.805555556
98	AUGUSTINE JOSEPH	2580	VELIYAMPARA	360000	6600	1.833333333
99	RAIJU JOSEPH	2580	MANKULAM,MUNI-PARA	360000	6700	1.861111111
100	DEVASSYA MICHEAL	2580	VELIYAMPARA	360000	6800	1.888888889

Table 10. Economic benefits of BSF

4. Geographic and Income Variations

- Higher-income households saw a lower percentage of income saved but still benefited from reduced energy costs.
- Lower-income households experienced a more substantial percentage of savings relative to their earnings, demonstrating the importance of BSF implementation in economically weaker sections.
- Locations such as Komalikudi, Muttukad, Thalayar, and Padikappu recorded the highest cumulative savings, showcasing the impact of BSF in improving economic stability.

The TIES Bio-Sand Filter initiative has provided tangible economic relief by reducing energy expenditure, improving health conditions, and enhancing financial stability for stakeholders. The impact is particularly evident in rural and economically weaker households, demonstrating the necessity of sustainable water purification solutions in community development.

4.10.2.Ecological Benefits of the TIES BioSand Filter

1. Reduces Water Contamination – Effectively removes pathogens, heavy metals, and suspended solids, preventing waterborne diseases and protecting aquatic ecosystems.

2. Minimizes Groundwater Exploitation – By providing clean surface water for drinking and household use, it reduces dependency on groundwater extraction, aiding in aquifer recharge and long-term water sustainability.

3. Reduces Plastic Pollution – Decreases reliance on bottled water, lowering plastic waste generation and reducing the environmental impact of plastic disposal.

4. Improves Soil and Agricultural Health – Clean water reduces soil contamination, promoting healthier crop growth and improving agricultural yield.

5. Enhances Biodiversity – Limits pollution runoff into freshwater bodies, supporting the survival of sensitive aquatic species like odonates, fish, and amphibians.

6. Lowers Energy Consumption & Carbon Footprint – Operates without electricity or chemicals, reducing reliance on energy-intensive water purification methods and lowering greenhouse gas emissions.

7. Prevents Eutrophication – By filtering out organic pollutants and excess nutrients, it helps prevent algal blooms and eutrophication in nearby water bodies.

8. Encourages Sustainable Living – Promotes environmentally friendly water management practices within communities, fostering long-term ecological conservation.

4.10.3. Health Benefits of the TIES BioSand Filter

The TIES BioSand Filter significantly improves drinking water quality by removing harmful pathogens, including bacteria, viruses, and parasites, which are major causes of waterborne diseases like diarrhea, cholera, and typhoid. By providing access to clean and safe water, it reduces the risk of gastrointestinal infections, especially among children and vulnerable populations. The filter also removes suspended solids and heavy metals, leading to better overall health, improved digestion, and reduced exposure to toxic substances that can cause long-term health complications.

In addition to disease prevention, the BioSand Filter contributes to overall well-being by promoting proper hydration with contaminant-free water. Clean water enhances immune function, supports metabolic processes, and improves skin health. By eliminating the need for boiling water, the filter reduces household exposure to indoor air pollution caused by burning firewood or other fuels. This also minimizes respiratory issues, particularly in women and children, who are most affected by smoke inhalation. Ultimately, the TIES BioSand Filter plays a crucial role in fostering healthier communities by ensuring a consistent supply of safe drinking water.

4.11. Conclusions

The installation of biosand filters across various locations in Munnar, including households, anganwadis, schools, dispensaries, tea offices, and factories, has significantly improved water quality over three phases of testing. Before the intervention (Phase 1), water samples showed widespread non-compliance with permissible limits, particularly in turbidity, pH, total coliform, fecal coliform, and E. coli presence. Post-installation results indicate a marked improvement in water quality. Turbidity levels improved substantially, with samples within permissible limits rising from 21 in Phase 1 to 74 in Phase 3. Similarly, pH compliance increased from 50 samples in Phase 1 to 83 samples in Phase 3. A substantial improvement was observed during 2nd phase with 97 samples achieving pH values within the limits. This increase reflects the positive impact of the biosand filters and better management practices. Conductivity remained within WHO limits throughout all phases. Microbial contamination saw notable reductions, with 36 and 47 samples showing decreased total coliform counts in Phases 2 and 3, respectively. Fecal coliform and E. coli contamination also declined, with 47 samples showing reduced fecal coliform counts and E. coli absence increasing to 15 samples in Phase 3. However, persistent challenges, such as inconsistent daily filtration, improper cleaning of the diffuse basin, lack of safe storage containers, and irregular usage, hinder optimal filter performance. Addressing these issues through enhanced user awareness and regular maintenance practices is essential to ensure the consistent production of safe, contaminant-free drinking water, maximizing the benefits of biosand filters for community health and well-being.

BENEFICIARIES OF BSF

Figure 23. Ajimol M B, Chanaganasserykada (Anganwadi)

Figure 24. Akhil, Muttukad (Household)

Figure 25. Bindhu, Komalikudi (Anganwadi)

Figure 26. Ganeshan, Komalikudi (Temple)

Figure 27. Jayasree, Societymedu (Anganwadi)

Figure 28. Jomet, Societymedu Junction (Shop)

Figure 29. Mohan T K, Muttukad (Household)

Figure 30. Ponnuswami, Komalikudy (Household)

Figure 31. Thankachan, Muttukadu (Household)

Figure 32. Chattamunnar Top Division Dispensary

Figure 33. GHSS, Vaguvarrai (School)

Figure 34. GLPS, Thalayar (School)

Figure 34. GLPS, Thalayar (School)

Figure 36. Thalayar Tea Factory

Figure 37. Jaqualin Mary, Anthoniyar Colony (Household)

Figure 38. Chinnappa Rajan, Anthoniyar Colony (Household)

Figure 39. Thalayar Estate Office

Figure 40. Mohanan, Munnar (Family Care Homestay)

Figure 41. Reena Charles, Anthoniyar Colony (Household)

Figure 42. S George, Anthoniyar Colony (Household)

Figure 43. Selvam, Anthoniyar Colony (Household)

Figure 44. Vellathooval Anganwadi

Figure 45. Jayan, Kunjithanny (Household)

Figure 46. Sreeja, Kunjithanny (Household)

Figure 47. Renjith, Muttukadu (Household)

Figure 48. Thalayar Anganwadi

Figure 49. Pambanmaley Dispensary

Figure 50. Kadukumudi Anganwadi


Figure 51. Koompanpara Anganwadi


Figure 52. Ambazhachal Anganwadi


Figure 53. George M J, Thalumkandam (Household)

Figure 54. SHIVAN, PADIKAPPU


Figure 55. Chattamunnar lower dispensary


Figure 56. JOSEPHINE, Anthoniyar Colony

Figure 57. JOSEPH RAJ, Anthoniyar Colony

Figure 58. MANOJ JOSEPH, Munipara

Figure 59. RAJENDRAN, MUNIPARA

Figure 60. TAHA MON, MUNIPARA

Figure 61. ROY CHACKO, MUNIPARA

Figure 62. JINTO DEVASYA, MUNIPARA

Figure 63. GIREESH V, MUNIPARA

Figure 64. PRAMOD, MANKULAM

Figure 65. RAGHAVAN PILLAI, MANKULAM

Figure 66. SHAJAN JOSEPH, MANKULAM

Figure 67. SUNNY NJ, MANKULAM

Figure 68. PK MANI

Figure 69. SCARIA KURIAKOSE, KAMBILINE

Figure 70. KUNJAPPAN. KAMBILINE

Figure 71. PUSPA GOPI, KAMBILINE

Figure 72. DOLLY PARAKKETHHOTTIL, KAMBILINE

Figure 73. SHAJI PANAMBIL, KAMBILINE

Figure 74. PRASANNAKUMAR, KAMBILINE

Figure 75. SIJO GEORGE, THALUMKANDAM

Figure 76. POTTY, PADIKAPPU

Figure 77. SUMESH, PADIKAPPU

Figure 78. VASU, PADIKAPPU

Figure 79. KUTTY, PADIKAPPU

Figure 80. MUTHAIAN, PADIKAPPU

Figure 81. CHINNADI, PADIKAPPU

Figure 82. RATHEESH, PADIKAPPU

Figure 83. ELSON, PADIKAPPU

Figure 84. THANKAPPAN, PADIKAPPU

Figure 85. SAJEEV, PADIKAPPU

Figure 86. SHIVAN, PADIKAPPU

Figure 87. JOJO AUGUSTINE, VELIYAMPARA

Figure88. SAVITHRI, VELIYAMPARA

Figure 89. JOMON, VELIYAMPARA

Figure 90. THANKACHAN KM, VELIYAMPARA

Figure 91. SHAJI AUGUSTINE, VELIYAMPARA

Figure 93. JOSHY THOMAS, VELIYAMPARA

Figure 94. JOMON CHERIYAN, VELIYAMPARA

Figure 95. JINESH, VELIYAMPARA

Figure 96. SHIBU, VELLATHOOVAL

Figure 97. BIJU GEORGE, VELIYAMPARA

Figure 98. AJIMON OLICKAL, VELIYAMPARA

Figure 99. ANCY VARKEY, VELIYAMPARA

Figure 100. RAJU AGUSTIN, VELIYAMPARA

Figure 101. GEORGE MJ, THALUMKANDAM

Figure 102. JOSE UTHUP

Figure 103. SOLLY PHILIP, THOKKUPARA ANGANWADI

Figure 104.MINI CV, PAINADHAN KUNNU ANGANWADI

Figure 105.RAJI UG, SENGULAM ANGANWADI

Figure 106. ANNIS MM, ANVIRATTY ANGANWADI

Figure 108. SHEEBA KK, ODAKKACITY ANGANWADI

Figure 109. SALMA VM, KOOMPANPARA ANGANWADI

Figure 110. LAILA MM, NAIKUNNU ANGANWADI

Figure 111. KUNJUMON PK, ODAKKACITY

Figure 112. SOMY BABU, VELLATHOOVAL

Figure 113. SHIBU, VELIYAMPARA

Figure 114. ARUNRAJ, VELLATHOOVAL

Figure 115. SEENA, VELATHOOVAL

Figure 116. SHAINY, VELLATHOOVAL

Figure117. RAHUL, VELLATHOOVAL

Figure 118. LEKSHMI, VELATHOOVAL

Figure 119. SINDHU KANNAN, VELATHOOVAL

Figure 120. AUGUSTINE JOSEPH, VELIYAMPARA

Figure 121. RAIJU JOSEPH, MANKULAM,MUNIPARA

Figure 122. DEVASSYA MICHEAL, VELIYAMPARA

Figure 123. BALAKRISHNAN,PAMPAN MALEY THALAYAR

Figure 124. JIJI KUMARI, MUTUKAD ANGANWADI

Report of distribution of biosand filter to households & anganvadis for the conservation of fresh water habitat & threatened species

Conducted as part of

Protection of fresh water ecosystems for the conservation of threatened species in munnar, western ghats, india.

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