NewTap
Network on Water Technology in Asia and Pacific

Sukhothai Water Treatment Plant
Sukhothai, Thailand

1. Background information

Sukhothai province is located in the valley of the Yom River on the lower edge of the northern region, 427 km from north of Bangkok. Sukhothai water treatment plant (SWTP) is owned and operated by Provincial Waterworks Authority (PWA) of Thailand, a state-owned company established in 1979. This water treatment plant is one of the 69 water treatment plants under PWA. It was constructed in 1995 with the capacity of 13,920 m^3/d.

Table 1 Overall information of Sukhothai water treatment plant

Constructed Year	1995
Water Source	Yom River and Tung Tale Luang Lake
Number of connections	11,723
Peak Operating Flow (m^3/h)	742
Design capacity (m^3/h)	580
No. of operators working at the plant	4
Treated water standard	Royal Thai Government Gazette (1978)
Automation	No
Date of access of the source information	2015
Reference	Ratchanet (2013)

In 2014, the SWTP supplied 11,832 m^3/d of tap water to 11,723 residents of Sukhothai province. The SWTP has two sources of raw water, Yom River during the rainy season, and in the dry season water is taken from Tung Tale Luang Lake. A new water treatment plant was additionally constructed on the existing treatment plant site for meeting water demand in future.

2. Water treatment process flow

The major water treatment unit processes are presented as below (**Figure 1**):

- Raw water extraction (river & lake) →Raw water pumping → Pipe-line static mixing (alum) and hydraulic jump (pre-chlorine) → Flocculation (mechanical mixing & baffled channel type) → Sedimentation (rectangular, tube settler) → Rapid sand filters → Disinfection (chlorine) → Clear Well → High lift pump building

- Sludge treatment: slugged generated from sedimentation and backwashing is disposed to Yom River without any treatment

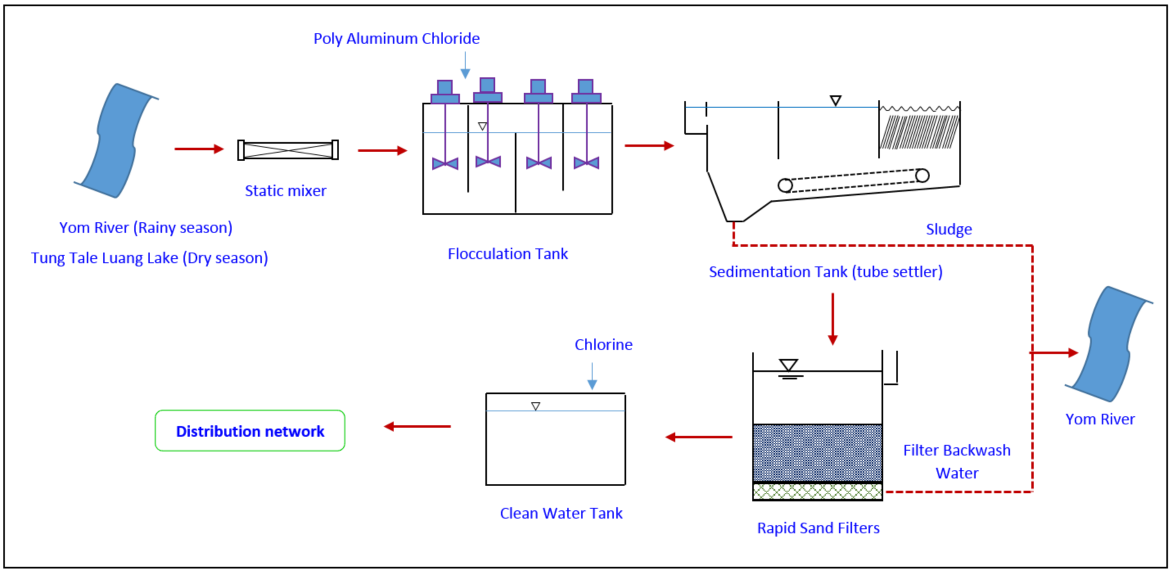

Figure 1 Water Treatment Process

2.1 Chemicals used

Two kinds of chemicals are mainly used for water treatment, powder PAC as a coagulant and liquid chlorine for pre-and-post chlorination. Powder poly aluminum chloride (PAC) is firstly dissolved in water in the solution tank (**Figure 2**). Then, it is transferred to the alum storage tank to inject into the static mixer. Chlorine used is a liquid chlorine form, in a 100 kg container (**Figure 3**).

Figure 2 Alum Solution Tank

Figure 3 Chlorine Container

2.2 Static mixing

Alum is injected into a static mixer which is installed as a part of the inflow pipeline (**Figure 4**), and chlorine is injected for pre-chlorination before the flocculation basin (**Figure 5**). The main purpose of pre-chlorination is to prevent algae growth in flocculation and sedimentation basins.

Figure 4 Static Mixer (Alum) **Figure 5 Pre-chlorination**

2.3 Flocculation

There are two kinds of flocculation, mechanical flocculator and hydraulic mixing. Three out of total four basins have installed mechanical mixers as 3 stages (2 mixers per stage, 3 stages per basin). But these mixers are not in operation now due to its higher energy consumption. The fourth basin uses a very simple hydraulic mixing. The hydraulic retention time of water in flocculation tank is 17 minutes.

Figure 6 Mechanical Mixing (3 basins) **Figure 7 Hydraulic Mixing (1 basin)**

2.4 Sedimentation

Sedimentation tank at Sukothai WTP is designed with the rectangular type (with tube settler installed). The surface loading rate is the primary parameter to design the sedimentation basin and typical surface loading rate is in the range from 20 to 60 m^3/m^2.d (0.8 to 2.5 m^3/m^2.h). However, if the surface area of the sedimentation tank is covered by the settler module, the maximum surface loading rate should be limited 7.5 to 8.8 m^3/m^2.h (Kawamura, 2000). The surface loading rate of sedimentation tank at Sukhothai WTP is 6.5 m^3/m^2.h. It is satisfied the suggested guideline. Sedimentation tank has been cleaned manually once every three months and sludge produced is discharged to the Yom River. According to the guideline for water treatment plant design (AWWA, 1999), sedimentation tank with manual cleaning should have the hydraulic detention time of 4 h. However, the detention time of the sedimentation tank at Sukhothai WTP is 1.3 h. Effluent water quality of sedimentation is not in good condition (cannot see the tube settler by a naked eye due to high turbidity).

Figure 8 Sedimentation Tank (4 basins)

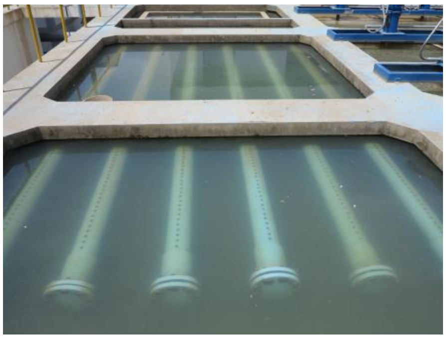

Figure 9 Effluent Part of Sedimentation Tank

2.5 Filtration

The media utilized in rapid filters is fine sand with the effective size of 0.7 mm, with a uniform coefficient of 1.4 and filter depth of 63 cm (according to AWWA (1999), the depth of filter media is about 70 cm). Backwash process uses an elevated tank filled by pumping water from clear well. Backwash process is carried out by control of manual valve. The average filter run time is 1 to 2 days.

Figure 10 Filter Tank (7 basins)

Figure 11 Elevated Tank for Backwashing (120 m^3)

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

- The Sukhothai treatment plant uses fold type process (**Figure 12**), not the straight type. Compared to general treatment process type, it looks like a very compacted design. However, unlike the straight type, the inlet water during the treatment process does not naturally flowing because it is rotates at 180 degrees in the sedimentation tank. Due to the short length of sedimentation basin, even though the tube settler was installed in the basin to reduce the surface loading, the operation and management of tube settler are difficult. Consequently, more the sedimentation basin is cleaned manually only once every three months.

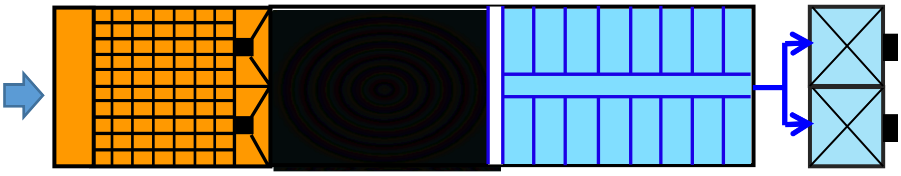

Figure 12 General Water Treatment Process Type (straight type)

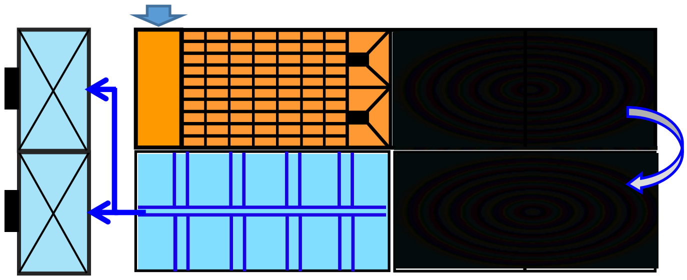

Figure 13 Sukhothai Water Treatment Process Type (fold type)

- Most modern treatment plants provide approximately 20 minutes of flocculation time (at 20 °C) under maximum plant flows, and some references recommend the flocculation time of 30 min or longer (AWWA, 1999). The Sukhothai treatment plant has only 17 minutes of hydraulic detention time in flocculation basin. Besides, mechanical mixers in the flocculation tank are not being operated now to reduce energy consumption. Thus, the size of flocs observed in flocculation basin is very small.

Figure 14 Mechanical flocculator (not operating)

- Effluent water quality in sedimentation basin is also not in good condition (high turbidity). Surface of sedimentation observed much scum with very fine flocs (**Figure 15**). The main reason assumed here is that the pretreatment is not optimized. According to Kawamura (2000), plant operators have two methods for optimizing pretreatment. The first involves the coagulant, the determination of the optimum dosage by jar-test. The second concerns the mixing energy level and mixing time. The Sukhothai treatment plant is suggested to check whether pretreatment is appropriate or not.

Figure 15 Scum in Sedimentation Basin

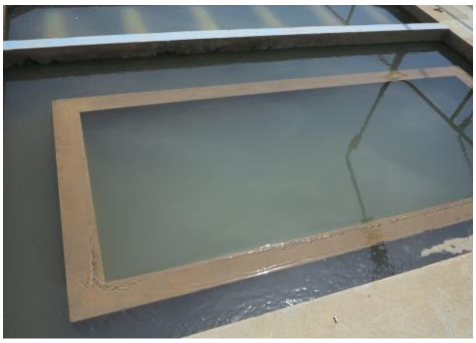

Figure 16 High Turbidity of Effluent Part

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

- Water source is not enough for whole year. Water level in Yom River is greatly redcued in dry season. Thus, the Sukhothai treatment plant has to switch to Tung Tale Luang Lake, 3 km away from the treatment plant for water during dry season.

- Current water capacity is not enough to meet water demand. Peak operation flow (m^3/h) sometimes exceeds the designed flow (around 1.3 times), causing difficulties for managing water quality. Continuous supply of tap water is an issue when the sedimentation basin and clear well are cleaned periodically. The reason is that clear well and storage capacity are not enough.

- Most conventional coagulant plants produce two major residuals (waste), from the sedimentation basin and from backwashing a filter. The quantity of sludge generated from water treatment plants depends on the raw water quality, dosage of chemicals used, the performance of the treatment process, method of sludge removal, efficiency of sedimentation, and backwash frequency. However, the Sukhothai treatment plant does not have any sludge disposal facility. Now solid waste, generated from sedimentation basin and backwashing of the filter is discharged directly to Yom River. This direct disposal of sludge could potentially cause aluminum toxicity from alum coagulant wastes, affecting the aquatic environment in Yom River.

- Generally treatment plant site should consider future plant expansion as well as construction cost, accessibility, site maintenance cost, and operator safety (Kawamura, 2000). The Sukhothai treatment plant has a narrow area, especially sedimentation basin is very small sized (installed tube settler). It is expected to have some difficulties in case of O&M of WTP and future installation and expansion of new facilities.

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

- PWA is constructing a new treatment plant next to the existing treatment plant for increasing water supply **(Figure 17).** This new treatment plant is composed of general treatment process (straight type), unlike the existing treatment process (fold type). It is expected to increase capacity of water production after the construction of new water treatment plant. However, other main issues remain unchanged, such as lack of water source, water quality management, sludge disposal, and narrow space.

Figure 17 New Treatment Plant under Construction

6. Recent investment made for the plant's improvement

- Four sedimentation basins installed tube settlers to decrease surface loading because of the small sedimentation area (**Figure 19**). However, sedimentation basin is not in good condition (high turbidity, scum) at present.

Figure 18 Tube Settler Type Installed in Sedimentation Basin

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

- First, intake facilities need to be introduced with continuous water quality monitoring devices for real-time monitoring of rapidly changing raw water quality in Yom River and Tung Tale Luang Lake. Especially, turbidity meter is required to inject optimum coagulant dosage through quick response to the change of raw water quality.

- Second, rapid mixing is required for strong energy level for completely mixing water and chemical under a limited time. It is hard to meet this mixing from the existing static mixing method. Thus, high efficient mixer, non-power static mixer needs to be introduced for pretreatment optimization.

- Third, regardless of the type of flocculator, tapered mixing across the flocculation tank is always an important consideration. The Sukhothai treatment plant is required to improve the current flocculation system to promote the growth of floc size.

- Fourth, sludge dewatering process needs to be introduced in future. It is recommended to natural dewatering processes such as sand drying beds or solar drying beds. These processes are less complex, are easier to operate, and require less energy to operate than mechanical systems, although they require a large land area and labor-intensive.

- Fifth, current filtration process consists of fine sand (with the media depth of 63 cm) and water wash with surface washing. To increase the filter run time, use of coarse sand or dual media type is recommended. In addition, water wash with air scour is also needed to reduce water consumption compared to existing water wash with surface washing. In fact, the current backwash system is often affected to a capacity of elevated tank because it takes too many hours to refill the elevated tank after backwashing.

- Lastly, PWA needs to establish a low turbidity goal than PWA water quality standard (of 5 NTU) for improving water quality. For example, sedimentation effluent turbidity should not exceed 5 NTU, and the filtered water turbidity should be less than 1 NTU.

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

- Customers want provision of better water service with enough water supply of better quality throughout the day. Distribution system in PWA 10 regional office consists of complicated and long supply line (small size). The current leakage rate is as high as 26 percent. In addition, some new residents want tap water from Sukhothai treatment plant, but they are required to lay a new pipeline, which is a time consuming administrative process.

- According to the complaint data of Suhkothai treatment plant (**Table 2**), higher number of complaints are recorded about the quantity of water supplied (67%), water quality (13%), and overall service of the SWTP (10 %).

Table 2 Complains of Sukhothai Water Treatment Plant (between 2013 and 2014)

Complains	Water quantity	Water quality	Service	New connection	Others
Number	20	4	3	1	2
Percentage	66.7	13.3	10.0	3.0	6.0

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

The Sukhothai treatment plant constructed 20 years ago, and has conventional treatment process. However, tube settler was introduced to increase the surface area of sedimentation due to small area basin.

10. Other Highlights

- Treatment plant is operated by four operators, 8 hours 4 shift system
- Two kinds of chemicals are usually used, alum and chlorine. Alkaline chemical (lime) is not used in the treatment process because alkalinity concentration is very high (around 170 mg/L)
- Alum and chlorine provided to each treatment plant by lump-sum purchasing system from PWA headquarter. Thus, most treatment plants have to use the same kind of chemicals, not considering characteristics of raw water quality
- Laboratory facility is equipped to measure simple parameters only (pH, turbidity, jar-test, residual chlorine, etc.)
- PWA differentiates the color of different valves to prevent the confusion for operators during the operational process **(Figure 19)**
- Each sampling lines are prepared in a laboratory room for sampling conveniently at any time **(Figure 20)**

Figure 19 Identification of valve color

Figure 20 Sampling points in laboratory room

11. Water quality data

This data of water quality obtained is an average value of three times measurement. All measured parameters are under Thailand national standard for drinking water.

Table 3 Water quality data (Ratchanet, 2013; PWA, 2014)

Parameters	Unit	Raw water (2013)		Treated water (2014)		Standard (Thailand)
		Min	Max	Min	Max	
pH	-	8.1	8.2	7.6	8.5	6.5-8.5
Turbidity	NTU	9.2	22.3	0.71	5.0	5
Conductivity	µs/cm	326	349	218	446	-
Total hardness	mg/L	122	168	76	148	-
NO_3-N	mg/L	0.005	0.592	0.15	0.56	45
Iron	mg/L	1.00	1.18	0.03	0.28	0.5
Manganese	mg/L	0.30	0.42	0.01	0.10	0.3
Copper	mg/L	0.01	0.05	0.02	0.04	1.0
Zinc	mg/L	0.02	0.04	0.02	0.09	5.0
Chloride	mg/L	3	8	6	25	250

12. References

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