



# Chapter 3

## Slow Sand Filtration for Water Treatment

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### ABSTRACT

*Slow sand filtration (SSF) is one of the traditional methods of water treatment yet gaining attention as a promising method. The rising demand is owing to its simplicity, environmental friendliness and effectiveness, which can reach 90-95%. This chapter reviews the principles and mechanisms underlying SSF, particularly addressing the physical, biological, and chemical processes that contribute to its effectiveness. Furthermore, the chapter delves into the design and construction of SSF systems, with a particular emphasis on the critical components and factors that facilitate the attainment of optimal performance. The efficacy of the method in enhancing water quality is assessed through a variety of analytical methods, including the removal of turbidity, the reduction of pathogens, and the removal of organic matter. The chapter also encompasses the environmental impact assessment of SSF to guarantee its long-term sustainability.*

### I INTRODUCTION

Slow sand filtration can be considered as a technology that is easy to develop, process, control and adapt to communities that lack a safe water supply for human consumption and that face economic, educational and geographical constraints. Since this system has an efficiency of more than 95% in the removal of organic material and pathogenic microorganisms that cause gastrointestinal diseases, it can

DOI: 10.4018/979-8-3693-7505-1.ch003

be considered as an economically, technically, socially and environmentally sustainable and viable alternative to water purification.

The World Health Organization (WHO) estimates that about 80% of diseases are transmitted through contaminated water. Given that the problem of water supply is widespread and that in most cases it leads to diseases mainly of the gastrointestinal tract, a viable option is the introduction of decentralized water treatment systems that are affordable and easy to maintain. Thus, SSF becomes an alternative adapted to the environmental and social context that needs to be taken into account when working.

SSF is an established and effective method for treating drinking water, removing pathogens and particles. It has been used since the early 1800s and is still widely used globally (Haig et al., 2015). This technique has been documented to remove significant amounts of enteric bacteria from water, demonstrating its effectiveness in controlling microbiological contamination (Haig et al., 2015; Bai et al., 2024b). It is particularly suitable for use in small water systems, such as those found in rural areas and developing countries. SSF is recognized as the most suitable technology for producing safe drinking water in these regions (Ndi et al., 2008; Elhaya et al., 2024).

Research has shown that slow sand filters are an efficient way to provide safe drinking water for communities that do not have access to centralized water supply systems (Abdiyev et al., 2023). This is due to the fact that SSF is effective in removing pathogens, as demonstrated by the absence of *Cryptosporidium* oocysts in water treated with these filters, even when this parasite is present in raw water entering the system (Le Dantec et al., 2002). Additionally, slow sand filters effectively remove *Giardia lamblia* cysts and other harmful microorganisms, making them a preferred method for water treatment by federal and state authorities due to their simplicity of use and historical reliability (Haig et al., 2015; Bai et al., 2024b).

While SSF is primarily used for water treatment, it can also be adapted for wastewater disinfection (Alnahhal et al., 2024). Due to its simplicity and passive nature, this method is especially suitable for small water systems. It has been shown to be highly effective at removing bacteria and pathogens from water (Bellamy et al., 1985).

To ensure the effectiveness of slow sand filtration, it is important to use sterilized sand and regularly test the quality of the filtered water to ensure its safety (Karon et al., 2011).

The aim of this chapter is to provide a comprehensive understanding of SSF as a viable water treatment method, emphasizing its historical significance, operational principles, and modern innovations. It seeks to explore how SSF can be implemented effectively to address water contamination issues in both developed and developing regions, with particular attention to the removal of pathogens, suspended solids, and emerging pollutants such as pharmaceuticals and microplastics.

The specific objectives include:

1. To outline the principles and mechanisms underlying the effectiveness of slow sand filtration, including both physical and biological processes.
2. To examine various design and operational considerations of SSF systems, such as filter media, flow rates, and maintenance procedures.
3. To highlight the role of SSF in the removal of pathogenic microorganisms, turbidity, and other water pollutants, as well as its application in decentralized water systems.
4. To present advancements and modifications in SSF technology aimed at improving efficiency, particularly for emerging contaminants.

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