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# Comparative Evaluation of Sedimentation and Pulsator Clarifier Systems Using Aluminium Sulphate Coagulant in Water Treatment

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## 1 Introduction

In Sri Lanka, surface water is the main source for the urban drinking water supply system. Surface water bodies are recharged during the rainy season to supply the required amount of water for drinking and agricultural use. However, the use of surface water introduces several key challenges for engineers and scientists, including variable water quality, high turbidity, and the presence of natural organic matter and emerging contaminants. Coagulation is widely used worldwide to remove mainly colloidal and suspended particles. *(Maldhure et al., 2021).*

In water treatment plants (WTPs), the coagulant plays a crucial role in neutralizing the electrostatic repulsive forces of these particles. The coagulant's metal ion attracts these negatively charged particles and coagulates with them to form small-sized floc *(Maldhure et al., 2021)*. Mainly, aluminum-based coagulants, such as alum and poly-aluminum chloride, are widely used in Sri Lanka.

Conventional WTPs typically include the aeration process, pre-chlorination, coagulation, sedimentation, and rapid sand filtration. Modern systems incorporate pulsator technology as an alternative to traditional sedimentation. Pulsator clarifier's function uses a sludge-blanket-assisted, pulsator mechanism that improves floc collection and turbidity removal efficiency under the raw water conditions *(Mirbagheri et al., 2014)*.

While both sedimentation tanks and pulsator clarifiers are typically used, there is limited comparative evidence on their performance under tropical water conditions, such as those found in Sri Lanka. This study addresses this gap by measuring the operational performance of both systems in the Gatembe Water Treatment Plant using long-term data and jar test experiments.

The objectives of this study are:

- Variation of turbidity, pH, and residual aluminum removal efficiencies of sedimentation and pulsator clarifiers.
- Determine the suitable coagulant dosage using jar tests.
- The operational behavior of the pulsator system under raw-water variations.

## 2 Experimental Section

### 2.1 Study Area

The study was conducted at the Gatembe Water Treatment Plant (GWTP) controlled by the Kandy Municipal Council. Established in 1963, the plant has a production capacity of 36,000 m³/day and the water is collected from the Mahaweli River. Main treatment processes include an aerator, coagulation process, mixing, sedimentation tank, four pulsator tanks, and nine rapid sand filters. Lime is added for managing pH level and controlling hardness levels, and chlorination is used for pre- and post-disinfection.

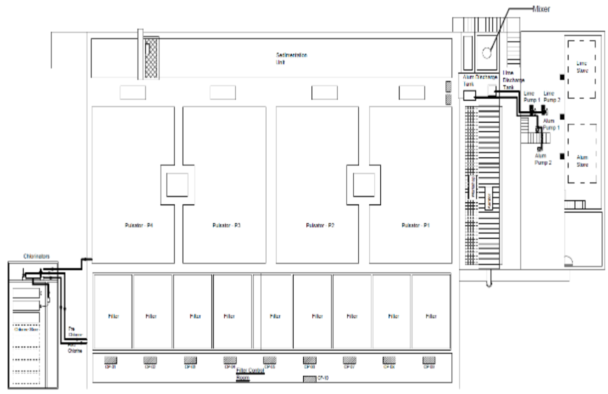

**Figure 01:** Water Treatment Plant, Gatembe, Kandy Municipal Council.

### 2.2 Coagulant addition experiments (jar test)

Jar tests were performed following the APHA standard method to measure the suitable alum dosage. Firstly, six one-liter beakers were filled with raw water and measured for raw water pH and turbidity. Prepared alum solutions of known concentrations were added to each of the six beakers.

The mixing procedure was as follows:

- Rapid mixing at 100 rpm for 1 minute to check uniform coagulant dispersion.
- Slow mixing at 30 rpm for 20 minutes to promote floc formation.
- A 20-minute settling period to allow complete

floc sedimentation.

After settling, the floc was visually observed, and pH and turbidity were determined to find a suitable alum dosage for plant performance.

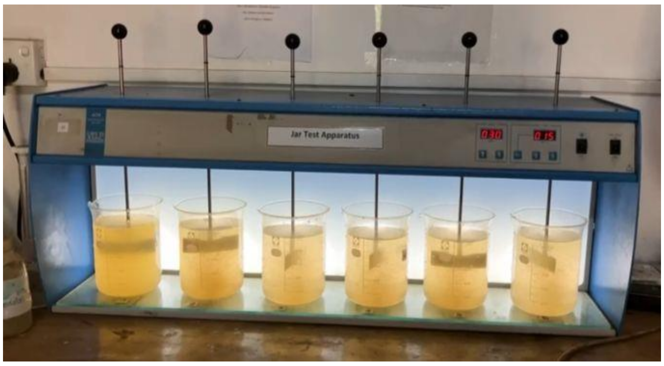

**Figure 02:** Jar Test Apparatus.

### 2.3 Analysis of treated water

Water samples from the raw water, sedimentation tank, pulsator, and final treated water were analyzed using APHA methods. pH was measured using a pH/EC/TDS multiparameter. A Lovibond TB 300IR turbidity meter was used to measure turbidity. Residual aluminum was measured using a DR 6000 spectrophotometer. These parameters were used to evaluate the performance of both the sedimentation tank and pulsator system.

### 2.4 Pulsator Sludge Blanket Formation

The pulsator works on a vacuum system. Water enters a vacuum chamber where the level rises to a set height. When this level is reached, the vacuum breaker activates and then releases a pulse of water that distributes evenly through the stilling plates into the sludge blanket zone.

Main functioning parameters include:

- Flushing time: Generally, 20–80s, dependent on water level in the vacuum chamber.
- Suction time: The break time between pulses, normally 5–10s.
- Flushing height: Adjusted the height on raw water quality (turbidity), approximately 20–90 cm.

In the rainy season, raw water turbidity can be increased (approx. 800 NTU), needing operational changes to keep the sludge blanket formation. A stable sludge blanket improves water quality.

**Figure 03:** Pulsator Technology, Water Treatment Plant, Kandy Municipal Council.

## 3 Results and Discussion

### 3.1 Effect of Alum dosage

The suitable alum dose identified from jar tests ranged between 6mg/L and 15 mg/L, consistent with typical values for water treatment. Raw water turbidity remained below 10 NTU during dry periods, requiring a small amount of coagulant. Normally, alum shows the highest reaction efficiency in the pH range of 6.0–8.0, and lime was added to keep the pH in range.

### 3.2 Water Quality Variation

Ten months of functioning data were analyzed to determine the variation of water quality parameters like turbidity and pH at four main points: raw water, sedimentation tank, pulsator clarifier, and treated water. Residual aluminum concentrations were measured at the sedimentation tank, pulsator clarifiers, and treated water points to measure coagulant performance with quality drinking water standards.

**Table 01.** Summary of Monthly pH Variation – 2025.

| Month | pH | | | |
|---|---|---|---|---|
| | Raw | Settling Tank | Pulsator | Final Water |
| January | 6.42 | 6.39 | 6.45 | 6.55 |
| February | 6.47 | 6.42 | 6.47 | 6.58 |
| March | 6.32 | 6.41 | 6.53 | 6.64 |
| April | 6.37 | 6.46 | 6.49 | 6.54 |
| May | 6.72 | 6.70 | 6.73 | 6.78 |
| June | 6.67 | 6.61 | 6.63 | 6.67 |
| July | 6.54 | 6.47 | 6.52 | 6.64 |
| August | 6.45 | 6.51 | 6.53 | 6.60 |
| September | 6.39 | 6.45 | 6.54 | 6.66 |
| October | 6.27 | 6.39 | 6.46 | 6.57 |

Based on results (Table 01), the average pH values of the treatment steps were: raw water 6.50, sedimentation tank

6.45, pulsator clarifier 6.54, and treated water 6.65. Hydrated lime was added as required to keep the pH within the correct range for alum coagulation.

**Table 02.** Summary of Monthly Turbidity Variation – 2025.

| Month | Turbidity (NTU) | | | |
|---|---|---|---|---|
| | Raw | Settling Tank | Pulsator | Final Water |
| January | 25.36 | 10.42 | 3.89 | 0.49 |
| February | 6.34 | 3.26 | 0.85 | 0.47 |
| March | 8.45 | 2.19 | 1.29 | 0.51 |
| April | 147.6 | 29.41 | 10.84 | 0.91 |
| May | 49.38 | 8.91 | 6.49 | 0.64 |
| June | 5.94 | 2.67 | 1.91 | 0.39 |
| July | 10.3 | 4.87 | 2.25 | 0.44 |
| August | 15.4 | 8.45 | 2.81 | 0.57 |
| September | 128.3 | 25.61 | 8.32 | 0.64 |
| October | 167.3 | 29.7 | 10.7 | 0.87 |

Based on the data, the sedimentation tank reached an average turbidity removal efficiency of around 85%, while the pulsator system further improved turbidity reduction to around 95%. These results show that both processes are operational efficiently under the experimental raw water conditions (Table 02).

**Table 03.** Summary of Monthly Residual Aluminum Variation – 2025.

| Month | Residual Aluminum (RAl) (mg/L) | | |
|---|---|---|---|
| | Sedimentation tank | Pulsators | Final Water |
| January | 0.046 | 0.042 | 0.036 |
| February | 0.037 | 0.029 | 0.021 |
| March | 0.046 | 0.037 | 0.026 |
| April | 0.073 | 0.066 | 0.049 |
| May | 0.072 | 0.067 | 0.058 |
| June | 0.058 | 0.047 | 0.043 |
| July | 0.053 | 0.039 | 0.031 |
| August | 0.049 | 0.037 | 0.025 |
| September | 0.069 | 0.066 | 0.054 |
| October | 0.081 | 0.073 | 0.067 |

Residual alum (RAl) concentrations reduced throughout the treatment units. In the sedimentation tank, RAl concentration was 0.07 mg/L, 0.05 mg/L after the pulsator clarifier, and 0.03 mg/L in the treated water. These values show that the correct coagulant dosage improved water quality (Table 03).

## 3.3 Pulsator Technology

The pulsator clarifier consists of the following components:

1. Raw water inlet
2. Vacuum chamber
3. Raw water distribution line
4. Stilling plates
5. Sludge removal valve

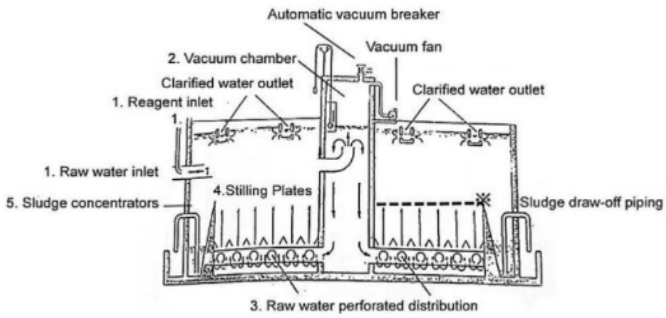


**Figure 04:** Schematic Flow Diagram of Pulsator *(Tomonori et al., 2016).*

Pulsator performance is determined by flushing height, flushing time, suction time, and the quality of the raw water. The sludge blanket provides a high surface area for particle capture, reducing turbidity and RAl concentration under changing turbidity variation.

Sedimentation tanks and pulsator clarifiers respond quickly to changes in the variation of raw water, making them suitable for tropical countries that experience rapid turbidity variations.

**Figure 05:** Sludge Blanket Formation.

## 4 Conclusions

This study observed sedimentation tank and pulsator clarifier performance in a conventional WTP. The jar test experiment was finding the best alum dosage between 6mg/L and 15 mg/L. Both sedimentation tanks and pulsator clarifiers operated efficiently, with pulsators able to reduce turbidity and residual alum concentrations. Pulsators confirmed superior adaptability to raw water variations due to the sludge blanket mechanism and pulsating flow. Proper adjustment of flushing height, flushing time, and suction time is important for maintaining sludge blanket formation during high and low turbidity conditions. The conclusions provide valuable supervision for optimizing pulsator operations in similar treatment plants.

## Declaration of Competing Interest

The authors declare no competing interests.

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## Credit Authorship Statement

**H.D. Jayathilake**; conceptualization, methodology, investigation, writing (original draft and review/editing)

## Keywords

water Treatment, pulsator, sedimentation, coagulant, alum, sludge blanket

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