LAMPIRAN

Lampiran 1. Output Analisis Data

A. Uji Regresi Linier
1. pH
a. Ketebalan Pasir

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.716[a]	.513	.504	.1680

a. Predictors: (Constant), Ketebalan Pasir

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.722	1	1.722	61.017	.000[b]
	Residual	1.637	58	.028		
	Total	3.359	59			

a. Dependent Variable: pH
b. Predictors: (Constant), Ketebalan Pasir

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.429	.034		158.313	.000
	Ketebalan Pasir	.021	.003	.716	7.811	.000

a. Dependent Variable: pH

b. Alum + Soda Ash

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.214[a]	.046	.029	.2351

a. Predictors: (Constant), Alum + Soda Ash

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.154	1	.154	2.789	.100[b]
	Residual	3.205	58	.055		
	Total	3.359	59			

a. Dependent Variable: pH
b. Predictors: (Constant), Alum + Soda Ash

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.523	.074		74.300	.000
	Alum + Soda Ash	.005	.003	.214	1.670	.100

a. Dependent Variable: pH

c. Ketebalan Pasir dan Alum + Soda Ash

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.747[a]	.559	.543	.1613

a. Predictors: (Constant), Alum + Soda Ash, Ketebalan Pasir

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.876	2	.938	36.061	.000[b]
	Residual	1.483	57	.026		
	Total	3.359	59			

a. Dependent Variable: pH
b. Predictors: (Constant), Alum + Soda Ash, Ketebalan Pasir

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.316	.057		93.216	.000
	Ketebalan Pasir	.021	.003	.716	8.136	.000
	Alum + Soda Ash	.005	.002	.214	2.434	.018

a. Dependent Variable: pH

2. NTU

a. Ketebalan Pasir

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.515[a]	.265	.253	1.9833

a. Predictors: (Constant), Ketebalan Pasir

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	82.369	1	82.369	20.941	.000[b]
	Residual	228.140	58	3.933		
	Total	310.509	59			

a. Dependent Variable: NTU
b. Predictors: (Constant), Ketebalan Pasir

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	8.288	.405		20.473	.000
	Ketebalan Pasir	-.143	.031	-.515	-4.576	.000

a. Dependent Variable: NTU

b. Alum + Soda Ash

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.678[a]	.460	.451	1.7003

a. Predictors: (Constant), Alum + Soda Ash

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	142.830	1	142.830	49.405	.000[b]
	Residual	167.679	58	2.891		
	Total	310.509	59			

a. Dependent Variable: NTU
b. Predictors: (Constant), Alum + Soda Ash

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	10.303	.538		19.162	.000
	Alum + Soda Ash	-.138	.020	-.678	-7.029	.000

a. Dependent Variable: NTU

c. Ketebalan Pasir dan Alum + Soda Ash

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.852[a]	.725	.716	1.2234

a. Predictors: (Constant), Alum + Soda Ash, Ketebalan Pasir

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	225.199	2	112.600	75.233	.000[b]
	Residual	85.310	57	1.497		
	Total	310.509	59			

a. Dependent Variable: NTU
b. Predictors: (Constant), Alum + Soda Ash, Ketebalan Pasir

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11.738	.433		27.139	.000
	Ketebalan Pasir	-.143	.019	-.515	-7.419	.000
	Alum + Soda Ash	-.138	.014	-.678	-9.769	.000

a. Dependent Variable: NTU

3. TDS

a. Ketebalan Pasir

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.510[a]	.260	.247	28.4553

a. Predictors: (Constant), Ketebalan Pasir

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16483.600	1	16483.600	20.358	.000[b]
	Residual	46962.936	58	809.706		
	Total	63446.536	59			

a. Dependent Variable: TDS
b. Predictors: (Constant), Ketebalan Pasir

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	313.765	5.808		54.019	.000
	Ketebalan Pasir	-2.030	.450	-.510	-4.512	.000

a. Dependent Variable: TDS

b. Alum + Soda Ash

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.775[a]	.601	.594	20.8985

a. Predictors: (Constant), Alum + Soda Ash

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	38115.141	1	38115.141	87.270	.000[b]
	Residual	25331.396	58	436.748		
	Total	63446.536	59			

a. Dependent Variable: TDS
b. Predictors: (Constant), Alum + Soda Ash

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	349.823	6.609		52.934	.000
	Alum + Soda Ash	-2.254	.241	-.775	-9.342	.000

a. Dependent Variable: TDS

c. Ketebalan Pasir dan Alum + Soda Ash

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.928[a]	.861	.856	12.4589

a. Predictors: (Constant), Alum + Soda Ash, Ketebalan Pasir

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	54598.741	2	27299.370	175.870	.000[b]
	Residual	8847.796	57	155.224		
	Total	63446.536	59			

a. Dependent Variable: TDS
b. Predictors: (Constant), Alum + Soda Ash, Ketebalan Pasir

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	370.123	4.405		84.026	.000
	Ketebalan Pasir	-2.030	.197	-.510	-10.305	.000
	Alum + Soda Ash	-2.254	.144	-.775	-15.670	.000

a. Dependent Variable: TDS

4. WARNA

a. Ketebalan Pasir

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.923[a]	.852	.850	2.0420

a. Predictors: (Constant), Ketebalan Pasir

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1393.580	1	1393.580	334.217	.000[b]
	Residual	241.842	58	4.170		
	Total	1635.422	59			

a. Dependent Variable: WARNA
b. Predictors: (Constant), Ketebalan Pasir

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	17.081	.417		40.979	.000
	Ketebalan Pasir	-.590	.032	-.923	-18.282	.000

a. Dependent Variable: WARNA

b. Alum + Soda Ash

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.002[a]	.000	-.017	5.3101

a. Predictors: (Constant), Alum + Soda Ash

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.007	1	.007	.000	.987[b]
	Residual	1635.414	58	28.197		
	Total	1635.422	59			

a. Dependent Variable: WARNA
b. Predictors: (Constant), Alum + Soda Ash

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	11.203	1.679		6.672	.000
	Alum + Soda Ash	-.001	.061	-.002	-.016	.987

a. Dependent Variable: WARNA

c. Ketebalan Pasir dan Alum + Soda Ash

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.923[a]	.852	.847	2.0598

a. Predictors: (Constant), Alum + Soda Ash, Ketebalan Pasir

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1393.588	2	696.794	164.233	.000[b]
	Residual	241.834	57	4.243		
	Total	1635.422	59			

a. Dependent Variable: WARNA
b. Predictors: (Constant), Alum + Soda Ash, Ketebalan Pasir

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	17.106	.728		23.489	.000
	Ketebalan Pasir	-.590	.033	-.923	-18.124	.000
	Alum + Soda Ash	-.001	.024	-.002	-.042	.967

a. Dependent Variable: WARNA

5. Total Coliform
a. Ketebalan Pasir

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.364[a]	.132	.117	1505.479

a. Predictors: (Constant), Ketebalan Pasir

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20022250.000	1	20022250.000	8.834	.004[b]
	Residual	131455083.333	58	2266466.954		
	Total	151477333.333	59			

a. Dependent Variable: Total Coliform
b. Predictors: (Constant), Ketebalan Pasir

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	6314.167	307.305		20.547	.000
	Ketebalan Pasir	-70.750	23.804	-.364	-2.972	.004

a. Dependent Variable: Total Coliform

b. Alum + Soda Ash

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.878[a]	.771	.767	773.088

a. Predictors: (Constant), Alum + Soda Ash

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	116812800.000	1	116812800.000	195.449	.000[b]
	Residual	34664533.333	58	597664.368		
	Total	151477333.333	59			

a. Dependent Variable: Total Coliform
b. Predictors: (Constant), Alum + Soda Ash

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8726.667	244.472		35.696	.000
	Alum + Soda Ash	-124.800	8.927	-.878	-13.980	.000

a. Dependent Variable: Total Coliform

c. Ketebalan Pasir dan Alum + Soda Ash

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.950[a]	.903	.900	506.835

a. Predictors: (Constant), Alum + Soda Ash, Ketebalan Pasir

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	136835050.000	2	68417525.000	266.338	.000[b]
	Residual	14642283.333	57	256882.164		
	Total	151477333.333	59			

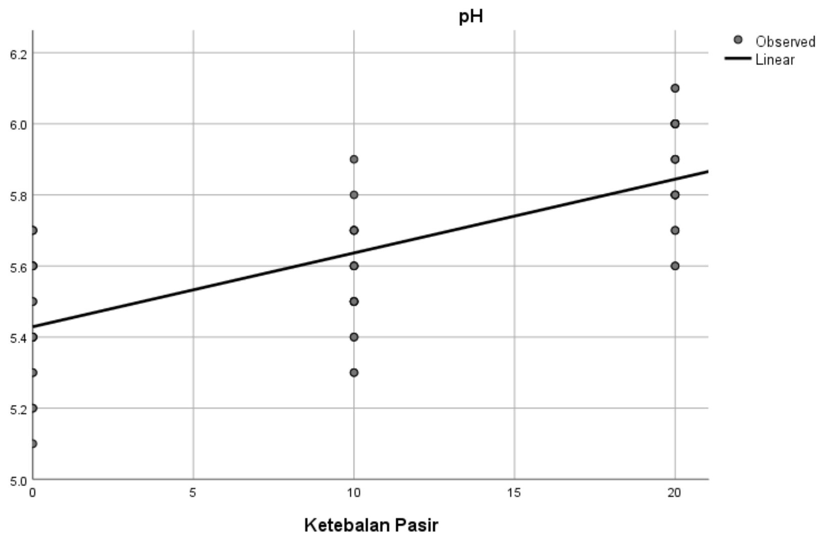
a. Dependent Variable: Total Coliform
b. Predictors: (Constant), Alum + Soda Ash, Ketebalan Pasir

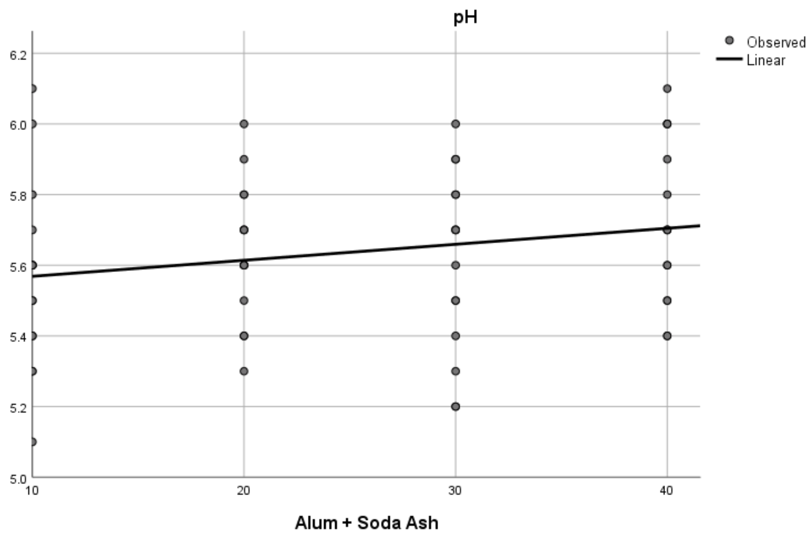
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	9434.167	179.193		52.648	.000
	Ketebalan Pasir	-70.750	8.014	-.364	-8.829	.000
	Alum + Soda Ash	-124.800	5.852	-.878	-21.324	.000

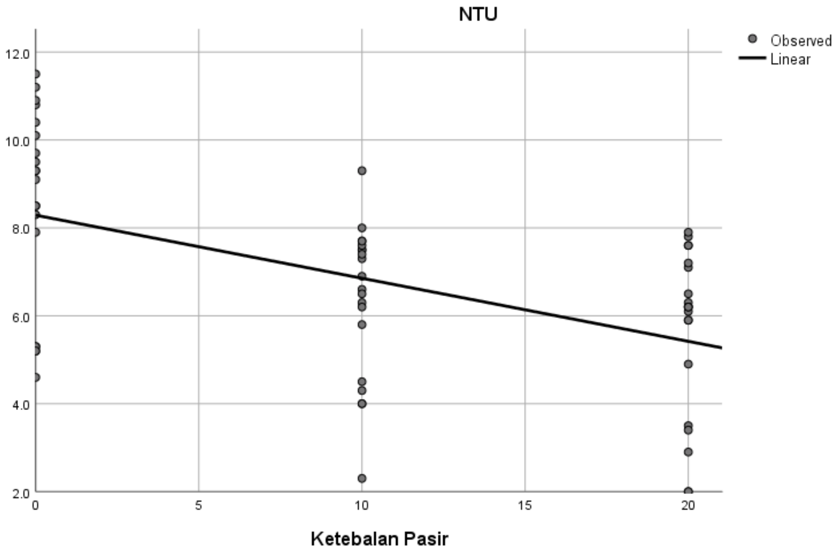
a. Dependent Variable: Total Coliform

B. Grafik Uji Regresi
1. pH

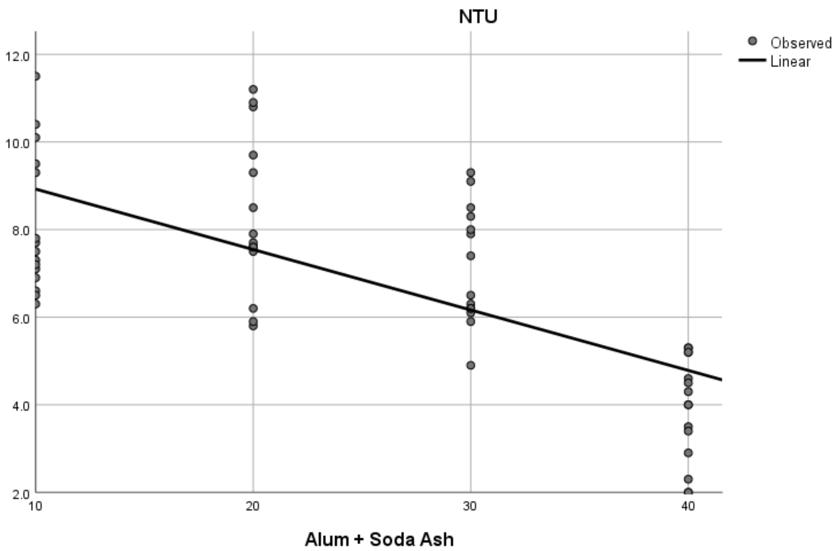




2. NTU

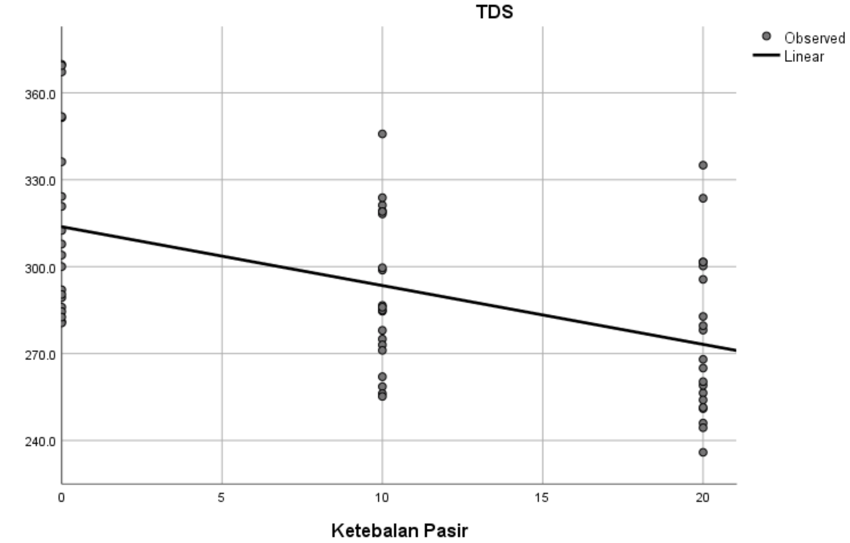


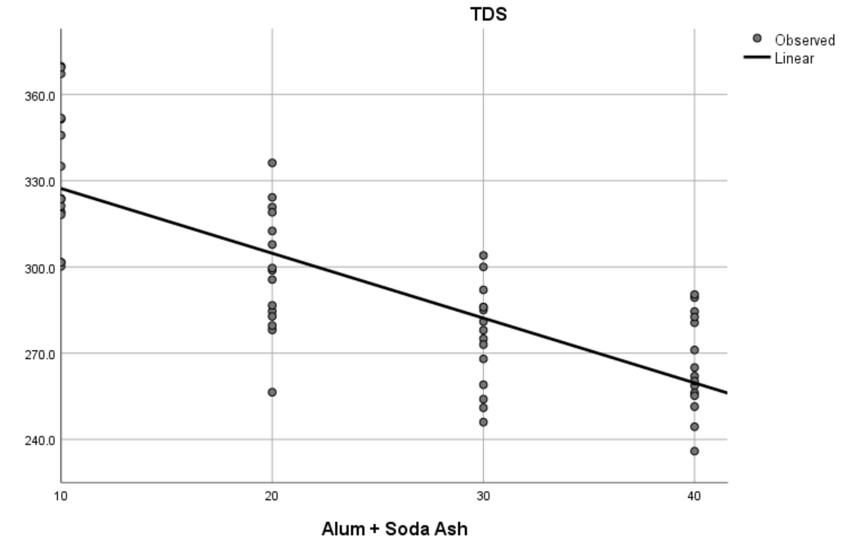
NTU
Observed
Linear
12.0
10.0
8.0
6.0
4.0
2.0
0
5
10
15
20
Ketebalan Pasir



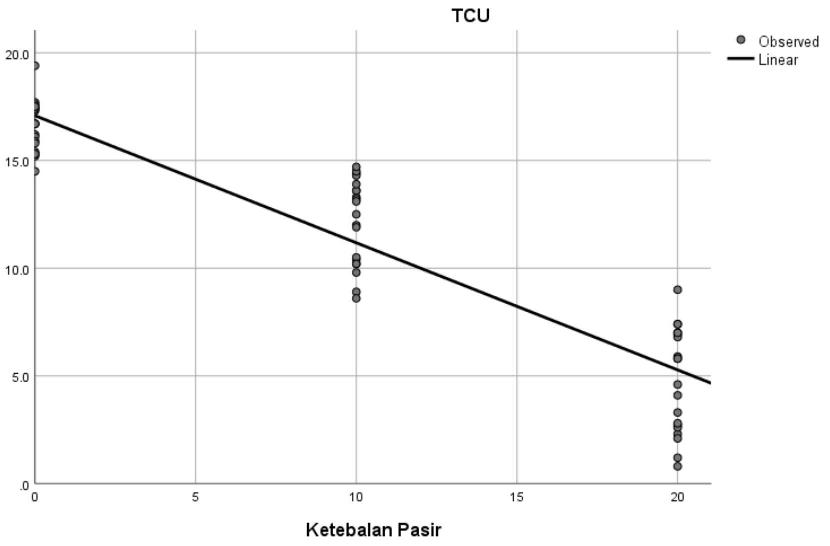
NTU
Observed
Linear
12.0
10.0
8.0
6.0
4.0
2.0
10
20
30
40
Alum + Soda Ash

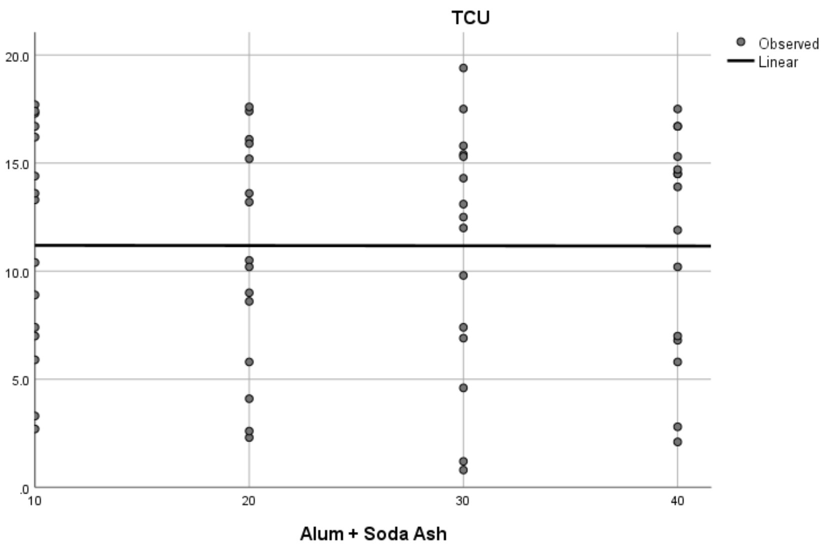
3. TDS


TDS
Observed
Linear
360.0
330.0
300.0
270.0
240.0
0
5
10
15
20
Ketebalan Pasir

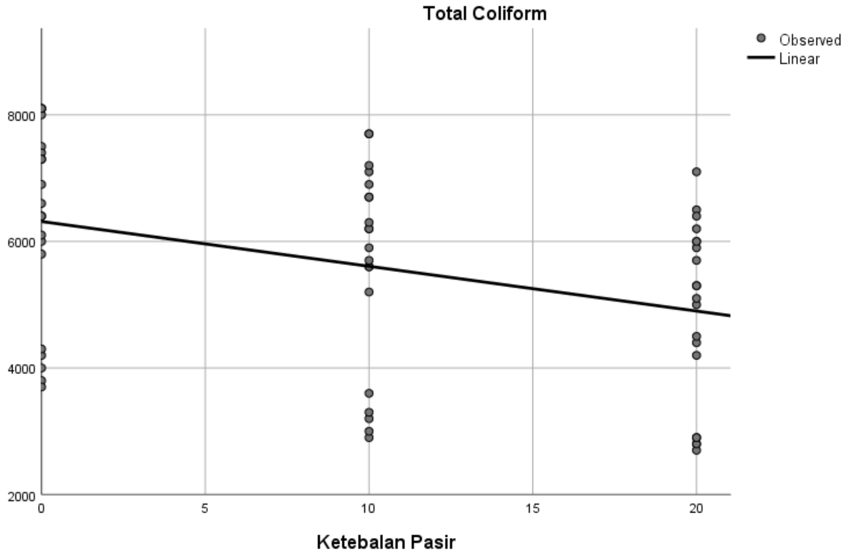

TDS
Observed
Linear
360.0
330.0
300.0
270.0
240.0
10
20
30
40
Alum + Soda Ash

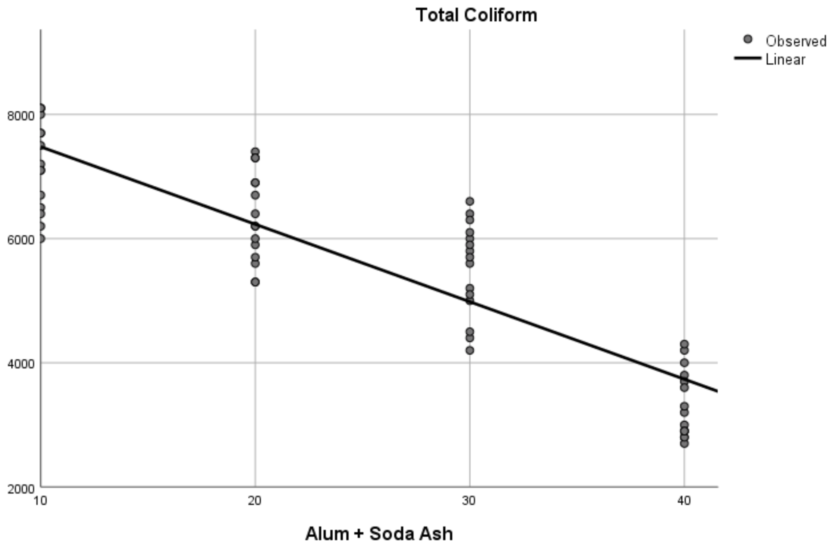
4. WARNA


TCU
Observed
Linear
20.0
15.0
10.0
5.0
.0
0
5
10
15
20
Ketebalan Pasir


TCU
Observed
Linear
20.0
15.0
10.0
5.0
.0
10
20
30
40
Alum + Soda Ash

5. Total Coliform





LAMPIRAN DOKUMENTASI

Tanggal	Gambar	Keterangan
		Sampel awal yaitu greywater dengan air hujan
		Alum dan soda ash dilarutkan dengan aquades utk jartes
		Timbangan yang berfungsi utk menimbang alum dan soda ash utk dilarutkan ke dalam aquades
	 	Pasir cor menggunakan diameter 3mm

		Filter bertingkat

LEMBAR PERBAIKAN UJIAN TESIS

Nama	:	Edi Suprapto
NIM	:	21121046
Judul Tesis	:	Model Fisik Pengolahan Air Limbah Domestik Dan Air Hujan Menggunakan Filter Bertingkat Menjadi Air Bersih Pada Lokasi Danau Bukit Sekatup Damai Di Kota Bontang

No	Dosen Penguji/ Pembahas	Tanggapan/Saran/Masukan	Keterangan
1.	Prof. Dr.Ir Lalu Mulyadi, MT (Penguji 1)	- Judul "greywater" diubah menjadi "air limbah domestik"	- Sudah diperbaiki
		- Spasi paragraf cover	- Sudah diperbaiki
		- Jumlah kata pada abstrak maksimal 200 kata	- Sudah diperbaiki hal.ii-iii
		- Perbaiki Kata Pengantar	- Sudah diperbaiki hal.vii
		- Sesuaikan Halaman di Daftar isi, daftar gambar	- Sudah diperbaiki hal.viii - xiii
		- Bab I – catatan kaki di Latar Belakang	- Sudah diperbaiki hal. 1-3
		- Bab II - Sesuaikan Tinjauan Pustaka dan Daftar Pustaka	- Sudah diperbaiki hal. 7-25
		- Perbaiki table waktu penelitian	- Sudah diperbaiki hal.39
		- Regresi linier di Bab III dipindah ke Bab II	- Sudah diperbaiki hal 22
		- Tambahkan judul gambar pada Bab IV	- Sudah diperbaiki hal 47-49
		- Perbaiki cara penulisan daftar Pustaka	- Sudah diperbaiki hal.74-75
2.	Dr. Erni Yulianti, ST., MT (Penguji 2)	- Penulisan abstrak 1 spasi	- Sudah diperbaiki hal. ii-iii
		- Sesuaikan Halaman di Daftar isi, daftar gambar	- Sudah diperbaiki hal.viii - xiii
		- Bab II sumber referensi	- Sudah diperbaiki 7-25
		- Bab IV judul grafik, dan keterangan grafik	- Sudah diperbaiki hal.52-70
		- Bab VI kesimpulan huruf awal pada kalimat "Kota Bontang" kapital	- Sudah diperbaiki Hal 72
		- Perbaiki cara penulisan daftar Pustaka	- Sudah diperbaiki hal.74-75
		- Perbaiki keterangan foto pada lampiran	- Sudah diperbaiki

Persetujuan Dosen Penguji 1	Persetujuan Dosen Penguji 2
Prof. Dr.Ir Lalu Mulyadi, MT	**Dr. Erni Yulianti, ST., MT**

LEMBAR PERBAIKAN UJIAN TESIS

Nama : Edi Suprapto

NIM : 21121046

Judul Tesis : Model Fisik Pengolahan Air Limbah Domestik Dan Air Hujan Menggunakan Filter Bertingkat Menjadi Air Bersih Pada Lokasi Danau Bukit Sekatup Damai Di Kota Bontang

No	Dosen Penguji/ Pembahas	Tanggapan/Saran/Masukan	Keterangan
1.	Prof. Dr.Ir Lalu Mulyadi, MT (Penguji 1)	- Judul "greywater" diubah menjadi "air limbah domestik"	- Sudah diperbaiki
		- Spasi paragraf cover	- Sudah diperbaiki
		- Jumlah kata pada abstrak maksimal 200 kata	- Sudah diperbaiki hal.ii-iii
		- Perbaiki Kata Pengantar	- Sudah diperbaiki hal.vii
		- Sesuaikan Halaman di Daftar isi, daftar gambar	- Sudah diperbaiki hal.viii - xiii
		- Bab I – catatan kaki di Latar Belakang	- Sudah diperbaiki hal. 1-3
		- Bab II - Sesuaikan Tinjauan Pustaka dan Daftar Pustaka	- Sudah diperbaiki hal. 7-25
		- Perbaiki table waktu penelitian	- Sudah diperbaiki hal.39
		- Regresi linier di Bab III dipindah ke Bab II	- Sudah diperbaiki hal 22
		- Tambahkan judul gambar pada Bab IV	- Sudah diperbaiki hal 47-49
		- Perbaiki cara penulisan daftar Pustaka	- Sudah diperbaiki hal.74-75
2.	Dr. Erni Yulianti, ST., MT (Penguji 2)	- Penulisan abstrak 1 spasi	- Sudah diperbaiki hal. ii-iii
		- Sesuaikan Halaman di Daftar isi, daftar gambar	- Sudah diperbaiki hal.viii - xiii
		- Bab II sumber referensi	- Sudah diperbaiki 7-25
		- Bab IV judul grafik, dan keterangan grafik	- Sudah diperbaiki hal.52-70
		- Bab VI kesimpulan huruf awal pada kalimat "Kota Bontang" kapital	- Sudah diperbaiki Hal 72
		- Perbaiki cara penulisan daftar Pustaka	- Sudah diperbaiki hal.74-75
		- Perbaiki keterangan foto pada lampiran	- Sudah diperbaiki

Persetujuan
Dosen Penguji 1

Prof. Dr.Ir Lalu Mulyadi, MT

Persetujuan
Dosen Penguji 2

Dr. Erni Yulianti, ST., MT

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Turn Greywater into Clean Water by Applying a Simple Technology in Bontang, Indonesia

Edi Suprapto[1], Hery Setyobudiarso[2], Lies Kurniawati Wulandari[3]

[1] *Student, Department of Civil Engineering, National Institute of Technology, Malang, Indonesia.*
[2,3]*Senior Lecturer, Department of Civil Engineering, National Institute of Technology, Malang, Indonesia.*

Date of Submission: 14-06-2023 Date of Acceptance: 24-06-2023

ABSTRACT: The water crisis in urban areas is getting more critical and demands a solution. On the other hand, water needs for various anthropogenic activities are increasing over time. One solution that has double benefits is wastewater treatment, which can provide clean water for human activities and at the same time lower the case of environmental pollution due to wastewater discharge. This study develops a simple technique for turning greywater into clean water by filtrating the pollutants using sand and neutralizing the pH level using PAC (poly aluminium chloride) and soda ash (sodium chloride). Observations were performed on water quality parameters consisting of pH and turbidity (NTU). Furthermore, primary data were analysed using the linear regression method and descriptive statistics. Based on the results, it is confirmed that the sand filter is effective in decreasing the turbidity of greywater -indicating that suspended solids are successfully removed. In addition, PAC and soda ash can neutralize the pH level. This simple and affordable greywater treatment plant can produce output that meets the standard of grade II raw water according to government regulations. Output water is clean and can be reused for daily needs; washing vehicles, watering plants, laundry, cleaning the exterior of the house, etcetera. Wide replication of this technology can solve the water crisis in urban areas, but it also suggests further development. Therefore, future studies are expected to develop the technology of greywater treatment that can produce grade I raw water.

KEYWORDS: Water Treatment, Urban, Greywater, Filtration and Regression.

I. INTRODUCTION

The water demand increases following the rapid development and human population, especially in urban areas. One of the main and biggest uses of clean water is for domestic/ household needs. Currently, water resources are managed by the local water companies by utilizing groundwater sources. In urban areas, however, groundwater sources are limited, or if there are many, the quality of the water is below the standard due to high pollution. This situation is worsened by the high production of domestic wastewater; greywater and blackwater. Greywater production is high due to the inefficiency of water use, where clean water is only used for only one purpose and then discharged directly into the sewage. Necessarily, the water can still be used for other purposes without having to be disposed of directly. This inefficiency exacerbates the crisis in water needs.

Greywater is one of the largest wastes that enter water bodies, such as rivers. Greywater is liquid waste originating from kitchens, laundry, and bathrooms [7]. Around 60-85% of the total volume of clean water needs will become domestic wastewater [17]. The share of greywater itself is about 75% of the total volume of domestic waste. This shows that the utilization of greywater has high potential [15]. In almost all regions in Indonesia, greywater enters river bodies without prior treatment, causing water contamination [11]. Greywater which is generally discharged directly into the drainage canal generally contains elements of nitrogen, phosphate, and potassium. These elements are nutrients for plants, so if greywater is simply dumped into water bodies, it can cause eutrophication [17]. Waste water treatment is an obligatory program that must be executed as it is

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crucial for environmental sustainability and broadly affects many aspects [8].

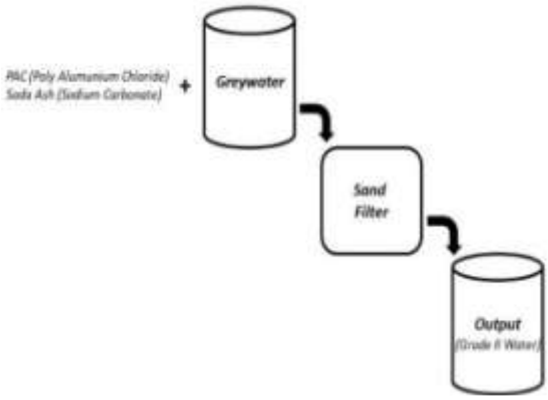
Water pollution due to greywater contamination can be overcome by treating wastewater before disposal. However, recent research trends show that in addition to processing greywater for disposal, greywater can be reused as a source of clean water. In other words, greywater treatment must reach a point where the output meets clean water quality standards. So far, reuse has been limited to flush toilets, crop irrigation, and washing vehicles. However, the reuse of greywater can help reduce the use of available clean water sources. To improve the quality of treated water, as well as to support the adequacy of water raw materials, greywater can be mixed with rainwater. Arifin explains that rainwater is a source of clean water that can be used as an alternative to meeting daily water needs [1].

Currently, the fulfillment of clean water in Bontang City is fulfilled by the local drinking water company; Perumdam Tirta Bontang City Park. The need for clean water in Bontang City is 632.10 liters/second, which is to meet the needs of a population of 185,251 people [3]. The raw water source utilized by the local drinking water company is a deep well, where the quality of the water decreases over time. The amount of water currently produced is 414.38 litres/second from 22 well units, so the total deficit of water demand is 217.72 litres/second. For this reason, an alternative source is needed to meet the need for clean water in Bontang City. Meanwhile, this condition is exacerbated by the limited reach of waterways. The high cost of transportation to the islands has resulted in around 500 households (KK) in four villages located in the Bontang waters archipelago which has become a challenge in itself and has contributed to difficulties in accessing clean water. There are at least four villages; Melahing, Tihi-tihi, Busung, and Selangan -with an average population of 140-150 households – that still do not receive clean water from the local drinking water company. So far, people in these villages buy water from PDAM customers in coastal areas for IDR 4,000 to IDR 5,000 per cubic meter. The price is certainly more expensive if added to the cost of transportation.

This research proposes a solution to overcome the shortage of clean water in Bontang City through the reuse of greywater. Briefly, the simple technology applied is filtration using sand media. Besides being simple, this technology is also inexpensive and does not require a complicated design, so it can be imitated by the local community to meet their household's clean water needs. Of course, this idea can not only be applied in Bontang City, but also in other areas that have limited clean water resources. Observations were made based on the parameters of pH and turbidity (NTU).

II. METHOD

This study implements quantitative methods with an experimental approach. Greywater was obtained from the channel of Gunung Elai Village, North Bontang District. Observations are based on pH and turbidity (NTU) parameters, namely based on the national standard for class II water issued by the Government Regulation of The Republic of Indonesia No. 82 of 2001 [6]. The required pH level is 6-9, while the maximum turbidity level is 5 NTU. The wastewater treatment design is explained in figure the concept of the greywater treatment process. First of all, the greywater is treated with chemicals in the form of PAC (Poly Aluminium Chloride) and soda ash (Sodium Chloride) to help neutralize pH levels. Variations in the provision of PAC and soda ash (grams) trials were carried out to obtain the best pH levels; 10 grams, 20 grams, 30 grams, and 40 grams. Meanwhile, filtration with sand media is also applied with variations in thickness, namely 0 cm (without sand filtration), 10 cm, and 20 cm. The pH level was measured with a pH meter, while the turbidity level was measured with a nephelometer. Water quality data from the treatment combinations were then analysed using descriptive and linear regression methods to determine the best results, which meet the criteria for class II raw water.



The Concept of The Greywater Treatment Process

III. RESULT AND DISCUSSION

DESCRIPTIVE ANALYSIS

In this paper, the water quality parameters discussed are pH and turbidity (NTU). Descriptive analysis was carried out to find out the description of water quality improvement based on these two parameters. Before processing, the pH and turbidity

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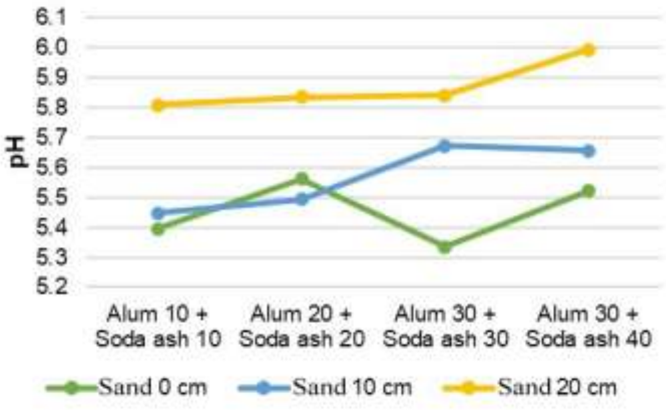
levels of greywater were first measured, where the initial levels of each parameter were 5.2 and 12.8 NTU. pH is an important parameter in water quality analysis because it is closely related to biological and chemical processes [12]. pH states the intensity or concentration of hydrogen ion concentration in water, which in principle can control the balance of the proportion of carbon dioxide, carbonate, and bicarbonate content [9]. Meanwhile, turbidity represents the transparency of water, where the level decreases as the suspended matter content increases [13].

According to Government Regulation Number 82 of 2001, the recommended pH level for class II water is 6-9, while the standard for turbidity level is 5 NTU. The results of measuring pH and turbidity levels throughout the experimental process are presented in table below. Furthermore, the dynamics of water quality based on pH and turbidity parameters in each relevant treatment are explained visually in figure about pH and turbidity level of water during treatment.

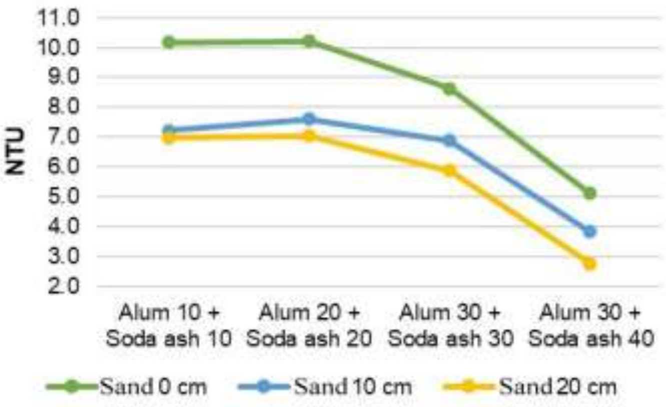
pH and Turbidity Level of Water on Each Treatments

GREYWATER DISCHARGE (litre/minutes)	THE THICKNESS OF THE SAND FILLER (cm)	pH NEUTRALIZING AGENT	pH	TURBIDITY (NTU)
1	0	PAC 10 grams + Soda ash 10 grams	5.4	10.2
		PAC 20 grams + Soda ash 20 grams	5.6	10.2
		PAC 30 grams + Soda ash 30 grams	5.3	8.6
		PAC 30 grams + Soda ash 40 grams	5.5	5.1
1.5	10	PAC 10 grams + Soda ash 10 grams	5.4	7.2
		PAC 20 grams + Soda ash 20 grams	5.5	7.6
		PAC 30 grams + Soda ash 30 grams	5.7	6.9
		PAC 30 grams + Soda ash 40 grams	5.7	3.8
2	20	PAC 10 grams + Soda ash 10 grams	5.8	7.0
		PAC 20 grams + Soda ash 20 grams	5.8	7.0
		PAC 30 grams + Soda ash 30 grams	5.8	5.9
		PAC 30 grams + Soda ash 40 grams	6.0	2.8

Based on the data presented in table pH and turbidity level of water on each treatment, it can be seen that the pH level tends to increase along with the increase in PAC and soda ash levels. This is in line with the theory that these two chemicals can neutralize pH which tends to be acidic [4,10]. Visualization of an increase in pH levels (close to neutral) can be seen in figure the concept of the greywater treatment process. The best pH levels are those that are included in the pH threshold range for class II water (6-9), which is found in the treatment of 20 cm sand thickness with 30 grams PAC and soda ash 40 grams. The best pH level is 6, and it meets the qualifications for class II water according to Government Regulation Number 82 of 2001 concerning Water Quality Management and Water Pollution Control. The thickness of the sand of 20 cm in the suspended solids filtration process is also more optimal in filtering out pollutants in the form of suspended solids, thereby contributing to an increase in pH levels



pH Level of Water During Treatment



Turbidity Level of Water During Treatment

The Results of Regression Analysis on pH Parameter

VARIABLE		COEF.	SIG.	EQUATION	R^2
Constant	C	5.316	0.000	Y = 5.316 + 0.021 X1 + 0.005 X2 + c	55.9%
Sand Thickness	X1	0.021	0.000		
PAC + Soda ash	X2	0.005	0.018		
pH	Y				

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The Results of Regression Analysis on Turbidity Parameter

VARIABLE		COEF.	SIG.	EQUATION	R^2
Constant	C	11.738	0.000	Y = 11.738 - 0.144 X1 - 0.138 X2 + c	72.5%
Sand Thickness	X1	-0.144	0.000		
PAC + Soda ash	X2	-0.138	0.000		
Turbidity	Y				

Regarding the turbidity parameter, table pH and turbidity level of water on each treatment shows that the NTU value of greywater decreases throughout the processing process. The graph of decreasing turbidity level can be seen in figure pH level of water during treatment, where this condition is more related to the filtration process with sand media. In theory, sand has excellent potential to purify water [2,5]. Suspended solids that have been lost in the filtering process will make the water clearer [14]. Based on the processing results, greywater has turned into class II water with a turbidity level of only 2.8 NTU. This value is below the turbidity threshold according to Government Regulation Number 82 of 2001 concerning Water Quality Management and Water Pollution Control, which requires a maximum level of 5 NTU.

REGRESSION ANALYSIS

Regression analysis was performed to determine the significance of the treatment on water quality, which in this article is limited to the parameters pH and turbidity (NTU). The results of the analysis are declared significant if the significance value (p-value) is less than the significant level (α) of 0.05. According from table the results of regression analysis on pH parameter, the regression graph depicts the relationship between treatments; the application of PAC and soda ash, as well as variations in the thickness of the sand, on the quality of the treated water; pH, and turbidity.

Furthermore, table the results of regression analysis on turbidity parameter, demonstrates that the treatment applied has a significant effect on stabilizing pH levels, which is seen from a significance value that is smaller than or less than the significant level (α) of 0.05. In addition, it was seen that there was a linear relationship in a positive direction, where the addition of PAC and soda ash levels was able to increase the pH level which initially tended to be low (acid). This finding can be seen from the positive coefficient. The effect of giving PAC and soda ash, as well as the treatment of filtration with sand on pH levels, was

55.9%. Previous research conducted by Bacin and Nuzila [4] also reported that giving PAC and soda ash could improve water quality, namely stabilizing pH and reducing turbidity levels. Similar findings were also reported by Amri and Pasaribu [10] who had succeeded in clearing and stabilizing the pH of raw water for PDAM Tirtanadi Martubung Medan by providing PAC and soda ash. However, the water quality needs to be improved again by filtering treatment, which in this study was carried out with sand material.

Overall, the table explains the findings that the treatment of PAC and soda ash, as well as the treatment of variations in the thickness of the sand filter, proved to have a significant effect on reducing the turbidity of treated greywater (p-value < α 0.05). This is particularly related to the treatment of the sand filter. The thicker the sand filter layer that is applied, the more successful the turbidity level will be reduced. The thicker layer of sand in the filter box allows all suspended particles to be filtered out thoroughly. Statistically, this linear negative relationship can be seen from the negative coefficients. The treatment applied has a large effect of 72.5% on the decrease in water turbidity. In other words, filtration techniques are very effective in removing pollutant particles contained in greywater. This finding is in line with previous research conducted by Wulandari et al. where sand material has great potential in filtering suspended pollutants contained in blackwater wastewater [18]. He explained that sand not only has good pollutant filtering potential but is also easy to obtain at a relatively low cost. In addition, previous studies conducted by Coenraad et al. and Artidarma et al. are also in line with the results of this study, where sand is very effective in purifying water [2,5].

IV. CONCLUSION

This study confirms that PAC and soda ash can neutralize the pH levels of greywater. In addition, the application of filtration techniques with sand material has also been shownto significantly reduce turbiditylevels. Improving water quality based on these two parameters turns greywater into class II raw water. Based on the results of the experiment, the recommended use of PAC and soda ash is 30 grams and 40 grams, respectively. Furthermore, the recommended sand filter layer thickness is 20 cm. This study's best water treatment results had a pH level of 6 and a turbidity level of 2.8 NTU. This researchcan be further developed to reach a pH level of 7 and even lower levels of turbidity (class I water). Therefore, future researchers can apply a combination of various media filter techniques, with various thickness treatments. Observations can also be made on more complete water quality parameters to obtain measurement results that are representative of the actual output water quality.

REFERENCES

[1]. Arifin, H-R, 2021, “Analisis Pemanfaatan Air Hujan sebagai Alternatif Penyediaan Air Sanitasi dan Pertamanan pada Kompleks Gedung Pemerintahan Kota Bandung,” Prosiding FTSP Series 1, Seminar Nasional dan Diseminasi Tugas Akhir 2021.

[2]. Artidarma, B; Saptanty; Fitria, L; and Sutrisno, H., 2021, “Pengolahan Air Bersih dengan Saringan Pasir Lambat Menggunakan Pasir Pantai dan Pasir Kuarsa,” Jurnal Teknologi Lingkungan Lahan Basah, Vol. 9(2), pp. 71-81.

[3]. Badan Pusat Statistik Kota Bontang, 2022, “Statistik Air Bersih Kalimantan Timur”. (https://bontangkota.bps.go.id/)

[4]. Bancin, J-B; and Nuzlia, C., 2021, “Pengaruh Penambahan AL2(SO4)3 dan Na2CO3 terhadap Turbiditas dan pH Air Baku pada Instalasi Pengolahan Air Bersih,” AMINA Jurnal Universitas Islam Negeri Ar- Rainiry, Vol. 1(3), pp. 139-147. (DOI: 10.22373/amina.v1i3.494)

[5]. Coenraad, R.; Wiratno; and Karelius, 2019, “Perancangan Filter Penjernih Air Sungai Kahayan Berbasis Pasir Silika dan Lempung Alam Asal Kalimantan Tengah,” Jurnal Jejaring Matematika dan Sains, Vol. 1(2), pp. 70-76. (DOI:https://doi.org/10.36873/jjms.v1i2.213)

[6]. Government of The Republic of Indonesia, 2001, “Pengelolaan Kualitas Air dan Pengendalian Pencemaran Air,” Peraturan Pemerintah Nomor 82 Tahun 2001. (https://peraturan.bpk.go.id/Home/Details/53103/pp-no-82-tahun-2001)

[7]. Haandel, V; Adrianus; and Lubbe, V-J., 2012, “Handbook of Biological Wastewater Treatment,” London, IWA Publishing.

[8]. Hamzah, A-H-P, 2022, “Pemanfaatan Ozon Sebagai Teknologi Berkelanjutan Daur Ulang Air Limbah Domestik Hotel X Lembang,” Insologi: Jurnal Sains dan Teknologi, Vol. 1(2), pp. 96-103. (DOI: 10.55123/insologi.v1i2.234)

[9]. Hasrianti and Nurasia, 2017, “Analisis Warna, Suhu, pH, dan Salinitas Air Sumur Bor di Kota Palopo,” Prosiding Seminar Nasional, Vol. 02(01), pp. 747-753.

[10]. Khairul, A., 2018, *Pengaruh Penambahan PAC (Poly Aluminium Chloride) dan Soda ASH Terhadap pH, Turbiditas dan TDS (Total Dissolved Solids) pada Air Baku PDAM Tirtanadi Martubung Medan*, [Master Thesis, University of Sumatera Utara], University of Sumatera Utara Research Repository. http://repositori.usu.ac.id/handle/123456789/12104

[11]. Khotimah, S-N; Mardhotillah, N-A; Arifaini, N; and Sumiharni, 2021, “Karakterisasi Limbah Cair Greywater pada level Rumah Tangga Berdasarkan Sumber Emisi,” Jurnal Saintis, Vol. 21(2), pp. 71-78. (DOI: 10.25299/saintis.2021.vol21(02).7876)

[12]. Munirah, N-S; Kusin, F-M; Lee, A-L-S; Ukang, T-A; Yusuf, F-M; and Ibrahim, Z-Z., 2016, “Performance of Vetiver Grass (Vetiveria zizanioides) for Phytoremediation of Contaminated Water,” Matec Web of Conferences, 103, 06003. (DOI: 10.1051/matecconf/201710306003)

[13]. Rachmansyah, F; Utomo, S-B; and Sumardi, 2019, “Perancangan dan Penerapan Alat Ukur Kekeruhan Air Menggunakan Metode Nefelometrik pada Instalasi Pengolahan Air dengan Multi Media Card (MMC) Sebagai Media Penyimpanan: Studi Kasus di PDAM

Jember," Jurnal Berkala Sainstek, Vol. 2(1), pp. 17-21.

[14]. Said, N-I., 2017, "Teknologi Pengolahan Air Limbah: Teori dan Aplikasi," Jakarta, Erlangga.

[15]. Sungkowo, T-H; Shinta, E; and Ivnaini, A., 2015, "Pengolahan Limbah Cair Industri Tahu Menggunakan Tanaman Typha latifolia dan Enceng Gondok dengan Metode Fitoremediasi," JOM Fteknik, Vol. 2, pp 1-8.

[16]. Wicaksana, A; Harmono, H; and Yuniarti, S., 2021, "Pengaruh Inventarisasi Aset, Penggunaan Aset, Pengamanan dan Pemeliharaan Asset terhadap Optimalisasi Aset Tetap Tanah pada Pemerintah Kabupaten Malang," Jurnal Administrasi Publik, Vol. 6(1), pp. 1-14. (DOI: 10.26905/pjiap.v6il.5514)

[17]. Wulandari, L-K., 2019, "Model Fisik Pengolahan Limbah Blackwater pada Septictank Komunal," Volume 1, Malang, Dream Litera Buana.

[18]. Wulandari, L-K., 2019, "Rancangan dan Hasil Model Fisik Blackwater pada Septicktank Komunal Standar Air Pertanian," Volume 2, Malang, Dream Litera Buan.

RANCANGAN PENGOLAHAN *GREYWATER* DAN AIR HUJAN MENJADI AIR BERSIH SEBAGAI ALTERNATIF AIR BAKU DALAM PENANGANAN KRISIS AIR DI KOTA BONTANG

Edi Suprapto[1], Hery Setyo Budiarso[2], Lies Kurniawati Wulandari[3]

[1, 2, 3] Design on The Treatment of Greywater and Rain Water to Produce Clean Water - An Alternative to Solve Water Crisis in Bontang City

ABSTRAK

Penelitian ini mengembangkan sebuah teknik pengolahan air limbah *greywater* dan air hujan menjadi air bersih, yakni dengan teknik filtrasi menggunakan pasir sebagai material filter, serta penambahan PAC (*Poly Alumunium Chloride*) dan soda ash (*Sodium Chloride*) untuk menetralisir pH. Pengamatan dilakukan terhadap variabel variasi kadar PAC dan soda ash (X_1) dan variasi ketebalan pasir (X_2) terhadap parameter kualitas air (Y) yaitu Total Coliform (Jml/100 ml). Analisis data dilakukan dengan menggunakan metode regresi linier. Secara umum, teknik pengolahan yang diterapkan terbukti mampu merubah limbah *greywater* dan air hujan menjadi air bersih kelas II; berdasarkan parameter kualitas air yang diamati. Dengan kata lain, air telah dapat digunakan untuk keperluan sehari-hari, namun tidak untuk dikonsumsi. Metode filtrasi mampu menghilangkan polutan yang terkandung dalam air limbah *greywater*, dan dapat menjadi solusi pemenuhan air bersih di kawasan perkotaan, khususnya Kota Bontang, Kalimantan Timur.

Kata kunci: Pengolahan air, *greywater*, filtrasi, pasir, regresi linier.

1. PENDAHULUAN

Tingkat pertumbuhan penduduk di kota-kota besar memiliki korelasi yang berbanding lurus dengan tingkat konsumsi air yang dimanfaatkan oleh masyarakat. Konsumsi air bersih yang terbesar salah satunya adalah untuk pemenuhan kebutuhan domestic rumah tangga. Pemenuhan akan air bersih Sebagian besar dilakukan oleh Perusahaan Daerah Air Minum (PDAM) dan Perusahaan swasta yang mengambil air bakunya dari air tanah. Krisis air pada wilayah-wilayah perkotaan sering kali diakibatkan oleh penggunaan air bersih yang tidak mengikuti pola efisien. Terdapat banyak pemanfaatan sumber air baku yang dilakukan hanya satu kali penggunaan, sementara pada beberapa aktifitas konsumsi air sehari-hari masih ada yang bisa memanfaatkan air limbah domestic dari aktivitas konsumsi yang pertama yang tidak membutuhkan kualitas air yang baik. Penanganan *greywater* di Indonesia saat ini adalah langsung dibuang ke saluran drainase tanpa pengelolaan terlebih dahulu. Karakteristik *greywater* pada umumnya banyak mengandung unsur nitrogen, fosfat dan potassium [9]. Unsur-unsur tersebut merupakan nutrient bagi tumbuhan, sehingga jika *greywater* dialirkan begitu saja ke badan air permukaan maka akan menyebabkan eutrofikasi pada badan air tersebut [10].

Khotimah [6] mengatakan bahwa limbah cair *greywater* merupakan limbah terbesar yang masuk ke badan air seperti sungai. Hampir di seluruh wilayah di Indonesia, limbah cair *greywater* masuk ke badan sungai tanpa adanya pengolahan terlebih dahulu dan ini menyebabkan kontaminasi air. permasalahan pencemaran badan air oleh limbah cair *greywater* dapat diatasi dengan adanya pengolahan limbah cair sebelum dibuang ke badan air. Trend penelitian terbaru menunjukkan, bahwa selain perlu adanya pengolahan *greywater* untuk mengurangi pencemaran air, pengolahan limbah cair *greywater* dapat dijadikan sumber alternatif baru sumber air bersih yaitu dengan konsep penggunaan kembali (*reuse*) dari limbah cair *greywater*. Penggunaan kembali limbah cair *greywater* memang untuk saat ini masih terbatas seperti untuk *flush toilet*, irigasi tanaman, mencuci mobil, dan mencuci jendela karena kualitas air bersihnya masih rendah. Namun demikian, penggunaan kembali limbah cair *greywater* dapat membantu mengurangi penggunaan sumber air bersih yang tersedia.

Arifin [1] menjelaskan bahwa sebagai salah satu sumber air bersih, air hujan yang turun ke permukaan bumi memiliki banyak manfaat bagi makhluk hidup. Secara alamiah sebagian besar air hujan akan menyerap ke dalam tanah melalui proses infiltrasi dan berubah menjadi cadangan air tanah. Ketika musim kemarau, air hujan dapat dijadikan alternatif pemenuhan kebutuhan air bersih. Dewasa ini dengan bantuan teknologi sederhana maupun modern, air hujan dapat diolah menjadi bahan baku air bersih.

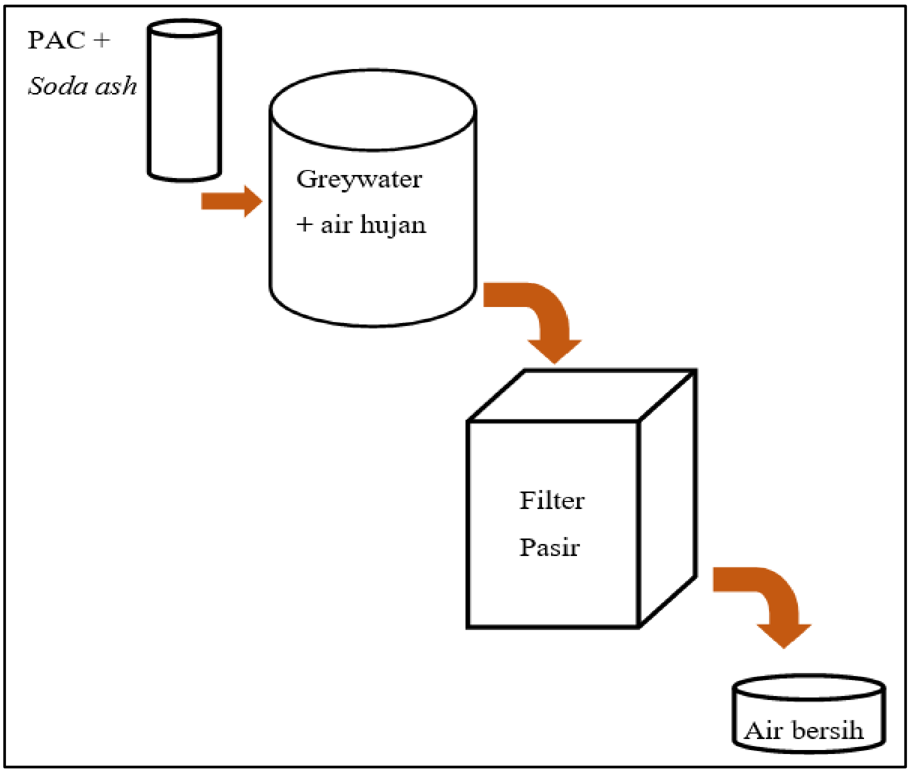
Saat ini pemenuhan air bersih di Kota Bontang dipenuhi oleh Perumdam Tirta Taman Kota Bontang, saat ini kebutuhan air bersih Kota Bontang mencapai 632,10 liter/detik dengan jumlah penduduk Tahun 2022 adalah 185.251 jiwa [2]. Sumber air baku yang digunakan adalah sumur dalam dikarenakan belum adanya sumber air baku permukaan di Kota Bontang. Namun terjadi penurunan kualitas air baku dibeberapa sumur yang disebabkan oleh faktor alam dan mengalami penurunan kualitas level air. Sistem pelayanan saat ini belum optimal karena terdapat beberapa lokasi yang terlayani air bersih hanya selama 19 jam/hari dengan jumlah pelayanan 31.347 unit SR (Sambungan Rumah). Jumlah air yang produksi saat ini adalah 414,38 liter/detik dari 22 unit sumur dalam, sehingga total kebutuhan air untuk saat ini defisit 217,72 liter/detik. Minimnya ketersediaan air baku untuk pemenuhan layanan air bersih jangka pendek 1-2 tahun belum tersedia karena hanya mengandalkan *Deep Well,* untuk saat ini sedang dalam proses pengkajian terkait alternatif sumber air baku permukaan jangka menengah dan panjang. WHO menggarisbawahi pentingnya; pengelolaan kotoran manusia (tinja dan urin) secara aman, dan dibuang secara aman. Untuk mengurangi dampak negatif terhadap lingkungan, dibutuhkan upaya yang menyeluruh dan berkelanjutan agar air limbah domestik dapat dibuang secara aman atau dilakukan daur ulang sehingga dapat dimanfaatkan kembali [3].

Penelitian ini mengajukan sebuah solusi untuk mengatasi defisiensi air bersih di Kota Bontang melalui pemanfaatan kembali air limbah greywater dan air hujan. Secara singkat, teknologi sederhana yang diterapkan adalah penyaringan (filtrasi) dengan menggunakan media pasir. Selain sederhana, teknologi tersebut juga murah dan tidak membutuhkan desain yang rumit, sehingga dapat ditiru oleh masyarakat setempat untuk memenuhi kebutuhan air bersih di rumah tangga masing-masing.

Gagasan ini tentu saja tidak hanya dapat diterapkan di Kota Bontang saja, namun juga di wilayah lain yang memiliki keterbatasan sumber daya air bersih. Pengamatan dilakukan berdasarkan parameter dari total coliform (Jml/100 ml).

2. METODE PENELITIAN

Penelitian ini merupakan penelitian kuantitatif dengan pendekatan eksperimen. Limbah greywater diperoleh dari drainase perumahan Bukit Sekatup Damai (BSD) Kelurahan Gunung Elai, Kecamatan Bontang Utara. Pengamatan didasarkan pada parameter total coliform (jml/100, yakni berdasarkan Peraturan Pemerintah No. 82 Tahun 2001 untuk air kelas II [4]. Kandungan total coliform (jml/100 ml) yang dipersyaratkan adalah sebesar 5000. Desain pengolahan air limbah dijelaskan melalui Gambar 1. Pertama-tama, limbah greywater dan air hujan diberi bahan kimia berupa PAC (*Poly Alumunium Chloride*) dan soda ash (*Sodium Chloride*) untuk membantu mengurangi kandungan total coliform dalam sampel . Percobaan variasi pemberian PAC dan soda ash (gram) dilakukan untuk mengurangi kandungan total coliform; 10 gram, 20 gram, 30 gram, dan 40 gram. Sementara itu, filtrasi dengan media pasir juga diterapkan dengan variasi ketebalan, yakni 0 cm (tanpa filtrasi pasir), 10 cm, dan 20 cm. Pengukuran kandungan total coliform (jml/100 ml) dilakukan dengan uji lab sebelum dan sesudah dilakukan treatment. Data kualitas air dari kombinasi perlakuan tersebut selanjutnya dianalisis dengan metode deskriptif dan regresi linier untuk menentukan hasil terbaik, yang memenuhi kriteria air baku kelas II.



Gambar 1. Skema Pengolahan Limbah Greywater dan Air Hujan

3. HASIL PENELITIAN

3.1 Analisis Deskriptif

Dalam naskah ini, parameter kualitas air yang dibahas adalah total coliform (jml/100 ml). Analisis deskriptif dilakukan untuk mengetahui gambaran peningkatan kualitas air berdasarkan parameter tersebut. Sebelum dilakukan pengolahan, limbah greywater dan air hujan terlebih dahulu dilakukan uji laboratorium, di mana kadar awal parameter adalah 9200. Total coliform (jml/100 ml) merupakan parameter penting dalam analisis kualitas air karena sangat terkait dengan proses-proses biologis dan kimia [5]. Total Coliform adalah banyaknya bakteri pathogen jenis coliform di perairan yang sangat perlu di kendalikan kandungannya agar bakteri tersebut tidak menjadi penyakit yang mudah menular. Menurut Peraturan Pemerintah Nomor 82 Tahun 2001, kandungan total coliform (jml/100 ml) yang direkomendasikan untuk air kelas II adalah 5000. Hasil pengukuran kandungan total coliform (jml/100 ml) sepanjang proses eksperiman disajikan pada Tabel 1. Selanjutnya, dinamika kualitas air berdasarkan parameter total coliform (jml/100 ml) pada tiap perlakuan relevan dijelaskan secara visual melalui Gambar 2.

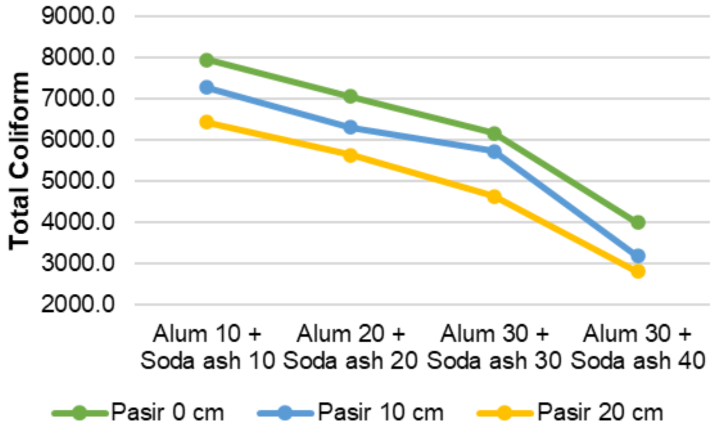
Tabel 1. Data Hasil Pengukuran Total Coliform pada tiap perlakuan

Ketebalan pasir (cm)	Debit Air (liter/menit)	Total Coliform Awal	Total Coliform PAC + *Soda ash*	Total Coliform Filter bertingkat	Standar
0	1	9200	4200	4000	5000
10	1,5	9200	3800	3200	
20	2	9200	3100	2800	

Ketebalan Pasir	Debit Air	Filter	Total Coliform
Pasir 0 cm	1 liter/menit	PAC 10 + *Soda ash* 10	7960
		PAC 20 + *Soda ash* 20	7060
		PAC 30 + *Soda ash* 30	6180
		PAC 30 + *Soda ash* 40	4000
Pasir 10 cm	1.5 liter/menit	PAC 10 + *Soda ash* 10	7280
		PAC 20 + *Soda ash* 20	6320
		PAC 30 + *Soda ash* 30	5740
		PAC 30 + *Soda ash* 40	3200
Pasir 20 cm	2 liter/menit	PAC 10 + *Soda ash* 10	6440
		PAC 20 + *Soda ash* 20	5640
		PAC 30 + *Soda ash* 30	4640
		PAC 30 + *Soda ash* 40	2820

Ketebalan Pasir	Debit Air	Filter	Total Coliform
0 cm	1 liter/menit	PAC 30 + *Soda ash* 40	4000
10 cm	1.5 liter/menit	PAC 30 + *Soda ash* 40	3200
20 cm	2 liter/menit	PAC 30 + *Soda ash* 40	2820

Sumber: Data penelitian (2023)



Gambar 2. Grafik Perubahan Total Coliform Berdasakan Ketebalan Pasir dan Penggunaan PAC + *Soda ash*

Sumber: Data penelitian (2023)

Hasil deskripsi parameter Total Coliform menunjukkan bahwa setiap penambahan ketebalan pasir dan bertambahnya penggunaan PAC + *soda ash* dapat menurunkan nilai Total Coliform. Penggunaan filter pasir dengan ketebalan 20 cm menunjukkan Total Coliform paling rendah, sedangkan filter pasir dengan ketebalan 0 cm menunjukkan Total Coliform paling tinggi. Berdasarkan standar kualitas air pada Total Coliform yaitu 5000, hasil perubahan nilai Total Coliform sudah memenuhi ketentuan yaitu dengan menggunakan filter pasir dengan ketebalan 20 cm dan penggunaan PAC 30 + *soda ash* 40.

3.2 Analisis Regresi

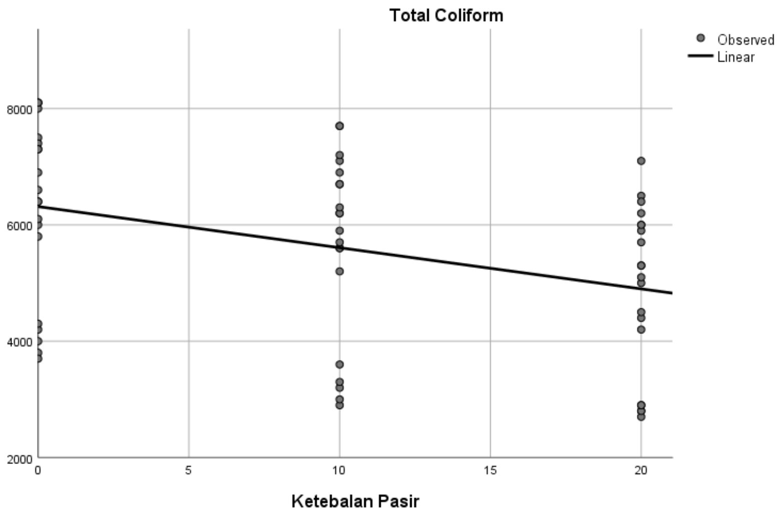
Analisis regresi dilakukan untuk mengetahui signifikansi dari perlakuan yang dilakukan terhadap kualitas air, yang dalam artikel ini dibatasi pada parameter total coliform (jml/100 ml). Hasil analisis dinyatakan signifikan jika nilai signifikansi (p-value) lebih kecil dari taraf nyata (α) 0,05. Tabel 2 menampilkan hasil analisis regresi dari parameter total coliform (jml/100 ml). Selanjutnya, grafik regresi menggambarkan hubungan antara perlakuan; pemberian PAC dan soda ash, serta variasi ketebalan pasir, terhadap kualitas air yang diolah dengan total coliform (jml/100 ml).

Tabel 2. Ringkasan Hasil Uji Regresi Linier terhadap Total Coliform

No	Variabel bebas		Koef.	Sig.	Persamaan	R Square
1	Konstanta	C	6314.17	0.000	Y = 6314.17 - 70.75 X1 + e	13.2%
	Ketebalan Pasir	X1	-70.75	0.004		
2	Konstanta	C	8726.67	0.000	Y = 8726.67 - 124.80 X2 + e	77.1%
	PAC + *Soda ash*	X2	-124.80	0.000		
3	Konstanta	C	9434.17	0.000	Y = 9434.17 - 77.75 X1 - 124.80 X2 + e	90.3%
	Ketebalan Pasir	X1	-70.75	0.000		
	PAC + *Soda ash*	X2	-124.80	0.000		
	Total Coliform	Y				

Sumber: Data penelitian (2023)

Pada tabel 2. Pengaruh ketebalan pasir terhadap parameter Total Coliform menunjukkan adanya pengaruh negatif signifikan dengan koefisien regresi sebesar -70,75 dan p-value sebesar 0,004 (p < 0,05), artinya semakin besar nilai ketebalan pasir akan berpengaruh signifikan terhadap Total Coliform, yaitu setiap bertambahnya ketebalan pasir sebesar 1 cm akan menurunkan Total Coliform sebesar 70,75 satuan.



Gambar 3. Kurva Linier Pengaruh Ketebalan Pasir terhadap Total Coliform

Sumber: Data penelitian (2023)

Pengaruh ketebalan pasir terhadap parameter Total Coliform menunjukkan adanya pengaruh negatif signifikan dengan koefisien regresi sebesar -70,75 dan p-value sebesar 0,000 ($p < 0,05$), artinya semakin besar nilai ketebalan pasir akan berpengaruh signifikan terhadap semakin rendah Total Coliform, yaitu setiap bertambahnya ketebalan pasir sebesar 1 cm akan menurunkan nilai Total Coliform sebesar 70,75 satuan. Dengan kata lain, teknik filtrasi sangat efektif dalam menghilangkan partikel polutan yang terkandung dalam limbah greywater. Temuan ini sejalan dengan penelitian terdahulu yang dilakukan oleh Wulandari et al. [10] di mana material pasir sangat potensial dalam menyaring polutan tersuspensi yang terkandung dalam air limbah blackwater. Dijelaskan bahwa pasir tidak hanya memiliki potensi menyaring polutan yang baik, namun juga mudah diperoleh dengan biaya yang relatif murah. Selain itu, penelitian Coenraad et al. [7] dan Artidarma et al. [8] juga menemukan temuan yang sejalan dengan hasil penelitian ini, di mana pasir sangat efektif dalam menjernihkan air

4. KESIMPULAN

Penelitian ini membuahkan temuan empiris yang menegaskan bahwa PAC dan soda ash yang mampu mengurangi kandungan total coliform (jml/100 ml) dalam greywater dan air hujan. Selain itu, penerapan teknik filtrasi dengan pasir juga terbukti mampu menurunkan secara signifikan. Berdasarkan hasil eksperimen, maka penggunaan PAC dan soda ash yang disarankan masing-masing adalah 30 gram dan 40 gram. Selanjutnya, ketebalan lapisan filter pasir yang disarankan adalah 20 cm. Adapun hasil pengolahan air terbaik dalam penelitian ini memiliki kabdungan total coliform sebesar 2800. Penelitian ini tentu dapat dikembangkan kembali hingga mencapai kadar total coliformnya menjadi 1000 untuk air kelas 1. Untuk itu, peneliti selanjutnya dapat menerapkan teknik filter kombinasi berbagai media, dengan perlakuan berbagai ketebalan. Pengamatan juga dapat dilakukan pada parameter kualitas air yang lebih lengkap sehingga memperoleh hasil pengukuran yang representatif terhadap kualitas air output yang sebenarnya.

5. DAFTAR PUSTAKA

[1] Arifin, Moch.Hikmat Ramadhan. (2021). *Analisis Pemanfaatan Air Hujan Sebagai Alternatif Penyediaan Air Sanitasi Dan Pertamanan Pada Kompleks Gedung Pemerintahan Kota Bandung*. Seminar Nasional dan Diseminasi

[2] Badan Pusat Statistik Kota Bontang (2022). Statistik Air Bersih Kalimantan Timur. https://bontangkota.bps.go.id/

[3] Fathar, Imam Rozali (2022). *Pemanfaatan Ozon sebagai Teknologi Berkelanjutan Daur Ulang Air Limbah Domestik Hotel X Lembang*. Insologi: Jurnal Sains dan Teknologi Fakultas Sains dan Teknologi. Universitas Terbuka.

[4] Haandel, V. Adrianus, & Lubbe, V. der Jeroen. (2012). Handbook of Biological Wastewater Treatment. London: IWA Publishing.

[5] Hasrianti, & Nurasia. (2017). Analisis Warna, Suhu, pH, dan Salinitas Air Sumur Bor di Kota Palopo. Prosiding Seminar Nasional, 02(01): 747-753.

[6] Khotimah, Siti Nurul. (2021). *Karakterisasi Limbah Cair Greywater pada level Rumah Tangga Berdasarkan Sumber Emisi*. Jurnal Teknik Sipil. Universitas Lampung.

[7] Said, Nusa I. (2017). Teknologi Pengolahan Air Limbah: Teori dan Aplikasi. Jakarta: Erlangga.

[8] Sungkowo, T.H., Shinta, E., & Ivnaini, A. (2015). Pengolahan Limbah Cair Industri Tahu Menggunakan Tanaman Typha latifolia dan Enceng Gondok dengan Metode Fitoremediasi. JOM Fteknik, Vol 2, No 2.

[9] Wulandari, Lies Kurniawati. (2019). *Model Fisik Pengolahan Limbah Blackwater Pada Septictank Komunal* Volume 1. Malang. Dream Litera Buana.

[10] Wulandari, Lies Kurniawati. (2019). *Rancangan dan Hasil Model Fisik Blackwater pada Septicktank Komunal Standar Air Pertanian.* Volume 2. Malang. Dream Litera Buana.

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