Chembarambakkam Water Treatment Plant
Chennai, India

1. Background information

Chennai city, the capital of Tamil Nadu, one of the states of India, is the fourth largest city of India with the total area of 184.88 km^2. It has a population of 7.09 million as per 2011 census. The water demand (which also includes the industrial demand) for Chennai city for the year 2021 is projected to be 1,980,000 m^3/day. In Chennai organized water supply commenced in 1872 and protected water supply started since 1914. Currently, there are seven water treatment plants (WTP) to treat and supply the water. The raw water sources, the capacity of WTP and the technology is shown in **Table 1**.

Table 1. Details of WTPs of Chennai city

S.N	Location of WTP	Raw water source	Capacity of the source (Mm^3)	Capacity of WTP (m^3/day)	Technology used
1	Kilpauk	Poondi Reservoir	91	270,000	Conventional WTP with Rapid Sand filters (RSF)
		Cholavaram	24		
		Redhills Reservoir	93		
2	Puzhal	Redhills Reservoir	93	300,000	Conventional WTP with RSF
3	Surapet	Redhills Reservoir	93	14,000	Conventional WTP with RSF
4	Vadakkuthu	Veeranam lake	41	180,000	Conventional WTP with RSF
5	Chembarambakkam	Chembarambakkam lake	103	530,000	Pulsator clarifier and Aquazar V filters
6	Minjur	Seawater		100,000	Desalination plant (DP)
7	Nenmeli	Seawater		100,000	Desalination plant
Total capacity				**1,494,000**	

Chembarambakkam WTP (CWTP) has the capacity of 530,000 m^3/day and is the India's second largest single stage water treatment facility and is unconventional treatment plant with Pulsator clarifier and Aquzur V- filters. It is located at Nazarathpet, 25 km away from Chennai city and is very close to its raw water source, Chembarambakkam Lake (CL). CL receives rainwater from its own catchment and also from Krishna water source located in the adjacent state of Andhra Pradesh through an open canal. CWTP is owned by Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) and it was constructed in the year 2007 by Degremont company and is being operated and maintained by the company. This plant supplies treated water to southern part of the city.

Table 2 Overall Information of CWTP

Constructed Year	2007
Water Source	Chembarambakkam lake
Number of connections	0.195 million house service connections
Peak operating flow (m^3/day)	265,000 (present) due to non-commissioning of second treated water transmission main
Design capacity (m^3/day)	530,000
Automation	Yes
Date of access of the source information	February 2016
Reference	Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB)

CWTP makes use of state-of-the-art, proven technologies of Pulsator clarifiers and Degremont's patented Aquazur V filters and provides highly efficient treatment with minimal water losses and a small overall footprint.

2. Water treatment process flow

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

- Raw water extraction (Chembarambakkam lake) → Raw water pumping → Cascade Aerator Pipeline → Coagulation tank → Distribution Chamber→ Pulsator Clarifier → Aquazur V-filter → Disinfection (post-chlorination) → Chlorine Contact Tank → Clean Water Reservoir → Treated water pumping →Distribution

- Sludge treatment: Sludge generated from pulsator clarifier is transferred to the Sludge thickner while the wastewater received from the Aquazur V Filter is primarily recovered through the wastewater recovery tank. The recovered water is channeled to the distribution chamber while the sludge generated from it is transferred to the sludge thickener. The thickened sludge is then dewatered through centrifuge unit. Sludge generated is then used for landfilling purpose at low-lying areas.

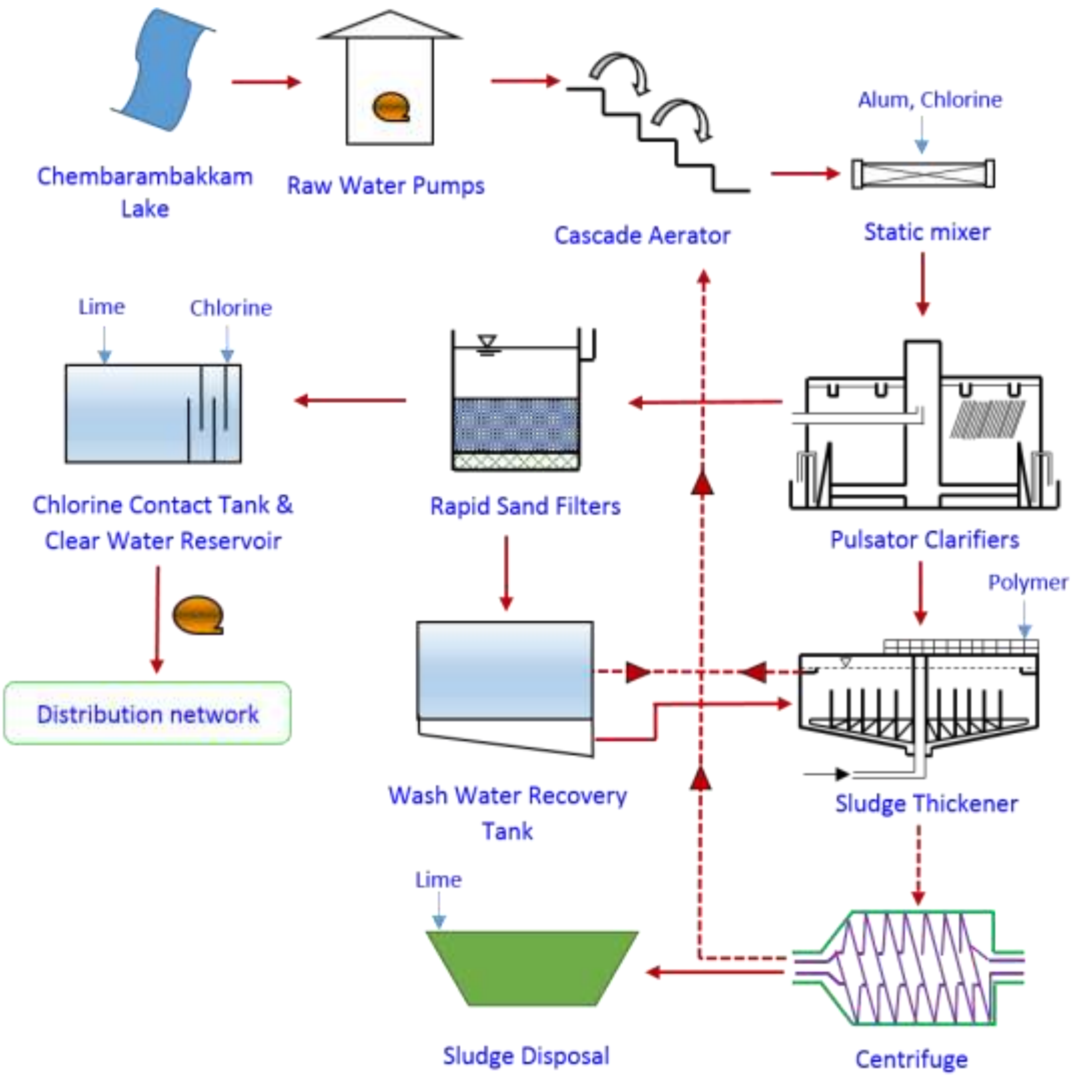

Figure 1 Water Treatment Process

2.1 Details of the Major Units of Treatment Plant

Table 2 provides the detail of the treatment facilities and units present in the CWTP for the treatment of the raw water.

Table 2 Details of the Major Treatment Units

Units	Number	Remark
Intake tower with bar screen	1	
Raw water pumping station	1	
Raw water transmission main (1500 mm dia MS pipes of 3 km long)	1	
Cascade Aerator	1	

Alum Dosing Tanks	2	
Pulsator Distribution Chambers	8	
Pulsator Clarifiers – 40m x 33.5m x 5.2m size	8	Out of 8 one is standby
Aquazur –V- Filters – 16.3m x 8m x 4m size	22	Out of 22 three are standby
Chlorine Contact Tank Cum Treated Water Reservoir	1	Divided into two compartment
Treated Water Pumping Station	1	
Transmission Pipe Lines of 11Km (each of 2000 mm diameter MS line)	2	
Clarifier Sludge Balancing Tank	1	
Waste wash water Recovery Tanks	1	Divided into Two compartments
Sludge Thickeners	3	
Centrifuges	3	

2.2 Chemicals used

Alum and liquid chlorine are the two main chemicals used at CWTP. The alum solution is prepared by mixing alum blocks (each tank consist of 20 kg's of 200 blocks and gives 5% concentration alum solution) in alum preparation tanks, filled with water and thoroughly mixed with air blower.

Figure 2. Chlorine containers

2.3 Cascade Aerator

Raw water drawn from the Chembarambakkam Lake is withdrawn through an intake with bar screen and pumped to the WTP. Initially, raw water tumbles through an elevated cascade aerator which reduces the CO_2 and H_2S concentration. Cascade aerator consist of three steps and the fall in each step is 0.5 meter. The intake tower is capable of drawing 675,000 m^3/day of raw water. After coagulation with alum the water flows first to the distribution chamber and then into the Pulsator clarifiers.

Figure 3. Cascade aerator

2.4 Pulsator Clarifier

The Pulsator clarifier (**Figure 4**) is based on sludge blanket process and consists of the vacuum chamber and flat-bottomed tank with a series of perforated distribution pipes with deflectors at its base to distribute the raw water uniformly over the entire bottom. It also consists clarified water collection channels. Pulsator clarifier with its components is shown in **Figure 5**.

Figure 4. Pulsator clarifier

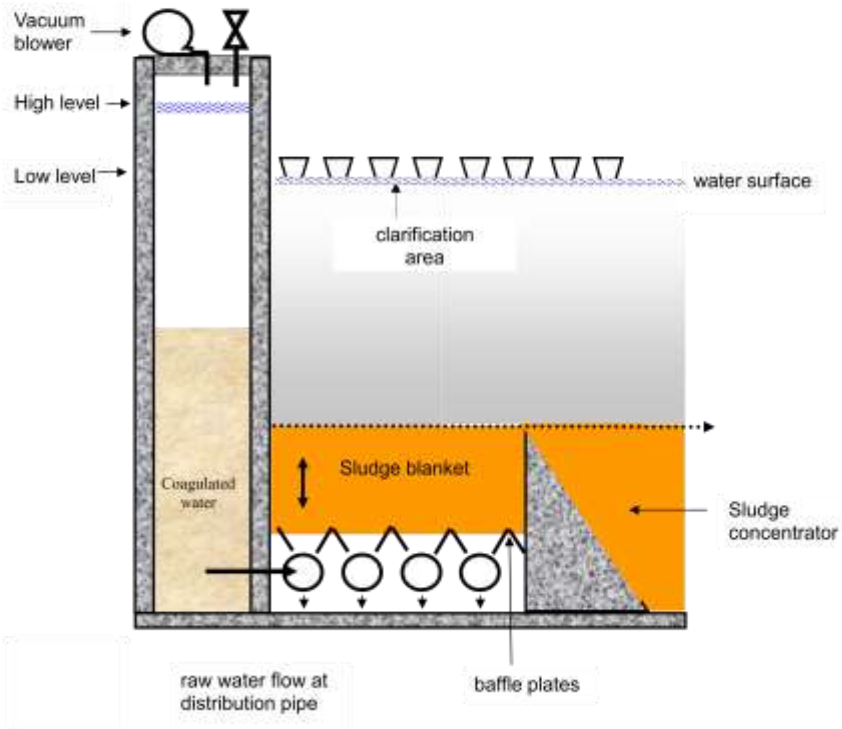

Figure 5. Cross section of Pulsator clarifier with its components

The coagulated water from distribution chamber flows to the upper part of the vacuum chamber. To provide an intermittent supply to the distribution pipes the air is sucked from the top of the vacuum chamber with a blower. As a result, the water level is lifted gradually inside the vacuum chamber. When it reaches a specified level above the water level in the clarifier, the vacuum break valve (**Figure 6**) gets open which allows atmospheric air into the vacuum chamber. Due to the atmospheric pressure, the water level in the vacuum chamber is lowered and the coagulated water rushes into the distribution pipes with deflectors (baffle plates) at high velocity and correspondingly the level in the vacuum chamber drops. When the water level inside the vacuum chamber reaches the lower set point, the vacuum break valve is closed and the cycle continues.

Figure 6. Vacuum break valve

The arrangements of perforated distribution pipes and the deflectors (baffle plates) of Pulsator clarifier are shown in **Figures 7 and 8.**

Figure 7. Distribution pipes of Pulsator clarifier

Figure 8. Distribution pipes with deflectors of Pulsator clarifier

The water then flows upward through sludge blanket and the clarified water is collected by the clarified water collection channels provided at the top of the Pulsator (**Figure 9**), to flow evenly and to prevent any velocity irregularities within the tank.

Figure 9. Clarified water collection channels of clarifier

The sludge blanket in the lower part of the Pulsator clarifier is subjected to alternating vertical motions similar to heart pulsation. It expands during the entry of water at a high velocity for a short time of 10-15 sec., (adjustable) and then contracts during stopping of flow for 30-50 sec, (adjustable). The Pulsator has no mechanical sludge stirring system and it is the sludge blanket, which is constantly in motion expanding and contracting within few seconds when the vacuum system is at operation. This process ensures the complete and rapid formation of the flocs and entrapment of the flocs during the expansion of the sludge blanket.

The volume of sludge blanket gradually increases because of the entrapped and settled flocs from the flocculated water. The thickness of the blanket, therefore, rises regularly, and the sludge from the top of the sludge blanket falls into the concentrators, from where the sludge is extracted at regular intervals by to the sludge sump. Pulsator clarifier at the CWTP has the retention time of 2 hours and the suspended solid removal rate is about 80%.

2.5 Filtration

Clarified water from the Pulsator clarifier then fed to Aquazur V filters. There are 22 units (19 numbers working and 3 numbers standby) of Aquazur V filters each with the dimension of 16.3m x 8m x 4m, for filtration. The filters have 120 cm of sand media with the effective size of 0.95 mm. The average filtration rate of 158 Lpm/m^2 is normally observed. The Aquazur V filter is a rapid gravity filter system and consists of a rectangular tank that is divided longitudinally into two filtration bays by a central channel. The underdrain system is constructed of perforated 600 mm square precast concrete slabs fitted with long stem plastic air diffuser nozzles as shown in **Figure 10 and 11**. During the filtering, cycle water drains through the under-drain nozzles into the filtered water plenum and discharges into clear water reservoir where the chlorination is performed. During the backwashing cycle both filtered water and pressurized air travel in a reverse path into the plenum below the slab and escape through the under-drain nozzles into the filter media to clean the filter. The backwashing is normally done once in 3 days and it takes about 10 minutes to finish the backwashing.

Figure 10. Floor level of filter with perforated precast RCC slab

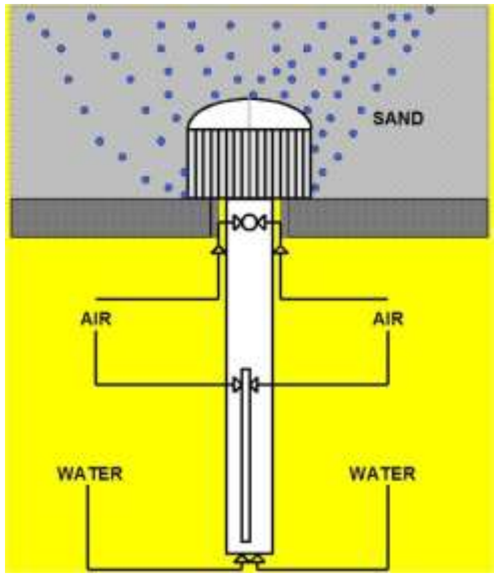

Figure 11. Air diffuser nozzle

2.6 Chlorine contact tank and Clean water reservoir

The filtered water flows to the chlorine contact tank (CCT). Chlorine is dosed at 2.0 mg/L as disinfectant and the free residual chlorine of 0.5 mg/L is maintained in the CCT of 61.0m x 47 m x 4.6m which has the chlorine contact time of 30 min. Further, lime is also added to maintain the pH of the treated water in between 7 to 8.5. The lime solution dosage is determined by conducting the jar test in the laboratory. Disinfected water is collected in a clear water reservoir and then pumped through 2000 mm transmission main for distribution.

2.7 Wash-water Recovery

The dirty backwash water from the filter cleaning is collected in wastewater recovery tank, where suspended solids are allowed to settle. The supernatant is collected and pumped back to cascade aerator and mixed with raw water for treatment. Supernatant has the turbidity of 20 NTU which is twice raw water turbidity.

2.8 Sludge Management

The sludge from the concentrator of Pulsator clarifier is drawn by gravity at regular interval into the sludge sump. From there the sludge is pumped to the sludge thickeners. The polyelectrolyte solution is dosed at the dosing chamber to the thickeners. The thickened sludge is pumped by variable speed positive displacement pumps to the centrifuges (30 m^3/h) to dewater the thickened sludge. The polymer dose is about 5 kg/tonnes of sludge. Lime powder is also added to the dewatered sludge to improve the dryness of the solids before disposal by filling in the low-lying area within WTP site. The recovered water is returned back to the cascade aerator.

Figure 12. Sludge Thickener

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

Chembarambakkam Lake is prone to water pollution as no regulation and monitoring mechanism exists for controlling the dumping of wastewater in it. Agricultural activity in its catchment also contaminates the lake water due to the runoff of agricultural waste in the lake. In 2007 government has planned to build an industrial park near the Chembarambakkam Lake which can further pollute the source water. Moreover during the rainy season the sewer water gets mixed with the lake water which makes the treatment process expensive.

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

- One of the environmental groups has raised a question about the threat from industrial effluents as Tamil Nadu lacks regulation on industrial effluents which could lead to contamination of source water in future[3]. Thus, Chembarambakkam Lake could see the rise of persistent organic effluents which could threaten the quality of the treated water in future.
- The WTP is presently operated at 50% design capacity, since the second 1200 mm dia. clear water pumping main is under construction.
- During floods, the turbidity increases to about 50 NTU which is higher than the normal level.

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

- Monitoring of Chembarambakkam Lake for microbiological and physiochemical parameters
- Alum dose is adjusted based on the result of jar test to cope with the peaked turbidity during the flood.

- New pipelines are being laid to expand the distribution network. Thus more water can be produced after the completion of the expansion project.

6. Recent investment made for the plant's improvement

No recent improvement has been made as the plants have been recently constructed and are equipped with modern technology.

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

No operational difficult is felt. However, the treatment plant has been running at 50% of its capacity and needs a proper distribution network to operate at its full potential.

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

CMWSSB has clarified that the water quality complies with the drinking water quality and it meets all the standards and is safe for drinking. CSWSSB staffs collect the sample from the various residence and public taps for the field test every day which is then examined at the lab. CMWSSB recently released results of the samples that quantify the supplied water to be of good quality with all the physical, chemical (calcium, magnesium, total hardness, chlorides, sulfates, iron, dissolved oxygen) and bacteriological parameters under the permissible limit.

However, regarding the quantity of the water supply, CMWSSB is unable to meet the water demand. In addition, water is distributed through small distribution reservoirs (2 m^3 capacity Sintex tanks with taps) fed by mobile water tankers to the economically weaker section of people, who do not have the affordability for house service connections. People collects this water for their consumptive uses. For other uses, they collect water from groundwater fitted with hand pump/power pump. The distribution pipes in core city are very old and are being replaced in phases. The residual chlorine in the tail end of the distribution system is zero. Hence chlorination is done in the distribution system to increase the residual chlorine level to about 0.2 mg/L. The distribution pipeline for the CWTP is under construction and the completion of this network will relieve the pressure of CSWSSB to some extent.

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

Chembarambakkam WTP Plant operation is fully automated and managed using SCADA system with the support of Program Logic Controller (PLC).

10. Other Highlights

- It is the second largest single WTP in India.

- CWTP production process only has 1.5% of water loss and the dewatered water from sludge thickener and backwash water is sent back to the cascade aerator for the treatment process.

11. Water quality data

The quality of raw water and treated water are presented in **Table 3**. The treated water quality is well within the national standard for drinking water of India

Table 3 Raw Water and Treated Water Quality

Parameter	Units	Raw water characteristics of Chembrambakkam lake		Average quality of treated water	Standard of Government of India
		Minimum	Maximum		
Turbidity	NTU	10	100	0	1
pH		7.0	9.0	7.2	7.0 – 8.5
Alkalinity	mg/L as $CaCo_3$	30	200	50	200
Total Hardness	mg/L as $CaCo_3$	20	200	50	200
Total dissolved solids (TDS)	mg/L	50	150	75	500

12. References

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