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Effect of Reverse Osmosis Pressure in Groundwater Treatment Based on Silica Sand, Manganese Zeolite, and Activated Carbon Pretreatment

***Rachmat Rahadiansyah*[1], *Setyo Purwoto*[2]**

[1,2] Department of Environmental Engineering, Faculty of Engineering, University of PGRI Adi Buana Surabaya, Indonesia

ABSTRACT

Many rural communities in Indonesia still use well water as a source of water for their lives, but most of it has been polluted by human activities so it is not suitable for consumption. This study was conducted for public awareness and has considered important parameters regarding the quality of clean water, namely: total dissolved solid (TDS), iron (Fe), manganese (Mn), and E.Coli. The method used in this research is groundwater treatment with pretreatment of silica sand, manganese zeolite, and activated carbon followed by real treatment of microfiltration by reverse osmosis with pressure variations of 30, 40, and 50 psi. Improving the quality of groundwater that has been polluted due to human activities using reverse osmosis technology with pretreatment of silica sand, manganese zeolite and activated carbon obtained the best total dissolved solid (TDS) removal at RO pressure of 40 psi with an average of 1535.1 mg/L (94, 41%), the optimum removal of manganese (Mn) and iron (Fe) at RO pressures of 40 psi and 50 psi, where for Mn the average is more than 0.4108 mg/L (>94.65%), and Fe is greater than 1.1452 mg/L (>98.72%). At 50 psi RO pressure treatment, the best average removal for fecal coliform (E.Coli) was >22.2 MPN/100 ml (>92.5%).

Keywords; Groundwater, Iron, Manganese, Total Dissolved Solids, Reverse Osmosis Escherichia Coli

1. Introduction

Water is the source of life for living things on earth. Water has many functions in human life such as bathing, eating, and drinking to industrial needs. The requirements for clean water quality standards in Indonesia refer to the Ministry of RI regulation no. 32 of 2017 which regulates Environmental Health Quality Standards and Health Requirements for Sanitary Hygiene, Swimming Pools, Solis Per Aqua, and Public Baths. Water quality is a worldwide concern, especially in densely populated developing countries. This study is relevant to today's needs. This study is very important considering the welfare of the community environment. Currently, there are still many Indonesian people who use well water as a source of water in their lives. But with the increase in population, the pollution caused by human activities also increases. Many dug wells have been polluted by human activities and are unfit for use. The initial test of the sample obtained data that TDS levels were 1669 mg/L, iron levels were 1.41 mg/L, manganese levels were 0.979 mg/L and E.Coli bacteria levels were 26 MPN/100 ml. While the permissible threshold value, Total Dissolved Solid (TDS) is 1000 mg/L, iron (Fe) content is 1 mg/L, manganese (Mn) content is 0.5 mg/L and E.Coli bacteria content is 0 MPN/100 ml. Water purification can be carried out as environmentalists' learning as well as increasing human resources in terms of application of appropriate technology. The learning of filtration constituting the combination of coagulation, absorption, and ion exchange as the treatment of water treatment can be followed by micro filtration in the form of reverse osmosis (RO). (Purwoto et al., 2017).

The purpose of this research is to improve the quality of groundwater as an environmental concern through reverse osmosis technology with silica sand, manganese zeolite, and activated carbon pretreatment. The parameters studied were total dissolved solid (TDS), iron (Fe), manganese (Mn), and E.Coli with different reverse osmosis pressures with initial treatment in the form of filtration based on silica sand, activated carbon, and manganese zeolite.

2. Method

The method used in this research is groundwater treatment with silica sand, manganese zeolite, and activated carbon pretreatment followed by microfiltration real treatment using reverse osmosis with pressure variations: 30, 40, and 50 psi arranged in parallel.

According to (Purwoto et al., 2020) dan (Said et al., 2000) water treatment process to obtain better water quality can be done in the following steps:

1. Sedimentation and coagulation for discrete particle deposition using Sucolite coagulant;
2. Filtration of sludge and dissolved solids using silica sand;
3. Decrease of iron (Fe) and manganese (Mn) using ferrolite;
4. Hardness softening process and absorbent of iron (Fe) and manganese (Mn) binding using manganese green sand;
5. Exchange of anions (decrease of cation in water) using anion resin;
6. Exchange of cations (decrease of the anion in water) using cations resin (Montgomery 2005);
7. Decrease of coliform bacteria using reverse osmosis process with RO membrane;

8. Use of UV light.

The research was carried out in the following ways: Sample water from the raw tank (1) was flowed using a pump (2) to 3 filter housings containing silica sand (4), manganese zeolite (5), and activated carbon (6). Then the effluent is accommodated in the intermediate tank (7). The resulting effluent is processed using a reverse osmosis membrane (10) using a booster pump (8). The pressure variables carried out are 30, 40 and 50 psi set using a pressure gauge (9) according to a parallel circuit.

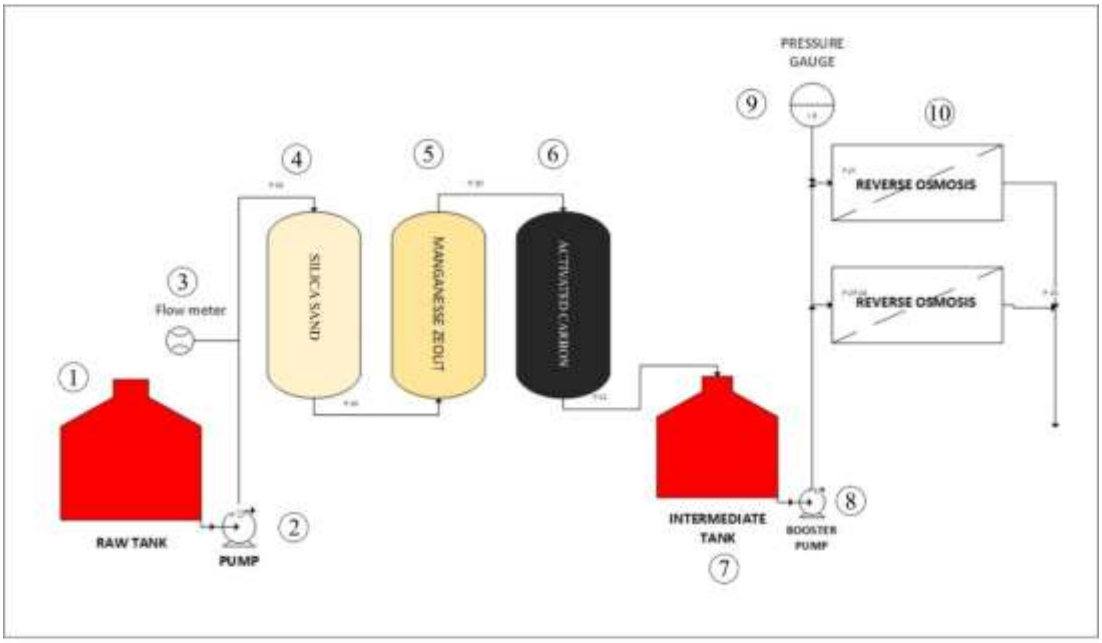

Fig. 1 - Treatment Process Flowchart

Caption:

1. Raw Tank
2. Pump
3. Flow-meter
4. Silica Sand
5. Manganese Zeolite
6. Carbon Active
7. Intermediate Tank
8. Booster Pump
9. Pressure Gauge
10. Reverse Osmosis

Data analysis method

Data from laboratory test results are described based on their group for the effectiveness of removing levels of total dissolved solid, iron (Fe), manganese (Mn), and fecal coliform according to the following formula:

$$\text{Efficiency Removal } (\%R) = \frac{S_0 - S_1}{S_0} \ x \ 100$$

where ;

%R : Efficiency Removal

S0 : Concentration Inlet/ Before Treatment

S1 : Concentration Outlet/ After Treatment

3. Results and Discussion

3.1. Results Research

3.1.1. Raw Water Sample

Laboratory tests of raw water samples for the parameters of total dissolved solid (TDS), iron (Fe), manganese (Mn), and E.Coli are presented in table 1

Table 1 - Water Quality Test Results Before Treatment

Parameters	Unit	Laboratory Result	Standard	Description
TDS	mg/L	1669	1000	exceed
Fe	mg/L	1.41	1	exceed
Mn	mg/L	0.979	0.5	exceed
E.Coli	MPN/100 mL	26	-	exceed

Based on table 1, it can be seen that the parameters of total dissolved solid (TDS), iron (Fe), manganese (Mn), and E.Coli all exceed the quality standards required by the Ministry of RI regulation no. 32 of 2017 concerning clean water.

3.1.2. Removal Parameters of Silica Sand, Manganese Zeolite, and Activated Carbon Pretreatment Results

Removal of total dissolved solid (TDS), iron (Fe), manganese (Mn), and E.Coli using silica sand, manganese zeolite, and activated carbon pretreatment is presented in Table 2.

Table 2 - Water Quality Test Results After Pre-Treatment of Silica Sand, Manganese Zeolite, and Activated Carbon

Sample	Unit	Parameter			
		Total Dissolved Solid	Mangan (Mn)	Iron (Fe)	E.Coli
inlet	mg/L	1669	0.979	1.41	26
outlet	mg/L	1626	0.434	1.16	24
Removal	mg/L	43	0.545	0.25	2
Efisiensi	%	2.58	55.67	17.73	7.7

Referring to Table 2, the results show that the parameters of total dissolved solid (TDS), iron (Fe), manganese (Mn), and E.Coli all decreased, where the decrease in total dissolved solid (TDS) was up to 1626 mg/L (2.58 %), manganese (Mn) up to 0.434 mg/L (55.67 %), iron (Fe) content up to 1.16 mg/L (17.73 %), and Fecal Coliform (E.Coli) up to 24 MPN/100 mL (7.7% %). Furthermore, the results of the effluent were carried out by microfiltration using a reverse osmosis (RO) membrane with pressure variations in parallel.

3.1.3. Removal of TDS parameters from the treatment of Silica Sand, Manganese Zeolite, Activated Carbon, and RO.

After pretreatment using silica sand, manganese zeolite, and activated carbon, followed by real treatment in the form of microfiltration using reverse osmosis (RO) with pressure variations of 30, 40 and 50 psi carried out twice, namely with the code RO-1 and RO-2, obtained data levels total dissolved solid (TDS) as presented in Table 3.

Table 3 - Test Results of Total Dissolved Solid Levels After Reverse Osmosis Treatment

Sample	Unit	RO (Pressure)		
		30 Psi	40 Psi	50 Psi
Inlet	mg/L	1626	1626	1626
RO-1	mg/L	152	101.3	140
RO-2	mg/L	105	80.5	73.2
Rerata	mg/L	128.5	90.9	106.6
Removal	mg/L	1497.5	1535.1	1519.4
Efficiency	%	92.10	94.41	93.44

Based on table 3, it is known that the levels of total dissolved solid (TDS) generally show a decrease. In reactor 1 (RO-1) with a pressure of 40 Psi showed the highest decrease up to 101.3 mg/L. The 2nd reactor (RO-2) with a pressure of 50 Psi showed the highest decrease up to 73.2 mg/L.

3.1.4. Removal of Fe parameters as a result of treatment of Silica Sand, Manganese Zeolite, Activated Carbon, and RO

After pretreatment using silica sand, manganese zeolite and activated carbon followed by real treatment in the form of microfiltration using reverse osmosis (RO) with pressure variations of 30, 40 and 50 psi, the data obtained for iron (Fe) content as presented in Table 4.

Table 4 - Test Results of Iron (Fe) Levels After Reverse Osmosis Treatment

Sample	Unit	RO (Pressure)		
		30 Psi	40 Psi	50 Psi
Inlet	mg/L	1.16	1.16	1.16
RO-1	mg/L	0.133	<0.0148	<0.0148
RO-2	mg/L	0.116	<0.0148	<0.0148
Rerata	mg/L	0.1245	<0.0148	<0.0148
Removal	mg/L	1.0355	>1.1452	>1.1452
Efficiency	%	89.27	>98.72	>98.72

Based on table 4 shows that the levels of iron (Fe) in general decreased. Reactor 1 (RO-1) with pressures of 40 and 50 Psi showed the highest decrease up to <0.0148 mg/L with the removal of more than 1.1452 mg/L. Reactor 2 (RO-2) with pressures of 40 and 50 Psi showed the highest decrease up to <0.0148 mg/L with removal of more than 1.1452 mg/L. The removal of Fe and Mn using ferrolite, decreased hardness using manganese greensand, cation reduction using anion resin, and reduction of anion using cation resin. Microfiltration uses the RO membrane, and as a water sterilizer uses UV light (Purwoto et al., 2020a).

3.1.5. Removal of Mn parameters from the treatment of Silica Sand, Manganese Zeolite, Activated Carbon, and RO.

After pretreatment using silica sand, manganese zeolite, and activated carbon followed by real treatment in the form of microfiltration using reverse osmosis (RO) with pressure variations of 30, 40, and 50 psi, the data obtained for manganese (Mn) levels are as presented in Table 5

Table 5 - Test Results of Manganese (Mn) Levels After Reverse Osmosis Treatment

Sample	Unit	RO (Pressure)		
		30 Psi	40 Psi	50 Psi
Inlet	mg/L	0.434	0.434	0.434
RO 1	mg/L	0.0232	<0.0232	<0.0232
RO 2	mg/L	0.0232	<0.0232	<0.0232
Rerata	mg/L	0.0232	<0.0232	<0.0232
Removal	mg/L	0.4108	>0.4108	>0.4108
Efficiency	%	94.65	>94.65	>94.65

Based on table 5, it is known that manganese (Mn) levels generally show a decrease. Reactor 1 (RO-1) with pressures of 40, and 50 Psi showed the highest decrease up to <0.0232 mg/L. Reactor 2 (RO-2) with pressures of 40 and 50 Psi showed the highest decrease to <0.0232 mg/L.

3.1.6. Removal of E-Coli Parameters from the treatment of Silica Sand, Manganese Zeolite, Activated Carbon, and RO.

After pretreatment using silica sand, manganese zeolite, and activated carbon followed by real treatment in the form of microfiltration using reverse osmosis (RO) with pressure variations of 30, 40, and 50 psi, data on Escherichia coli (E-Coli) levels were obtained as presented in Table 6

Table 6 - Test Results of E.Coli Bacterial Levels After Reverse Osmosis Treatment

Sample	Unit	RO (Pressure)		
		30 Psi	40 Psi	50 Psi
Inlet	MPN/100 mL	24	24	24
RO 1	MPN/100 mL	15	13	<1.8
RO 2	MPN/100 mL	6	<1.8	<1.8
Rerata	MPN/100 mL	10,5	<7.4	<1.8
Removal	MPN/100 mL	13.5	>16.6	>22.2
Efficiency	%	56.25	>69.167	>92.5

Based on table 6, it is known that fecal coliform (E.Coli) levels generally showed a decrease. Reactor 1 (RO-1) with a pressure of 50 Psi showed the highest decrease to <1.8 MPN/100 ml. Reactor 2 (RO-2) with pressures of 40 and 50 Psi showed the highest decrease up to <1.8 MPN/100 ml.

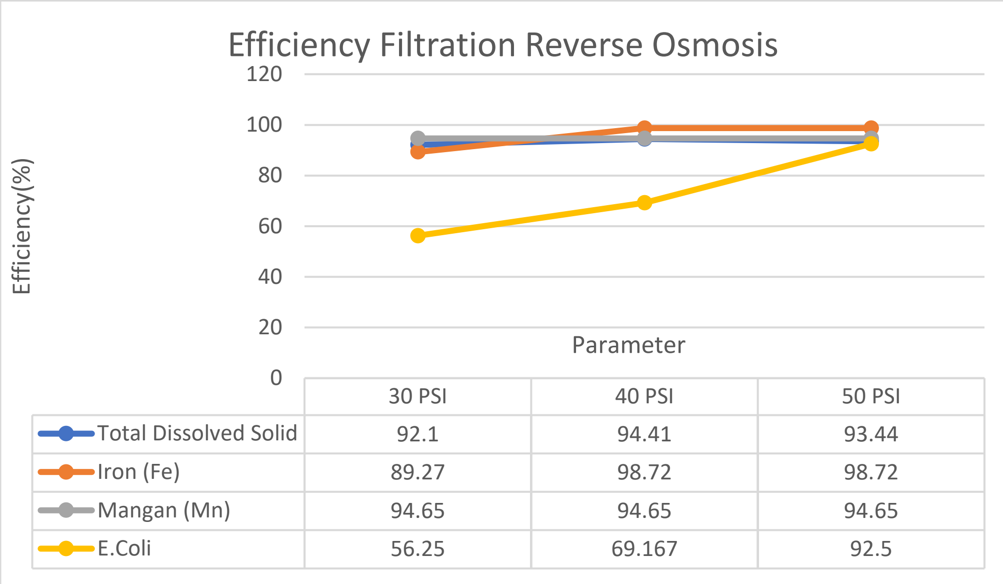

Fig. 2 - Graph of Filtration Efficiency with Reverse Osmosis

3.2. Discussion

According to (Purwoto et al., 2019) health risks relating to pollutants can generally be caused by, among other things, industrial and agricultural activities. Whereas e Coli bacteria constitute a parameter in water use. Based on the results of data analysis, the levels of total dissolved solid (TDS), iron (Fe), manganese (Mn), and E.Coli generally showed a decrease. This is evidenced by the smaller concentration of total dissolved solid (TDS) with a yield of 1626 mg/L. The decrease in total dissolved solid (TDS) levels was due to some filter media absorbing dissolved solids. Total dissolved solid (TDS) is the number of charged particles in water (Sutrisno et al., 2020). According to (Mugiyantoro et al., 2017) zeolite media and activated charcoal can bind the metal content contained in water. Zeolite filter media are compounds with active cations that move and generally act as ion exchangers. This is evidenced by the lower concentration of iron (Fe) at 1.16 mg/L. The decrease in iron (Fe) levels was caused by manganese zeolite media. Manganese zeolite functions as a catalyst at the same time the iron and manganese present in water are oxidized to form ferric oxides and manganese oxides which are insoluble in water (Purwoto et al., 2016). Based on the results of data analysis, manganese (Mn) levels generally showed a decrease. This is evidenced by the lower concentration of manganese (Mn) levels, which is 0.545 mg/L. The decrease in manganese (Mn) levels was caused by the presence of silica sand, manganese zeolite, and activated carbon media. According to research conducted (Sutrisno et al., 2020). Based on the results of data analysis, fecal coliform (E.Coli) levels generally showed a decrease, even though it was small. This is evidenced by the lower concentration of fecal coliform (E.Coli) levels, which is 24 MPN/100 mL. The results of measurements of fecal coliform (E.Coli) content showed that the results were not optimal by using filtration based on silica sand, manganese zeolite, and activated carbon. Water that will pass through the membrane with higher pressure, then the concentration of the solution in the permeate will be lower so that the dirt that escapes will decrease. If the concentration of feed water is increased, the pressure in the water will decrease because the osmotic pressure in the feed water increases. The pressure on the reverse osmosis membrane will affect the removal capacity. The rate of diffusion of salt and water through the reverse osmosis membrane depends on the chemical potential gradient, namely the difference in concentration and pressure between the two sides of the membrane (Ariyanti et al., 2017).

Based on research conducted by Purwoto (2014) that reducing E.Coli levels using a reverse osmosis membrane can reduce up to 8 col/ml. at 43 psi. it is more effective in reducing E.coli levels with a decrease to <1.8 MPN/100 mL. This is because the reverse osmosis membrane has pores measuring 0.0001 micrometers (Nalco, 2018). Meanwhile, E. Coli is a gram-negative bacterium, coccobacillus with a size of 2.4 x 0.4 -0.7 micrometer (Prasetya et al., 2019). Reverse osmosis can reduce the content of several coliform bacteria (Purwoto et al., 2020).

4. Conclusion

Improving the quality of groundwater that has been polluted due to human activities using reverse osmosis technology with pretreatment of silica sand, manganese zeolite and activated carbon obtained the best total dissolved solid (TDS) removal at RO pressure of 40 psi with an average of 1535.1 mg/L (94, 41%), the optimum removal of manganese (Mn) and iron (Fe) at RO pressures of 40 psi and 50 psi, where for Mn the average is more than 0.4108 mg/L (>94.65%), and Fe is greater than 1.1452 mg/L (>98.72%). At 50 psi RO pressure treatment, the best average removal for fecal coliform (E.Coli) was >22.2 MPN/100 ml (>92.5%).

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