DAFTAR LAMPIRAN

Lampiran 1 Perhitungan Pembuatan Larutan Stok Cu(II) 100 ppm

Perhitungan :

Diketahui : Volume akhir = 100 mL

Massa molar $CuSO_4 \cdot 5H_2O$ = 249,62 g/mol

Massa atom relatif Cu = 63,55 g/mol

Ditanya : Massa $CuSO_4 \cdot 5H_2O$ dibutuhkan?

Dijawab :

Penentuan massa Cu(II) dalam larutan stok Cu(II) 100 ppm :

Kons. larutan stok Cu(II) ppm $= \frac{\text{Massa Cu(II)}(mg)}{\text{Volume (L)}}$

100 mg/L $= \frac{\text{W Cu(II)}}{0{,}1\ \text{L}}$

W Cu(II) $= 100\ \text{mg/L} \times 0{,}1\ \text{L}$

$= 10$ mg

$= 0{,}01$ g

Dalam 100 mL jumlah $CuSO_4 \cdot 5H_2O$ yang diperlukan adalah:

W $CuSO_4 \cdot 5H_2O$ $= \frac{\text{Mr } CuSO_4 \cdot 5H_2O}{\text{Ar Cu(II)}}$

W $CuSO_4 \cdot 5H_2O$ $= \frac{249{,}62 \frac{\text{g}}{\text{mol}}}{63{,}55 \frac{\text{g}}{\text{mol}}}$

W $CuSO_4 \cdot 5H_2O$ $= \frac{249{,}62 \frac{\text{g}}{\text{mol}}}{63{,}55 \frac{\text{g}}{\text{mol}}} \times 0{,}01$ g

W $CuSO_4 \cdot 5H_2O$ $= 0{,}0393\ g$

Lampiran 2 Perhitungan Pembuatan Larutan Cu(II) 5 ppm

Perhitungan :

Diketahui : Konsentrasi larutan induk = 100 ppm = 100 mg/L

Volume akhir = 1000 mL

Ditanya : Volume Cu(II) 100 ppm yang dipipet (V1)?

Dijawab :

Dalam 1000 mL, volume Cu 100 ppm yang dipipet adalah:

M1 x V1 = M2 x V2

100 ppm x V1 = 5 ppm x 1000 mL

$$V1 = \frac{5 \text{ ppm x } 1000 \text{ mL}}{100 \text{ ppm}}$$

$$V1 = 50 \text{ mL}$$

Lampiran 3 Perhitungan Pembuatan Larutan HCl 0,1 M

Perhitungan :

Diketahui : Konsentrasi larutan HCl pekat (M1) = 37% = 12,1 M

Konsentrasi larutan dibuat (M2) = 0,1 M

Volume akhir (V2) = 100 mL

Ditanya : Volume larutan induk HCl 37% yang dipipet (V1)?

Dijawab :

$$M1 \times V1 = M2 \times V2$$

$$12{,}1 \text{ M} \times V1 = 0{,}1 \text{ M} \times 100 \text{ mL}$$

$$V1 = \frac{0{,}1 \text{ M} \times 100 \text{ mL}}{12{,}1 \text{ M}}$$

$$V1 = 0{,}8 \text{ mL}$$

Lampiran 4 Perhitungan Pembuatan Larutan NaOH 0,1 M

Perhitungan :

Diketahui : Mr NaOH = 40 g/mol

Volume akhir = 100 mL

Ditanya : Massa NaOH yang dibutuhkan?

Dijawab :

Dalam 100 mL, jumlah NaOH yang dibutuhkan adalah:

$$M = \frac{\text{massa NaOH}}{\text{Mr NaOH}} \times \frac{1000 \text{ mL}}{volume\ larutan}$$

$$0{,}1 = \frac{\text{massa NaOH}}{40 \text{ mg/L}} \times \frac{1000 \text{ mL}}{100 \text{ mL}}$$

$$\text{Massa NaOH} = \frac{400}{1000}$$

$$\text{Massa NaOH} = 0{,}4\ g$$

Lampiran 5 Perhitungan Kapasitas Adsorpsi Konsentrasi Awal Cu

$y = 0{,}144 \times C + 0{,}0369$

$3{,}641 = 0{,}144 \times C + 0{,}0369$

$$C = \frac{3{,}641 - 0{,}0369}{0{,}144}$$

$C = 25{,}02$ mg/L

Kapasitas Adsorpsi WK.15 (I)

y = 0,144 × C + 0,0369

0,527 = 0,144 × C + 0,0369

$C = \frac{0,527 - 0,0369}{0,144}$

C = 3,403 mg/L

$\text{Kapasitas Adsorpsi} = \frac{\text{c awal} - \text{c akhir } (\frac{\text{mg}}{\text{L}})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

$\text{Kapasitas Adsorpsi} = \frac{25,02 - 3,403}{4} \times 0,05$

Kapasitas Adsorpsi = 0,270 mg/g

Kapasitas Adsorpsi WK.15 (II)

y = 0,144 × C + 0,0369

0,227 = 0,144 × C + 0,0369

$C = \frac{0,227 - 0,0369}{0,144}$

C = 1,320 mg/L

$\text{Kapasitas Adsorpsi} = \frac{\text{c awal} - \text{c akhir } (\frac{\text{mg}}{\text{L}})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

$\text{Kapasitas Adsorpsi} = \frac{25,02 - 1,320}{4} \times 0,05$

Kapasitas Adsorpsi = 0,296 mg/g

Kapasitas Adsorpsi WK.15 (III)

y = 0,144 × C + 0,0369

0,457 = 0,144 × C + 0,0369

$C = \frac{0,457 - 0,0369}{0,144}$

C = 2,917 mg/L

$\text{Kapasitas Adsorpsi} = \frac{\text{c awal} - \text{c akhir } (\frac{\text{mg}}{\text{L}})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

$\text{Kapasitas Adsorpsi} = \frac{25,02 - 2,917}{4} \times 0,05$

Kapasitas Adsorpsi = 0,276 mg/g

$\text{Rata – Rata Kapasitas Adsorpsi WK.A} = \frac{0,270 + 0,296 + 0,276}{3} = 0,281$ mg/g

Kapasitas Adsorpsi WK.30 (I)

y = 0,144 × C + 0,0369

1,598 = 0,144 × C + 0,0369

$C = \frac{1,598 - 0,0369}{0,144}$

C = 10,841 mg/L

Kapasitas Adsorpsi = $\frac{\text{c awal} - \text{c akhir } (\frac{mg}{L})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

Kapasitas Adsorpsi = $\frac{25,02 - 10,841}{4} \times 0,05$

Kapasitas Adsorpsi = 0,177 mg/g

Kapasitas Adsorpsi WK.30 (II)

y = 0,144 × C + 0,0369

0,604 = 0,144 × C + 0,0369

$C = \frac{0,604 - 0,0369}{0,144}$

C = 3,938 mg/L

Kapasitas Adsorpsi = $\frac{\text{c awal} - \text{c akhir } (\frac{mg}{L})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

Kapasitas Adsorpsi = $\frac{25,02 - 3,938}{4} \times 0,05$

Kapasitas Adsorpsi = 0,264 mg/g

Kapasitas Adsorpsi WK.30 (III)

y = 0,144 × C + 0,0369

0,962 = 0,144 × C + 0,0369

$C = \frac{0,962 - 0,0369}{0,144}$

C = 6,424 mg/L

Kapasitas Adsorpsi = $\frac{\text{c awal} - \text{c akhir } (\frac{mg}{L})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

Kapasitas Adsorpsi = $\frac{25,02 - 6,424}{4} \times 0,05$

Kapasitas Adsorpsi = 0,232 mg/g

Kapasitas Adsorpsi Rata-Rata WK.B = $\frac{0,177 + 0,264 + 0,232}{3}$ = 0,224 mg/g

Kapasitas Adsorpsi WK.45 (I)

y = 0,144 × C + 0,0369

0,909 = 0,144 × C + 0,0369

$C = \frac{0,909 - 0,0369}{0,144}$

C = 6,056 mg/L

Kapasitas Adsorpsi = $\frac{\text{c awal}-\text{c akhir } (\frac{\text{mg}}{\text{L}})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

Kapasitas Adsorpsi = $\frac{25{,}02-6{,}056}{4} \times 0{,}05$

Kapasitas Adsorpsi = 0,237 mg/g

Kapasitas Adsorpsi WK.45 (II)

y = 0,144 × C + 0,0369

0,753 = 0,144 × C + 0,0369

C = $\frac{0{,}753-0{,}0369}{0{,}144}$

C = 4,973 mg/L

Kapasitas Adsorpsi = $\frac{\text{c awal}-\text{c akhir } (\frac{\text{mg}}{\text{L}})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

Kapasitas Adsorpsi = $\frac{25{,}02-4{,}973}{4} \times 0{,}05$

Kapasitas Adsorpsi = 0,251 mg/g

Kapasitas Adsorpsi WK.45 (III)

y = 0,144 × C + 0,0369

1,030 = 0,144 × C + 0,0369

C = $\frac{1{,}030\ -0{,}0369}{0{,}144}$

C = 6,897 mg/L

Kapasitas Adsorpsi = $\frac{\text{c awal}-\text{c akhir } (\frac{\text{mg}}{\text{L}})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

Kapasitas Adsorpsi = $\frac{25{,}02-6{,}897}{4} \times 0{,}05$

Kapasitas Adsorpsi = 0,227 mg/g

Kapasitas Adsorpsi Rata-Rata WK.C = $\frac{0{,}237+0{,}251+0{,}227}{3} = 0{,}238$ mg/g

Kapasitas Adsorpsi WK.60 (I)

y = 0,144 × C + 0,0369

0,237 = 0,144 × C + 0,0369

C = $\frac{0{,}237-0{,}0369}{0{,}144}$

C = 1,390 mg/L

Kapasitas Adsorpsi = $\frac{\text{c awal}-\text{c akhir } (\frac{\text{mg}}{\text{L}})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

Kapasitas Adsorpsi = $\frac{25{,}02-1{,}390}{4} \times 0{,}05$

Kapasitas Adsorpsi = 0,295 mg/g

Kapasitas Adsorpsi WK.60 (II)

y = 0,144 × C + 0,0369

0,238 = 0,144 × C + 0,0369

$C = \frac{0,238 - 0,0369}{0,144}$

C = 1,397 mg/L

$\text{Kapasitas Adsorpsi} = \frac{\text{c awal} - \text{c akhir } (\frac{\text{mg}}{\text{L}})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

$\text{Kapasitas Adsorpsi} = \frac{25,02 - 1,397}{4} \times 0,05$

Kapasitas Adsorpsi = 0,295 mg/g

Kapasitas Adsorpsi WK.60 (III)

y = 0,144 × C + 0,0369

0,371 = 0,144 × C + 0,0369

$C = \frac{0,371 - 0,0369}{0,144}$

C = 2,320 mg/L

$\text{Kapasitas Adsorpsi} = \frac{\text{c awal} - \text{c akhir } (\frac{\text{mg}}{\text{L}})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

$\text{Kapasitas Adsorpsi} = \frac{25,02 - 2,320}{4} \times 0,05$

Kapasitas Adsorpsi = 0,284 mg/g

$\text{Kapasitas Adsorpsi Rata-Rata WK.C} = \frac{0,295 + 0,295 + 0,284}{3} = 0,\ 291\ \text{mg/g}$

Kapasitas Adsorpsi WK.75 (I)

y = 0,144 × C + 0,0369

0,848 = 0,144 × C + 0,0369

$C = \frac{0,848 - 0,0369}{0,144}$

C = 5,633 mg/L

$\text{Kapasitas Adsorpsi} = \frac{\text{c awal} - \text{c akhir } (\frac{\text{mg}}{\text{L}})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

$\text{Kapasitas Adsorpsi} = \frac{25,02 - 5,633}{4} \times 0,05$

Kapasitas Adsorpsi = 0,242 mg/g

Kapasitas Adsorpsi WK.75 (II)

y = 0,144 × C + 0,0369

0,673 = 0,144 × C + 0,0369

C = $\frac{0,673 - 0,0369}{0,144}$

C = 4,417 mg/L

Kapasitas Adsorpsi = $\frac{\text{c awal} - \text{c akhir } (\frac{\text{mg}}{\text{L}})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

Kapasitas Adsorpsi = $\frac{25,02 - 4,417}{4} \times 0,05$

Kapasitas Adsorpsi = 0,258 mg/g

Kapasitas Adsorpsi WK.75 (III)

y = 0,144 × C + 0,0369

1,513 = 0,144 × C + 0,0369

C = $\frac{1,513\ - 0,0369}{0,144}$

C = 10,251 mg/L

Kapasitas Adsorpsi = $\frac{\text{c awal} - \text{c akhir } (\frac{\text{mg}}{\text{L}})}{\text{massa biosorben (g)}} \times volume\ adsorbat\ (L)$

Kapasitas Adsorpsi = $\frac{25,02 - 10,251}{4} \times 0,05$

Kapasitas Adsorpsi = 0,185 mg/g

Kapasitas Adsorpsi Rata-Rata WK.E = $\frac{0,242+0,258+0,185}{3} = 0,228$ mg/g

Lampiran 6 Perhitungan Rata-Rata (%) Kapasitas Adsorpsi

Persen Adsorpsi = $\frac{\text{c awal } \left(\frac{\text{mg}}{\text{L}}\right) - \text{rerata c akhir } (\frac{\text{mg}}{\text{L}})}{\text{c awal}} \times 100\%$

Rata-rata % Kapasitas Adsorpsi Rata-rata Cu(II) sisa WK. 15 menit

$Rata - rata\ konsentrasi\ Cu(II) sisa = \frac{(\text{I}) + (\text{II}) + (\text{III})}{3} = mg/L$

$Rata - rata\ konsentrasi\ Cu(II) sisa = \frac{3,403+1,320+2,917}{3} = 2,54\ mg/L$

Persen adsorpsi = $\frac{\mathbf{25,02-2,54}}{\mathbf{25,02}} \times \mathbf{100}\% = \mathbf{89,84}\%$

Rata-rata % Kapasitas Adsorpsi WK. 30 menit

$Rata - rata\ konsentrasi\ Cu(II) sisa = \frac{10,841+3,938+6.424}{3} = 7,06\ mg/L$

Persen adsorpsi = $\frac{\mathbf{25,02-7,06}}{\mathbf{25,02}} \times \mathbf{100}\% = \mathbf{71,78}\%$

Rata-rata % Kapasitas Adsorpsi WK. 45 menit

$Rata - rata\ konsentrasi\ Cu(II) sisa = \frac{6,056+4,973+6,897}{3} = 5,97\ mg/L$

Persen adsorpsi = $\frac{\mathbf{25,02-5,97}}{\mathbf{25,02}} \times \mathbf{100}\% = \mathbf{76,13}\%$

Rata-rata % Kapasitas Adsorpsi Cu(II) WK. 60 menit

$Rata - rata\ konsentrasi\ Cu(II) sisa\ \frac{1{,}390+1{,}397+2{,}320}{3} = 1{,}70\ mg/L$

Persen adsorpsi = $\frac{\mathbf{25{,}02-\ 1{,}70}}{\mathbf{25{,}02}} \times \mathbf{100}\% = \mathbf{93{,}20}\%$

Rata-rata % Kapasitas Adsorpsi WK. 75 menit

$Rata - rata\ konsentrasi\ Cu(II) sisa = \frac{5{,}633+4{,}417+10{,}251}{3} = 6{,}76\ mg/L$

Persen adsorpsi = $\frac{\mathbf{25{,}02-6{,}76}}{\mathbf{25{,}02}} \times \mathbf{100}\% = \mathbf{72{,}98}\%$

Lampiran 7 Data Penimbangan Massa Adsorben

No.	Variasi Waktu Kontak (menit)	Replikasi	Penimbangan Massa Adsorben (gram)
1.	15	I	4,000
		II	4,000
		III	4,000
2.	30	I	4,000
		II	4,000
		III	4,000
3.	45	I	4,000
		II	4,000
		III	4,000
4.	60	I	4,000
		II	4,000
		III	4,000
5.	75	I	4,000
		II	4,000
		III	4,000

Lampiran 8 Data Hasil Absorbansi, Konsentrasi Cu(II) sisa, Kapasitas Adsorpsi, serta Rata-Rata Kapasitas Adsorpsi

No.	Variasi Waktu Kontak (menit)	Replikasi	Absorbansi (A)	Konsentrasi Cu(II) sisa (mg/L)	Kapasitas Adsorpsi (mg/g)
1.	15	I	0,527	3,403	0,270
		II	0,227	1,320	0,296
		III	0,457	2,917	0,276
Rata - Rata Kapasitas Adsorpsi (mg/g)					0,281
2.	30	I	1,598	10,841	0,177
		II	0,604	3,938	0,264
		III	0,962	6,424	0,232
Rata - Rata Kapasitas Adsorpsi (mg/g)					0,224
3.	45	I	0,909	6,056	0,237
		II	0,753	4,973	0,251
		III	1,030	6,897	0,227
Rata - Rata Kapasitas Adsorpsi (mg/g)					0,238
4.	60	I	0,237	1,390	0,295
		II	0,238	1,397	0,295
		III	0,371	2,320	0,284
Rata - Rata Kapasitas Adsorpsi (mg/g)					0,291
5.	75	I	0,848	5,633	0,242
		II	0,673	4,417	0,258
		III	1,513	10,251	0,185
Rata - Rata Kapasitas Adsorpsi (mg/g)					0,228

Lampiran 9 Hasil Pengujian

KEMENTERIAN AGAMA
UNIVERSITAS ISLAM NEGERI MAULANA MALIK IBRAHIM MALANG
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Lampiran : No. B-53/KIM/OT.01.06/05/2025
tentang hasil pengujian logam Cu

Nama : Arzweta Fara Mahuri
Instansi/Perusahaan : Poltekkes Kemenkes Malang
Alamat : Jl. Jakarta dalam No. 136 Kota Malang
No.Telpon : 085865193331

No.	Nama/Kode sampel	Konsentrasi/ Absorbansi	Satuan	Metode
	CalZero/Blank	0,0001	A	FAAS
	Std 1,0 ppm	0,1779	A	FAAS
	Std 2,0 ppm	0,3242	A	FAAS
	Std 3,0 ppm	0,4723	A	FAAS
	Std 4,0 ppm	0,6198	A	FAAS
	Std 5,0 ppm	0,7500	A	FAAS
1.	Cu awal	3,641		FAAS
2.	WK A1	0,527		FAAS
3.	WK A2	0,227		FAAS
4.	WK A3	0,457		FAAS
5.	WK B1	1,598		FAAS
6.	WK B2	0,604		FAAS
7.	WK B3	0,962		FAAS
8.	WK C1	0,909		FAAS
9.	WK C2	0,753		FAAS
10.	WK C3	1,030		FAAS
11.	WK D1	0,237		FAAS
12.	WK D2	0,238		FAAS
13.	WK D3	0,371		FAAS
14.	WK E1	0,848		FAAS
15.	WK E2	0,673		FAAS
16.	WK E3	1,513		FAAS

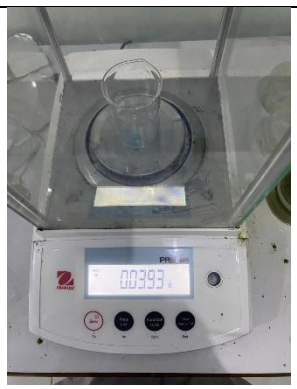
Hasil pengujian ini merupakan hasil murni dari AAS sesuai sampel yang dianalisa, pemilik sampel perlu melakukan konversi apabila sampelnya berwujud padat, dan/atau pemilik sampel melakukan pengenceran

Malang, 20 Mei 2025
Analis,

Moh. Taufiq, M.Si

Lampiran 10 Gambar

	Pengumpulan daun puring segar dengan warna daun hijau tua bercorak khas kuning.
	Pencucian daun puring untuk menghilangkan kotoran dan debu.
	Pengeringan daun puring di bawah sinar matahari.
	Pengeringan daun puring dengan oven suhu 60ºC selama 4 jam.

	Serbuk daun puring.
	Penetapan bobot konstan adsorben.
	Penimbangan padatan $CuSO_4 \cdot 5H_2O$
	Pengkondisian pH larutan Cu.

	Penimbangan biosorben.
	Pengkontakkan biosorben dengan larutan Cu 5 ppm.
	Penyaringan filtrat.
	Filtrat hasil kontak biosorben dengan larutan Cu 5 ppm.