LAMPIRAN

LAMPIRAN 1

PEMBUATAN LARUTAN Cr SEBAGAI KONTAMINAN

A. Konsentrasi Cr dalam tanah kaolinit, Godean : 8,3 µg/g (ppm)

B. Tanah disimulasi dengan Cr_2O_3 (M =152 gr/mol) sampai konsentrasi Cr dalam tanah : 500 µg/g

C. Konsentrasi Cr yang harus ditambahkan dalam tanah adalah

= 500 µg/g-8,3 µg/g

= 491,7 µg/g ≈ 0,5 gr/kg

D. Berat sampel tanah = Berat tanah + berat air

= 150 kg + 50 kg = 200 kg. maka

E. Cr yang harus ditimbang :

$$Cr_2O_3 \cong \frac{BM.Cr_2O_3}{BA.Cr} x0{,}5\,gr/kg$$

$$\cong \frac{152\,gr/mol}{104\,gr/mol} x0{,}5\,gr/kg x \frac{100}{60}$$

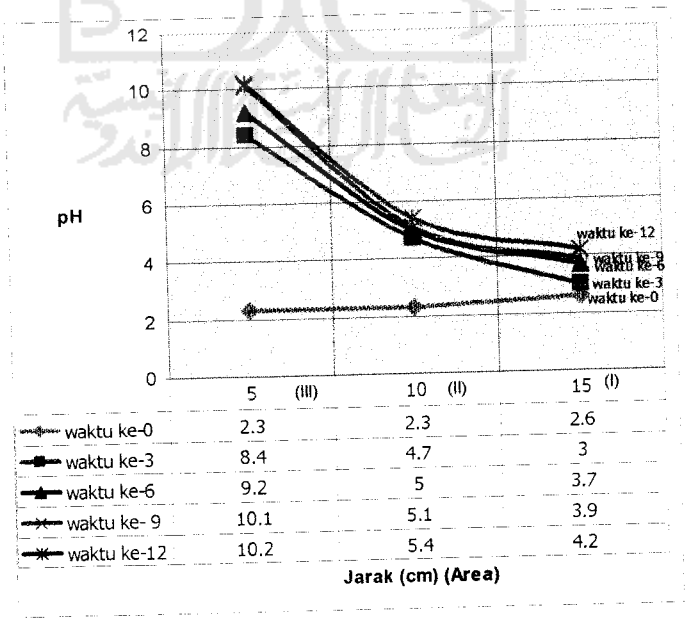
$$\cong 1{,}22\,gr/kg$$

Maka Cr_2O_3 yang harus ditimbang untuk tanah sebanyak 200 kg adalah = 1,22 gr/kg x 200 kg = 244 gr.

LAMPIRAN 2

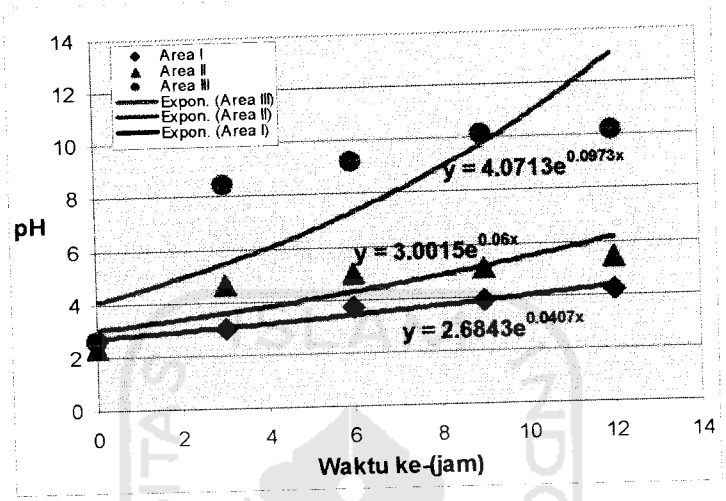
HASIL ANALISIS pH PADA SETIAP AREA EFEKTIF

Jarak dari katoda (cm)	pH	Jarak dari katoda (cm)	pH
5	2.3	10	5
5	8.4	10	5.1
5	9.2	10	5.4
5	10.1	15	2.6
5	10.2	15	3
10	2.3	15	3.7
10	4.7	15	3.9
		15	4.2



LAMPIRAN 3

HUBUNGAN pH terhadap WAKTU di AREA EFEKTIF



PERHITUNGAN pH dan WAKTU OPTIMUM

AREA III $y = 4{,}0713e^{0.0973x}$

pH maksimum pada area III = 11, maka

$$\frac{\ln y}{\ln 4{,}0713} = 0{,}0973x$$

$$\frac{\ln 11}{\ln 4{,}0713} = 0{,}0973x$$

$$x = 17\,jam$$

AREA I $y = 2{,}6843^{0.407x}$

Dengan waktu yang sama maka :

$$\frac{\ln y}{\ln 2{,}6843} = 0{,}0407x \Rightarrow \frac{\ln y}{\ln 2{,}6843} = 0{,}0407(17) \Rightarrow y = 1{,}9$$

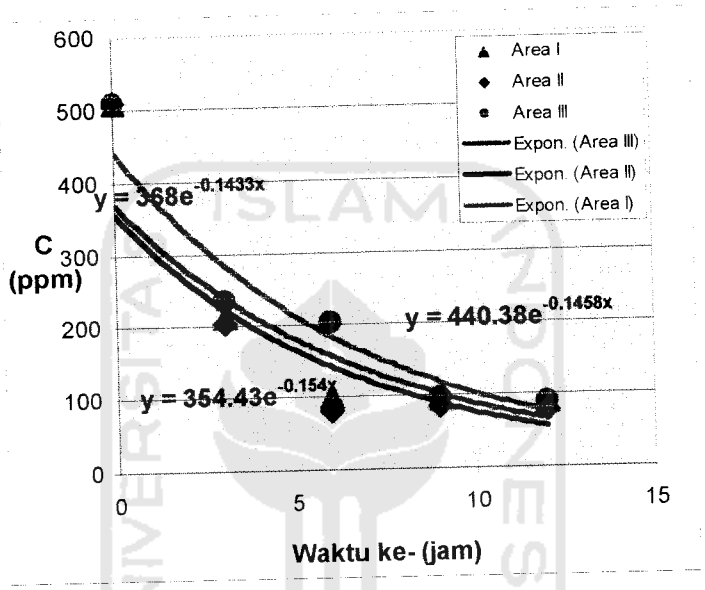
AREA II $y = 3{,}0015e^{0.06x}$

Dengan waktu yan sama maka :

$$\frac{\ln y}{\ln 3{,}0015} = 0{,}06x \Rightarrow \frac{\ln y}{\ln 3{,}0015} = 0{,}06(17) \Rightarrow y = 3$$

LAMPIRAN 4

HUBUNGAN KONSENTRASI Cr terhadap WAKTU di AREA EFEKTIF



Area III $y = 440e^{-0,1458x}$

Dengan waktu (x) = 17 jam, maka :

$$\frac{\ln y}{\ln 440} = -0,1458(17) \Rightarrow y = 3.10^{-7}$$

Area II $y = 354e^{-0,154x}$

Dengan waktu yang sama (x=17) : $\frac{\ln y}{\ln 354} = -0,154(17) \Rightarrow y = 21.10^{-7}$

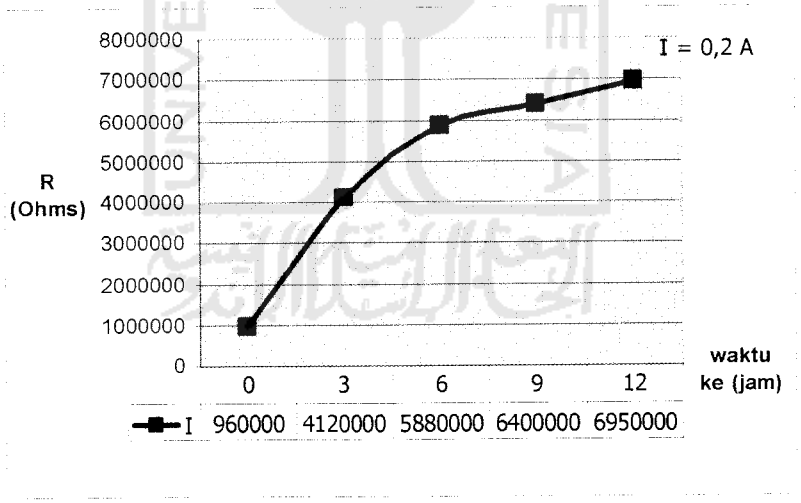
Area I $y = 368e^{-0,1433x}$

Dengan waktu yang sama (x=17) : $\frac{\ln y}{\ln 368} = -0,143(17) \Rightarrow y = 6.10^{-7}$

LAMPIRAN 5

HASIL ANALISIS ARUS dan RESISTENSI pada SETIAP AREA

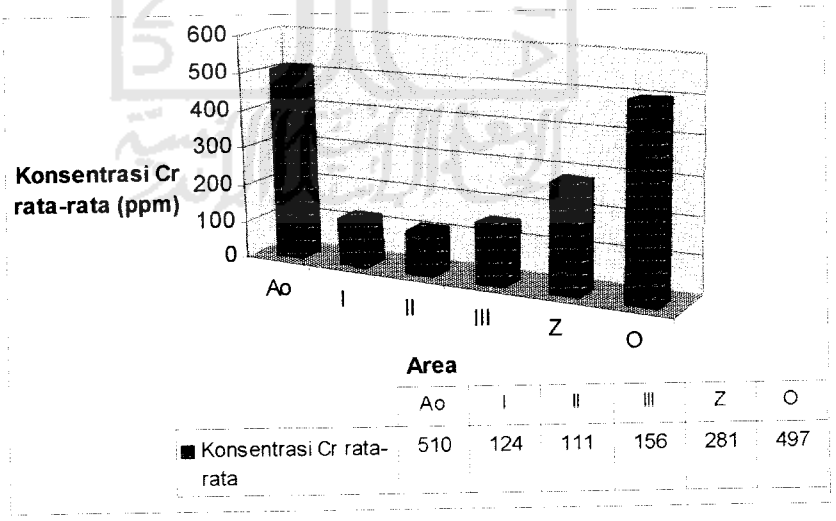
Waktu ke- (jam)	Resistensi (Ω)	Arus (Ampere)
0	96000	0.2
3	412000	0.2
6	588000	0.2
9	640000	0.2
12	695000	0.2



LAMPIRAN 6

KONSENTRASI Cr RATA-RATA dalam TANAH di SELURUH TITIK SAMPLING

Area	Konsentrasi Cr rata-rata (µg/g)
Ao	510
I	124
II	111
III	156
Z	281
O	497



LAMPIRAN 7

HASIL ANALISIS KONSENTRASI Cr

dan pH

BADAN TENAGA NUKLIR NASIONAL
PUSAT PENELITIAN DAN PENGEMBANGAN TEKNOLOGI MAJU
Jl. Babarsari Kotak Pos 1008, Yogyakarta 55010, Telepon (0274) 488435/484436

LABORATORIUM KIMIA ANALITIK

Bentuk Sampel : Padatan
Pengirim Sampel : Siti Fatimah
Asal Sampel : Lempung
Parameter : Kadar Crom (Cr) dalam lempung
Metode : APN

No	Kode Sampel	Konsentrasi (µg/g)	No	Kode Sampel	Konsentrasi (µg/g)
1	Ao	509,524	16	E2,2	83,989
2	A1	206,551	17	E3,2	85,479
3	A1,2	94,006	18	F1,2	83,742
4	B1	107,081	19	F2,2	73,065
5	C1	101,122	20	F3,2	92,928
6	D1	88,967	21	Z1	385,572
7	D2	83,742	22	Z2	231,438
8	D3	96,566	23	Z3	322,782
9	E1	94,086	24	Z4	276,353
10	E2	80,869	25	Z5	274,620
11	E3	201,843	26	Z6	291,430
12	F1	217,571	27	Z3,1	207,821
13	F2	202,689	28	Z5,2	259,738
14	F3	235,182	29	O	497,324
15	E1,2	88,211			

LABORATORIUM KUALITAS LINGKUNGAN
JURUSAN TEKNIK LINGKUNGAN
FAKULTAS TEKNIK SIPIL DAN PERENCANAAN
UNIVERSITAS ISLAM INDONESIA
Jl. Kaliurang km 14.4 Yogyakarta 55584. Phone 0274-895042, 895707, Fax 0274-895330

REMEDIASI ELEKTROKINETIK dengan MODEL KONFIGURASI ELEKTRODA 2-D *HEXAGONAL* pada TANAH TERKONTAMINASI LOGAM BERAT Cr

A. Hasil Pengukuran pH pada Area Efektif

Waktu ke- (jam)	Area Anoda	pH
0	A1	2,6
3	A1	2,8
	F1	3,2
6	B1	3,8
	E1	3,6
9	C1	4,0
	D1	3,8
12	A1	4,1
	F1	3,8
	E1	4,8

Waktu ke- (jam)	Area Katoda	pH
0	A	2,3
3	A	8,1
	F	8,7
6	B	9,5
	E	8,9
9	C	10,2
	D	10,0
12	A	9,5
	F	10,0
	E	11,2

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Waktu ke- (jam)	Area II	pH
0	A2	2,3
3	A2	4,5
	F2	4,8
6	B2	5,0
	E2	5,0
9	C2	5,2
	D2	5,0
12	A2	5,8
	F2	4,9
	E2	5,5

B. Hasil Pengukuran Resistensi dan Arus

Waktu ke- (jam)	Resistensi (kΩ)	Arus (A)
0	96	0
3	412	0,2
6	588	0,2
9	640	0,2
12	695	0,2

LAMPIRAN 8

AMBANG BATAS KONTAMINAN TANAH

Soil samples XYZ-1 – XYZ-6 were taken for analysis of metals for an area suspected of metals contamination. Average results are presented below.

Contaminant	Average Concentration mg/kg 0-2 m	Average Concentration mg/kg 0.5 m	Average Concentration mg/kg 1.0 m	Human Health Guidelines	Ecological Guidelines
Copper	120.0	8.5	1.0	Not limited[1]	100
Chromium (total)	20.9	2.0	<0.2	360[1]	1 (Cr VI) 400 (Cr III)
Zinc	17.2	2.1	<0.2	500[1]	20
Cobalt	3.6	<0.2	<0.2	500[2]	
Cadmium	0.8	<0.2	<0.2	100[2]	3
Nickel	15.3	<0.2	<0.2	3000[2]	60
Lead	520.3	180.5	12.4	35000[2]	200

1 Guidelines for Timber Treatment Chemicals: 1997.

2 National Environmental Protection Measure:
Assessment of site Contamination Schedule B (1)
Soil Investigation Levels. National Environment
Protection Council 1999.

The results show that ecological guideline values for soil are exceeded for copper, chromium and zinc. Further work analysing Cr VI specifically would be needed to check whether the concentrations measured are of concern, as Cr VI has a greater toxicity than Cr III.
The assessment indicates that average concentrations of copper and zinc exceed guideline values only in the shallow soils

LAMPIRAN 9

PENELITIAN REMEDIASI ELEKTROKINETIK

Table A 2.3: Synthesis of Laboratory Data Reported by Various Investigators on the Removal of Chemical Species from Soils

Ref.	Soil Type	Pore Fluid	Species	Initial Conc.	Current Density	Voltage	Duration (hrs)	Energy kW/m^3	Removal (%)	Remarks
1	Silty Sand	NA	Cu	617	.01-.05 mA/cm^2	0.165 V/cm	24-72	NA	50	Cylindrical Specimens (D=0.75in, L=6 in.). Final concentration 290-543 mg/kg.
2,3	Kaolinite	DIW	Pb	100-1064 mg/kg	0.012-0.123 mA/cm^2	2.5 V/cm	100-1285	29-60	75-95	Bench-scale tests conducted on kaolinite samples loaded with Pb at concentrations below and above the CEC. Demonstrates the effect of pH changes on the process.
2,4	Kaolinite	DIW	Cd Cr	100-140 mg/kg	0.037 mA/cm^2	2-2.5 V/cm	480-1600	50-120	92-100 65-70	Bench-scale tests demonstrate the feasibility of the process. The study demonstrates the development of nonlinear electric potential distribution due to the electrochemical changes across the sample.
5	Silty Clay	GW	Cr	150-1500 mg/kg	NA	0.1-1.0 V/cm	24-168	NA	NA	Field specimens are used (D=5.1 cm, L=2.5cm to 6.7 cm). Hydraulic and electric potentials are used simultaneously.

DIW: Deionized Water, DW: Distilled Water, GW: Ground Water, HS: HumicSolution, TW: Tap Water, NA: Not Available.

Table A 2.3: Synthesis of Laboratory Data Reported by Various Investigators on the Removal of Chemical Species from Soils (cont'd)

Ref.	Soil Type	Pore Fluid	Species	Initial conc.	Current Density	Voltage	Duration (hrs)	Energy	Removal (%)	Remarks
6	Kaolinite	D I W	Cu $Cu(NO_3)_2$ sol.	1.3 meq/kg	0.3-2.0 mA	0.25 V/cm	16-48	4.5-7.4	NA	Demonstrates that buffering theanoderesultsinhigher electroosmotic flow than buffereing the cathode. Citrate treatment was not effective in removing precipitated copper from the cathode zone.
7, 19	Kaolinite	D W	Cd. co, Ni, Sr	400-700 mg/kg	NA	30 v 4 *V/cm*	2430	NA	85-95	Conducted bench-scale tests *on the* feasibility of the process. The results display that removal efficiencies (or %removal) *is higher* for high *initial* concentrations. The results show that kaolinite has the highest removal followed by clayey sand while Na-monimorillonite shows the lowest removal efficiency
	Kaolinite	HS.	Cd. Co, Ni, Sr	600-750 mg/kg	NA	30v 4 *V/cm*	2430	NA	85-95	
	Kaolinite	GW	Cd, Co, Ni. Sr	550-1100 mg/kg	NA	30 v 4 V/cm	24-50	NA	85-95	
	Na-Montm.	DW	Cd, Co, Ni, Sr	4500-3600 mg/kg	NA	30 v 4 *V/cm*	24-50	NA	85-95	
	Sand + 10% Na-Montm.	DW	Cd, Co, Ni, Sr'	400-1500 mg/kg	NA	30 v 4 *V/cm*	24-50'	NA	85-95	

DIW: Deionized Water, DW: Distilled Water, GW: Ground Water, HS: Humic Solution, TW: Tap water, NA: Not Available.

Table A 2.3: Synthesis of Laboratory Data Reported by Various Investigators on the Removal of Chemical Species from Soils (cont'd)

Ref.	Soil Type	Pore Fluid	Species	Initial Conc.	Current Density	Voltage	Duration (hrs)	Energy kWh/m 3	Removal (%)	Remarks
8	Kaolinite Kaolinite	Delon. Water Delon. Water	Uranium Thorium	1000 pCi/g 41-313 pCi/g	0.127 mA/cm^2 0.127 mA/cm^2	0.5-12 V/cm 0.5-12 V/cm	85-550 144-785	50-300 kWh/m^3 100-300 kWh/m^3	85-95 20-75	The results demonstrate the feasibility of removing radionuct ides from bench-scale kaolinite sampler. Thorium and radium removal were incomplete due to formation of (horuim hydroxide and radium sulphate.
9	Unsat. Sand	0.005M $CaSO_4$	Chromate	100 mg/kg	0.35 mA/cm^2	89-150 V 4-7 V/cm	22	NA	NA	Demonstartes the efficiency of using the process for partially saturated samples. Rale of ion-migration Is 20 times the rate of electroosmosis.
10	Unsat. Sand	NA	Cu ($CuSO_4$ sol.)	617 mg/l	NA	2 V 0.13 V/cm	3, 5, 7, and 9 days	NA	NA	Fully saturated samples showed higher removal efficiencies than unsaturated samples.
11	Sand	DW	$CuSO_4$	0.001M $CuSO_4$ (65 mg/l Cu Sol.)	NA	2.5 V 0.2 V/cm	7-48	NA	NA	Demonstartes the efficiency of using ion-migration for preconcentration of tons that are difficult to remove by pump-and-treat
12, 13	Altamont Caly (Illite)	NaCl Sol.	NaCl	0.02N NaCl	NA	10 V 0.1 V/cm	500 day	NA	NA	Investigates the feasibility of using electrokinetic clay barriers.

DIW: Deionized water, DW: Distilled Water. GW Ground Waler, HS: Humic Solution TW: Tap Waler, NA: Not Available.

Table A 2.3: Synthesis of Laboratory Data Reported by Various Investigators on the Removal of Chemical Species from Soils (cont'd)

Ref.	Soil Type	Poro Fluid	Species	Initial Conc.	Current Density	Voltage	Duration (hrs)	Energy kWh/m 3	Removal (%)	Remarks
14. 15. I6	Kaolinite Kaolinite	NA	acetic acid Phenol	0.5 M, 0.1 M 450 ppm 45 ppm	NA NA	2s v 0.62 V/cm	20-100 days up 10 60 days	3.7 Kwh/t 5.3-260 kwh/t	95 45 9s 75	0. IM NaCl purging solution was used to optimize the process.
I7	Kaolinite	DIW	Phenol	500 mg/kg	0.037 mA/cm^2	0.4-2.4 V/cm	78-144	18-39	85-95	Most of the phenol removed from the sample was collected with the effluent.
18	Kaolinite	TW	BTXs Comp.	1-150 mg/kg	NA	0.4 'V/cm	NA'	NA	see remarks	Different organics (TCE 150 mg/kg. benzene I30 mg/kg. toluene 70 mg/kg. m-xylene 30 mg/kg) showed transport and removal horn cylindrical bench-scale samples (L-30cm) by electroormosis.
I9	Kaolinite Na-Monl Sand	DW GW HS	Aceton (see remarks)	100-6800 ppm	NA	30 v 4 V/cm	24-50	NA	Varies 5.8-100	Different organics (aceltic acid, aceton, phenol, and hexachlorobenzene) showed transport and accumulation at center and towards the cathode.

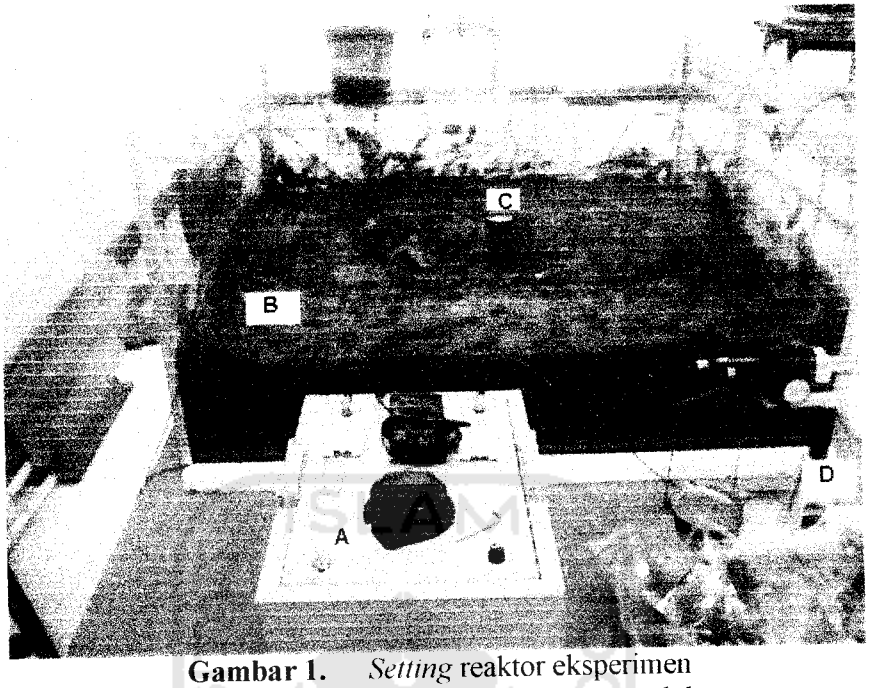
DIW: Delonized Water:DW: Distilled Water, GW: Ground Water, HS: HumicSolution, TW: TapWater, NA Not Ava ila

Table 2.4: References for Data Presented in Table 2.3

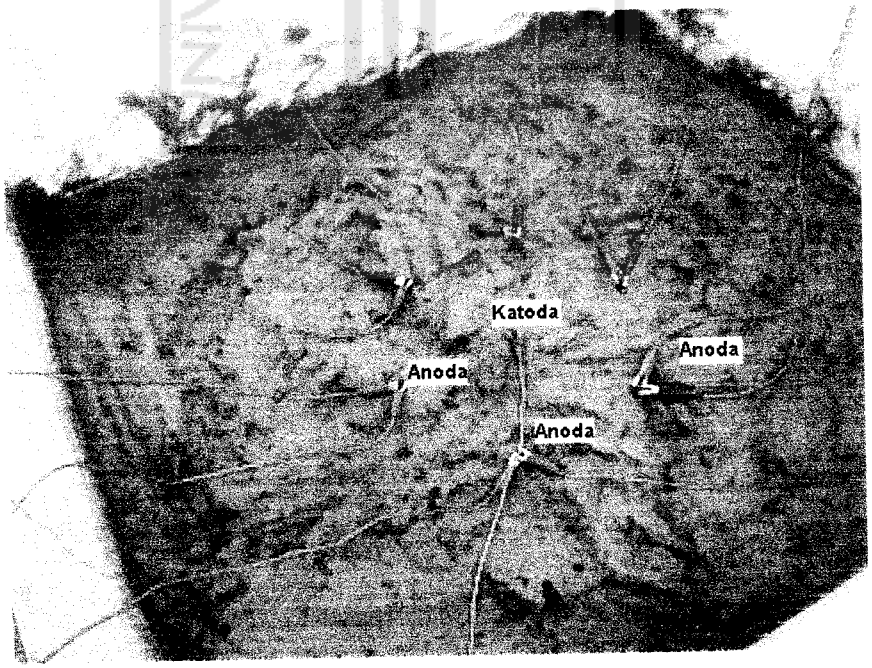
1	Runnels and Larson (1986)
2	Hauled (1990)
3	Hamed, Acar, and Gale (1991)
4	Acar, Hamed, Alshawabkeh, and Gale (1994)
5	Banerjee, Horng, Ferguson, and Nelson (1990)
6	Eykholt (1992)
7	Pamukcu and Wittle (1992)
8	Ugaz, Puppala, Gale, and Acar (1994)
9	Lindgren, Mattson, and Kozak (1992)
10	Dabab, Kelly, and Godaya (1992)
11	Runnels and Wahli (1993)
12	Yeung (1990)
13	Mitchell and Yeung (1991)
14	Shapiro, Renauld, and Probstein (1989)
15	Shapiro and Probstein (1993)
16	Probstein and Hicks (1993)
17	Acar, Li, and Gale (1992b)
18	Bruell, Segal, and Walsh (1992)
19	Wittle and Pamukcu (1993)

LAMPIRAN 10

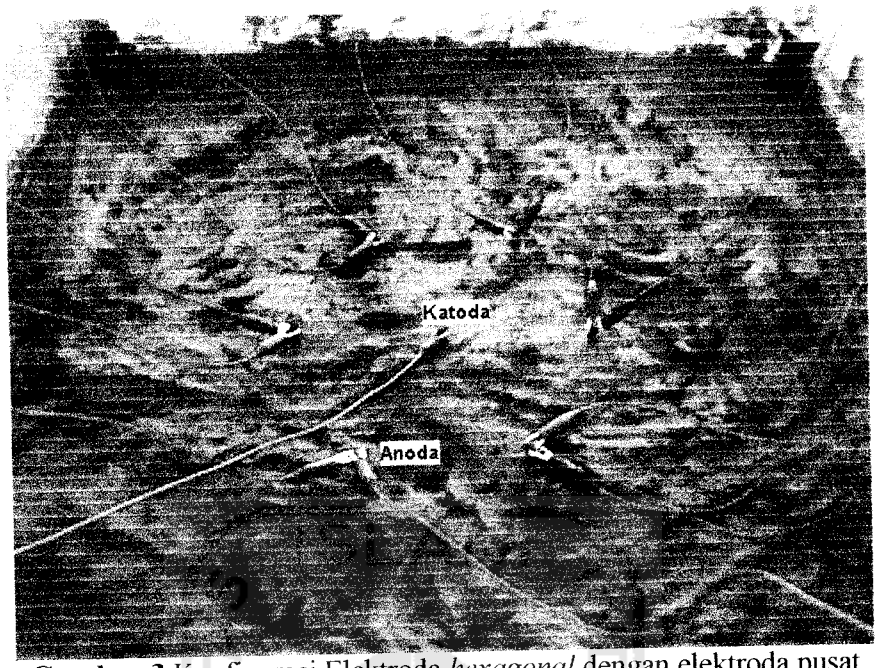
DOKUMENTASI PENELITIAN



Gambar 1. *Setting* reaktor eksperimen
Keterangan : A. *power supply* B. Bak kaca
C. pH meter D.. Neraca



Gambar 2. Media penelitian dalam bak reaktor



Gambar 3. Konfigurasi Elektroda *hexagonal* dengan elektroda pusat adalah katoda

Gambar 4. Pengukuran pH pada area katoda
Keterangan : A. pHmeter, B. media yang diambil sebagai sampel, C. Anoda