LAMPIRAN A
DATA PENGAMATAN

Tabel A.1 Hasil Uji Nilai COD Pada Biogas

No.	Tanggal Sampel	Komposisi Sampel	Parameter Uji	Metode Uji	Vol. FAS Sampel	Vol. FAS Blanko	Vol. Std.	Hasil Uji
1.	23 April 2022	Kotoran Sapi : Air (1 : 2)	COD (*Chemical Oxygen Demand*)	Titrimetri	10,1 ml	11 ml	25,1 ml	35856 mg/L
2.	28 April 2022				10,5 ml	11,3 ml	25 ml	32000 mg/L
3.	3 Mei 2022				10,6 ml	11,4 ml	25,2 ml	31744 mg/L
4.	8 Mei 2022				10,7 ml	11,5 ml	25,4 ml	31488 mg/L
5.	13 Mei 2022				11,3 ml	12 ml	24,8 ml	28224 mg/L
6.	18 Mei 2022				11,4 ml	12 ml	24,8 ml	24192 mg/L

Tabel A.2 Hasil Perhitungan Massa Jenis Biogas

No.	Tanggal Sampel	Komposisi Sampel	ρ CH_4 (kg/m^3)	ρ CO_2 (kg/m^3)	Hasil Uji (kg/m^3)
1.	28 April 2022	Kotoran Sapi : Air (1 : 2)	0,668	1,842	1,7388054
2.	3 Mei 2022				1,7035854
3.	8 Mei 2022				1,3246182
4.	13 Mei 2022				1,2531216
5.	18 Mei 2022				1,2061616

Tabel A.3 Hasil Pengamatan Tekanan dan pH Pada Biogas

No.	Tanggal Sampel	Komposisi Sampel	Tekanan (bar)	pH
1.	23 April 2022	Kotoran Sapi : Air (1 : 2)	0	6
2.	28 April 2022		0,1	6
3.	3 Mei 2022		0,25	6
4.	8 Mei 2022		0,2	7
5.	13 Mei 2022		0,4	7
6.	18 Mei 2022		0,45	7

Tabel A.4 Hasil Analisa Biogas Menggunakan Alat *Biogas Analyzer*

No.	Tanggal Sampel	Jenis Sampel	Parameter Uji	Metode Uji	Hasil Uji
1.	28 April 2022	Biogas	O_2 (%)	*Biogas Analyzer*	20,31
			CO_2 (%)		12,02
			CH_4 (%)		8,79
			H_2S (ppm)		12,00
			Net cal. val (MJ/kg)		2,10
			Gross cal. val (MJ/kg)		2,70
			Net cal. val (MJ/m^3)		3,40
			Gross cal. val (MJ/m^3)		4,30
2.	3 Mei 2022		O_2 (%)		20,18
			CO_2 (%)		0,04
			CH_4 (%)		11,79
			H_2S (ppm)		17,00
			Net cal. val (MJ/kg)		6,70
			Gross cal. val (MJ/kg)		7,40
			Net cal. val (MJ/m^3)		8,20
			Gross cal. val (MJ/m^3)		9,10
3.	8 Mei 2022		O_2 (%)		9,31
			CO_2 (%)		31,09
			CH_4 (%)		44,07
			H_2S (ppm)		2224,00
			Net cal. val (MJ/kg)		11,80
			Gross cal. val (MJ/kg)		13,40
			Net cal. val (MJ/m^3)		13,30
			Gross cal. val (MJ/m^3)		14,90
4.	13 Mei 2022		O_2 (%)		11,72
			CO_2 (%)		38,78
			CH_4 (%)		50,16
			H_2S (ppm)		1805,00
			Net cal. val (MJ/kg)		19,50
			Gross cal. val (MJ/kg)		21,80
			Net cal. val (MJ/m^3)		18,10
			Gross cal. val (MJ/m^3)		20,00
5.	18 Mei 2022		O_2 (%)		8,28
			CO_2 (%)		37,34
			CH_4 (%)		54,16
			H_2S (ppm)		1034,00
			Net cal. val (MJ/kg)		18,40
			Gross cal. val (MJ/kg)		20,60
			Net cal. val (MJ/m^3)		19,80
			Gross cal. val (MJ/m^3)		22,20

LAMPIRAN B
PERHITUNGAN

1. Mencari Nilai COD

   a. Normalitas Ferro Ammonium Sulfat (FAS)

      Diketahui :

Tabel B.1 Hasil Standarisasi Larutan FAS

No.	Tanggal Sampel	Volume $K_2Cr_2O_7$ (ml)	N $K_2Cr_2O_7$ (N)	Volume Titran (ml)
1.	23 April 2022	10	0,25	25,1
2.	28 April 2022			25
3.	3 Mei 2022			25,2
4.	8 Mei 2022			25,4
5.	13 Mei 2022			24,8
6.	18 Mei 2022			24,8

Rumus (SNI, 2004) :

$$\text{N FAS} = \frac{ml\ K_2Cr_2O_7 \times N\ K_2Cr_2O_7}{ml\ standarisasi\ larutan\ FAS}$$

- 23 April 2022

$$\text{N FAS} = \frac{ml\ K_2Cr_2O_7 \times N\ K_2Cr_2O_7}{ml\ standarisasi\ larutan\ FAS}$$

$$\text{N FAS} = \frac{10\ ml \times 0{,}25\ N}{25{,}1\ ml}$$

N FAS = 0,0996 N

- 28 April 2022

$$\text{N FAS} = \frac{ml\ K_2Cr_2O_7 \times N\ K_2Cr_2O_7}{ml\ standarisasi\ larutan\ FAS}$$

$$\text{N FAS} = \frac{10\ ml \times 0{,}25\ N}{25\ ml}$$

N FAS = 0,1 N

- 3 Mei 2022

  N FAS = $\frac{ml\ K_2Cr_2O_7 \times N\ K_2Cr_2O_7}{ml\ standarisasi\ larutan\ FAS}$

  N FAS = $\frac{10\ ml \times 0{,}25\ N}{25{,}2\ ml}$

  N FAS = 0,0992 N

- 8 Mei 2022

  N FAS = $\frac{ml\ K_2Cr_2O_7 \times N\ K_2Cr_2O_7}{ml\ standarisasi\ larutan\ FAS}$

  N FAS = $\frac{10\ ml \times 0{,}25\ N}{25{,}4\ ml}$

  N FAS = 0,0984 N

- 13 Mei 2022

  N FAS = $\frac{ml\ K_2Cr_2O_7 \times N\ K_2Cr_2O_7}{ml\ standarisasi\ larutan\ FAS}$

  N FAS = $\frac{10\ ml \times 0{,}25\ N}{24{,}8\ ml}$

  N FAS = 0,1008 N

- 18 Mei 2022

  N FAS = $\frac{ml\ K_2Cr_2O_7 \times N\ K_2Cr_2O_7}{ml\ standarisasi\ larutan\ FAS}$

  N FAS = $\frac{10\ ml \times 0{,}25\ N}{24{,}8\ ml}$

  N FAS = 0,1008 N

Tabel B.2 Normalitas FAS

No.	Tanggal Sampel	N FAS
1.	23 April 2022	0,0996 N
2.	28 April 2022	0,1 N
3.	3 Mei 2022	0,0992 N
4.	8 Mei 2022	0,0984 N
5.	13 Mei 2022	0,1008 N
6.	18 Mei 2022	0,1008 N

b. Nilai COD

Diketahui :

Tabel B.3 Hasil Titrasi Sampel dan Blanko

No.	Tanggal Sampel	Volume Titran Blanko (a) (ml)	Volume Titran Sampel (b) (ml)	N FAS (N)	Volume Sampel (ml)
1.	23 April 2022	11	10,1	0,0996	10
2.	28 April 2022	11,3	10,5	0,1	
3.	3 Mei 2022	11,4	10,6	0,0992	
4.	8 Mei 2022	11,5	10,7	0,0984	
5.	13 Mei 2022	12	11,3	0,1008	
6.	18 Mei 2022	12	11,4	0,1008	

Rumus (SNI, 2004) :

$$\text{COD} = \frac{(a-b)(N\ FAS)(8000)(P)}{ml\ sampel}$$

- 23 April 2022

$$\text{COD} = \frac{(a-b)(N)(8000)(P)}{ml\ sampel}$$

$$\text{COD} = \frac{(11 - 10{,}1)\ ml \times 0{,}0996\ N \times 8000 \times 500\ ml}{10\ ml}$$

COD = 35856 mg/L O_2

- 28 April 2022

$$\text{COD} = \frac{(a-b)(N)(8000)(P)}{ml\ sampel}$$

$$\text{COD} = \frac{(11{,}3 - 10{,}5)\ ml \times 0{,}1\ N \times 8000 \times 500\ ml}{10\ ml}$$

COD = 32000 mg/L O_2

- 3 Mei 2022

$$\text{COD} = \frac{(a-b)(N)(8000)(P)}{ml\ sampel}$$

$$\text{COD} = \frac{(11{,}4 - 10{,}6)\ ml \times 0{,}0992\ N \times 8000 \times 500\ ml}{10\ ml}$$

COD = 31744 mg/L O_2

- 8 Mei 2022

  COD = $\frac{(a-b)(N)(8000)(P)}{ml\ sampel}$

  COD = $\frac{(11{,}5-10{,}7)\ ml \times 0{,}0984\ N \times 8000 \times 500\ ml}{10\ ml}$

  COD = 31488 mg/L O_2

- 13 Mei 2022

  COD = $\frac{(a-b)(N)(8000)(P)}{ml\ sampel}$

  COD = $\frac{(12-11{,}3)\ ml \times 0{,}1008\ N \times 8000 \times 500\ ml}{10\ ml}$

  COD = 28224 mg/L O_2

- 18 Mei 2022

  COD = $\frac{(a-b)(N)(8000)(P)}{ml\ sampel}$

  COD = $\frac{(12-11{,}4)\ ml \times 0{,}1008\ N \times 8000 \times 500\ ml}{10\ ml}$

  COD = 24192 mg/L O_2

Tabel B.4 Nilai COD

No.	Tanggal Sampel	COD (mg/L O_2)
1.	23 April 2022	35856
2.	28 April 2022	32000
3.	3 Mei 2022	31744
4.	8 Mei 2022	31488
5.	13 Mei 2022	28224
6.	18 Mei 2022	24192

2. Mencari Nilai Massa Jenis Biogas

Diketahui :

Tabel B.5 Massa Jenis dan Konsentrasi CH_4 dan CO_2

No.	Tanggal Sampel	ρCH_4 (kg/m^3)	ρCO_2 (kg/m^3)	C_{CH_4} (%)
1.	28 April 2022			8,79
2.	3 Mei 2022			11,79
3.	8 Mei 2022	0,668	1,842	44,07
4.	13 Mei 2022			50,16
5.	18 Mei 2022			54,16

Rumus (Tabatabaei, 2018) :

$$\rho_{\text{biogas}} = C_{CH_4} \times \rho_{CH_4} + (1 - C_{CH_4}) \times \rho_{CO_2}$$

- 28 April 2022

$\rho_{\text{biogas}} = C_{CH_4} \times \rho_{CH_4} + (1 - C_{CH_4}) \times \rho_{CO_2}$

ρ_{biogas} = 0,0879 x 0,668 kg/m^3 + (1 - 0,0879) x 1,842 kg/m^3

ρ_{biogas} = 0,0587172 kg/m^3 + 1,6800882 kg/m^3

ρ_{biogas} = 1,7388054 kg/m^3

- 3 Meil 2022

$\rho_{\text{biogas}} = C_{CH_4} \times \rho_{CH_4} + (1 - C_{CH_4}) \times \rho_{CO_2}$

ρ_{biogas} = 0,1179 x 0,668 kg/m^3 + (1 - 0,1179) x 1,842 kg/m^3

ρ_{biogas} = 0,0787572 kg/m^3 + 1,6248282 kg/m^3

ρ_{biogas} = 1,7035854 kg/m^3

- 8 Mei 2022

$\rho_{\text{biogas}} = C_{CH_4} \times \rho_{CH_4} + (1 - C_{CH_4}) \times \rho_{CO_2}$

ρ_{biogas} = 0,4407 x 0,668 kg/m^3 + (1 - 0,4407) x 1,842 kg/m^3

ρ_{biogas} = 0,2943876 kg/m^3 + 1,0302306 kg/m^3

ρ_{biogas} = 1,3246182 kg/m^3

- 13 Mei 2022

$\rho_{biogas} = C_{CH_4} \times \rho_{CH_4} + (1 - C_{CH_4}) \times \rho_{CO_2}$

ρ_{biogas} = 0,5016 x 0,668 kg/m^3 + (1 - 0,5016) x 1,842 kg/m^3

ρ_{biogas} = 0,3350688 kg/m^3 + 0,9180528 kg/m^3

ρ_{biogas} = 1,2531216 kg/m^3

- 18 Mei 2022

$\rho_{biogas} = C_{CH_4} \times \rho_{CH_4} + (1 - C_{CH_4}) \times \rho_{CO_2}$

ρ_{biogas} = 0,5416 x 0,668 kg/m^3 + (1 - 0,5416) x 1,842 kg/m^3

ρ_{biogas} = 0,3617888 kg/m^3 + 0,8443728 kg/m^3

ρ_{biogas} = 1,2061616 kg/m^3

Tabel B.6 Nilai Massa Jenis Biogas

No.	Tanggal Sampel	ρ_{biogas} (kg/m^3)
1.	28 April 2022	1,7388054
2.	3 Mei 2022	1,7035854
3.	8 Mei 2022	1,3246182
4.	13 Mei 2022	1,2531216
5.	18 Mei 2022	1,2061616

Tabel B 7. Densitas Gas

Gas	Formula	Molecular weight	*Density - ρ -*	
			(kg/m³)	*(lb/ft³)*
Acetylene (ethyne)	C_2H_2	26	1.092[1)] 1.170[2)]	0.0682[1)] 0.0729[2)]
Air		29	1.205[1)] 1.293[2)]	0.0752[1)] 0.0806[2)]
Ammonia	NH_3	17.031	0.717[1)] 0.769[2)]	0.0448[1)] 0.0480[2)]
Argon	*Ar*	39.948	1.661[1)] 1.7837[2)]	0.1037[1)] 0.111353[2)]
Benzene	C_6H_6	78.11	3.486	0.20643
Blast furnace gas			1.250[2)]	0.0780[2)]
Butane	C_4H_{10}	58.1	2.489[1)] 2.5[2)]	0.1554[1)] 0.156[2)]
Butylene (Butene)	C_4H_8	56.11	2.504	0.148[2)]
Carbon dioxide	CO_2	44.01	1.842[1)] 1.977[2)]	0.1150[1)] 0.1234[2)]
Carbon disulphide		76.13		
Carbon monoxide	*CO*	28.01	1.165[1)] 1.250[2)]	0.0727[1)] 0.0780[2)]
Carbureted Water Gas				0.048
Chlorine	Cl_2	70.906	2.994[1)]	0.1869[1)]
Coal gas			0.58[2)]	
Coke Oven Gas				0.034[2)]
Combustion products			1.11[2)]	0.069[2)]
Cyclohexane		84.16		
Digester Gas (Sewage or Biogas)				0.062
Ethane	C_2H_6	30.07	1.264[1)]	0.0789[1)]
Ethyl Alcohol		46.07		
Ethyl Chloride		64.52		
Ethylene	C_2H_4	28.03	1.260[2)]	0.0786[2)]
Helium	*He*	4.02	0.1664[1)] 0.1785[2)]	0.01039[1)] 0.011143[2)]
N-Heptane		100.20		
Hexane		86.17		
Hydrogen	H_2	2.016	0.0899[2)]	0.0056[2)]
Hydrochloric Acid		36.47	1.63[2)]	
Hydrogen Chloride	*HCl*	36.5	1.528[1)]	0.0954[1)]
Hydrogen Sulfide	H_2S	34.076	1.434[1)]	0.0895[1)]
Krypton			3.74[2)]	
Methane	CH_4	16.043	0.668[1)] 0.717[2)]	0.0417[1)] 0.0447[2)]
Methyl Alcohol		32.04		

Methyl Butane		72.15		
Methyl Chloride		50.49		
Natural gas		19.5	0.7 - 0.9[2)]	0.044 - 0.056[2)]
Neon	*Ne*	20.179	0.8999[2)]	0.056179[2)]
Nitric oxide	*NO*	30.0	1.249[1)]	0.0780[1)]
Nitrogen	N_2	28.02	1.165[1)] 1.2506[2)]	0.0727[1)] 0.078072[2)]
Nitrogen Dioxide	NO_2	46.006		
N-Octane		114.22		
Nitrous Oxide	N_2O	44.013		0.114[1)]
Nitrous Trioxide	NO_3	62.005		
Oxygen	O_2	32	1.331[1)] 1.4290[2)]	0.0831[1)] 0.089210[2)]
Ozone	O_3	48.0	2.14[2)]	0.125
N-Pentane		72.15		
Iso-Pentane		72.15		
Propane	C_3H_8	44.09	1.882[1)]	0.1175[1)]
Propene (propylene)	C_3H_6	42.1	1.748[1)]	0.1091[1)]
R-11		137.37		
R-12		120.92		
R-22		86.48		
R-114		170.93		
R-123		152.93		
R-134a		102.03		
Sasol				0.032
Sulfur	*S*	32.06		0.135
Sulfur Dioxide	SO_2	64.06	2.279[1)] 2.926[2)]	0.1703[1)] 0.1828[2)]
Sulfur Trioxide	SO_3	80.062		
Sulfuric Oxide	*SO*	48.063		
Toluene	C_7H_8	92.141	4.111	0.2435
Water Vapor, steam	H_2O	18.016	0.804	0.048
Water gas (bituminous)				0.054
Xenon			5.86[2)]	

Sumber : *Engineering ToolBox*, 2012

LAMPIRAN C
DOKUMENTASI

1. Pembuatan Biogas
   - Persiapan alat dan bahan pembuatan biogas menggunakan biodigester



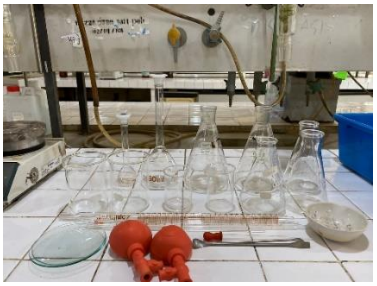
   - Pengambilan biogas dan *slurry* pada biodigester


   - Analisa biogas menggunakan alat *Biogas Analyzer*


- Mengukur pH slurry

2. Analisa COD Pada *Slurry*

- Menyiapkan alat-alat yang digunakan



- Melakukan pengenceran 500 ml *slurry*

- Menimbang dan membuat larutan $K_2Cr_2O_7$ dan FAS

- Menyiapkan sampel dan blanko untuk kemudian direfluks


- Melakukan titrasi dengan larutan FAS

- Perubahan warna sampel sebelum dititrasi dan setelah dititrasi