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Design & Modification of Slow Sand Filter

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ABSTRACT: Slow sand filtration is a traditional and effective method for water purification, particularly suited for small to medium-sized communities. This process relies on natural biological and physical mechanisms to remove contaminants from water, making it a sustainable and low-cost solution for producing clean drinking water. Unlike rapid sand filters, which depend on chemical treatments and frequent backwashing, slow sand filters operate at a much slower rate, allowing a biofilm layer known as the "schmutzdecke" to form on the sand surface. This layer is critical for the filtration process, as it traps and breaks down organic matter, pathogens, and other impurities.

The design of a slow sand filter is relatively simple, consisting of a bed of fine sand, a layer of gravel, and an underdrain system to collect filtered water. Water flows through the sand bed at a slow rate, typically between 0.1 and 0.3 meters per hour, allowing time for the biological processes to occur.

KEYWORDS: Sand Bed Gravel, Support Layer, UV filter, Solar panel.

I. INTRODUCTION

Access to clean and safe drinking water is a fundamental human need, yet millions of people worldwide still lack this basic resource. Contaminated water is a leading cause of waterborne diseases, which can have devastating effects on public health, particularly in developing regions. To address this challenge, various water treatment methods have been developed, ranging from advanced chemical processes to simple, natural filtration systems. Among these, slow sand filtration stands out as one of the oldest, most reliable, and sustainable methods for water purification. This method has been used for centuries and continues to be a viable solution for providing safe drinking water, especially in small to medium-sized communities and rural areas.

II. LITERATURE SURVEY

1st Paper American Water Works Association (AWWA). (2012). Water Treatment Plant Design. 5th ed McGraw-Hill.

The "Water Treatment Plant Design" by the American Water Works Association (AWWA) is a comprehensive resource that covers the principles and practices of water treatment facility design. The 5th edition, published by McGraw-Hill in 2012, includes updated information on regulatory requirements, design criteria, and advanced

treatment technologies. It serves as a critical reference for engineers, planners, and water utility managers involved in the design and operation of water treatment plants.

2nd Paper Slow Sand Filters for the 21st Century: A Review John K. Sruthi Dasika and Chad T. Jafvert

In 2017, approximately 30% of the world population still lacked access to a safely managed drinking water source, with 159 million people collecting drinking water directly from surface water sources [1]. Safe drinking water access is a primary issue in rural communities of developing nations, with UNICEF reporting that 80% of people without access to an improved drinking water source live in rural areas [1,2]. Sub-Saharan Africa still lags behind with only 27% access to safely managed water systems, and a further 34% access to a basic water supply [1,3]. As a result of limited access to safe water, the disease burden is worse in developing regions. In 2012, over half a million deaths in low- and middle-income countries were attributed to drinking water [4]. These WASH-related diseases can be controlled with adequate access to safe water, proper sanitation, improved hygiene, and better water management practices, thus preventing around 10% of the global disease burden 5.2 Slow Sand Filters for the 21st Century: A Review John K. Maiyo Sruthi Dasika and Chad T. Jafvert

3rd Paper Gary S. Logsdon, Dir.; Water Process Res., Black & Veatch, 10250 Alliance Rd., Cincinnati, OH, American Society of Civil Engineers, New York, NY

This report, Slow Sand Filtration, was prepared by the Task Committee on Slow Sand Filtration of the Water Supply Committee of the Environmental Engineering Division of the American Society of Civil Engineers. With stricter federal regulations concerning the treatment of surface water, communities with small water systems must use some sort of filtration process. Slow sand filters are considered to be appropriate for small systems since the operating procedures and maintenance associated with the process are uncomplicated and not burdensome to them. The purpose of this report is to describe slow sand filtration practice in the United States and to explain the process so that those who design or review and approve these filters will have a solid understanding of the process.

III. METHODOLOGY

1. Design and Setup of the Filter

- **Filter Construction:** Construct a slow sand filter using locally sourced materials. The filter typically consists of a gravel layer (for drainage), a sand layer (for filtration), and a top layer of finer sand.
- **Dimensions:** Standard filter dimensions may vary, but a common design includes a filter bed depth of 0.9 to 1.2 meters, with a surface area tailored to the intended flow rate and treatment capacity.
- **Instrumentation:** Equip the filter with monitoring devices to measure inflow rates, water quality parameters (e.g., turbidity, total coliforms), and hydraulic pressure.

2. Water Source and Pre-treatment

- **Water Source Selection:** Identify a suitable water source for testing, such as river, pond, or well water, with known contamination levels.
- **Pre-treatment:** Conduct a preliminary screening of the water to remove large debris and particles, using a coarse mesh or sieve if necessary, to prevent clogging of the sand layer.

3. Operational Parameters

- **Flow Rate Determination:** Establish a controlled flow rate (typically between 0.1 to 0.5 m/h) to optimize filtration performance. This can be adjusted using valves or siphons.
- **Monitoring:** Regularly monitor the filter for flow rate stability, pressure buildup, and the formation of the schmutzdecke.

IV. EXPERIMENTAL RESULTS

Slow sand filters (SSFs) are complex systems where physical, biological, and hydraulic processes interact to purify water. To optimize their design and predict performance, engineers and researchers use mathematical models,

computational simulations, and experimental data analysis. Below is a detailed breakdown of the key aspects of SSF modeling and analysis.



Figure 1: Slow sand Filter Model

Slow sand filters (SSFs) are highly effective for water purification, especially in small to medium-scale systems. Their performance depends on biological and physical processes. Below is a detailed explanation of their results in terms of water quality, operational efficiency, and limitations.

Contaminant	Removal Efficiency	Notes
Bacteria (E. coli)	90-99%	Very effective
Viruses	70-99%	Depends on filter age & design
Protozoa (Giardia)	99%+	Excellent removal
Worm eggs	99%+	Too big to pass through
Turbidity (dirt)	90-99%	Water looks clear
Chemicals (metals, pesticides)	Low (unless biochar is added)	Weak point of basic filters

i. Water Quality Tests (Before and After Filtration)

- To evaluate the filter's effectiveness:
- Turbidity Test – Measures the cloudiness of water.
- Total Coliform and E. coli Count – Assesses microbial contamination.
- pH Test – Checks acidity/alkalinity of water.
- Dissolved Oxygen (DO) – Important for biological activity in the filter.
- Biological Oxygen Demand (BOD) – Measures organic pollution.
- Total Dissolved Solids (TDS) – Indicates dissolved substances in water.
- Iron and Manganese Tests – For chemical quality, especially in groundwater.

ii. Turbidity Test Result

- Before Filtration (Raw Water): Turbidity = 5–50 NTU (can vary depending on source)
- After Filtration (Filtered Water): Turbidity = < 1 NTU (ideally around 0.1–0.5 NTU)

Observation:

A reduction in turbidity from high (cloudy water) to below 1 NTU indicates effective removal of suspended particles and good performance of the slow sand filter.

iii. pH Test Result

- Before Filtration: pH = 6.5 – 8.5 (depends on source water)
- After Filtration: pH = 6.5 – 8.5 (usually remains stable)

Observation:

Slow sand filtration does not significantly change the pH of the water, as it's a biological and physical process, not chemical.



Figure 2: Before filter Water



Figure 3: After Filter Water

V. CONCLUSION

In conclusion, slow sand filtration offers a cost-effective and reliable solution for improving water quality, particularly in areas with limited access to advanced water treatment technologies. Its ability to remove pathogens and reduce turbidity makes it a valuable tool for providing safe drinking water to communities.

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