# Greater Kegalle Water Treatment Plant
# Kegalle, Sri Lanka

## 1. Background information of the water treatment plant

Kegalle is located about 80 Km East of Colombo and the Greater Kegalle water treatment plant (WTP) is located in Moronthota which is 11 km away from Kegalle city. Greater Kegalle water treatment plant is owned and operated by National Water Supply and Drainage Board (NWSDB), Sri Lanka. Greater Kegalle water treatment plant was constructed by the NWSDB with financial assistance from Asian Development Bank. Construction of Greater Kegalle water treatment plant commenced in 2005 and the WTP was commissioned on 2007. This water treatment plant was expected to provide safe water to about 50,000 consumers living in and around the Kegalle city.

**Table 1 Overall information of Greater Kegalle water treatment plant**

| | |
|---|---|
| **Constructed Year** | 2007 |
| **Water Source** | Gurugoda Oya River |
| **Number of connections** | 11,050 |
| **Peak Operating Flow ($m^3/h$)** | 345 |
| **Design capacity ($m^3/h$)** | 530 |
| **Peak/Design flow** | 0.65 |
| **No. of operators working at the plant** | 3 |
| **Date of access of the source information** | 2015 |
| **References** | (Cowi Consultants, 2004; NWSDB,2014) |

## 2. Water treatment process flow

The major water treatment unit processes are as follows:

- Raw water extraction → Raw water pumping → Aeration → Coagulation of alum & lime → Flocculation → Sedimentation → Filtration → Disinfection → Clear water tank → Treated water pumping → Service reservoir → Distribution network

- Sludge treatment: Sludge from clarifiers and filters → Thickening (*sludge thickener*) → Drying (*sludge drying beds*)

The sketch diagram of water treatment process is shown in Figure 1

### 2.1 Aeration

Cascade aeration is the next step of water treatment after raw water extraction and it reduces the tastes, odors and oxidizes the soluble irons. The specific functional requirement of the aerator at Greater Kegalle WTP is to increase DO, since the raw water intake is from stagnated water near a hydropower dam DO of raw water is 3.2 mg/L and DO of aerated water is 7.0 mg/L. The design

loading rate of cascade type aerator is 3.9 $m^2$/ML per day. The recommended rate is 2 – 6 $m^2$/ML per day.

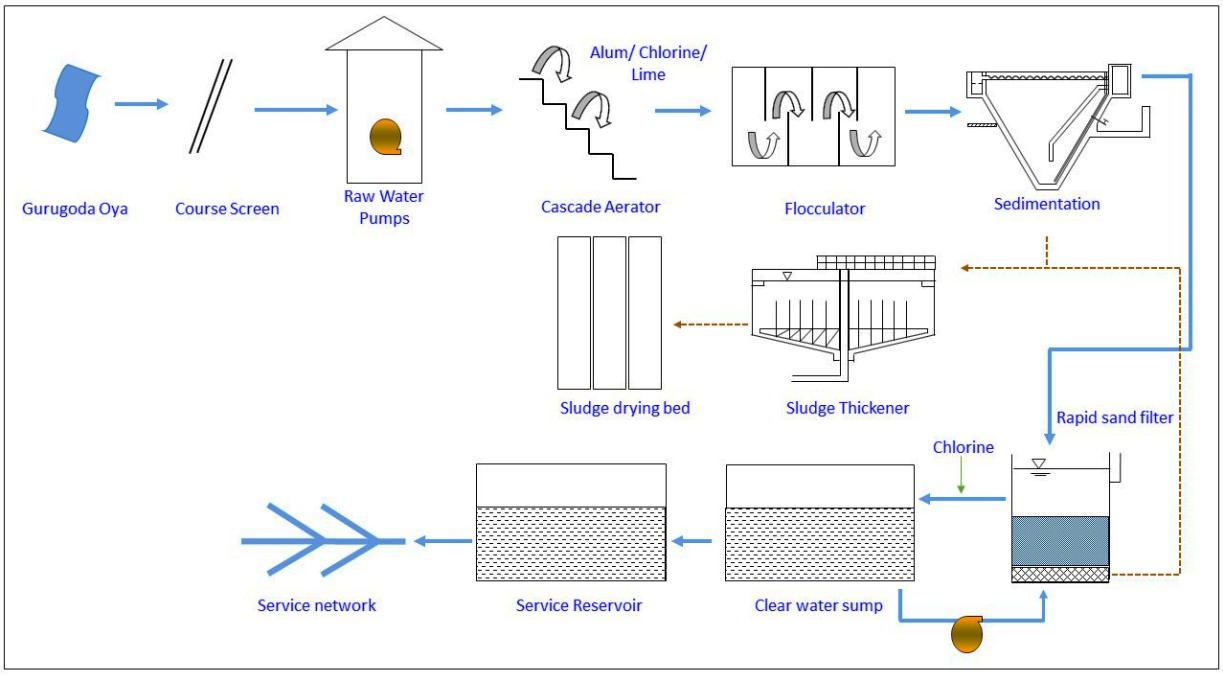
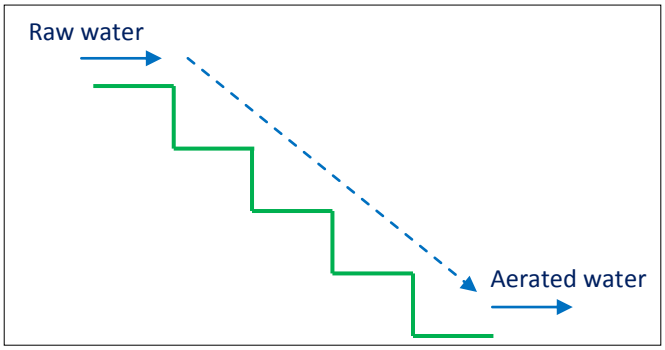



**Figure 1 Sketch diagram of treatment process**




**Real unit** **Sketch diagram**

**Figure 2 Cascade Aerator**

### 2.2 Chemical feeding and rapid mixing

Mainly alum, lime and gas chlorine are used for water treatment. Lime for pH adjustment, alum is used as the coagulant. Alum and lime is gravitated to a hydraulic jump at the entrance of flocculator through a constant flow feeding arrangement. Post chlorine is added at the effluent gallery of the filter.

Chlorine is dosed using vacuum feed chlorinators and the maximum dosing rate of the chlorinator is 2 kg/h. However, the current dosing rate is 0.8 kg/h. Alum, lime and gas chlorine is purchased by

competitive bidding procedure from the local agents of several companies in India. The total chemical cost of the WTP is 3.16 USD / 1000 $m^3$.

**Figure 3 Gas chlorine cylinders (900 kg)**

### 2.3 Flocculation

Greater Kegalle WTP has a hydraulic slow mixing method with round-the-end baffled channels. The design detention time is 11 minutes and the velocity gradient (G) is 12 $s^{-1}$ to 45 $s^{-1}$. The flocculator retention time of 11 minutes is not adequate according to Kawamura (2000). Normally, it is in the range from 30-40 minutes for horizontal baffle. Therefore, the quality of flocs might be reduced due to the insufficient contact time.

**Figure 4a Baffled channel flocculator**

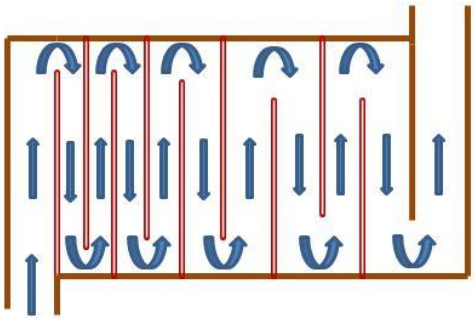


**Figure 4b Round-the-end baffled channel type flocculator**

### 2.4 Sedimentation

Sedimentation basin consists of three units of square up flow type hopper bottom sedimentation tanks with square-notched weir. The detention time is 4.3 h and surface loading is 1.5 $m^3/m^2 \cdot h$. Sludge is removed by sludge cone and sludge valve. The recommended detention time is 2 h and surface loading is 1.7 – 2.5 $m^3/m^2 \cdot h$ (Quasim et al, 2012).

**Figure 5a Sedimentation (3 units)**

**Figure 5b Square notch weir**

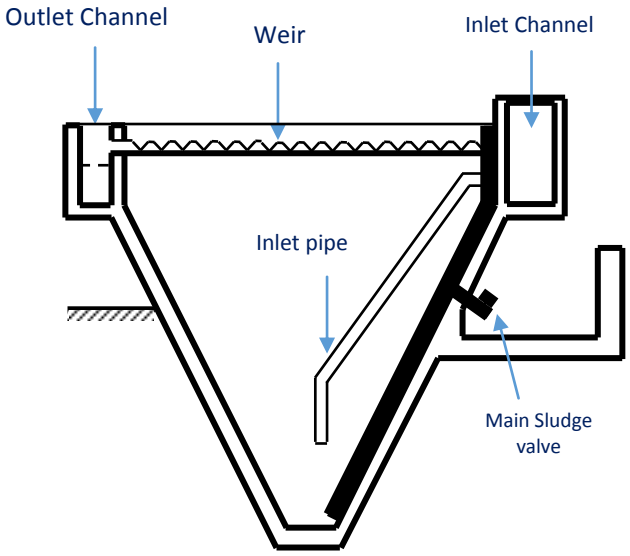



**Figure 6 Sketch diagram of sedimentation tank**

### 2.5 Filtration

The media utilized in rapid filters is fine sand with 1.0 mm of effective size, 1.4 of uniform coefficient and 0.75 cm of filter depth. Filter backwash method consist of water wash followed by air scouring. The filtration rate is 4.5 m/h. The filters are backwashed every 48 hours or when head loss in filter reaches 1.2 m, whichever happens first. The filters are cleaned 4 times a month to remove algae growth. The loss of filter media due to backwash is about 10% per year. The treated water turbidity varies from 0.2 to 1.2 NTU.

**Figure 7a Filter (4 units)**

**Figure 7b Filter Backwashing**

### 2.6 Sludge disposal

The designed sludge disposal system has been abandoned due to difficulty in maintaining the system. The designed sludge disposal method is sludge drying beds followed by sludge thickener. The supernatant from sludge thickener was proposed to be sent to Gurugoda Oya. Therefore, now, the backwash water and sludge from sedimentation tank is directly sent to Gurugoda Oya. Amount of solids produced is 1275 kg/day and amount of sludge produced is 11.3 L / $m^3$ of treated water.

**Figure 8a Sludge thickener**

**Figure 8b Sludge drying beds (3 units)**

## 3. Aspects of treatment processes posing most difficulty for daily operation

- When there are sudden heavy rains, the WTP receives shock load of turbidity. The Jar test has to be carried out to decide the optimum alum dosage for flocculation and the Jar test takes about 45 minutes to decide the optimum alum dosage (Kawamura, 2000). During this time period, the treated water produced by the WTP does not comply the recommended turbidity value by SLS 614:1983 (SLSI, 1983).

- The detention time of the flocculator is not adequate as per the recommendation of Kawamura which is 30 – 40 min (Kawamura, 2000). In addition, the wooden baffle boards are severely damaged and water flow is short – circuited and the efficiency of flock formation is reduced. Therefore it is planned to remove the existing wooden baffled boards and to fix PVC baffle boards.
- Loosing of filter media during operation and backwashing of filters is a major operational issue faced at the Greater Kegalle WTP. The main reason for loss of sand during operation is due to

the underdrain system of perforated pipes without filter nozzles. The other reason for loss of sand during filter backwashing is the high backwash water flow rate. During the backwash, the filter media is expanded and fluidized. In this state the vertical velocity of the water is approximately equal to the settling velocity of the media and causes the media to be partially supported by water. This allows the smaller floc particles that have lower settling velocity to be washed and removed from the bed (Quasim et al, 2012). The backwash water flow rate of Greater Kegalle WTP is 50 $m^3$/h. But the recommended design value for backwashing with simultaneous air and low-rate water backwash followed by low-rate water backwash option is 15 – 18 $m^3/m^2$.h (Vigneswaran and Visvanathan, 1995).

- The sludge disposal system of the Greater Kegalle WTP is not functioning properly. This is due to the high amount of filter backwash water entering the sludge thickener. The sludge thickener is overflowing and the sludge drying beds are not adequate to handle the volume of both filtration and sedimentation sludge.

- It is extremely important to monitor and identify continuously water quality of water treatment process. Thus, monitoring equipment requires to properly maintain for measuring exact value of pH, turbidity and color of water at all time. There is no online monitoring system at Greater Kegalle WTP and this reduces the safety of produced water.

## 4. Aspects of water services management in general posing most difficulty at the moment

- The high percentage of Non-Revenue Water (NRW) is the main issue regarding water services management. The percentage of NRW is 30% as per the Monthly Operations Report of Kegalle WSS.

  This is mainly due to:

  + Frequent breakdowns in the PVC pipes laid in rock areas without placing suitable pipe surrounding and bedding materials.

  + Overflowing of storage reservoirs: There are four storage reservoirs namely Kankeriya, Hettimulla, Adurapotha and Mirihalla with capacities 650, 1000, 450 and 1800 $m^3$ respectively. Only Adurapotha reservoir is overflowing in the night sometimes because it is at the lowest elevation and % of loss of treated water is 1.5 % of treated water per month.

- The water quality is degraded during distribution by several causes such as infiltration of polluted ground water and improperly maintained storage facilities.

## 5. Measures now being taken to cope with 3) and 4)

- It is planned to fix a control valve to the backwash pumping line and introduce filter nozzles to the underdrain system to stop losing the filter and to rehabilitate the sludge disposal system. The existing sludge thickener will be converted as backwash recovery tank and new backwash recirculation tank, sludge regulation tank and a sludge thickener will be constructed. The proposed system is shown in Figure 9.

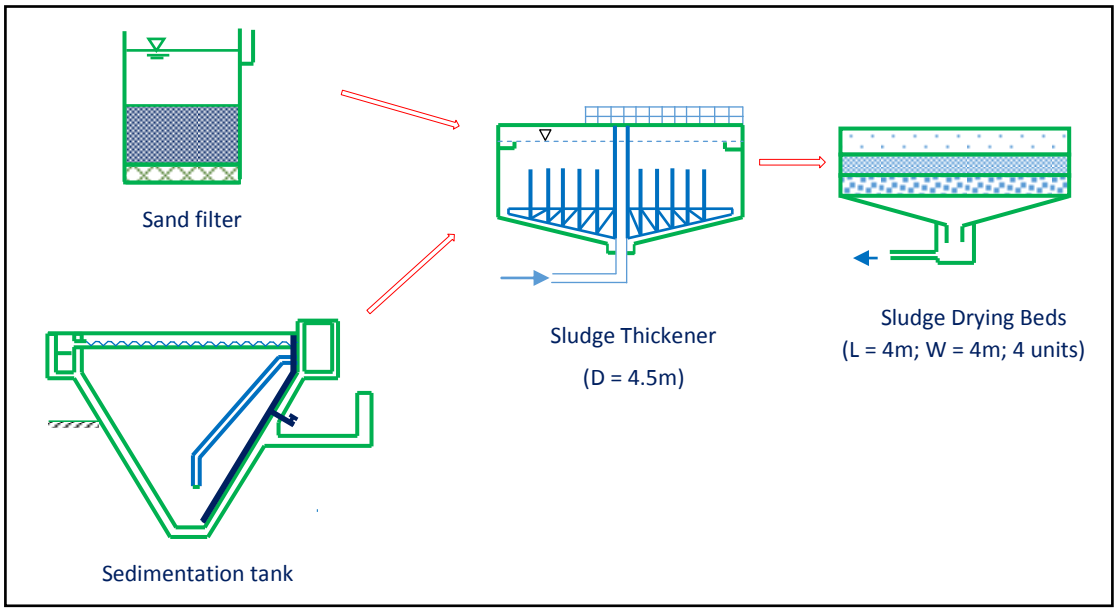



**Figure 9 Proposed Sludge Disposal System**

**6. Recent investments made for the plant's improvement**

- No investment for improvement has been made after commissioning.

**7. Technologies, facilities or other types of assistance needed to better cope with operational and management difficulties in 3) and 4)**

- Online pH, turbidity and color measuring system.

**8. Customer's opinion on water quality and water services in general**

- Customers complain about poor quality water during rainy season.

**9. Advanced technology used in this water treatment plant or any points to improve the process, water quality and capacity**

- Advanced technology: none
- Laboratory facility is equipped to measure simple parameters only (pH, Turbidity, Jar-test, Alkalinity etc.)

**10. Other Highlights**

- Chemical usage: Alum, lime and gas chlorine. Alum and lime is fed using a constant flow gravity feeding arrangement
- Average water tariff: Domestic – 0.2 USD/$m^3$, Commercial – 0.64 USD/$m^3$

## 11. Water quality data

Raw water and treated water quality of Greater Kegalle WTP is presented in following table. Treated water quality parameters complies the Sri Lanka standard for drinking water SLS 614:1983.

**Table 2 Raw water and treated water quality (NWSDB, 2015)**

| Parameter | Unit | Raw water (2014) | | Treated water (2014) | | SLS 614:1983 |
|---|---|---|---|---|---|---|
| | | Maximum | Minimum | Maximum | Minimum | |
| **pH** | - | 7.2 | 6.8 | 7.1 | 6.7 | 6.5-9.0 |
| **Turbidity** | NTU | 1000 | 4.5 | 1.2 | 0.2 | 2 |
| **EC** | mS/cm | 103 | 49 | 106 | 52 | 0.75 |
| **Total hardness** | mg/L | 22 | 8 | 25 | 8 | 250 |
| **Total alkalinity** | mg/L | 18 | 7 | 20 | 10 | 200 |
| **Iron** | mg/L | <0.1 | <0.1 | <0.1 | <0.1 | 0.3 |
| **Ca** | mg/L | 20 | 6 | 20 | 5 | 100 |
| **Cl** | mg/L | <0.2 | <0.2 | <0.2 | <0.2 | 200 |
| **$N\text{-}NO_3$** | mg/L | <0.2 | <0.2 | <0.2 | <0.2 | 10 |
| **$N\text{-}NO_2$** | mg/L | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 |
| **Mn** | mg/L | <0.01 | <0.01 | <0.01 | <0.01 | 0.03 |

## 12. References

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