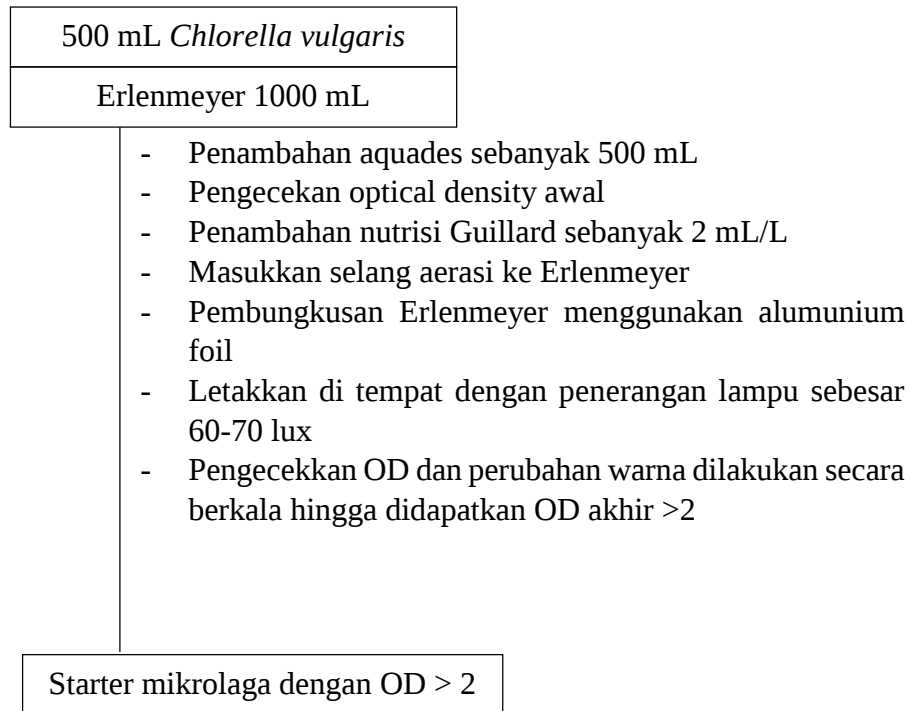


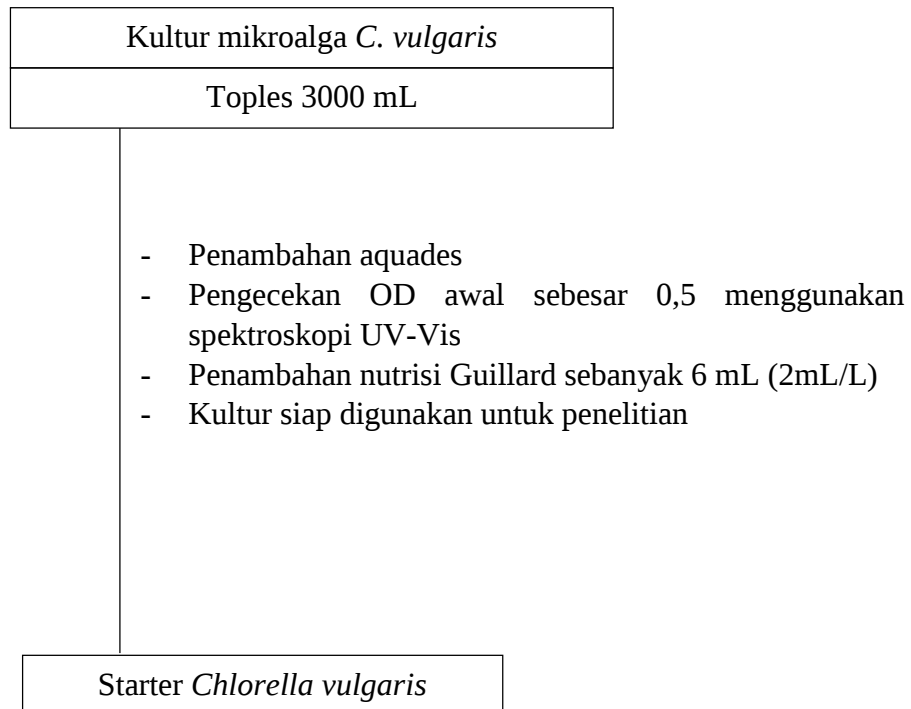
LAMPIRAN

Lampiran 1 : Skema Penelitian

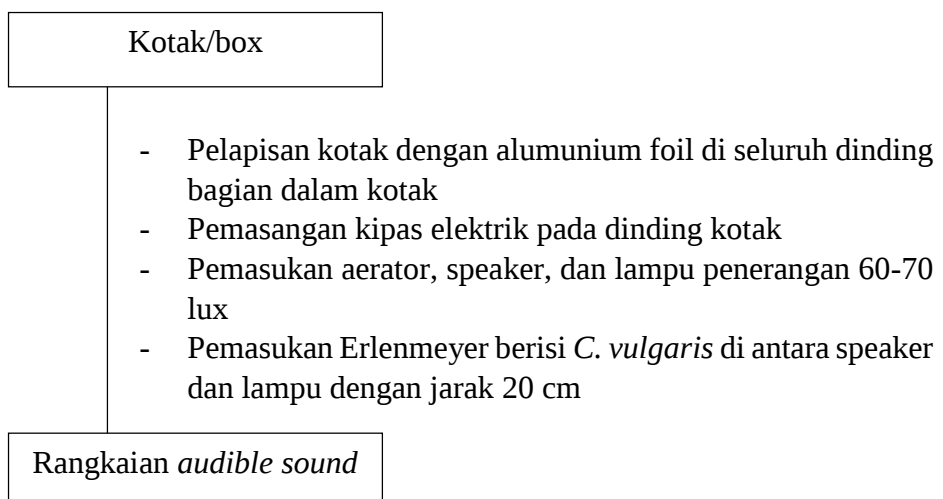
1. Pembuatan Stok Starter



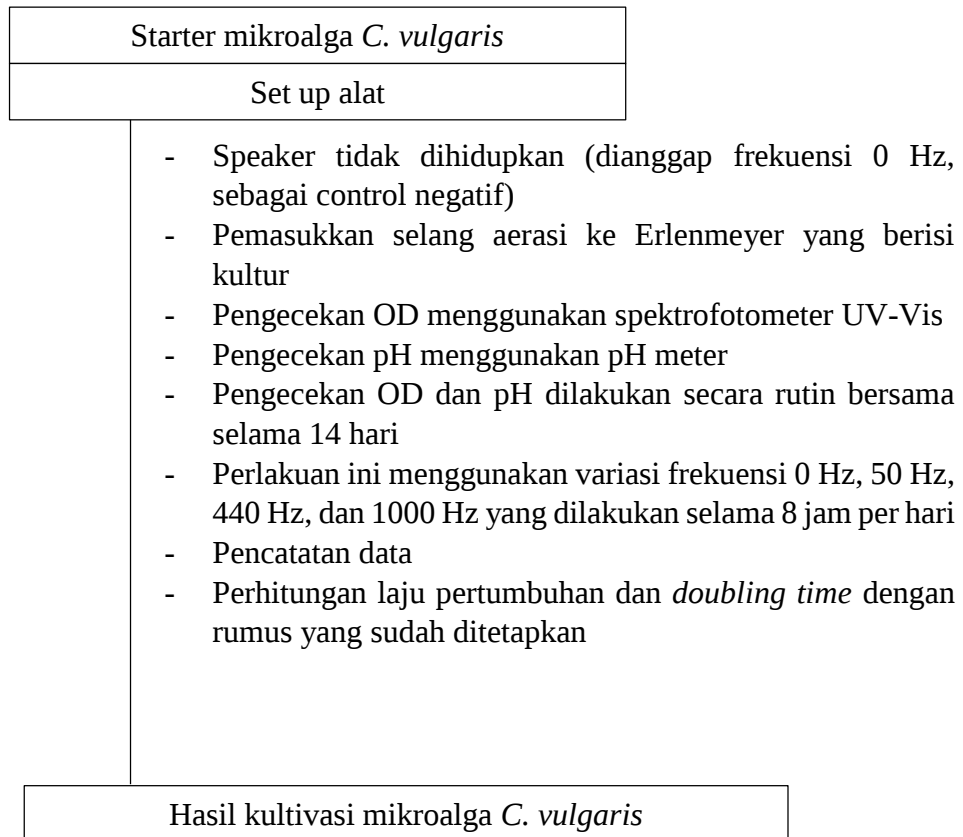
2. Pembuatan Kultur



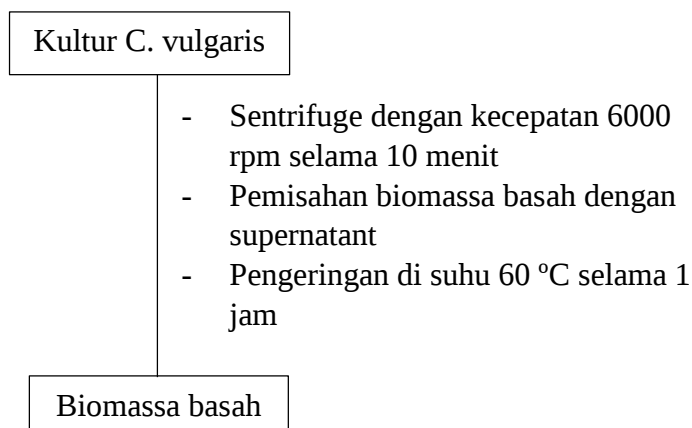
3. Pembuatan Set-Up Alat



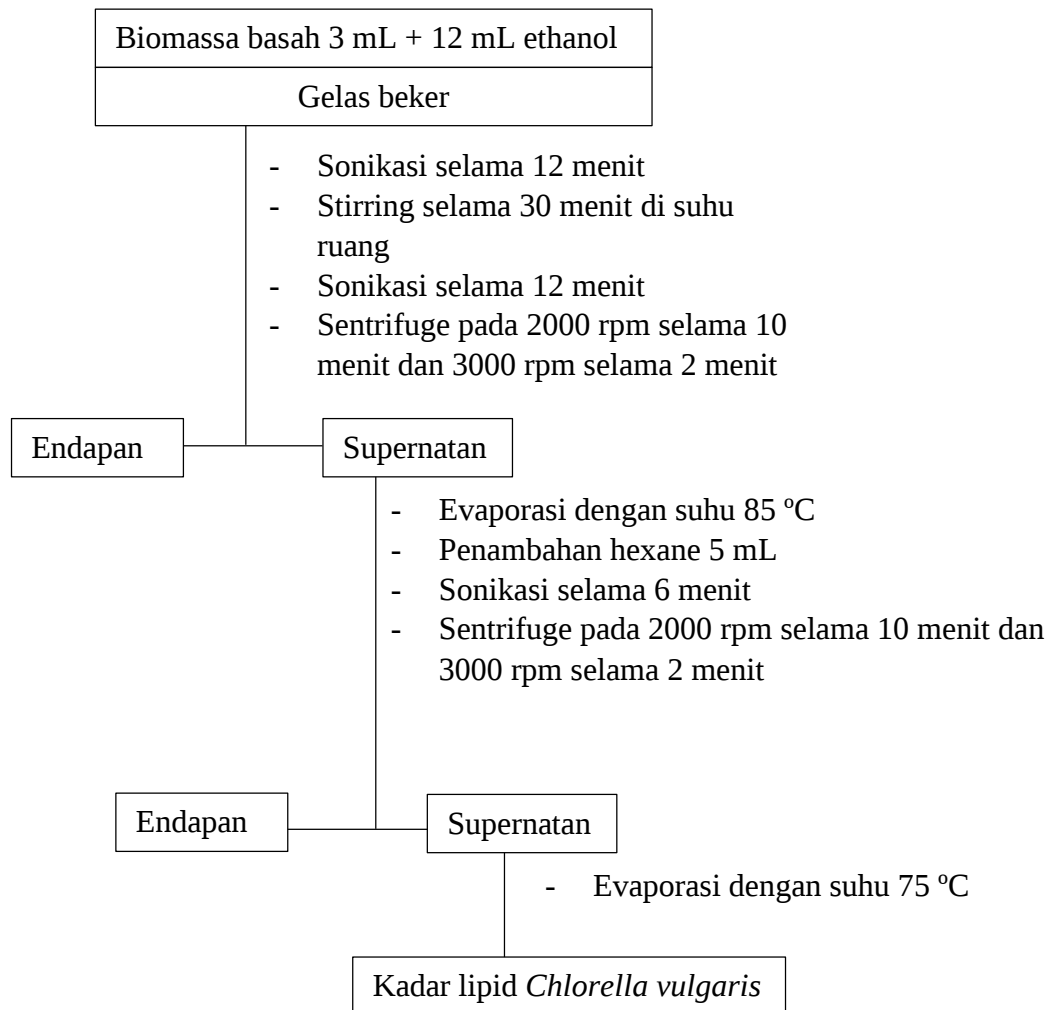
4. Kultivasi Mikroalga *Chlorella vulgaris*



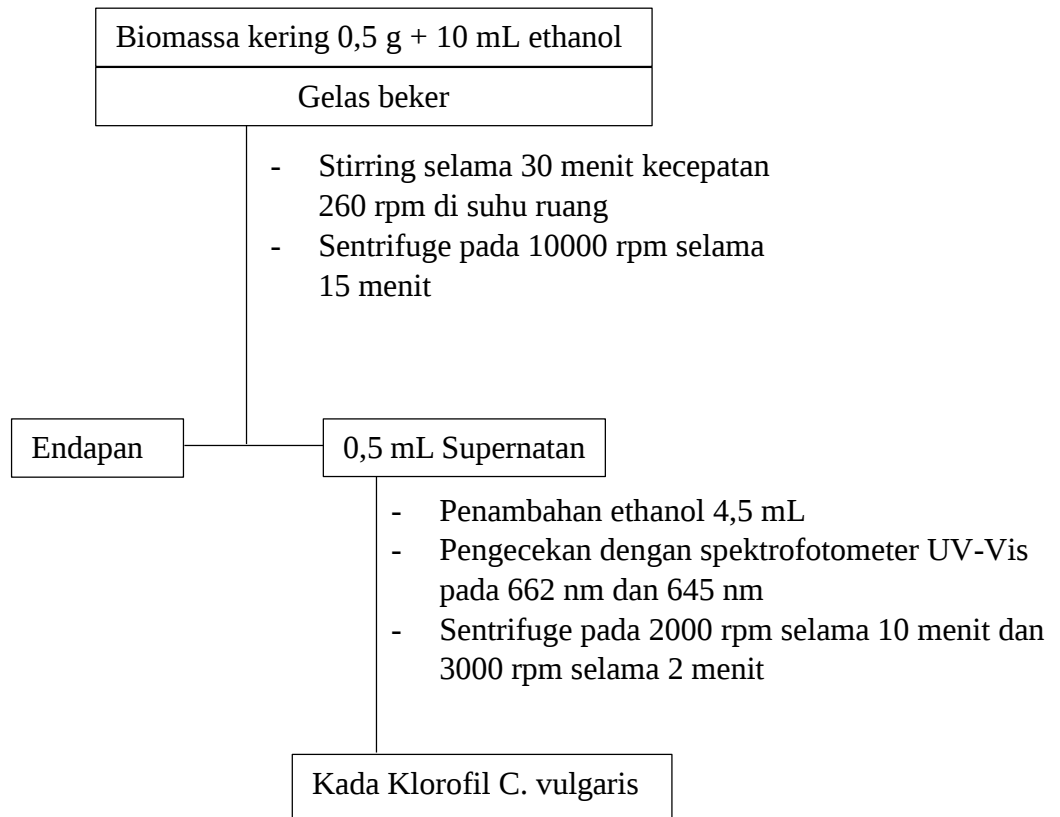
5. Pengambilan Biomassa



6. Pengujian Kadar Lipid



7. Pengujian Kadar Klorofil



Lampiran 2 : Data Penelitian

1. Growth Rate *Chlorella vulgaris* (OD_{680nm})

Hari ke-	Rata-Rata OD normalisasi			
	0 Hz	50 Hz	440 Hz	1000 Hz
0	0,505	0,501	0,506	0,501
1	0,503	0,591	0,649	0,522
2	0,512	0,671	0,684	0,543
3	0,543	0,713	0,730	0,554
4	0,560	0,761	0,771	0,569
5	0,582	0,775	0,817	0,590
6	0,599	0,795	0,842	0,595
7	0,631	0,878	0,872	0,597
8	0,637	0,867	0,902	0,605
9	0,651	0,879	0,944	0,609
10	0,668	0,935	0,935	0,613
11	0,671	1,018	0,946	0,619
12	0,695	1,038	0,968	0,623
13	0,706	1,055	1,000	0,630
14	0,703	1,069	1,015	0,635

2. Laju Pertumbuhan

$$\mu = \frac{OD_t - OD_0}{t_t - t_0}$$

– Frekuensi 0 Hz

- Kultivasi 1

$$\mu = \frac{OD_6 - OD_0}{t_6 - t_0} = \frac{0,625 - 0,0506}{6 - 0} = 0,035$$

- Kultivasi 2

$$\mu = \frac{OD_{10} - OD_0}{t_{10} - t_0} = \frac{0,689 - 0,509}{10 - 0} = 0,030$$

- Kultivasi 3

$$\mu = \frac{OD_{11} - OD_0}{t_{11} - t_0} = \frac{0,706 - 0,501}{11 - 0} = 0,026$$

- Rata-rata

$$\bar{\mu} = \frac{0,035 + 0,030 + 0,026}{3} = 0,031$$

– Frekuensi 50 Hz

- Kultivasi 1

$$\mu = \frac{OD_{11} - OD_0}{t_{11} - t_0} = \frac{1,042 - 0,501}{11 - 0} = 0,067$$

- Kultivasi 2

$$\mu = \frac{OD_{11} - OD_0}{t_{11} - t_0} = \frac{0,993 - 0,50}{11 - 0} = 0,062$$

- Rata-rata

$$\bar{\mu} = \frac{0,067 + 0,062}{2} = 0,064$$

– Frekuensi 440 Hz

- Kultivasi 1

$$\mu = \frac{OD_9 - OD_0}{t_9 - t_0} = \frac{1,074 - 0,506}{11 - 0} = 0,084$$

- Kultivasi 2

$$\mu = \frac{OD_9 - OD_0}{t_9 - t_0} = \frac{0,993 - 0,50}{9 - 0} = 0,066$$

- Rata-rata

$$\bar{\mu} = \frac{0,084 + 0,066}{2} = 0,075$$

- Frekuensi 1000 Hz

- Kultivasi 1

$$\mu = \frac{OD_{11} - OD_0}{t_{11} - t_0} = \frac{1,042 - 0,501}{11 - 0} = 0,067$$

- Kultivasi 2

$$\mu = \frac{OD_{11} - OD_0}{t_{11} - t_0} = \frac{0,993 - 0,50}{11 - 0} = 0,062$$

- Rata-rata

$$\bar{\mu} = \frac{0,067 + 0,062}{2} = 0,064$$

3. Doubling time

$$td = \frac{\ln 2}{\mu}$$

- Frekuensi 0 Hz

- Kultivasi 1

$$td = \frac{\ln 2}{0,035} = 19,690$$

- Kultivasi 2

$$td = \frac{\ln 2}{0,030} = 22,892$$

- Kultivasi 3

$$td = \frac{\ln 2}{0,026} = 26,355$$

- Rata-rata

$$\overline{td} = \frac{19,690+22,892+26,355}{3} = 22,979$$

- Frekuensi 50 Hz

- Kultivasi 1

$$td = \frac{\ln 2}{0,067} = 10,412$$

- Kultivasi 2

$$td = \frac{\ln 2}{0,062} = 11,113$$

- Rata-rata

$$\overline{td} = \frac{10,412+11,113}{2} = 10,763$$

- Frekuensi 440 Hz

- Kultivasi 1

$$td = \frac{\ln 2}{0,084} = 8,290$$

- Kultivasi 2

$$td = \frac{\ln 2}{0,066} = 10,520$$

- Rata-rata

$$\overline{td} = \frac{8,290+10,520}{2} = 9,405$$

- Frekuensi 1000 Hz

- Kultivasi 1

$$td = \frac{\ln 2}{0,032} = 22,055$$

- Kultivasi 2

$$td = \frac{\ln 2}{0,034} = 20,210$$

- Rata-rata

$$\overline{td} = \frac{22,055 + 20,210}{2} = 21,133$$

4. Konsentrasi Biomassa Kering

$$\text{Konsentrasi Biomassa Kering} = \frac{\text{total biomassa selama kultivasi}}{\text{volume kultur}}$$

– Frekuensi 0 Hz

- Kultivasi 1

$$\text{Konsentrasi Biomassa Kering} = \frac{125 \text{ mg}}{2,5 \text{ L}} = 50 \text{ mg/L}$$

- Kultivasi 2

$$\text{Konsentrasi Biomassa Kering} = \frac{131,8 \text{ mg}}{2,3 \text{ L}} = 57,3 \text{ mg/L}$$

- Kultivasi 3

$$\text{Konsentrasi Biomassa Kering} = \frac{94,4 \text{ mg}}{1,5 \text{ L}} = 62,91 \text{ mg/L}$$

- Rata-rata

$$\text{rata - rata} = \frac{(50 + 57,3 + 62,91) \frac{\text{mg}}{\text{L}}}{3} = 56,74 \text{ mg/L}$$

– Frekuensi 50 Hz

- Kultivasi 1

$$\text{Konsentrasi Biomassa Kering} = \frac{174 \text{ mg}}{2,5 \text{ L}} = 69,6 \text{ mg/L}$$

- Kultivasi 2

$$\text{Konsentrasi Biomassa Kering} = \frac{190,9 \text{ mg}}{2,3 \text{ L}} = 83 \text{ mg/L}$$

- Rata-rata

$$rata - rata = \frac{(69,6 + 83) \frac{mg}{L}}{2} = 76,3 \text{ mg/L}$$

– Frekuensi 440 Hz

- Kultivasi 1

$$Konsentrasi \text{ Biomassa Kering} = \frac{196,8 \text{ mg}}{2,3 \text{ L}} = 85,57 \text{ mg/L}$$

- Kultivasi 2

$$Konsentrasi \text{ Biomassa Kering} = \frac{148,5 \text{ mg}}{2 \text{ L}} = 74,25 \text{ mg/L}$$

- Rata-rata

$$rata - rata = \frac{(85,57 + 74,25) \frac{mg}{L}}{2} = 79,91 \text{ mg/L}$$

– Frekuensi 1000 Hz

- Kultivasi 1

$$Konsentrasi \text{ Biomassa Kering} = \frac{181,1 \text{ mg}}{2,5 \text{ L}} = 72,44 \text{ mg/L}$$

- Kultivasi 2

$$Konsentrasi \text{ Biomassa Kering} = \frac{170,8 \text{ mg}}{2,3 \text{ L}} = 74,26 \text{ mg/L}$$

- Rata-rata

$$rata - rata = \frac{(72,44 + 74,26) \frac{mg}{L}}{2} = 73,35 \text{ mg/L}$$

5. Produktivitas Biomassa Kering

$$\text{Produktivitas Biomassa} = \frac{\text{konsentrasi biomassa kering}}{\text{waktu kultivasi}}$$

– Frekuensi 0 Hz

- Kultivasi 1

$$\text{Produktivitas Biomassa} = \frac{125 \text{ mg}}{2,5 \text{ L} \times 14 \text{ hari}} = 3,571 \frac{\text{mg}}{\text{L.hari}}$$

- Kultivasi 2

$$\text{Produktivitas Biomassa} = \frac{131 \text{ mg}}{2,3 \text{ L} \times 14 \text{ hari}} = 4,093 \frac{\text{mg}}{\text{L.hari}}$$

- Kultivasi 3

$$\text{Produktivitas Biomassa} = \frac{94,36 \text{ mg}}{1,5 \text{ L} \times 14 \text{ hari}} = 4,493 \frac{\text{mg}}{\text{L.hari}}$$

- Rata-rata

$$\text{rata - rata} = \frac{3,571 + 4,093 + 4,493}{3} = 4,05 \frac{\text{mg}}{\text{L.hari}}$$

– Frekuensi 50 Hz

- Kultivasi 1

$$\text{Produktivitas Biomassa} = \frac{174 \text{ mg}}{2,5 \text{ L} \times 14 \text{ hari}} = 4,971 \frac{\text{mg}}{\text{L.hari}}$$

- Kultivasi 2

$$\text{Produktivitas Biomassa} = \frac{190,9 \text{ mg}}{2,3 \text{ L} \times 14 \text{ hari}} = 5,929 \frac{\text{mg}}{\text{L.hari}}$$

- Rata-rata

$$\text{rata - rata} = \frac{4,971 + 5,929}{2} = 5,450 \frac{\text{mg}}{\text{L.hari}}$$

– Frekuensi 440 Hz

- Kultivasi 1

$$\text{Produktivitas Biomassa} = \frac{196,8 \text{ mg}}{2,3 \text{ L} \times 14 \text{ hari}} = 6,112 \frac{\text{mg}}{\text{L.hari}}$$

- Kultivasi 2

$$\text{Produktivitas Biomassa} = \frac{148,5 \text{ mg}}{2 \text{ L} \times 14 \text{ hari}} = 5,304 \frac{\text{mg}}{\text{L.hari}}$$

- Rata-rata

$$\text{rata - rata} = \frac{6,112 + 5,304}{2} = 5,71 \frac{\text{mg}}{\text{L.hari}}$$

– Frekuensi 1000 Hz

- Kultivasi 1

$$\text{Produktivitas Biomassa} = \frac{181,1 \text{ mg}}{2,5 \text{ L} \times 14 \text{ hari}} = 5,17 \frac{\text{mg}}{\text{L.hari}}$$

- Kultivasi 2

$$\text{Produktivitas Biomassa} = \frac{170,8 \text{ mg}}{2,3 \text{ L} \times 14 \text{ hari}} = 3,30 \frac{\text{mg}}{\text{L.hari}}$$

- Rata-rata

$$\text{rata - rata} = \frac{5,17 + 3,30}{2} = 4,24 \frac{\text{mg}}{\text{L.hari}}$$

6. Pengujian Kadar Klorofil

$$\text{klorofil a} \left(\frac{\mu\text{g}}{\text{mL}} \right) = 13,36 \times A_{664} - 5,19 \times A_{649}$$

$$\text{klorofil b} \left(\frac{\mu\text{g}}{\text{mL}} \right) = 27,43 \times A_{649} - 8,12 \times A_{664}$$

$$\text{klorofil total} \left(\frac{\mu\text{g}}{\text{mL}} \right) = \text{klorofil a} + \text{klorofil b}$$

Variasi	Klorofil A664			Klorofil A649			Kadar Klorofil A (µg/mL)			Rata-rata	st.dev
	1	2	3	1	2	3	1	2	3		
0 Hz	1,643	1,697	1,602	1,108	0,993	1,067	16,20	17,52	15,86	16,53	0,71
50 Hz	2,771	2,922		1,268	1,399		30,44	31,78		31,11	0,67
440 Hz	3,184	3,068		1,761	1,742		33,44	31,92		32,67	0,73
1000 Hz	2,891	2,759		1,386	1,297		31,43	30,13		30,78	0,65
Variasi	Klorofil A664			Klorofil A649			Kadar Klorofil B (µg/mL)			Rata-rata	st.dev
	1	2	3	1	2	3	1	2	3		
0 Hz	1,643	1,697	1,602	1,108	0,993	1,067	17,05	13,46	16,26	15,59	1,54
50 Hz	2,771	2,922		1,268	1,399		12,28	14,65		13,46	1,18
440 Hz	3,184	3,068		1,761	1,742		22,45	22,87		22,66	0,21
1000 Hz	2,891	2,759		1,386	1,297		14,54	13,17		13,86	0,68

Variasi	Uji Kadar Klorofil		
	Klorofil A (µg/mL)	Klorofil B (µg/mL)	Total Klorofil (µg/mL)
0 Hz	16,53	15,59	32,12
50 Hz	31,11	13,46	44,57
440 Hz	32,67	22,66	55,33
1000 Hz	30,78	13,86	44,64

7. Pengujian Kadar Lipid

$$\text{Lipid content} = \left[\frac{\text{final weight} - \text{initial weight}}{\text{dried biomass}} \right] \times 100\%$$

Variasi	Lipid (%)			Rata-rata	st.dev
	1	2	3		
0 Hz	12,24	12,4183	11,52	12,06	0,39
50 Hz	10,625	11,017		10,82	0,20
440 Hz	3,40	5,67		4,54	1,14
1000 Hz	3,67	1,03		2,35	1,32

Lampiran 3: Gambar Penelitian

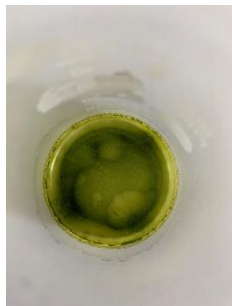
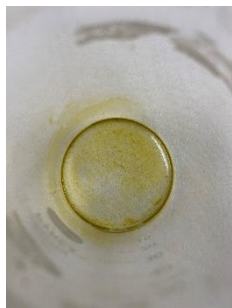
1. Kultur *Chlorella vulgaris*



2. Set-Up Box Kultivasi Mikroalga *Chlorella vulgaris*

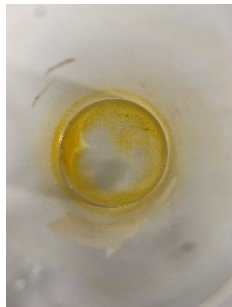


3. Pengamatan Kadar Lipid *Chlorella vulgaris*



Variasi Frekuensi 0 Hz

Variasi Frekuensi 50 Hz



Variasi Frekuensi 440 Hz

Variasi Frekuensi 1000 Hz