EFFICIENCY OF VERTICAL UP-FLOW ROUGHING FILTER FOR TURBIDITY REMOVAL BY ADDING A COAGULANT CHEMICAL

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INTRODUCTION

The prominent drinking water treatment process practised to eliminate turbidity from surface water, especially during high turbidity occurrence in the surface water, is coagulation, sedimentation and rapid sand filtration for many years. It is a vital requirement to remove the organic matter in the potable water treatment process due to its stress on the treatment process and potential to form carcinogenic disinfection byproducts, and the impacts on plant efficiency and impacts on aesthetic effect (Wegelin, 1996). The coagulation process is highly valued and used in most water treatment plants (WTP) by water supply engineers as the most accepted and cost-effective pretreatment process for the removal of organic matter and suspended solids present in water.

There are few pre-treatment techniques to treat raw water to prevent rapid clogging and frequent cleaning of the WTP. However, the roughing filtration process is one of the most reliable techniques used currently. Reducing the turbidity load on the slow sand filter can be obtained by the proper functioning of a roughing filter. Either down flow or up flow filters are the operating flow patterns in the vertical-flow roughing filters. Vertical-flow roughing filters are designed to have completely submerging of the filter media, often with the gravel, with various particle sizes in layers (Nkwonta & Ochieng, 2009).

During the coagulation process, the surface charge properties of solids are changed to enhance the agglomeration and/or enmeshment of tiny particles into larger flocs by a few Al-based compounds or polymers, namely, aluminium chloride, aluminium sulphate (alum), and poly aluminium chloride (PACl). The coagulation process is one of the very effective processes of removing turbidity when PACl is added (Zhao et al., 2011). Previous studies indicate that the efficiency of PACl as the coagulant is more than that of alum, mainly due to its higher overall positive charge (Zouboulis et al., 2008).

The necessity of backwashing is inevitable in any WTP. The main purpose of backwashing in the roughing filter is to clean the filter media. The filter bed is fluidised by a backwashing mechanism in most of the filters. The filter bed is well arranged due to the fluidization process, which enables the fine grains to draw up to the top of the filter layer while keeping the coarse grains at the bottom. This will create a wide range of grain sizes in the filter bed through which the filter efficiency increased (Hasan, 1994).

As per the WTP operation manual, the raw water turbidity level must be less than 80 NTU before it enters the RF for proper operation (NJS Consultants Co., 2019). However, the turbidity of raw water increases to 100-350 NTU during the rainy season, which results in stopping the plant's efficient operations. Hence, the research objective was to study the turbidity removal efficiency in roughing filters when pre-adding poly-aluminium chloride (PACl) as a coagulating chemical as the pre-treatment method needed for treating surface water by the slow sand filtration treatment process, by utilizing the existing WTP structures.

METHODOLOGY

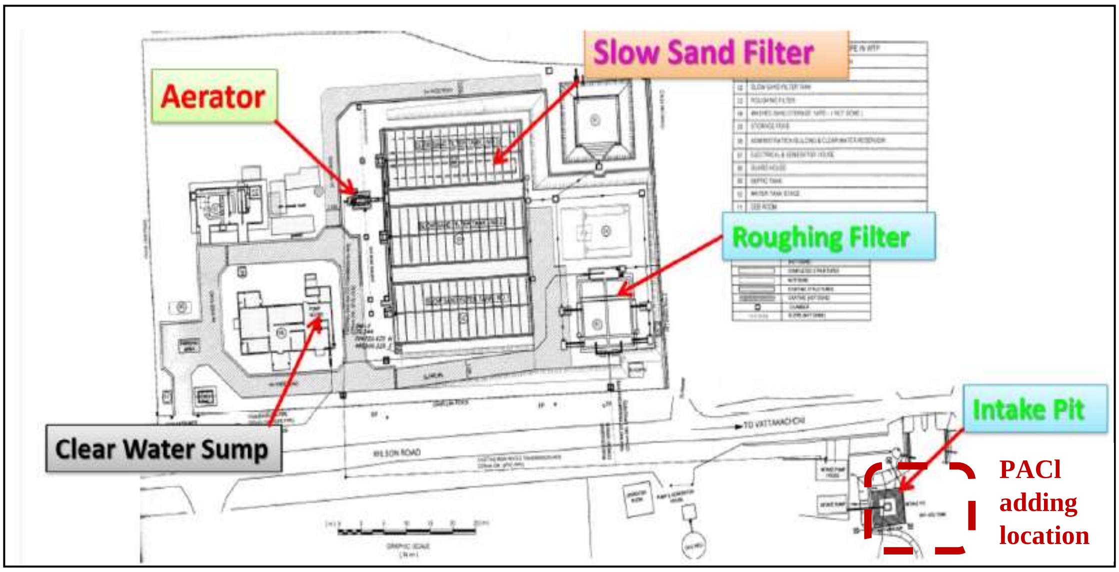
The treatment process of the Kilinochchi water treatment plant starts with pumping water from the intake to the roughing filter, the aerator, the SSF, and finally to the clear water ground sump. However, a new methodology was adapted to the existing treatment process by keeping the process as it is to encounter the threat of a higher level of raw water turbidity, especially during the rainy season.

As per the WTP operation manual, raw water turbidity must be less than 30 NTU before it enters the slow sand filter to prevent clogging of the filter media of SSF (NWSDB, 1989). Therefore, the methodology used was to add PACl as the coagulant chemical to activate the coagulation process from which the suspended solid particle can efficiently form clogs within a short period.

For this study, 1% of PACl was prepared and dosed at the rate of 20 mg/L. The prepared solution was mixed with raw water in the water intake chamber before it reached the roughing filter, as shown in Figure 1. In addition, the inlet structure of the roughing filter was modified to improve the mixing of PACl with raw water. The experiment was carried out for the water inflow rate ranging from 1500-2000 m^3/day. As filter media, gravel with various particle sizes of 4-8 mm, 8-12 mm, and 12-16 mm with a layer thickness of 1,000 mm each was used in the roughing filter.

The turbidity level of raw water and the treated water from the roughing filter was measured in six-hour intervals for one month. The turbidity was measured and analysed for 58 nos of trails. Turbidity was measured by a 2100Q turbidity meter at the site laboratory, which is located in the water treatment plant site.

The necessity of backwashing is inevitable in any WTP. In practice, the backwashing of the roughing filter occurs once in 2-3 days for 3-4 hours during the rainy season when the raw water turbidity increases drastically, and once in 2 weeks for 2 hours during the dry season in this plant. The water flow during the treatment process is in the upward direction and hence, water is sent in a downward direction during the backwashing process. The raw water is filled into the roughing filter and the drain valve is rapidly opened to shock the filter layers and increase the degree of cleaning. Raw water being used to backwash instead of using treated water could curtail the plant's operational costs. Backwash water is sent to a drying bed to trap the filter media particles and sludge and finally, the water is safely disposed downstream



of the river via a channel.

Figure 1: WTP layout and PACl mixing location

RESULTS AND DISCUSSION

As representative test results, Figure 2 shows turbidities in raw water and treated water by the roughing filter when PACl is added as the coagulant agent. The samples whose raw water turbidity exceeds the limit of 80 NTU were taken into consideration for the analysis. The raw water, before sending to SSF, generally needs to be less than 30 NTU to prevent the clogging of slow sand filter media.

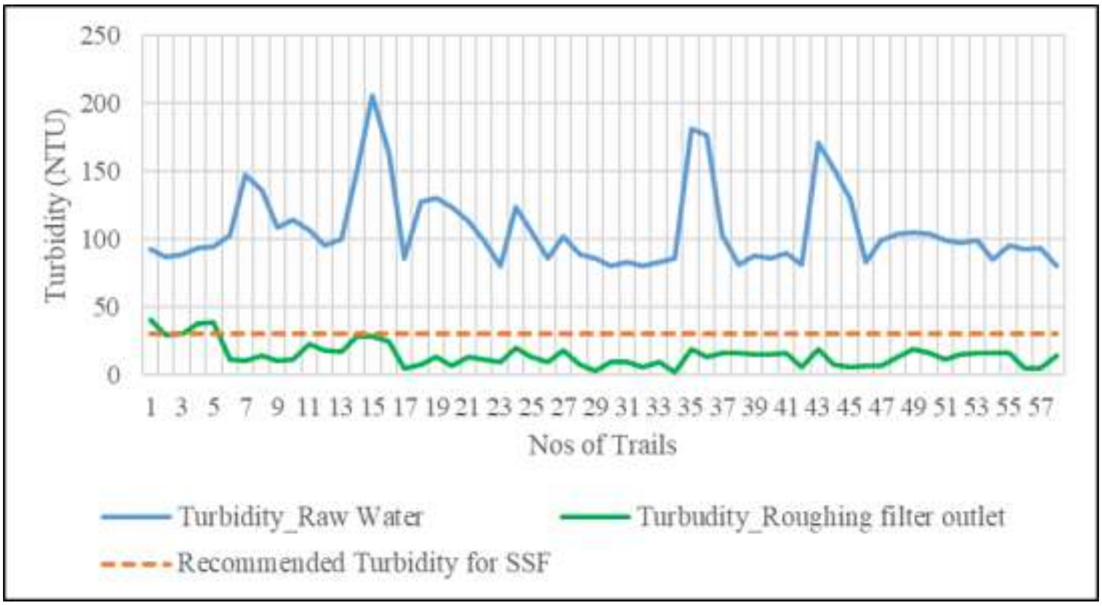


Figure 2: Comparison of turbidity in raw water and treated water

The result illustrates that turbidity is removed significantly by the proposed methodology with the addition of PACl with raw water and treatment by the roughing filter. The turbidity of treated water by the roughing filter was observed to be well below the threshold limit of 30 NTU in 95% of the treated samples by the roughing filter when this method is applied. The turbidity of raw water for 19 days during the testing period varied in the range of 80.2 - 206 NTU, whereas turbidity of the filtered water from the roughing filter was observed between 5-41 NTU.

Figure 3 indicates that 53 out of 58 samples were observed to be above 80% efficiency in removing turbidity. Further, there is a correlation observed between the time and turbidity removal efficiency, where the efficiency increases with the days of operation.

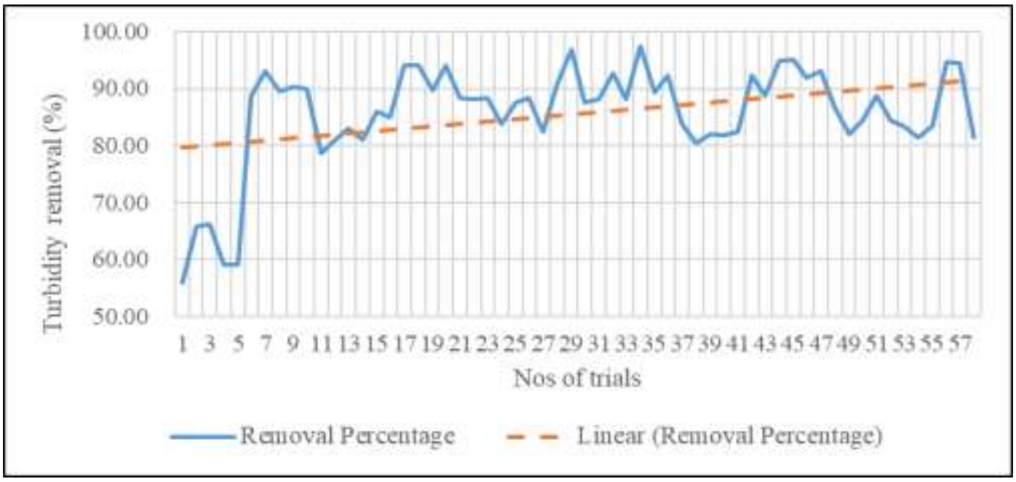


Figure 3: Turbidity removal efficiency vs trails

In a previous study, the same methodology was assessed through a vertical up flow roughing filter prototype model of the same water treatment plant. As per previous studies using the roughing filter prototype model, turbidity removal efficiency of the roughing filter by adding PACL was recorded as 82%, and it increased with the increased turbidity of the inlet water to the roughing filter. Consequently, the current study records the average turbidity removal efficiency of roughing filters as 83.1%.

The turbidity removal efficiency using this method was compared against the turbidity level of the raw water, plotted in Figure 4. A positive correlation was observed, such as the way the efficiency in removing turbidity increases when the raw water turbidity level increases.

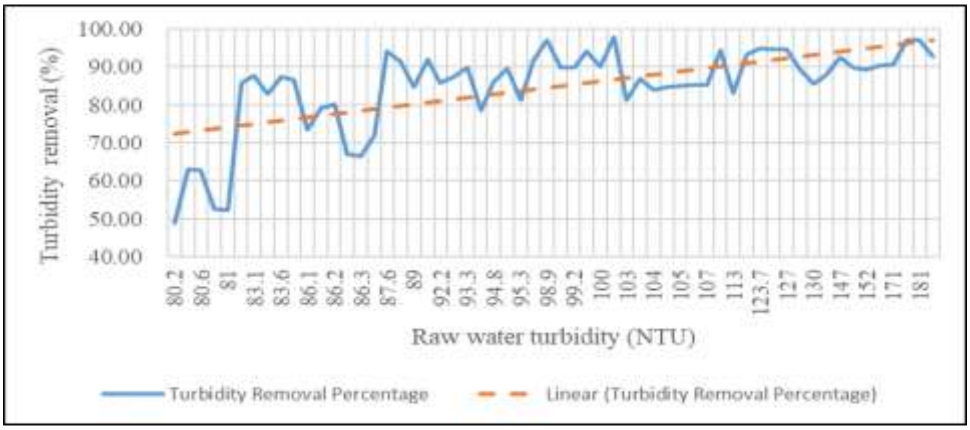


Figure 4: Turbidity removal efficiency vs raw water turbidity level

CONCLUSIONS/RECOMMENDATIONS

The research objective was to study the turbidity removal efficiency in roughing filters when pre-adding poly-aluminium chloride (PACl) as a coagulating chemical to treat the surface water to supply potable water. The past year's records show the WTP stops its operation when raw water turbidity is high, especially during the rainy season. The result illustrates that turbidity is removed significantly by this method due to the very effective coagulation process of removing turbidity when PACI is added. The treated turbidity level is well below the threshold limit of 30 NTU in all the trails when this method is used. The turbidity removal efficiency increases with the days of operation because PACl coagulation behavior occurs by a sweep flocculation form and by charge neutralization over time. The efficiency in removing turbidity increases when the raw water turbidity level increases as PACl is capable of performing efficiently in terms of residual turbidity. This method can be used as the solution for higher raw water turbidity issues in conventional drinking water treatment plants, with the use of jar tests and by considering the treatment process.

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