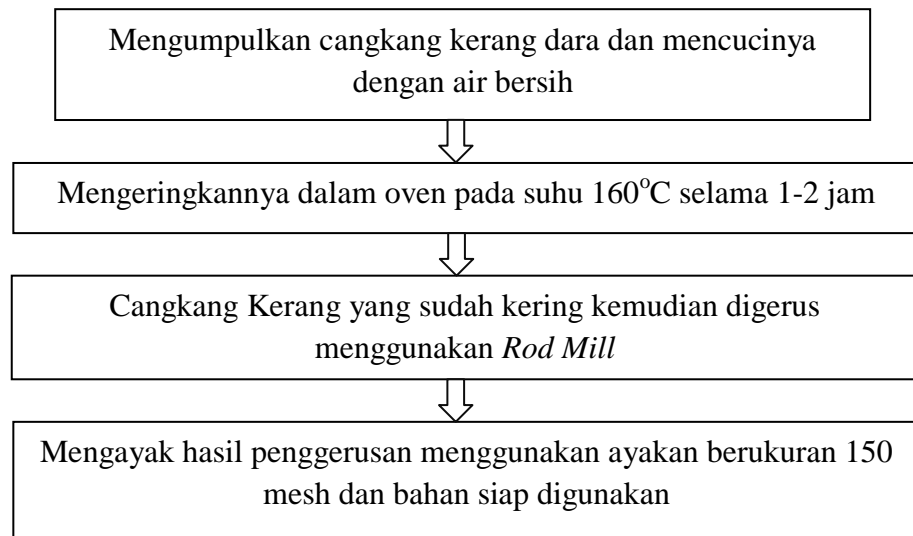


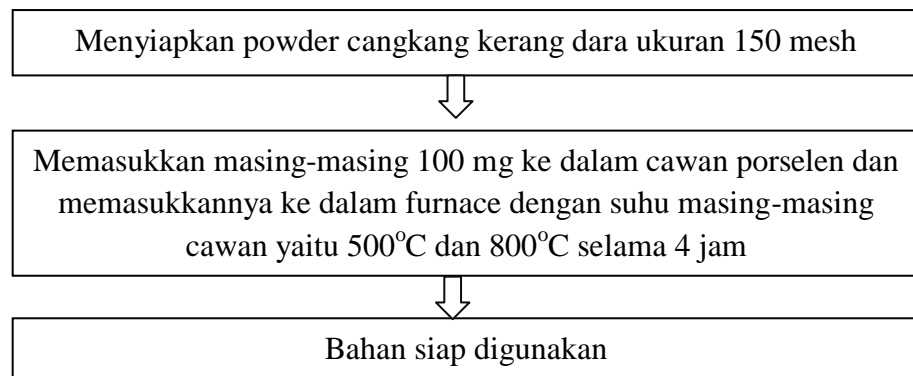
## LAMPIRAN I

### LANGKAH KERJA PENELITIAN ADSORPSI Cu (II)

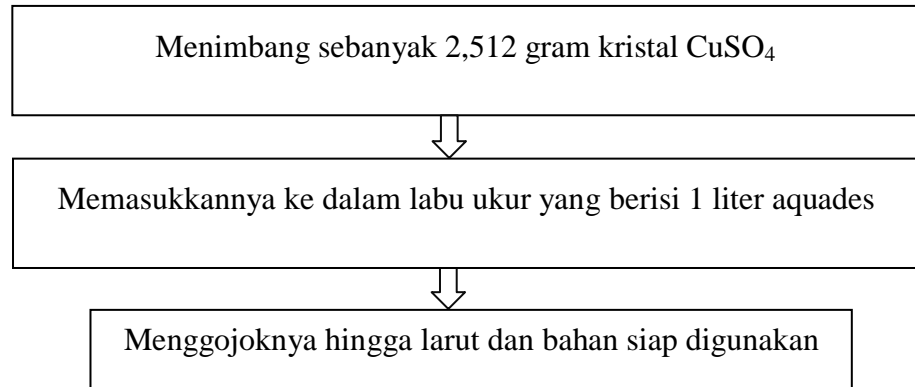
#### 1. Persiapan Bahan Adsorben Murni



#### 2. Proses Aktivasi Adsorben Cangkang Kerang Dara (*Anadara Granosa*)

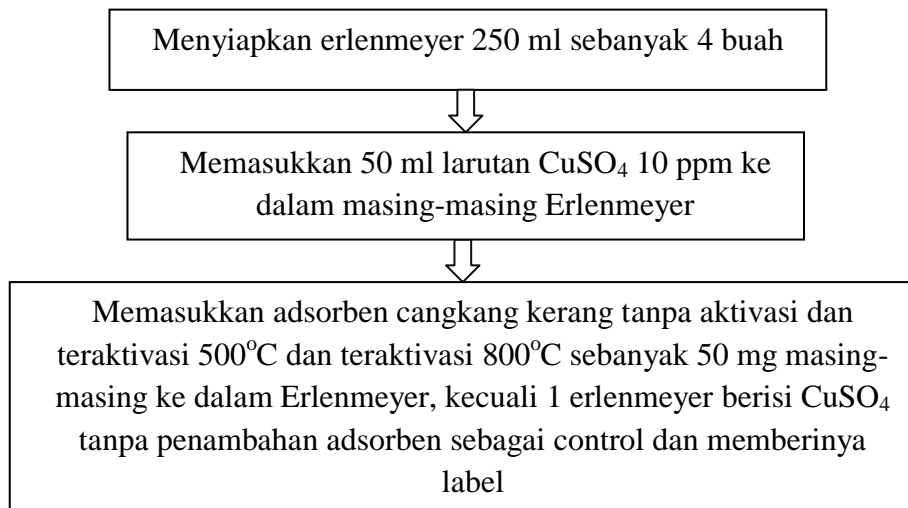


### 3. Pembuatan Larutan Induk $\text{CuSO}_4$ 1000 ppm

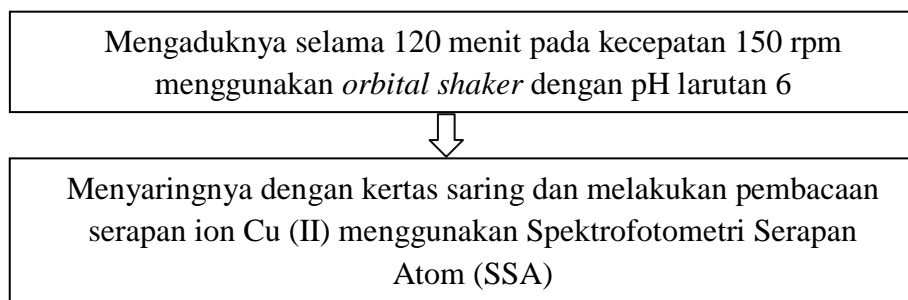


### 4. Pengujian Daya Serap Adsorben Cangkang Kerang Dara

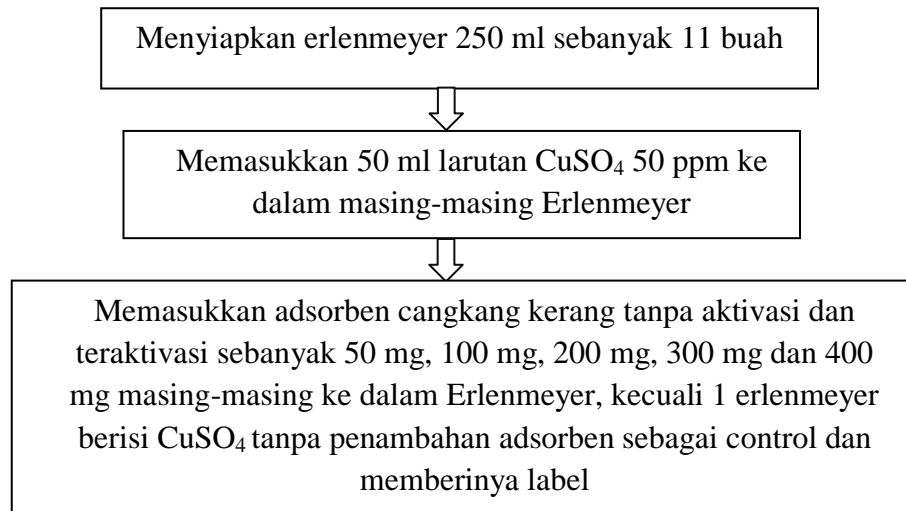
#### 4.1. Menentukan Suhu Adsorben Optimum



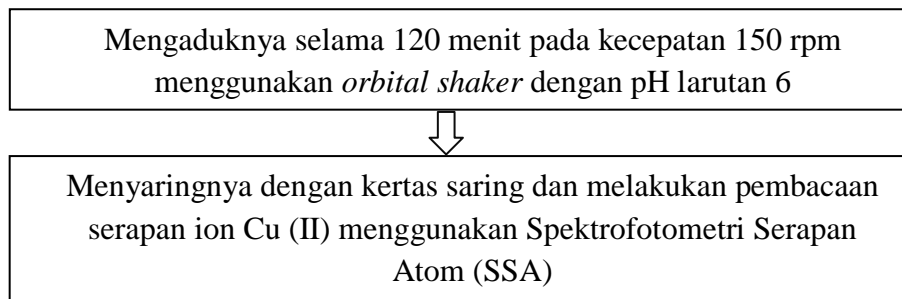
#### Lanjutan



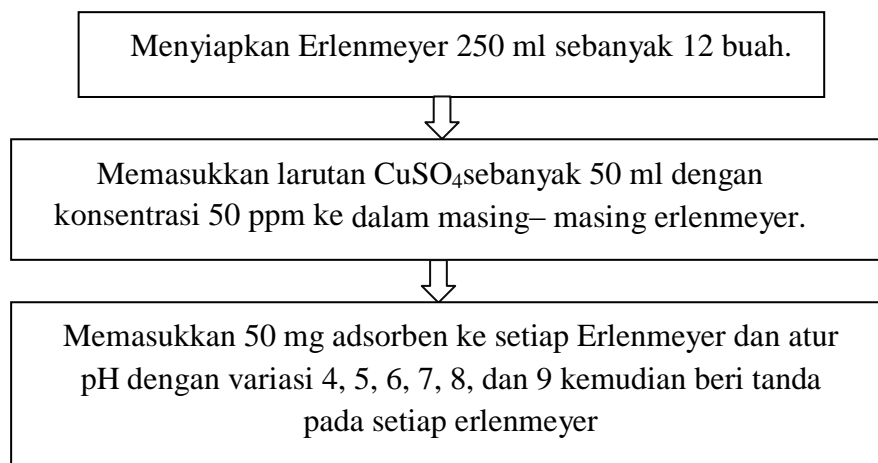
#### 4.2. Menentukan Massa Adsorben Optimum

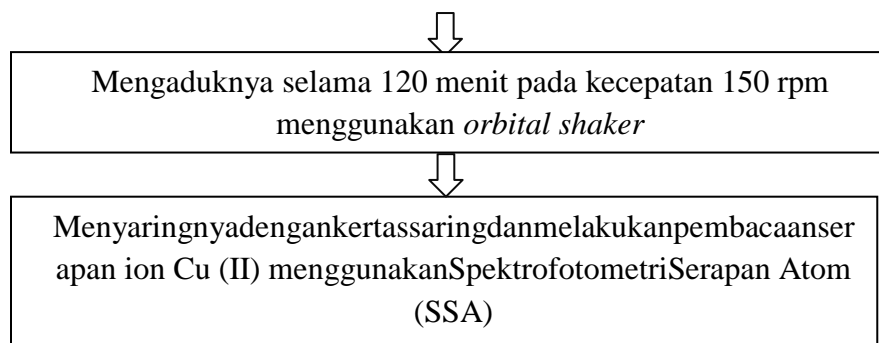


Lanjutan :

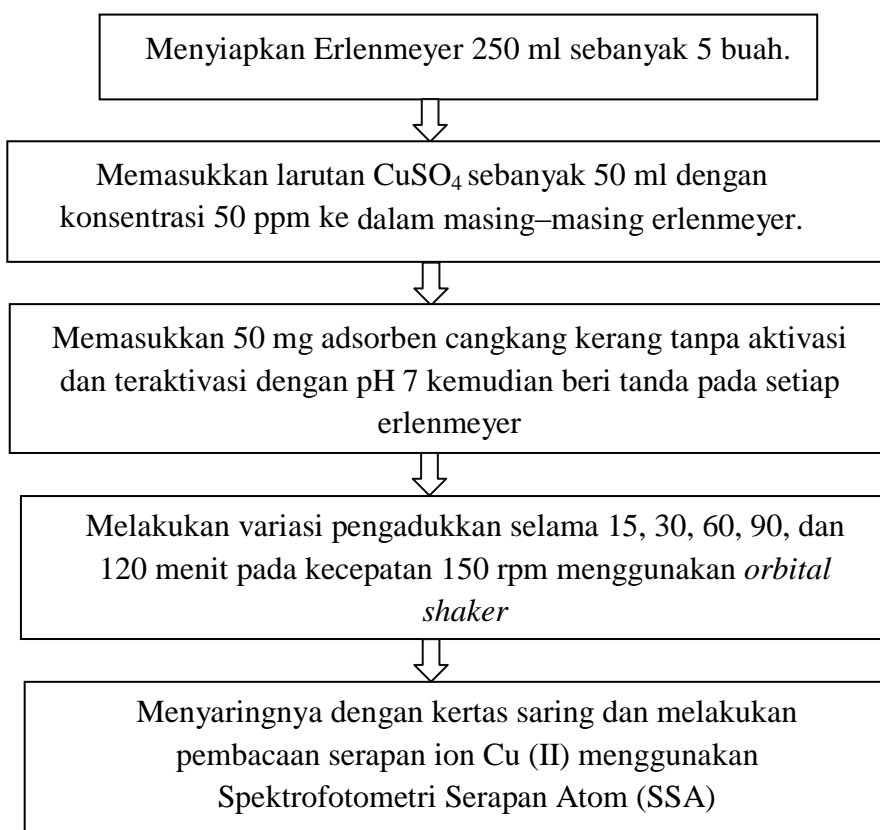


#### 4.3. Menentukan pH Larutan Optimum

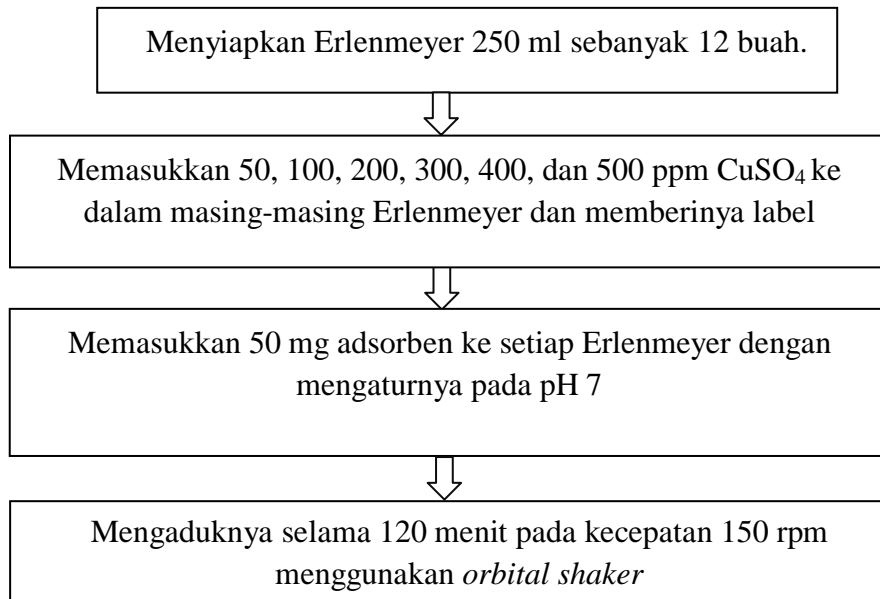




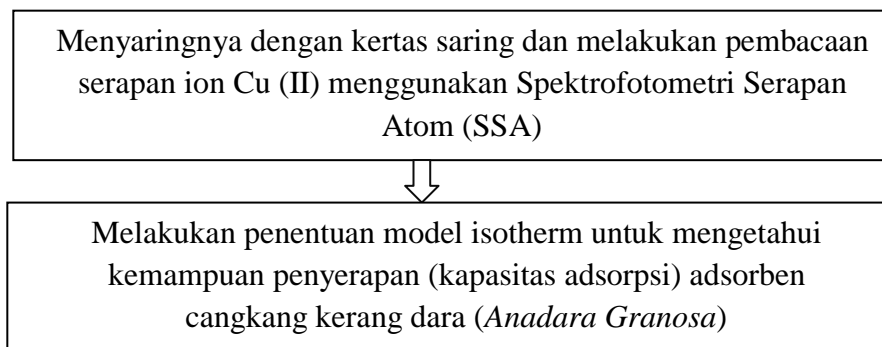
#### 4.4. Menentukan Waktu Pengadukkan Optimum



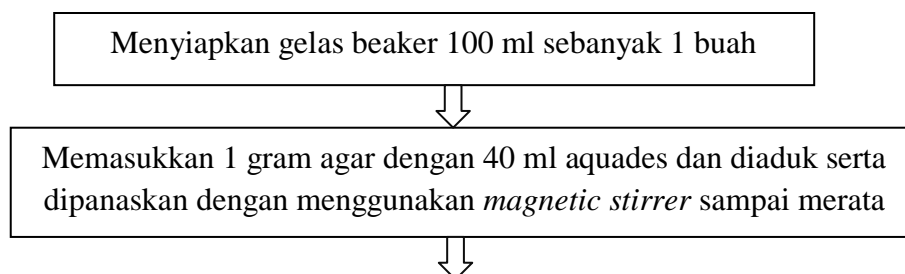
#### 4.5. Menghitung Efisiensi Kemampuan Adsorben

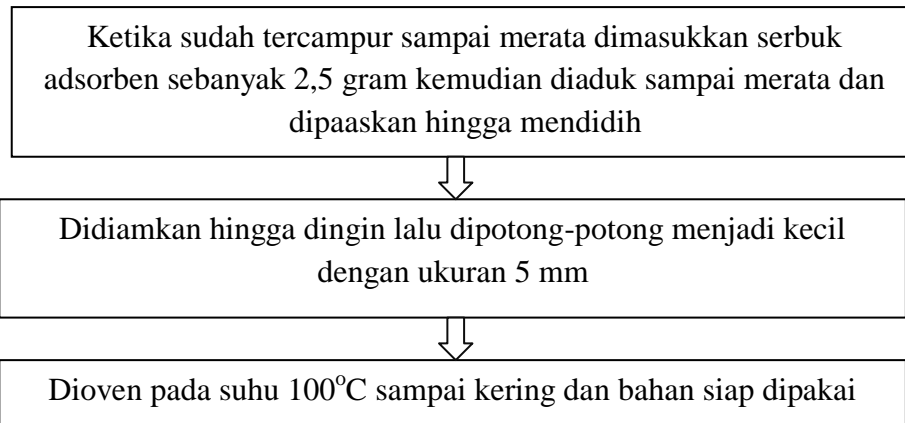


Lanjutan :



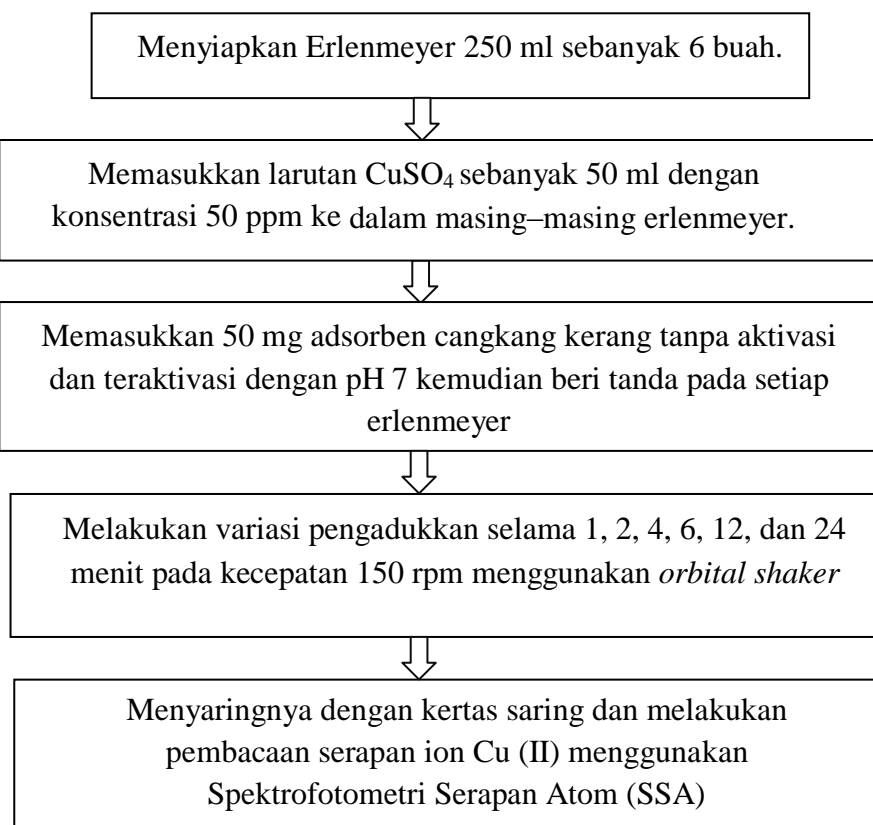
#### 5. Pembuatan Enkapsulasi Agar



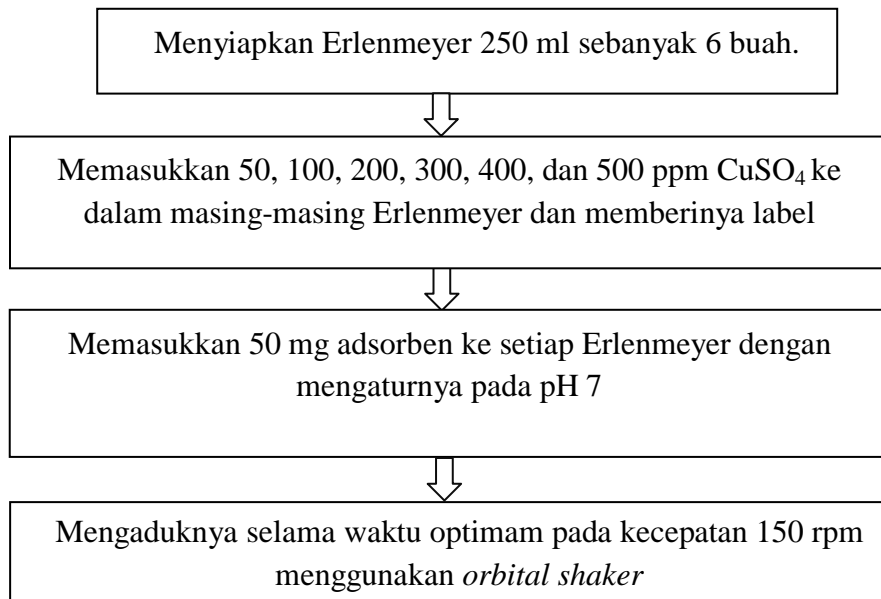


## 6. Pengujian Daya Serap Adsorben Cangkang Kerang Dara Dengan Metode Enkapsulasi

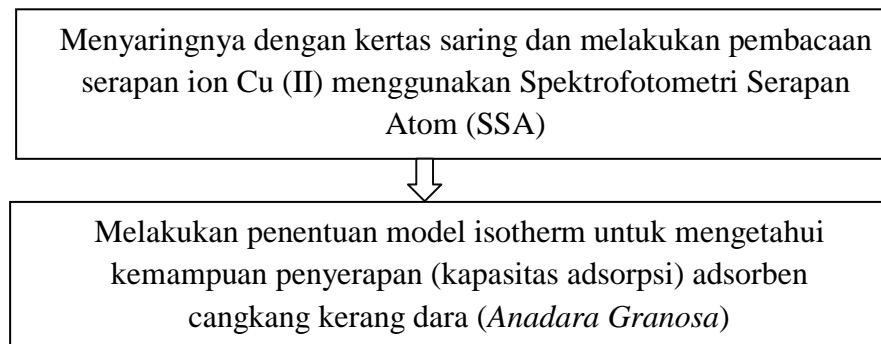
### 6.1. Menghitung Waktu Pengadukan Optimum Dengan Metode Enkapsulasi



## 6.2. Menghitung Efisiensi Kemampuan Adsorben Dengan Metode Enkapsulasi



Lanjutan :



**LAMPIRAN II**  
**PERHITUNGAN**

1. Membuat Larutan Induk CuSO<sub>4</sub> 1000 ppm

$$\begin{aligned} \text{Massa CuSO}_4 &= \frac{\text{ppm} \times V \times Mr (\text{CuSO}_4)}{Ar \text{ CuSO}_4} \\ &= \frac{1000 \times 1 \times 159,5}{63,5} \\ &= 2,512 \text{ gram} \end{aligned}$$

2. Membuat Larutan CuSO<sub>4</sub> 10 ppm sebanyak 1 liter

$$\begin{aligned} 1000 \text{ ppm} \times V &= 10 \text{ ppm} \times 1000 \text{ ml} \\ V &= 10 \text{ ml} \end{aligned}$$

3. Membuat Larutan CuSO<sub>4</sub> 50 ppm sebanyak 1 liter

$$\begin{aligned} 1000 \text{ ppm} \times V &= 50 \text{ ppm} \times 1000 \text{ ml} \\ V &= 50 \text{ ml} \end{aligned}$$

4. Membuat Larutan CuSO<sub>4</sub> 100 ppm sebanyak 100 ml

$$\begin{aligned} 1000 \text{ ppm} \times V &= 100 \text{ ppm} \times 100 \text{ ml} \\ V &= 10 \text{ ml} \end{aligned}$$

5. Membuat Larutan CuSO<sub>4</sub> 200 ppm sebanyak 100 ml

$$\begin{aligned} 1000 \text{ ppm} \times V &= 200 \text{ ppm} \times 100 \text{ ml} \\ V &= 20 \text{ ml} \end{aligned}$$

6. Membuat Larutan CuSO<sub>4</sub> 300 ppm sebanyak 100 ml

$$\begin{aligned} 1000 \text{ ppm} \times V &= 300 \text{ ppm} \times 100 \text{ ml} \\ V &= 30 \text{ ml} \end{aligned}$$

7. Membuat Larutan CuSO<sub>4</sub> 400 ppm sebanyak 100 ml

$$\begin{aligned} 1000 \text{ ppm} \times V &= 400 \text{ ppm} \times 100 \text{ ml} \\ V &= 40 \text{ ml} \end{aligned}$$

8. Membuat Larutan CuSO<sub>4</sub> 500 ppm sebanyak 100 ml

$$\begin{aligned} 1000 \text{ ppm} \times V &= 500 \text{ ppm} \times 100 \text{ ml} \\ V &= 50 \text{ ml} \end{aligned}$$



## 9. Isoterm Adsorpsi (Langmuir dan Freundlich)

### 9.1. Isoterm Langmuir

#### 9.1.1. Isoterm Langmuir Adsorpsi Tanpa Aktivasi

Variasi Konsentrasi Biosorben Tanpa Aktivasi								
Massa Adsorben (gr)	Volume Larutan (ml)	Konsentrasi Awal (C <sub>0</sub> )	Konsentrasi Akhir (C <sub>e</sub> )	Selisih (ΔC)	Persentase Penyisihan	Langmuir		
						Q <sub>e</sub>	1/Q <sub>e</sub>	1/C <sub>e</sub>
0,05	50	34	0,347	33,65	98,98	33,653	0,03	2,882
0,05	50	73,48	10,54	62,94	85,66	62,940	0,02	0,095
0,05	50	142,88	25,56	117,32	82,11	117,320	0,01	0,039
0,05	50	216,96	37,92	179,04	82,52	179,040	0,01	0,026
0,05	50	321,84	74,4	247,44	76,88	247,440	0,00	0,013
0,05	50	359,3	76,4	282,90	78,74	282,900	0,00	0,013

<b>slope</b>	0,0079
<b>intercept</b>	0,0072
	<b>142,857</b>

Diketahui :

Massa Adsorben = 0,05g

Volume larutan = 50 ml

C<sub>0</sub> = 34 mg/L

C<sub>e</sub> = 0,347 mg/L

C<sub>r</sub> = C<sub>0</sub> - C<sub>e</sub> = 34 mg/L - 0,347 mg/L = 33,65 mg/L

(%) removal = (34 mg/L - 0,347 mg/L) / 34 mg/L = 98,98%

$$Q_e = \frac{33,65 \frac{\text{mg}}{\text{L}} \times 0,05 \text{ l}}{0,05 \text{ gram}} = 33,65 \text{ mg/g}$$

1/C<sub>e</sub> = x dan 1/Q<sub>e</sub> = y

No	x	y	xy	x <sup>2</sup>	y <sup>2</sup>
1	2,882	0,03	0,085634	8,305027	0,0008830
2	0,095	0,02	0,001507	0,009002	0,0002524
3	0,039	0,01	0,000333	0,001531	0,0000727
4	0,026	0,01	0,000147	0,000695	0,0000312
5	0,013	0,00	5,43E-05	0,000181	0,0000163
6	0,013	0,00	4,63E-05	0,000171	0,0000125
<b>Jumlah</b>	<b>3,069</b>	<b>0,067</b>	<b>0,088</b>	<b>8,317</b>	<b>0,001</b>

Regresi linear  $y = 0,007x + 0,007$  dan  $R^2 = 0,820$

$y = bx + a$

$$b = \frac{\sum xy - (\sum x \sum y)/n}{\sum x^2 - ((\sum x)^2 / n)}$$

$$b = \frac{\sum 0,088 - (\sum 3,069 \cdot \sum 0,067)/6}{\sum 8,317 - ((\sum 3,069)^2 / 6)} = 0,0079$$

$$a = \frac{\sum y - (b \cdot \sum x)}{n}$$

$$a = \frac{0,067 - (0,0079 \times 3,069)}{6} = 0,007$$

$$R^2 = \frac{n \cdot (\sum XY) - (\sum X \cdot \sum Y)}{(n \cdot (\sum X^2) - (\sum X)^2)^{\frac{1}{2}} \cdot (n \cdot (\sum Y^2) - (\sum Y)^2)^{\frac{1}{2}}}$$

$$R^2 = \frac{6(0,088) - (3,069 \times 0,067)}{(6(8,317) - (3,069)^2)^{0,5} (6(0,001) - (0,067)^2)^{0,5}} = 0,820$$

Sehingga,  $Q_m$  = kemampuan maksimum adsorpsi adsorben cangkang kerang (mg/gr)

$$= 1/0,007 = 142,857 \text{ mg/gr}$$

$K$  = Konstanta yang berkaitan dengan kecepatan adsorpsi

$$= 1/(0,007 \times 142,857) = 1,000001$$

### 9.1.2. Isoterm Langmuir Adosrpsi Teraktivasi

Variasi Konsentrasi Biosorben Teraktivasi								
Massa Adsorben (gr)	Volume Larutan (ml)	Konsentrasi Awal (C0)	Konsentrasi Akhir (Ce)	Selisih (ΔC)	Persentase Penyisihan	Langmuir		
						Qe	1/Qe	1/Ce
0,05	50	34	1,1	32,90	96,76	32,900	0,03	0,909
0,05	50	73,48	7,68	65,80	89,55	65,800	0,02	0,130
0,05	50	142,88	21,72	121,16	84,80	121,160	0,01	0,046
0,05	50	216,96	39,24	177,72	81,91	177,720	0,01	0,025
0,05	50	321,84	46,4	275,44	85,58	275,440	0,0036	0,022
0,05	50	359,3	82,8	276,50	76,96	276,500	0,0036	0,012

<b>slope</b>	0,0279
<b>intercept</b>	0,0058
	<b>172,4182</b>

Diketahui :

Massa Adsorben = 0,05g

Volume larutan = 50 ml

$C_o$  = 34 mg/L

$C_e$  = 1,1 mg/L

$C_r = C_o - C_e = 34 \text{ mg/L} - 1,1 \text{ mg/L} = 32,90 \text{ mg/L}$

(%) removal =  $(34 \text{ mg/L} - 1,1 \text{ mg/L}) / 34 \text{ mg/L} = 96,76\%$

$$Q_e = \frac{32,90 \frac{\text{mg}}{\text{L}} \times 0,05 \text{ l}}{0,05 \text{ gram}} = 32,900 \text{ mg/g}$$

$1/C_e = x$  dan  $1/Q_e = y$

No	x	y	xy	x <sup>2</sup>	y <sup>2</sup>
1	0,909	0,03	0,027632	0,826446	0,0009239
2	0,130	0,02	0,001979	0,016954	0,0002310
3	0,046	0,01	0,00038	0,002120	0,0000681
4	0,025	0,01	0,000143	0,000649	0,0000317
5	0,022	0,0036	7,82E-05	0,000464	0,0000132
6	0,012	0,0036	4,37E-05	0,000146	0,0000131
<b>Jumlah</b>	<b>1,144</b>	<b>0,067</b>	<b>0,030</b>	<b>0,847</b>	<b>0,001</b>

Regresi liner  $y = 0,027x + 0,005$  dan  $R^2 = 0,907$

$y = bx + a$

$$b = \frac{\sum xy - (\sum x \sum y) / n}{\sum x^2 - ((\sum x)^2 / n)}$$

$$b = \frac{\sum 0,030 - (\sum 1,144 \cdot \sum 0,067) / 6}{\sum 0,847 - ((\sum 1,144)^2 / 6)} = 0,027$$

$$a = \frac{\sum y - (b \cdot \sum x)}{n}$$

$$a = \frac{0,067 - (0,027 \times 1,144)}{6} = 0,005$$

$$R^2 = \frac{n \cdot (\sum XY) - (\sum X \cdot \sum Y)}{(n \cdot (\sum X^2) - (\sum X)^2)^{\frac{1}{2}} \cdot (n \cdot (\sum Y^2) - (\sum Y)^2)^{\frac{1}{2}}}$$

$$R^2 = \frac{6(0,030) - (1,144 \times 0,067)}{(6(0,847) - (1,144)^2)^{0,5}(6(0,001) - (0,067)^2)^{0,5}} = 0,907$$

Sehingga,  $Q_m$  = kemampuan maksimum adsorpsi adsorben cangkang kerang (mg/gr)

$$= 1/0.005 = 200 \text{ mg/gr}$$

$K$  = Konstanta yang berkaitan dengan kecepatan adsorpsi

$$= 1/(0,005 \times 200) = 1,00$$

## 9.2. Isoterm Freundlich

### 9.2.1. Isoterm Freundlich Adsorpsi Tanpa Aktivasi

Variasi Konsentrasi Biosorben Tanpa Aktivasi								
Massa Adsorben (gr)	Volume Larutan (ml)	Konsentrasi Awal (C0)	Konsentrasi Akhir (Ce)	Selisih ( $\Delta C$ )	Persentase Penyisihan	Freundlich		
						Qe	Log Qe	Log Ce
0,05	50	34	0,347	33,65	98,98	33653	4,53	-0,460
0,05	50	73,48	10,54	62,94	85,66	62940	4,80	1,023
0,05	50	142,88	25,56	117,32	82,11	117320	5,07	1,408
0,05	50	216,96	37,92	179,04	82,52	179040	5,25	1,579
0,05	50	321,84	74,4	247,44	76,88	247440	5,39	1,872
0,05	50	359,3	76,4	282,90	78,74	282900	5,45	1,883

No	x	Y	xy	x <sup>2</sup>	y <sup>2</sup>
1	-0,460	4,53	-2,08094	0,211297	20,4939444
2	1,023	4,80	4,908537	1,046203	23,0296978
3	1,408	5,07	7,13545	1,981228	25,6985330
4	1,579	5,25	8,293716	2,492825	27,5934844
5	1,872	5,39	10,09427	3,502785	29,0895176
6	1,883	5,45	10,26593	3,546041	29,7203018
<b>Jumlah</b>	<b>7,304</b>	<b>30,493</b>	<b>38,617</b>	<b>12,780</b>	<b>155,625</b>

Diketahui  $y = 0,384x + 4,614$

Nilai slope (b) dihitung dengan cara :

$$b = \frac{\sum xy - (\sum x \cdot \sum y)/n}{\sum x^2 - ((\sum x)^2/n)}$$

$$b = \frac{38,617 - (7,304 \times 30,493)/6}{12,78 - \left(\frac{7,304^2}{6}\right)} = 0,384$$

Sementara itu nilai intercept (a) dapat dihitung sebagai berikut.

$$a = \frac{\sum y - (b \cdot \sum x)}{n}$$

$$a = \frac{30,493 - (0,384 \times 7,304)}{6} = 4,614$$

Untuk koefisien korelasi dapat dihitung dengan rumus:

$$R^2 = \frac{n \cdot (\sum XY) - (\sum X \cdot \sum Y)}{(n \cdot (\sum X^2) - (\sum X)^2)^{\frac{1}{2}} \cdot (n \cdot (\sum Y^2) - (\sum Y)^2)^{\frac{1}{2}}}$$

$$R^2 = \frac{6 \cdot (38,617) - (7,304 \times 30,493)}{(6 \cdot (13,05) - (7,304)^2)^{\frac{1}{2}} \cdot (6 \cdot (155,625) - (30,493)^2)^{\frac{1}{2}}} = 0,882$$

Sehingga,  $K_f$  = konstanta Freundlich yang berkaitan dengan kapasitas adsorpsi

$$= e^{4,614} = 100,8869$$

$1/n$  = konstanta Freundlich yang berkaitan dengan afinitas adsorpsi

$$= 1/0,384 = 2,604$$

### 9.2.2. Isoterm Freundlich Adsorpsi Teraktivasi

Variasi Konsentrasi Biosorben Teraktivasi								
Massa Adsorben (gr)	Volume Larutan (ml)	Konsentrasi Awal (C0)	Konsentrasi Akhir (Ce)	Selisih (ΔC)	Persentase Penyisihan	Freundlich		
						Qe	Log Qe	Log Ce
0,05	50	34	1,1	32,90	96,76	32900	4,52	0,041
0,05	50	73,48	7,68	65,80	89,55	65800	4,82	0,885
0,05	50	142,88	21,72	121,16	84,80	121160	5,08	1,337
0,05	50	216,96	39,24	177,72	81,91	177720	5,25	1,594
0,05	50	321,84	46,4	275,44	85,58	275440	5,44	1,667
0,05	50	359,3	82,8	276,50	76,96	276500	5,44	1,918

No	x	y	xy	x <sup>2</sup>	y <sup>2</sup>
1	0,041	4,52	0,186979	0,001713	20,4050588
2	0,885	4,82	4,26587	0,783864	23,2153008
3	1,337	5,08	6,795739	1,787194	25,8405414
4	1,594	5,25	8,366657	2,539972	27,5597313
5	1,667	5,44	9,065903	2,777282	29,5938939
6	1,918	5,44	10,43734	3,678840	29,6120459
<b>Jumlah</b>	<b>7,442</b>	<b>30,550</b>	<b>39,118</b>	<b>11,569</b>	<b>156,227</b>

Diketahui  $y = 0,524x + 4,441$

Nilai slope (b) dihitung dengan cara :

$$b = \frac{\sum xy - (\sum x \cdot \sum y)/n}{\sum x^2 - ((\sum x)^2/n)}$$

$$b = \frac{39,118 - (7,442 \times 30,550)/6}{11,569 - \left(\frac{(7,442)^2}{6}\right)} = 0,524$$

Sementara itu nilai intercept (a) dapat dihitung sebagai berikut.

$$a = \frac{\sum y - (b \cdot \sum x)}{n}$$

$$a = \frac{30,550 - (0,524 \times 7,442)}{6} = 4,441$$

Untuk koefisien korelasi dapat dihitung dengan rumus:

$$R^2 = \frac{n \cdot (\Sigma XY) - (\Sigma X \cdot \Sigma Y)}{(n \cdot (\Sigma X^2) - (\Sigma X)^2)^{\frac{1}{2}} \cdot (n \cdot (\Sigma Y^2) - (\Sigma Y)^2)^{\frac{1}{2}}}$$

$$R^2 = \frac{6 \cdot (39,118) - (7,442 \times 30,550)}{(6 \cdot (11,569) - (7,442)^2)^{\frac{1}{2}} \cdot (6 \cdot (156,227) - (30,550)^2)^{\frac{1}{2}}} = 0,954$$

Sehingga,  $K_f$  = konstanta Freundlich yang berkaitan dengan kapasitas adsorpsi

$$= e^{4,441} = 84,8598$$

$1/n$  = konstanta Freundlich yang berkaitan dengan afinitas adsorpsi

$$= 1/0.524 = 1,9083$$