NewTap
Network on Water Technology in Asia and Pacific

Phichit Water Treatment Plant
Phichit Province, Thailand

1. Background information of the water treatment plant

Phichit Water Treatment Plant (PWTP) is situated in the Phichit Province which is located in the northern part of Thailand. PWTP 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 233 water treatment plants under PWA. PWTP has two treatment unit. 1st water treatment plant (1st WTP) has the capacity of 4,800 m^3/d and was built in 2001 and 2nd water treatment plant (2nd WTP) has the capacity of 9,600 m^3/d and was built in 2007.

Table 1 Overall information of Phichit water treatment plant

Constructed Year	2001/2007
Water Source	Nan River
Number of connections	14,388
Peak Operating Flow (m^3/h)	853
Design capacity (m^3/h)	600
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 Phichit water treatment plant supplied 12,262 m^3/d of tap water to 14,388 households of Phichit province. Water source for PWTP is Nan River which flows adjacent to water treatment plant. Main characteristics of treatment process are hydraulic mixing, mechanical sludge collector system, fine sand, 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 (Nan river) → Raw water pumping → Hydraulic mixing (alum) → Flocculation (baffled channel type) → Sedimentation (rectangular, mechanical sludge collection) → Rapid sand filters → Disinfection (chlorine) → Clear Well → High lift pump building

- Sludge treatment: Sludge generated from sedimentation and backwashing are drained to pond (lagoon)

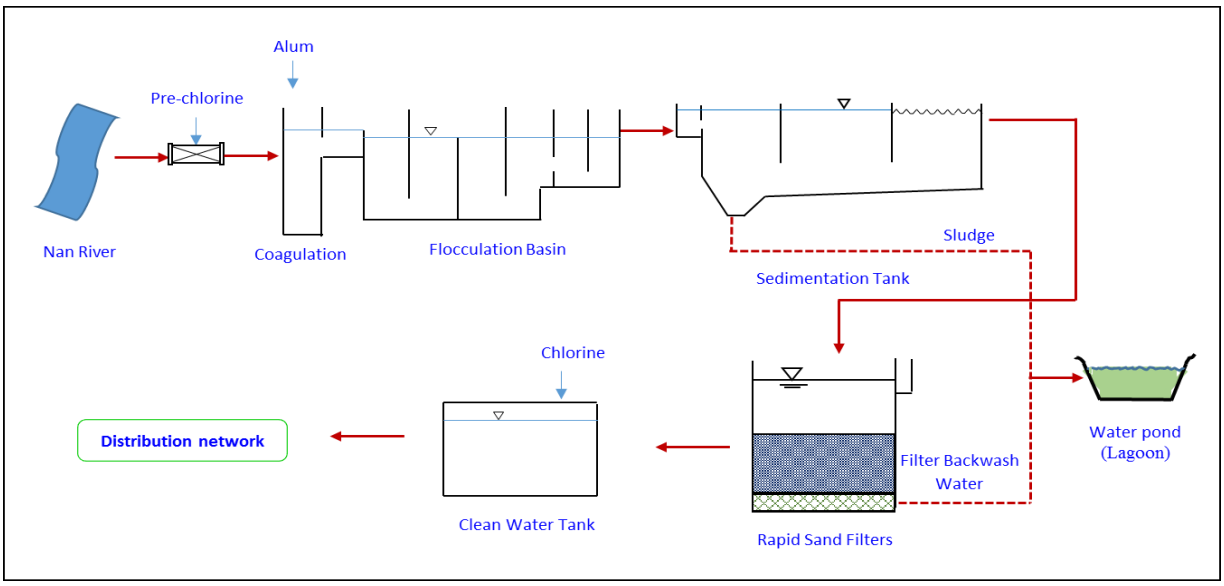


Figure 1 Water Treatment Process

2.1 Chemical used

Two kinds of chemical are mainly used for water treatment: powder poly aluminium chloride PAC (used as coagulant) and liquid chlorine (used for pre-and-post chlorination). Powder PAC is firstly dissolved in water in the solution tanks and then transferred to the storage tank **(Figure 2).** Chlorine is used in the form of liquid chlorine for pre and post chlorination, in a 100 kg container **(Figure 3).**

Figure 2 Alum Solution Tank (left) and storage tank (right)

Figure 3 Chlorine Container

2.2 Hydraulic mixing

Alum is injected in the receiving well (mixing basin) by hydraulic jump, and chlorine is injected through static mixer in inflow pipe-line **(Figure 4)** during the pre-chlorination. However, alum can also be injected by static mixing method in inflow pipe-line. The main purpose of pre-chlorination is to prevent algae growth in flocculation, sedimentation, and filter basins.

Figure 4 Hydraulic jump of alum (left) and static mixing of pre-chlorine (right)

2.3 Flocculation

Flocculation can be done either by hydraulic methods or by mechanical devices. PWTP utilizes hydraulic method for the flocculation. Hydraulic flocculation methods are simple and effective, especially if flow is relatively constant. The disadvantages of hydraulic flocculator is that G values (velocity gradient value) which is a function of flow cannot be easily adjusted (AWWA, 2005). There are usually two kinds of baffle channel types, the horizontally baffled (around-the-end flow) and the vertically baffled (over- and under flow) channels. PWTP consists of horizontal baffle channel type **(Figure 5, 6)**. The hydraulic retention time of water in flocculation tank is of 38 minutes.

Figure 5 Baffle channel type (4 basins)

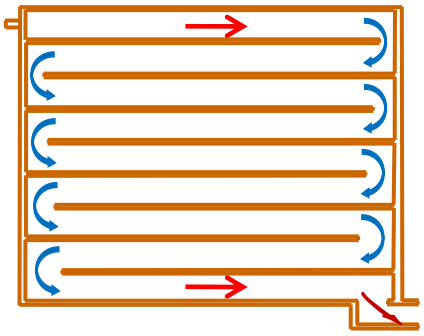


Figure 6 Horizontal baffled channel type (plan)

2.4 Sedimentation

Sedimentation tank at PWTP is designed to be rectangular in shape **(Figure 7**). The surface loading rate is the primary parameter to design the sedimentation basin and for the sedimentation tank at PWTP it is 1.9 $m^3/m^2 \cdot h$. Generally the typical surface loading rate lies in the range from 20 to 60 $m^3/m^2 \cdot d$ (0.8 to 2.5 $m^3/m^2 \cdot h$). Settled solids are collected by mechanical solid collector system and is drained to water pond (lagoon). It has a detention time of 2.1 hour. Detention time of conventional basins ranges from 1.5 to 3.0 hour (Kawamura, 2000).

Figure 7 1st WTP sedimentation basin (left) and 2nd WTP sedimentation basin (right)

Figure 8 mechanical sludge collector (2nd WTP sedimentation basin)

2.5 Filtration

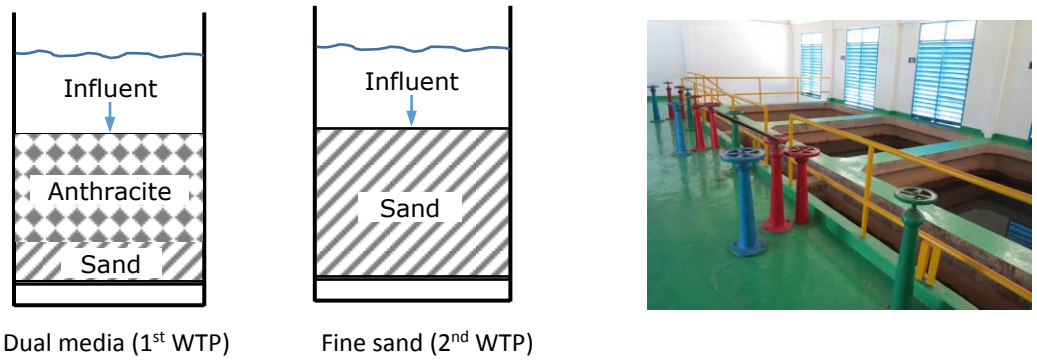
The media utilized in rapid filters is a fine sand with: the effective size of 0.65 mm, the uniform coefficient of 1.35 and filter depth of 70 cm. 2nd WTP is installed with dual media (Anthracite and sand). Backwash process utilizes elevated tank which is filled with pumped clean water and used for backwashing the filter. Average filter run time is of 3 days.

Figure 9 Filter Tank (10 basins)

Figure 10 Elevated tank for backwashing (250 m^3)

3. Explain, what aspects of treatment processes pose most difficulty in terms of daily operation

- PWTP applies two kinds of filter media: dual media (anthracite and sand) at 1st WTP and conventional fine sand at 2nd WTP **(Figure 9)**. However most of the anthracite is now disappearing because of rapid swelling. According to AWWA's reference book (2005), optimal expansion is suggested to be less than 20 percent. In fact, it is difficult to control constant expansion rate when filter is backwashed. Valves used in the 1st WTP are manually operated. Manual operation of valves poses risk when the valves are opened with random rate.



Dual media (1st WTP) Fine sand (2nd WTP)

Figure 11 Filter media (left) and manual handle valve of filter basin 1st WTP (right)

- Another main issue is bad flocculation in 1st WTP compared to 2nd WTP. Although there are two treatment plants, alum is injected at the receiving well of 2nd WTP. After the mixing of alum with water, some amount of mixture is conveyed to 1st WTP flocculation basin through pipeline (about the length of 30m). Floc of 1st stage WTP is of very small size, and effluent quality of sedimentation is not in good condition compared to 2nd stage WTP. It is assumed that small floc formed by rapid mixing is broken in conveyance process in 1st WTP.

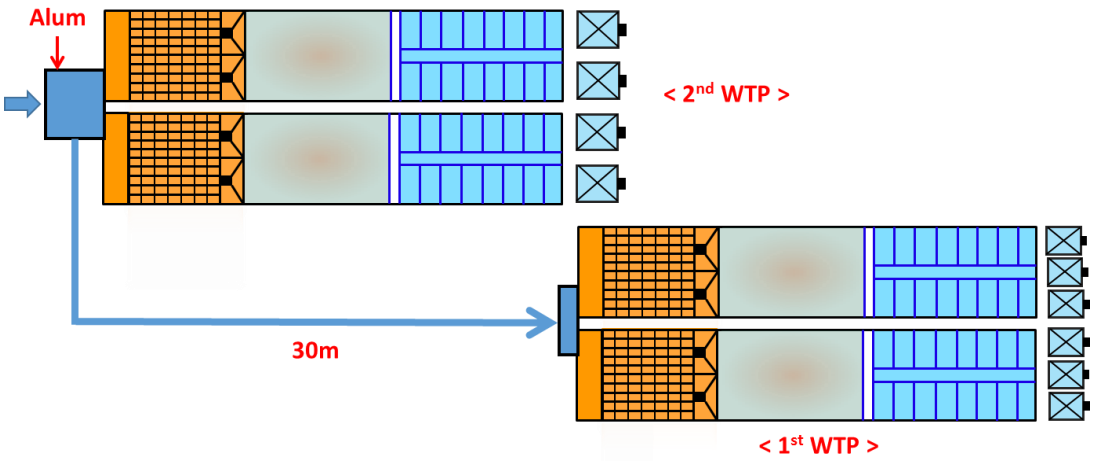


Figure 12 Layout of Phichit water treatment process

4. Explain, what aspects of water services management in general pose most difficulty at the moment

- Water quality of Nan River is greatly influenced by the seasonal changes. In dry season, as the water level lowers, water intake is performed using the floating pumps **(Figure 13)**. This results in higher energy consumption during the dry season when compared to the rainy season. In rainy season, the water intake hole can be varied according to the water level **(Figure 14)**. Therefore, operator should always pay attention to the change of water level.

Figure 13 Floating pumping

Figure 14 Variable intake hole

- Current water treatment capacity is not enough to meet the required water demand. Sometimes peak operation flow greatly exceeds the design flow (around 1.4 times), causing difficulties in water quality management. Especially it is difficult to continually supply water to consumers when sedimentation basin and clean well needs to be cleaned periodically. The capacity of clear well and storage capacity are not enough to meet the current demand.

5. Explain, what measures are now being taken to cope with 3) and 4)

- PWA has four treatment plants in Phichit province. Phichit WTP and Khok Salut WTP are two of the four WTP in Phichit province. Unlike Phichit WTP, Khok Salut WTP operates only 14 hours a day because of lower water demand. Thus, PWA has plans to connect a distribution network between Khok Salut WTP and Phichit WTP to increase the water supply rate in Phichit province **(Figure 15)**. It is also planned to operate the Khok Salut WTP continually without any intermittent operation for reducing the overproduction burden of PWTP.

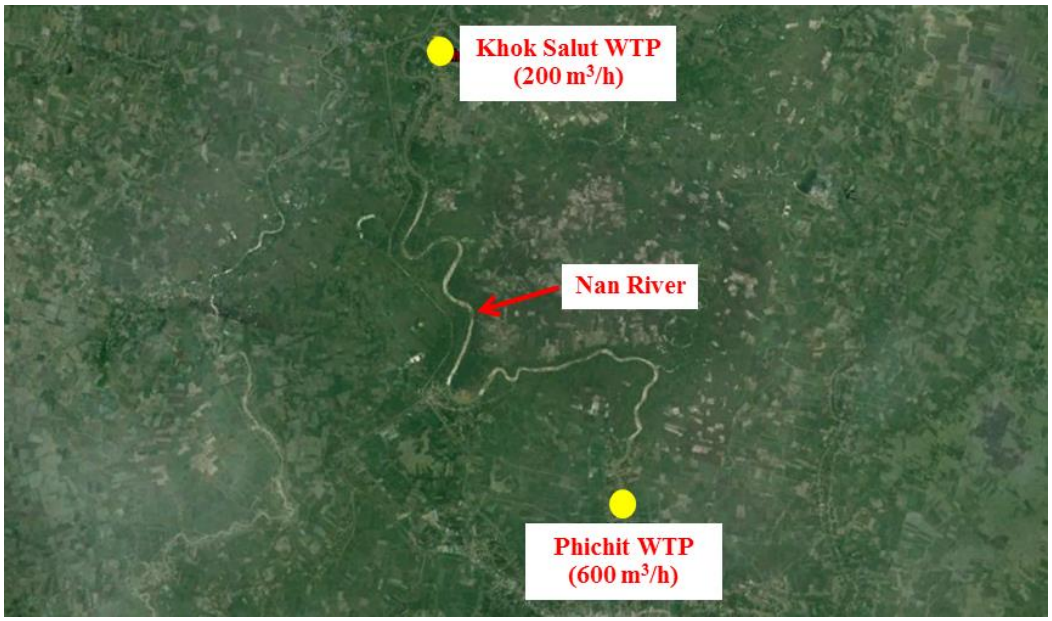


Figure 15 Location map between Phichit WTP and Khok Salut WTP

6. List out the types of investment for improvement have been made recently at the plant

- As seen in **Figure 16**, treatment plant is installed on the roof of flocculation and sedimentation basins to preventing algae growth. In addition, each treatment process installed net for preventing birds in treatment plant because a flock of birds make treatment facility dirty by their dropping and feathers. This practice helps to maintain cleanliness in the treatment facility by preventing the input of other debris (leaf, dust) or birds.

Figure 16 The roof (left) and net (right) of flocculation and sedimentation basin building

- Most treatment plants under PWA regional office 10 (province number 10) are cleaned manually on a regular cycle (per two or three months) without continuous sludge collector. Some treatment plants including Phichit has installed mechanical sludge collector system to increase operation and management efficiency (**Figure 17**). 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 into the outlet piping, and away to the sludge removal through (Leopold, 2010). This practice improves effluent water quality of sedimentation basin because raw water turbidity of Nan River is higher than that of other rivers.

Figure 17 Mechanical sludge collector motor (left) and sludge collector (right)

7. List out technologies, facilities or other types of assistance would be needed to better cope with operational and management difficulties in 3) and 4)?

- Alum is injected in receiving well basin of 2nd WTP for rapid mixing of 1st and 2nd WTP. Floc of WTP is of very fine size (reflects bad condition) compared to that of 2nd WTP. To prevent floc formed to be broken, 1st WTP is required to inject alum separately rather than the current practice of integrated mixing.

- 1st WTP's filter is composed of dual media. Most anthracite here has been disappeared by rapid swelling. Current manually operated valve is not an easy way of maintaining appropriate expansion rate of backwash (as the valves needs to be slowly opened). Thus it is recommended to change to motor-operated valve **(Figure 19)** such as filter valves of 2nd WTP from the existing manually operated valve **(Figure 18).**

Figure 18 Manual operated valve (1st WTP)

Figure 19 Motor-operated valve (2nd WTP)

8. Customer's opinion on water quality and water services in general (expectations, specific opinions for improvement, etc.)?

- According to the complaint data of PWTP (**Table 2**), higher number of complaints are recorded about water service (33%) followed by water quantity, which accounts for 25 percent of the complaints.

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

Complains	Water quantity	Water quality	Connection to tap water	Service	Others
Number	3	1	2	4	2
Percentage (%)	25.0	8.3	1.7	33.3	1.7

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

- PWTP is a representative water treatment plant in PWA regional office 10 (province number 10 of Thailand). Advanced technologies such as dual-media of filter, mechanical sludge collector of sediments, and on-line water quality monitoring system of raw water and treated water are currently in use inside PWTP.

- Intake facilities is equipped with real time monitoring device **(Figure 20)** for continuous water quality monitoring. It can measure parameters like pH, turbidity, conductivity, ORP, DO which varies greatly in Nan River. One of the objective behind real-time monitoring is to inject optimum coagulant dosage through quick response. Nan River has higher turbidity than other rivers (Ping, Yom River) and it changes a lot. In addition, continuous water quality monitoring devices has also been installed to monitor the treated quality of water. It can monitor parameters such as pH, turbidity and residual chlorine.

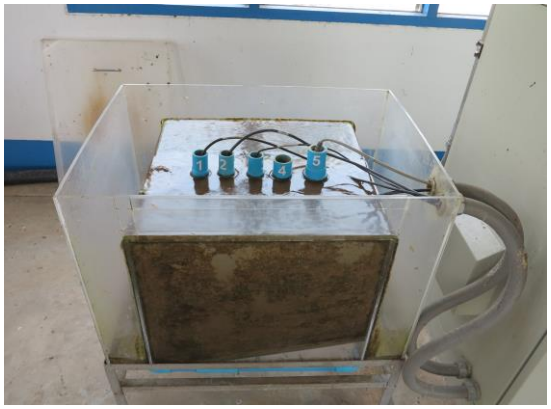


Figure 20 On-line monitoring devices: raw water (left) and treated water (right)

10. Other Highlights

- PWTP consists of fish monitoring system to check if raw water has any harmful toxic contaminant in it. **(Figure 21)**
- Sampling lines are connected in the laboratory room for sampling convenience **(Figure 22)**

Figure 21 Fish monitoring system

Figure 22 Sampling points in laboratory room

11. Water quality data

The data of water quality were obtained from PWA regional office 10 **(Table 3)**. All measured parameters are under Thailand national standard for drinking water.

Table 3 Water quality data

Parameters	Unit	Raw water (2014)		Treated water (2014)		Standard (Thailand)
		Min	Max	Min	Max	
pH	-	6.7	8.0	7.5	7.8	6.5-8.5
Turbidity	NTU	19	98	0.40	1.1	5
Conductivity	µs/cm	127	159	129	165	-
Total hardness	mg/L	64	74	52	76	-
NO_3-N	mg/L	0.53	0.86	0.47	0.87	45
Iron	mg/L	-	3.6	0.01	0.09	0.5
Manganese	mg/L	0.06	0.60	0.01	0.02	0.3
Copper	mg/L	0.01	0.05	0.01	0.02	1.0
Zinc	mg/L	0.02	0.04	ND	0.02	5.0
Chloride	mg/L	5	10	9	16	250

* ND: Not detected

12. References

American Water Works Association. (1999). Water Quality and Treatment (6th edition). New York: McGraw-Hill. ISBN: 978-0071630115

American Water Works Association. (2005). Water Treatment Plant Design (4th ed.). New York: McGraw-Hill. ISBN: 0-07-141872-5

Kawamura, S. (2000). Integrated design and operation of water treatment facilities (2nd edition). John Wiley and Sons. ISBN: 978-0471350934

Leopold (2010). Leopold Clari-DAF and FilterWorx Systems Featured at AWWA 2010 Conference in Chicago. Retrieved May, 2015, from http://www.allerton.com/leopold/company/news/

Ratchanet, K. (2013). Performance appraisal of the provincial water works authority water supply system in PWA region 10, Nakhonsawan, Thailand. (Master thesis No. EV-13-36, Asian Institute of Technology, 2013). Bangkok: Asian Institute of Technology, Thailand.

Wikipedia (2015). Kamphaeng Phet Province. Retrieved May, 2015, from http://en.wikipedia.org/wiki/Kamphaeng_Phet_Province

Prepared by:

Mr. Park Dong Hak

PhD Candidate - Environmental Engineering and Management Program

School of Environment, Resources and Development, Asian Institute of Technology, PO Box 4, Klongluang, Pathumthani, 12120, Thailand.

Published on: 24 September 2015

NewTap
Network on Water Technology in Asia and Pacific

URL: http://www.jwrc-net.or.jp/aswin/en/newtap

Email: newtap@jwrc-net.or.jp