Jungzhina Water Treatment Plant
Thimpu, Bhutan

1. Background Information

Thimphu, the capital and the largest city of Bhutan, is situated in the western central part of the country. The water supply for Thimphu is catered from about five different water supply systems and these systems are all operated and maintained by Thimphu Thromde (municipality). Jungzhina water treatment plant (JWTP) is one of the treatment plant supplying water for Thimphu and has an installed capacity of 6500 m^3/day. The plant was commissioned in October 2004. The background information is presented in **Table 1**.

Table 1 Overall Information of Jungzhina Water Treatment Plant

Year of commissioning	October 2004
Water source	Jungzhina River
Peak operating flow (m^3/day)	5000
Design capacity (m^3/day)	6500
No. of operators working at the plant	4
Treated water standard	WHO guidelines for drinking water quality
Automation	No
Date of access of the source information	2015
Cost of Construction	1.1 Million USD
References	Water safety plan for JWTP 2015

Figure 1: Jungzhina Water Treatment Plant

The treatment plant is a conventional type of treatment plant with coagulation and flocculation, clarification, filtration, and disinfection unit. High and medium pressure water pumps are used to pump/supply the water to various service reservoirs within the supply area. The treated water is supplied to Langjophakha, Thimphu Core area, Sunday Market, Hejo, Zilukha, Changjiji and Tashichhodzong areas.

2. Water treatment process flow

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

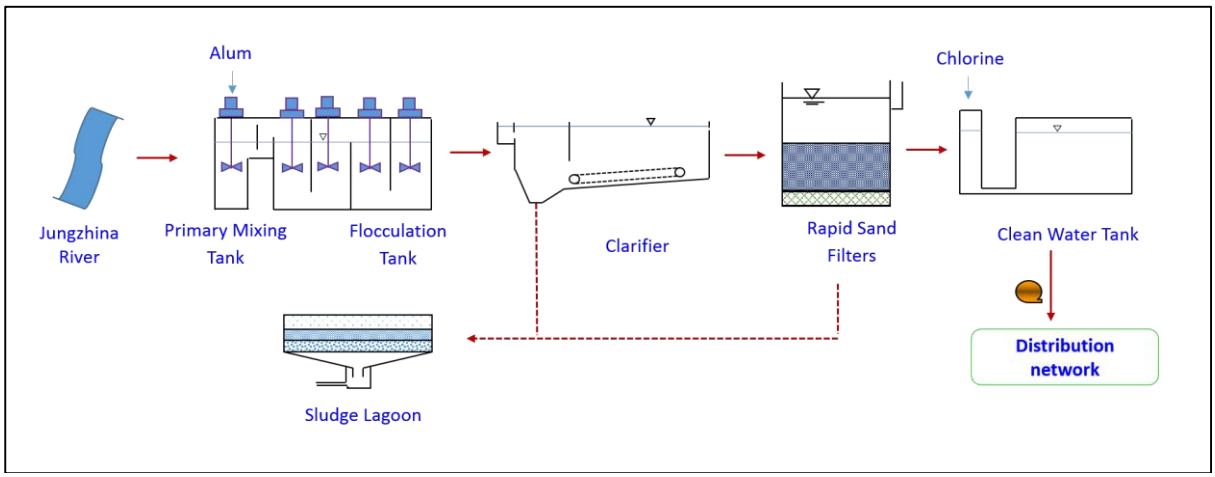

Figure 2: Schematic Diagram of Water Treatment Processes

The major water treatment process at JWTP includes:

Raw water extraction →Coagulation &Flocculation→Clarification (hopper bottom)→ Rapid Sand Filter →Chlorination→Clearwater Reservoir→ Distribution.

Sludge generated from clarification tanks and filter backwash is collected in the sludge and wash water lagoons.

2.1 Water intake

The source for the treatment plant is Jungzhina stream and is trapped from the tail race of the Samtenling Mini Hydelmicro hydropower plant located at Jungzhina. There is also an alternate intake located upstream of the Micro Hydropower Plant which is used during the shutdown of the Micro Hydropower Plant for annual maintenance. A 300 mm diameter ductile iron pipe carries the raw water from the open channel to the treatment plant. The flow through the pipe is regulated by a slice valve (outside the building) and a butterfly valve (inside the building). The intake chamber outlet is equipped with a screen to filter out grass, pieces of wood, straw and other materials. The raw water flows through the Parshell flume which measures the quantity of flowing water by an ultrasonic measuring transducer, reading the height of the water flowing through the flume.

2.2 Chemicals

At the JWTP, three kinds of chemicals are mainly used for the water treatment process namely alum for coagulation, hydrated lime for pH control of raw water and bleaching powder (calcium hypochlorite) for disinfection. The chemical dosing equipment consists of a mixing tank (one working and one standby) and a dosing tank with connecting pipes and fittings and the chemicals are all dosed through gravity flow. The required quantity of chemical is poured into the chemical mixing tank and water is added until a volume of 1 m^3 is reached. The chemicals are agitated vigorously by the mixer or agitator until the chemical is fully dissolved. The mixer is operated manually and is fitted with blades or impellers.

Table 2: Usage of chemicals

Chemical	% solution/ suspension	Dosing point	Frequency of dosing
Alum	10% solution	WTP inlet	During monsoon
Hydrated lime	5% suspension	WTP inlet & After clarification	During monsoon
Calcium hypochlorite	0.8% Cl+ solution	Clear water tank	Daily

As turbidity of the raw water significantly drops down to <5 NTU, alum dosing is not required during the dry season. In 2014, turbidity reached the maximum level of 2.83 NTU in the dry season (October to May) while during the wet season (June to September) the maximum raw water turbidity was 27.73 NTU. Moreover, in times of sudden heavy downpours, the raw water turbidity peaks to around 100 NTU during which the operators divert the flow from the treatment plant until the turbidity is reduced.

Figure 3: Chlorine dosing tank with mixer

Figure 4: Alum dosing tank with mixer

2.3 Coagulation-Flocculation

Currently, JWTP is using alum as a coagulant and flocculation is being done through rapid mixing and hydraulic flocculation method. There is one unit of coagulator and flocculator and has a Hydraulic Retention Time (HRT) of 20 minutes.

Figure 5: Coagulation and flocculation

2.4 Clarification

Water from the flocculation is sent to the four candy tanks (8 m x 8m X 7.6 m) which are hopper bottom tanks with the vertical flow. The sedimentation tanks are cleaned once in a month. The clarified water flows in a channel to the rapid sand filters and the sludge from the clarifier is sent to the sludge lagoon.

Figure 6: Clarification Tanks

2.5 Rapid filtration tank

There are four units of rapid sand filters which have an area of 14.5 m^2 each. It utilizes fine sand along with gravels as the media. Configuration of the sand and gravel in the rapid sand filter are as follow:

Table 3: Media in Rapid Sand Filter

Media	Effective Size (mm)	Thickness (mm)
Sand	1.1-1.5	1200
Gravel	3-5	100
Gravel	5-8	100
Gravel	8-15	100
Gravel	25-35	100

The filter media filters impurities with the filtration rate of 4.5 $m^3/h/m^2$. Backwashing is done by blowing air through an air compressor followed by backwashing with treated water from the clear water reservoir. Backwashing is done once in twelve days on normal days and more frequent during the monsoon. Backwash water is drained to the sludge lagoon.

Figure 7 Rapid sand filter

Figure 8 Control panel for backwashing

2.6 Disinfection process

Chlorine is finally added to the water based on the flow and the target chlorine dose. Standard Operating Procedures for the dose calculation are also available. There is two chlorinators (1 working and 1 for standby) at JWPT.

2.7 Clearwater storage tank

The treated water is then stored in a reinforced cement concrete tank with the capacity of 600 m^3 which is then pumped to various service reservoirs within the service area.

2.8 Sludge disposal

The backwash water from the filters and the sludge from the coagulation and flocculation is collected in the sludge lagoon. Sludge is removed through the lever operated valves located at the bottom of the flocculation tanks. The effluent from the sludge lagoon is drained to the storm water drains while the obtained sludge is disposed to the landfill.

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

The alternative intake located on the upstream side of the Micro Hydropower Plant is used during the shutdown of the Plant for annual maintenance. Further upstream of the alternative intake, there are few human settlements which discharge untreated wastewater and solid waste in the raw water source making it difficult for the treatment.

Also, since the treatment plant lies on a lower ground, water has to be pumped out from the plant to various reservoirs. In order to supply 6,500 m^3 of water in a day, it is expected that pumps are operated for twenty-four hours a day. Unfortunately, due to the breakdowns, the pump has not been able to operate continuously thereby leading to underproduction of treated water.

Figure 9: Medium pressure pumps

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

- Non-Revenue Water for the JWTP is 30% and the main reason behind it is the leakages, illegal connections, etc.
- The JWTP collects water from the tailrace channel of the Samtenling Mini Hydel (a micro hydropower). The raw water runs along the road in an open channel from the hydel to the intake chamber. Since the channel is open and close to the road, it causes surface water to accumulate in it during the monsoon season. This leads to added pollution load to the treatment units during the monsoon season.

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

The water safety plan (WSP) for JWTP has been developed and implementation of the plan has been initiated by the municipality. The water safety plan is a systematic risk management approach encompassing the whole system from the source to the consumers. Moreover, water safety plans are valuable tools to guide the municipality in identifying and prioritizing system needs, from low-cost operational and management solutions to more capital-intensive infrastructure improvements. WSPs serve to maximize the effectiveness and sustainability of the treatment plant by ensuring that appropriate operations and management systems are in place to support the water supply system over the long term.

6. Recent investment made for the plant's improvement

- Backwash outlet pipe was recently cleaned for the improving the performance.
- Training program for the development of water safety plan was conducted.

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

- Improvement of laboratory facilities and equipment
- Need for online operational monitoring of the water treatment plant
- Development of skills of the operators on operational monitoring of the treatment plant

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

The municipality maintains a complaint register and more than half of the complaints are related to the quantity of water. According to a random household survey carried out in 2015 to assess the water supply scenario for Thimphu city, about 72% of the consumers reported to be satisfied with the water services provided by the Municipality. Unsatisfied consumers highlighted the need of an adequate supply of water followed by reliability, quality, and pressure of the supplied water.

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

In JWTP, the raw water first flows through the Parshall flume which measures the volume of the intake. Parshall flume is equipped with an ultrasonic measuring transducer which reads the height of the water flowing through the flume.

10. Other Highlights

Coagulant and lime dosing are done only during the monsoon season which usually falls between June to September. This is because in the dry season, the turbidity of the raw water is significantly less (<5 NTU).

11. Water quality data

Raw water and treated water quality are analyzed and monitored at the treatment plant. The water quality data for 2014 is as shown in Table 3.

Table 4: Water quality data (2014)

Parameter	Unit	Raw water		Treated water	
		Min	Max	Min	Max
Turbidity	NTU	0	27.73	0	4.56
pH		6.5	7.6	6.5	7.5
Conductivity	µs/cm	13	25	-	-
Hardness	mg/L	30	50	30	50
Residual Chlorine*	mg/L	NA	NA	1	2

*Source: http://www.phls.gov.bt/web/wp-content/uploads/2015/07/volume2.pdf

12. References

1. Jungzhina water treatment plant. (2015).Water safety plan for JWTP 2015 (Internal Report)

2. PHL (Public Health Laboratory), 2015. Quarterly Disease Surveillance Bulletin. Ministry of Health, Thimpu, Bhutan. Retrieved from: http://www.phls.gov.bt/web/wp-content/uploads /2015/07/ volume2.pdf. Accessed on 31 March 2016

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