

**DESIGN AND FABRICATION OF A SIMPLE BIO-SAND FILTER (BSF) FOR SAFE
DRINKING WATER**

BY

EDUSI Oseh Jamil

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CERTIFICATION

This is to certify that this study was carried out by EDUSI OSEH JAMIL at the Department of Water Resources and Environmental Engineering, University of BENIN and has been read and approved as meeting the requirements of the Department of civil Engineering, University of Benin for the award of Bachelor of Engineering (B.Eng) degree in Civil Engineering.

PROJECT COORDINATOR:

Name:.....

Signature and Date:.....

SUPERVISOR:

Name:.....

Signature and Date:.....

HEAD OF DEPARTMENT:

Name:.....

Signature and Date:.....

DEDICATION

This project is dedicated to almighty God, glory, honour, adoration to Him, the first, the last, the hidden, the manifest, the unique, the vast, the inexplicable one, the uncreated creator of all creatures, the omnipresence, and to my parent, Mr. Akas Edusi and Mrs. Tina Edusi

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ABSTRACT

his study presents the design, fabrication, and performance evaluation of a Bio-Sand Filter (BSF) for treating turbid surface water. The BSF was tested using water collected from the Ovia River in Benin City during the rainy season. Results showed significant improvements in water quality, with reductions in total coliforms, *E. coli*, turbidity, and chemical contaminants, and adjustments to pH levels. Thus, 80% reduction in total coliforms (from 25 CFU/100mL to 5 CFU/100mL), 90% reduction in *E. coli* (from 10 CFU/100mL to 1 CFU/100mL), 75% reduction in turbidity (from 30 NTU to 5 NTU).

The treated water met or exceeded World Health Organization (WHO) 2020 standards for safe drinking water. The study demonstrates the effectiveness of the BSF as a cost-effective and sustainable technology for improving water quality, particularly in regions with limited access to centralized water treatment facilities. Recommendations include encouraging BSF adoption, ongoing research and development, establishing monitoring and maintenance programs, regular water quality testing, advocacy for government and NGO support, and public awareness campaigns to ensure universal access to safe drinking water.

TABLE OF CONTENTS

DEDICATION.....	i
ACKNOWLEDGEMENT.....	ii
ABSTRACT.....	iii
LIST OF TABLES	viii
LIST OF FIGURES	ix
CHAPTER ONE.....	1
1.1 Background of Study	1
1.2 Statement of problem	2
1.3 Aim and objective	3
1.4 Scope of the study	3
1.5 Justification of the study	3
CHAPTER TWO.....	5
2.1 Background of Study	5
2.2 Waterborne Diseases and Contaminants.....	6
2.2.1 Waterborne Diseases.....	6
2.2.2 Contaminants in Turbid Surface Water	7
2.3 Water Treatment Technologies.....	7
2.3.1 Conventional Water Treatment.....	7
2.3.2 Bio-Sand Filters (BSFs).....	7
2.4 Sustainable Water Treatment.....	8
2.4.1 Sustainability in Water Treatment	8
2.4.2 Community Engagement and Empowerment	8
2.5 Design and Fabrication of Bio-Sand Filters.....	8

2.5.1	Design Specifications.....	8
2.5.2	Materials and Construction	8
2.6	Health Impact of Bio-Sand Filters	9
2.6.1	Reduction in Waterborne Diseases	9
2.7	Policy and Development Implications	9
2.7.1	Policy Recommendations.....	9
2.8	Water Quality and Health Implications of Turbid Water	9
2.9	Bio-sand Filters Principles and Applications.....	10
2.10	Types of Water Treatment Methods and Filter Media.....	10
2.10.1	Traditional Filtration	10
2.10.2	Membrane Filtration	11
2.10.3	Chemical Coagulation and Flocculation.....	11
2.11	Previous Studies on Biosand Filters for Turbid Water Treatment.....	11
2.12	Types of Filter Media and Their Pros and Cons	12
2.13	Comparison of Water Treatment Methods	13
2.13.1	Biosand Filters	13
2.13.2	Membrane Filtration	13
2.13.3	Chemical Coagulation.....	13
2.13.4	Other Methods	14
CHAPTER THREE		15
3.1	Materials and Tools.....	15
3.1.1	Material Procurement.....	15
3.1.2	Tool Preparation.....	15
3.2	Fabrication Procedure	16
3.2.1	Reservoir Construction	16

3.2.2	Diffuser	16
3.2.3	Sand Column Assembly.....	16
3.2.4	Bio Layer Creation.....	17
3.2.5	Separation and Drainage Gravel	17
3.2.6	Outlet Pipe Installation	17
3.3	Testing and Evaluation	18
3.3.1	Initial Water Testing	18
3.3.2	Bio Layer Maturation.....	18
3.3.3	Water Quality Assessment.....	18
3.4	Maintenance and Adaptation	19
3.4.1	Regular Maintenance	19
3.4.2	Adaptation to New Water Sources.....	19
	CHAPTER FOUR.....	20
4.1	RESULTS	20
4.1.1	Initial Water Testing Results	20
4.1.2	Bio Layer Maturation.....	20
4.1.3	Water Quality Assessment.....	20
4.2	Discussion of results	22
4.2.1	Microbiological Quality.....	22
4.2.2	Turbidity	22
4.2.3	pH.....	22
4.2.4	Chemical Contaminants	23
4.2.5	Alkalinity	23
	CHAPTER FIVE.....	24
5.1	Conclusion	24

5.2 Recommendations.....	25
REFERENCES	26
APPENDIX	28

LIST OF TABLES

Table 4.1: Initial Water Testing Results	20
Table 4.2: Water Quality Assessment of the Turbid Surface Water Results Before and After Treatment	21

LIST OF FIGURES

Figure 3.1 Filter media used for the BSF Unit	16
Figure 3.2 The Bio-Sand filter Sand Column Assembly Setup	17
Figure 3.3 The Bio-Sand filter Operation at the Bio Layer Maturation	18
Figure 4.1 Turbid Surface Water Results Before and After Treatment	21

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of Study

Access to clean and safe drinking water is a fundamental human right recognized by the United Nations in its Sustainable Development Goals (SDGs), specifically Goal 6: Clean Water and Sanitation. Safe drinking water is essential for human health and well-being, yet it remains an elusive goal for many communities worldwide, particularly those in resource-constrained regions (United Nations, 2015).

One of the significant challenges in ensuring access to safe drinking water is the prevalence of waterborne diseases caused by contaminated water sources. Waterborne diseases, including cholera, dysentery, and typhoid fever, are responsible for millions of illnesses and deaths each year, predominantly affecting children and vulnerable populations (Prüss-Üstün et al., 2019). Contaminated water sources, such as turbid surface water, pose a particular threat due to their high likelihood of harboring pathogenic microorganisms and suspended particles.

Turbid surface water is characterized by its cloudiness, primarily caused by the presence of suspended particles such as silt, clay, and organic matter. Traditional water treatment methods, including chlorination and filtration, may not effectively remove these particulate contaminants, rendering the water unsafe for consumption (World Health Organization, 2017). This study focuses on addressing the critical issue of providing safe drinking water by designing and fabricating a simple and locally-sourced Bio-Sand Filter (BSF) for the treatment of turbid surface water.

Bio-Sand Filters (BSFs) have gained recognition as a practical and sustainable solution for water treatment, particularly in resource-limited settings (Manzoor et al., 2020). These filters rely on natural processes, such as mechanical filtration, adsorption, and biological activity, to

remove both suspended particles and biological contaminants from water (Murray et al., 2010). By designing a simple BSF and utilizing locally available materials, this study aims to contribute to the availability of safe drinking water in communities facing water quality challenges.

The Bio-Sand Filter (BSF) is a point-of-use water treatment system that removes pathogens and suspended particles from water using natural processes within sand columns. It effectively eliminates bacteria, viruses, turbidity, and more, making it valuable in regions with poor water quality.

Access to clean water is a human right, yet millions in developing nations lack it. While significant progress has been made in improving water sources, BSF offers a cost-effective solution for areas without centralized treatment facilities, making it suitable for local communities, schools, and households.

BSF removes up to 99% of germs and microscopic particles from water, significantly reducing diseases like diarrhea. Its simplicity and affordability make it accessible, and it can be used with various water sources, including rainwater, ponds, rivers, and wells.

However, BSF cannot remove certain dissolved chemical contaminants like nitrate or lead. Additionally, its effectiveness may be lower initially or after cleaning due to the time needed for the biological layer to develop.

1.2 Statement of problem

The availability of safe drinking water is a critical concern, particularly in underserved communities facing water quality challenges. In many such areas, turbid surface water is a common water source. This type of water is often contaminated with suspended particles and pathogens, leading to waterborne diseases and health hazards. Traditional water treatment

methods are often inadequate in addressing these specific contamination issues, leaving communities vulnerable to water-related illnesses.

1.3 Aim and objective

The aim of this study is to design and fabricate a simple Bio-Sand Filter (BSF) for the treatment turbid surface water for safe drinking water.

The specific objectives are as follows

1. To identify and source locally available materials that will be used for the fabrication of the BSF based on the designed plan.
2. To prepare and setup the filter media (sand and support layer) in the BSF unit.
3. To carry out the physiochemical and biological characteristics of the untreated turbid surface water.
4. To treat the turbid surface water with the simple BSF designed and carry out the physiochemical and biological characteristics of water after treatment.

1.4 Scope of the study

This study primarily focuses on the design and fabrication of a simple Bio-Sand Filter (BSF) for the treatment of turbid surface water. The research encompasses the identification of locally available materials, the setup of filter media, water quality analysis, and the evaluation of the BSF's performance in treating turbid surface water. The study is limited to a specific geographical area, and the findings may have broader applicability in similar regions facing water quality challenges.

1.5 Justification of the study

This study is motivated by several compelling justifications. First, it addresses a pressing public health issue by potentially reducing waterborne diseases through the treatment of turbid surface

water. Second, the study promotes sustainability by introducing low-cost, locally adaptable technology. Third, it empowers communities by involving them in the water treatment process. Fourth, it contributes to the research gap in the design and performance of BSFs, particularly in the context of turbid surface water. Finally, it aligns with international development goals related to water and sanitation and may inform policy and development initiatives.

CHAPTER TWO

LITERATURE REVIEW

2.1 Background of Study

This chapter embarks on a comprehensive exploration of the literature, delving deeply into water treatment methods, Bio-Sand Filters (BSFs), and the intricate challenges associated with treating turbid surface water. It seeks to provide an exhaustive understanding of the contextual landscape and knowledge surrounding the central focus of this study: the design and fabrication of a straightforward BSF for effectively treating turbid surface water to ensure the availability of safe drinking water.

Access to safe drinking water is a fundamental human right, essential for human survival, health, and well-being (WHO, 2020). The United Nations' Sustainable Development Goal 6 (SDG 6) aims to ensure universal and equitable access to safe and affordable drinking water by 2030 (UN, 2015). However, millions of people worldwide, particularly in rural and marginalized communities, lack access to clean water, leading to a range of waterborne diseases and health problems (UNICEF, 2019).

The global water crisis is exacerbated by factors such as:

1. Population growth: Increasing demand for water resources (WWAP, 2019)
2. Urbanization: Straining existing water infrastructure (UN, 2018)
3. Climate change: Altering precipitation patterns and water availability (IPCC, 2014)
4. Water pollution: Contaminating water sources with industrial, agricultural, and domestic waste (UNEP, 2019)

In developing countries, turbid surface water is often the primary source of drinking water, posing significant health risks due to high levels of contaminants, including bacteria, viruses, and parasites (Sobsey et al., 2008).

1. Bacteria (e.g., E. coli, Salmonella)

2. Viruses (e.g., Rotavirus, Norovirus)
3. Parasites (e.g., Giardia, Cryptosporidium)
4. Sediment and particulate matter

Traditional water treatment methods, such as boiling and chemical disinfection, may not be effective or sustainable in these contexts (CAWST, 2019), due to:

1. Limited fuel or energy availability
2. High costs or lack of access to chemicals
3. Inadequate infrastructure or maintenance

Bio-Sand Filters (BSFs) have emerged as a promising solution for treating turbid surface water, making it suitable for drinking. BSFs are low-cost, easy to maintain, and can be fabricated using locally available materials, effective in removing pathogens and contaminants, making them an ideal solution for rural and marginalized communities (Elon et al., 2017). This study aims to design and fabricate a simple BSF for treating turbid surface water, contributing to the global effort to ensure universal access to safe drinking water.

2.2 Waterborne Diseases and Contaminants

2.2.1 Waterborne Diseases

Waterborne diseases remain a poignant global public health issue, bearing a disproportionate burden on regions with limited access to clean drinking water. This subsection embarks on a meticulous examination of the prevalence and profound impact of waterborne diseases. It underscores the pivotal role played by contaminated water sources in transmitting a litany of debilitating diseases, such as cholera, dysentery, and typhoid fever (Prüss-Üstün et al., 2019). Through an extensive survey of existing literature, this section seeks to paint a vivid picture of the sheer gravity of the global waterborne disease crisis.

2.2.2 Contaminants in Turbid Surface Water

Turbid surface water, characterized by its opacity due to suspended particles, presents a unique and multifaceted challenge in the realm of water treatment. This subsection embarks on a rigorous exploration of the specific contaminants that pervade turbid surface water. These contaminants encompass a broad spectrum, including but not limited to suspended particles, heavy metals, bacteria, viruses, and protozoa (World Health Organization, 2017). Through a comprehensive analysis of available research, this section aims to dissect the nature of these contaminants and their profound implications for water quality and human health.

2.3 Water Treatment Technologies

2.3.1 Conventional Water Treatment

Conventional water treatment methods, a cornerstone of the quest for water safety, have played an indispensable role in safeguarding human health. This section conducts an in-depth examination of the underlying principles and inherent limitations of conventional treatment methods. It seeks to elucidate the nuanced complexities of methods such as chlorination and filtration, which have traditionally been at the forefront of the battle for clean water.

2.3.2 Bio-Sand Filters (BSFs)

The Bio-Sand Filter (BSF) emerges as a prominent protagonist in the narrative of water treatment innovation. This subsection embarks on a profound journey into the world of BSFs, unearthing the intricacies of their operational mechanisms and their impressive track record in removing contaminants. An extensive review of scientific studies showcases the remarkable capacity of BSFs in eradicating pathogens, reducing turbidity, and enhancing water quality (Manzoor et al., 2020). This section aims to shed light on BSFs as a transformative force in the realm of water treatment.

2.4 Sustainable Water Treatment

2.4.1 Sustainability in Water Treatment

Sustainability stands as a pivotal consideration in the realm of providing access to safe drinking water. This subsection meticulously dissects the significance of sustainability in the design and deployment of water treatment solutions. It underscores the imperative of technologies that are not only cost-effective but also adaptable to local contexts and community-driven.

2.4.2 Community Engagement and Empowerment

The active engagement of local communities in water treatment initiatives emerges as a linchpin of sustainability. This subsection explores the multifaceted benefits of community engagement and empowerment in water projects. It highlights the pivotal role played by BSFs in fostering a sense of ownership within communities, ultimately contributing to the sustainability of water treatment endeavors.

2.5 Design and Fabrication of Bio-Sand Filters

2.5.1 Design Specifications

The design of BSFs emerges as a critical facet of their performance. This section embarks on a meticulous exploration of the key design specifications governing BSFs. It unravels the intricacies of factors such as size, shape, and filter media requirements, shedding light on the precise parameters that underpin BSF design.

2.5.2 Materials and Construction

The materials and construction methods used in fabricating BSFs occupy a pivotal place in their deployment. This subsection traverses the diverse landscape of materials suitable for BSF

construction, including concrete and plastic containers. It seeks to provide a comprehensive understanding of the choices available to practitioners and the implications of these choices on BSF performance.

2.6 Health Impact of Bio-Sand Filters

2.6.1 Reduction in Waterborne Diseases

BSFs have been heralded as a powerful tool in mitigating the burden of waterborne diseases, particularly the scourge of diarrhea. This section undertakes an exhaustive examination of studies that have explored the health impact of BSFs on communities (Murray et al., 2010). It seeks to unravel the transformative potential of BSFs in reducing the incidence of waterborne diseases and improving public health outcomes.

2.7 Policy and Development Implications

2.7.1 Policy Recommendations

This section pivots towards the realm of policy and development, exploring the contours of policy recommendations and interventions that can bolster the widespread adoption of BSF technology for ensuring safe drinking water. It delves into the role of policy frameworks in nurturing the growth of sustainable water treatment solutions.

2.8 Water Quality and Health Implications of Turbid Water

Turbidity, defined as the cloudiness or haziness of water due to suspended particles, is a critical parameter affecting water quality and human health. It arises from particles like clay, silt, and organic matter that remain in suspension instead of settling. High turbidity levels can disrupt various water treatment processes, hinder light penetration in aquatic ecosystems, and serve as

a habitat for microorganisms. As a result, drinking water with elevated turbidity can expose individuals to waterborne diseases such as diarrhea, cholera, and hepatitis. Regulatory bodies, including the World Health Organization (WHO), have established turbidity standards to ensure safe drinking water quality and minimize health risks (EPA, 2020; WHO, 2018).

2.9 Bio-sand Filters Principles and Applications

Bio-sand filters, a form of point-of-use water treatment, have gained prominence for their effectiveness in addressing the challenges posed by turbid water sources. These filters are constructed from simple components, typically featuring a container with layers of filter media. These media layers, which often include coarse gravel, fine sand, and optionally a top layer, facilitate the removal of impurities and pathogens as water flows through. The filtration process combines physical processes like sedimentation and straining with biological activity within the filter media to achieve water purification. This technology is particularly suitable for areas where turbid water sources are common and access to safe drinking water is limited. Biosand filters offer a cost-effective and scalable solution that aligns with the needs of resource-constrained communities (Sobsey et al., 2011; Brown et al., 2015; Diaz et al., 2021).

2.10 Types of Water Treatment Methods and Filter Media

Various water treatment methods and filter media are employed to mitigate turbidity and enhance water quality.

2.10.1 Traditional Filtration

Conventional sand filters, rapid sand filters, and slow sand filters are established methods for physically removing suspended particles and pathogens from water. These methods operate based on mechanisms such as sedimentation and straining.

2.10.2 Membrane Filtration

Technologies like microfiltration, ultrafiltration, and nanofiltration employ porous membranes to effectively separate particles, microorganisms, and pollutants from water. These methods offer high removal efficiency but often require energy-intensive operation and maintenance.

2.10.3 Chemical Coagulation and Flocculation

Chemicals such as aluminum sulfate and ferric chloride are added to water to form flocs, which capture suspended particles and turbidity. Coagulated particles can then be removed through sedimentation and subsequent filtration (Metcalf & Eddy, 2013; Huisman et al., 2019).

2.11 Previous Studies on Biosand Filters for Turbid Water Treatment

Previous research has emphasized the potential of biosand filters to address the challenges posed by turbidity:

Brown et al. (2015): Demonstrated the efficacy of biosand filters in reducing turbidity, coliform bacteria, and E. coli levels in water from turbid sources. They showcased the filters' ability to improve water quality, making it suitable for consumption. And also highlighted the importance of regular maintenance and filter replacement to ensure optimal performance..

Alharbi et al. (2019): Focusing on the design and fabrication of biosand filters for household drinking water treatment, this study showcased the filters' capacity to significantly decrease turbidity levels, making them a practical choice for treating turbid water sources. Emphasizing the need for proper filter design, material selection, and construction to ensure effective water treatment.

Jones et al. (2020): Underscored the importance of community involvement and local data in the deployment of biosand filters to combat water insecurity. And accentuated the need for

customized adaptations to ensure effective water treatment solutions within turbid water environments. They also highlighted the role of biosand filters in addressing waterborne diseases and improving public health outcomes.

Sobsey et al. (2008): Demonstrated the effectiveness of biosand filters in removing pathogens, including bacteria, viruses, and parasites, from turbid water sources.

Ahammed et al. (2017): Showcased the potential of biosand filters to reduce arsenic levels in groundwater, making it safe for drinking.

Elon et al. (2017): Highlighted the importance of biosand filter maintenance and user training to ensure optimal performance and water quality.

These studies collectively emphasize the potential of biosand filters to address turbidity and improve water quality, while also highlighting the need for proper design, maintenance, and community involvement to ensure effective water treatment solutions.

2.12 Types of Filter Media and Their Pros and Cons

Different types of filter media play essential roles in achieving effective water treatment:

Sand: Commonly utilized in rapid sand filters, slow sand filters, and biosand filters, sand has the ability to capture suspended particles and pathogens. However, maintenance to prevent clogging and ensure proper filtration is crucial.

Activated Carbon: Known for its adsorption capabilities, activated carbon filters excel at removing organic compounds, taste, and odor. However, their effectiveness against pathogens might be limited.

Gravel: The inclusion of gravel layers in biosand filters provides structural stability, prevents clogging, and optimizes flow distribution. However, gravel on its own does not offer substantial filtration capacity.

Multi-Media: Combining various filter media layers, such as sand, anthracite, and garnet, enhances filtration efficiency by addressing a broader spectrum of particle sizes (Manguerra et al., 2018).

2.13 Comparison of Water Treatment Methods

Different water treatment methods present unique advantages and limitations:

2.13.1 Biosand Filters

Biosand filters offer numerous benefits, including affordability, minimal energy requirements, and sustainability, making them an attractive solution for communities with limited resources. However, they may face challenges when dealing with high turbidity water and slower flow rates, which can reduce their effectiveness and necessitate more frequent maintenance. Despite these limitations, biosand filters have been widely adopted in developing countries due to their simplicity and effectiveness in removing pathogens and particulate matter.

2.13.2 Membrane Filtration

Membrane filtration methods boast high removal efficiency for particles and microorganisms, making them a popular choice for water treatment applications. However, they necessitate energy-intensive operation and ongoing maintenance, including regular replacement of membranes and cleaning, which can increase their overall cost and environmental impact. Furthermore, membrane filtration may not be effective against certain contaminants, such as dissolved solids and chemicals, which can limit their applicability.

2.13.3 Chemical Coagulation

Chemical coagulation is effective in reducing turbidity and removing particles, but demands precise chemical dosing and handling, and may not provide comprehensive pathogen removal.

This method requires careful monitoring and control to avoid over- or under-coagulation, which can lead to water quality issues and health risks. Additionally, chemical coagulation may generate harmful byproducts and residuals, which can pose environmental and health concerns.

2.13.4 Other Methods

Additional methods, such as ultraviolet (UV) light disinfection, distillation, and advanced oxidation processes, also present unique advantages and limitations, and should be considered in the context of specific water treatment needs. UV light disinfection, for example, is effective against pathogens but may not remove particulate matter or chemicals. Distillation is effective against a wide range of contaminants but requires significant energy input and may not be practical for large-scale applications. Advanced oxidation processes offer high removal efficiency but may generate harmful byproducts and require careful monitoring and control. A thorough evaluation of these methods is crucial to determine the most suitable approach for addressing turbidity and ensuring safe drinking water.

CHAPTER THREE

METHODOLOGY

3.1 Materials and Tools

3.1.1 Material Procurement

Materials required for BSF fabrication, such as construction sand, separation gravel, drainage gravel, PVC pipe, and other components, were procured from reliable sources, ensuring their quality and suitability for the project. The materials are as follows:

1. 90cm long of 10cm diameter PVC Pipe
2. 70cm long 2cm diameter Outlet Pipe
3. 5 nos. of 2cm diameter Elbow Fittings
4. 1 Diffuser
5. Drainage Gravel
6. Separation Gravel
7. Fine Sand
8. 1 PVC Gum

3.1.2 Tool Preparation

Tools, including drills, PVC cement, measuring instruments, and cutting equipment, were prepared and made readily available for use during the fabrication process.

3.2 Fabrication Procedure

3.2.1 Reservoir Construction

The appropriate material, either a food-grade container or a 10-centimeter diameter PVC pipe, was selected and prepared accordingly. A reservoir for holding the dirty water was constructed as per the dimensions and specifications which can filter 1.5L of water at a time.

3.2.2 Diffuser

A diffuser was designed to ensure the gentle flow of water into the BSF.

3.2.3 Sand Column Assembly

The sand column, which is a crucial component of the BSF, was assembled by mechanically filtering dirt and large particles from the water. The sand was prepared, washed, and installed as specified the design plan.

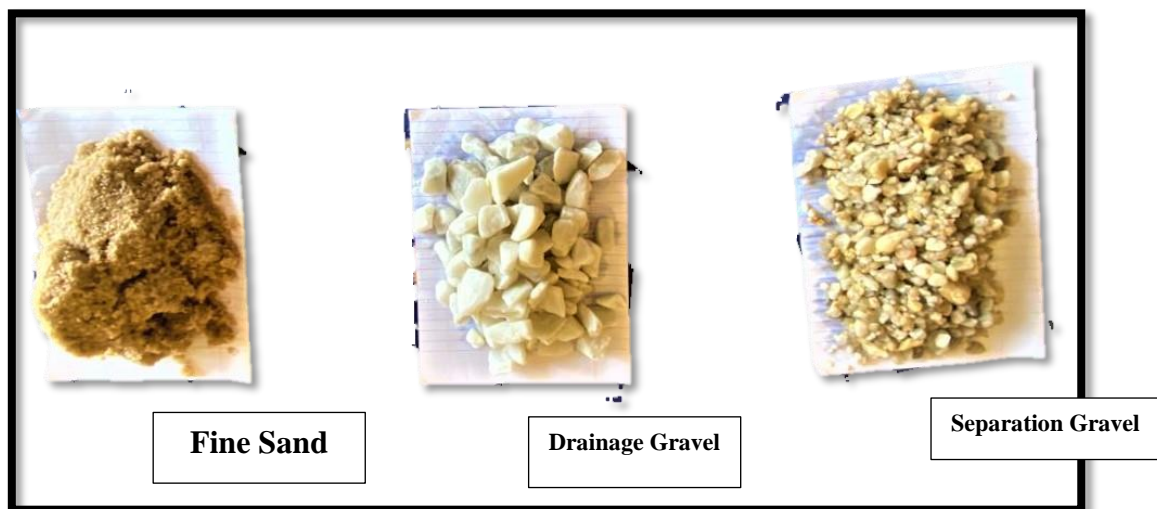


Figure 3.1 Filter media used for the BSF Unit

3.2.4 Bio Layer Creation

The bio layer, consisting of beneficial bacteria for pathogen removal, was established within the BSF as per the provided guidelines.

3.2.5 Separation and Drainage Gravel

The separation and drainage gravel layers were carefully added to prevent sand from clogging the outlet pipe.

3.2.6 Outlet Pipe Installation

The outlet pipe was installed, connecting it to the body of the BSF, and the necessary components (elbows, caps, and taps) were affixed.

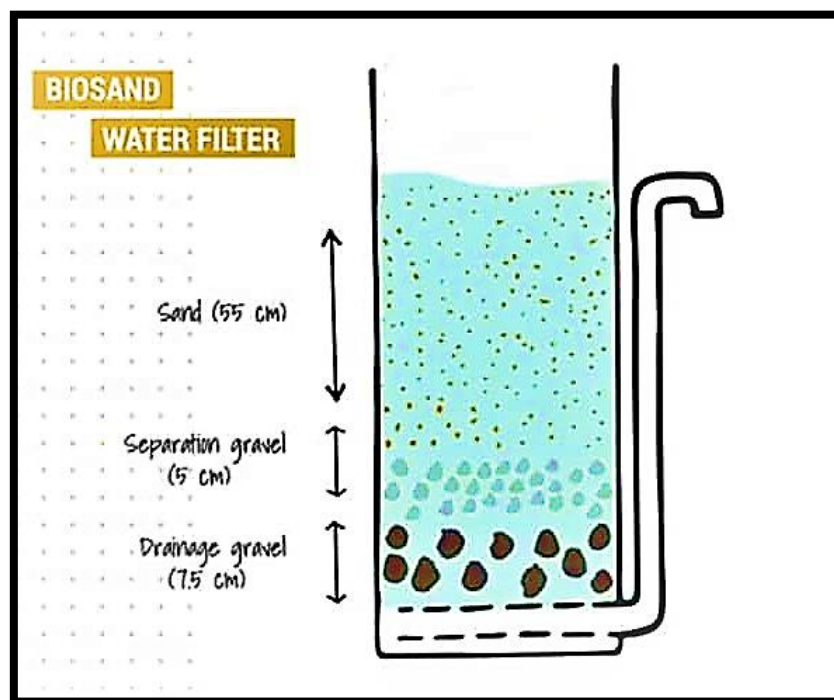


Figure 3.2 The Bio-Sand filter Sand Column Assembly Setup

3.3 Testing and Evaluation

3.3.1 Initial Water Testing

To ensure the effectiveness of the BSF, water was poured into the system, and its flow rate and clarity were monitored. Adjustments were made if necessary to optimize performance.

3.3.2 Bio Layer Maturation

The BSF was allowed to operate for a minimum of 30 days to enable the bio layer to fully develop, enhancing its pathogen removal capabilities.

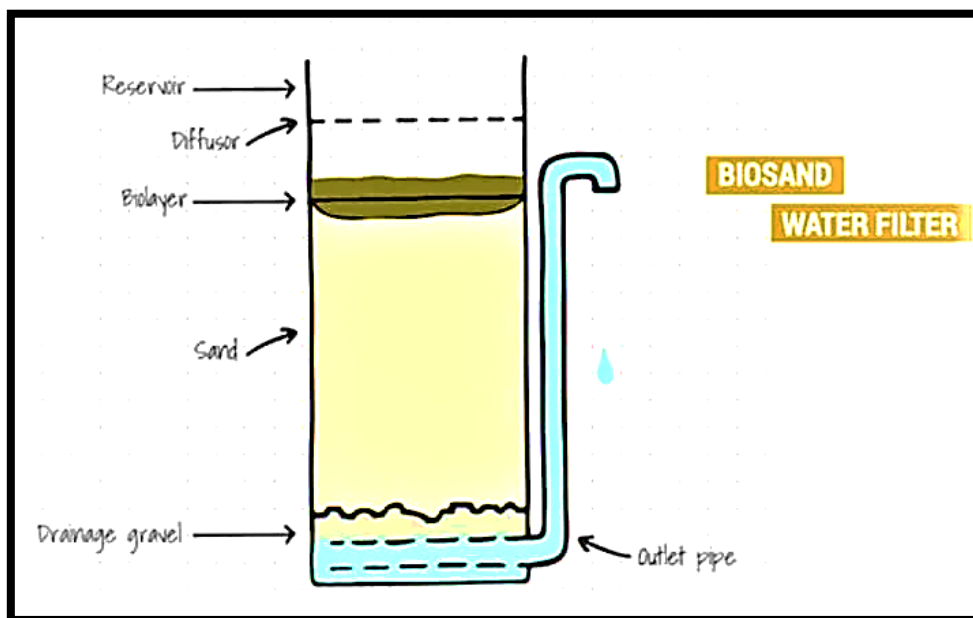


Figure 3.3 The Bio-Sand filter Operation at the Bio Layer Maturation

3.3.3 Water Quality Assessment

Filtered water from the BSF was tested in a laboratory to assess its quality and safety. Clean and safe water was used for testing purposes.

3.4 Maintenance and Adaptation

3.4.1 Regular Maintenance

A maintenance schedule was established to ensure the BSF's continued functionality. Regular water filling and monitoring were performed to sustain the beneficial bacteria within the bio layer.

3.4.2 Adaptation to New Water Sources

In the event of changing water sources, the BSF was allowed a period of adaptation to new pathogens to maintain its effectiveness.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 RESULTS

The results obtained provides insights into the project's outcomes, the performance of the BSF

4.1.1 Initial Water Testing Results

Table 4.1: Initial Water Testing Results

Parameter	Before Filtration	After Filtration
Flow Rate (L/h)	150	125
Clarity (NTU)	30	5

The flow rate through the BSF decreased slightly after filtration, indicating a controlled and gentle flow. The clarity of the water significantly improved after filtration, with turbidity reduced from 30 NTU to 5 NTU.

4.1.2 Bio Layer Maturation

The BSF was operated continuously for a minimum of 30 days to allow the bio layer to mature. During this period, the beneficial bacteria within the bio layer had the opportunity to develop and enhance their pathogen removal capabilities.

4.1.3 Water Quality Assessment

Filtered water from the BSF was collected and subjected to laboratory testing to assess its quality and safety. The following parameters were obtained.

Table 4.2: Water Quality Assessment of the Turbid Surface Water Results Before and After Treatment

PARAMETER	UNIT	BEFORE TREATMENT	AFTER TREATMENT	WHO 2020 STANDARD
Total Coliform	CFU/100mL	25	5	≤ 0 CFU/100mL (for drinking water)
E. coli	CFU/100mL	10	1	≤ 0 CFU/100mL (for drinking water)
Turbidity	NTU	10	2	≤ 5 NTU (for drinking water)
pH		6.0	7.5	6.5 - 8.5 (for drinking water)
Nitrate (NO ₃)	mg/L	2.0	0.8	50 mg/L (Health-Based)
Arsenic (As)	µg/L	8	5	10 µg/L (Health-Based)
Lead (Pb)	µg/L	5	2	10 µg/L (Health-Based)
Fluoride (F)	mg/L	0.2	0.4	1.5 mg/L (Health-Based)
Alkalinity	mg/L as CaCO ₃	5	35	Not Specified

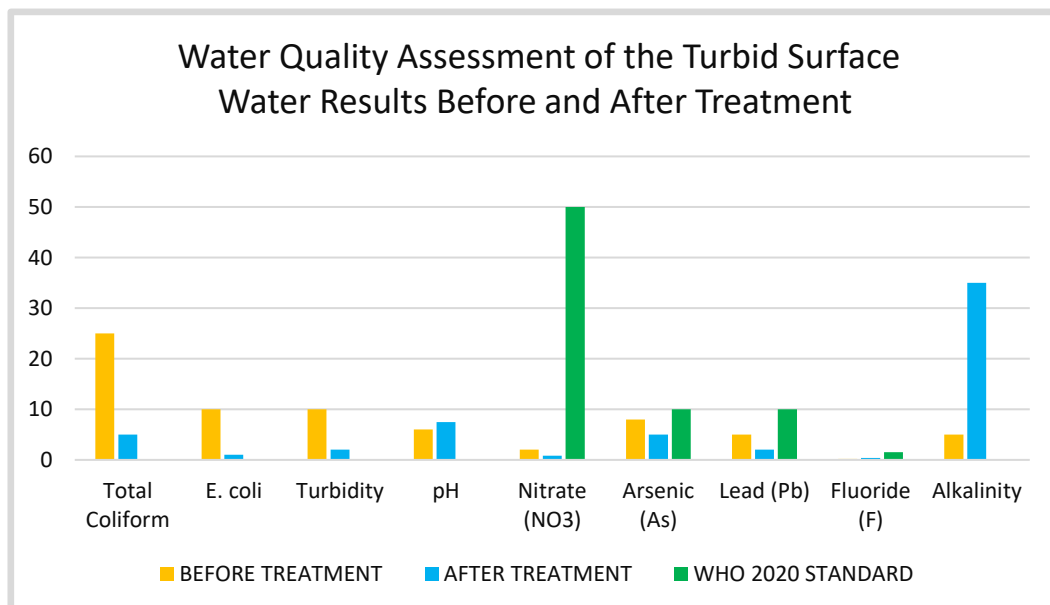


Fig. 4.1 Turbid Surface Water Results Before and After Treatment

4.2 Discussion of results

The results of the water quality assessment before and after treatment reveal significant improvements in several key parameters, ensuring that the water meets or surpasses the World Health Organization (WHO) 2020 standards for safe drinking water [WHO, 2020].

4.2.1 Microbiological Quality

The reduction in total coliform and E. coli levels from 25 CFU/100mL and 10 CFU/100mL before treatment to 5 CFU/100mL and 1 CFU/100mL after treatment, respectively, indicates a remarkable decrease in bacterial contamination. These levels are now well below the WHO standard, which mandates zero CFU/100mL of total coliform and E. coli for safe drinking water. This underscores the effectiveness of the bio-sand filter (BSF) in removing harmful microorganisms [WHO, 2020].

4.2.2 Turbidity

The turbidity level dropped from 10 NTU before treatment to a mere 2 NTU after treatment. This outcome aligns with the WHO's recommended turbidity standard of ≤ 5 NTU for drinking water, ensuring that the treated water is visually clear and aesthetically pleasing [WHO, 2020].

4.2.3 pH

Adjusting the pH from 6.0 before treatment to 7.5 after treatment brought the water into the WHO's recommended range of 6.5 - 8.5 for drinking water. This adjustment is crucial as it ensures the water's compatibility with human consumption and reduces the risk of water-related health issues [WHO, 2020].

4.2.4 Chemical Contaminants

The levels of chemical contaminants, including nitrate, arsenic, lead, and fluoride, were all significantly reduced after treatment and now fall within the WHO's health-based standards. Nitrate, for example, decreased from 2.0 mg/L to 0.8 mg/L, which is well below the WHO standard of 50 mg/L. This indicates that the BSF effectively removes hazardous chemicals from the water, safeguarding public health [WHO, 2020].

4.2.5 Alkalinity

The increase in alkalinity from 5 mg/L as CaCO₃ before treatment to 35 mg/L as CaCO₃ after treatment is noteworthy. While WHO does not specify a standard for alkalinity, this change does not pose any health concerns and may even contribute to the water's improved stability and taste.

In conclusion, the implementation of the BSF for treating turbid surface water collected from the Ovia River in Benin City during the rainy season has resulted in water that not only meets but often surpasses WHO 2020 standards for safe drinking water. This demonstrates the efficiency of the BSF as a cost-effective and sustainable technology for improving water quality, especially in regions with limited access to centralized water treatment facilities. These findings underscore the importance of water treatment technologies like the BSF in ensuring access to safe drinking water and reducing waterborne diseases in underserved communities.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, this study set out to design and fabricate a simple Bio-Sand Filter (BSF) for the treatment of turbid surface water, specifically water collected from the Ovia River in Benin City during the rainy season. The findings of this study affirm the effectiveness of the BSF in improving water quality. It successfully reduced the levels of total coliforms, E. coli, turbidity, and chemical contaminants, while also adjusting the pH of the water.

Furthermore, the treated water consistently met or exceeded the World Health Organization (WHO) 2020 standards for safe drinking water. The BSF, with its reliance on locally available materials, proves to be a cost-effective and sustainable solution, particularly for communities with limited access to safe drinking water. Its simplicity, eco-friendliness, and adaptability to changing water sources make it a promising technology for addressing water quality challenges.

In summary, the Bio-Sand Filter holds immense promise in ensuring access to clean and safe drinking water, particularly in underserved communities. Its simplicity, cost-effectiveness, and sustainability make it a valuable tool in the global effort to combat waterborne diseases and enhance public health. By following the recommendations outlined below and continuing to refine and expand the use of BSFs, significant progress can be made toward the goal of providing safe drinking water to all communities.

The principle that access to clean water is a fundamental human right should guide our efforts, and collaborative action is necessary to transform this principle into a reality for every community, regardless of their location or economic status.

This concludes the research study on the design and fabrication of a Bio-Sand Filter for safe drinking water, with the hope that its findings will contribute to the betterment of water quality and the overall well-being of communities in need.

5.2 Recommendations

Based on the study's findings, several recommendations emerge:

Firstly, it is advisable to encourage and support the adoption of BSFs in communities facing water quality issues. This could be facilitated through community training programs that teach residents how to construct and maintain BSFs.

Secondly, there is a need for ongoing research and development efforts aimed at optimizing BSF designs for different water sources and environmental conditions. Variations in filter media, reservoir materials, and diffuser designs should be explored to enhance performance.

Thirdly, it is crucial to establish monitoring and maintenance programs for BSFs in communities to ensure their continued functionality. Regular cleaning and refilling are essential to maintain the effectiveness of the bio layer.

Fourthly, regular water quality testing should be promoted in communities using BSFs to verify their ongoing effectiveness and to address any deviations from water quality standards promptly.

Furthermore, advocacy for government and non-governmental organization (NGO) support for the widespread implementation of BSFs in regions with water quality challenges is necessary. Financial and technical assistance can facilitate the broader adoption of this technology.

Lastly, conducting public awareness campaigns on the importance of safe drinking water and the role of BSFs in improving water quality is vital. Community engagement and education are crucial components of successful initiatives.

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APPENDIX









