Surface water conditioning for household slow sand filtration: validation of a simplified pre-treatment and operational challenges

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Highlights:

- Sedimentation followed by filtration through a non-woven blanket offers efficient, simple, and cost-effective household pre-treatment.
- Increasing the sedimentation time from 24 to 96 h, simulating usual household storage conditions, allows optimization of the pre-treatment.
- Results showed the pre-treatment feasibility for surface water treatment in isolated communities.

Keywords: Clarification; Sedimentation; non-woven synthetic fabric.

INTRODUCTION

To ensure safe drinking water, a multiple barrier approach is recommended from source to consumer. In water treatment systems, this sequential approach combines two or more treatment technologies to strengthen overall performance. Furthermore, when raw water has high turbidity, a pre-treatment step is essential to reduce interference with the effectiveness of the technology used (WHO, 2022).

For the Household Slow Sand Filter (HSSF) – a widely used decentralized treatment system – a sedimentation step is recommended when raw water turbidity is above 50 NTU. Thus, avoiding rapid clogging of the filter media and ensuring the proper functioning of the technology (CAWST, 2012). Nevertheless, to meet more restrictive drinking water standards, the initial turbidity must be up to 10 NTU (Sabogal-Paz *et al.*, 2020).

Previous studies with HSSF used a pre-treatment consisting of a 24-hour sedimentation step followed by filtration through a non-woven synthetic fabric (Terin *et al.*, 2021; Freitas *et al.*, 2023). However, this previous step can be a limiting factor for users to accept the treatment system, requiring daily maintenance to fill the raw water reservoir.

In this way, the objective of this study was to increase the pre-treatment sedimentation time of a HSSF from 24 to 96 hours, aiming to optimize the removal of turbidity and apparent color from raw water and reduce the frequency of system maintenance.

METHODOLOGY

The pre-treatment of surface water involved a sedimentation step followed by filtration through a non-woven synthetic fabric to feed an HSSF for 140 days, which was based on studies carried out by Terin *et al.* (2021) and Freitas *et al.* (2023).

The first phase of pre-treatment consisted of storing raw water in a 500 L reservoir twice a week. However, as the water was treated every day, the sedimentation time varied between 24 and 96 hours. After this time, effluent water from sedimentation reservoir was transferred daily to a non-woven filtration tank, concluding pre-treatment stage. Water quality was monitored daily by turbidity and apparent color (APHA *et al.*, 2012).

Normality distribution was evaluated by Shapiro-Wilk test, while hypothesis tests by Student's t-test or Mann-Whitney test. All statistical analyses were performed on PAST 4.03 software (PAlaeontological Statistics) considering a significance level of 5% ($p < 0.05$).

RESULTS AND CONCLUSIONS

Given the proposed pre-treatment, the average turbidity removal was 45.5±21.0% ($p < 0.05$), and apparent color was reduced by 35.5±22.7%, both statistically significant. Turbidity values decreased as sedimentation time increased (Figure 1a), 94% of pre-treated water samples had turbidity values below the ideal limit of 50 NTU for HSSF operation, as recommended by CAWST (2012). With a more restrictive criterion, 75% of the samples had turbidity below 10 NTU, as indicated by Sabogal-Paz *et al.* (2020) (Figure 1b). Regarding apparent color (Figure 1c), a significant reduction ($p < 0.05$) was observed after 24 hours, but between 48 and 96 hours, no further reductions were achieved due to the presence of dissolved water compounds that are difficult to remove by sedimentation processes ($p > 0.05$).

In comparison, two studies applied the same pre-treatment, with only 24 hours of sedimentation. Freitas et al. (2021) and Terin et al. (2021) achieved an average turbidity removal of 46±23% after pre-treatment, while apparent color was reduced by 21±19%. Regarding turbidity, despite an increase in sedimentation time, similar efficiency was observed compared to that of this study. Conversely, apparent color removal was optimized with an increase in sedimentation time, as the removal values were higher compared to the cited studies.

Considering the improvement in water quality, simplicity of construction and operation and reduced maintenance frequency, the proposed pre-treatment presented potential for application as an initial step to adapt water for HSSF operation. Mainly in surface water sources that have a high variation in physical-chemical and microbiological parameters, as in Brazil. Thus, enabling better water quality and greater acceptance and sustainability of this treatment system in small communities.

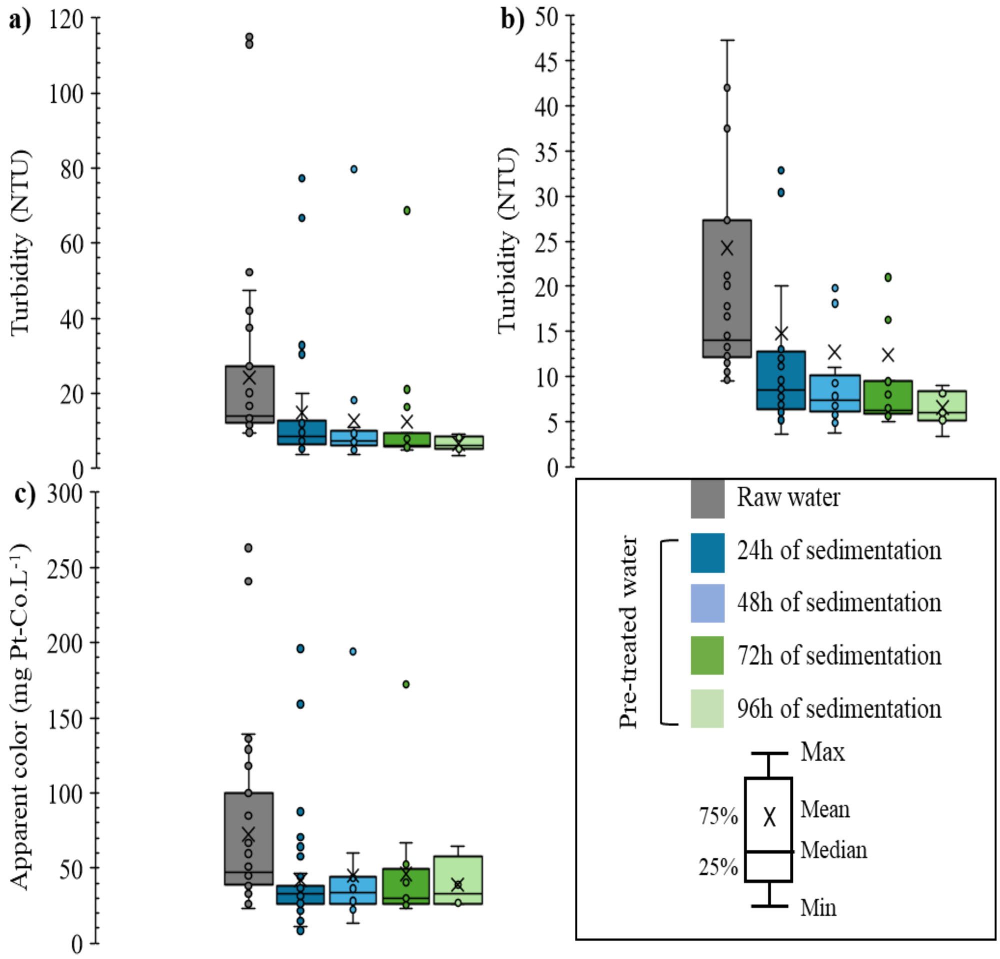

Figure 1: Overall values of (a) turbidity, (b) below 50 NTU, and (c) apparent color of pre-treated water between 24 and 96 hours of sedimentation.

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