An Duong Water Treatment Plant
Hai Phong, Vietnam

1. Background Information

An Duong Water Treatment Plant (ADWTP) is located in Le Chan, Hai Phong, Vietnam. The total land area of ADWTP is 86.43 km^2. ADWTP is managed and operated by Hai Phong Water Supply Company, Ltd. since 1959. It was built with an initial capacity of 20,000 m^3/d which was then increased to 60,000 m^3/d in 1965, 100,000 m^3/d in 1999 and 140,000 m^3/d in 2013. According to the planned expansion of water supply system project for the year 2014-2015, ADWTP is further being upgraded to the capacity of 200,000 m^3/d. Presently, the produced water is supplied to urban districts: Hong Bang, Le Chan, Ngo Quyen and Hai An**.** The general information of ADWTP is shown in **Table 1**.

Table 1 Overall Information of An Duong Water Treatment Plant

Constructed Year	1959
Water Source	Re River
Number of connections (by 3/2013)	193,416
Design capacity (m^3/d)	200,000
Topography	Plain/Tropical
Date of access of the source information	5 September, 2015
Reference	Water Safety Plan (2013) Hai Phong Water Supply Company

2. Water treatment process flow

The water treatment process at ADWTP is illustrated in **Figure 1**.

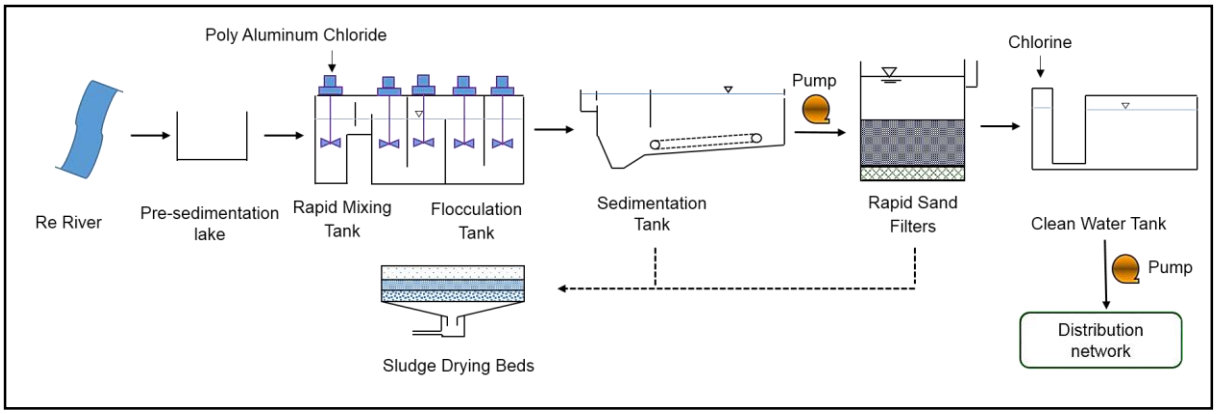

Figure 1 Schematic Diagram of Water Treatment Processes

The major water treatment process at ADWTP includes:

Raw water extraction → Pre-sedimentation → Rapid Mixing → Flocculation → Sedimentation → Rapid Sand Filter → Disinfection → Clear water Tank → Distribution network.

Sludge generated from sedimentation tank and filtration backwash is collected and dried at the sludge drying beds.

2.1 Water intake

Raw water is collected from the Re river. The net and bar screen system (**Figure 2**) are located outside pumping sump to prevent garbage entering into the pumps. Water transferring to ADWTP is managed by Quan Vinh pumping station, shown in the **Figure 3**.

Figure 2 Water Intake from Re River

Figure 3 Quan Vinh Pumping Station

2.2. Pre-sedimentation tank

The pre-sedimentation tank (**Figure 4**) has an area of 12,000 m^2 with the storage capacity of 30,000 m^3. The water level varies in the range of 1.7 - 4.2 m . The retention time is 4 h in the case of production capacity of 7,500 m^3/d.

Figure 4 Pre-sedimentation Tank of An Duong Water Treatment Plant

2.3 Chemical building

Usually poly aluminum chloride (PAC) or alum sulfate ($Al_2(SO_4)_3$ is used as coagulant in water treatment process. Jar test experiment is done to find out the optimum dosage of the chemicals. **Figure 5** shows the chemical building at ADWTP.

Figure 5 Chemical Building

There are four chemical mixing tanks, each with the volume of 8 m^3 at ADWTP (**Figure 6**). The average concentration of the solution is around 5 %. To mix and dissolve the chemicals in the solution tank, the motor drive with the capacity of 1.5 KW are operated with the speed of 75 rpm.

Figure 6 Chemical Mixing Tanks

There are two metering pumps used in chemical building at ADWTP. One of the pump has two entrances with the flow rate of 1.15 m^3/h while the other one, which is a reserve pump, has a single entrance with the flow rate of 1.0 m^3/h. These pumps (**Figure 7**) are used to transfer chemical solution to the mixing tank.

Figure 7 Chemical Pumps

2.4 Mixing tank and Coagulation-Flocculation

Mixing tank consists of two mechanical mixing compartments. Each chambers has the volume of 46 m^3. The capacity of mixing motor is 5.5 KW with the stirring speed of 50 rpm. The chemical contact time at mixing tank is around 5 s.

Coagulation and flocculation unit (**Figure 8**) consists of four tanks and each of the tanks include two compartments. Thus, the coagulation and flocculation system consists of eight compartments (four tank each with two compartments) with the total volume of 1,360 m^3. These four tanks are located consecutively and uses four types of stirring motors with the descending capacity of 4KW/3.0 rpm, 3KW/2.5 rpm, 1.1KW/2.0 rpm and 0.55KW/1.5 rpm. The hydraulic retention time of water at this unit is about 180 s.

Figure 8 Flocculation Tank

2.5 Sedimentation tank

There are two horizontal sedimentation tanks (**Figure 9**) with the total storage capacity of 16,000 m^3. The length and width of each tank is 110 m and 32 m respectively. The hydraulic retention time of the tank is maintained at 3 h. The water level in the tank is in the range from 2.2 to 2.4 m. The settled sludge is discharged from the sedimentation tank by suction pump in the interval of 6 h.

Figure 9 Horizontal Sedimentation Tank

2.6 Rapid filtration tank

There are 3 gravity rapid filtration tanks with 18 compartments (**Figure 12**). The footprint area of each tank is 43 m^2. The filtration media of anthracite carbon layer (0.5m in thickness) and silica sand layer (0.6 m in thickness) are used in this tank. The filtration rate this unit is 8-10 m/h and it operates in semi-automatic mode . The backwash cycle during the summer season is of 24 h and for the winter season it is doubled to 48 h.

Figure 10 Filtration Tank

2.7 Pumping station

2.7.1 Pumping station No. 1

The pumping station no.1 is used to pump treated water from the horizontal sedimentation tank to the filtration tank. There are five pumps (**Figure 10**) with the total maximum capacity of approximately 9,000 m^3/h. The specifications of these pumps are shown in **Table 2.**

Figure 11 Pumping Station No. 1

Table 2 Specifications of Pumps Used in the Pumping Station No. 1

Pumps No.	Model	Capacity (m^3/h)	Total head (m)	Motor Power (KW)
1	Д2500-17	2,500	17	160
2	14SH28	1,260	16.2	75
3	Д5000-32	3,850	18	250
4	24НДС	4,000	14	200
5	Д3200-33	3,000	23	160

2.7.2 Pumping station No. 2

The function of the pumping station no. 2 (**Figure 11**) is to deliver purified water from clean water storage tank to the distribution system. This station consists of nine horizontal centrifugal pumps with the operating pressure from 3 to 4 bars. The specifications of each pump used at the second pumping station are presented in **Table 3**.

Figure 12 Pumping Station No. 2

Table 3 Specifications of Pumps Used in the Pumping Station No.2

Pumps No.	Type - Model	Capacity (m^3/h)	Total head (m)	Motor Power (KW)
1	20SH19	2,016	22	250
2	Д2500-62	2,100	32	250
3	СРН3000-435/412	1,080	50	250
4	12НДС-60Т	1,080	50	250
5	12НДС-60Т	1,080	50	250
6	7-AD355MD	1,800	50	320
7	FGJ 355L-4	2,000	45	320
8	18НДС	2,100	32	250
9	20SH19	2,016	22	160

2.7.3 Backwash pumping station

This pumping station consists of 4 pumps that serve for the backwashing process of filter tanks. The description of these pumps is illustrated in **Table 4**.

Table 4 Specifications of backwash pumps

Pumps No.	Type - Model	Capacity (m^3/h)	Total head (m)	Motor Power (KW)
1	PN10 (water)	1,000	15	55
2	PN10 (water)	1,000	15	55
3	N7 (air)	55.5 m^3/min	2.5	75
4	KPHR42 (air)	42.0 m^3/min	7	90

2.8 Disinfection process

Liquid chlorine is used for disinfection of the treated water at ADWTP. The chlorine dosage is determined by the Jar test experiment conducted at a technical quality lab. To determine the free chlorine concentration in water, Poly - 1, 4 D- glucosamine (DPD) tablet test or orthotolidine test is performed. There are two chlorinators with the delivery flow rate of 20 kg/h and 10 kg/h (**Figure 13**). ADWTP also consists of neutralization tower to ensure safety when chlorine leakage occurs (**Figure 14**).

Figure 13 Chlorinators

Figure 14 Neutralization Tower

2.9 Purified water storage tank

There are four clean water tanks with the total storage capacity of 9,500 m^3. First tank has the volume of 2,500 m^3, second and third tank has the volume of 3,000 m^3 and the fourth tank has the volume of 1,000 m^3. The chemical disinfection is performed in the water pipeline before it ends up in the storage tank. The chemical contact time for this process is around 30 minutes.

2.10 Sludge disposal

Sludge generated from sedimentation tank and filtration backwash is discharged into the sludge drying beds (**Figure 15**). There are six sludge drying beds with the total area of 2,280 m^2. The drained water from these drying beds is recirculated to the pre-sedimentation lake.

Figure 15 Sludge Drying Beds

2.11 Distribution system

The treated water is supplied to consumers via water supply network, which includes: main pipelines (D300-D700 in total length of 79.5 km), smaller pipelines (D150-D250, 104.2 km; D32-D100, 730.0 km) and the smallest pipelines (D25, 580.0 km).

The pipeline network was installed back in 1990 and the leakage ratio of water supply network in 2012 was reported to be 13.75 %.

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

The raw water (surface water from inland rivers) is contaminated mostly by organic pollutants from domestic wastewater and fertilizers which causes increased dosage of coagulant, chlorine and PAC (Powder Activated Carbon) resulting in the rise of treatment cost.

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

The pollution sources of the Re River include:

- Illegal discharge of domestic wastewater from some communes, such as: An Duong, Le Loi, Dang Cuong, Hong Thai, Dong Thai and An Dong.
- Hospital wastewater from “Transportation Hospital” and industrial wastewater from “Hanvico Company”.
- Solid waste, wastewater and chemical runoff (i.e. pesticide, insecticide) from some farms along the river.
- Wastewater leaking from the landfill of Kim Tan ward, Kim Thanh District.
- Leakage from the cemetery of the Hung Vuong commune, Le Loi ward and An Duong District.

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

Hai Phong water supply company has implemented the water safety plan (WSP) following the manual of WHO since 2011. The main objectives of WSP are indicated as follows:

- Ensuring: maintenance of water pressure, stable supply of water in sufficient quantity and meeting required water quality standards.
- Planning to cope with unexpected incidents and hazards which may occur during the entire production process (water intake to distribution).
- Contributing to protect public health, reducing water-related disease and disease prevention
- Contributing to reduce wastage, saving water resources and environmental protection

Some activities carried out to protect the raw water sources (Re River) are:

- On 23 November, 1999, the people's committee of Hai Phong City had issued a rule (Decree no. 2106/QD-UB) to protect water source of the Re River at the Quan Vinh pumping station area.
- Frequent checking of the industries to prevent unauthorized discharging of waste and wastewater
- Conducting awareness programs like posters publication and organization of some community program to raise residential awareness

6. Recent investment made for the plant's improvement

- Telemetry system (**Figure 16**) is now installed in the control building to monitor and supervise the operation of the plant and the parameters like flow, pressure, pH and chlorine residual at some points over the water network
- Installation of Supervisory Control And Data Acquisition (SCADA) system (**Figure 17**) to monitor the flow and additional pressure at few points in the water supply network
- Online measurement of residual chlorine in the distribution system (**Figure 18**)

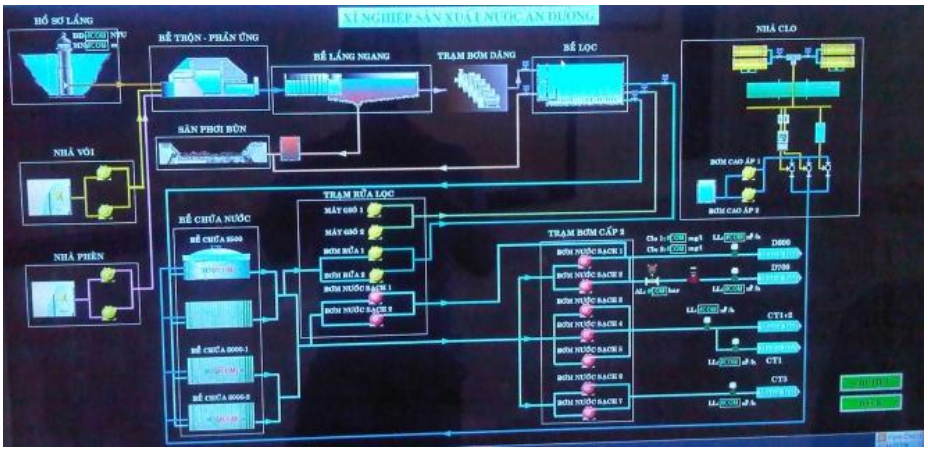

Figure 16 Telemetry System

Figure 17 SCADA System

Figure 18 Chlorination measurement

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

- Upgrading the management quality by application of GIS based information technology
- Innovating and diversifying revenue collection methods to improve labor productivity

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

ADWTP conducts an annual survey to evaluate the customer satisfaction. The results in 2014 dipcited that over 99% of customers were satisfied with the water quality and services of ADWTP

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

ADWTP are currently using PAC to adsorb pollutants in raw water. Similarly they have installed a telemetry system in the administration office. They have also planned to install a Javel injection system along the street no. 355 which is located close to the City Police hospital

10. Other Highlights

ADWTP has 193,416 connections in its distribution system out of which, the number of connections to household, administrations, industries and business/services are 190,474 (98.5%), 921 (0.5%), 1,575 (0.8%) and 446 (0.2%) respectively.

11. Water quality data

Table 4 presents the quality of raw water and treated water at ADWTP in 2014. All the measured parameters of treated water were found to be under the national drinking water standard regulated by Ministry of Health, Vietnam.

Table 4 Raw Water and Treated Water Quality in 2014

No.	Parameters	Unit	Raw Water		Treated Water		Standard (QCVN 01:2009/BYT)
			Min	Max	Min	Max	
1	Color	Pt-Co			<5	<5	≤ 15
3	Turbidity	NTU	13.02	23.04	0.16	0.26	≤ 2
4	pH		7.23	7.44	7.13	7.35	6.5-8.5
5	Calcium	mg$CaCO_3$/L	90	127	98	128	≤ 300
6	Chloride	mgCl-/L	12.31	24.57	18.39	30.08	≤ 250
7	Permanganate (MnO_4^-)	mgO_2/L	2.07	4.24	0.83	1.75	≤ 2,0
8	Manganese	mg/L	0.057	0.268	0.006	0.020	≤ 0,3
9	Nitrate	mg/L	0.518	1.297	0.560	1.880	≤ 11.36
10	Nitrite	mg/L	0.017	0.171	<0,002	0.002	≤ 0.91
11	Iron	mg/L	0.123	0.778	<0,020	0.032	≤ 0,30
12	Sulfate	mg/L			17.00	48.00	≤ 250
13	Total Residual Chlorine	mg/L			0.54	0.67	0.3-0.5
14	Total Coliform	CFU/100mL	2422	10725	0	0	0
15	Fecal Coliform	CFU/100mL	1200	4650	0	0	0

12. References

Hai Phong Water Supply Company. (2014). *Information Publish Material*. Retrieved on 7 September, 2015, from: http://www.msbs.com.vn/Sites/QuoteVN/SiteRoot/1_201507cdab5._Ban_cong_bo_thong_tin_cap_nuoc_HP.pdf

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