Badak Singa Water Treatment Plant
Bandung City, Indonesia

1. Background Information

Bandung, the capital of West Java province, is located in a highland of about 190 kilometers from Jakarta. Bandung consists of 26 sub-districts with a land area of 16,729.50 km² and a population of 2.4 million (year 2014), with an average population growth of 2.0%. Topographically, the northern part of the city is mountainous while in the southern part is relatively flat. Elevations of the city range from 675 m in the south above sea level (ASL) to 1,050 m ASL in the north. The city center is about 770 m ASL.

Badak Singa water treatment plant (BSWTP) is situated in the central part of Bandung City, West Java, Indonesia within a 2 km distance from the city center (see **Figure 1**). The WTP is managed by a water state enterprise (PDAM) of Tirtawening which is owned by the Bandung Municipal Administration. The company aims to provide clean water for the people of Bandung and its surroundings.

Figure 1 Orientation map of Badak Singa WTP

The company was initiated in 1916 by the dutch colonial named as Stadsgemente Water Leiding Bandung. The planning of water supply system for the people of Bandung was started in 1928-1948 under the "Technische Ambtenaar". Construction of the first phase of the WTP was done by Degreemont in 1956 with an initial treatment capacity of 86,400 m^3/d. The second phase of construction was conducted in 1992 to increase the treatment capacity to 172,800 m^3/d. It is reported that the actual flowrate of treated water is 165,890 – 166,750 m^3/d (Personal communication, 2016).

(a) (b)

Figure 2 PDAM Tirtawening, Badak Singa WTP Office: (a) Office Badak Singa WTP, and (b) Open house for students from local universities
Source: Primary field visit conducted in 1st August 2016

Table 1 Overall Information of Badak Singa Water Treatment Plant

Constructed Year	Phase I: 1956, Phase II: 1992
Water Source	Cisangkuy River (phase I), Phase II: Cisangkuy and Cikapundung river
Design capacity (m^3/d)	172,800
Operating capacity (m^3/d)	165,890 – 166,750
No of Connections	150,236
Automation	Semi automation
Number of Employees	540
Date of access of the source information	1st August 2016
Reference	Interview and various references listed in the reference list

2. Water treatment process flow

The water treatment process at BSWTP is illustrated in **Figure 2**.

The major water treatment process at BSWTP includes:

Raw water extraction → Screening → Rapid Mixing → Coagulation and flocculation→ Sedimentation → Rapid Sand Filter → Disinfection → Clearwater Tank → Storage Reservoirs and Distribution network.

Sludge generated from sedimentation tank and filtration backwash is discharged to the downstream of Cikapundung River.

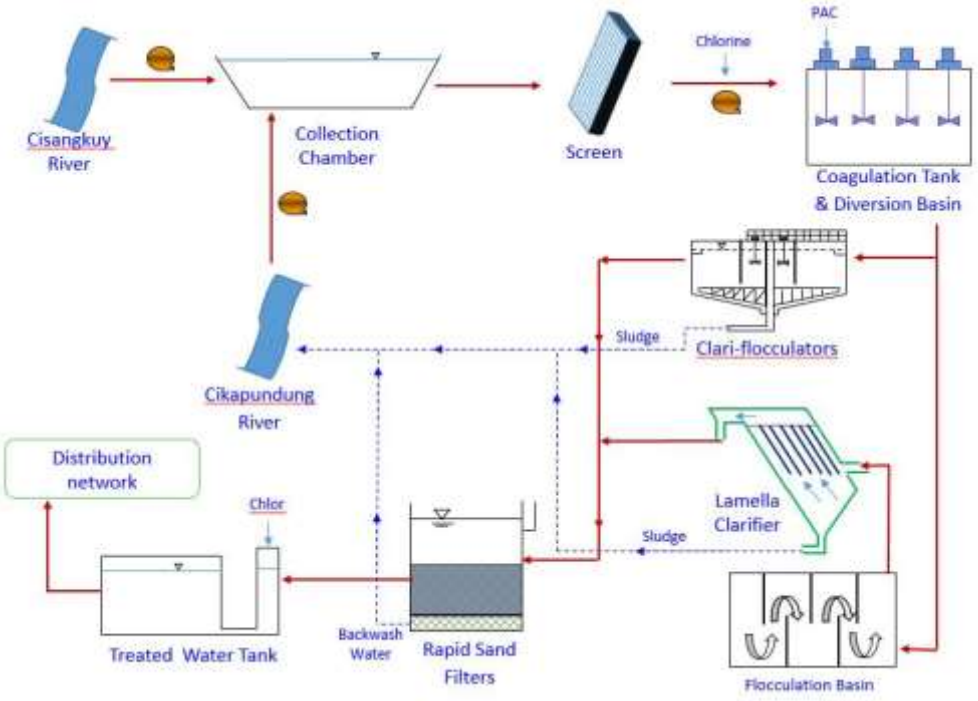


Figure 3 Schematic Diagram of Water Treatment Processes

2.1 Water intake

BWWTP takes raw water from two rivers:

i. Cisangkuy River that is a major tributary of Citarum Great River. The PDAM intake is about 150 meters downstream of the three PLN Cikalong Hydro-electric Power Plants (PLTA). The average intake flow for the WTP is 112,320-120,960 m^3/d. It was reported that the normal turbidity of water in Cisangkuy river is 5 – 20 NTU (USAID, 2006a).
ii. Cikapundung river is the another source of raw water for BSWTP. About 17,280-51,840 m^3/d of water is drawn from. (Notodarmojo et al., 2004).

Figure 4 Cleaning at the Cikapundung river water intake
Source: PDAM Tirtawening twitter

Raw water from Cisangkuy and Cikapundung is first mixed in the collection chamber. The mixing of the raw water of two river is targeted to reduce the higher turbidity from the Cikapundung River. BSWTP is designed to receive raw water with maximum turbidity of 200 NTU (USAID, 2006a). The mixed raw water from the collection chamber then pass through a bar screen which screens debris, solid waste, etc before being diverted to further treatment process (see **Figure 5**). Pre-chlorination is also done before the water enters the coagulation and diversion tank for further treatment.

(a) (b)

Figure 5 (a) Collecting chamber 1 receiving water from Cikapundung river, and (b) collection chamber 2 receiving water from Cisangkuy river with bar screen
Source: field visit, 1st August 2016

2.4 Diverting Basin/Coagulation Unit

From collecting chamber, water flows to a canal with water jam for hydraulic mixing (see Figure 6). At that point Poly-aluminum chloride (PAC) is added for a rapid mixing process. About 150 tons of PAC is used for coagulation every month. Effluent is then diverted to clarifiers and to flocculation units (baffle chamber) for further treatment.

(a) (b)

Figure 6 (a)PAC injection point and (b) chamber to divert water to clarifier and baffle chamber
Source: Field visit, 1st August 2016

2.4.1 Accelerators/Clarifiers

There are 4 unit of accelators/clarifiers (circular shape) in BSWTP (see **Figure 7**). The key principle of accelator's operation is its low-shear rotor-impeller combination, which controls mixing and slurry recirculation at independent rates to handle rapid changes in water characteristics. This combines flocculation and sedimentation in one unit. The sludge deposited in the bottom of the tank is discharged without any treatment to Cikapundung River. The retention time of clarifier is about 1 hour and it is cleaned twice in a month. Effluent then flows to the sand filtration unit.

Figure 7 Accelators/clarifiers unit
Source: Field visit, 1st August 2016

2.4.2 Hydraulic Flocculator and Rectangular Sedimentation Tank

This unit consists of several chambers using baffle channel to create mixing (see **Figure 8**). From this unit, effluent of water will go to the sedimentation tank (rectangular shape). The tank is equipped

with lamella separator to trap the flocs. Sedimentation basin residuals (sludge) are discharged to the Cikapundung River without further treatment (**Figure 8**).

(a) (b)

Figure 8 (a) Baffle channel of flocculation unit & (b) sedimentation tank (with lamella separator)
Source: Field visit, 1st August 2016

2.6 Rapid filtration tank

Sand filtration unit receives water from clarifier and sedimentation tank. Filters are backwashed by air scouring and water wash every 24 hours (**Figure 9**). This unit filtrates small flocs that were not removed in the previous unit process. The plant operates 24 hours a day with two shifts, each with 4 operators and one supervisor. Backwash water from this unit is also discharged to Cikapundung river.

Figure 9 Rapid sand filter unit in Badak Singa WTP
Source: Field visit, 1st August 2016

2.8 Disinfection process

Sand filter effluent flows to the reservoir. Before that, disinfectant (chlorine) is injected to kill the microorganism. It allows some contact time in the reservoir to undergo the disinfection process before distributing clean water to the consumers. Residual chlorine is analyzed in the laboratory and reported in a regular basis. It was reported that chlorine consumption is on average 8 kg/h. Treated water needs to meet at least: Turbidity of < 10 NTU; pH of 6.5-8.5 and; Residual chlorine concentration of 0.2-0.8 ppm

Figure 10 Chlor injection point and chlor storage room

2.9 Purified water storage tank

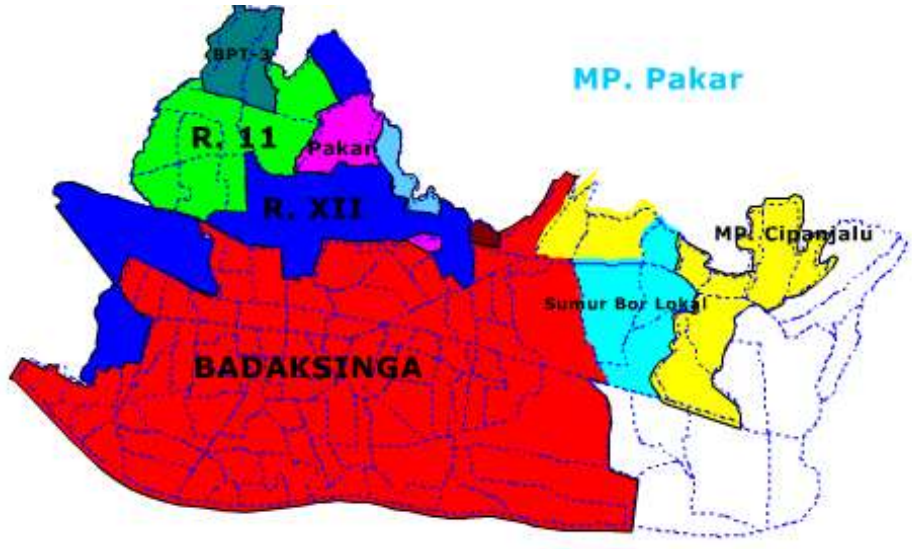
There are two storage tanks with the total storage capacity of 10,000 m^3. The treated water is then distributed by through gravity flow.

2.10 Sludge disposal

There is no sludge treatment facility in the plant. All sludge generated from the processes is discharged to Cikapundung River which is located within a distance of 1 km.

2.11 Distribution system

PDAM Tirtawening serves of almost 1.7 million people of Bandung thus the level of service is about 71% (of total 2.4 million populations in 2014). The company serves the plateau of Bandung (marked with red, see **Figure 3**). In total (2015), there were 150,236 pipe connections in the city of different sectors (detail in **Figure 3**).



Household	126,442
Social	2,109
Commercial	18,785
Industry	473
Government	2,427
Total	**150,236**

Figure 11 Coverage of service of PDAM Tirtawening
Source: http://www.pambdg.co.id/new2/index.php?option=com_content&view=article&id=80&Itemid=68

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

This plant uses raw water from two rivers with different quality. Cisangkuy river (from Southern part of Bandung) has better quality especially lower turbidity as compared to Cikapundung river which flows from a hilly areas of Northern part of Bandung with higher turbidity due to the soil erosion. Main intention is to increase flow rate of input raw water to BSWTP. There is a need to separate the treatment for Cikapundung River for example to install pre-sedimentation tank. There is also a need to construct sludge treatment plant as of now the sludge is still discharged back to Cikapundung river.

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

The age of the transmission pipe is more than 40 years. Transmission pipe problems have been frequently encountered annually and it create negative impact to the consumers. Transmission revitalization program needs to be designed and implemented in the future.

Another major problems realized by the PDAM Tirtawening is high non-revenue water of 32-38% which is due to illegal connection, water leakages in the distribution, inaccurate water meter and water loss in the Badak Singa WTP. The water loss in the treatment process was reported to contribute of around 4-8% to the total non-revenue water.

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

For sludge management, detail engineering design (DED) of the sludge treatment plant was made and the budget for construction has been proposed. Regular maintenance and control of distribution pipe leakage especially for the old pipeline has been done by the monitoring team. Inventory/quantification of non-revenue water was conducted by involving the local and international universities (i.e. Bandung Institute of Technology and Delf University) in a joint research program. Seasonal variation of raw water quality has been monitored and has been anticipated including emergency step to bypass the water with very high turbidity to the river.

6. Recent investment made for the plant's improvement

The recent investments made by PDAM Tirtawening are listed as follows (USAID, 2006b):

i. Production and Distribution sector:
- Increase or addition of water debit from spring and artesian well
- Optimization of transmission pipe water debit of Cisangkuy River amounting to ± 100 l/second
- Arrangement of clean water network in Brandgang, old channel closing, and pressure evaluation in various areas
- Decrease in water loss by closing channels that are potential to lose water, and control over old pipeline.

ii. Service administration:
- Updating of customers' data
- Application of on-line system in 14 auxiliary cashiers
- Application of call center 109 and SMS gateways
- Control over customers' accounts receivable with notice on areas
- Acceleration of reporting on financial and performance positions.

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

Various cooperation has been conducted by the corporate with various academic institutions to provide different needed assistance such as:
1. Potential new source for raw water
2. Design and construction of sludge treatment facility

3. Increase unit processes efficiency and to reduce water loss in order to increase treated water for consumers

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

Customer's opinion is summarized based on newspaper headline, social media, and personal communication. It is found that satisfaction level of the consumers is still low mainly due to the frequent day-off of water supply from PDAM Tirtawening. There is also growing request for new pipe connection especially for those who stay in the hilly areas of Northern part of Bandung. However, due to geographical location, the requests still could not be accommodated by the PDAM Tirtawening. Decentralization of new WTP is still under technical planning and political process to overcome such demand.

Water price is declared based on Bandung Major Decree No 270, 2013. It is stated that the price of water consumption per 1,000 liter varies for commercial, industry, household, and social sector. The detail can be found at: http://www.pambdg.co.id/new2/index.php?option=com_content&view=article&id=73&Itemid=87.

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

PDAM Tirtawening proposes to reorganize the water supply system from Sungai Cisangkuy by changing the existing old pipe 900 mm transmission pipeline to deliver water to the Southern area of Kota Bandung (950 L/s) and to Kabupaten Bandung (150 L/s). The existing new pipe of 850 mm would remain unchanged and continue to deliver water to IPA Badaksinga (USAID, 2006a).

PDAM Tirtawening also proposes a water treatment facility for the Cisangkuy water and a replacement water supply for IPA Badaksinga. Therefore, the proposed project also includes:

- Constructing IPA Cimenteng (1100 L/s) at a location about 4 kilometers from the water source (Sungai Cisangkuy) to treat the water
- Constructing transmission pipelines from PLTA Dago Bengkok II to deliver 600 L/s from the Sungai Cikapundung to IPA Badak Singa.

10. Other Highlights

BSWTP has its own water quality laboratory which serves the need of laboratory analysis of water quality in the plant. The company also has several trucks with water tank to serve the areas which are affected by flow disturbances due to pipe maintenance and other causes.

11. Water quality data

Raw water and the effluent after the filtration quality is presented based on the work of Notodarmojo et al. (2004) in the following table.

Table 2 Raw water and treater water quality in 2002

Parameters	Unit	Raw water	Treated water	Desirable limit*
Turbidity	NTU	121	0.33	10
Color	TCU	87.5	5	15
TSS	mg/L	0.27	0.12	50
Iron (Fe)	mg/L	9	0.15	0.3
Hardness ($CaCO_3$)	mg/L	73	146	500
Chlor (Cl)	mg/L	12.6	113	250
Manganese (Mn)	mg/L	0.36	0.035	0.1
Organic ($KMnO_4$)	mg/L	37.2	5.2	-
COD	mg/L	17.6	3.5	10

Source: Notodarmojo et al., 2004, * Government Decree No 82, 2001, class I for drinking water

12. References

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