Report On Study Of Desalination Process Of Seawater At Chennai India

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*Picture 1: Me at the desalination plant in Chennai**

*Note: *Photography is not allowed at this plant except for the one shared here with prior permission.*

Abstract

Desalination is the process of removing the salt content from sea water and treating it through a series of mechanical and chemical processes, to make it potable. The plant that I visited is located at a distance of 45 kilometres from Chennai and is built next to the sea. It is designed to extract sea water, treat it and then supply it to the city of Chennai.

This plant has been built by Wabag which is a 90+ years old multinational company specialising in water treatment for municipalities and industries alike. Here are more details about the company - https://www.wabag.com/about-us/

In this report, I explain the process of desalination and the learning from my visit.

Acknowledgements

I am thankful to Mr. Amir Basha, CTO of the WABAG Desalination plant at Chennai. Mr Basha helped me understand the process in detail and also showed me around the plant, explaining each stage of desalination in detail.

I am also grateful to Mr Shailesh Kumar, CEO at VA Tech WABAG for accepting my request to visit the plant and arranging this field study visit for me.

Table Of Contents

1. Background 1

2. The Desalination Process 1

    1. Intake System 2

    2. Pre-Treatment System 2

    3. Reverse Osmosis System 2

    3.1 Energy Recovery Device 3

    4. Re-Mineralisation System 3

    5. Brine Disposal System 4

3. Conclusion 4

4. References 4

Background

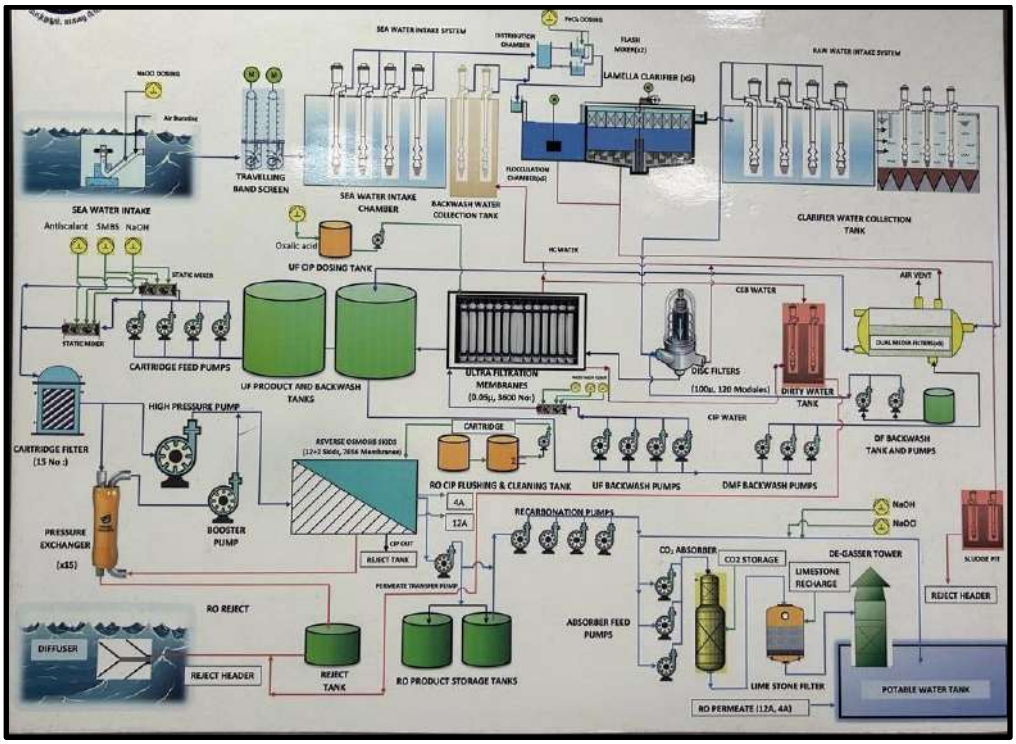
Chennai has grown into a metropolis like many other Indian cities and has an estimated population of 12.4 million. The water supply from various sources in the city, including groundwater, is approximately 985 million litres per day (MLD) against a demand of 1200 MLD, which itself is expected to grow to 2000 MLD in the next 5-7 years. Alternate sources of water supply including desalination plants, RO plants and water channels from distant reservoirs have been planned and deployed over the last few years. Groundwater recharge has been depleting over the years and is grossly insufficient to meet the needs of the burgeoning population.

Chennai also attracts a large number of tourists and citizens of neighbouring countries for medical treatments. The floating population itself is estimated to be half a million at any point in time.

The Desalination Process

Desalination of seawater is one of the sustainable ways of keeping up with the water requirements of the city.

Desalination process: Process flow diagram



Source: WABAG

The desalination process comprises five systems. Each of these systems are also stages in desalination.

1. **Intake System**: The function of the intake system is to bring the sea water to the plant. Water is taken from 1 km deep in the sea, and because of the sump, the water flows automatically. Chlorine is added to prevent the growth of algae or marine organisms during this phase of the transfer of water from the sea to the plant.

2. **Pre-Treatment System**: This system pre-treats the water and makes it suitable for the Reverse Osmosis (RO) area. RO membranes require a certain quality of water that can permeate through them and hence pre-treatment is necessary. This process is also in stages.

    a. The first stage is to remove particles above 4mm through a sieve. If it gets clogged, it starts rotating and a spray nozzle removes the separated waste into a chute that takes the waste into a skip and then onto trucks, for disposal. Usually, small shells, algae, jellyfish, etc. are removed at this level.
    b. The water then moves to the distribution chamber. Ferric Chloride is added to water in the distribution chamber, to agglomerate the particles. This is then sent to the flocculator that has a paddle which rotates at very slow speeds of 1.6 RPM. Due to this rotation motion and presence of ferric chloride, the particles get attached to each other (agglomeration) and the heavier particles settle down.
    c. The water is then sent to the Lamella Clarifier system which has multiple plates of membranes, inclined at 65 degrees. This makes the particles fall into the hopper and settle down and form a sludge which is removed.
    d. The clear water is then sent to disc filters which have 100 micron membrane filters.
    e. Water with particles less than 100 micros then moves to the next stage of the ultra-filtration system which has membranes of 0.5 microns. This can even remove bacteria.
    f. Every hour there is a backwash process that removes the particles that are stopped from going through and clears the filter membranes.
    g. This pre-treated water is now pure salt water. Sodium Metabisulfite is added at this stage, which is an oxygen scavenging agent and removes chlorine at this stage. Antiscalant is also added at this stage. A 5-micron filter is used before sending this to the RO system.

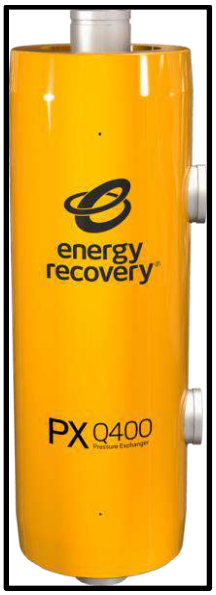
3. **Reverse Osmosis System**: This is the heart of the plant. The RO system consists of multiple membranes with very fine pores. Since RO is a cold process, a high pressure pumping system is also part of this stage to push the water through the membranes at pressures of 60 bars. When water is pushed through these membranes, only the water molecules pass through and the salt in the water is retained. This can eventually block the membranes. So the RO process allows only 44% of the sea water to get converted

into pure water. This water is called **permeate** water. The 56% which is rejected contains the salt and is fed back into the sea. This water is called **brine**. This saves the membranes from scaling due to salt deposition. Antiscalant chemicals are also injected to prevent scaling.

There are software programmes that can project the safe limit of any sample of seawater. These are used to decide what percentage of water can be treated. The RO water filters used at homes use the same principle and a lot of water is rejected.

Energy Recovery Device: This is a unique machine which is considered a breakthrough innovation for energy conservation and sustainability. The equipment does not use any energy or bearings.

Energy recovery device



Source : https://energyrecovery.com/

The brine water which is rejected carries the pressure energy in it. This water transfers its energy through the energy transfer device to the low pressure feed water on the other end. The specific power consumption of the high pressure pump, due to this energy recovery, has reduced to one third of what it used to be. In actual terms, the plant used to need 9 KWH/metre cube (of water) of specific energy which has now reduced to 3.7 KWH/ metre cube.

A video describing how the energy recovery device works is here:
https://energyrecovery.com/pressure-exchangers/high-pressure-px

4. **Re-Mineralisation System**: The RO water that comes out of the third stage is slightly acidic in nature with a pH of 6.5-6.7. The water that needs to be supplied is required to have a pH of 8.3-8.5 with some chlorine content for preservation of water during storage, transmission, etc. Remineralisation is the process of adding calcium and

chlorine to the permeate water. Calcium is added by injecting carbon dioxide into the permeate water that converts it into carbonic acid. This then passes through a line that contains calcite. The carbonic acid releases the lime in the calcite and calcium gets added into the water. This hardens the water and also increases the pH to the required levels.

LSI: Langelier Saturation Index - this is a measure of how corrosive the water is. This is found out through saturation levels of calcium carbonate ($CaCO_3$) which should be in the range of -0.3 to +0.3. Ideal LSI is 0 and anything less than -0.3 makes the water corrosive. The remineralisation process also checks the LSI of water and makes it positive so that when it is supplied it does not corrode the transmission pipes.

5. **Brine Disposal System**: If all the rejected water is released into the sea in one place, due to high salt concentration, it can endanger marine life. Therefore, the water is discharged through a diffuser which has multiple nozzles. The diffuser is immersed to depths of 500 metres into the sea and water is gradually released through these nozzles to help its gradual mixing with the natural seawater.

Thermal Desalination: All other systems are the same, except for the RO system. Instead of that, the water is heated and distilled. Disposal of waste is also more carefully done because of the high temperatures involved in the process.

Conclusion

Climate change has highlighted the need for more sustainable means of consuming natural resources, by humans. We must also respect other living beings on our planet and not harm them in the pursuit of consuming more natural resources. All such initiatives, which form a part of sustainability efforts, need to be mainstreamed. Seawater desalination is one such way of giving back to the planet and marine life. I learnt about the intricacies of this process and will be ever grateful for this opportunity to appreciate the mechanics of environmental science. I want to make my pursuit of science and engineering purposeful and impactful.

References

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