Dongmakkhai Water Treatment Plant
Vientiane City, Lao PDR

1. Background information

Vientiane is the capital and largest city of Laos which is situated on the banks of the Mekong River near the border of Thailand. The estimated population of the city is 760,000.

Dongmakkhai Water Treatment Plant (DWTP) is owned and operated by Nam Papa Nakhone Luang (NPNL) of Lao PDR, a state-owned water utility company established in 1971. This water treatment plant is one of the four water treatment plants under NPNL. It was constructed in 2006 with the capacity of 20,000 m^3/d.

Table 1 Overall information of Donmakkhai water treatment plant

Constructed Year	2006
Water Source	Nam Ngum River
Number of connections	11,073
Peak Operating Flow (m^3/h)	1,108
Design capacity (m^3/h)	833
No. of operators working at the plant	8
Treated water standard	Ministry of Health (2005)
Automation	No
Date of access of the source information	2014
Reference	NPNL Annual Report (2012, 2013)

In 2013 DWTP supplied 22,656 m^3/d of tap water to 11,073 households of Vientiane capital (7 towns). Water source of DWTP is Nam Ngum River, located 10 km away from water treatment plant. Main characteristics of treatment process are hydraulic mixing, manual cleaning of sedimentation basin, single-medium deep-bed filter (coarse sand), and upflow water backwash with air scour.

2. Water treatment process flow

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

- Raw water extraction (Nam Ngum river) → Raw water pumping → Hydraulic mixing (alum, pre-chlorine) → Flocculation (baffled channel type) → Sedimentation (rectangular, manual cleaning) → Rapid sand filters (Coarse sand, water wash with air scour) → Disinfection (chlorine) → Clear Well → High lift pump building

- Sludge treatment: slugged generated from sedimentation and backwashing is drained to water pond (lagoon)

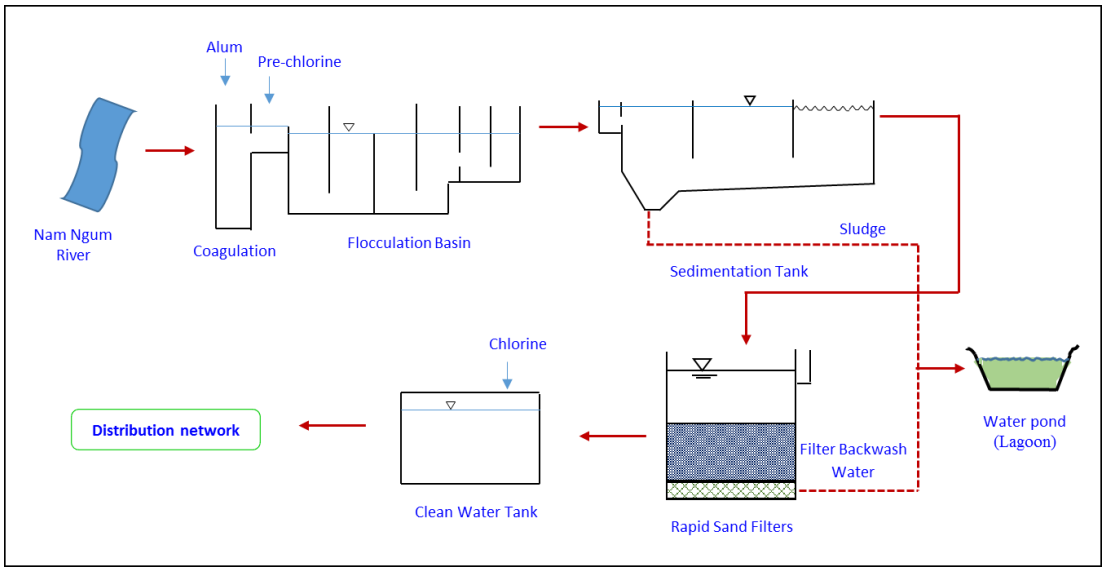

Figure 1 Water Treatment Process

2.1 Chemicals used

Two kinds of chemicals are used for water treatment. Solid alum is used as a coagulant while calcium hypochlorite ($CaOCl_2$) is used for pre and post chlorination. As seen in **Figure 2**, solid alum is firstly dissolved in water in the solution tank. Then, it is transferred to the alum storage tank to inject into receiving well (mixing basin). Hypochlorite is firstly dissolved in water in the solution tank and it is transferred to the receiving tank for pre-chlorination and clear well for post-chlorination. These chemicals are imported from Thailand.

Figure 2 Alum (Solid) Solution Tank (left) and Chlorine ($CaOCl_2$) Solution Tank (right)

2.2 Rapid mixing

Alum is injected into receiving well (mixing basin) by hydraulic jump (**Figure 3**). Chlorine is also intermittently injected into receiving well by hydraulic jump during the pre-chlorination process to prevent algae growth in flocculation, sedimentation, and filter basins. However in case of higher turbidity during the wet session it is injected into the effluent weir of sedimentation for preventing algae growth in filter basin.

Figure 3 Hydraulic jump of alum in receiving well basin

2.3 Flocculation

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. DWTP consists of vertical baffle channels **(Figure 4)**, and the hydraulic retention time of water in flocculation tank is 25 minutes.

Figure 4 Vertical baffle channel (2 basins)

2.4 Sedimentation

Sedimentation tank at DWTP is designed to be rectangular in shape **(Figure 5)**. The surface loading rate is the primary parameter to design the sedimentation tank and for the sedimentation tank at DWTP it is 40 m^3/m^2.d. In general the surface loading rate lies in the range of 20 to 60 m^3/m^2.d (0.8 to 2.5 m^3/m^2.h). Settled solids are cleaned manually on a regular cycle in the dry season (per two months) and in the wet season (per month). The drained waste is directly collected in the water pond. DWTP has a detention time of 2.2 hour. Detention time of conventional basins ranges from 1.5 to 3.0 h (Kawamura, 2000).

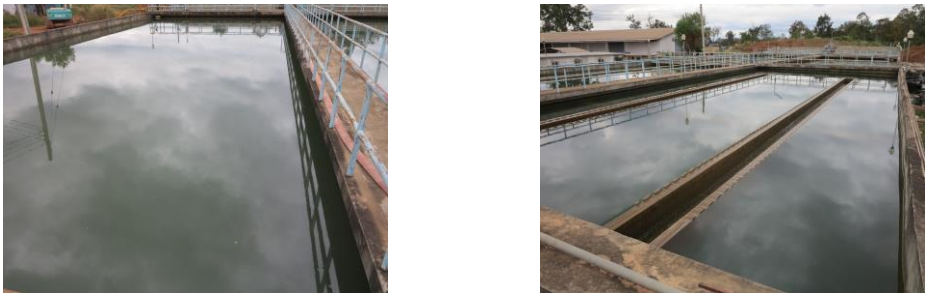

Figure 5 Settling part (left) and effluent part (right) of sedimentation tank (2 basins)

2.5 Filtration

There are three types of typical configuration of filter media: conventional fine sand, dual media, and single sand deep bed filters (AWWA, 1999). Dual media and single sand deep bed filters is preferred because convention fine sand removes most of the solids in the top of the sand but not through its full bed depth. The filter media used in DWTP is single-medium deep-bed (coarse sand) about 100 cm deep with 1.0 mm effective size.

There are two basic types of filter washing system, fluidized-bed backwash with surface wash and water backwash with air scour. Backwash method used in DWTP is water backwash with air scour. The average filter run time is 1 to 2 days **(Figure 6)**.


Figure 6 Filter Tank (5 basins)

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

- DWTP manually cleans the sedimentation basins to remove the settled solid on a constant interval (every one or two months). However, DWTP has several problems in meeting the high demand of water as it consists of only 2 sedimentation basins. Water supply depends on only one sedimentation basin when one of the sedimentation basin is being cleaned.
- **Figure 7** illustrates the damaged V notch weir in the sedimentation basin. Water excessively flows over the damaged weir (V notch), thus effluent water quality of sedimentation is of concern.


Figure 7 Damaged V notch weir

- Under current disinfection system of DWTP **(Figure 8) ,** it is difficult to maintain exact chlorine concentration in each injection. Although, DWTP has assigned the concentration of disinfectant (0.8 mg/L in the plant & at least 0.2 mg/L at the end of pipe), it is impossible to

maintain constant concentration because water quality monitoring is performed intermittently by manual observation.

(a) Chlorine ($CaOCl_2$) Solution Tank (b) chlorine storage tank

(d) Chlorine injection to clear well c) Chlorine injection pipe

Figure 8 Chlorine injection system of Dongmakkhai WTP

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

- DWTP is producing water at a higher rate than its design capacity **(Figure 9).** The main reason is that NPNL has a huge water loss of non-revenue water (25 to 30 percent). Moreover it has a low water supply rate (70 percent) and fails to meet the water demand.

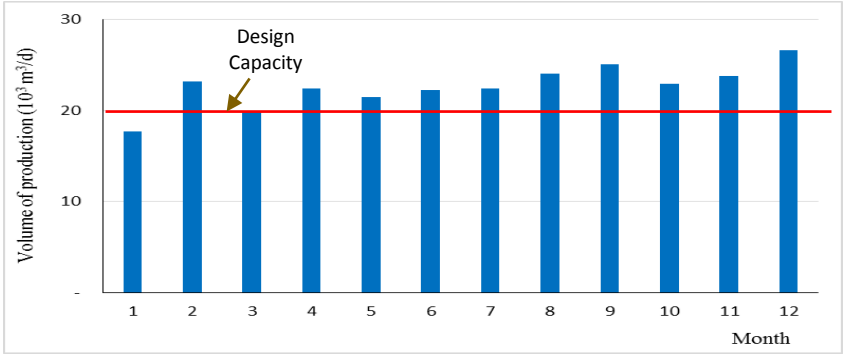

Figure 9 Average volume of water production per month in 2013 (DWTP)

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

- As seen in **Figure 10**, NPNL is constructing a new WTP with higher capacity (100,000 m^3/d of capacity) near DWTP. New WTP is scheduled to be constructed by 2015 after which the water supply rate will be increased by 90 percent.

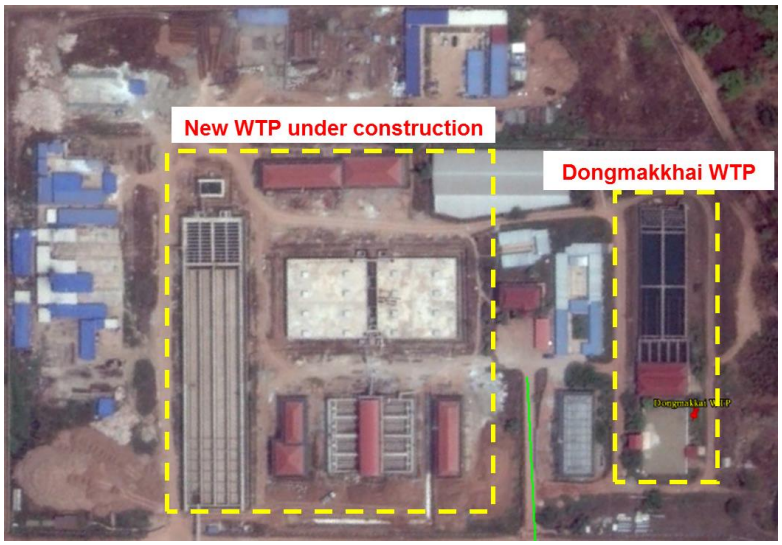

Figure 10 New water treatment plant under construction

6. Recent investment made for the plant's improvement

There are lots of construction, rehabilitation and expansion of WTP in NPNL as seen in **Figure 11**. DWTP was constructed with the capacity of 20,000 m^3/d on 2006. Now the plant is unable to meet the water demand which caused the investment to be diverted in building new WTP.

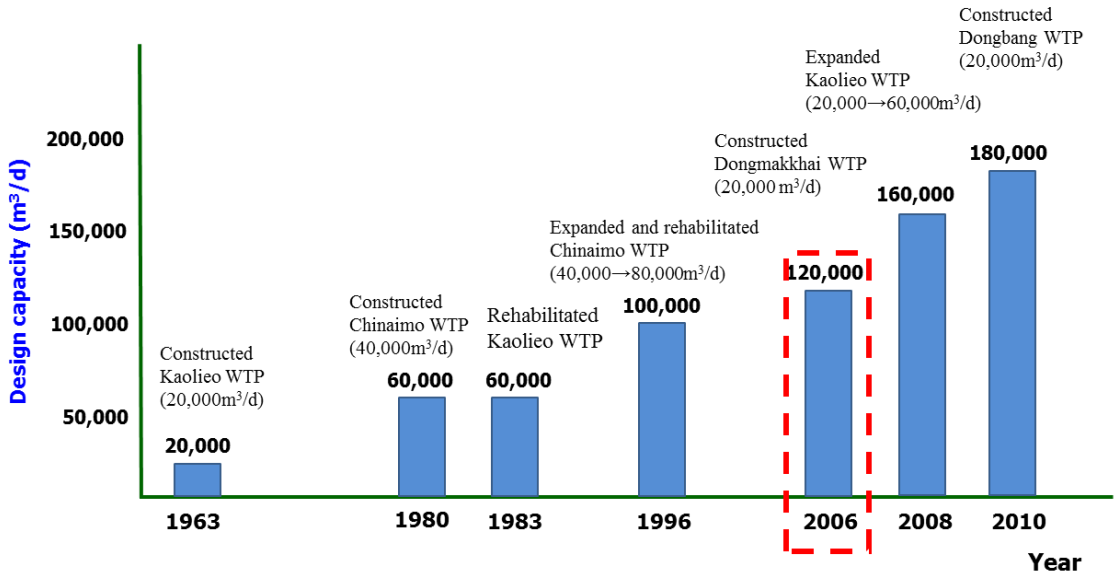

Figure 11 Development of water supply system in NPNL (Vientiane city)

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

- DWTP does not have any water quality monitoring system. General water quality parameters including pH, conductivity, alkalinity and turbidity are proposed to be monitored in the raw water (Nam Ngum River).

- Advanced motionless mixing (static mixer) method can be an attractive alternative to conventional static mixing for complete mixing of water and chemical under a limited time.

- Mechanical sludge collector system in sedimentation basin needs to be introduced in DWTP for smooth operation and maintenance.

- DWTP needs to improve chlorine feeding system for injection of exact concentration of chlorine. Clear wells need to install baffle to increase contact time with water and chlorine

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

According to NPNL complaints in 2013 and 2014 **(Figure 12)**, leakage of distribution system was the most serious problem which was then followed by lack of water quantity.

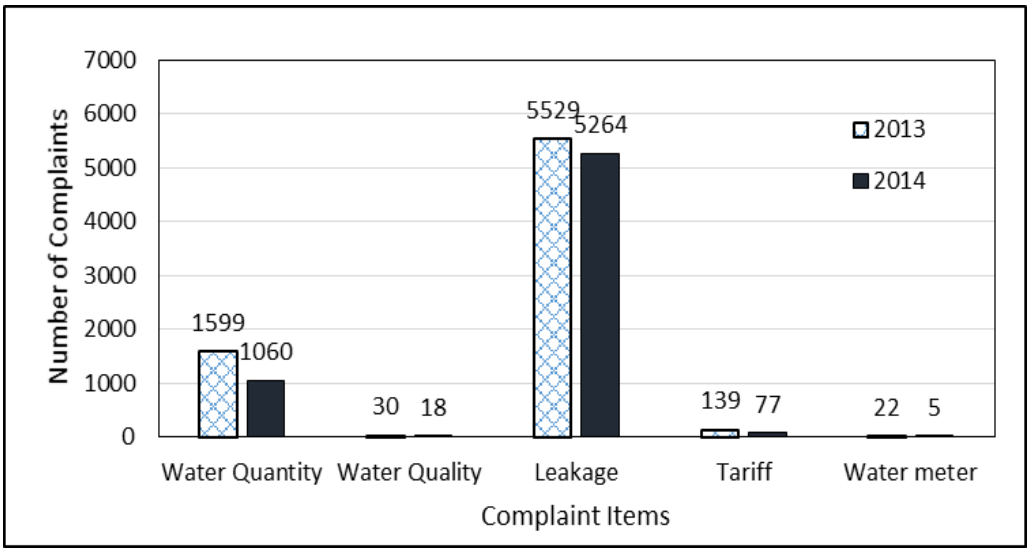

Figure 12 Complaints from customers in NPNL (2013, 2014)

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

- In filtration, single sand deep bed filter (coarse sand) was utilized from the start of DWTP.
- DWTP has used water wash with air scour as a backwash method

10. Other Highlights

- In case of DWTP, water source is 10 km away from the water treatment plant. Raw water is conveyed from Nam Ngum River to water reservoir (pond) located near WTP through the canal. This water is then pumped to water treatment plant (Figure 13).

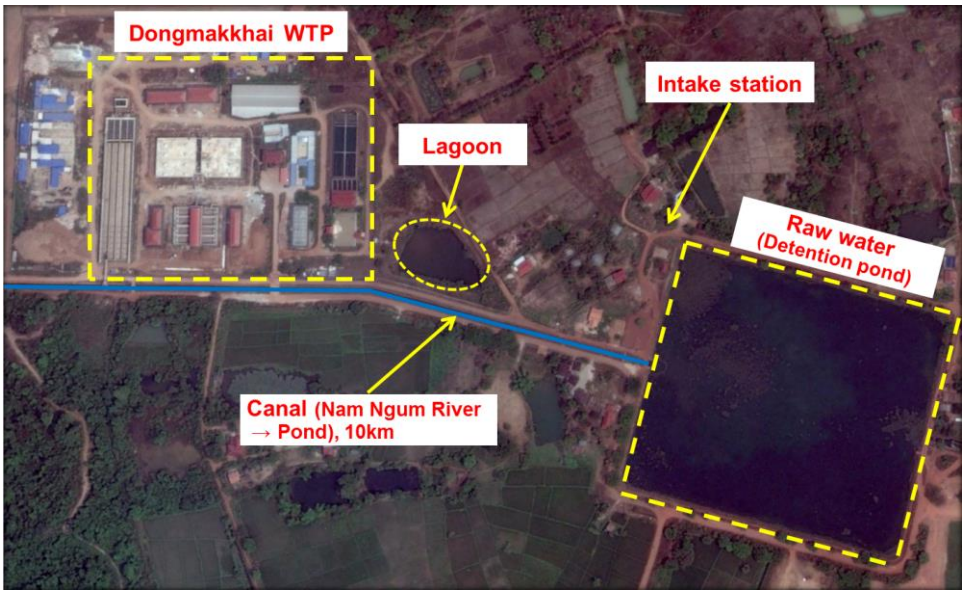

Figure 12 Layout of Dongmakkhai WTP (Google Earth)

11. Water quality data

This data of water quality obtained from DWTP annual report (2014)

Table 2 Water quality data

Parameters	Unit	Raw water		Treated water		Standard (Lao PDR)
		Min	Max	Min	Max	
pH	-	7.3	8.0	7.4	7.5	6.5-8.5
Turbidity	NTU	4	90	0.2	0.5	10
Alkalinity	mg/L	37	55	36	55	-
Conductivity	µs/cm	NA	NA	NA	NA	-
Total hardness	mg/L	NA	NA	NA	NA	100-300
NO_3-N	mg/L	NA	NA	NA	NA	40
Iron	mg/L	NA	NA	NA	NA	0.3
Manganese	mg/L	NA	NA	NA	NA	0.5
Chloride	mg/L	NA	NA	NA	NA	-

NA: Not Available

12. References

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

Donmakkhai (2013). Annual report of Donmakkhai water treatment plant. Nam Papa Nakong Luang: Lao PDR

Donmakkhai (2014). Annual report of Donmakkhai water treatment plant. Nam Papa Nakong Luang: Lao PDR

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

Ministry of Health (2005). Minister's Resolution (NO. 1371/MOH, Water quality targets of drinking water quality). Vientiane: Lao PDR

Nam Papa Nakhone Luang. (2012). Annual Report in 2012. Vientiane: Lao PDR

Nam Papa Nakhone Luang. (2013). Annual Report in 2013. Vientiane: Lao PDR

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: 20 June 2015

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

Email: newtap@jwrc-net.or.jp