LAMPIRAN

Lampiran 01. Perhitungan Pembuatan Larutan

a) Sintesis Hijau CuO-NPS

1. Pembuatan larutan Prekursor $Cu(CH_3COO)_2.H_2O$ 0,3 M

$$M = \frac{massa}{Mr} \times \frac{1000}{v}$$

$$0{,}3\ M = \frac{massa}{199{,}65\ g/mol} \times \frac{1000\ mL}{250\ mL}$$

$$massa = \frac{199{,}65\ g/mol\ X\ 250\ mL}{1000\ mL} \times 0{,}3\ M$$

$$massa = 14{,}97375\ g$$

2. Pembuatan larutan 0,4 M NaOH

$$M = \frac{massa}{Mr} \times \frac{1000}{v}$$

$$0{,}5\ M = \frac{massa}{40\ g/mol} \times \frac{1000\ mL}{250\ mL}$$

$$massa = \frac{40\ g/mol\ X\ 250\ mL}{1000\ mL} \times 0{,}4\ M$$

$$massa = 4\ g$$

b) Pembuatan Bioplastik

1. Pembuatan larutan gliserol 5% dari gliserol 85%

$$M_1 \times V_1 = M_2 \times V_2$$

$$85\% \times V_1 = 5\% \times 200\ mL$$

$$V_1 = \frac{5\% \times 200\ mL}{85\%}$$

$$V_1 = 11{,}7647\ mL$$

2. Pembuatan larutan asam asetat 10% dari asam asetat 25%

$$M_1 \times V_1 = M_2 \times V_2$$

$$25\% \times V_1 = 10\% \times 100\ mL$$

$$V_1 = \frac{10\% \times 100\ mL}{25\%}$$

$$V_1 = 40\ mL$$

Lampiran 02. Perhitungan Hasil Karakterisasi Nanopartikel CuO

a) Perhitungan Ukuran Kristalit

Perhitungan ukuran kristalit menggunakan persamaan Scherrer yang dapat dilihat pada persamaan 3.1

- Langkah awal menentukan theta dan FWHM dengan satuan radian

  Data yang diperoleh adalah data 2 theta dan FWHM (deg), maka perhitungan adalah sebagai berikut.

  1. 2Theta = 32,76; maka Theta = $\frac{32,76}{2}$ = 16,38° = 0,28588 radian
  2. FWHM = 0,37° = 0,00646 radian

Adapun hasil perhitungan dalam bentuk radian untuk data difraktogram yang diberikan sebagai berikut.

No.	2Theta	Theta	theta (rad)	FWHM	FWHM (rad)
1	32,76	16,38	0,285884931	0,37	0,00645772
2	35,794	17,897	0,312361576	0,43	0,00750492
3	38,979	19,4895	0,340155945	0,53	0,00925025
4	46,57	23,285	0,406399916	0,2	0,00349066
5	49,036	24,518	0,427919826	0,528	0,00921534
6	53,67	26,835	0,468359105	0,64	0,01117011
7	58,55	29,275	0,510945139	0,54	0,00942478
8	61,8	30,9	0,539306739	0,45	0,00785398
9	66,53	33,265	0,580583776	0,95	0,01658063
10	68,37	34,185	0,596640805	0,61	0,01064651
11	72,66	36,33	0,634078117	0,55	0,00959931
12	75,22	37,61	0,656418332	0,71	0,01239184
13	80,43	40,215	0,701884159	0,53	0,00925025
14	83,19	41,595	0,725969702	1,51	0,02635447

- Menentukan ukuran kristalit rata-rata

$$D1 = \frac{K\,\lambda}{\beta\,\cos\theta} = \frac{0,94\,.1,54056\,\text{Å}}{0,00646.\ 0,95941} = 233,73407\text{Å} = 23,37341\ \text{nm}$$

Adapun hasil perhitungan ukuran kristalit untuk data difraktogram yang diberikan dan rata-rata ukurannya dapat dilihat pada rincian berikut.

No.	K	λ	FWHM (rad)	Cos-theta	D	D (nm)
1	0,94	1,54056	0,00646	0,95941	233,73407	23,37341
2	0,94	1,54056	0,00750	0,95161	202,76894	20,27689
3	0,94	1,54056	0,00925	0,94270	166,06515	16,60652
4	0,94	1,54056	0,00349	0,91855	451,64411	45,16441
5	0,94	1,54056	0,00922	0,90983	172,71676	17,27168
6	0,94	1,54056	0,01117	0,89231	145,28918	14,52892
7	0,94	1,54056	0,00942	0,87228	176,14814	17,61481
8	0,94	1,54056	0,00785	0,85806	214,88022	21,48802
9	0,94	1,54056	0,01658	0,83614	104,45402	10,44540
10	0,94	1,54056	0,01065	0,82723	164,42740	16,44274
11	0,94	1,54056	0,00960	0,80562	187,25661	18,72566
12	0,94	1,54056	0,01239	0,79218	147,51805	14,75180
13	0,94	1,54056	0,00925	0,76363	205,00854	20,50085
14	0,94	1,54056	0,02635	0,74786	73,47408	7,34741
					D (nm)	**18,89561**

b) Perhitungan *d-spacing*

Persamaan untuk perhitungan *d-spacing* dapat dilihat pada persamaan 4.1

$$n\lambda = 2d\ sin\theta$$

$$2d = \frac{n\lambda}{sin\theta} = \frac{1{,}54056\ \text{Å}}{0{,}282006576} = 5{,}4628513\ \text{Å}$$

$$d = \frac{5{,}4628513\ \text{Å}}{2} = 2{,}731426\ \text{Å} = 0{,}273143\ \text{nm}$$

Adapun hasil perhitungan *d-spacing* untuk data difraktogram yang diberikan dan rata-rata *d-spacing* dapat dilihat pada rincian berikut.

No.	λ	sin-theta	λ/sin theta	d	d (nm)
1	1,54056	0,282007	5,4628513	2,731426	0,273143
2	1,54056	0,307307	5,013101	2,506551	0,250655
3	1,54056	0,333634	4,6175135	2,308757	0,230876
4	1,54056	0,395305	3,8971423	1,948571	0,194857
5	1,54056	0,414979	3,7123798	1,85619	0,185619
6	1,54056	0,451423	3,4126773	1,706339	0,170634
7	1,54056	0,489002	3,1504173	1,575209	0,157521
8	1,54056	0,513541	2,9998758	1,499938	0,149994
9	1,54056	0,548512	2,808616	1,404308	0,140431
10	1,54056	0,561867	2,7418597	1,37093	0,137093
11	1,54056	0,592435	2,6003862	1,300193	0,130019

12	1,54056	0,610283	2,5243353	1,262168	0,126217
13	1,54056	0,645658	2,3860324	1,193016	0,119302
14	1,54056	0,663861	2,3206064	1,160303	0,11603
				d (nm)	**0,170171**

c) Perhitungan Parameter Kisi

$$\frac{1}{d_{hkl}^2} = \frac{1}{sin^2\beta°}\left[\frac{h^2}{a^2} + \frac{k^2}{b^2}sin^2\beta° + \frac{l^2}{c^2} - \frac{2hl\cos\beta°}{ac}\right]$$

1. Mencari c (h=0, k=0, l=4)

$$\frac{1}{1{,}26217^2} = \frac{1}{0{,}97287}\left[\frac{0^2}{a^2} + \frac{0^2}{b^2}0{,}97287 + \frac{4^2}{c^2} - \frac{2\times 0\times 0\cos\beta°}{ac}\right]$$

$$\frac{1}{1{,}59308} = \frac{1}{0{,}97287}\left[\frac{4^2}{c^2}\right]$$

$$0{,}62772 = 16{,}44614\,\frac{1}{c^2}$$

$$c^2 = \frac{16{,}44614}{0{,}62772}$$

$$c^2 = 26{,}1998$$

c = 5,11857 nm

2. Mencari b (h=0, k=2, l=0)

$$\frac{1}{1{,}70634^2} = \frac{1}{0{,}97287}\left[\frac{0^2}{a^2} + \frac{2^2}{b^2}0{,}97287 + \frac{0^2}{c^2} - \frac{2\times 0\times 0\cos\beta°}{ac}\right]$$

$$\frac{1}{2{,}91159} = \frac{1}{0{,}97287}\left[\frac{4}{b^2}0{,}97287\right]$$

$$0{,}34345 = \left[\frac{4}{b^2}\right]$$

$$b^2 = \frac{4}{0{,}34345}$$

$$b^2 = 11{,}64637$$

b = 3,41268 nm

3. Mencari a (h=1, k=1, l=0)

$$\frac{1}{2{,}73143^2} = \frac{1}{0{,}97287}\left[\frac{1^2}{a^2} + \frac{1^2}{b^2}0{,}97287 + \frac{0^2}{c^2} - \frac{2 \times 1 \times 0 \cos\beta°}{ac}\right]$$

$$\frac{1}{7{,}46069} = \frac{1}{0{,}97287}\left[\frac{1^2}{a^2} + \frac{1^2}{3{,}41268^2}0{,}97287\right]$$

$$\frac{1}{7{,}46069} = \frac{1}{0{,}97287}\left[\frac{1^2}{a^2} + \frac{1}{11{,}64637}0{,}97287\right]$$

$$\frac{1}{7{,}46069} = \frac{1}{0{,}97287a^2} + \left[\frac{1}{0{,}97287} \times \frac{1}{11{,}64637}0{,}97287\right]$$

$$\frac{1}{7{,}46069} = \frac{1}{0{,}97287a^2} + \frac{1}{11{,}64637}$$

$$0{,}13404 = \frac{1}{0{,}97287a^2} + 0{,}08586$$

$$0{,}13404 - 0{,}08586 = \frac{1}{0{,}97287a^2}$$

$$0{,}04817 = \frac{1}{0{,}97287a^2}$$

$$a^2 = \frac{1}{0{,}97287 \times 0{,}04817}$$

$$a^2 = 21{,}33768$$

$$\boldsymbol{a = 4{,}61927\ \text{nm}}$$

d) Perhitungan Volume Unit Sel

$V = abc \sin \beta°$

$= 4{,}61927 \times 3{,}41268 \times 5{,}11857 \times \sin 99{,}48°$

$= 80{,}68964 \times 0{,}98634$

$= 79{,}58767 \text{ Å}^3$

Lampiran 03. Perhitungan Karakterisasi terhadap Bioplastik

a) Kuat Tarik, Perpanjangan Putus, dan Modulus Young

Bioplastik Kontrol

Diketahui : Lebar = 2,5 cm = 0,025 m

Panjang awal = 6 cm = 0,06 m

Ketebalan = 0,11 mm = 0,00011 m

F = 16,862 N

Pertambahan panjang = 26,9812 mm = 0,02698 m

Jawab :

A = luas penampang = lebar × ketebalan

= 0,025 m × 0,00011 m

= 0,00000275 m^2

1. **Kuat Tarik (σ)** = $\frac{F}{A}$

= $\frac{16{,}862\ N}{0{,}00000275\ m^2}$

= 6131636,364 N/m^2

= 6,131636364 MPa

2. ***Elongation* (e)** = $\frac{\Delta L}{L_0}$

= $\frac{0{,}02698\ \text{m}}{0{,}06\ \text{m}}$

= 0,449686667

***Elongation* (%)** = 0,449686667 × 100%

= 44,96867%

3. **Modulus Young** = $\frac{\sigma}{e}$

= $\frac{6{,}131636364\ MPa}{0{,}449686667}$

= 13,63535 MPa

Data Pengujian Kuat Tarik

Bioplastik Kontrol			Maximum point Load (F)	Elongation (Pertambahan panjang)
Lebar (m)	Panjang (m)	Ketebalan (m)	N	mm
0,025	0,06	0,00011	16,862	26,9812
			19,72	22,5531
			20,509	22,4135

Luas Penampang
0,00000275 m^2

Bioplastik SGC-1			Maximum point Load (F)	Elongation (Pertambahan panjang)
Lebar (m)	Panjang (m)	Ketebalan (m)	N	mm
0,025	0,06	0,00012	12,75	24,5877
			14,883	20,8571
			17,024	19,4615

Luas Penampang
0,000003 m^2

Bioplastik SGC-2			Maximum point Load (F)	Elongation (Pertambahan panjang)
Lebar (m)	Panjang (m)	Ketebalan (m)	N	mm
0,025	0,06	0,00012	12,709	24,508
			15,742	23,5704
			17,631	23,7498

Luas Penampang
0,000003 m^2

Bioplastik SGC-3			Maximum point Load (F)	Elongation (Pertambahan panjang)
Lebar (m)	Panjang (m)	Ketebalan (m)	N	mm
0,025	0,06	0,00012	17,047	25,3459
			20,254	26,0638
			25,002	24,9467

Luas Penampang
0,000003 m^2

Bioplastik SGC-4			Maximum point Load (F)	Elongation (Pertambahan panjang)
Lebar (m)	Panjang (m)	Ketebalan (m)	N	mm
0,025	0,06	0,00015	23,028	31,3672
			15,847	21,436
			18,759	20,0996

Luas Penampang
0,00000375 m^2

Bioplastik SGC-5			Maximum point Load (F)	Elongation (Pertambahan panjang)
Lebar (m)	Panjang (m)	Ketebalan (m)	N	mm
0,025	0,06	0,00014	16,093	27,1408
			19,003	32,4842
			20,028	25,4855

Luas Penampang
0,0000035 m^2

Hasil Perhitungan Kuat Tarik, Perpanjangan Putus dan Modulus Young

Sampel	Pengulangan	Kuat Tarik	Persen Elongasi	Modulus young
Kontrol	U1	6,131636 MPa	44,96867 %	13,63535 MPa
	U2	7,170909 MPa	37,5885 %	19,0774 MPa
	U3	7,457818 MPa	37,35583 %	19,96427 MPa
	Rata-Rata	6,920121 MPa	39,971 %	17,55901 MPa
	SD	0,697754	4,329669	3,426796
SGC-1	U1	4,25 MPa	40,9795 %	10,37104 MPa
	U2	4,961 MPa	34,76183 %	14,2714 MPa
	U3	5,674667 MPa	32,43583 %	17,49505 MPa
	Rata-Rata	4,961889 MPa	36,05906 %	14,04583 MPa
	SD	0,712334	4,417086	3,56736
SGC-2	U1	4,236333 MPa	40,84667 %	10,37131 MPa
	U2	5,247333 MPa	39,284 %	13,35743 MPa
	U3	5,877 MPa	39,583 %	14,84728 MPa
	Rata-Rata	5,120222 MPa	39,90456 %	12,85867 MPa
	SD	0,827686	0,829476	2,279289
SGC-3	U1	5,682333 MPa	42,24317 %	13,45149 MPa
	U2	6,751333 MPa	43,43967 %	15,54186 MPa
	U3	8,334 MPa	41,57783 %	20,04433 MPa
	Rata-Rata	6,922556 MPa	42,42022 %	16,34589 MPa
	SD	1,3341	0,94346	3,369164
SGC-4	U1	6,1408 MPa	52,27867 %	11,74628 MPa
	U2	4,225867 MPa	35,72667 %	11,82833 MPa
	U3	5,0024 MPa	33,49933 %	14,93283 MPa
	Rata-Rata	5,123022 MPa	40,50156 %	12,83581 MPa
	SD	0,963148	10,2599	1,816536
SGC-5	U1	4,598 MPa	45,23467 %	10,16477 MPa
	U2	5,429429 MPa	54,14033 %	10,02844 MPa
	U3	5,722286 MPa	42,47583 %	13,47186 MPa
	Rata-Rata	5,249905 MPa	47,28361 %	11,22169 MPa
	SD	0,583246	6,096209	1,949899

b) Ketahanan terhadap Air

Air yang diserap (%) = $\frac{W-W_0}{W_0} \times 100\%$

Ketahanan air = 100% - Air yang diserap (%)

1. Ketahanan air pada Bioplastik Kontrol

Air yang diserap (%)= $\frac{0,3521-0,1929}{0,1929} \times 100\%$

$= \frac{0,1592}{0,1929} \times 100\%$

$= 0,82530 \times 100\%$

= 82,52981%

Ketahanan air (%) = 100% - Air yang diserap (%)

= 100% - 82,52981%

= **17,47019%**

Adapun hasil perhitungan ketahanan air (%) untuk semua sampel bioplastik dapat dilihat pada rincian berikut.

Pengulangan 1

Berat	Sebelum (W0)	Sesudah (W)
Kontrol	0,1929	0,3521
SGC 1	0,2980	0,4278
SGC 2	0,2588	0,3754
SGC 3	0,2890	0,4310
SGC 4	0,2485	0,4218
SGC 5	0,2783	0,4506

	W-W0	Air yang diserap
Kontrol	0,1592	0,82530
SGC 1	0,1298	0,43557
SGC 2	0,1166	0,45054
SGC 3	0,1420	0,49135
SGC 4	0,1733	0,69738
SGC 5	0,1723	0,61912

Pengulangan 2

Sebelum	Sesudah
0,2246	0,3660
0,2824	0,4100
0,2783	0,4063
0,2309	0,3488
0,2622	0,4204
0,2554	0,4470

W-W0	Air yang diserap
0,1414	0,62956
0,1276	0,45184
0,1280	0,45994
0,1179	0,51061
0,1582	0,60336
0,1916	0,75020

Pengulangan 3

Sebelum	Sesudah
0,2358	0,4204
0,2804	0,3820
0,2394	0,3432
0,2751	0,4193
0,2237	0,3464
0,2388	0,4347

W-W0	Air yang diserap
0,1846	0,78287
0,1016	0,36234
0,1038	0,43358
0,1442	0,52417
0,1227	0,54850
0,1959	0,82035

% Air yang diserap = Air yang diserap x 100%

	P1	P2	P3
Kontrol	82,52981	62,95637	78,28668
SGC 1	43,55705	45,18414	36,23395
SGC 2	45,05410	45,99353	43,35840
SGC 3	49,13495	51,06107	52,41730
SGC 4	69,73843	60,33562	54,85025
SGC 5	61,91161	75,01958	82,03518

%Ketahanan Air = 100% - %air yang diserap

	P1	P2	P3
Kontrol	17,47019	37,04363	21,71332
SGC 1	56,44295	54,81586	63,76605
SGC 2	54,94590	54,00647	56,64160
SGC 3	50,86505	48,93893	47,58270
SGC 4	30,26157	39,66438	45,14975
SGC 5	38,08839	24,98042	17,96482

KETAHANAN AIR (%)(rata-rata)

	Ketahanan Air	SD
Kontrol	25,40905	10,29678
SGC 1	58,34162	4,76762
SGC 2	55,19799	1,33553
SGC 3	49,12889	1,64940
SGC 4	38,35857	7,52950
SGC 5	27,01121	10,21433

c) Biodegradasi Tanah

Kehilangan berat (%) = $\frac{W_1 - W_2}{W_1} \times 100\%$

Laju degradabilitas = $\frac{W_1 - W_2(mg)}{Waktu\ uji}$

1. Presentase kehilangan berat pada bioplastik kontrol

   Minggu ke-1

   Kehilangan berat (%) $= \frac{0{,}2017 - 0{,}1389}{0{,}2017} \times 100\%$

   $= \frac{0{,}0628}{0{,}2017} \times 100\%$

   = 31,13535%

   Minggu ke-2

   Kehilangan berat (%) $= \frac{0{,}2017 - 0{,}131}{0{,}2017} \times 100\%$

   $= \frac{0{,}0707}{0{,}2017} \times 100\%$

   = 35,05206%

2. Laju degradasi pada bioplastik kontrol

   Minggu ke-1

   Laju Degrabilitas $= \frac{0{,}2017 - 0{,}1389}{7}$

   $= \frac{0{,}0628\ g}{7}$

   $= \frac{62{,}8\ mg}{7}$

   = 8,97143 mg/hari

   Minggu ke-2

   Laju Degrabilitas $= \frac{0{,}1389 - 0{,}131}{7}$

   $= \frac{0{,}0079\ g}{7}$

   $= \frac{7{,}9\ mg}{7}$

= 1,12857 mg/hari

Adapun hasil perhitungan biodegradasi dan laju degrabilitas semua variasi bioplastik dari minggu ke -1 sampai minggu ke-5 dapat dilihat pada rincian berikut.

	Minggu ke-0	Minggu ke-1	Minggu ke-2	Minggu ke-3	Minggu ke-4	Minggu ke-5
Kontrol	0,2017	0,1389	0,131	0,1211	0,1131	0,1058
SGC 1	0,2649	0,1866	0,172	0,1619	0,1508	0,1397
SGC 2	0,2203	0,1545	0,1412	0,1322	0,1255	0,1154
SGC 3	0,2180	0,1545	0,1416	0,1269	0,121	0,1135
SGC 4	0,2262	0,1554	0,1437	0,1351	0,1232	0,1137
SGC 5	0,2336	0,1600	0,1558	0,1415	0,135	0,1257

Kehilangan Berat = berat minggu ke 1-Berat Minggu ke 0

Kehilangan Berat

Kontrol	0,0628	0,0707	0,0806	0,0886	0,0959
SGC 1	0,0783	0,0929	0,103	0,1141	0,1252
SGC 2	0,0658	0,0791	0,0881	0,0948	0,1049
SGC 3	0,0635	0,0764	0,0911	0,097	0,1045
SGC 4	0,0708	0,0825	0,0911	0,103	0,1125
SGC 5	0,0736	0,0778	0,0921	0,0986	0,1079

Kehilangan Berat per-minggu (gram)

0,0628	0,0079	0,0099	0,008	0,0073
0,0783	0,0146	0,0101	0,0111	0,0111
0,0658	0,0133	0,009	0,0067	0,0101
0,0635	0,0129	0,0147	0,0059	0,0075
0,0708	0,0117	0,0086	0,0119	0,0095
0,0736	0,0042	0,0143	0,0065	0,0093

% Kehilangan Berat = kehilangan berat/berat awal x 100%

Kontrol	31,13535	35,05206	39,96034	43,92662	47,54586
SGC 1	29,55832	35,06984	38,88260	43,07286	47,26312
SGC 2	29,86836	35,90558	39,99092	43,03223	47,61689
SGC 3	29,12844	35,04587	41,78899	44,49541	47,93578
SGC 4	31,29973	36,47215	40,27409	45,53492	49,73475
SGC 5	31,50685	33,30479	39,42637	42,20890	46,19007

Kehilangan Berat per-minggu (mg)

62,8	7,9	9,9	8,0	7,3
78,3	14,6	10,1	11,1	11,1
65,8	13,3	9,0	6,7	10,1
63,5	12,9	14,7	5,9	7,5
70,8	11,7	8,6	11,9	9,5
73,6	4,2	14,3	6,5	9,3

%KEHILANGAN BERAT

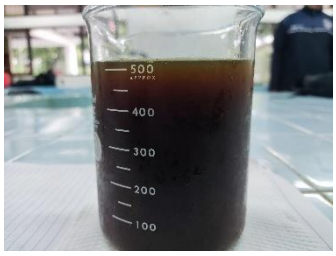
	Kontrol	SGC-1	SGC-2	SGC-3	SGC-4	SGC-5
Minggu ke-1	31,13535	29,55832	29,86836	29,12844	31,29973	31,50685
Minggu ke-2	35,05206	35,06984	35,90558	35,04587	36,47215	33,30479
Minggu ke-3	39,96034	38,88260	39,99092	41,78899	40,27409	39,42637
Minggu ke-4	43,92662	43,07286	43,03223	44,49541	45,53492	42,20890
Minggu ke-5	47,54586	47,26312	47,61689	47,93578	49,73475	46,19007

LAJU DEGRABILITAS

	Kontrol	SGC-1	SGC-2	SGC-3	SGC-4	SGC-5
Minggu ke-1	8,97143	11,18571	9,40000	9,07143	10,11429	10,51429
Minggu ke-2	1,12857	2,08571	1,90000	1,84286	1,67143	0,60000
Minggu ke-3	1,41429	1,44286	1,28571	2,10000	1,22857	2,04286
Minggu ke-4	1,14286	1,58571	0,95714	0,84286	1,70000	0,92857
Minggu ke-5	1,04286	1,58571	1,44286	1,07143	1,35714	1,32857

Lampiran 04. Dokumentasi Penelitian

Pembuatan ekstrak



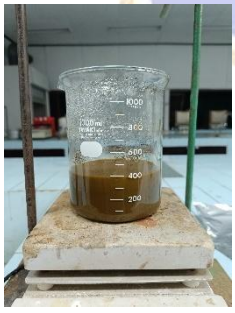
Ekstrak daun kelor

Menimbang prekursor

Larutan prekursor

Setelah penambahan ekstrak

Setelah penambahan NaOH sampai pH 11



Setelah reaksi selama 4 jam

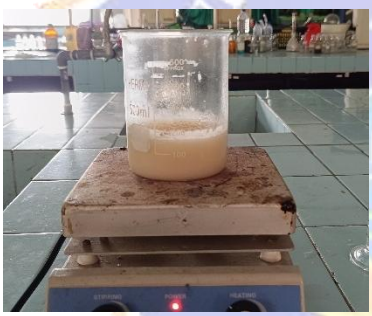
Hasil sentrifugasi

Oven padatan CuO-NPs

Kalsinasi CuO-NPs

Menimbang tepung *E. spinosum*

Menimbang CuO-NPs



Pembuatan bioplastik kontrol

10 mL larutan gliserol 5%

2 mL larutan asam asetat 10%

3 mL limbah cair penyulingan nilam

Pembuatan bioplastik SGC-5

Pengadukan air + CuO-NPs selama 2 jam

Sonikator air + CuO-NPs 30 menit

Pembuatan bioplastik SGC-3

Bioplastik kontrol basah

Bioplastik SGC-5 basah

Pengovenan bioplastik suhu 60℃

Bioplastik SGC-3 basah

Pengovenan suhu 40℃

Bioplastik SGC-3 kering

Bioplastik kontrol kering

Bioplastik SGC-5 kering

Lampiran 05. Karakterisasi Nanopartikel CuO-NPs

a) Kristalinitas

Crystallinity

General information

Analysis date	2025/03/14 18:36:28		
Sample name		Measurement date	2025/03/14 16:34:36
File name	CuO.ras	Operator	administrator
Comment			

Peak list

No.	2-theta(deg)	d(ang.)	Height(cps)	FWHM(deg)	Int. I(cps deg)	Int. W(deg)	Asym. factor
1	32.76(4)	2.731(3)	607(71)	0.37(3)	240(26)	0.40(9)	1.1(4)
2	35.794(6)	2.5066(4)	9093(275)	0.430(5)	4989(39)	0.55(2)	1.30(7)
3	38.979(7)	2.3088(4)	8545(267)	0.530(6)	5751(42)	0.67(3)	0.87(4)
4	46.57(2)	1.9486(8)	229(44)	0.20(7)	50(18)	0.22(12)	5(10)
5	49.036(18)	1.8562(6)	2174(135)	0.528(14)	1406(33)	0.65(6)	1.09(15)
6	53.67(5)	1.7063(16)	579(69)	0.64(5)	425(33)	0.74(15)	0.8(3)
7	58.55(4)	1.5753(11)	1047(93)	0.54(4)	795(32)	0.76(10)	1.6(6)
8	61.80(3)	1.4999(7)	1791(122)	0.45(3)	1171(32)	0.65(6)	1.2(4)
9	66.53(3)	1.4043(6)	1441(110)	0.95(3)	1769(36)	1.23(12)	2.8(6)
10	68.37(2)	1.3710(4)	1466(111)	0.61(3)	1154(33)	0.79(8)	2.8(6)
11	72.66(8)	1.3002(12)	549(68)	0.55(9)	441(32)	0.80(16)	2.1(17)
12	75.22(6)	1.2621(9)	773(80)	0.71(6)	677(39)	0.88(14)	0.5(2)
13	80.43(6)	1.1930(8)	167(37)	0.53(15)	95(17)	0.6(2)	1.1(3)
14	83.19(11)	1.1603(12)	371(56)	1.51(9)	594(50)	1.6(4)	1.1(3)

Crystallinity

Data set name	Crystallinity(%)
CuO	100.000000

b) Ukuran Kristalit dan Regangan Kisi

Crystallite Size and Lattice Strain

General information

Analysis date	2025/03/14 18:37:03		
Sample name		Measurement date	2025/03/14 16:34:36
File name	CuO.ras	Operator	administrator
Comment			

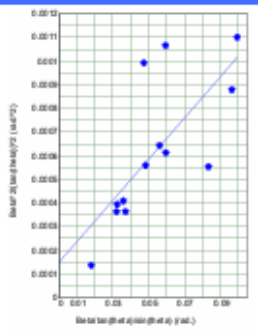
Qualitative analysis results

Phase name	Formula	Figure of merit	Phase reg. detail	DB card number
Copper Oxide	Cu O	0.308	ICDD (PDF2.DAT)	00-074-1021

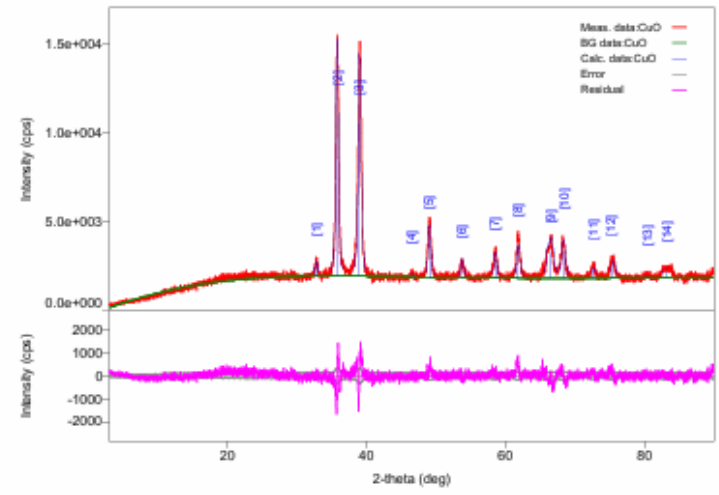
Crystallite size and lattice strain

Phase name	Crystallite size(A)	Strain(%)
Copper Oxide	186(53)	0.30(15)

Equation
Y=0.009X+0.00015



Measurement profile



c) Hasil Analisis Kualitatif

Qualitative Analysis Results

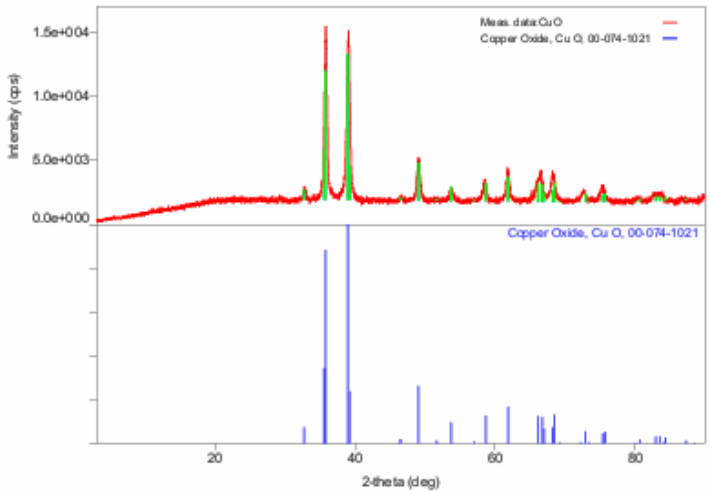
General information

Analysis date	2025/03/14 18:35:34		
Sample name		Measurement date	2025/03/14 16:34:36
File name	CuO.ras	Operator	administrator
Comment			

Qualitative analysis results

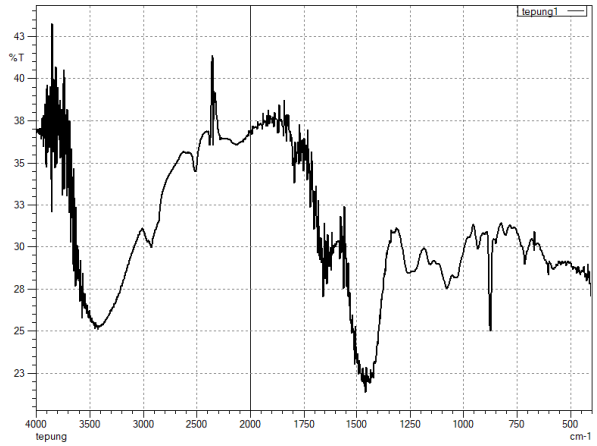
Phase name	Formula	Figure of merit	Phase reg. detail	DB card number
Copper Oxide	Cu O	0.308	ICDD (PDF2.DAT)	00-074-1021

Phase data pattern

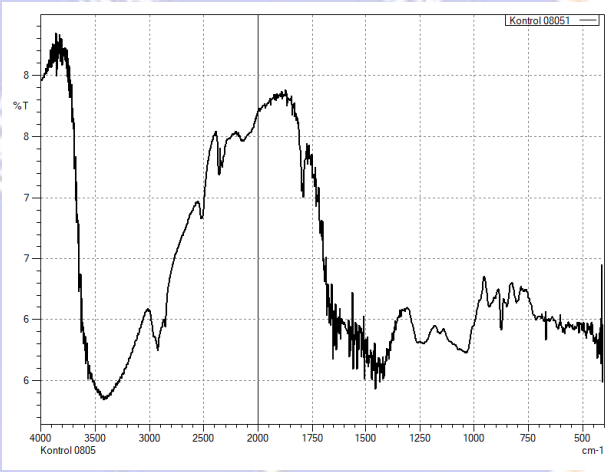


Lampiran 06. Karakterisasi Bioplastik

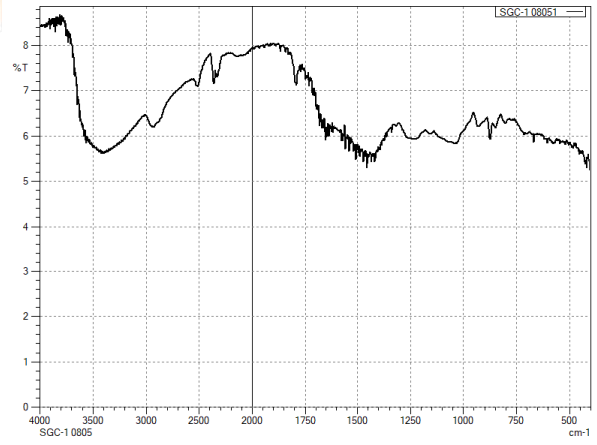
a) Karakterisasi FTIR



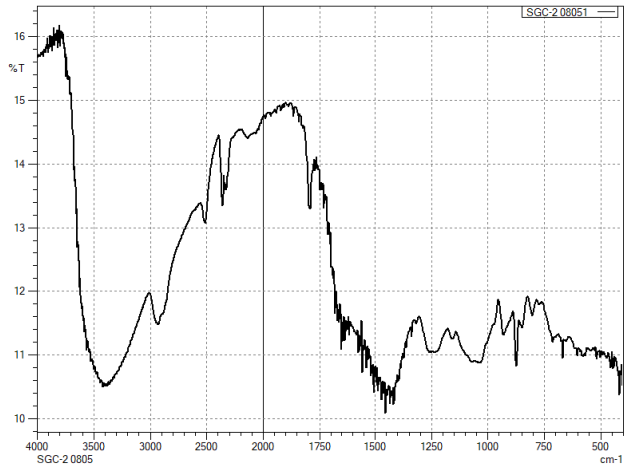
FTIR Tepung Rumput Laut *Eucheuma spinosum*



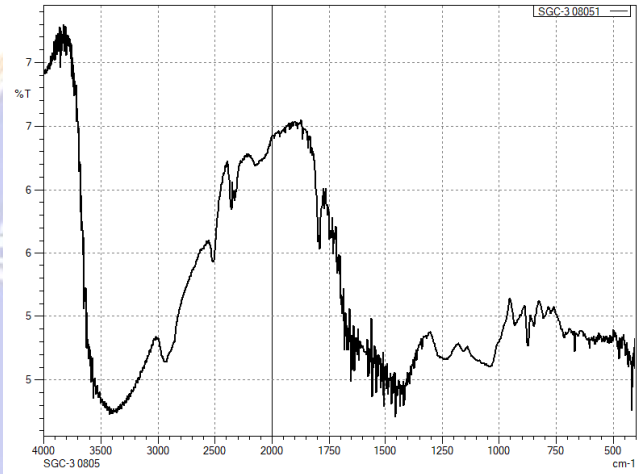
FTIR Bioplastik Kontrol



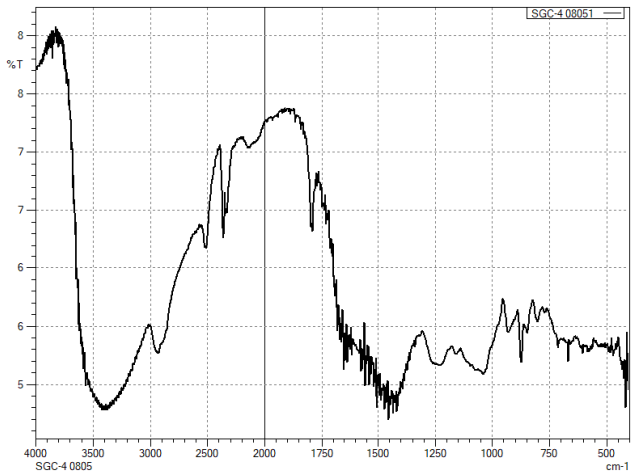
FTIR Bioplastik SGC-1



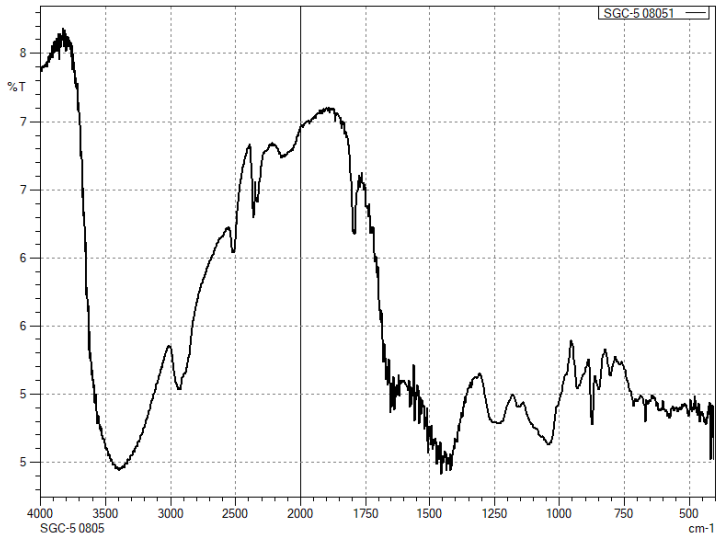
FTIR Bioplastik SGC-2



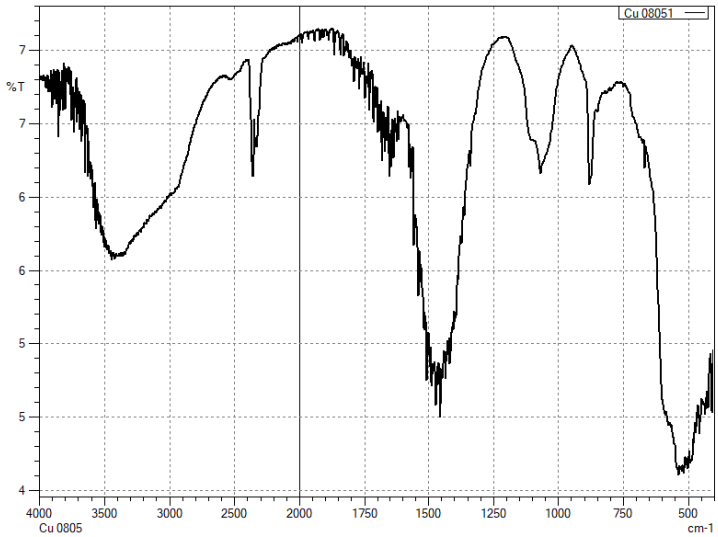
FTIR Bioplastik SGC-3



FTIR Bioplastik SGC-4



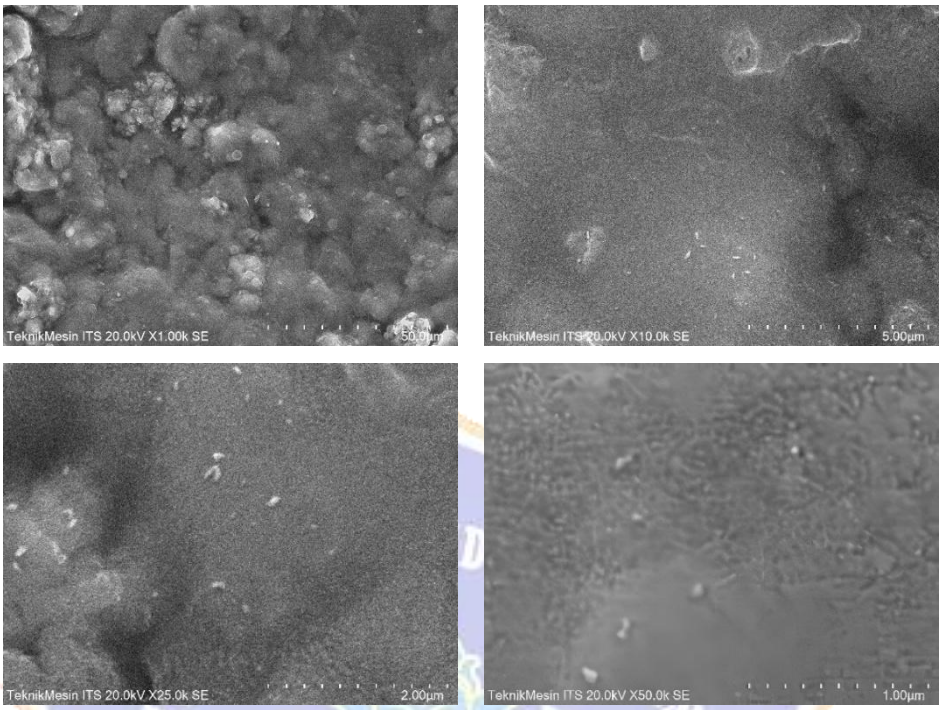
FTIR Bioplastik SGC-5



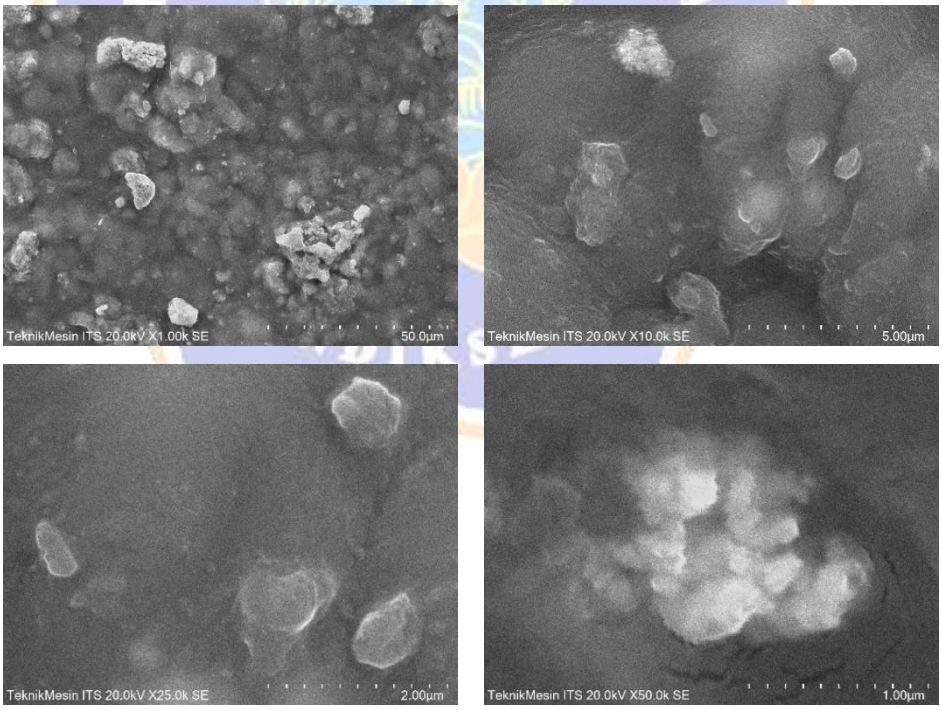
FTIR Nanopartikel CuO

b) Karakterisasi SEM-EDS

1. Karakterisasi SEM

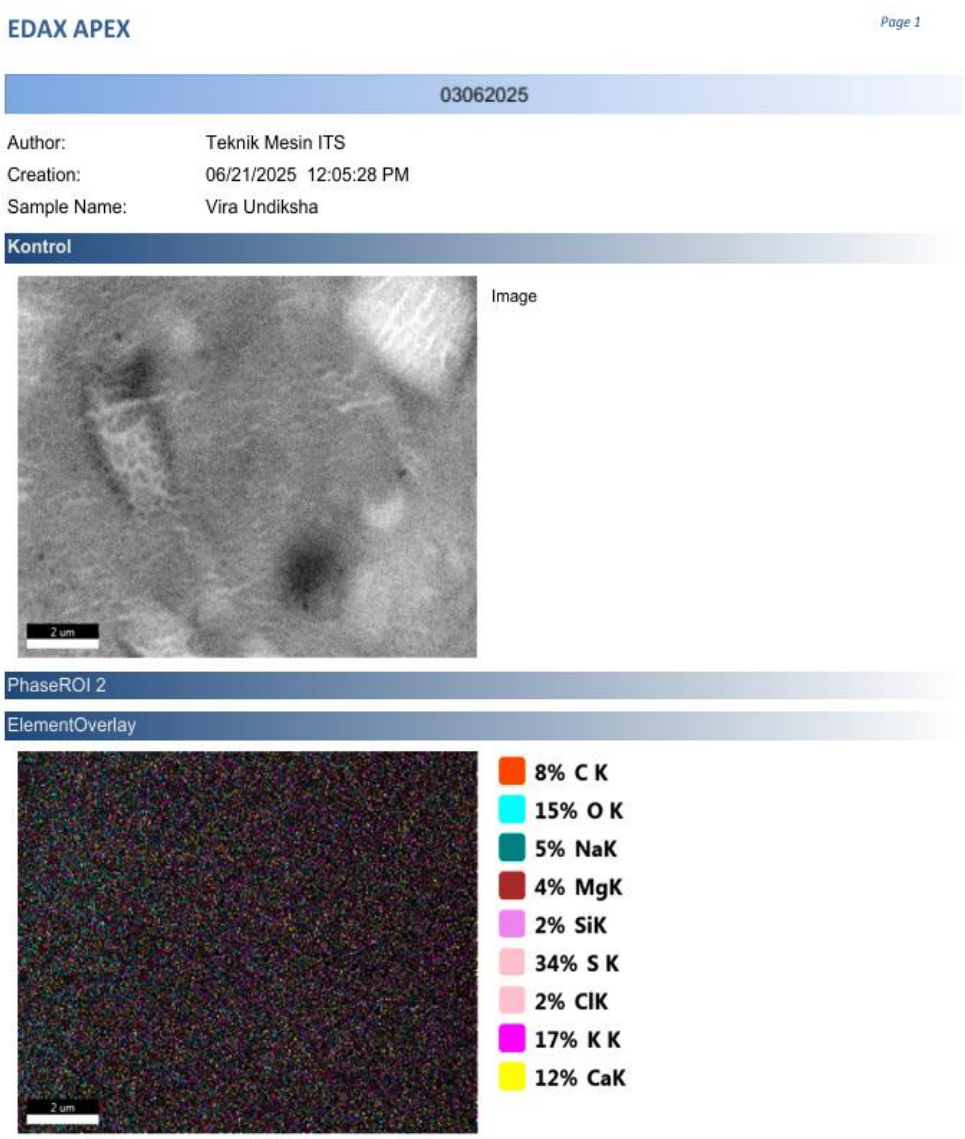


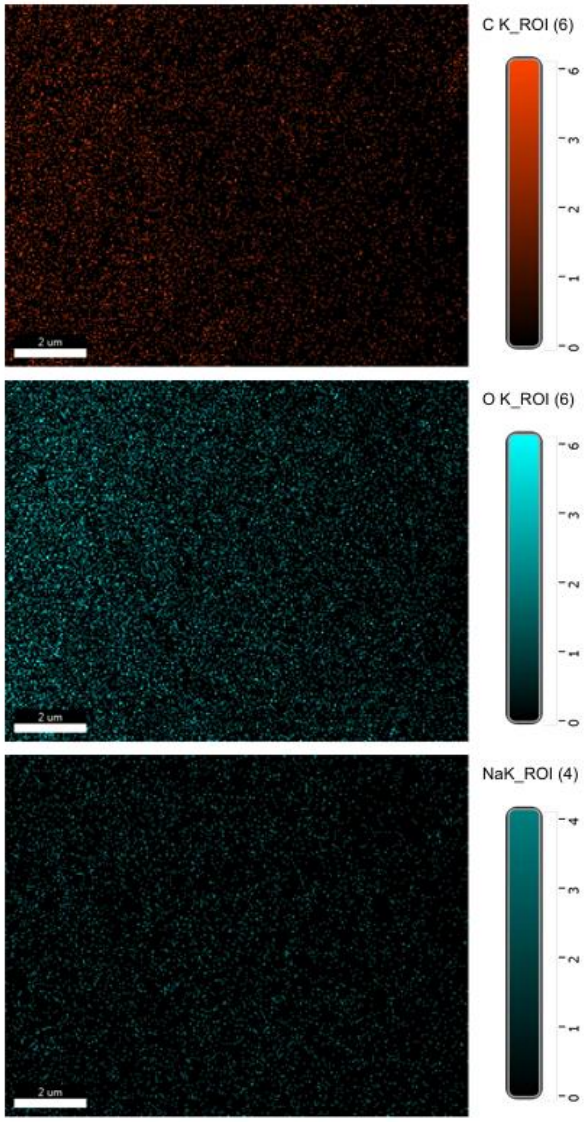
Morfologi Bioplastik Kontrol

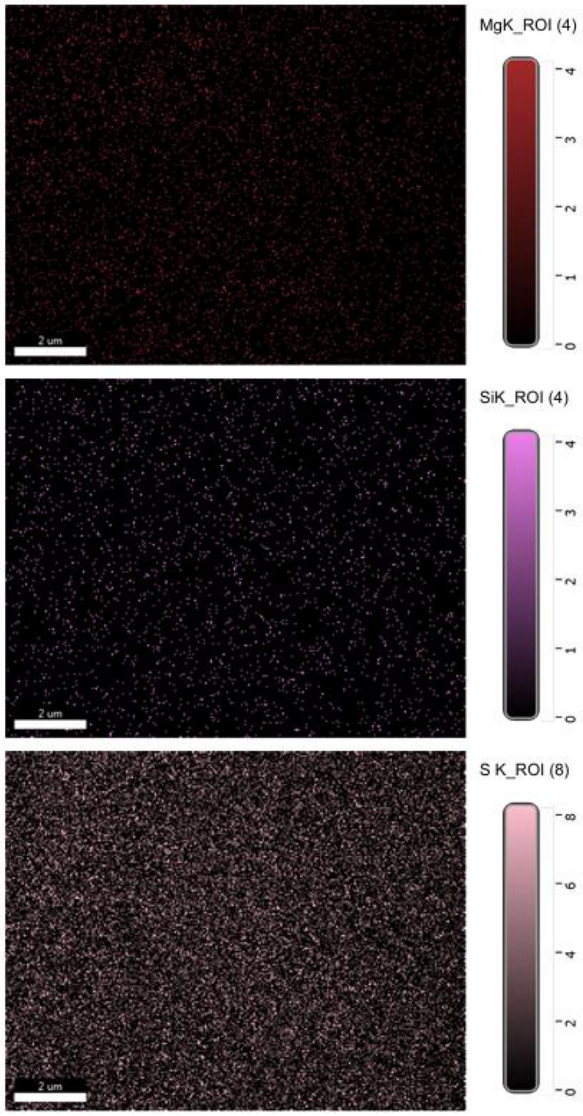


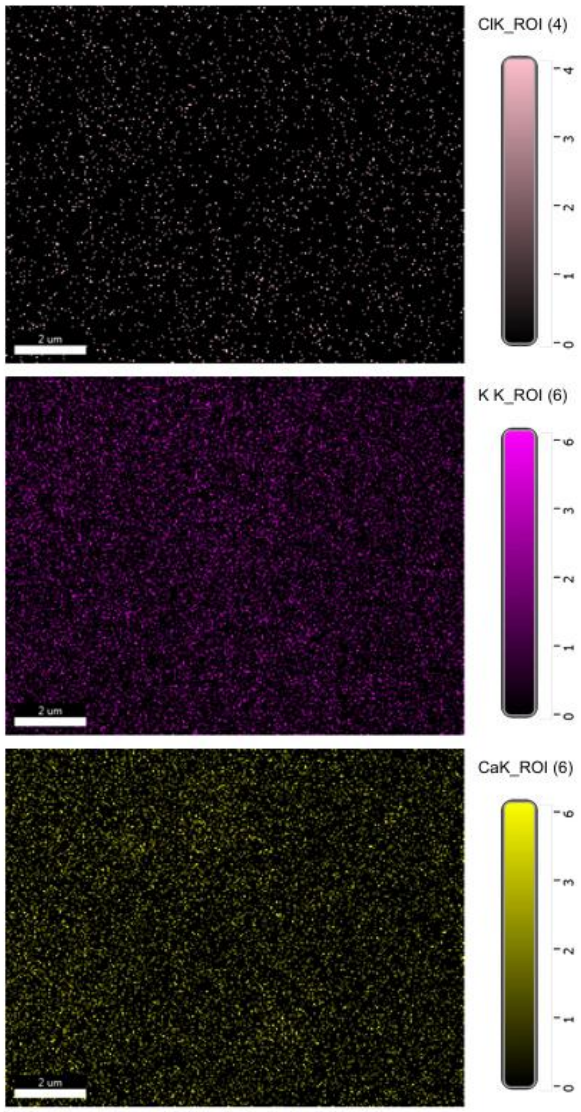
Morfologi Bioplastik SGC-3

2. Karakterisasi EDS *mapping*
   - Bioplastik Kontrol




C K_ROI (6)
6
3
2
1
0
2 um
O K_ROI (6)
6
3
2
1
0
2 um
NaK_ROI (4)
4
3
2
1
0
2 um

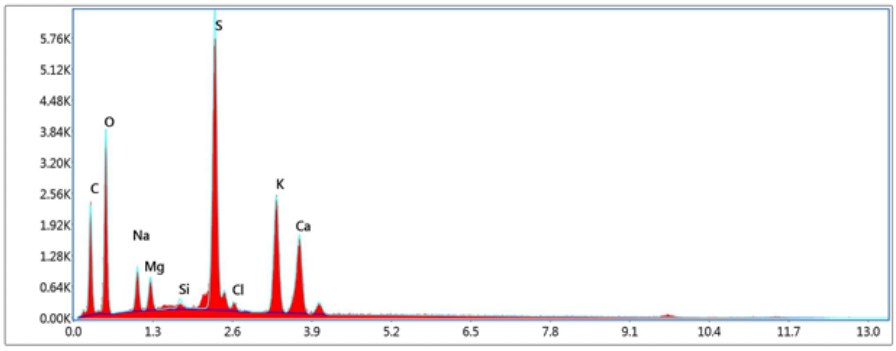

MgK_ROI (4)
0
1
2
3
4
2 um
SiK_ROI (4)
0
1
2
3
4
2 um
S K_ROI (8)
0
2
4
6
8
2 um


ClK_ROI (4)
0
1
2
3
4
2 um
K K_ROI (6)
0
1
2
3
6
2 um
CaK_ROI (6)
0
1
2
3
6
2 um

EDAX APEX

kV: 20 | Mag: 10000 | Takeoff: 30 | Live Time(s): 102.4 | Amp Time(µs): 3.84 | Resolution:(eV) 130

Sum Spectrum



Smart Quant Results

Element	Weight %	Atomic %	Net Int.	Error %	Kratio	Z	A	F
C K	21.47	33.17	84.05	10.82	0.0416	1.0830	0.1790	1.0000
O K	37.65	43.67	225.53	10.26	0.0570	1.0374	0.1459	1.0000
NaK	4.51	3.64	62.71	9.36	0.0142	0.9431	0.3342	1.0017
MgK	2.06	1.57	49.56	8.80	0.0091	0.9594	0.4602	1.0030
SiK	0.42	0.28	16.32	14.14	0.0029	0.9445	0.7296	1.0093
S K	15.80	9.15	578.57	2.46	0.1337	0.9252	0.9049	1.0105
ClK	0.59	0.31	17.28	14.75	0.0043	0.8802	0.8275	1.0164
K K	9.53	4.52	255.54	2.94	0.0785	0.8761	0.9230	1.0184
CaK	7.97	3.69	177.32	3.27	0.0650	0.8922	0.9065	1.0070

- Bioplastik SGC-3

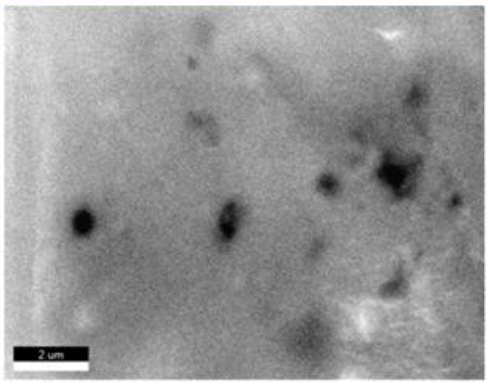
EDAX APEX

Page 1

03062025

Author: Teknik Mesin ITS
Creation: 06/21/2025 12:06:48 PM
Sample Name: Vira Undiksha

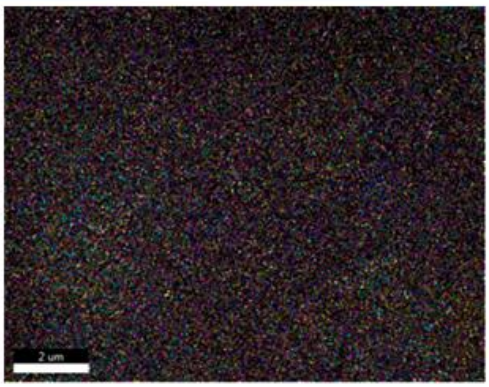
SGL-3



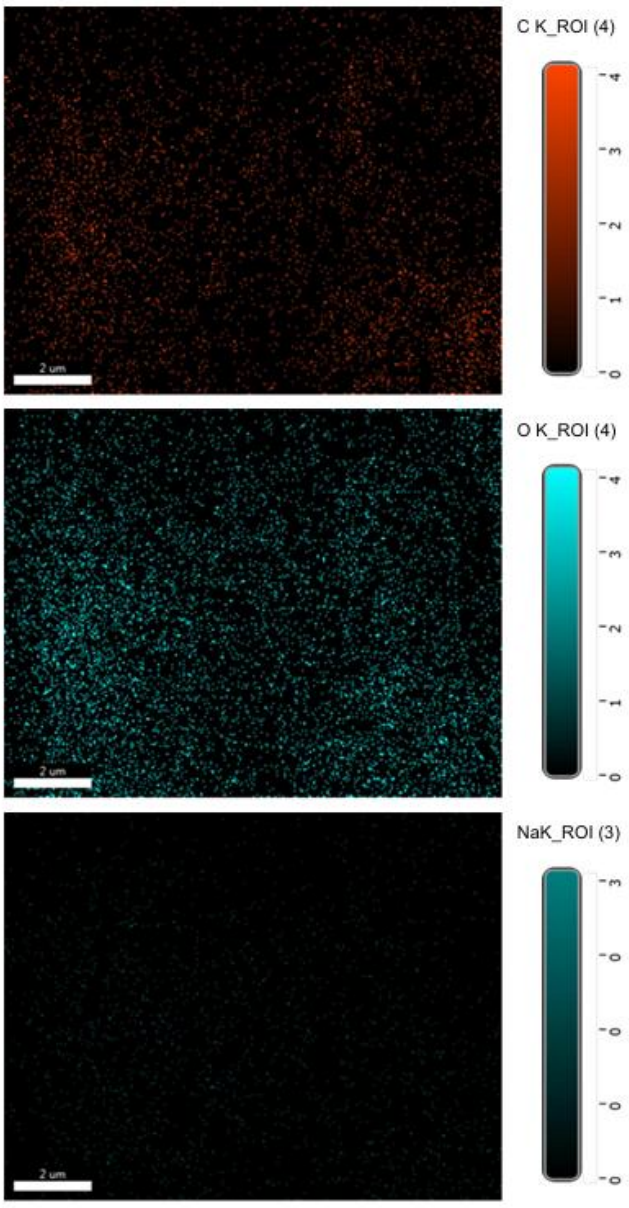
Image

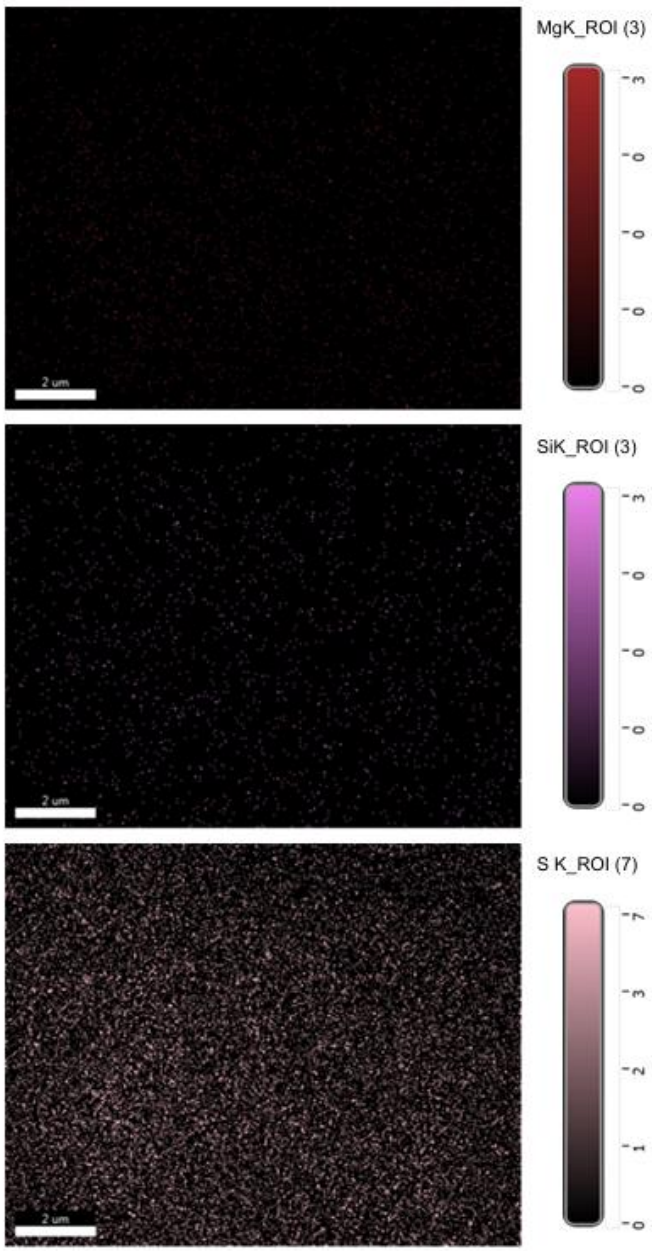
PhaseROI 2

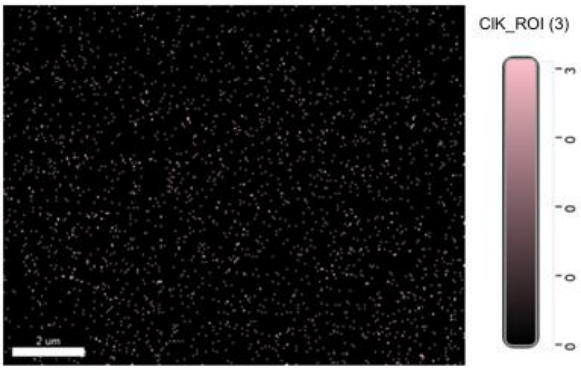
ElementOverlay

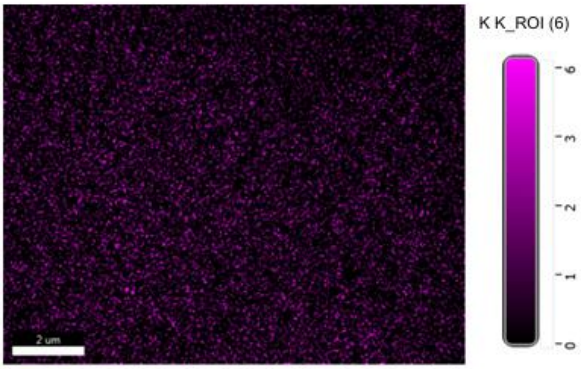


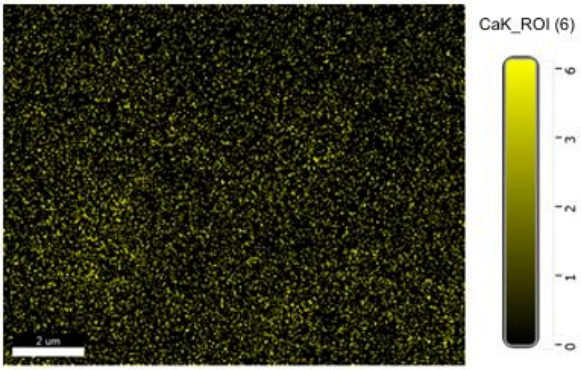
5% C K
9% O K
2% NaK
3% MgK
2% SiK
34% S K
3% ClK
19% K K
20% CaK
2% CuK

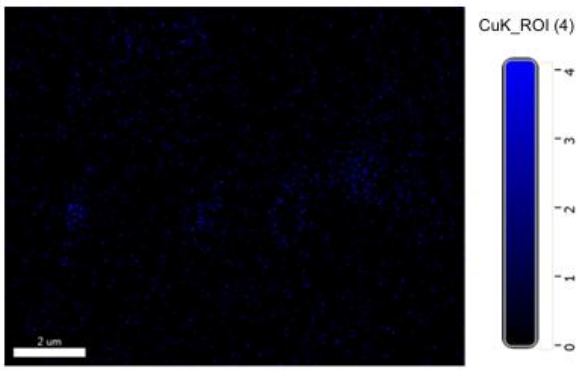

C K_ROI (4)
4
3
2
1
0
2 um
O K_ROI (4)
4
3
2
1
0
2 um
NaK_ROI (3)
3
0
0
0
0
2 um


MgK_ROI (3)
3
0
0
0
0
2 um
SiK_ROI (3)
3
0
0
0
0
2 um
S K_ROI (7)
7
3
2
1
0
2 um


ClK_ROI (3)
3
0
0
0
0
2 um


K K_ROI (6)
6
3
2
1
0
2 um

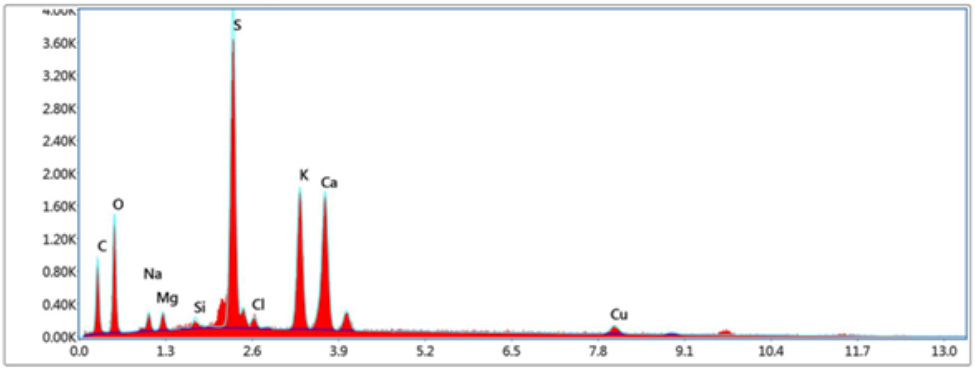

CaK_ROI (6)
6
3
2
1
0
2 um


CuK_ROI (4)
4
3
2
1
0
2 um

EDAX APEX

kV: 20 Mag: 10000 Takeoff: 30 Live Time(s): 122.9 Amp Time(µs): 3.84 Resolution:(eV) 130

Sum Spectrum



Smart Quant Results

Element	Weight %	Atomic %	Net Int.	Error %	Kratio	Z	A	F
C K	16.47	28.93	28.18	11.85	0.0302	1.1086	0.1653	1.0000
O K	29.96	39.50	70.68	11.22	0.0387	1.0631	0.1214	1.0000
NaK	2.12	1.95	12.81	13.60	0.0063	0.9675	0.3061	1.0015
MgK	1.22	1.06	13.29	12.08	0.0053	0.9845	0.4416	1.0027
SiK	0.47	0.35	8.49	16.34	0.0033	0.9697	0.7179	1.0084
S K	18.33	12.06	314.75	2.69	0.1574	0.9503	0.8944	1.0102
ClK	0.82	0.49	11.14	17.15	0.0061	0.9043	0.8035	1.0161
K K	12.30	6.64	153.77	3.31	0.1022	0.9003	0.9051	1.0200
CaK	15.15	7.98	155.22	3.50	0.1231	0.9170	0.8803	1.0059
CuK	3.16	1.05	12.93	11.99	0.0264	0.7843	0.9950	1.0692

Lampiran 07. Uji Statistik Anova One Way dan Uji Lanjut (LSD)

a) *Staphylococcus aureus*

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Bioplastik	Statistic	df	Sig.	Statistic	df	Sig.
Staphylococcus aureus	Kontrol	.	3	.	.	3	.
	SGC1	.339	3	.	.851	3	.242
	SGC2	.334	3	.	.860	3	.268
	SGC3	.202	3	.	.994	3	.855
	SGC4	.301	3	.	.911	3	.423
	SGC5	.	3	.	.	3	.

a. Lilliefors Significance Correction

Descriptives

Staphylococcus aureus

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Kontrol	3	.0000	.00000	.00000	.0000	.0000	.00	.00
SGC1	3	11.9467	.39577	.22850	10.9635	12.9298	11.67	12.40
SGC2	3	12.4767	.67929	.39219	10.7892	14.1641	11.70	12.96
SGC3	3	10.9233	.26577	.15344	10.2631	11.5835	10.67	11.20
SGC4	3	7.3800	.52374	.30238	6.0790	8.6810	6.97	7.97
SGC5	3	.0000	.00000	.00000	.0000	.0000	.00	.00
Total	18	7.1211	5.45389	1.28549	4.4090	9.8333	.00	12.96

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Staphylococcus aureus	Based on Mean	5.692	5	12	.006
	Based on Median	.860	5	12	.535
	Based on Median and with adjusted df	.860	5	5.349	.561

	Based on trimmed mean	5.000	5	12	.010

ANOVA

Staphylococcus aureus

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	503.737	5	100.747	627.710	.000
Within Groups	1.926	12	.161		
Total	505.663	17			

Multiple Comparisons

Dependent Variable: Staphylococcus aureus

LSD

(I) Bioplastik	(J) Bioplastik	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Kontrol	SGC1	-11.94667*	.32711	.000	-12.6594	-11.2340
	SGC2	-12.47667*	.32711	.000	-13.1894	-11.7640
	SGC3	-10.92333*	.32711	.000	-11.6360	-10.2106
	SGC4	-7.38000*	.32711	.000	-8.0927	-6.6673
	SGC5	.00000	.32711	1.000	-.7127	.7127
SGC1	Kontrol	11.94667*	.32711	.000	11.2340	12.6594
	SGC2	-.53000	.32711	.131	-1.2427	.1827
	SGC3	1.02333*	.32711	.009	.3106	1.7360
	SGC4	4.56667*	.32711	.000	3.8540	5.2794
	SGC5	11.94667*	.32711	.000	11.2340	12.6594
SGC2	Kontrol	12.47667*	.32711	.000	11.7640	13.1894
	SGC1	.53000	.32711	.131	-.1827	1.2427
	SGC3	1.55333*	.32711	.000	.8406	2.2660
	SGC4	5.09667*	.32711	.000	4.3840	5.8094
	SGC5	12.47667*	.32711	.000	11.7640	13.1894
SGC3	Kontrol	10.92333*	.32711	.000	10.2106	11.6360
	SGC1	-1.02333*	.32711	.009	-1.7360	-.3106
	SGC2	-1.55333*	.32711	.000	-2.2660	-.8406
	SGC4	3.54333*	.32711	.000	2.8306	4.2560
	SGC5	10.92333*	.32711	.000	10.2106	11.6360
SGC4	Kontrol	7.38000*	.32711	.000	6.6673	8.0927

	SGC1	-4.56667*	.32711	.000	-5.2794	-3.8540
	SGC2	-5.09667*	.32711	.000	-5.8094	-4.3840
	SGC3	-3.54333*	.32711	.000	-4.2560	-2.8306
	SGC5	7.38000*	.32711	.000	6.6673	8.0927
SGC5	Kontrol	.00000	.32711	1.000	-.7127	.7127
	SGC1	-11.94667*	.32711	.000	-12.6594	-11.2340
	SGC2	-12.47667*	.32711	.000	-13.1894	-11.7640
	SGC3	-10.92333*	.32711	.000	-11.6360	-10.2106
	SGC4	-7.38000*	.32711	.000	-8.0927	-6.6673

*. The mean difference is significant at the 0.05 level.

b) *Escherichia coli*

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Bioplastik	Statistic	df	Sig.	Statistic	df	Sig.
Escherichia coli	Kontrol	.	3	.	.	3	.
	SGC1	.321	3	.	.881	3	.328
	SGC2	.356	3	.	.818	3	.157
	SGC3	.196	3	.	.996	3	.878
	SGC4	.338	3	.	.852	3	.247
	SGC5	.	3	.	.	3	.

a. Lilliefors Significance Correction

Test of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Escherichia coli	Based on Mean	4.591	5	12	.014
	Based on Median	1.076	5	12	.421
	Based on Median and with adjusted df	1.076	5	4.955	.470
	Based on trimmed mean	4.205	5	12	.019

Descriptives

Escherichia coli

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum

					Lower Bound	Upper Bound		
Kontrol	3	.0000	.00000	.00000	.0000	.0000	.00	.00
SGC1	3	20.4633	.58595	.33830	19.0078	21.9189	20.03	21.13
SGC2	3	20.6900	.24331	.14048	20.0856	21.2944	20.53	20.97
SGC3	3	20.8967	.45092	.26034	19.7765	22.0168	20.43	21.33
SGC4	3	15.7667	.23288	.13445	15.1882	16.3452	15.50	15.93
SGC5	3	.0000	.00000	.00000	.0000	.0000	.00	.00
Total	18	12.9694	9.60959	2.26500	8.1907	17.7482	.00	21.33

ANOVA

Escherichia coli

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1568.531	5	313.706	2851.442	.000
Within Groups	1.320	12	.110		
Total	1569.851	17			

Multiple Comparisons

Dependent Variable: Escherichia coli

LSD

(I) Bioplastik	(J) Bioplastik	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Kontrol	SGC1	-20.46333*	.27082	.000	-21.0534	-19.8733
	SGC2	-20.69000*	.27082	.000	-21.2801	-20.0999
	SGC3	-20.89667*	.27082	.000	-21.4867	-20.3066
	SGC4	-15.76667*	.27082	.000	-16.3567	-15.1766
	SGC5	.00000	.27082	1.000	-.5901	.5901
SGC1	Kontrol	20.46333*	.27082	.000	19.8733	21.0534
	SGC2	-.22667	.27082	.419	-.8167	.3634
	SGC3	-.43333	.27082	.136	-1.0234	.1567
	SGC4	4.69667*	.27082	.000	4.1066	5.2867
	SGC5	20.46333*	.27082	.000	19.8733	21.0534
SGC2	Kontrol	20.69000*	.27082	.000	20.0999	21.2801
	SGC1	.22667	.27082	.419	-.3634	.8167
	SGC3	-.20667	.27082	.460	-.7967	.3834

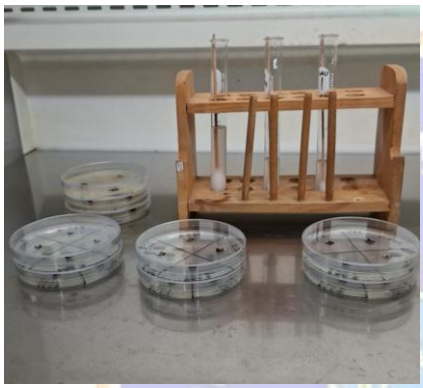
	SGC4	4.92333*	.27082	.000	4.3333	5.5134
	SGC5	20.69000*	.27082	.000	20.0999	21.2801
SGC3	Kontrol	20.89667*	.27082	.000	20.3066	21.4867
	SGC1	.43333	.27082	.136	-.1567	1.0234
	SGC2	.20667	.27082	.460	-.3834	.7967
	SGC4	5.13000*	.27082	.000	4.5399	5.7201
	SGC5	20.89667*	.27082	.000	20.3066	21.4867
SGC4	Kontrol	15.76667*	.27082	.000	15.1766	16.3567
	SGC1	-4.69667*	.27082	.000	-5.2867	-4.1066
	SGC2	-4.92333*	.27082	.000	-5.5134	-4.3333
	SGC3	-5.13000*	.27082	.000	-5.7201	-4.5399
	SGC5	15.76667*	.27082	.000	15.1766	16.3567
SGC5	Kontrol	.00000	.27082	1.000	-.5901	.5901
	SGC1	-20.46333*	.27082	.000	-21.0534	-19.8733
	SGC2	-20.69000*	.27082	.000	-21.2801	-20.0999
	SGC3	-20.89667*	.27082	.000	-21.4867	-20.3066
	SGC4	-15.76667*	.27082	.000	-16.3567	-15.1766

*. The mean difference is significant at the 0.05 level.

Lampiran 08. Dokumentasi Pengujian Antibakteri dan Antijamur

Persiapan Media

Media PDA dan MHA



Pengujian Aktivitas Antimikroba

Kontrol Positif dan Kontrol Negatif terhadap bakteri *S. aureus*

Kontrol Positif dan Kontrol Negatif terhadap bakteri *E. coli*

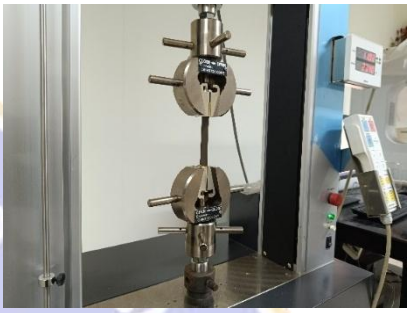
Kontrol Positif dan Kontrol Negatif terhadap jamur *C. albicans*

Lampiran 09. Dokumentasi Uji Kuat Tarik

Penggunaan Alat Kuat Tarik

Alat Kuat Tarik

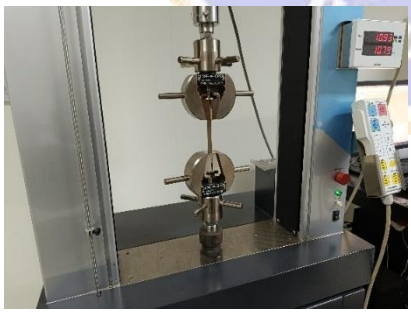
Uji Kuat Tarik Bioplastik Kontrol



Uji Kuat Tarik Bioplastik SGC-1

Uji Kuat Tarik Bioplastik SGC-2

Uji Kuat Tarik Bioplastik SGC-3



Uji Kuat Tarik Bioplastik SGC-4

Uji Kuat Tarik Bioplastik SGC-5

Lampiran 10. Dokumentasi Uji Ketahanan Air

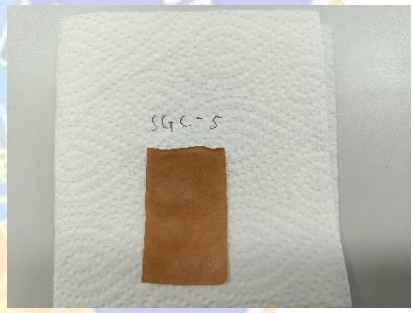
Perendaman selama 1 menit

Pengeringan bioplastik SGC-1

Pengeringan bioplastik SGC-2

Pengeringan bioplastik SGC-3

Pengeringan bioplastik SGC-4



Pengeringan bioplastik SGC-5

Menimbang Kontrol

Menimbang K setelah perendaman

Menimbang SGC-1

Menimbang SGC-1 setelah perendaman

Menimbang SGC-2

Menimbang SGC-2 setelah perendaman

Menimbang SGC-3

Menimbang SGC-3 setelah perendaman

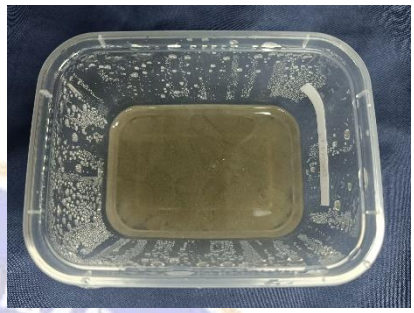
Menimbang SGC-4

Menimbang SGC-4 setelah perendaman

Menimbang SGC-5

Menimbang SGC-5 setelah perendaman

Bioplastik Kontrol setelah 30 hari



Bioplastik SGC-1 setelah 30 hari

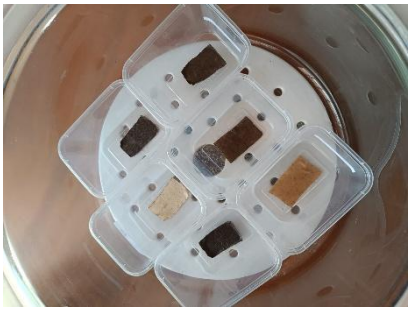
Bioplastik SGC-2 setelah 30 hari

Bioplastik SGC-3 setelah 30 hari

Bioplastik SGC-4 setelah 30 hari

Bioplastik SGC-5 setelah 30 hari

Lampiran 11. Dokumentasi Uji Biodegradasi



Sampel Diletakan Pada Desikator selama 24 jam

Menimbang Tanah

Kontrol Minggu ke-0

SGC-1 Minggu ke-0

SGC-2 Minggu ke-0

SGC-3 Minggu ke-0

SGC-4 Minggu ke-0

SGC-5 Minggu ke-0

Kontrol Minggu ke-1

SGC-1 Minggu ke-1

SGC-2 Minggu ke-1

SGC-3 Minggu ke-1

SGC-4 Minggu ke-1

SGC-5 Minggu ke-1

Kontrol Minggu ke-5

SGC-1 Minggu ke-5

SGC-2 Minggu ke-5

SGC-3 Minggu ke-5

SGC-4 Minggu ke-5

SGC-5 Minggu ke-5

Bioplastik Kontrol Setelah 5 Minggu

Bioplastik SGC-1 Setelah 5 Minggu

Bioplastik SGC-2 Setelah 5 Minggu

Bioplastik SGC-3 Setelah 5 Minggu

Bioplastik SGC-4 Setelah 5 Minggu

Bioplastik SGC-5 Setelah 5 Minggu

RIWAYAT HIDUP

Putu Vira Agustini lahir di Singaraja pada tanggal 30 Agustus 2002. Penulis merupakan anak dari pasangan suami istri Bapak Made Lestariana dan Ibu Made Sri Rahyati. Penulis berkebangsaan Indonesia dan beralamat di Lingkungan Bakung, Kecamatan Sukasada, Kabupaten Buleleng, Bali.

Penulis menyelesaikan pendidikan dasar di SD Negeri 1 Banjar Jawa dan lulus pada tahun 2015. Kemudian penulis melanjutkan pendidikan jenjang SMP/MTs di SMP Negeri 1 Singaraja dan lulus pada tahun 2018. Kemudian pada tahun 2021, penulis lulus dari SMA Negeri 1 Singaraja jurusan MIPA dan melanjutkan ke jenjang Sarjana Jurusan Kimia di Universitas Pendidikan Ganesha. Pada semester akhri tahun 2025 penulis telah menyelesaikan studi S1 Kimia dengan Skripsi yang berjudul "Pengaruh Limbah Cair Penyulingan Nilam dan CuO-NPs Terhadap Sifat Antibakteri dan Antijamur Bioplastik Rumput Laut *Eucheuma spinosum* dan Gliserol"