Government Center Water Treatment Plant
Kamphaeng Phet Province, Thailand

1. Background information

Kamphaeng Phet is a province in the lower north of Thailand. The Ping River (main tributary of the Chao Phraya River) is located at the east of the province, while the west part is mostly mountains covered with forests. Government Center Water Treatment Plant (GCWTP) is owned and operated by the Provincial Waterworks Authority (PWA) of Thailand, a state-owned company established in 1979. This water treatment plant is one of the 233 water treatment plants under PWA. The GCWTP was constructed in 2003 with the capacity of 12,000 m^3/d. Additional information is presented in **Table 1.**

Table 1 Overall Information of Government Center Water Treatment Plant

Constructed Year	2003
Water Source	Ping River
Number of connections	12,376
Peak operating flow (m^3/h)	603
Design capacity (m^3/d)	12,000
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 GCWTP supplied 11,419 m^3/d of tap water to 12,376 households in Kamphaeng Phet province. Water source, the Ping River, is at a distance of 4 km from the water treatment plant. Main components of the treatment process are hydraulic mixing, mechanical sludge collector system, fine sand filter, and water backwash with surface washing.

2. Water treatment process flow

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

- Raw water extraction (Ping river) → Raw water pumping → Pipeline static mixing (alum) and hydraulic jump (pre-chlorination) → Flocculation (baffled channel type) → Sedimentation (rectangular, mechanical sludge collector) → Rapid sand filter → Disinfection (post-chlorination) → Clear Well → High lift pump building

- Sludge treatment: sludge generated from sedimentation and backwashing is transferred to three ponds.

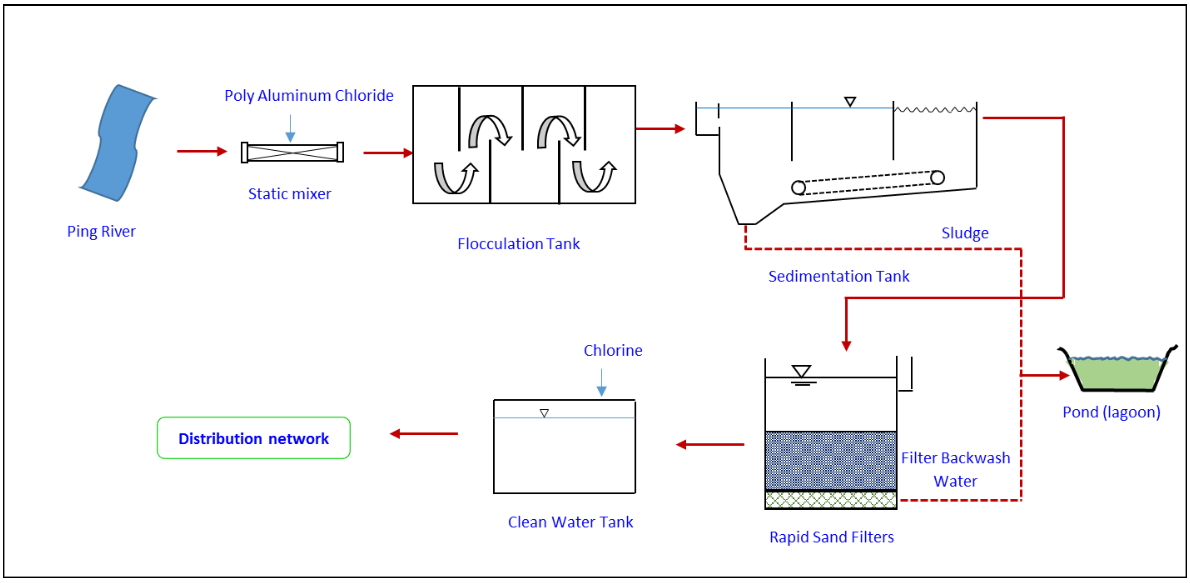


Figure 1 Water Treatment Process

2.1 Chemicals used

Powder poly aluminum chloride (PAC) and liquid chlorine are two main chemicals used at GCWTP. Powder PAC is used as a coagulant and liquid chlorine is for pre-and-post chlorination. Solid powder PAC is mixed and dissolved in water (5.05 %) in the solution tank (**Figure 2**) before transferring to the storage tank. From here, PAC solution is injected into the raw water through a static mixer (before the flocculation tank). The concentration of PAC in water at this point is 1 % (Ratchanet, 2013). Liquid chlorine is stored in a 100 kg container (**Figure 3**).

Figure 2 Alum Solution Tank

Figure 3 Chlorine Container

2.2 Static mixing

Figure 4 shows the image of static mixer that is installed as a part of the inflow pipeline, before the flocculation tank. Here, PAC and chlorine solutions are mixed properly with raw water. The growth of algae in the flocculation and sedimentation tanks is prevented by such pre-chlorination. Due to the high available alkalinity concentration in raw water (170 mg/L), lime is not used in the GCWTP.

Figure 4 Static Mixer (alum and chlorine)

2.3 Flocculation

There are 4 flocculation basins at GCWTP (**Figure 5**). Flocculation can be achieved by hydraulic methods or mechanical devices. Hydraulic methods are used most often in small plants, but they are simple and effective if flow is relatively constant. However, the disadvantage of hydraulic flocculator is that the velocity gradient (G) values are a function of flow that cannot be easily adjusted (AWWA, 2005). At GCWTP, the velocity gradient of water mixing in the flocculation tank is 42 s^{-1}. There are usually two kinds of baffle channel, horizontal baffled (around-the-end flow) and vertical baffled (over- and under flow) channels. The GCWTP is now using horizontal baffle channel type **(Figure 6)**. The hydraulic retention time of water in the flocculation tank is 36 minutes. This retention time is in the range of 30 to 40 minutes for baffle hydraulic mixing, according to Kawamura (2000).

Figure 5 Flocculation Tank (4 basins)

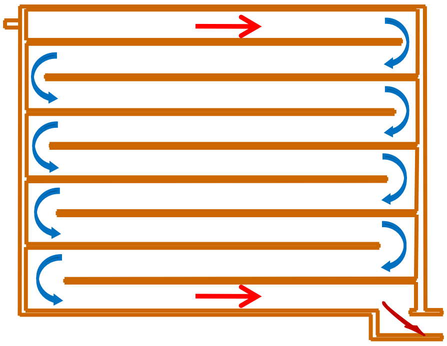


Figure 6 Horizontal Baffled Channel Type

2.4 Sedimentation

Sedimentation tank at GCWTP is designed with the rectangular type (**Figure 7**). The surface loading rate of sedimentation tank at the GCWTP is 1.8 m^3/m^2.h. Normally, the surface loading rate is in the range from 0.8 to 2.5 m^3/m^2.h. The settled sludge is collected by a mechanical sludge collector system **(Figure 8)** and drained to water pond (lagoon). The hydraulic retention time of conventional sedimentation basin is from 1.5 to 3.0 h (Kawamura, 2000). The hydraulic retention value of the GCWTP is 2.5 h.

Figure 7 Sedimentation Tank (4 basins)

Figure 8 Sludge Collector System

2.5 Filtration

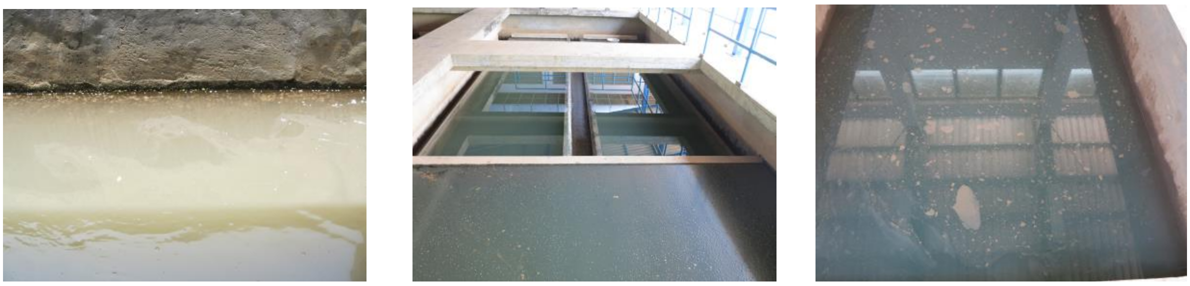
There are three typical configurations of filter media; conventional fine sand, dual media, and single sand media deep bed filters. The highest effective filter media are dual media and single sand media deep bed filters, because the conventional fine sand removes most of the particles in the top of the sand, not full bed depth. The media utilized in GCWTP is fine sand with the effective size of 0.74 mm, with a uniform coefficient of 1.4 and a filter depth of 50 cm. There are 10 filter tanks in total at GCWTP (**Figure 9**). According to AWWA (1999), the depth of filter media is suggested to be in the range of 60 to 70 cm. Thus, GCWTP needs to supplement another 20 cm of sand in filter basins. The average filter cycle is 2 days. The GCWTP clean the filter tank by combining surface wash with air scour, then water backwash. The water used for filter backwash is extracted from the clean water tank (treated water) and stored at an elevated tank **(Figure 10)**

Figure 9 Filter Tank (10 basins)

Figure 10 Elevated Tank for Backwashing (500 m^3)

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

At each treatment unit, water quality does not reach the condition as designed (**Figure 11**). Typically, flocs observed in the flocculation tank have very small size. The effluent water from the sedimentation tank has high turbidity. The above phenomena have strongly affected the downstream unit processes, such as filtration. The main reason assumed here is that the pre-treatment is not optimized; such as the determination of the optimum dosage by jar-test or the mixing energy level and mixing time. The GCWTP is suggested to check whether the pre-treatment step is proper or not.



a) Flocculation basin b) Sedimentation basin c) Surface water of filter basin

Figure 11 Water quality of each treatment process in GCWTP

The conventional WTP normally has two main sludge flows, from the sedimentation tank and from filter backwash. In GCWTP, there are three ponds (**Figure 12**) for storing the generated sludge. However, the settled sludge in these ponds is disposed within the plant area (**Figure 13**) instead of dumping site (landfill, ocean dump).

Figure 12 Water pond (lagoon)

Figure 13. Sludge disposal of treatment plant site

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

Currently, water demand in Kamphaeng Phet province is higher than the production capacity of the GCWTP. In 2014, the average amount of water produced was 11,419 m^3/d (reached 95 % of the design capacity).

The peak operation flow often exceeded the design flow (about 1.2 times). This operating condition would create difficulties for the plant management (both water quantity and quality). When the sedimentation tank and clean water tank are cleaned periodically, it is difficult to maintain the continuous water supply to consumers.

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

To satisfy the water demand, PWA plans to expand the plant's capacity from 500 to 700 m^3/h by rehabilitating the existing treatment process, not construct a new plant. There are several methods such as changing both filter media (fine sand → dual media) and underdrain system in filter basin, additional installment of pump for raw water and distribution, new construction of clear well or storage tank.

6. Recent investment made for the plant's improvement

In 2014, the GCWTP installed roof for sedimentation basins for preventing algae growth **(Figure 14)**. Although chlorine is injected through a static mixer for pre-chlorination, the pre-chlorination alone is not enough to prevent algae growth due to hot weather and strong sunlight all the year.


Figure 14 Roof at Sedimentation Tank

Most treatment plants under PWA clean the sedimentation tank manually with a regular cycle (per two or three months). The GCWTP has installed a mechanical sludge collector system to improve the treatment efficiency **(Figure 15 and 16)**. Submerged sludge collector operates on the simple principle of gravity and removes sludge by taking advantage of a differential head. Water pressure in the main tank forces the sludge through the header collector in the outlet piping, and away to the sludge removal through (Leopold, 2010). It is expected to improve water quality of sedimentation basin because raw water turbidity of the Ping River is higher than that of other rivers.

Figure 15 Mechanical Sludge Collector Motor

Figure 16 Sludge collector System (Leopold CT2 type)

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

Water quality monitoring devices (especially turbidity meter) are necessary for continuous monitoring of rapidly changing raw water quality in Ping River. It helps the chemical injection equipment (alum) to quickly adjust the chemical dosage.

There are two methods to control and optimize pre-treatment process. One is the optimum dosage of coagulant, determined by jar-test. Another method manages the mixing level and chemical contact time (Kawamura; 2000). Thus, the plant operators at GCWTP need to check whether optimizing pre-treatment is carried out or not.

The settled sludge in the lagoon should be disposed following an appropriate method, especially during rainy season. This sludge primarily has aluminum toxicity (from coagulation step). It would affect the surrounding environment if disposed inappropriately.

Regarding turbidity concern, PWA should set up stricter standard than the current requirement to improve the water quality and treatment process. For example, the turbidity of effluent from the sedimentation tank must not exceed 5 NTU, and the turbidity of filtered water must less than 1 NTU.

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

According to the complaints received by the GCWTP (**Table 2**), the percentage of complaints regarding the quantity of water supplied, leakage and other service are 59 %, 24 % and 18 % respectively.

Table 2 Complains of Government Center Water Treatment Plant (from 2013 to 2014)

Complaints	Water quantity	Water quality	Leakage	Service	Others
Number	10	-	4	1	2
Percentage	58.8	-	23.5	5.9	11.8

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

For post-chlorination, the GCWTP injects chlorine into the pipeline between filter basin and clear well through a static mixer. Also, at this injecting point, there is another pipeline for lime injection, to prevent corrosive water when the pH in treated water is low **(Figure 17)**. Now, it is not used because both pH and alkalinity are very high (pH 7.9 and alkalinity 103 mg/L).

Figure 17 Lime injection pipe

10. Other Highlights

- The treatment plant is operated and managed by 4 operators
- Two commonly used chemicals are alum and chlorine. Alkaline chemical (lime) is not used in treatment process because the alkalinity concentration is very high (around 103 mg/L)
- Alum and chlorine provided to each treatment plant by lump-sum purchasing system from PWA headquarter
- Ready recorder is located inside chemical room to quickly check the injection rate of chemicals **(Figure 18)**
- PWA differentiates the color of different valves to prevent any confusion by operators (**Figure 19**), such as, red color for surface washing line, blue color of backwash line, green color for the effluent water line

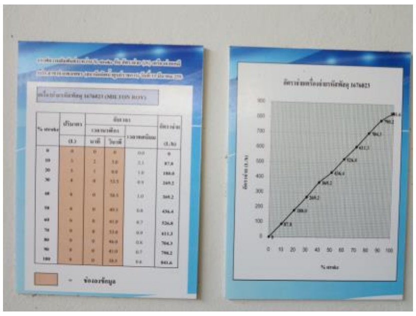


Figure 18 Ready Recoder of Alum Injection Pump **Figure 19 Identification of Pipe Line**

11. Water quality data

The quality of raw water and treated water are presented in **Table 3**. The treated water quality is well within the national standard for drinking water of Thailand.

Table 3 Raw Water and Treated Water Quality (Ratchanet, 2013; PWA, 2014)

Parameters	Unit	Raw water (2013)		Treated water (2014)		Standard (Thailand)
		Min	Max	Min	Max	
pH	-	8.1	8.2	7.5	8.1	6.5-8.5
Turbidity	NTU	9.2	22.3	0.46	1.0	5
Conductivity	µs/cm	326	349	187	243	-
Total hardness	mg/L	122	168	84	116	-
NO_3-N	mg/L	0.005	0.592	-	-	45
Iron	mg/L	1.00	1.18	0.02	0.15	0.5
Manganese	mg/L	0.30	0.42	0.01	0.07	0.3
Copper	mg/L	0.01	0.05	-	-	1.0
Zinc	mg/L	0.02	0.04	-	-	5.0
Chloride	mg/L	3	8	5	13	250

12. References

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