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Studying the Chemical Properties of RO Water in Thermal Power Station

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ABSTRACT

This work deals with the studying the chemical properties of RO water of thermal power plant. The research involved the analysis of RO water through key water quality parameters and by the most convenient analytical tools. The study deals with the conferences of AL-Doura power thermal station that was built in 1966, and bombed in 1980 in first Gulf war, made additional built (two unit each produced 160 Mw) in 1985 by Siemens and in 1988 built second two unit each produced 160Mw by Ansaldo. Quality of representative samples of the RO water permeate stream was accomplished in January 2016, April 2016 and July 2015 during the day and at evening.

The results show that the average of conductivity values at evening was lower than at day. Also, the average of conductivity values at January was lower than April and July; the average of conductivity values of April was lower than July.
Keywords: RO Water; Reverse Osmosis; Pretreatment in Thermal Power Station

I. INTRODUCTION

A thermal power station is a power plant in which heat energy is converted to electric power. In most of the world the turbine is steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated; this is known as a Rankine cycle. The greatest variation in the design of thermal power stations is due to the different heat sources, fossil fuel dominates here, although nuclear heat energy and solar heat energy are also used. Some prefer to use the term energy center because such facilities convert forms of heat energy into electrical energy. Certain thermal power plants also are designed to produce heat energy for industrial purposes of district heating, or desalination of water, in addition to generating electrical power. (1)

II. METHODS AND MATERIAL

Water systems of thermal power plants:-

Figure 1 gives an example of water-related systems used at thermal power plants. In the main water system of power plants, water circulates starting as condensate, followed by boiler feed water, boiler water (in the boiler) and steam (in the turbine), and finally returning to condensate. The water that is lost during the circulation is compensated for by supplying make-up water. The other water-related systems are:

1. The make-up water treatment system to supply highly-purified water obtained after the treatment of raw water such as industrial water.
2. The chemical dosing and water quality monitoring systems to monitor and adjust water quality for corrosion prevention.
3. The condensate treatment system to purify the circulating-water in a plant (mainly installed for once-through boilers).
4. The wastewater treatment system to purify wastewater from the devices and components of thermal power plant facilities. (2)

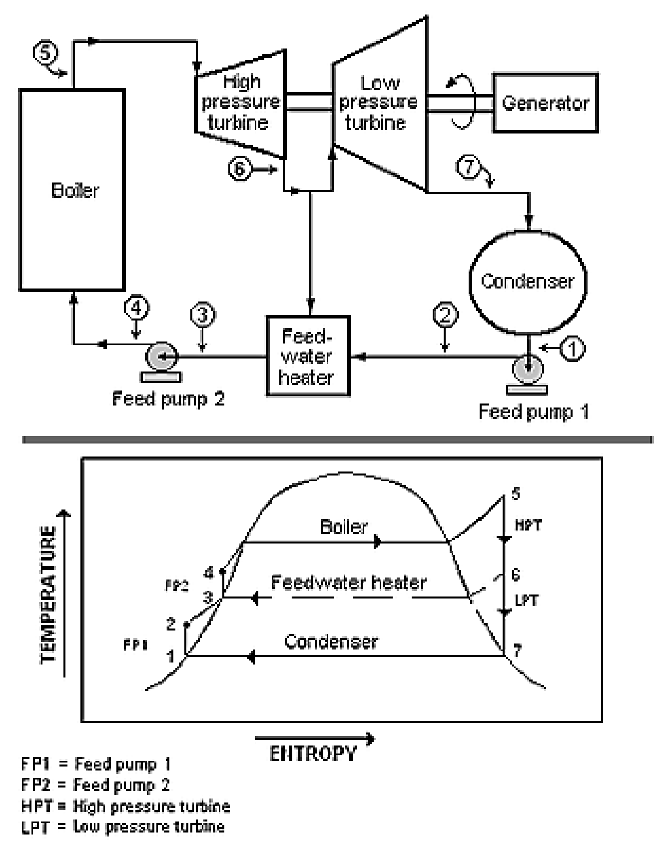


Figure 1:- water-related system at thermal power plant

Make – Up Water Treatment Stages:-

Power plants that burn fossil fuels or produce nuclear reactions for the generation of electricity require almost 560 billion Liters of water per day for steam production and cooling purposes. In order to keep these plants as efficient as possible, the quality of the water is vital.

Ultra-high-purity water is required for makeup in high pressure steam generating systems. However, relatively high concentrations of impurities can be tolerated in makeup water for open recirculating cooling systems. These plants require a constant intake of water to replace water lost through sampling systems, steam losses, evaporation from cooling, and blow down.

- ✓ Since there is a constant loss of cycle water for one reason or another, it is always necessary to have a continual source of incoming water.
- ✓ Treating this water is the beginning of the power plant's cycle chemistry.
- ✓ Makeup treatment almost always consists of demineralization to remove dissolved impurities.
- ✓ Other pretreatment equipment consists of softeners, clarifiers, and filters.
- ✓ On an increasing basis, membrane technology is being used along with ion exchangers for effective demineralization treatment.
- ✓ The overall goal of the demineralization treatment is to yield high purity water for use in the overall feed-water/condensate cycle. (3)

Across the spectrum of industrial and municipal water utilization and treatment plants, extensive desalination and purification of water relies on the use of reverse osmosis (RO) membranes. Sustaining the productivity of RO plants as continuous processes for water purification has been since the late 1970s, and still is, a significant technological challenge. The challenge is magnified on the one hand by the increasing shortages of water thus driving down the quality of available raw waters, and on the other hand by the demand and the high cost of lost production that can result from insufficient productivity of RO systems. Reduced productivity of RO plants exerts serious economic impact on the downstream production of steam, power, microelectronics, pharmaceuticals and beverages among other products. Not only used in the front-end to provide supply of high quality process water, the loss of RO capacity to process wastewater at the back-end to allow regulated discharges can shut down production or operation of some industrial complexes. With all these requirements, efficient operation and maintenance (O&M) of RO plants based on an understanding of chemistry is essential. (4)

Reverse Osmosis

Osmosis is a natural phenomenon in which a solvent (usually water) passes through a Semi permeable barrier from the side with lower solute concentration to the higher solute concentration side. As shown in Figure 2a, water flow continues until chemical potential equilibrium of the solvent is established. At equilibrium, the pressure difference between the two sides of the membrane is equal to the osmotic pressure of the solution. To reverse the flow of water (solvent), a pressure difference greater than the osmotic pressure difference is applied Figure 2b; as a result, separation of water from the solution occurs as pure water flows from the high concentration side to the low concentration side. This phenomenon is termed reverse osmosis (it has also been referred to as hyperfiltration).

A reverse osmosis membrane acts as the semi permeable barrier to flow in the RO process, allowing selective passage of a particular species (solvent, usually water) while partially or completely retaining other species (solutes). Chemical potential gradients across the membrane provide the driving forces for solute and solvent transport across the membrane Figure 2c. (5)

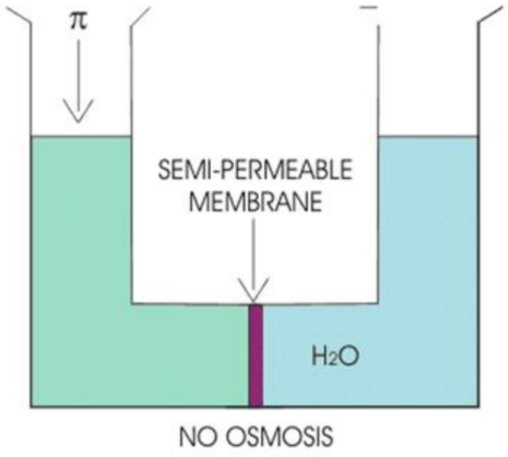


Figure 2a:- No Osmosis

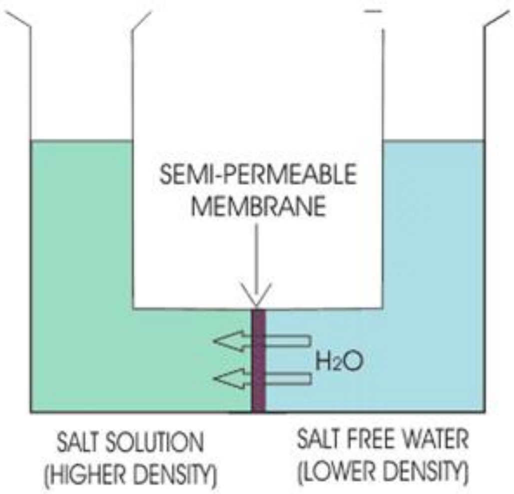


Figure 2b:- Osmosis phenomenon

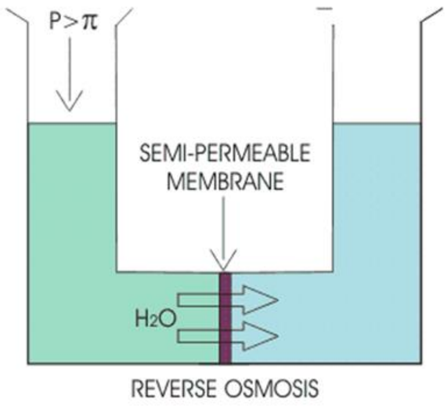


Figure 2c:- Reverse Osmosis Process

RO Process Description and Terminology

The RO process is relatively simple in design. It consists of a feed water source, feed pretreatment, high pressure pump, RO membrane modules, and, in some cases, post treatment steps.

A schematic of the RO process is shown in Figure 2c. The three streams (and associated variables) of the RO membrane process are shown in Figure 3: the feed; the product stream called the permeate; and the concentrated feed stream, called the concentrate.

In a batch membrane system, water is recovered from the system as the concentrate is recycled to the feed tank; as a result, if the solute is rejected the feed concentration continuously increases over time. For a continuous membrane system, fresh feed is continuously supplied to the membrane.

Water flux is sometimes normalized relative to the initial or pure water flux. (6)

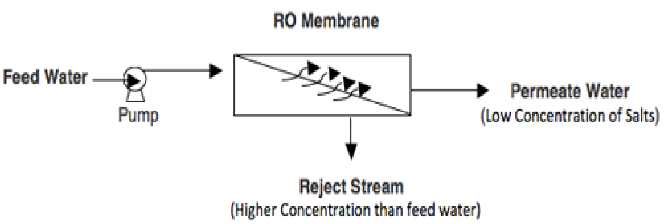
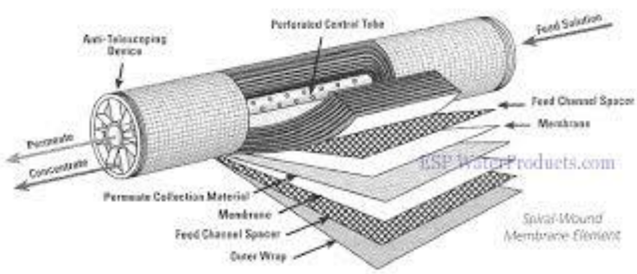


Figure 3:- The streams of the RO membrane process

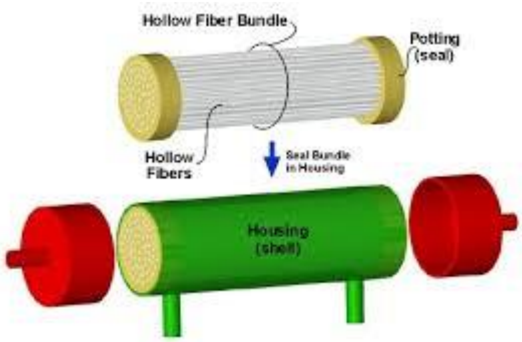
Membrane Modules

There are four main types of modules: plate-and-frame, tubular, spiral wound, and hollow fiber (Figure 4). The plate-and-frame module is the simplest configuration, consisting of two end plates, the flat sheet membrane, and spacers. In tubular modules, the membrane is often on the inside of a tube, and the feed solution is pumped through the tube. The most popular module in industry for nano filtration or reverse osmosis membranes is the spiral wound module. This module has a flat sheet membrane wrapped around a perforated permeate collection tube. The feed flows on one side of the membrane. Permeate is collected on the other side of the membrane and spirals in towards the center collection tube.

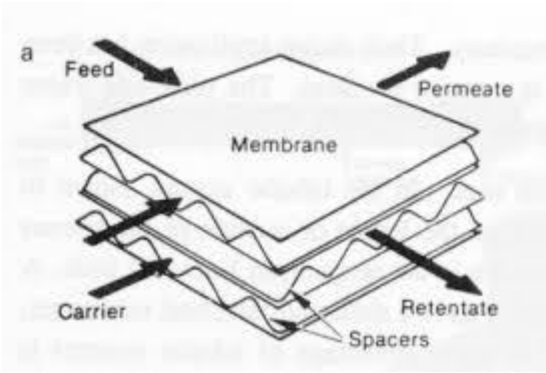
Hollow fiber modules used for seawater desalination consist of bundles of hollow fibers in a pressure vessel. They can have a shell-side feed configuration where the feed passes along the outside of the fibers and exits the fiber ends. Hollow fiber modules can also be used in a bore-side feed configuration where the feed is circulated through the fibers. Hollow fibers employed for waste water treatment and in membrane bioreactors are not always used in pressure vessels. Bundles of fibers can be suspended in the feed solution, and the permeate is collected from one end of the fibers. (7)



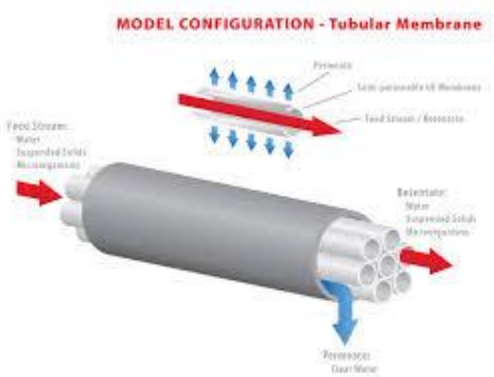
(a). Spiral wound type



(b). Hollow fiber type



(c). Plate-and-frame type



(d). Tubular type

Figure 4 : four main types of membrane modules

Experimental Work

Standard methods are used to conduct the measurements of conductivity of permeate stream of RO unit in thermal power station.

III. RESULTS AND DISCUSSION

Quality of representative samples of the RO water permeate stream in AL-Doura thermal power plant was accomplished in January 2016, April 2016 and July 2015 during the day and at evening.

The parameter (conductivity) of water quality RO water are presented in table 1,2 and table3 of the results in January 2016, April 2016 and July 2015 respectively at day and evening.

We take January as cold month, April as temperate month and July as hot month .It is found that the value of conductivity would varies between the operation during the day and at evening and also varies between the months according to the weather of these months. In

January the lowest conductivity value in 04/01/2016 was (18Ms\cm) at evening and the greater one in 30/01/2016 was (30 Ms\cm) at day.

In April the lowest conductivity value in 16/04/2016 was (29 Ms\cm) at evening and the greater one in 26/04/2016 and 30/04/2016 was (53 Ms\cm) at day. In July the lowest conductivity value in 02/07/2015 was (28 Ms\cm) at evening and the greater one in 26/07/2015 was (66 Ms\cm) at day.

The average of conductivity in January 2016 during the day was (23.9 Ms\cm) and at the evening was (21.7 Ms\cm) after removing the unnatural values because of unusual circumstance of operation.

The average of conductivity in April 2016 during the day was (45.5 Ms\cm) and at the evening was (36.1 Ms\cm).

The average of conductivity in July 2015 during the day was (55.8 Ms\cm) and at the evening was (39.7 Ms\cm). There are unnatural values out of ranges in 11/01/2016 at evening (52 Ms\cm) and in 13/01/2016 at day (160 Ms\cm) because of operation problems like the cell of RO stage needs to wash or regeneration or the membrane damage.

January 2016	**Conductivity (Ms\cm)**		**Date**	**Conductivity (Ms\cm)**	
Date	**At day**	**At evening**		**At day**	**At evening**
01/01/2016	25	23	16/01/2016	21	19
02/01/2016	24	22	17/01/2016	24	22
03/01/2016	23	21	18/01/2016	26	23
04/01/2016	21	18	19/01/2016	28	24
05/01/2016	22	19	20/01/2016	22	20
06/01/2016	23	20	21/01/2016	24	21
07/01/2016	21	20	22/01/2016	23	19
08/01/2016	21	20	23/01/2016	25	23
09/01/2016	20	19	24/01/2016	24	21
10/01/2016	21	20	25/01/2016	26	23
11/01/2016	22	52	26/01/2016	28	25
12/01/2016	22	20	27/01/2016	27	24
13/01/2016	160	22	28/01/2016	28	26
14/01/2016	23	21	29/01/2016	29	27
15/01/2016	22	20	30/01/2016	30	28

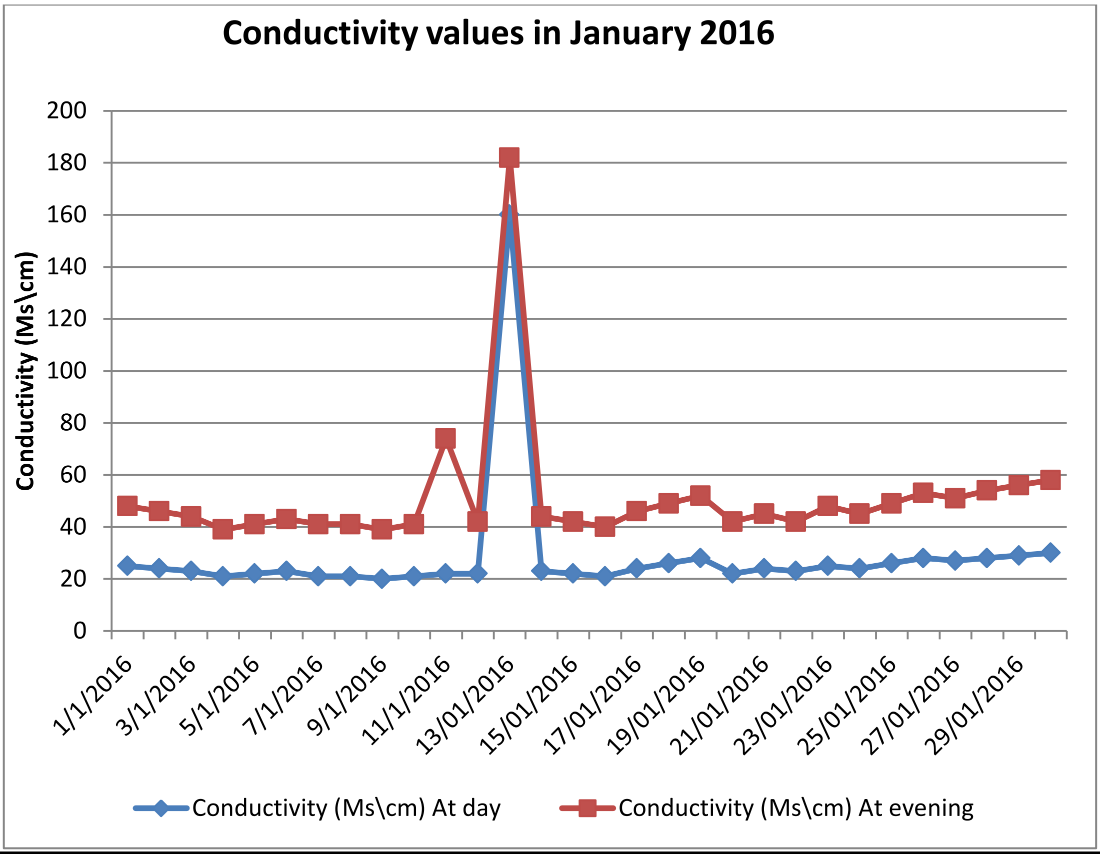
Table 1: The Conductivity of permeate stream of RO unit in January 2016

April 2016	Conductivity (Ms\cm)	
Date	**At day**	**At evening**
01/04/2016	42	31
02/04/2016	42	30
03/04/2016	44	30
04/04/2016	40	39
05/04/2016	42	32
06/04/2016	39	32
07/04/2016	51	40
08/04/2016	50	40
09/04/2016	43	37
10/04/2016	45	37
11/04/2016	42	35
12/04/2016	42	34
13/04/2016	40	31
14/04/2016	41	32
15/04/2016	42	30
16/04/2016	41	29
17/04/2016	44	33
18/04/2016	52	41
19/04/2016	50	41
20/04/2016	45	40
21/04/2016	44	39
22/04/2016	42	38
23/04/2016	48	39
24/04/2016	46	35
25/04/2016	50	39
26/04/2016	53	40
27/04/2016	51	41
28/04/2016	52	40
29/04/2016	50	39
30/04/2016	53	41

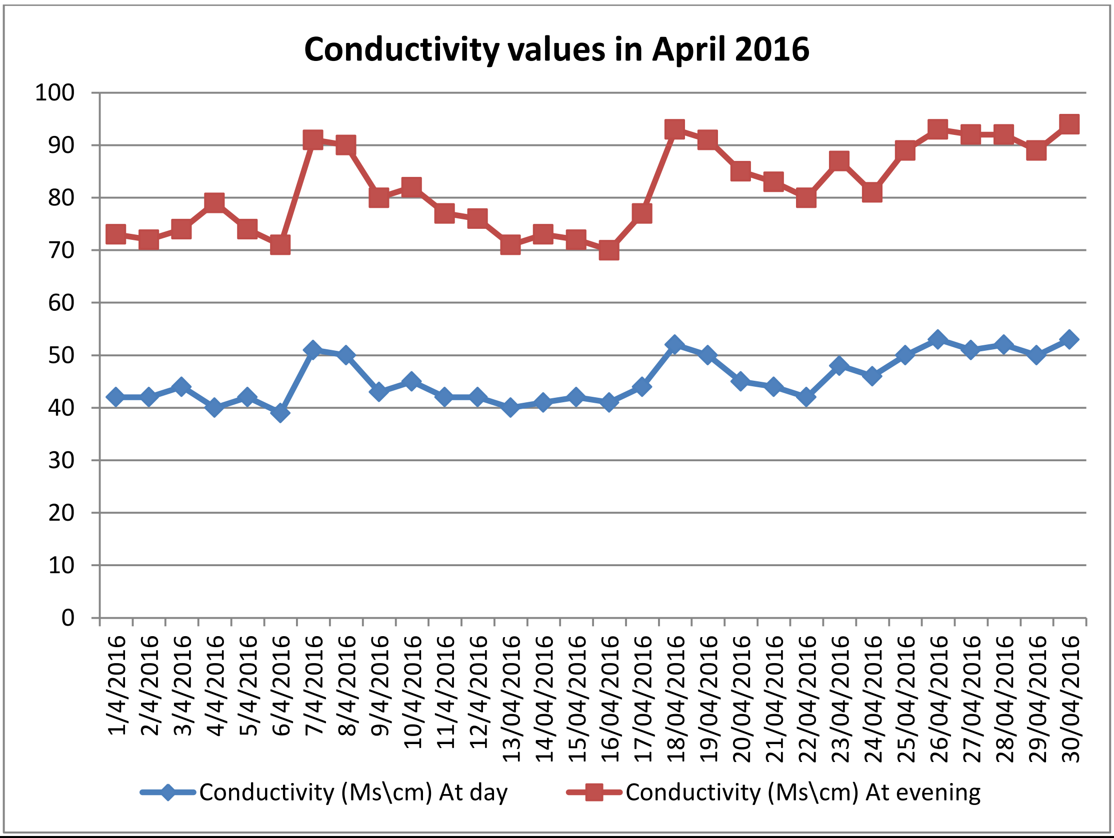
Table 2 : the Conductivity of permeate stream of RO unit in April 2016

July 2015	Conductivity (Ms\cm)	
Date	**At day**	**At evening**
01/07/2015	49	30
02/07/2015	41	28
03/07/2015	48	31
04/07/2015	42	33
05/07/2015	41	32
06/07/2015	48	31
07/07/2015	45	30
08/07/2015	45	29
09/07/2015	51	34
10/07/2015	55	36
11/07/2015	55	37
12/07/2015	55	36
13/07/2015	53	35
14/07/2015	53	36
15/07/2015	55	39
16/07/2015	53	36
17/07/2015	62	39
18/07/2015	54	37
19/07/2015	56	38
20/07/2015	59	42
21/07/2015	62	46
22/07/2015	51	38
23/07/2015	55	45
24/07/2015	61	42
25/07/2015	67	62
26/07/2015	66	58
27/07/2015	57	53
28/07/2015	58	50
29/07/2015	59	54
30/07/2015	60	56

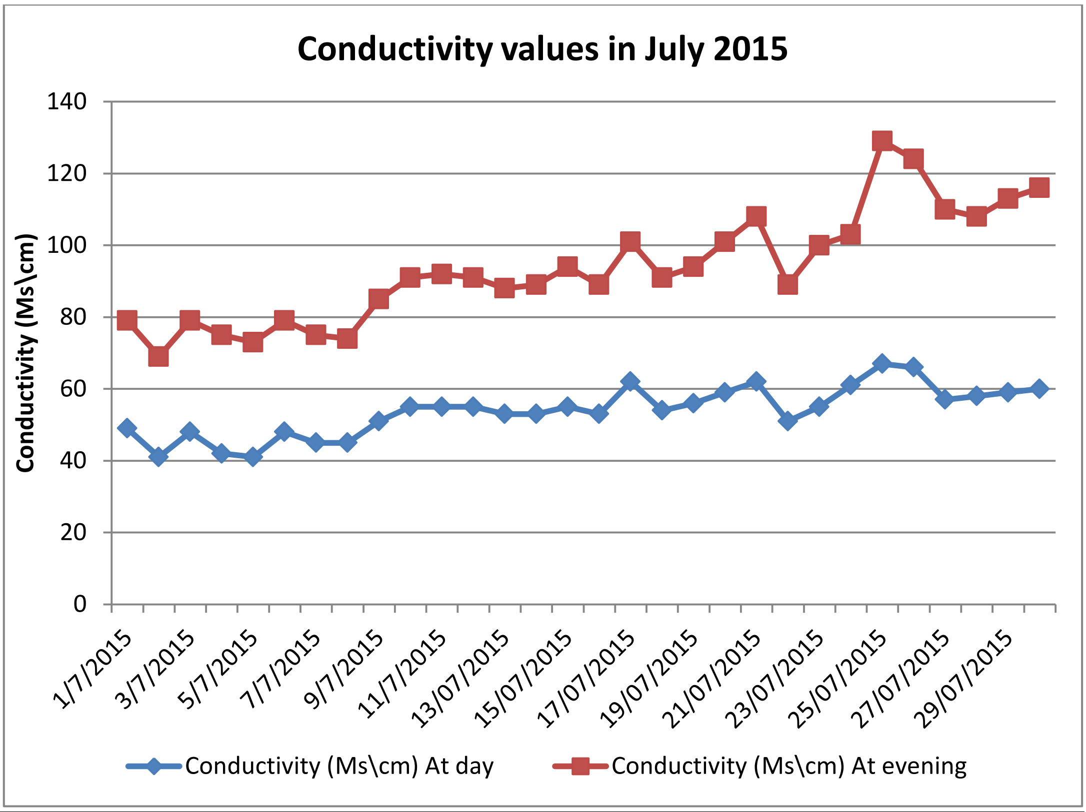
Table 3: the Conductivity of permeate stream of RO unit in July 2015



Conductivity values in January 2016
Conductivity (Ms\cm)
200
180
160
140
120
100
80
60
40
20
0
1/1/2016
3/1/2016
5/1/2016
7/1/2016
9/1/2016
11/1/2016
13/01/2016
15/01/2016
17/01/2016
19/01/2016
21/01/2016
23/01/2016
25/01/2016
27/01/2016
29/01/2016
Conductivity (Ms\cm) At day
Conductivity (Ms\cm) At evening



Conductivity values in April 2016
100
90
80
70
60
50
40
30
20
10
0
1/4/2016
2/4/2016
3/4/2016
4/4/2016
5/4/2016
6/4/2016
7/4/2016
8/4/2016
9/4/2016
10/4/2016
11/4/2016
12/4/2016
13/04/2016
14/04/2016
15/04/2016
16/04/2016
17/04/2016
18/04/2016
19/04/2016
20/04/2016
21/04/2016
22/04/2016
23/04/2016
24/04/2016
25/04/2016
26/04/2016
27/04/2016
28/04/2016
29/04/2016
30/04/2016
Conductivity (Ms\cm) At day
Conductivity (Ms\cm) At evening



IV. CONCLUSION

The temperature of the atmosphere was influence on the conductivity of permeate stream of RO unit in thermal power station therefore the average of conductivity values at evening was lower than at day.

Also, the average of conductivity values at January was lower than April and July; the average of conductivity values of April was lower than July.

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