Kelani Right Bank Water Treatment Plant

Sri Lanka

1. Background Information about the Water Treatment Plant

Kelani Right Bank (Biyagama) water treatment plant (BWTP) commenced its construction on 22 October, 2008. BWTP was planned with the intention of providing safe drinking water to towns in the Northern part of the Western Province in Sri Lanka, namely Biyagama, Kelaniya, Kiribathgoda, Kadawatha, Ragama, Wattala, Kandana, Ja-Ela, Seeduwa and Ganemulla. The initial capacity of BWTP is 180,000 m^3/d (phase 1) and the full design capacity (phase 2) is 360,000 m^3/d. Water is extracted from Kelani River.

Almost 95% of raw water is converted into clean water. The maximum water loss is about 5 % of the total amount of water intake. This loss is due to raw water transmission, sludge dewatering and backwash. **Figure 1** shows the view of BWTP.

Figure 1 Biyagama Water Treatment Plant

After completion of all construction works, the BWTP was officially commissioned on 23 July, 2013. Approximately 1 million population is benefitted by this water treatment plant. BWTP is the first water treatment plant in Sri Lanka that was awarded ISO 9001:2008 quality management certification for the water treatment process. **Table 1** presents the overall information of BWTP.

Table 1 Overall Information of Biyagama Water Treatment Plant

Type of source	Surface water
Name of the source	Kelani River
Year of construction	2008
Year of commissioning	2013
Design capacity (m^3/d)	360,000
Present production (m^3/d)	175,000
Treated water quality standard	SLS 614:2013
Number of connections	164,617
Number of consumers	1 million
Distribution length (km)	2357
Climate	Tropical climate
Automation	Supervisory Control and Data Acquisition

2. Water Treatment Process

The BWTP was designed at the conventional water treatment process (physic-chemical process) (**Figure 2**). The major processes are as follows:

- Raw water extraction (Kelani river) → Raw water pumping → Screening → Mixing chamber → Flocculator and Lamella clarifier → San filter → Clean water tank → Distribution network.

- Sludge generated from sedimentation and backwashing is thickened by sludge thickener. After that, sludge decanter reduces the water content and produce the sludge cake.

The quantity and capacity of each treatment unit is presented in **Table 2**

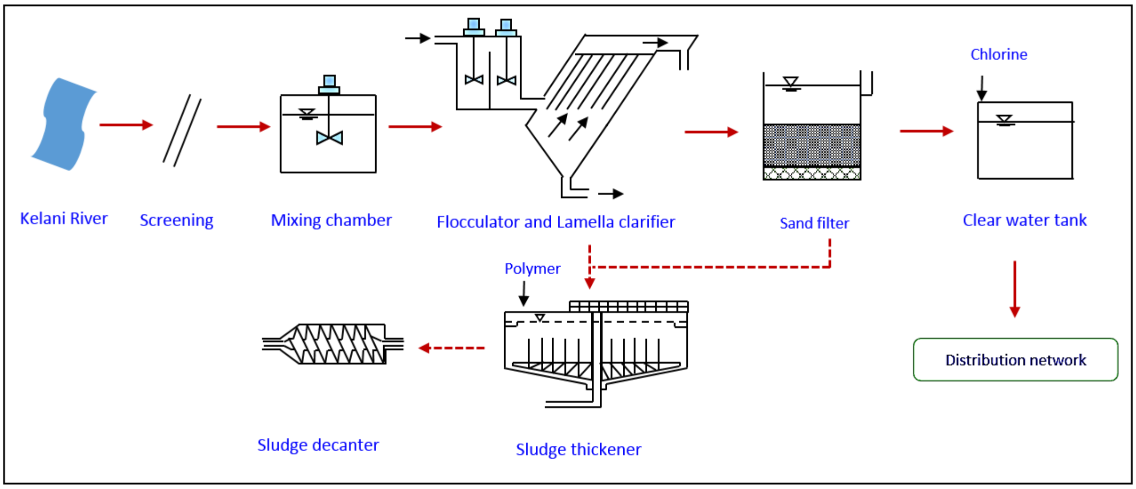

Figure 2 Water Treatment Process at BWTP

Table 2 Quantity and Design Capacity of Different Treatment Units

Unit	Design capacity		
	Quantity	Nominal flow (m^3/d)	Maximum flow (m^3/d)
Intake structure (stage 1 and 2)	2	381,800	381,800
Raw Water Regulation Tank	1	187,300	187,300
Mixing Chamber	1	187,300	187,300
Flocculator /clarifier	6	31,200	37,500
Filter	8	23,400	26,800
Clear water /contact tank	1	181,800	187,300

2.1 Chemical Addition and Rapid Mixing

Lime ($Ca(OH)_2$) is added to adjust the pH in water. pH before and after adjusting are 6.2-6.5 and 6.5-6.7 respectively. Alum (Al_2SO_4) is used as the coagulant. Alum and Lime are being delivered by dosing pumps from the alum saturation tank and the lime preparation tank as per the recommended dose rate. **Table 3** presents amount of chemicals used per day. The appearance of the mixing chamber is shown in **Figure 3.**

Figure 3 Mixing Chamber

Table 3 Amount of Chemicals Used per Day (June, 2015)

Description	Total (kg/month)	Daily Rate (kg/d)
Alum	51,500	1661.3
Pre-Lime	2,054	66.3
Post-Lime	45,176	1457.3
Pre-Chlorine (kg/h)	4,320	139.4
Post-Chlorine (kg/h)	7,200	232.3
Polymer (sludge thickener)	9.2	0.3
Polymer (sludge decanter)	79.3	2.6

2.2 Flocculation and Clarification

At this treatment plant, a double stage flocculator (propeller type) was designed and constructed. The first and second stage flocculator are driven by variable speed motors. The hydraulic retention time in floculator is 27 minutes. Lamella clarifier (a series of inclined-plate was installed on the surface) was instructed to remove flocs from the effluent of flocullator. With a smaller footprint, lamella clarifier provide a better and effective sedimentation in comparison with conventional sedimentation methods. Sludge settled at lamella clarifiers is collected at the hoppers. Desludging is achieved hydraulically by pipes installed at the sludge hoppers. **Figure 4** shows the appearance of the flocculation tank and lamella clarifier.

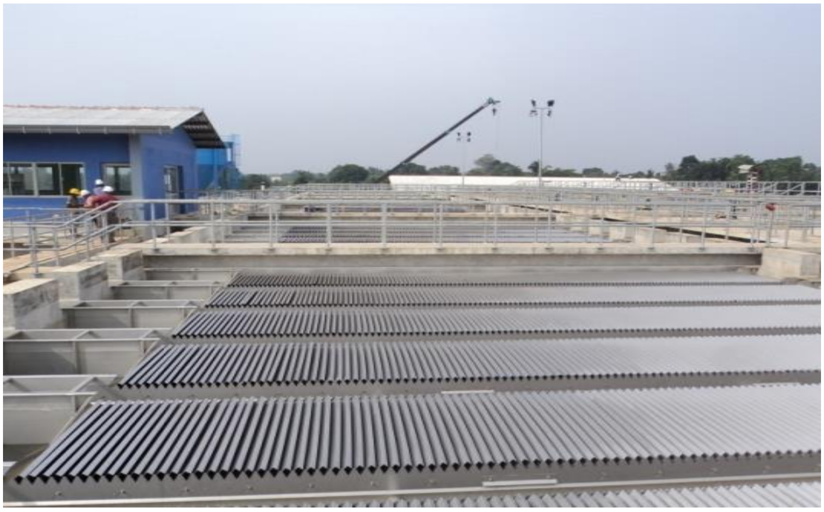

Figure 4 Flocculation Tank and Clarifier

The rotational speeds of two drives in floculators are 30 rpm and 20 rpm respectively. The up-flow velocity in lamella clarifiers is 0.005 m/s with the amount of sludge removed from clarifiers of 1,614 m^3/d. The inclined plates are made from stainless steel. Complete cleaning procedure of lamella clarifiers is conducted after the turbidity of settled water exceeds 12 NTU. Temporary day to day surface cleaning is carried out.

2.3 Filtration

There are 8 rapid sand filters (double-bed media) (**Figure 5**). The top layer is fine sand (effective size of 0.9 – 1.0 mm, uniformity coefficient of 1.7 and the depth of 900 mm), and the bottom layer is gravel with the effective size of 4.0 – 8.0 mm and the depth of 100 mm. The operating cycle of filtration tank is 48 h. There are 3 different steps in filter cycle. The first is "in-service" (filter is online and filtering the clarified water with filter inlet penstocks and outlet valve in opened position). The second is backwash and the last operation type is "out of service" (filter is offline, filter inlet penstock and outlet valve in closed position). The treated water has the turbidity of 0.5 NTU. Every 48 h or when the head exceeds 1.89 m, the filters are stopped and conducted the backwash step. The backwash process consumes 260 m^3 of treated water per time (approximately 0.15%)

Figure 5 Filters

2.4 Disinfection

Chlorine is used for disinfection (post-chlorination). Chlorine would provide a residual amount of treated water through the distribution system to prohibit the contamination of pathogens into water. It helps to prevent the waterborne diseases (i.e. cholera, typhoid). From the chlorine building (**Figure 6**), liquid chlorine is injected to the water by a vacuum pump. The concentration of residual chlorine in the distribution system is maintained in the range from 0.7 to 0.9 mg/L. Every day, BWTP consumes 384 kg of chlorine.

Figure 6 Chlorine Storage Building

2.5 Sludge Disposal

Sludge produced from the clarifier and filtration backwash is collected in the sludge balancing tank. At sludge thickener, polymer is added to form the flocs of sludge by increasing the possibility of sludge capture. Residues of water treatment process are removed in solid form. Sludge treatment unit consists of 2 units of wash water recovery tanks, 1 unit of sludge balancing tank, 1 unit of sludge thickener tank, 1 unit thickened sludge tank, 2 units of sludge decanter, 2 units of 5 tons diesel truck for sludge collection. Amount of polymer used per m^3 of sludge is 70 g. Operating time per batch of decanter is 2 days (**Figure 7**). The dried sludge is disposed at the landfill.

Figure 7 Sludge Treatment Unit

Polymer used in the sludge treatment process at BWTP is polyacrylamide (anionic polymer) . It is independent to pH changes and support the formation of large flocs, helps to reduce the sludge volume. The negative zeta potential reacts against with the positively charged suspension (depends on the anionic degree).

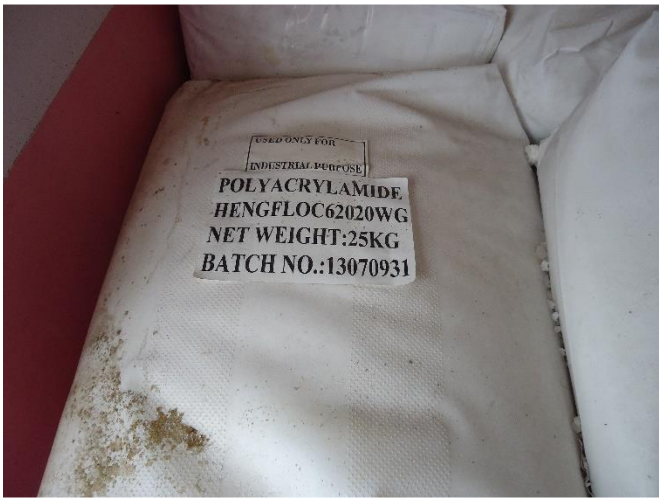

Figure 8 Polymer Used at BWTP

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

The heavy oil contamination from the Pattivila Canal will cause the failure of water treatment process. Three most possible effluent discharge sources to the surface water in Pattivila area are the Sapugaskanda oil refinery, Sapugaskanda diesel power plant and gas filling industries. The high concentration of oil exceeds the standard SLS 722:1985 as raw water for public water supplies (0.1 mg/L).

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

- It is hard to maintain a buffer stock of water treatment chemicals.
- Determination of heavy metals and organic chemicals are difficult due to lack of facilities in the laboratory.
- It is difficult to maintain an online analyser system due to inefficiency of supplying spare parts and poor attendance of the authorized dealers for required repairs.
- During the dry season, it is hard to operate Trible pumping due to less height of river level
- Salt intrusions during the dry seasons.

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

- Sand-bag barrier is implemented to avoid the salinity intrusion during the dry season. It is planned to award a contract to implement the second phase of permanent salinity barrier for increase river level at dry season and prevent the salinity intrusions

- Propose to divert the Pattivila Canal, which is contaminated with oil and grease to downstream of the intake

6. Recent investment made for the plant's improvement

- The filtered water channel had been increased
- Constructing a floating wetland on the upstream of the Pattivila Canal to reduce oil contamination
- Some water quality parameters are checked by outside laboratories

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

- Activated carbon feeder facilities should be implemented to treat the oil and colour when necessary

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

- Improving the water quality by flushing the distribution system in specific intervals to avoid the transmitting of sediment to consumers

- Controlling pollution in the Kelani river due to factory discharges and improve the raw water quality

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

- High technology instrument should be introduced for analyzing water quality parameters

- Introducing the activated carbon filters or activated carbon granules for minimizing colour effects and organic contaminations

10. Other Highlights

According to the past water quality data, raw water quality of the intake well in Biyagama Water Treatment plant confirmed the SLS requirements (SLS 722:1985). Some main water parameters such as: colour, turbidity, iron, manganese, oil and grease of raw water were rapidly varying with the rainfall variation. However, the treated water quality is achieved through the treatment process without any failure. **Table 4 and 5** below illustrates the raw and treated water quality results.

Table 4 Raw Water Quality (2014)

Parameter	Unit	Past water quality data	SLS 722:1985
Color	Pt-Co	110	-
Turbidity	NTU	20	-
Iron	mg/L	0.4	-
Manganese	mg/L	0.02	-
Oil and grease	mg/L	0.6	0.1

Recent modifications to the water treatment plant was not required as the treatment plant is operating within the design capacity.

Table 5 Treated Water Quality

Parameter	Unit	Treated water	SLS 614:2013
Turbidity	NTU	0.5	2
Total Aluminium	mg/L	0.05	0.2
pH		7.1	6.5-8.5
Iron (as Fe)	mg/L	0.03	0.3
Manganese (as Mn)	mg/L	0.008	0.1
Total hardness	mg/L $CaCO_3$	25	250
Conductivity	µS/cm	88.3	-
Chloride	mg/L	10.4	250
Fluoride	mg/L	0.1	1

Treated water quality is under the standard level of drinking water requirement (SLS 614:2013).

11. References

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Disclaimer:

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