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River Water Treatment Based on A Combination of Zeolite, Activated Carbon, and Reverse Osmosis (Case Study of Porong River)

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A B S T R A C T

The Porong River as a water resource has an important socio-economic and cultural function which is very important because it is used as irrigation for fish and shrimp ponds for residents along the river coast. The Porong River is currently polluted due to the large amount of industrial wastewater discharged and the Sidoarjo mud disposal outlet. This decline in river water quality can be overcome by using water treatment technology with a combination of Zeolite Filtration, Activated Carbon, and Reverse Osmosis. This study aimed to determine the differences in variations in the combination of Zeolite and Activated Carbon in reducing the parameters TDS, COD, Turbidity, and Cd Metal in Porong River water, Porong District, Sidoarjo Regency. In this study, raw water will pass through a combination of zeolite and activated carbon filter housing with a residence time of one hour, then be pumped into the RO membrane. The result of processed product water will be clean water. In this study, the best variables for reducing TDS were obtained, namely 75% activated carbon: 25% zeolite with a reduction efficiency of 1363 mg/l (51.38%); COD, namely 25% activated carbon: 75% zeolite with a reduction efficiency of 51 mg/l (67.11%); turbidity, namely 50% activated carbon: 50% zeolite with a reduction efficiency of 366 NTUs (98.12%); and Cd in variable 3, namely 25% activated carbon: 75% zeolite with a reduction efficiency of 2.997 (99.91%).

Keywords: Reverse Osmosis, Filtration, COD, TDS, Turbidity, Cd.

1. Introduction

Water plays an important role in all life because of its enormous benefits, especially for humans. Water can be consumed, as a source of irrigation, even for business continuity. In the human body, water is a determining factor for health, so consumption of clean water will determine this. Thus, the consumption of clean water should comply with standards, for example by boiling it first (Ministry Health Of RI, 1990). One of the eligibility requirements for water is in the RI Minister of Health No. 32 of 2017 concerning "Environmental Health Quality Standards and Health Requirements for Sanitary Hygiene Purposes, Solus Per Aqua Swimming Pools, and Public Baths". This study focuses on the need for sanitation hygiene which refers to Chemical Oxygen Demand (COD), Total Dissolved Solid (TDS), Turbidity, and Cadmium metal (Cd) to prove the feasibility of quality.

PT. Lapindo Brantas which occurred on May 29 2006 resulted in the inundation of residential, agricultural, and industrial areas in several sub-districts in Sidoarjo. Until now, the center of the mud is still spewing hot mud. Sidoarjo mud has a high percentage of pollutant content. The Sidoarjo Mud Management Agency (BPLS) directed the mud to the Porong River Watershed (DAS) to prevent the embankment from collapsing. This will further increase the pollution load on the water quality of the Porong River. The Porong River plays a role in supporting the daily activities of the surrounding community, especially regarding toilets (bathing, washing, toilet), agricultural irrigation, and pond water. From a study by Rachmawatie, et al, the heavy metal cadmium contained was in the range of 0.025 – 0.075 mg/l (Rachmawatie et al., 2013), the highest COD value ever measured was 34 mg/l (Suntoyo et al., 2015).

Initial laboratory tests for the Porong River showed TDS 2653 mg/l, COD 76 mg/l, turbidity 373 NTU, and metal Cd 3 mg/l. The maximum limit for TDS levels is 1000 mg/l, turbidity is 25 NTU, and Cd metal is 0.005 mg/l. The initial test results show that the Porong River's water quality is above the hygiene and sanitation water quality standards according to Ministry Of Health Regulatory No. 32 of 2017. Water purification can be carried out as environmentalists' learning and increasing human resources in terms of applying appropriate technology. Then, the technology used to reduce TDS, COD, turbidity, and Cd levels is a combination of activated carbon, zeolite, and reverse osmosis (RO) filtration. The learning of filtration constituting the combination of coagulation, absorption, and ion exchange as water treatment can be followed by microfiltration in reverse osmosis (RO) (Purwoto, 2023). The combination treatment; filtration using sediment poly propylene, absorption by carbon block and manganese zeolite, ion exchanger using synthetic anion resin and cation resin by depth of 70 cm, and then followed by Reverse Osmosis (RO) is a series of water treatment processes in order to reduce substances concentration which is a parameter for clean water (Purwoto et al., 2014).

2. Method

The method used in this research is River water treatment with a combination of activated carbon, zeolite, and reverse osmosis (RO) filtration. The variations used in the study were the different concentrations of activated carbon and zeolite with a residence time of 1 hour for each reactor. The concentration is 50% activated carbon: 50% zeolite, 75% activated carbon: 25% zeolite, and 25% activated carbon: 75% zeolite.

This research begins with collecting raw water. The raw water will flow into the filter housing which is made of a 100 cm PVC pipe filled with 70 cm thickness of the filter media combined with zeolite and activated carbon. then after 1 hour in the filter housing, the water will be pumped into the 100 gpd RO membrane with a pump pressure of 0.4 mpa. Processed water that comes out of the RO machine is then collected and tested after treatment. For variable replacement, the RO membrane will be cleaned first with aqua dest. This is done so that the RO membrane can run optimally and does not affect the test results. The outlet water that comes out of the RO machine will be tested for COD, TDS, Turbidity, and Cd levels in the laboratory.

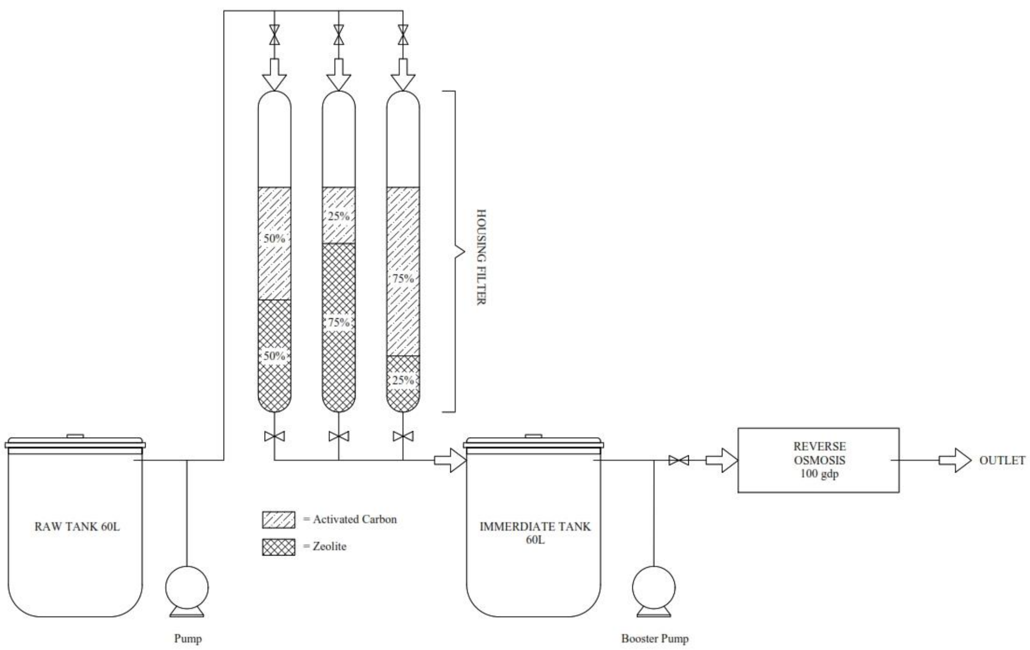

Fig. 1 – Treatment Process Flowchart

Data Analysis Method

The data collected in this study will be processed in the form of tabulations and presented in the form of tables and graphs. The data will be described based on the group. Calculation of the removal efficiency of COD, TDS, turbidity, and Cd is calculated to determine the removal value.

$$Removal\ (\%) = \frac{S_0 - S_1}{S_0} \times 100$$

Where S_0 is the parameter value before processing, while S_1 is the parameter value after processing.

3. Results and Discussion

3.1 Result Research

3.1.1 Raw Water Sample

Preliminary test results before treatment parameters of total dissolved solid (TDS), Chemical Oxigen Demand (COD), Turbidity, and Cadmium (Cd) can be seen in Table 1.

Table 1 - Water Quality Test Result Before Treatment

Parameters	Unit	Laboratory Result	Standart	Description
TDS	Mg/l	2653	1000	Exceed
COD	Mg/l	76	-	
Turbidity	NTU	373	25	Exceed
Cd	Mg/l	3	0.005	Exceed

Based on table 1, it can be seen that the parameters of total dissolved solid (TDS), turbidity, and Cadmium (Cd), 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 variable 1 50% Activated Carbon : 50% Zeolite for TDS, COD, Turbidity, and Cd

Decrease in the concentration of tds, cod, turbidity, and cd in variable 1 50% activated carbon: 50% zeolite can be seen in Table 2.

Table 2 - Water Quality Test Result On Variable 1 50% activated carbon: 50% zeolite

Sample	Unit	TDS	COD	Turbidity (NTU)	Cd
Before Treatment	Mg/l	2653	76	373	3
After Variable 1 Treatment	Mg/l	1354	30	7	0.0035
Removal	Mg/l	1299	46	366	2.997
Eficiency	%	48.96	60.53	98.12	99.88
After RO Treatment	Mg/l	319	2	0.15	0.0021
Removal	Mg/l	2334	74	372.85	2.998
Eficiency	%	87,98	97.37	99.96	99.93

referring to the second table, in variable 1, there was a decrease in all parameters, where the total decrease in TDS parameters reached 1299 mg/l (48.96%), COD 46 mg/l (60.53%), Turbidity 366 NTU (98.12%), and Cd 2.997 mg/l (99.88%). The TDS value in variable 1 has decreased, but the level is still above the clean water quality standard according to Ministry Of Health Regulatory No. 32 of 2017 which is a maximum of 1000 mg/l. After going through the Reverse Osmosis stage, the TDS level dropped significantly to a decrease of 2334 mg/l (87.98%) so that the level was below the quality standard. For other parameter values, it can already meet the clean water quality standards.

3.1.3 Removal Parameters of variable 2 75% Activated Carbon : 25% Zeolite for TDS, COD, Turbidity, and Cd

Decrease in the concentration of tds, cod, turbidity, and cd in variable 2 75% activated carbon: 25% zeolite can be seen in Table 3.

Table 3 - Water Quality Test Result On Variable 2 75% activated carbon: 25% zeolite

Sample	Unit	TDS	COD	Turbidity (NTU)	Cd
Before Treatment	Mg/l	2653	76	373	3
After Variable 2 Treatment	Mg/l	1290	33	16	0.0041
Removal	Mg/l	1363	43	357	2.996
Eficiency	%	51.38	56.58	95.71	99.86
After RO Treatment	Mg/l	320	2	0.07	0.0023
Removal	Mg/l	2333	74	372.93	2.998
Eficiency	%	87,94	97.37	99.98	99.92

Referring to the third table, in variable 2, there was a decrease in all parameters, where the total TDS parameter decreased to 1363 mg/l (51.38%), COD 43 mg/l (56.58%), Turbidity 357 NTU (95.71%), and Cd 2.996 mg/l (99.86%). The TDS value in the 2 filtration variable has decreased, but the level is still above the clean water quality standard according to Ministry Of Health Regulatory No. 32 of 2017 which is a maximum of 1000 mg/l. After going through the Reverse Osmosis stage, the TDS level dropped significantly to a decrease of 2333 mg/l (87.94%) so that the level was below the quality standard. For other parameter values, it can already meet the clean water quality standards.

3.1.4 Removal Parameters of variable 3 25% Activated Carbon : 75% Zeolite for TDS, COD, Turbidity, and Cd

Decrease in the concentration of tds, cod, turbidity, and cd in variable 3 75% activated carbon: 25% zeolite can be seen in Table 4.

Table 4 - Water Quality Test Result On Variable 3 25% activated carbon: 75% zeolite

Sample	Unit	TDS	COD	Turbidity (NTU)	Cd
Before Treatment	Mg/l	2653	76	373	3
After Variable 3 Treatment	Mg/l	1297	25	17	0.0026
Removal	Mg/l	1356	51	356	2.997
Eficiency	%	51.11	67.11	95.44	99.91
After RO Treatment	Mg/l	319	2	0.21	0.0034
Removal	Mg/l	2334	74	372.79	2.997
Eficiency	%	87,98	97.37	99.94	99.89

Referring to the fourth table, in variable 3, there was a decrease in all parameters, where the total TDS parameter decreased to 1356 mg/l (51.11%), COD 51 mg/l (67.11%), Turbidity 356 NTU (95.44%), and Cd 2.997 mg/l (99.91%). The TDS value in the 3 fitration variables has decreased, but the levels are still above the clean water quality standard according to Ministry Of Health Regulatory No. 32 of 2017 which is a maximum of 1000 mg/l. After going through the Reverse Osmosis stage, the TDS level dropped significantly to a decrease of 2334 mg/l (87.98%) so that the level was below the quality standard. For other parameter values, it can already meet the clean water quality standards.

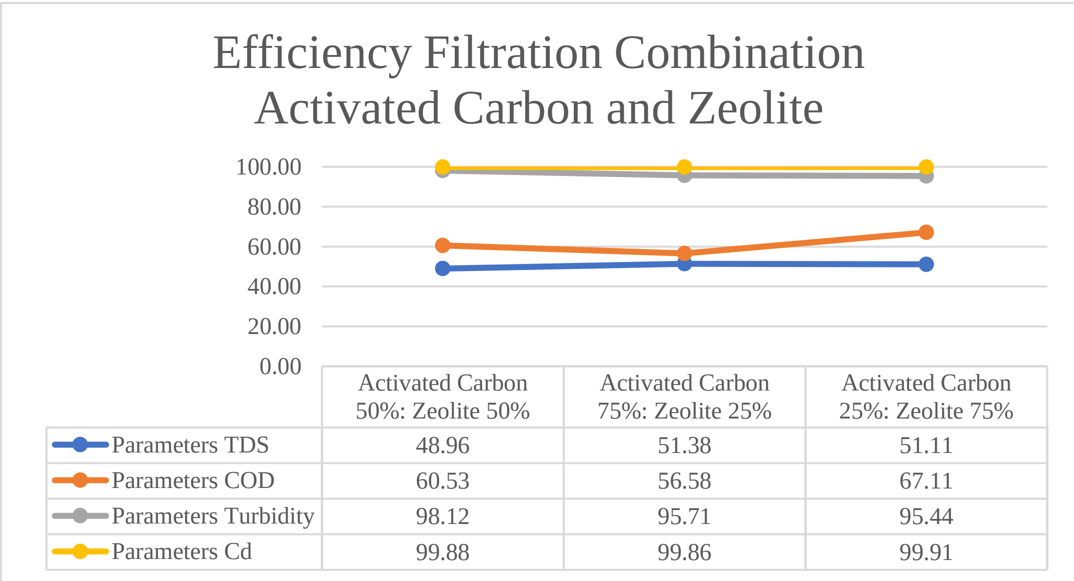

Fig. 2 – Graph of Filtration Efficiency with Combination Filtration

3.2 Discussion

The use of a combination of activated carbon and zeolite filtration for lowering the TDS value obtained successive reduction efficiency, namely 48.96%; 51.38%; and 51.11%. After going through RO filtration, obtained successive decrease efficiency is 89.98%; 87.94%; and 87.98%. The optimum conditions for lowering the TDS value are found in the filtration variations activated carbon 75%: Zeolite 25%. But in this treatment, all three variables are still not able to lower the TDS value below the threshold water quality standards for sanitation hygiene according to Ministry Of Health Regulatory No. 32 of 2017 which is at a maximum of 1000 mg/l. Therefore processing is required addition to be able to reduce TDS levels below the quality standard determined with a Reverse Osmosis membrane. The results can be seen that after passing through the RO membrane, the TDS value can be lowered in optimum conditions to reach 89.98%. RO membrane has pores of 0.0001 microns which can separate water from its components unwanted so that water will be obtained with a level of purity which is high (Meidinariasty et al., 2019).

On the COD parameter, the combination of activated carbon and zeolite filtration on the three variables experienced a decrease in efficiency respectively, namely 60.53%; 56.58%; and 67.11%. Under optimum conditions, the reduction results are obtained at 67.11% in the third variation, namely 25% activated carbon: 75% zeolite which can reduce COD levels from initial levels of 76 mg/l to 25 mg/l. After through the RO membrane, the COD value decreased efficiency reached 97.37% of the three variables that have been run. This decrease in COD levels is due to the higher the filling material used, the greater the value removal efficiency of the resulting COD content due to its presence adding volume to the zeolite media (Pungut et al., 2021).

On the Turbidity parameter, the combination of activated carbon and zeolite filtration the three variables experienced a decrease in successive efficiency, namely 98.12%; 95.71%; and 95.44% with optimum conditions obtained in the first variable is 50% activated carbon: 50% zeolite. After the water passes RO membrane obtained a successive decrease in efficiency of 99.96%; 99.98% and 99.94%. In this case, river water treatment uses the combination of activated carbon and zeolite filtration is capable enough to reduce the turbidity value below the quality standard of Ministry Of Health Regulatory No. 32 years 2017. The turbidity value can be lowered due to the nature of the zeolite and activated carbon as an adsorbent and a molecular filter that has a hollow structure so that the zeolite can absorb large amounts of molecules that are smaller or by the size of the cavity (Meidinariasty et al., 2019). The nature of zeolite as an adsorbent allows it to adsorb a number of molecules that are smaller or according to the size of the cavity. Adsorption occurs on the surface of the membrane pores. Zeolite particles have three types, macropore and micropore with sizes >50nm and <2nm. Between the two is the mesopore. Most of the adsorption events occur inside the micropore membrane (Nugroho & Purwoto, 2013).

On Cd metal parameters, combined activated carbon and zeolite filtration on the three variables experienced a decrease in efficiency respectively, namely 99.88%; 99.86%; and 99.91% with optimum conditions obtained on variables the second is activated carbon 75%; 25% zeolite. After the water passes through the RO membrane obtained successive reduction efficiency of 99.93%; 99.92% and 99.89%. There was no significant decrease after passing through the membrane RO because Cd metal has experienced a good reduction in the process of previous filtration. From the results of the study by Siska, et al showed that in the initial treatment the addition of 30 grams of zeolite for 36 hours was able to reduce the cadmium level by 0.045 mg/l from the initial cadmium level of 0.086 mg/l (Siska & Salam, 2013). In this case, river water treatment uses a combination of activated carbon and zeolite filtration has been able to reduce Cd value below the quality standard of Minister of Health No. 32 of 2017. Zeolite is very effective for adsorbing heavy metals due to zeolite has dehydrating properties, fairly high cation exchange, good catalyst, and as an adsorbent for other compounds (Pratomo et al., 2017).

4. Conclusion

In the combination of activated carbon and zeolite filtration technology in reducing impurities in Porong river water, the best TDS reduction efficiency was obtained in variable 2, namely 75% activated carbon: 25% zeolite with a reduction efficiency of 1363 mg/l (51.38%), efficiency the best reduction of COD in variable 3 is 25% activated carbon: zeolite 75% with a reduction efficiency of 51 mg/l (67.11%), the best reduction of turbidity in variable 1 is activated carbon 50%: 50% zeolite with a reduction efficiency of 366 NTUs (98.12%), and the best reduction efficiency of Cd on variable 3, namely 25% activated carbon: 75% zeolite with a reduction efficiency of 2.997 (99.91%). Optimum conditions obtained from four parameters (TDS, COD, Turbidity, Cd) is the third variable (25% activated carbon: Zeolite 75%) because it was able to reduce two parameters to the optimum point, namely COD and Cd parameters.

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