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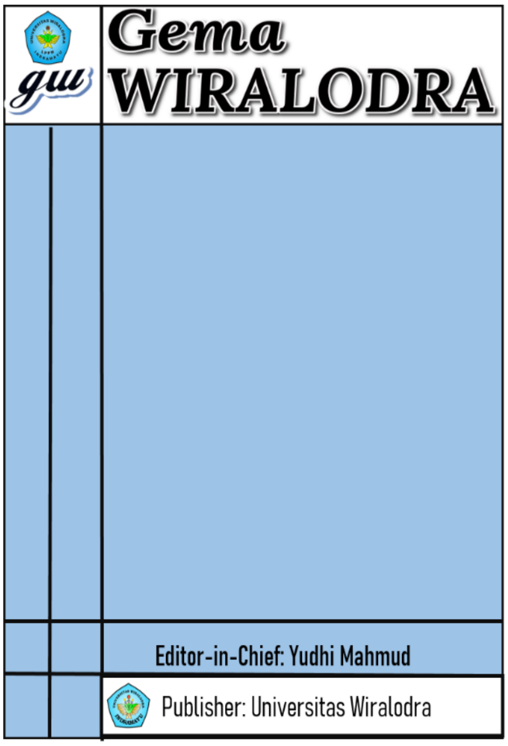

The effect of salt rejection, electric conductivity on reverse osmosis membrane performances

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Orginal Article

The effect of salt rejection, electric conductivity on reverse osmosis membrane performances

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Abstract
Process water has an important role in the petrochemical industry as a steam plant and cooling process. Sea water reverse osmosis seawater is processed through a Reverse osmosis Membrane serves to reduce the value of Total Disolved Solids contained in seawater. The performance of Sea Water Reverse Osmosis can be seen from the value of Flux, Coefficient of Permeability to TDS value and Salt Rejection. This research was conducted in February – March 2022 located at the SWRO unit of PT TPPI Tuban Regency, the methodology used was quantitative descriptive analysis based on field data which was then processed using Microsoft Excel. The results showed that the flux value of a membrane affects SWRO performance where the flux value is directly proportional to TDS and inversely proportional to salt rejection. The permeability coefficient is directly proportional to TDS and inversely proportional to salt rejection. The largest flux result is 12.623 L/m^{2}H permeability coefficient of 4508 L/m^2. H.atm with TDS value of 420.88 mg / L and salt rejection of 97.844%. The flux is directly proportional to the permeability coefficient.
Keywords: Fluks, membrane, permeability, reverse osmosis, SWRO

1. Introduction

The petrochemical industry is a sector that is being developed with products produced such as Paraxylene, Orthoxylene, and Metaxylene with raw materials from condensate and Light Naphta which is a refined product from petroleum. Currently, the national capacity for petrochemical products reaches 7.1 million tons, but imports of petrochemical products are still significant, reaching 4.6 million tons (Kemenprin, 2020). This happens because the need for Paraxylene increases and to reduce exports from outside. Paraxylene, Orthoxylene and Metaxylene will be processed into raw materials for the chemical industry such as PTA, ester resins, paint coatings, elmusifiers, abrasives, dyes, and adhesives that are widely needed in human life (Ariyanti, 2011).

PT Trans Pacific Petrochemical Indotama (TPPI) is a Petrochemical company that produces Aromatic products and petroleum products. The main products produced by PT Trans Pacific Petrochemical Indotama are Paraxylene, Ortoxylene, and Methaxylene and several petroleum products. PT TPPI produces Paraxylene 584 KTA, Orthoxylene 128 KTA and Methaxylene amounting to 38.8 kBD. Petroleum products produced by PT TPPI are Solar of 29 kBD, Fuel Oil of 4.6 kBD, Premium of 60 kBD and LPG of 80 KTA (TPPI, 2021).

The manufacture of aromatic and petroleum products requires a multilevel purification unit to obtain the desired purity of the product. Purification units and steam providers require raw water in the process (Sugiyanto, 2021, p.16). The raw water used must meet the established standards so as not to produce fouling and corrode the units involved. Many studies have been conducted to meet the needs of raw water using various methods and water treatment media, such as research that has been conducted by (Zulfi, 2014, p.23) in water treatment using manganese zeolite filters, activated carbon filters, 5 micron cartridge filters, and the use of UV as a sterilizer to produce raw water that generally does not meet water quality standards because there are still few bacteria in it.

The development of technology in water treatment has grown so rapidly, which is the answer to some of the problems that exist in the treatment of clean water into drinking water,

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one of which is filtration technology or filtration using membranes, namely Reverse Osmosis (Said, 2009). Reverse Osmosis (RO) is a filter media that has a semi-permeable membrane with pores of 0.0001 microns that can separate water from unwanted components so that water with a high level of purity will be obtained (William, 2003).

Reverse Osmosis technology uses a high-pressure pumping process to drain seawater through the membrane, which functions to separate or remove solutes in water (Husnah, 2018). RO is a controlled diffusion process that controls the mass transfer of solutes so that they can pass through the polymer membrane structure (Wenten, 1999). The diffusion of fresh water into seawater through a semipermeable membrane is influenced by osmotic force or pressure. The influence of pressure greater than osmosis pressure causes the flow of fresh water to reverse direction, namely from salt water to fresh water. Osmosis pressure is influenced by the characteristics of membrane type, temperature, salt concentration (salinity), and compounds dissolved in water (TDS) (Widiasa, 2008).

Water treatment plant is a utility unit that functions to supply raw water used for steam generation and cooling processes. Water Treatment Plant has several unit parts to treat water sourced from seawater into industrial water. Sea Water Reverse Osmosis is one of the units of the Water Treatment Plant which has a function as a converter of seawater into industrial water to support the process of making Petrochemical products in accordance with industrial water quality standards. The performance of Sea Water Reverse Osmosis can be seen from several factors such as the relationship between flux value and Permeability coefficient with the results of TDS value, EC value, and Salt Rejection (Ardiansyah, 2013).

Based on the background that has been described, a study is needed on membrane performance in terms of the value of electric conductivity and salt rejection in seawater desalination to produce fresh water using the RO system, especially for industrial raw water needs.

2. Method

This research consists of several stages, namely data collection, data processing, and data analysis. This study used quantitative descriptive method with field data collection. The data obtained is then carried out data processing and studies based on relevant research to strengthen the research.

Analysis

Analysis of TDS Indicator

The TDS value can be estimated by multiplying the DHL value by the number 0.55 – 0.75 (Canadian Water Quality Guidelines, 1987). The TDS value is usually smaller than the DHL value. In determining the TDS value, volatile materials are not measured because they involve a heating process.

$$TDS = KE.EC \quad (1)$$

Information:

TDS = Total Disolved Solid $(\frac{Mg}{L})$

KE = Faktor Korelasi (0,7)

EC = Konduktivitas Sample $(\frac{Mg}{L})$

Analysis of Flow Rate

According to the SWRO design data sheet of PT TPPI Tuban that the maximum flow rate used in SWRO is 142.86 m3 / h. The flow rate formula is as follows (Yoshi, 2016).

$$Q = A.V \quad (2)$$

Information:

Q = Debit aliran $(\frac{m3}{H})$

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A = Luas penampang m^2
V = Laju Alir $(\frac{m}{H})$

Analysis of Fluks Parameters

The average flux used in the performance of the swro membrane according to the swro data sheet is 12,65 $\frac{L}{m2.H}$. The formula for the influence of flux is as follows (Wenten, 2013).

$$J = \frac{Q}{A} \quad (3)$$

Information:
J = Fluks $(\frac{L}{m2.H})$
Q = Debit yang tersaring $(\frac{L}{H})$
A = Luas Active Area (m^2)

Analysis of Permeability Parameters

Permeability is a measure of the ease with which a liquid (e.g. water) can pass through a pore medium. Reverse Osmosis uses a semipermeable layer. The value to determine permeability uses the following formula (Wenten, 2013).

$$Lp = \frac{Jw1}{\Delta P} \quad (4)$$

Information:
Jw1 = Fluks $(\frac{L}{m2.H})$
Δp = Perubahan Tekanan (atm)
Lp = Koefisien *Permeabilitas* $(\frac{L}{m2.H,atm})$

Analysis of Salt Rejection

The percentage of salt wasted is at least ≥ 99.4%. If it is below this value, it can be estimated that there will be interference with RO and the need for cleaning (Yoshi, 2016). Salt rejection can be determined using the following equation.

$$S_R = 1 - \left(\frac{EC\ Permeate)}{EC\ Feed} x100\%\right) \quad (5)$$

Information:
SR = Garam Terbuang (%)
EC Feed = *Conductivity* Masuk $(\frac{Mg}{L})$
EC *Permeate* = *Conductivity* Produk $(\frac{Mg}{L})$

3. Results and Discussion

Result of Research Data

This research was carried out to determine the performance of reverse osmosis membranes in processing incoming feed in the form of seawater with salinity levels. Membrane has an area of 3954.82 m2 with an operating pressure of 45 – 46 kg /cm^2. Seawater as bait and permeate that enters is analyzed the value of electrical conductivity (EC) to determine the TDS value of the feed. The flow rate ranges from 45 – 50 m /hour with the same membrane surface area and pH between 7.8 – 8.1. The following data collection results are presented.

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Table 1
SWRO Data

Date	*Flow m³/H*	*EC Perm. µS/cm*	*EC Feed µS/cm*
17/07/2022	49,91	938	43500
18/07/2022	48,69	893	44300
19/07/2022	47,38	864	43000
20/07/2022	46,79	831	43100
21/07/2022	46,72	857	43800
22/07/2022	47,43	870	40100
23/07/2022	44,38	747	42500
24/07/2022	47,35	859	44800
25/07/2022	48,50	922	43500
26/07/2022	46,93	821	44300
27/07/2022	47,54	860	44600
28/07/2022	45,90	846	43300
29/07/2022	48,88	847	42700
30/07/2022	45,34	867	43100
31/07/2022	47,50	790	42700
Areas		3953,82 m^2	
Correlation Factors		0,7	
Time		1 H	

Table 2
Fluks Value Calculation Data

Date	Fluks L/m^2.H	*Salt Rejection* %	TDS Mg/L
17/07/2022	12,623	97,844	420,8806
18/07/2022	12,315	97,984	400,6891
19/07/2022	11,983	97,991	387,6768
20/07/2022	11,833	98,072	372,8697
21/07/2022	11,817	98,043	384,5359
22/07/2022	11,996	97,830	390,369
23/07/2022	11,225	98,242	335,1789
24/07/2022	11,976	98,083	385,4333
25/07/2022	12,267	97,880	413,7014
26/07/2022	11,869	98,147	368,3827
27/07/2022	12,024	98,072	385,882
28/07/2022	11,609	98,046	379,6002
29/07/2022	12,362	98,016	380,0489
30/07/2022	11,468	97,988	389,0229
31/07/2022	12,014	98,150	354,473

Permeability coefficient is one of the important parameters in determining the performance of a SWRO membrane. The Membrane Permeability Coefficient is a membrane parameter that can be passed by a species with pressure union (Rara, 2017).

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Table 3
Permeability Coefficient Value Calculation Data

Date	*Koef Permeab L/m2.H.atm*	TDS Mg/L	*Salt Rejection %*
17/07/2022	4,508	420,8806	97,844
18/07/2022	4,105	400,6891	97,984
19/07/2022	3,994	387,6768	97,991
20/07/2022	3,944	372,8697	98,072
21/07/2022	3,939	384,5359	98,043
22/07/2022	3,999	390,369	97,830
23/07/2022	3,742	335,1789	98,242
24/07/2022	3,992	385,4333	98,083
25/07/2022	4,089	413,7014	97,880
26/07/2022	3,956	368,3827	98,147
27/07/2022	4,008	385,882	98,072
28/07/2022	3,870	379,6002	98,046
29/07/2022	4,121	380,0489	98,016
30/07/2022	3,823	389,0229	97,988
31/07/2022	4,005	354,473	98,150

Discussions

The Effect of TDS Value on Membrane Flux Value

Flux is one of the membrane performance parameters in the Sea Water Reverse Osmosis process, where the flux value is a parameter to determine the amount of permeate that can be passed by the membrane per unit area per unit time, while TDS is the number of organic and inorganic compounds in a solution in the form of ions, molecules, or microgranular (colloids) (Alnori, 2013). The calculation of the TDS value in this study is obtained from the calculation of equation 2.1, while the flux value in is obtained from the calculation of equation 3.

Figure 1
Relations of Fluxs Value and TDS Value

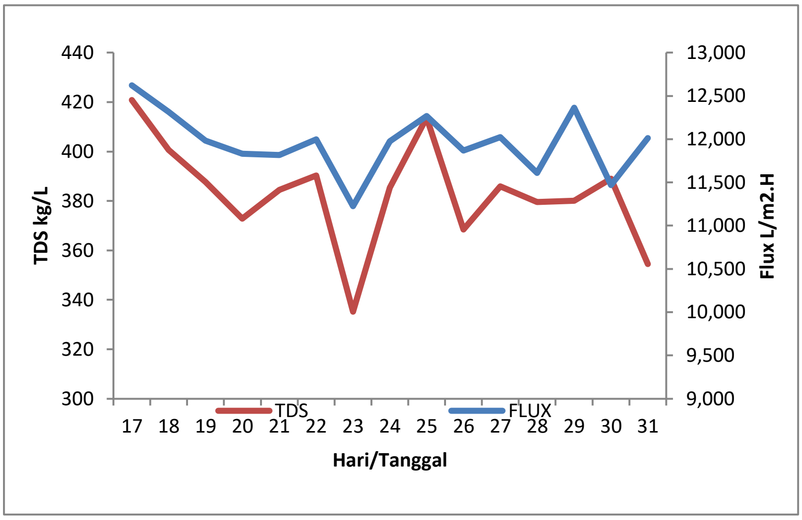

Figure 1 shows that the flux value of the membrane is directly proportional to the TDS value, where the greater the flux value, the greater the TDS value. Flux is the amount of permeate volume that passes through one unit surface area of membrane at a certain time with thrust in

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this case in the form of pressure (Fritzmann, 2007). The trend of flux and TDS values shows fluctuations, especially on the 23rd where the flux and TDS values decrease. The decrease in value correlates with the decreasing flow rate value which can be seen in table 1 on the 23rd. Permeate flux along the membrane has a direct relationship with pressure and feed flow rate where the greater the flow rate used, the volume of fluid passing through the membrane will increase so that there is an increase in flux.

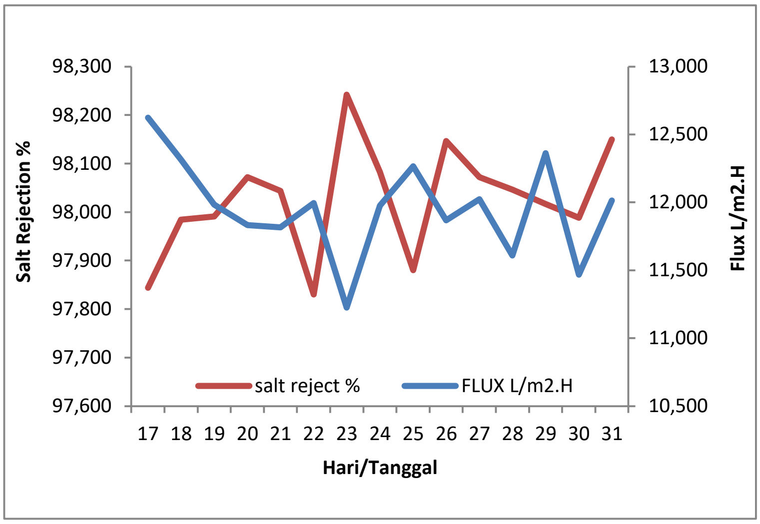
This is in accordance with the statement (Ghobeity, 2014) that flux is directly proportional to the flow rate and operating pressure with the same concentration, which means the osmotic pressure also does not change. The flow rate and operating pressure exerted on the feed water are increasing, causing the difference in operating pressure exerted with osmotic pressure to become even greater. This causes the thrust that occurs in water through the membrane to be greater, which has an impact on the greater the permeate flux produced.

Relation of flux value to salt rejection

Salt Rejection is one of the performance parameters of a SWRO membrane where the higher the salt rejection value, it can be said that the performance of the SWRO membrane is better. The value of Salt Rejection in this study was determined using equation 5.

Figure 2

Relation Fluks Value and Salt Rejection



From the data produced, it shows that the overall flux value is inversely proportional to the Salt Rejection value. The largest Salt Rejection value is obtained from the graph above, which is 98.24% with a Flux value of 11,225 $\frac{L}{m2.H}$. Reverse Osmosis is the opposite of osmosis, where reverse osmosis is the process of converting water from high concentration to low concentration by requiring a large flow rate and pressure, it can be said that the greater the flow rate, the greater the Salt Rejection that occurs in the membrane (Amaya, 2018). This indicates that the flux value should be directly proportional to salt rejection, where the higher the salt that is excluded, the higher the permeate rate on the membrane. Resosudarmo (2013) also explained that the relationship between flux value and salt rejection is directly proportional.

The flux value of salt rejection in this study is inversely proportional due to the buildup of salt concentration on the membrane surface and causes fouling. This is due to concentration polarization, which is a higher concentration of sodium chloride on the membrane wall than in the feed solution. The higher the concentration of sodium chloride in the feed solution, the greater the increase in sodium chloride concentration on the membrane wall, thus further inhibiting the rate of water flow through the membrane (Kurniawan, 2016).

In ultrafiltration membranes, a significant decrease in flux occurs based on an increase in salt concentration and correlates with the salt rejection value. The fouling potential is more dominant at high flow rates assuming the salt concentration does not change. This is in accordance with (Song, 2005, p.484) who in his research using colloidal silica, explained that the higher the salt concentration in the feed solution produces a lower flux value and the higher the fouling potential. The phenomenon can be explained based on the stability of the colloid.

The relationship of permeability value to TDS

TDS is the product of the EC value with a correlation factor, so TDS is directly proportional to EC. The permeability coefficient is the quotient between the flow rate and time, surface area and pressure changes.

Figure 3

Relations Permeability Factors and TDS

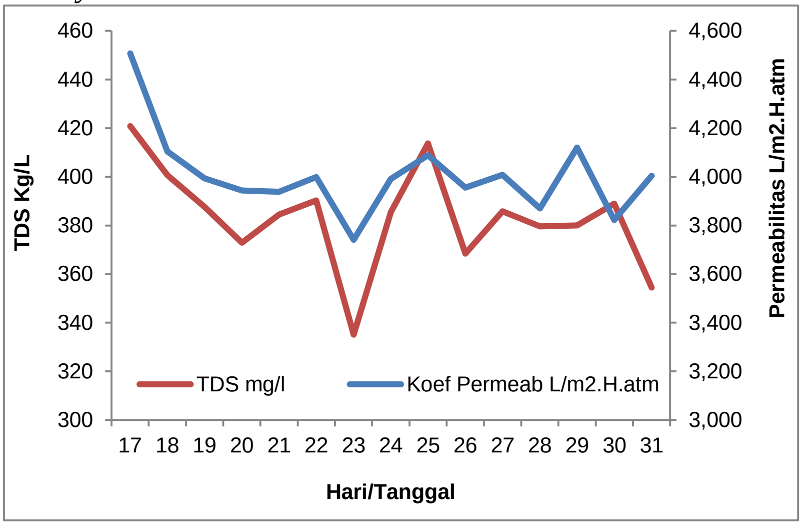


Figure 3 shows that the Permeability coefficient is directly proportional to the TDS value. The TDS value in this study is the result of the correlation factor with the conductivity of the sample. Higher sample conductivity values have an impact on high TDS values, and vice versa. Conductivity (Electrical Conductivity / DHL) is the ability of water to continue the flow of electricity. Therefore, the more dissolved salts that can be ionized, the higher the DHL value (Khairunnas, 2018). In this case, when more NaCl compounds in the solution are able to ionize by the membrane, the higher the permeate value produced. The nature of the electrolyte membrane that is hydrophilic is that if the ionic conductivity is large (large degree of sulfonation) then the permeability value is also large (polarity properties) (Tamburini, 2015).

The relationship of flux values to permeability coefficients

Flux is one of the determining parameters of SWRO performance, where flux is the ability of the membrane to produce process water in units of time. The Permeability Coefficient is the ability of the membrane to produce process water by comparing the pressure difference. The relationship between flux value and permeability of SWRO is shown in figure 4.

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Figure 4
Relations of Fluks Value and Permeability Factor

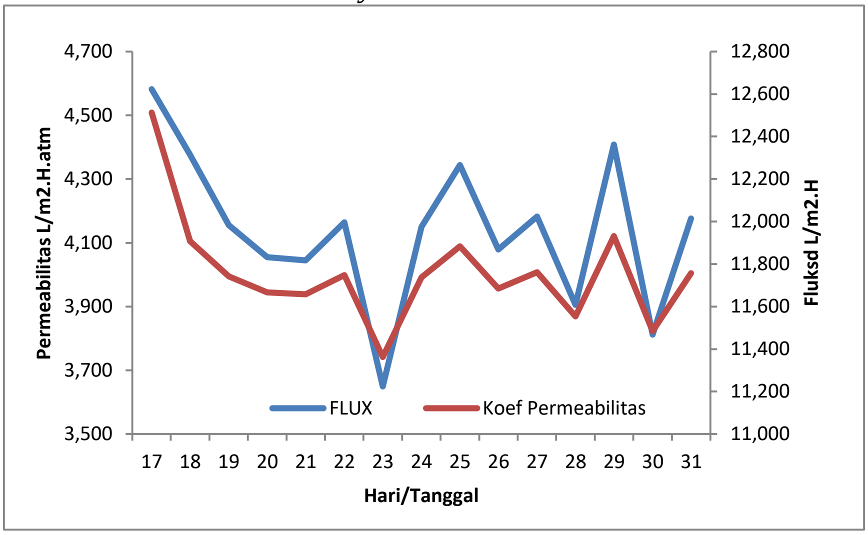

Figure 4 represents the relationship between the flux value and the SWRO membrane permeability coefficient. Where the relationship between flux value and Permeability is directly proportional to the Permeability coefficient. The Permeability Coefficient is a comparison between the flux value and pressure changes (Rara, 2017), so the greater the flux, the greater the Permeability Coefficient value. Figure 4 shows the largest flux value of 12.623 L/m^2. H with a Permeability coefficient value of 4.508 L/m^2. H.atm on July 17, 2022. The lowest flux value is 11.225 L/m^2. H with a value of Permeability coefficient 3.742 L/m^2. H.atm.

The decrease in flux value is influenced by a decrease in the flow rate produced by the Permeate Membrane, so that it will affect the value of the Permeability coefficient (Mohammed, 2014). Based on the SWRO data sheet given in the field that the flux value produced by the SWRO membrane is 12.6 L/m^2. H, while the data obtained has an average flux of 12 L / m^2.H. This shows a decrease in the ability of the membrane to produce process water.

4. Conclusion

The flux is directly proportional to TDS and inversely proportional to salt rejection. The largest flux result was 12,623 $\frac{L}{m2,H}$ with a TDS value 420,88 $\frac{Mg}{L}$ and *Salt Rejection* 97,844 %. The Permeability Coefficient is directly proportional to TDS and inversely proportional to Salt Rejection. The result of the largest Permeability coefficient is 4,508 $\frac{L}{m2,H}$ with TDS value is 420,88 $\frac{Mg}{L}$ and salt Rejection is 97,844 %.

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