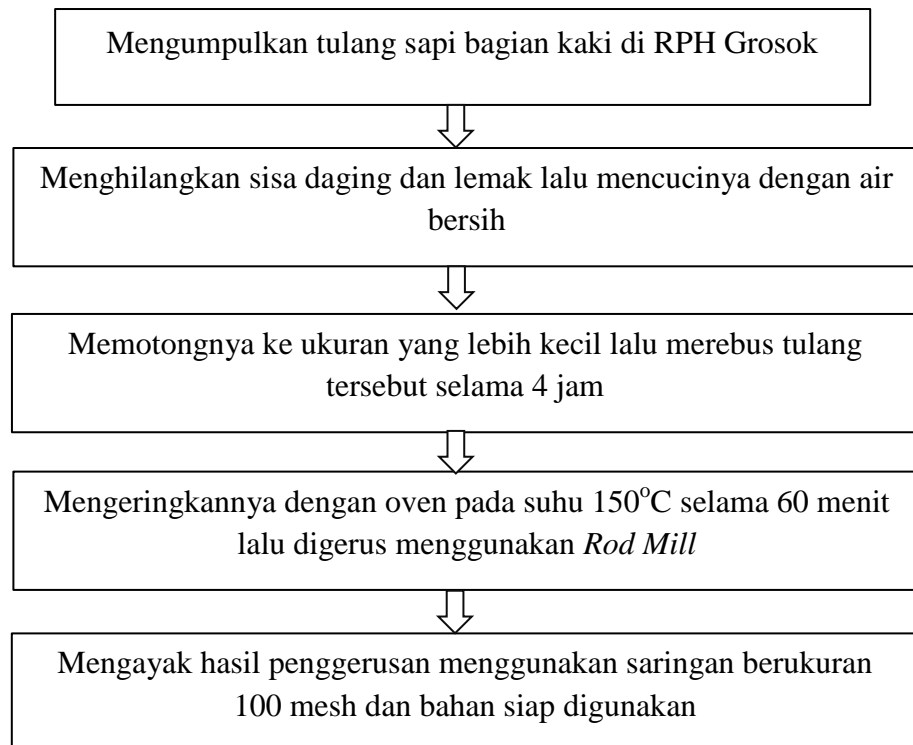


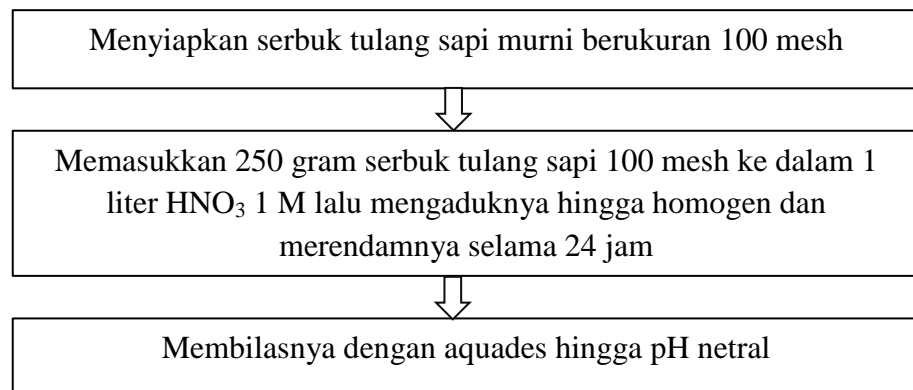
LAMPIRAN I

LANGKAH KERJA PENELITIAN ADSORPSI Cu (II)

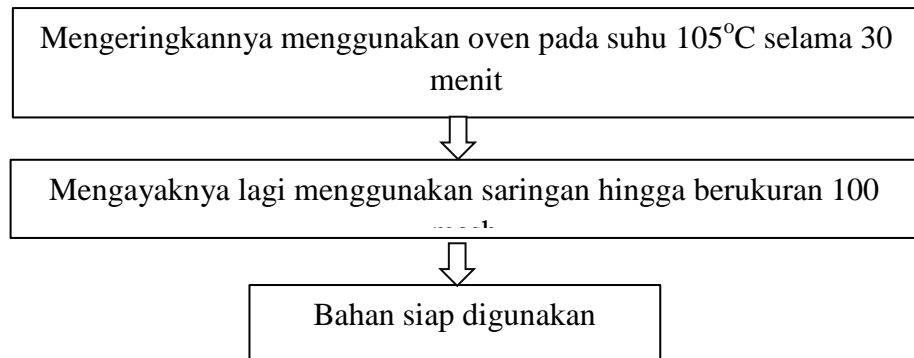
1. Persiapan Bahan Adsorben Murni



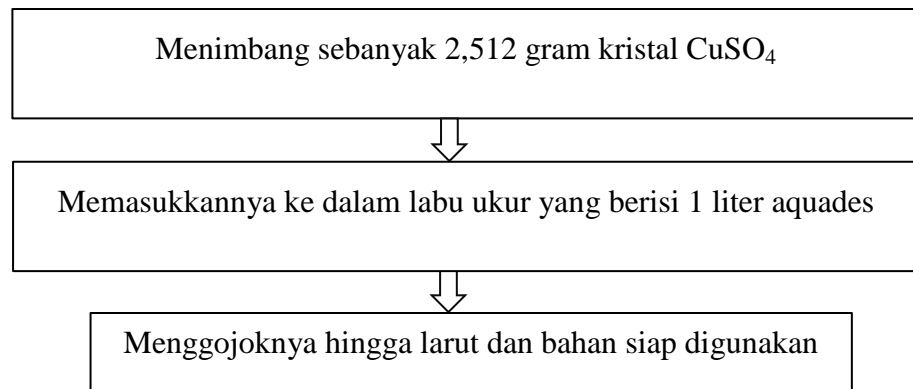
2. Proses Aktivasi Adsorben Tulang Sapi



Lanjutan :

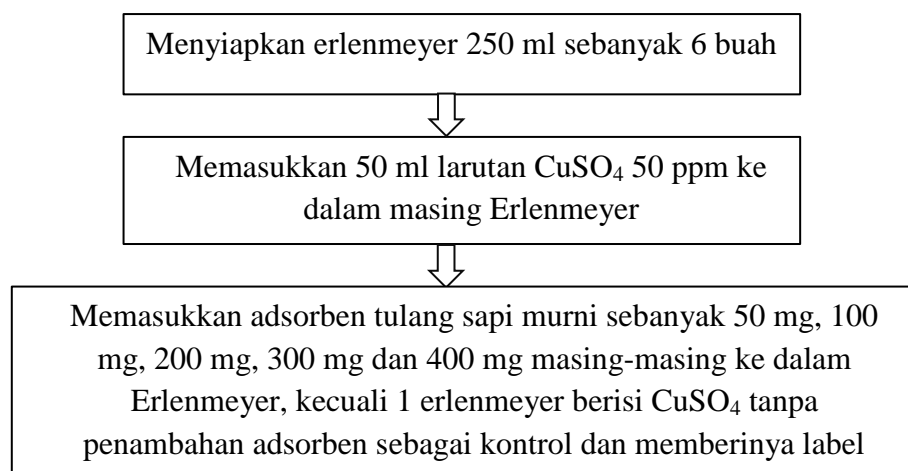


3. Pembuatan Larutan Induk CuSO₄ 1000 ppm

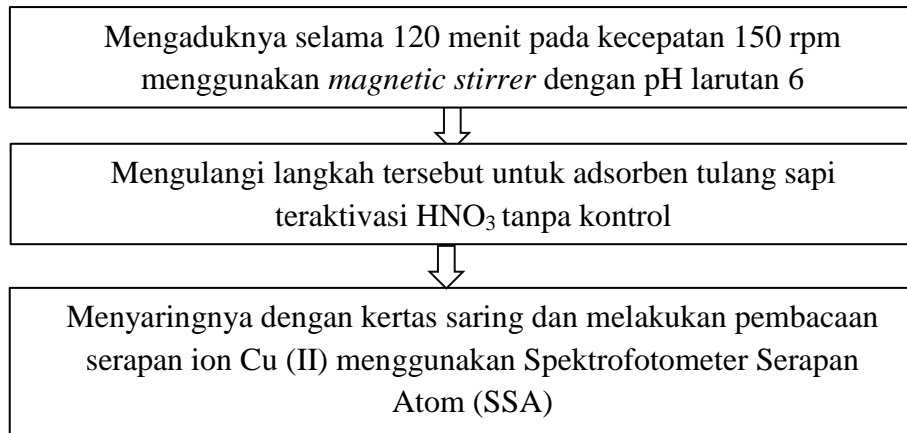


4. Pengujian Daya Serap Adsorben Tulang Sapi

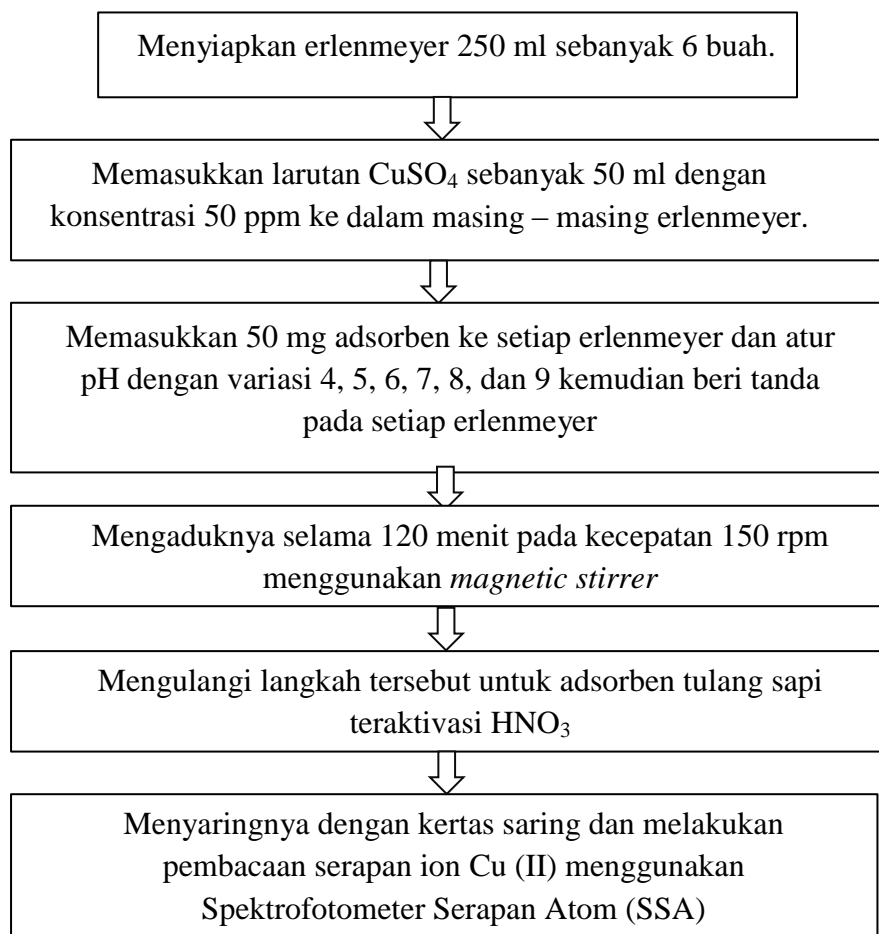
4.1. Menentukan Massa Adsorben Optimum



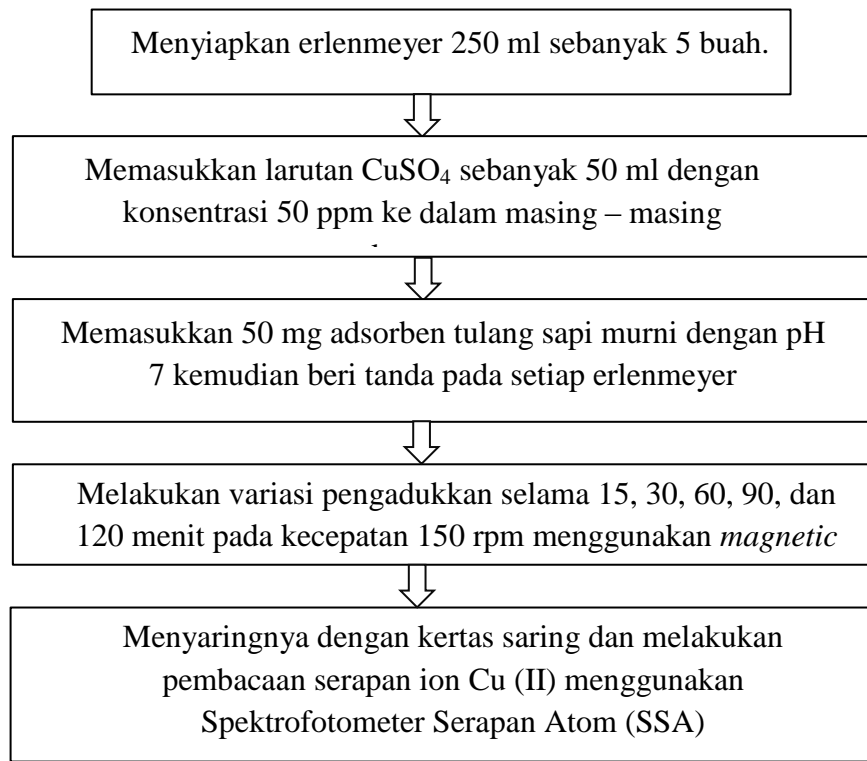
Lanjutan :



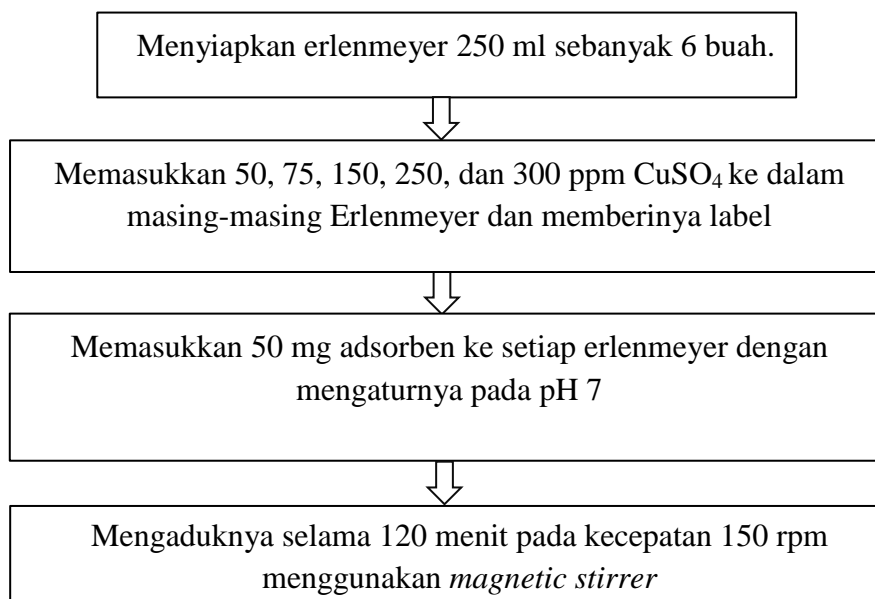
4.2. Menentukan pH Larutan Optimum



4.3. Menentukan Waktu Pengadukkan Optimum



4.4. Menghitung Efisiensi Kemampuan Adsorben



Lanjutan :

Menyaringnya dengan kertas saring dan melakukan pembacaan serapan ion Cu (II) menggunakan Spektrofotometer Serapan Atom (SSA)



Melakukan penentuan model isotherm untuk mengetahui kemampuan penyerapan (kapasitas adsorpsi) adsorben tulang sapi murni

LAMPIRAN II

PERHITUNGAN

1. Menghitung Asam Nitrat (HNO₃) 1M sebanyak 1000 ml

$$\begin{aligned}
 M &= \frac{\text{massa jenis } HNO_3}{Mr} \times \% HNO_3 \\
 &= \frac{1,39}{63} \times 65\% \\
 &= 14,34 M
 \end{aligned}$$

Diencerkan hingga 1 M :

$$\begin{aligned}
 M_1 V_1 &= M_2 V_2 \\
 14,34 M_1 &= 1 \times 1000 \text{ ml} \\
 &= 69,7 \text{ ml HNO}_3
 \end{aligned}$$

2. Membuat Larutan Induk CuSO₄ 1000 ppm

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

3. Membuat Larutan CuSO₄ 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 CuSO₄ 75 ppm sebanyak 100 ml

$$\begin{aligned}
 1000 \text{ ppm} \times V &= 75 \text{ ppm} \times 100 \text{ ml} \\
 V &= 7,5 \text{ ml}
 \end{aligned}$$

5. Membuat Larutan CuSO₄ 150 ppm sebanyak 100 ml

$$\begin{aligned}
 1000 \text{ ppm} \times V &= 150 \text{ ppm} \times 100 \text{ ml} \\
 V &= 15 \text{ ml}
 \end{aligned}$$

6. Membuat Larutan CuSO₄ 200 ppm sebanyak 100 ml

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

7. Membuat Larutan CuSO_4 250 ppm sebanyak 100 ml

$$1000 \text{ ppm} \times V = 250 \text{ ppm} \times 100 \text{ ml}$$

$$V = 25 \text{ ml}$$

8. Membuat Larutan CuSO_4 300 ppm sebanyak 100 ml

$$1000 \text{ ppm} \times V = 300 \text{ ppm} \times 100 \text{ ml}$$

$$V = 30 \text{ ml}$$

9. Isoterm Adsorpsi (Langmuir dan Freundlich)

9.1. Isoterm Langmuir

Konsentrasi Cu (ppm)	Massa Adsorben (gram)	Vol. Larutan (ml)	Konsentrasi		Cr (mg/L)	Removal (%)	Langmuir		
			C _{in} (mg/L)	C _e (mg/L)			Q _e (mg/g)	1/Q _e	1/C _e
50	0.05	50	48.25	0.392	47.86	99.19	47.858	0.021	2.551
75	0.05	50	76.9	5.525	71.38	92.82	71.375	0.014	0.181
150	0.05	50	146.7	37.65	109.05	74.34	109.050	0.009	0.027
250	0.05	50	263.5	149.6	113.90	43.23	113.900	0.009	0.007
300	0.05	50	304.7	183.1	121.60	39.91	121.600	0.008	0.005

slope	0.0045
intercept	0.0097
Q _m	102.67

Diketahui :

Massa Adsorben = 0,05g

Volume larutan = 50 ml

C_{in} = 48,25 mg/L

C_e = 0,392 mg/L

Cr = C_{in} - C_e = 48,25 mg/L - 0,392 mg/L = 47,858 mg/L

(%) removal = (48,25 mg/L - 0,392 mg/L) / 48,25 mg/L = 99,2%

$$Q_e = \frac{47,858 \frac{\text{mg}}{\text{L}} \times 0,05 \text{ l}}{0,05 \text{ gram}} = 47,858 \text{ mg/g}$$

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

No	x	y	xy	x ²	y ²
1	2.55102	0.02090	0.05330	6.50771	0.00044
2	0.18100	0.01401	0.00254	0.03276	0.00020
3	0.02656	0.00917	0.00024	0.00071	0.00008
4	0.00668	0.00878	0.00006	0.00004	0.00008
5	0.00546	0.00822	0.00004	0.00003	0.00007
jumlah	2.77072	0.06108	0.05619	6.54124	0.00086

Regresi linier $y = 0,0045x + 0,0097$ dan $R^2 = 0,8627$

$y = bx + a$

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

$$b = \frac{\sum 0,05619 - (\sum 2,77072 \sum 0,06108)/5}{\sum 6,54124 - ((\sum 2,77072)^2/5)} = 0,0045$$

$$a = \frac{0,06108 - (0,0045 \times 2,77072)}{5} = 0,0097$$

$$R^2 = \frac{5(0,05619) - (2,77072 \times 0,06108)}{(5(6,54124) - (2,77072)^2)^{0,5} (5(0,00086) - (0,06108)^2)^{0,5}} = 0,8627$$

Sehingga, Q_m = kemampuan maksimum adsorpsi adsorben tulang sapi (mg/gr)

$$= 1/0.097 = 102,67 \text{ mg/gr}$$

K = Konstanta yang berkaitan dengan kecepatan adsorpsi

$$= 1/(0,0097 \times 102,67) = 1,0041$$

9.2. Isoterm Freundlich

Konsentrasi Cu (ppm)	Massa Adsorben (gram)	Vol. Larutan (ml)	Konsentrasi		Cr (mg/L)	Removal (%)	Freundlich		
			Cin (mg/L)	Ce (mg/L)			Qe	Log Qe	Log Ce
50	0.05	50	48.25	0.392	47.86	99.19	47.858	1.68	-0.407
75	0.05	50	76.9	5.525	71.38	92.82	71.375	1.85	0.742
150	0.05	50	146.7	37.65	109.05	74.34	109.05	2.04	1.576
250	0.05	50	263.5	149.6	113.90	43.23	113.9	2.06	2.175
300	0.05	50	304.7	183.1	121.60	39.91	121.6	2.08	2.263

No	x	y	xy	x ²	y ²
1	-0.407	1.680	-0.683	0.165	2.822
2	0.742	1.854	1.376	0.551	3.436
3	1.576	2.038	3.211	2.483	4.152
4	2.175	2.057	4.473	4.730	4.229
5	2.263	2.085	4.718	5.120	4.347
Jumlah	6.349	9.713	13.094	13.050	18.986

Diketahui $y = 0,1525x + 1,7488$

Nilai slope (b) dihitung dengan cara :

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

$$b = \frac{13,094 - (6,349 \times 9,713)/5}{13,05 - \left(\frac{(6,349)^2}{5}\right)} = 0,1525$$

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

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

$$a = \frac{9,713 - (0,1525 \times 6,349)}{5} = 1,7488$$

Untuk koefisien korelasi dapat dihitung dengan rumus:

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

$$R^2 = \frac{5 \cdot (13,094) - (6,349 \times 9,713)}{(5 \cdot (13,05) - (6,349)^2)^{\frac{1}{2}} \cdot (5 \cdot (18,986) - (9,713)^2)^{\frac{1}{2}}} = 0,9738$$

Sehingga, K_f = konstanta Freundlich yang berkaitan dengan kapasitas adsorpsi

$$= e^{1,7488} = 5,75$$

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

$$= 1/0.1525 = 6,56$$

LAMPIRAN III
BAKU MUTU TEMBAGA DALAM AIR

LAMPIRAN
PERATURAN PEMERINTAH
NOMOR 82 TAHUN 2001
TANGGAL 14 DESEMBER 2001
TENTANG
PENGELOLAAN KUALITAS AIR DAN PENGENDALIAN PENCEMARAN AIR
Kriteria Mutu Air Berdasarkan Kelas.

PARAMETER	SATUAN	KELAS				KETERANGAN
		I	II	III	IV	
FISIKA						
Tempelatur	°C	deviasi 3	deviasi 3	deviasi 3	deviasi 5	Deviasi temperatur dari keadaan alaminya
Residu Terlarut	mg/ L	1000	1000	1000	2000	

Residu Tersuspensi	mg/L	50	50	400	400	Bagi pengolahan air minum secara konvensional, residu tersuspensi ≤ 5000 mg/ L
KIMIA ANORGANIK						
pH		6-9	6-9	6-9	5-9	Apabila secara alamiah di luar rentang tersebut, maka ditentukan berdasarkan kondisi alamiah
BOD	mg/L	2	3	6	12	
COD	mg/L	10	25	50	100	
DO	mg/L	6	4	3	0	Angka batas minimum
Total Fosfat sbg P	mg/L	0,2	0,2	1	5	
NO 3 sebagai N	mg/L	10	10	20	20	
NH3-N	mg/L	0,5	(-)	(-)	(-)	Bagi perikanan, kandungan amonia bebas untuk ikan yang peka $\leq 0,02$ mg/L sebagai NH3
Arsen	mg/L	0,05	1	1	1	
Kobalt	mg/L	0,2	0,2	0,2	0,2	
Barium	mg/L	1	(-)	(-)	(-)	
Boron	mg/L	1	1	1	1	

Selenium	mg/L	0,01	0,05	0,05	0,05	
Kadmium	mg/L	0,01	0,01	0,01	0,01	
Khrom (VI)	mg/L	0,05	0,05	0,05	0,01	
Tembaga	mg/L	0,02	0,02	0,02	0,2	Bagi pengolahan air minum secara konvensional, Cu ≤ 1 mg/L
Besi	mg/L	0,3	(-)	(-)	(-)	Bagi pengolahan air minum secara konvensional, Fe ≤ 5 mg/L
Timbal	mg/L	0,03	0,03	0,03	1	Bagi pengolahan air minum secara konvensional, Pb $\leq 0,1$ mg/L
Mangan	mg/L	0,1	(-)	(-)	(-)	
Air Raksa	mg/L	0,001	0,002	0,002	0,005	
Seng	mg/L	0,05	0,05	0,05	2	Bagi pengolahan air minum secara konvensional, Zn ≤ 5 mg/L
Khlorida	mg/l	600	(-)	(-)	(-)	
Sianida	mg/L	0,02	0,02	0,02	(-)	
Fluorida	mg/L	0,5	1,5	1,5	(-)	

LAMPIRAN V

DAFTAR PITA SERAPAN INFRA MERAH

468 Chapter 10 Infrared and Raman Spectrometries: Vibrational Spectrometries

Table 10B.2. Simplified Correlation Chart of Molecular Vibrations by Type*

Type of vibration		Frequency (cm ⁻¹)	Intensity [†]
C—H	Alkanes (stretch)	2800–2950	s
	Alkenes (stretch)	1450 and 1375	m
	Alkenes (out-of-plane bend)	1465	m
	Alkenes (out-of-plane bend)	3100–3000	m
	Aromatics (stretch)	1000–650	s
	Aromatics (out-of-plane bend)	3150–3050	s
	Alkyne (stretch)	900–690	s
	Aldehyde (stretch)	ca. 3300	s
C—C	Alkane	2900–2800	w
	Alkane	2800–2700	w
C=C	Alkene	not interpretatively useful	
	Aromatic	1680–1600	m-w
C≡C	Alkyne	1600 and 1475	m-w
	Alkyne	2250–2100	m-w
C=O	Aldehyde	1740–1720	s
	Ketone	1725–1705	s
	Carboxylic acid	1725–1700	s
	Ester	1750–1730	s
	Amide	1670–1640	s
	Anhydride	1810 and 1760	s
	Acid chloride	1800	s
	Alcohols, ethers, esters, carboxylic acids, anhydrides	1300–1000	s
O—H	Alcohols, phenols		
	Free	3650–3600	m
	H-bonded	3500–3200	m
N—H	Carboxylic acids	3400–2400	m
	Primary and secondary amines and amides (stretch)	3500–3100	m
C—N	Primary and secondary amines and amides (bend)	1640–1550	m-s
	Amines	1350–1000	m-s
C=C	Imines and oximes	1690–1640	w-s
C≡N	Nitriles	2260–2240	m
X=C=Y	Allenes, ketenes, isocyanates, isothiocyanates	2270–1950	m-s
N=O	Nitro (R—NO ₂)	1550 and 1350	s
S—H	Mercaptans	2550	w
S=O	Sulfoxides	1050	s
	Sulfones, sulfonyl chlorides	1375–1300 and	s
	Sulfates, sulfonamides	1200–1140	s
C—X	Fluoride	1400–1000	s
	Chloride	800–600	s
	Bromide, iodide	<667	s

*Data from Pavia, D. L., Lampman, G. M., Kriz, G. S. 1979. *Introduction to Spectroscopy: A Guide for Students of Organic Chemistry*.[†]s = strong, m = medium, w = weak.

TABLE 7-3 A Numerical Listing of Wavenumber Ranges in Which Some Functional Groups and Classes of Compounds Absorb in the Infrared

Range (cm ⁻¹) and Intensity ^a	Group and Class	Assignment and Remarks
3700-3600 (s)	-OH in alcohols and phenols	OH stretch (dil soln)
3520-3320 (m-s)	-NH ₂ in aromatic amines, primary amines and amides	NH stretch (dil soln)
3420-3250 (s)	-OH in alcohols and phenols	OH stretch (solids & liquids)
3360-3340 (m)	-NH ₂ in primary amides	NH ₂ antisym stretch (solids)
3320-3250 (m)	-OH in oximes	O-H stretch
3300-3250 (m-s)	≡CH in acetylenes	≡CH-H stretch
3300-3280 (s)	-NH in secondary amides	NH stretch (solids); also in polypeptides and proteins
3200-3180 (s)	-NH ₂ in primary amides	NH ₂ sym stretch (solids)
3200-3000 (v br)	-NH ₃ ⁺ in amino acids	NH ₃ ⁺ antisym stretch
3100-2400 (v br)	-OH in carboxylic acids	H-bonded OH stretch
3100-3000 (m)	≡CH in aromatic and unsaturated hydrocarbons	≡C-H stretch
2990-2850 (m-s)	-CH ₃ and -CH ₂ - in aliphatic compounds	CH antisym and sym stretching
2850-2700 (m)	-CH ₃ attached to O or N	CH stretching modes
2750-2650 (w-m)	-CHO in aldehydes	overtone of CH bending (Fermi resonance)
2750-2350 (br)	-NH ₃ ⁺ in amine hydrohalides	NH stretching modes
2720-2560 (m)	-OH in phosphorus oxyacids	associated OH stretching
2600-2540 (w)	-SH in alkyl mercaptans	S-H stretch; strong in Raman
2410-2280 (m)	-PH in phosphines	P-H stretch; sharp peak
2300-2230 (m)	N≡N in diazonium salts	N≡N stretch, aq soln
2285-2250 (s)	N=C=O in isocyanates	N=C=O antisym stretch
2260-2200 (m-s)	C≡N in nitriles	C≡N stretch
2260-2190 (w-m)	C≡C in alkynes (disubst)	C≡C stretch; strong in Raman
2190-2130 (m)	C≡N in thiocyanates	C≡N stretch
2175-2115 (s)	N≡C in isonitriles	N≡C stretch
2160-2080 (m)	N=N=N in azides	N=N=N antisym stretch
2140-2100 (w-m)	C≡C in alkynes (monosubst)	C≡C stretch
2000-1650 (w)	substituted benzene rings	several bands from overtone and combination bands
1980-1950 (s)	C=C=C in allenes	C=C=C antisym stretch
1870-1650 (vs)	C=O in carbonyl compounds	C=O stretch
1870-1830 (s)	C=O in β-lactones	C=O stretch
1870-1790 (vs)	C=O in anhydrides	C=O antisym stretch; part of doublet
1820-1800 (s)	C=O in acid halides	C=O stretch; lower for aromatic acid halides
1780-1760 (s)	C=O in γ-lactones	C=O stretch
1765-1725 (vs)	C=O in anhydrides	C=O sym stretch; part of doublet
1760-1740 (vs)	C=O in α-keto esters	C=O stretch; enol form
1750-1730 (s)	C=O in δ-lactones	C=O stretch
1750-1740 (vs)	C=O in esters	C=O stretch; 20 cm ⁻¹ lower if unsaturated
1740-1720 (s)	C=O in aldehydes	C=O stretch; 30 cm ⁻¹ lower if unsaturated
1720-1700 (s)	C=O in ketones	C=O stretch; 20 cm ⁻¹ lower if unsaturated
1710-1690 (s)	C=O in carboxylic acids	C=O stretch; fairly broad
1690-1640 (s)	C=N in oximes	C=N stretch; also imines
1680-1620 (s)	C=O and NH ₂ in primary amides	two bands from C=O stretch and NH ₂ deformation
1680-1635 (s)	C=O in ureas	C=O stretch; broad band
1680-1630 (m-s)	C=C in alkenes, etc.	C=C stretch
1680-1630 (vs)	C=O in secondary amides	C=O stretch (Amide I band)

^av = very, s = strong, m = medium, w = weak, br = broad.

TABLE 7-3 (Continued)





Range (cm ⁻¹) and Intensity*	Group and Class	Assignment and Remarks
1670-1640 (s-vs)	C=O in benzophenones	C=O stretch
1670-1650 (vs)	C=O in primary amides	C=O stretch (Amide I band)
1670-1630 (vs)	C=O in tertiary amides	C=O stretch
1655-1635 (vs)	C=O in β -ketone esters	C=O stretch; enol form
1650-1620 (w-m)	N-H in primary amides	NH deformation (Amide II band)
1650-1580 (m-s)	NH ₂ in primary amines	NH ₂ deformation
1640-1580 (s)	NH ₃ ⁺ in amino acids	NH ₃ deformation
1640-1580 (vs)	C=O in β -diketones	C=O stretch; enol form
1620-1610 (s)	C=C in vinyl ethers	C=C stretch; doublet due to rotational isomerism
1615-1590 (m)	benzene ring in aromatic compounds	ring stretch; sharp peak
1615-1565 (s)	pyridine derivatives	ring stretch; doublet
1610-1580 (s)	NH ₂ in amino acids	NH ₂ deformation; broad band
1610-1560 (vs)	COO ⁻ in carboxylic acid salts	 antisym stretch
1590-1580 (m)	NH ₂ primary alkyl amide	NH ₂ deformation (Amide II band)
1575-1545 (vs)	NO ₂ in aliphatic nitro compounds	NO ₂ antisym stretch
1565-1475 (vs)	NH in secondary amides	NH deformation (Amide II band)
1560-1510 (s)	triazine compounds	ring stretch; sharp band
1550-1490 (s)	NO ₂ in aromatic nitro compounds	NO ₂ antisym stretch
1530-1490 (s)	NH ₃ ⁺ in amino acids or hydrochlorides	NH ₃ ⁺ deformation
1530-1450 (m-s)	N=N-O in azoxy compounds	N=N-O antisym stretch
1515-1485 (m)	benzene ring in aromatic compounds	ring stretch, sharp band
1475-1450 (vs)	CH ₂ in aliphatic compounds	CH ₂ scissors vibration
1465-1440 (vs)	CH ₃ in aliphatic compounds	CH ₃ antisym deformation
1440-1400 (m)	OH in carboxylic acids	in-plane OH bending
1420-1400 (m)	C-N in primary amides	C-N stretch (Amide III band)
1400-1370 (m)	<i>t</i> -butyl group	CH ₃ deformations (two bands)
1400-1310 (s)	COO ⁻ group in carboxylic acid salts	 sym stretch; broad band
1390-1360 (vs)	SO ₂ in sulfonyl chlorides	SO ₂ antisym stretch
1380-1370 (s)	CH ₃ in aliphatic compounds	CH ₃ sym deformation
1380-1360 (m)	isopropyl group	CH ₃ deformations (two bands)
1375-1350 (s)	NO ₂ in aliphatic nitro compounds	NO ₂ sym stretch
1360-1335 (vs)	SO ₂ in sulfonamides	SO ₂ antisym stretch
1360-1320 (vs)	NO ₂ in aromatic nitro compounds	NO ₂ sym stretch
1350-1280 (m-s)	N=N-O in azoxy compounds	N=N-O sym stretch
1335-1295 (vs)	SO ₂ in sulfones	SO ₂ antisym stretch
1330-1310 (m-s)	CF ₃ attached to a benzene ring	CF ₃ antisym stretch
1300-1200 (vs)	N-O in pyridine <i>N</i> -oxides	N-O stretch
1300-1175 (vs)	P=O in phosphorus oxyacids and phosphates	P=O stretch
1300-1000 (vs)	C-F in aliphatic fluoro compounds	C-F stretch
1285-1240 (vs)	Ar-O in alkyl aryl ethers	C-O stretch
1280-1250 (vs)	Si-CH ₃ in silanes	CH ₃ sym deformation
1280-1240 (m-s)	C-C in epoxides	C-O stretch
1280-1180 (s)	C-N in aromatic amines	C-N stretch
1280-1150 (vs)	C-O-C in esters, lactones	C-O-C antisym stretch

TABLE 7-3 (Continued)

Range (cm ⁻¹) and Intensity*	Group and Class	Assignment and Remarks
1255-1240 (m)	<i>t</i> -butyl in hydrocarbons	skeletal vibration; second band near 1200 cm ⁻¹
1245-1155 (vs)	SO ₃ H in sulfonic acids	S=O stretch
1240-1070 (s-vs)	C—O—C in ethers	C—O—C stretch; also in esters
1230-1100 (s)	C—C—N in amines	C—C—N bending
1225-1200 (s)	C—O—C in vinyl ethers	C—O—C antisym stretch
1200-1165 (s)	SO ₂ Cl in sulfonyl chlorides	SO ₂ sym stretch
1200-1015 (vs)	C—OH in alcohols	C—O stretch
1170-1145 (s)	SO ₂ NH ₂ in sulfonamides	SO ₂ sym stretch
1170-1140 (s)	SO ₂ — in sulfones	SO ₂ sym stretch
1160-1100 (m)	C=S in thiocarbonyl compounds	C=S stretch; strong in Raman
1150-1070 (vs)	C—O—C in aliphatic ethers	C—O—C antisym stretch
1120-1080 (s)	C—O—H in secondary or tertiary alcohols	C—O stretch
1120-1030 (s)	C—NH ₂ in primary aliphatic amines	C—N stretch
1100-1000 (vs)	Si—O—Si in siloxanes	Si—O—Si antisym stretch
1080-1040 (s)	SO ₃ H in sulfonic acids	SO ₃ sym stretch
1065-1015 (s)	CH—O—H in cyclic alcohols	C—O stretch
1060-1025 (vs)	CH ₂ —O—H in primary alcohols	C—O stretch
1060-1045 (vs)	S=O in alkyl sulfoxides	S=O stretch
1055-915 (vs)	P—O—C in organophosphorus compounds	P—O—C antisym stretch
1030-950 (w)	carbon ring in cyclic compounds	ring breathing mode; strong in Raman
1000-950 (s)	CH=CH ₂ in vinyl compounds	=CH out-of-plane deformation
980-960 (vs)	CH=CH— in trans disubstituted alkenes	=CH out-of-plane deformation
950-900 (vs)	CH=CH ₂ in vinyl compounds	CH ₂ out-of-plane wag
900-865 (vs)	CH ₂ =C $\begin{matrix} R \\ \\ R' \end{matrix}$ in vinylidenes	CH ₂ out-of-plane wag
890-805 (vs)	1,2,4-trisubst benzenes	CH out-of-plane deformation (two bands)
860-760 (vs, br)	R—NH ₂ primary amines	NH ₂ wag
860-720 (vs)	Si—C in organosilicon compounds	Si—C stretch
850-830 (vs)	1,3,5-trisubst benzenes	CH out-of-plane deformation
850-810 (vs)	Si—CH ₃ in silanes	Si—CH ₃ rocking
850-790 (m)	CH=C $\begin{matrix} R \\ \\ R' \end{matrix}$ in trisubst alkenes	CH out-of-plane deformation
850-550 (m)	C—Cl in chloro compounds	C—Cl stretch
830-810 (vs)	<i>p</i> -disubst benzenes	CH out-of-plane deformation
825-805 (vs)	1,2,4-trisubst benzenes	CH out-of-plane deformation
820-800 (s)	triazines	CH out-of-plane deformation
815-810 (s)	CH=CH ₂ in vinyl ethers	CH ₂ out-of-plane wag
810-790 (vs)	1,2,3,4-tetrasubst benzenes	CH out-of-plane deformation
800-690 (vs)	<i>m</i> -disubst benzenes	CH out-of-plane deformation (two bands)
785-680 (vs)	1,2,3-trisubst benzenes	CH out-of-plane deformation (two bands)
775-650 (m)	C—S in sulfonyl chlorides	C—S stretch; strong in Raman
770-690 (vs)	monosubst benzenes	CH out-of-plane deformation (two bands)
760-740 (s)	<i>o</i> -disubst benzenes	CH out-of-plane deformation
760-510 (s)	C—Cl alkyl chlorides	C—Cl stretch
740-720 (w-m)	—(CH ₂) _n — in hydrocarbons	CH ₂ rocking in methylene chains; intensity depends on chain length
730-665 (s)	CH=CH in cis disubst alkenes	CH out-of-plane deformation
720-600 (s, br)	Ar—OH in phenols	OH out-of-plane deformation

TABLE 7-3 (Continued)

Range (cm ⁻¹) and Intensity ^a	Group and Class	Assignment and Remarks
710-570 (m)	C—S in sulfides	C—S stretch; strong in Raman
700-590 (s)	O—C=O in carboxylic acids	O—C=O bending
695-635 (s)	C—C—CHO in aldehydes	C—C—CHO bending
680-620 (s)	C—OH in alcohols	C—O—H bending
680-580 (s)	C≡C—H in alkynes	C≡C—H bending
650-600 (w)	S—C≡N in thiocyanates	S—C stretch; strong in Raman
650-600 (s)	NO ₂ in aliphatic nitro compounds	NO ₂ deformation
650-500 (s)	Ar—CF ₃ in aromatic trifluoro-methyl compounds	CF ₃ deformation (two or three bands)
650-500 (s)	C—Br in bromo compounds	C—Br stretch
645-615 (m-s)	naphthalenes	in-plane ring deformation
645-575 (s)	O—C—O in esters	O—C—O bend
640-630 (s)	=CH ₂ in vinyl compounds	=CH ₂ twisting
635-605 (m-s)	pyridines	in-plane ring deformation
630-570 (s)	N—C=O in amides	N—C=O bend
630-565 (s)	C—CO—C in ketones	C—CO—C bend
615-535 (s)	C=O in amides	C=O out-of-plane bend
610-565 (vs)	SO ₂ in sulfonyl chlorides	SO ₂ deformation
610-545 (m-s)	SO ₂ in sulfones	SO ₂ scissoring
600-465 (s)	C—I in iodo compounds	C—I stretch
580-530 (m-s)	C—C—CN in nitriles	C—C—CN bend
580-520 (m)	NO ₂ in aromatic nitro compounds	NO ₂ deformation
580-430 (s)	ring in cycloalkanes	ring deformation
580-420 (m-s)	ring in benzene derivatives	in-plane and out-of-plane ring deformations (two bands)
570-530 (vs)	SO ₂ in sulfonyl chlorides	SO ₂ rocking
565-520 (s)	C—C=O in aldehydes	C—C=O bend
565-440 (w-m)	C _n H _{2n+1} in alkyl groups	chain deformation modes (two bands)
560-510 (s)	C—C=O in ketones	C—C=O bend
560-500 (s)	 in amino acids	 rocking
555-545 (s)	=CH ₂ in vinyl compounds	=CH ₂ twisting
550-465 (s)	C—C=O in carboxylic acids	C—C=O bend
545-520 (s)	naphthalenes	in-plane ring deformation
530-470 (m-s)	NO ₂ in nitro compounds	NO ₂ rocking
520-430 (m-s)	C—O—C in ethers	C—O—C bend
510-400 (s)	C—N—C in amines	C—N—C bend
490-465 (variable)	naphthalenes	out-of-plane ring bending
440-420 (s)	Cl—C=O in acid chlorides	Cl—C=O in-plane deformation
405-400 (s)	S—C≡N in thiocyanates	S—C≡N bend

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