# LAMPIRAN

**Lampiran 1** Perhitungan Ukuran Nanopartikel

Ukuran kristal $Ca_3(PO_4)_2$-NPs dan MgO-NPs dihitung dengan persamaan *Scherrer* sebagai berikut:

$$D = \frac{K\,\lambda}{\beta \cos\theta}$$

Dimana:

D = ukuran partikel (nm) λ = Panjang gelombang (1,54056Å)

K = shape factor (0,9) β = FWHM (rad) $\theta$ = sudut bragg (°)

1. Ukuran kristal $Ca_3(PO_4)_2$-NPs

$D1 = \frac{0,9x\ 1,54056}{0,26 \text{ x } 26,02}$ $D26 = \frac{0,9x\ 1,54056}{0,42 \text{ x } 54,67}$

D1= 31,3599 D26= 21,2926

$D2 = \frac{0,9x\ 1,54056}{0,403 \text{ x } 26,62}$ $D27 = \frac{0,9x\ 1,54056}{0,28 \text{ x } 56,04}$

D2= 20,2572 D27= 32,13

$D3 = \frac{0,9x\ 1,54056}{0,24 \text{ x } 28,24}$ $D28 = \frac{0,9x\ 1,54056}{0,22 \text{ x } 57,3}$

D3= 34,1325 D28= 41,14

$D4 = \frac{0,9x\ 1,54056}{0,22 \text{ x } 28,66}$ $D29 = \frac{0,9x\ 1,54056}{0,29 \text{ x } 60,05}$

D4= 37,2701 D29= 31,64

$D5 = \frac{0,9x\ 1,54056}{0,26 \text{ x } 29,056}$ $D30 = \frac{0,9x\ 1,54056}{0,15 \text{ x } 60,52}$

D5= 31,5642 D30= 61,31

$D6 = \frac{0,9x\ 1,54056}{0,319 \text{ x } 30,33}$ $D31 = \frac{0,9x\ 1,54056}{0,32 \text{ x } 61,83}$

D6= 25,8024 D31= 28,93

$D7 = \frac{0,9x\ 1,54056}{0,227 \text{ x } 31,895}$

D7= 36,3977

$D8 = \frac{0,9x\ 1,54056}{0,373 \text{ x } 33,024}$

D8= 29,698

$D9 = \frac{0,9x\ 1,54056}{0,271 \text{ x } 34,21}$

D9= 30,6714

$D10 = \frac{0,9x\ 1,54056}{0,28 \text{ x } 35,62}$

D10= 29,800

$D11 = \frac{0,9x\ 1,54056}{0,17 \text{ x } 36,1}$

D11= 49,15

$D12 = \frac{0,9x\ 1,54056}{0,36 \text{ x } 39,288}$

D12= 23,4312

$D13 = \frac{0,9x\ 1,54056}{0,33 \text{ x } 39,951}$

D13= 25,6146

$D14 = \frac{0,9x\ 1,54056}{0,39 \text{ x } 42,2}$

D14= 21,83

$D15 = \frac{0,9x\ 1,54056}{0,2 \text{ x } 43,97}$

D15= 42,8364

$D32 = \frac{0,9x\ 1,54056}{0,26 \text{ x } 63,15}$

D32= 35,86

$D33 = \frac{0,9x\ 1,54056}{0,35 \text{ x } 64,18}$

D33= 26,7913

$D34 = \frac{0,9x\ 1,54056}{0,09 \text{ x } 64,7}$

D34= 104,48

$D35 = \frac{0,9x\ 1,54056}{0,32 \text{ x } 65,16}$

D35= 29,46

$D36 = \frac{0,9x\ 1,54056}{0,35\text{x } 66,51}$

D36= 27,14

$D37 = \frac{0,9x\ 1,54056}{0,36 \text{ x } 71,78}$

D37= 27,23

$D38 = \frac{0,9x\ 1,54056}{0,18 \text{ x } 72,4}$

D38= 54,69

$D39 = \frac{0,9x\ 1,54056}{0,36 \text{ x } 74,08}$

D39= 27,64

$D40 = \frac{0,9x\ 1,54056}{0,23 \text{ x } 75,11}$

D40= 43,56

$D16 = \frac{0,9x\ 1,54056}{0,31 \text{ x } 45,57}$

D16= 27,7958

$D17 = \frac{0,9x\ 1,54056}{0,26 \text{ x } 26,02}$

D17= 31,3599

$D18 = \frac{0,9x\ 1,54056}{0,22 \text{ x } 47,53}$

D18= 39,456

$D19 = \frac{0,9x\ 1,54056}{0,23 \text{ x } 48,20}$

D19= 37,8388

$D20 = \frac{0,9x\ 1,54056}{0,18 \text{ x } 48,736}$

D20= 48,45813

$D21 = \frac{0,9x\ 1,54056}{0,273 \text{ x } 49,616}$

D21= 32,05

$D22 = \frac{0,9x\ 1,54056}{0,307\text{x } 50,64}$

D22= 28,6276

$D23 = \frac{0,9x\ 1,54056}{0,28 \text{ x } 51,413}$

D23= 31,489

$D24 = \frac{0,9x\ 1,54056}{0,24 \text{ x } 52,21}$

$D41 = \frac{0,9x\ 1,54056}{0,21 \text{ x } 75,72}$

D41= 47,915

$D42 = \frac{0,9x\ 1,54056}{0,37 \text{ x } 74,08}$

D42= 27,472

$D43 = \frac{0,9x\ 1,54056}{0,22 \text{ x } 78,35}$

D43= 46,58

$D44 = \frac{0,9x\ 1,54056}{0,41 \text{ x } 83,4}$

D44= 25,95

$D45 = \frac{0,9x\ 1,54056}{0,28 \text{ x } 84,39}$

D45= 38,29

$D46 = \frac{0,9x\ 1,54056}{0,25 \text{ x } 85,52}$

D46= 43,281

$D47 = \frac{0,9x\ 1,54056}{0,29 \text{ x } 87,53}$

D47= 37,932

$D48 = \frac{0,9x\ 1,54056}{0,37 \text{ x } 77,193}$

D48= 27,47

$D49 = \frac{0,9x\ 1,54056}{0,17 \text{ x } 88,1}$

D24= 31,96

D49= 65,01

$$D25 = \frac{0{,}9x\ 1{,}54056}{0{,}30 \text{ x } 53{,}33}$$

D25= 29,53

$$D50 = \frac{0{,}9x\ 1{,}54056}{0{,}26 \text{ x } 88{,}58}$$

D50= 42,68

Ukuran rata-rata partikel $Ca_3(PO_4)_2$-NPs sebesar 36.11 nm

2. Ukuran kristal MgO-NPs

$$D1 = \frac{0{,}9x\ 1{,}54056}{0.353 \text{ x } 10{,}685}$$

D1= 22,6033

$$D10 = \frac{0{,}9x\ 1{,}54056}{0.21 \text{ x } 56{,}47}$$

D10= 42,9391

$$D2 = \frac{0{,}9x\ 1{,}54056}{0.43 \text{ x } 21.43}$$

D2= 18,8001

$$D11 = \frac{0{,}9x\ 1{,}54056}{0.83 \text{ x } 59{,}06}$$

D11= 11,0004

$$D3 = \frac{0{,}9x\ 1{,}54056}{0{,}235 \text{ x } 28.464}$$

D3= 34,8759

$$D12 = \frac{0{,}9x\ 1{,}54056}{0.539 \text{ x } 62{,}224}$$

D12= 17,2152

$$D4 = \frac{0{,}9x\ 1{,}54056}{0.239 \text{ x } 31{,}762}$$

D4= 34,5587

$$D13 = \frac{0{,}9x\ 1{,}54056}{0.14 \text{ x } 66{,}432}$$

D13= 67,8271

$$D5 = \frac{0{,}9x\ 1{,}54056}{0.34 \text{ x } 36{,}91}$$

D5= 24,6323

$$D14 = \frac{0{,}9x\ 1{,}54056}{0.2 \text{ x } 73{,}78}$$

D14= 49,6649

$$D6 = \frac{0{,}9x\ 1{,}54056}{0.178 \text{ x } 40{,}613}$$

D6= 47,5885

$$D15 = \frac{0{,}9x\ 1{,}54056}{0.24 \text{ x } 74{,}47}$$

D15= 41,576

$$D7 = \frac{0{,}9x\ 1{,}54056}{0.45 \text{ x } 42{,}896}$$

$$D16 = \frac{0{,}9x\ 1{,}54056}{0{,}39 \text{ x } 75{,}32}$$

D7= 18,96

D8 = $\frac{0,9x\ 1,54056}{0.22 \text{ x } 45,406}$

D8= 38,7907

D9 = $\frac{0,9x\ 1,54056}{0.22 \text{ x } 50,28}$

D9= 39,889

D16= 25,731

D17= $\frac{0,9x\ 1,54056}{0.69 \text{ x } 78,47}$

D17= 14,8646

D18 = $\frac{0,9x\ 1,54056}{0.57 \text{ x } 83,9}$

D18= 18,7398

Ukuran rata-rata partikel MgO-NPs = 31.68 nm.

**Lampiran 2** Hasil Kuat Tarik

| Variasi Sampel | | Gaya (N) | Kuat Tarik (MPa) |
|---|---|---|---|
| K | 1 | 36,22 | 14,49 |
| | 2 | 40,02 | 16,01 |
| | 3 | 38,12 | 15,25 |
| | | Rata-rata | 15,25 |
| A1 | 1 | 42,05 | 16,82 |
| | 2 | 46,47 | 18,59 |
| | 3 | 44,25 | 17,70 |
| | | Rata-rata | 17,70 |
| A2 | 1 | 39,90 | 15,96 |
| | 2 | 42,00 | 16,80 |
| | 3 | 44,10 | 17,64 |
| | | Rata-rata | 16,80 |
| A3 | 1 | 44,28 | 17,31 |
| | 2 | 45,55 | 18,22 |
| | 3 | 47,82 | 19,13 |
| | | Rata-rata | 18,22 |
| A4 | 1 | 42,95 | 17,18 |
| | 2 | 40,90 | 16,36 |
| | 3 | 38,85 | 15,54 |
| | | Rata-rata | 16,36 |
| A5 | 1 | 34,22 | 15,02 |
| | 2 | 36,02 | 17,54 |
| | 3 | 37,82 | 12,5 |
| | | Rata-rata | 15,02 |

**Perhitungan :**

TS(MPa) = $\frac{F}{A}$

$$TS(MPa) = \frac{36,22}{2,5} = 14,49 \text{ MPa}$$

Uji Normalitas Kuat Tarik

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Standardized Residual for KT | .181 | 12 | .200* | .870 | 12 | .066 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Diperoleh nilai signifikansi 0.065 > 0.05, maka nilai residual standar terdistribusi normal, sehingga memenuhi syarat pertama untuk uji ANOVA *Two-Way*.

Uji Homogenitas Kuat Tarik

**Levene's Test of Equality of Error Variances[a,b]**

| | | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| KT | Based on Mean | .052 | 3 | 8 | .983 |
| | Based on Median | .051 | 3 | 8 | .984 |
| | Based on Median and with adjusted df | .051 | 3 | 7.709 | .984 |
| | Based on trimmed mean | .052 | 3 | 8 | .983 |

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Dependent variable: KT

b. Design: Intercept + $Ca_3(PO_4)_2$ + MgO + $Ca_3(PO_4)_2$ * MgO

Nilai Sig 0,983 > 0.05, Maka dapat disimpulkan bahwa varian variabel hasil uji kuat tarik adalah homogen. Sehingga asumsi homogenitas dalam uji *two-way* terpenuhi.

Uji *Two-way* ANOVA Kuat Tarik

**Tests of Between-Subjects Effects**

Dependent Variable: KT

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 30.881[a] | 3 | 10.294 | 15.208 | .001 |
| Intercept | 3225.880 | 1 | 3225.880 | 4766.137 | <.001 |
| $Ca_3(PO_4)_2$ | 29.422 | 1 | 29.422 | 43.470 | <.001 |
| MgO | .078 | 1 | .078 | .116 | .742 |
| $Ca_3(PO_4)_2$ * MgO | 1.380 | 1 | 1.380 | 2.040 | .191 |
| Error | 5.415 | 8 | .677 | | |
| Total | 3262.176 | 12 | | | |
| Corrected Total | 36.295 | 11 | | | |

a. R Squared = .851 (Adjusted R Squared = .795)

1. Jika nilai Sig < 0.05, maka ada perbedaan/pengaruh hasil uji kuat tarik berdasarkan variabel faktor.
2. Jika nilai Sig > 0.05, maka tidak ada perbedaan/pengaruh hasil uji kuat tarik berdasarkan variabel faktor.

Kesimpulan menjawab rumusan masalah:

1. Diperoleh nilai Sig. sebesar 0.001 < 0.05, sehingga dapat disimpulkan bahwa ada interaksi penambahan $Ca_3(PO_4)_2$ dalam menentukan hasil uji kuat tarik.
2. Diperoleh nilai Sig. sebesar 0,742 > 0.05, sehingga dapat disimpulkan bahwa tidak ada interaksi penambahan MgO dalam menentukan hasil uji kuat tarik.
3. Diperoleh nilai Sig. sebesar 0,191 > 0.05, sehingga dapat disimpulkan bahwa tidak ada interaksi penambahan $Ca_3(PO_4)_2$ dengan MgO dalam menentukan hasil uji kuat tarik.

Uji LSD Kuat Tarik

**Multiple Comparisons**
Dependent Variable: KT
LSD

| (I) VS | (J) VS | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound | Upper Bound |
|---|---|---|---|---|---|---|
| K | A1 | -2.45333* | .64786 | .003 | -3.8649 | -1.0418 |
| | A2 | -1.55000* | .64786 | .034 | -2.9616 | -.1384 |
| | A3 | -2.97000* | .64786 | <.001 | -4.3816 | -1.5584 |
| | A4 | -1.38333 | .64786 | .054 | -2.7949 | .0282 |
| | A5 | .78000 | .64786 | .252 | -.6316 | 2.1916 |
| A1 | K | 2.45333* | .64786 | .003 | 1.0418 | 3.8649 |
| | A2 | .90333 | .64786 | .188 | -.5082 | 2.3149 |
| | A3 | -.51667 | .64786 | .044 | -1.9282 | .8949 |
| | A4 | 1.07000 | .64786 | .125 | -.3416 | 2.4816 |
| | A5 | 3.23333* | .64786 | <.001 | 1.8218 | 4.6449 |
| A2 | K | 1.55000* | .64786 | .034 | .1384 | 2.9616 |
| | A1 | -.90333 | .64786 | .188 | -2.3149 | .5082 |
| | A3 | -1.42000* | .64786 | .049 | -2.8316 | -.0084 |
| | A4 | .16667 | .64786 | .801 | -1.2449 | 1.5782 |
| | A5 | 2.33000* | .64786 | .004 | .9184 | 3.7416 |
| A3 | K | 2.97000* | .64786 | <.001 | 1.5584 | 4.3816 |
| | A1 | .51667 | .64786 | .044 | -.8949 | 1.9282 |
| | A2 | 1.42000* | .64786 | .049 | .0084 | 2.8316 |
| | A4 | 1.58667* | .64786 | .031 | .1751 | 2.9982 |
| | A5 | 3.75000* | .64786 | <.001 | 2.3384 | 5.1616 |
| A4 | K | 1.38333 | .64786 | .054 | -.0282 | 2.7949 |
| | A1 | -1.07000 | .64786 | .125 | -2.4816 | .3416 |
| | A2 | -.16667 | .64786 | .801 | -1.5782 | 1.2449 |
| | A3 | -1.58667* | .64786 | .031 | -2.9982 | -.1751 |
| | A5 | 2.16333* | .64786 | .006 | .7518 | 3.5749 |
| A5 | K | -.78000 | .64786 | .252 | -2.1916 | .6316 |
| | A1 | -3.23333* | .64786 | <.001 | -4.6449 | -1.8218 |
| | A2 | -2.33000* | .64786 | .004 | -3.7416 | -.9184 |
| | A3 | -3.75000* | .64786 | <.001 | -5.1616 | -2.3384 |
| | A4 | -2.16333* | .64786 | .006 | -3.5749 | -.7518 |

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

**Lampiran 3** Hasil Daya Serap Air

| Variasi sampel | | Massa Awal (g) | Massa Akhir (g) | Daya serap air (%) |
|---|---|---|---|---|
| K | 1 | 0,1327 | 0,2010 | 51,46 |
| | 2 | 0,1327 | 0,2011 | 51,54 |
| | 3 | 0,1327 | 0,2012 | 51,16 |
| Rata-rata = 51,38 | | | | |
| A1 | 1 | 0,1275 | 0,1699 | 33,25 |
| | 2 | 0,1275 | 0,1693 | 32,78 |
| | 3 | 0,1277 | 0,1701 | 33,07 |
| Rata-rata = 33,23 | | | | |
| A2 | 1 | 0,1320 | 0,1663 | 25,98 |
| | 2 | 0,1323 | 0,1660 | 25,47 |
| | 3 | 0,1326 | 0,1668 | 25,79 |
| Rata-rata = 25,74 | | | | |
| A3 | 1 | 0,1332 | 0,1584 | 18,91 |
| | 2 | 0,1333 | 0,1586 | 18,97 |
| | 3 | 0,1335 | 0,1589 | 19,02 |
| Rata-rata = 18,96 | | | | |
| A4 | 1 | 0,1245 | 0,1536 | 23,37 |
| | 2 | 0,1242 | 0,1534 | 23,51 |
| | 3 | 0,1241 | 0,1537 | 23,85 |
| Rata-rata = 23,57 | | | | |
| A5 | 1 | 0,1236 | 0,1726 | 39,64 |
| | 2 | 0,1232 | 0,1721 | 39,69 |
| | 3 | 0,1235 | 0,1728 | 39,91 |
| Rata-rata = 39,74 | | | | |

**Perhitungan :**

Daya Serap Air (%) = $\frac{w - w_0}{w_0} \times 100\%$

Daya Serap Air (%) = $\frac{0{,}2010 - 0{,}1327}{0{,}1327} \times 100\% = 51{,}46\%$

Uji Normalitas Daya Serap Air

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Standardized Residual for DSA | .204 | 12 | .181 | .957 | 12 | .734 |

a. Lilliefors Significance Correction

Diperoleh nilai signifikansi 0.734 > 0.05, maka nilai residual standar

terdistribusi normal, sehingga memenuhi syarat pertama untuk uji ANOVA *Two-Way*.

Uji Homogenitas Daya Serap Air

**Levene's Test of Equality of Error Variances[a,b]**

| | | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| DSA | Based on Mean | 1.919 | 3 | 8 | .205 |
| | Based on Median | .873 | 3 | 8 | .494 |
| | Based on Median and with adjusted df | .873 | 3 | 5.008 | .514 |
| | Based on trimmed mean | 1.837 | 3 | 8 | .219 |

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Dependent variable: DSA

b. Design: Intercept + $Ca_3(PO_4)_2$ + MgO + $Ca_3(PO_4)_2$ * MgO

Nilai Sig 0,219 > 0.05, Maka dapat disimpulkan bahwa varian variabel hasil uji daya serap air adalah homogen. Sehingga asumsi homogenitas dalam uji *two-way* terpenuhi.

Uji *Two-way* ANOVA Daya Serap Air

**Tests of Between-Subjects Effects**

Dependent Variable: DSA

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 1647.748[a] | 3 | 549.249 | 12438.181 | <.001 |
| Intercept | 15354.630 | 1 | 15354.630 | 347717.612 | <.001 |
| $Ca_3(PO_4)_2$ | 1133.935 | 1 | 1133.935 | 25678.850 | <.001 |
| MgO | 509.212 | 1 | 509.212 | 11531.513 | <.001 |
| $Ca_3(PO_4)_2$ * MgO | 4.600 | 1 | 4.600 | 104.180 | <.001 |
| Error | .353 | 8 | .044 | | |
| Total | 17002.731 | 12 | | | |
| Corrected Total | 1648.101 | 11 | | | |

a. R Squared = 1.000 (Adjusted R Squared = 1.000)

1. Jika nilai Sig < 0.05, maka ada perbedaan/pengaruh hasil uji daya serap air berdasarkan variabel faktor.
2. Jika nilai Sig > 0.05, maka tidak ada perbedaan/pengaruh hasil uji daya serap air berdasarkan variabel faktor.

Kesimpulan menjawab rumusan masalah:

1. Diperoleh nilai Sig. sebesar 0.001 < 0.05, sehingga dapat disimpulkan bahwa ada interaksi penambahan $Ca_3(PO_4)_2$ dengan MgO dalam menentukan hasil uji daya serap air.
2. Diperoleh nilai Sig. sebesar 0.001 < 0.05, sehingga dapat disimpulkan bahwa ada interaksi penambahan $Ca_3(PO_4)_2$ dengan MgO dalam menentukan hasil uji daya serap air.
3. Diperoleh nilai Sig. sebesar 0.001 < 0.05, sehingga dapat disimpulkan bahwa ada interaksi penambahan $Ca_3(PO_4)_2$ dengan MgO dalam menentukan hasil uji daya serap air.

Uji LSD Daya Serap Air

## Multiple Comparisons

Dependent Variable: DSA

LSD

| (I) VS | (J) VS | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound | 95% Confidence Interval Upper Bound |
|---|---|---|---|---|---|---|
| K | A1 | 18.35333* | .16580 | <.001 | 17.9921 | 18.7146 |
| | A2 | 25.64000* | .16580 | <.001 | 25.2788 | 26.0012 |
| | A3 | 32.42000* | .16580 | <.001 | 32.0588 | 32.7812 |
| | A4 | 27.81000* | .16580 | <.001 | 27.4488 | 28.1712 |
| | A5 | 11.64000* | .16580 | <.001 | 11.2788 | 12.0012 |
| A1 | K | -18.35333* | .16580 | <.001 | -18.7146 | -17.9921 |
| | A2 | 7.28667* | .16580 | <.001 | 6.9254 | 7.6479 |
| | A3 | 14.06667* | .16580 | <.001 | 13.7054 | 14.4279 |
| | A4 | 9.45667* | .16580 | <.001 | 9.0954 | 9.8179 |
| | A5 | -6.71333* | .16580 | <.001 | -7.0746 | -6.3521 |
| A2 | K | -25.64000* | .16580 | <.001 | -26.0012 | -25.2788 |
| | A1 | -7.28667* | .16580 | <.001 | -7.6479 | -6.9254 |
| | A3 | 6.78000* | .16580 | <.001 | 6.4188 | 7.1412 |
| | A4 | 2.17000* | .16580 | <.001 | 1.8088 | 2.5312 |
| | A5 | -14.00000* | .16580 | <.001 | -14.3612 | -13.6388 |
| A3 | K | -32.42000* | .16580 | <.001 | -32.7812 | -32.0588 |
| | A1 | -14.06667* | .16580 | <.001 | -14.4279 | -13.7054 |
| | A2 | -6.78000* | .16580 | <.001 | -7.1412 | -6.4188 |
| | A4 | -4.61000* | .16580 | <.001 | -4.9712 | -4.2488 |
| | A5 | -20.78000* | .16580 | <.001 | -21.1412 | -20.4188 |
| A4 | K | -27.81000* | .16580 | <.001 | -28.1712 | -27.4488 |
| | A1 | -9.45667* | .16580 | <.001 | -9.8179 | -9.0954 |
| | A2 | -2.17000* | .16580 | <.001 | -2.5312 | -1.8088 |
| | A3 | 4.61000* | .16580 | <.001 | 4.2488 | 4.9712 |
| | A5 | -16.17000* | .16580 | <.001 | -16.5312 | -15.8088 |
| A5 | K | -11.64000* | .16580 | <.001 | -12.0012 | -11.2788 |
| | A1 | 6.71333* | .16580 | <.001 | 6.3521 | 7.0746 |
| | A2 | 14.00000* | .16580 | <.001 | 13.6388 | 14.3612 |
| | A3 | 20.78000* | .16580 | <.001 | 20.4188 | 21.1412 |
| | A4 | 16.17000* | .16580 | <.001 | 15.8088 | 16.5312 |

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

**Lampiran 4** Hasil Biodegradasi

| Variasi Sampel | | W1 (g) | W6 (g) | %B hari ke 6 | W12 (g) | %B hari ke 12 | W18 (g) | %B hari ke 18 | W24 (g) | % B hari ke 24 | W30 (g) | %B hari ke 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| K | 1 | 0,1330 | 0,1200 | 9,77 | 0,1000 | 24,81 | 0,0700 | 47,37 | 0,0300 | 77,44 | TS | 100 |
| | 2 | 0,1345 | 0,1209 | 10,11 | 0,1005 | 25,27 | 0,0708 | 47,36 | 0,0306 | 77,24 | TS | 100 |
| | 3 | 0,1340 | 0,1207 | 9,92 | 0,1002 | 25,22 | 0,0711 | 46,94 | 0,0302 | 77,46 | TS | 100 |
| | Rata-rata | | | 9,93 | | 25,1 | | 47,22 | | 77,38 | | 100 |
| A1 | 1 | 0,1285 | 0,1000 | 22,17 | 0,0700 | 45,52 | 0,0400 | 68,87 | 0,0150 | 88,32 | TS | 100 |
| | 2 | 0,1280 | 0,1005 | 21,48 | 0,0708 | 44,68 | 0,0402 | 68,59 | 0,0145 | 88,67 | TS | 100 |
| | 3 | 0,1273 | 0,1009 | 20,73 | 0,0712 | 44,06 | 0,0407 | 68,02 | 0,0156 | 88,74 | TS | 100 |
| | Rata-rata | | | 21,46 | | 44,75 | | 68,49 | | 88,57 | | 100 |
| A2 | 1 | 0,1336 | 0.0950 | 28,90 | 0,0600 | 55,09 | 0,0300 | 77,54 | 0,0050 | 96,26 | TS | 100 |
| | 2 | 0,1339 | 0.0955 | 28,82 | 0,0598 | 55,33 | 0,0306 | 77,14 | 0,0053 | 96,04 | TS | 100 |
| | 3 | 0,1332 | 0.0958 | 28,07 | 0,0605 | 54,57 | 0,0302 | 77,32 | 0,0049 | 96,32 | TS | 100 |
| | Rata-rata | | | 28,60 | | 54,99 | | 77,33 | | 96,20 | | 100 |
| A3 | 1 | 0,1335 | 0,0800 | 39,98 | 0,0400 | 69,99 | 0,0150 | 88,75 | 0,0020 | 98,50 | TS | 100 |
| | 2 | 0,1333 | 0,0806 | 39,53 | 0,0406 | 69,54 | 0,0155 | 88,37 | 0,0022 | 98,34 | TS | 100 |
| | 3 | 0,1332 | 0,0804 | 39,63 | 0,0408 | 69,36 | 0,0153 | 88,51 | 0,0027 | 97,97 | TS | 100 |
| | Rata-rata | | | 39,71 | | 69,63 | | 88,54 | | 98,27 | | 100 |
| A4 | 1 | 0,1251 | 0,0900 | 28,06 | 0,0550 | 56,04 | 0,0250 | 80,02 | 0,0100 | 92,09 | TS | 100 |
| | 2 | 0,1246 | 0,0906 | 27,28 | 0,0557 | 55,29 | 0,0257 | 79,37 | 0,0108 | 91,33 | TS | 100 |
| | 3 | 0,1253 | 0,0904 | 27,85 | 0,0554 | 55,78 | 0,0263 | 79,01 | 0,0105 | 91,62 | TS | 100 |
| | Rata-rata | | | 27,73 | | 55,70 | | 79,46 | | 91,68 | | 100 |
| A5 | 1 | 0,1225 | 0,1000 | 18,37 | 0,0700 | 42,86 | 0,0400 | 67,35 | 0,0200 | 83,67 | TS | 100 |
| | 2 | 0,1219 | 0,1005 | 17,56 | 0,0708 | 41,91 | 0,0403 | 66,94 | 0,0201 | 83,51 | TS | 100 |
| | 3 | 0,1222 | 0,1002 | 18,00 | 0,0704 | 42,38 | 0,0409 | 66,53 | 0,0207 | 83,06 | TS | 100 |
| | Rata-rata | | | 17,97 | | 42,38 | | 66,94 | | 83,41 | | |

**%B: Persen Laju Biodegradasi**
**TS: Terdegradasi sempurna**

Laju Biodegradasi (%) = $\frac{w1-w2}{w_1} \times 100\%$

- Biodegradasi hari ke-6 $= \frac{w_1-w_6}{w_1} \times 100\%$
$= \frac{0,1330-0,1200}{0,1330} \times 100\% = 9,77\%$
- Biodegradasi hari ke-12 $= \frac{w1-w12}{w_1} \times 100\%$
$= \frac{0,1330-0,1000}{0,1330} \times 100\% = 24,81\%$
- Biodegradasi hari ke-18 $= \frac{w1-w18}{w_1} \times 100\%$
$= \frac{0,1330-0,0700}{0,1330} \times 100\% = 47,37\ \%$
- Biodegradasi hari ke-24 $= \frac{w1-w24}{w_1} \times 100\%$
$= \frac{0,1330-0,0300}{0,1330} \times 100\% = 77,44\ \%$

Uji Normalitas Biodegradasi

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| Standardized Residual for Bio | .242 | 12 | .051 | .880 | 12 | .088 |

a. Lilliefors Significance Correction

Diperoleh nilai signifikansi 0.088 > 0.05, maka nilai residual standar terdistribusi normal, sehingga memenuhi syarat pertama untuk uji ANOVA *Two-Way*.

Uji Homogenitas Biodegradasi

**Levene's Test of Equality of Error Variances[a,b]**

| | | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| Bio | Based on Mean | 2.672 | 3 | 8 | .118 |
| | Based on Median | 2.076 | 3 | 8 | .182 |
| | Based on Median and with adjusted df | 2.076 | 3 | 2.891 | .287 |
| | Based on trimmed mean | 2.640 | 3 | 8 | .121 |

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Dependent variable: Bio

b. Design: Intercept + $Ca_3(PO_4)_2$ + Mgo + $Ca_3(PO_4)_2$ * Mgo

Nilai Sig 0,121 > 0.05, Maka dapat disimpulkan bahwa varian variabel hasil uji biodegradasi adalah homogen. Sehingga asumsi homogenitas dalam uji *two-way* terpenuhi.

Uji *Two-way* ANOVA Biodegradasi

**Tests of Between-Subjects Effects**

Dependent Variable: Bio

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 567.237[a] | 3 | 189.079 | 4076.440 | <.001 |
| Intercept | 4669.302 | 1 | 4669.302 | 100667.668 | <.001 |
| $Ca_3(PO_4)_2$ | 403.796 | 1 | 403.796 | 8705.627 | <.001 |
| Mgo | 161.700 | 1 | 161.700 | 3486.170 | <.001 |
| $Ca_3(PO_4)_2$ * Mgo | 1.740 | 1 | 1.740 | 37.522 | <.001 |
| Error | .371 | 8 | .046 | | |
| Total | 5236.910 | 12 | | | |
| Corrected Total | 567.608 | 11 | | | |

a. R Squared = .999 (Adjusted R Squared = .999)

1. Jika nilai Sig < 0.05, maka ada perbedaan/pengaruh hasil uji biodegradasi berdasarkan variabel faktor.
2. Jika nilai Sig > 0.05, maka tidak ada perbedaan/pengaruh hasil uji biodegradasi variabel faktor.

Kesimpulan menjawab rumusan masalah:

1. Diperoleh nilai Sig. sebesar 0.001 < 0.05, sehingga dapat disimpulkan bahwa ada interaksi penambahan $Ca_3(PO_4)_2$ dalam menentukan hasil uji biodegradasi.
2. Diperoleh nilai Sig. sebesar 0.001 < 0.05, sehingga dapat disimpulkan bahwa ada interaksi penambahan MgO dalam menentukan hasil uji biodegradasi.
3. Diperoleh nilai Sig. sebesar 0.001 < 0.05, sehingga dapat disimpulkan bahwa ada interaksi penambahan $Ca_3(PO_4)_2$ dengan MgO dalam menentukan hasil uji biodegradasi.

Uji LSD Biodegradasi

## Multiple Comparisons

Dependent Variable: BIO

LSD

| (I) VS | (J) VS | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound | 95% Confidence Interval Upper Bound |
|---|---|---|---|---|---|---|
| K | A1 | -11.52667* | .35599 | <.001 | -12.3023 | -10.7510 |
| | A2 | -18.66333* | .35599 | <.001 | -19.4390 | -17.8877 |
| | A3 | -29.78000* | .35599 | <.001 | -30.5556 | -29.0044 |
| | A4 | -17.79667* | .35599 | <.001 | -18.5723 | -17.0210 |
| | A5 | -8.04333* | .35599 | <.001 | -8.8190 | -7.2677 |
| A1 | K | 11.52667* | .35599 | <.001 | 10.7510 | 12.3023 |
| | A2 | -7.13667* | .35599 | <.001 | -7.9123 | -6.3610 |
| | A3 | -18.25333* | .35599 | <.001 | -19.0290 | -17.4777 |
| | A4 | -6.27000* | .35599 | <.001 | -7.0456 | -5.4944 |
| | A5 | 3.48333* | .35599 | <.001 | 2.7077 | 4.2590 |
| A2 | K | 18.66333* | .35599 | <.001 | 17.8877 | 19.4390 |
| | A1 | 7.13667* | .35599 | <.001 | 6.3610 | 7.9123 |
| | A3 | -11.11667* | .35599 | <.001 | -11.8923 | -10.3410 |
| | A4 | .86667* | .35599 | .031 | .0910 | 1.6423 |
| | A5 | 10.62000* | .35599 | <.001 | 9.8444 | 11.3956 |
| A3 | K | 29.78000* | .35599 | <.001 | 29.0044 | 30.5556 |
| | A1 | 18.25333* | .35599 | <.001 | 17.4777 | 19.0290 |
| | A2 | 11.11667* | .35599 | <.001 | 10.3410 | 11.8923 |
| | A4 | 11.98333* | .35599 | <.001 | 11.2077 | 12.7590 |
| | A5 | 21.73667* | .35599 | <.001 | 20.9610 | 22.5123 |
| A4 | K | 17.79667* | .35599 | <.001 | 17.0210 | 18.5723 |
| | A1 | 6.27000* | .35599 | <.001 | 5.4944 | 7.0456 |
| | A2 | -.86667* | .35599 | .031 | -1.6423 | -.0910 |
| | A3 | -11.98333* | .35599 | <.001 | -12.7590 | -11.2077 |
| | A5 | 9.75333* | .35599 | <.001 | 8.9777 | 10.5290 |
| A5 | K | 8.04333* | .35599 | <.001 | 7.2677 | 8.8190 |
| | A1 | -3.48333* | .35599 | <.001 | -4.2590 | -2.7077 |
| | A2 | -10.62000* | .35599 | <.001 | -11.3956 | -9.8444 |
| | A3 | -21.73667* | .35599 | <.001 | -22.5123 | -20.9610 |
| | A4 | -9.75333* | .35599 | <.001 | -10.5290 | -8.9777 |

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

**Lampiran 5** Hasil SEM-EDS

Sampel Kontrol

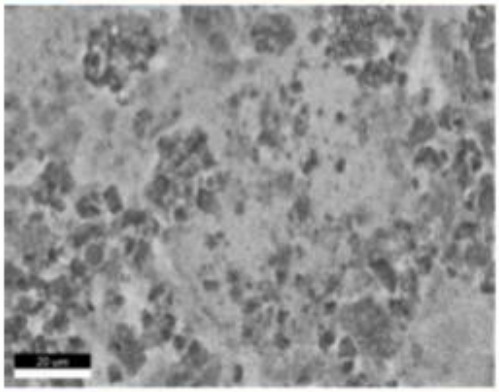
EDAX APEX

Page 1

11042025

Author: Teknik Mesin ITS
Creation: 04/27/2025 11:59:04 AM
Sample Name: Lidya Undiksha

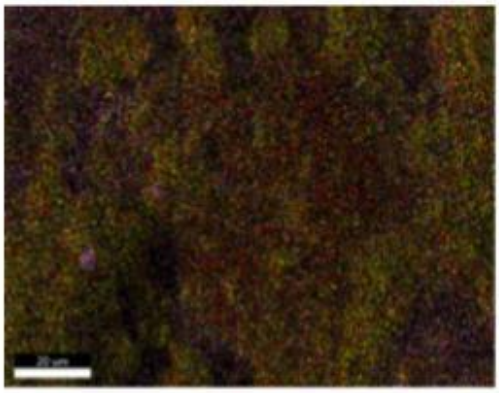
Kontrol



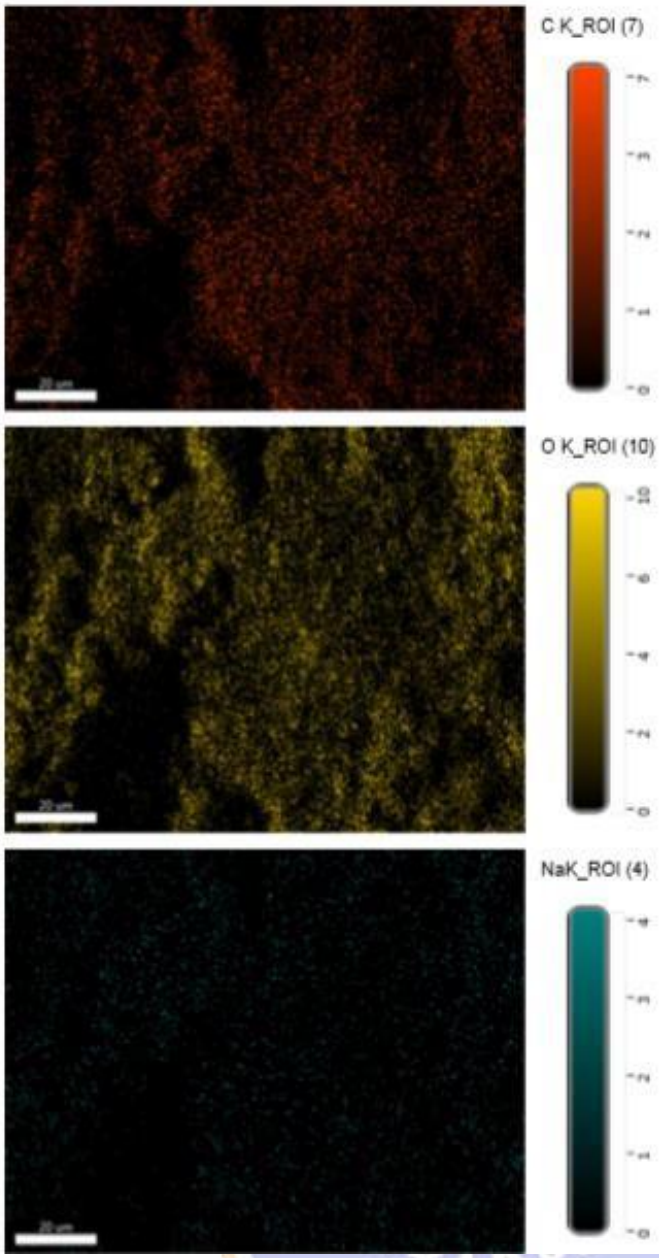
Image

PhaseROI 2

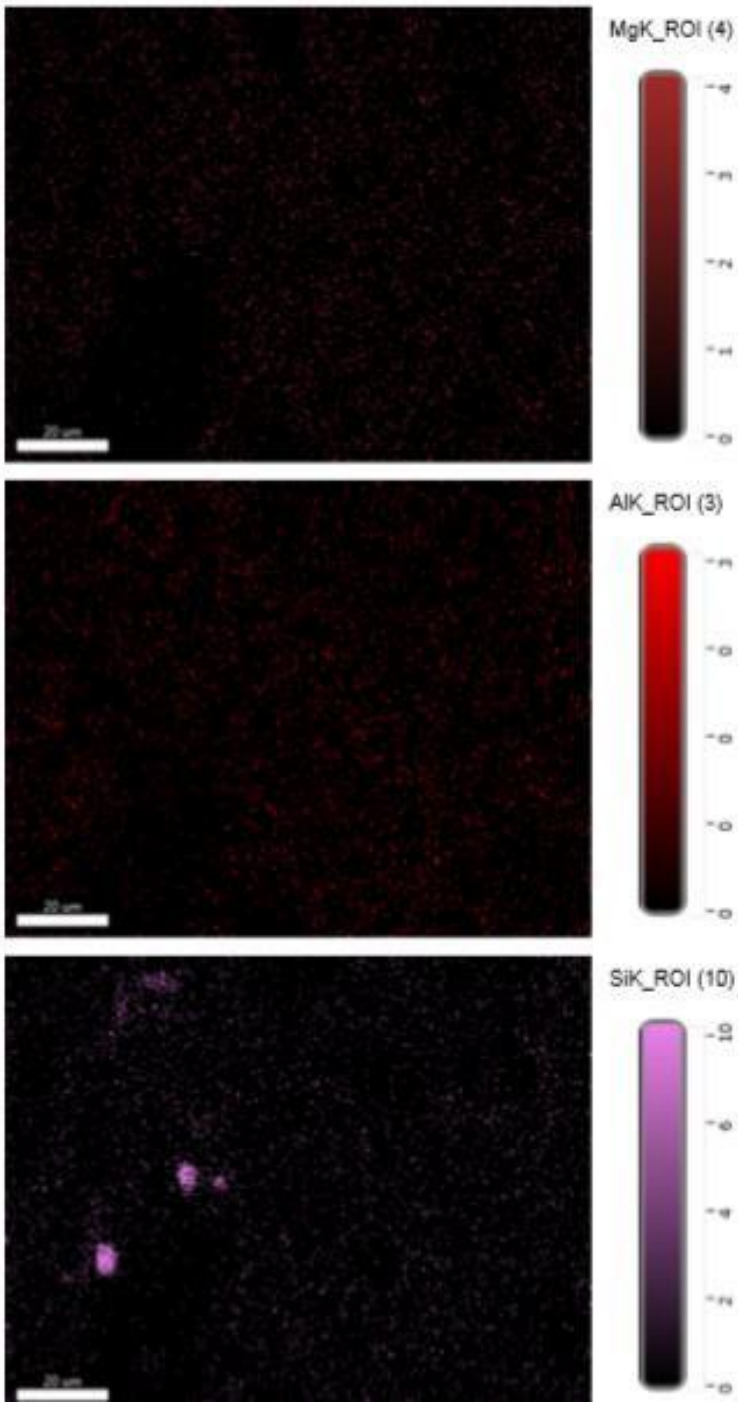
ElementOverlay

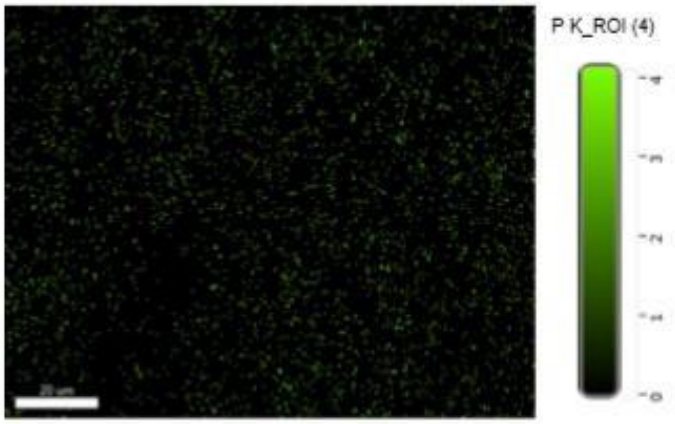


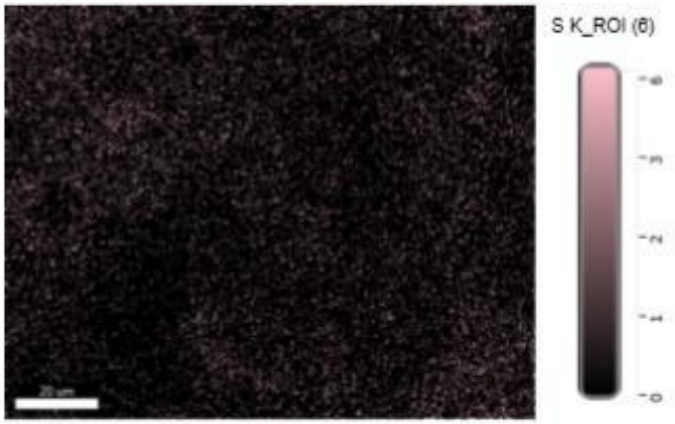
11% C K
21% O K
2% NaK
3% MgK
2% AlK
3% SiK
2% P K
12% S K
2% ClK
6% K K
36% CaK


C K_ROI (7)
O K_ROI (10)
NaK_ROI (4)

EDAX APEX

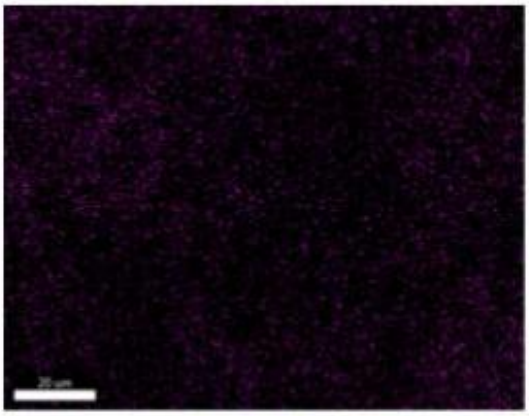


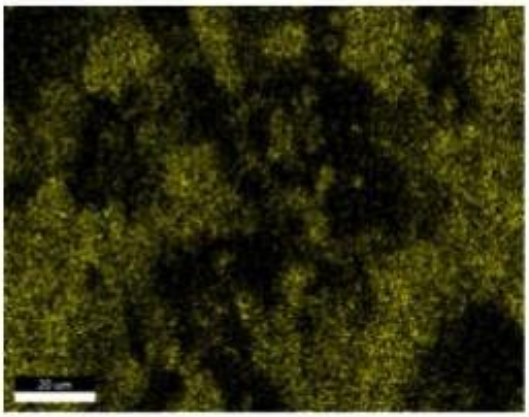

P K_ROI (4)


S K_ROI (6)


ClK_ROI (4)

EDAX APEX






**Smart Quant Results**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| C K | 19.23 | 28.67 | 146.43 | 9.02 | 0.0654 | 1.0733 | 0.3171 | 1.0000 |
| O K | 50.34 | 56.35 | 343.00 | 9.92 | 0.0782 | 1.0279 | 0.1512 | 1.0000 |
| NaK | 1.29 | 1.00 | 16.83 | 13.21 | 0.0035 | 0.9343 | 0.2869 | 1.0014 |
| MgK | 0.90 | 0.66 | 22.20 | 10.38 | 0.0037 | 0.9504 | 0.4322 | 1.0025 |
| AlK | 0.41 | 0.27 | 13.24 | 12.26 | 0.0022 | 0.9154 | 0.5813 | 1.0045 |
| SiK | 0.50 | 0.32 | 20.74 | 10.16 | 0.0034 | 0.9356 | 0.7153 | 1.0075 |
| P K | 0.35 | 0.20 | 13.01 | 6.51 | 0.0026 | 0.8987 | 0.8185 | 1.0124 |
| S K | 3.92 | 2.19 | 156.27 | 3.14 | 0.0326 | 0.9164 | 0.8929 | 1.0152 |
| ClK | 0.20 | 0.10 | 7.22 | 22.47 | 0.0016 | 0.8719 | 0.9119 | 1.0241 |
| K K | 1.87 | 0.86 | 60.03 | 4.55 | 0.0166 | 0.8677 | 0.9799 | 1.0485 |
| CaK | 20.99 | 9.38 | 557.80 | 1.68 | 0.1844 | 0.8836 | 0.9882 | 1.0064 |

Sampel A3

EDAX APEX

Page 1

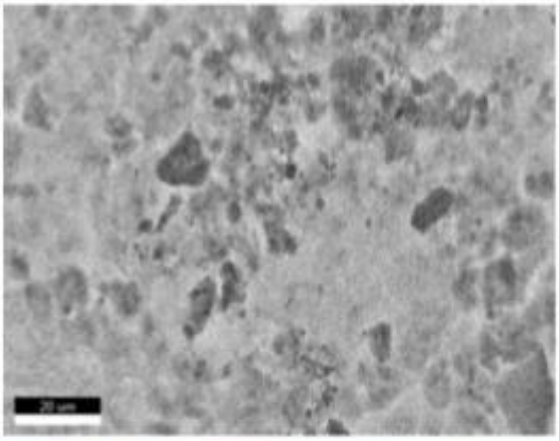
11042025

Author: Teknik Mesin ITS

Creation: 04/27/2025 12:00:43 PM

Sample Name: Lidya Undiksha

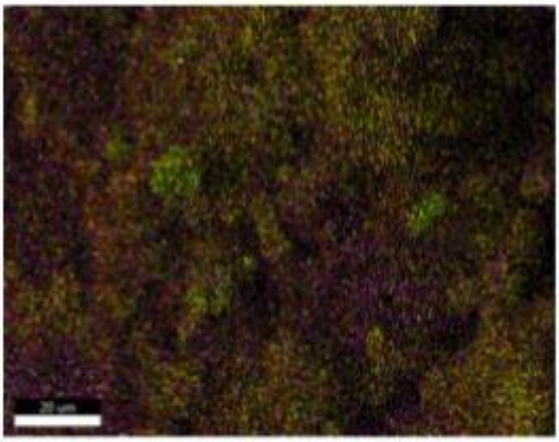
A3



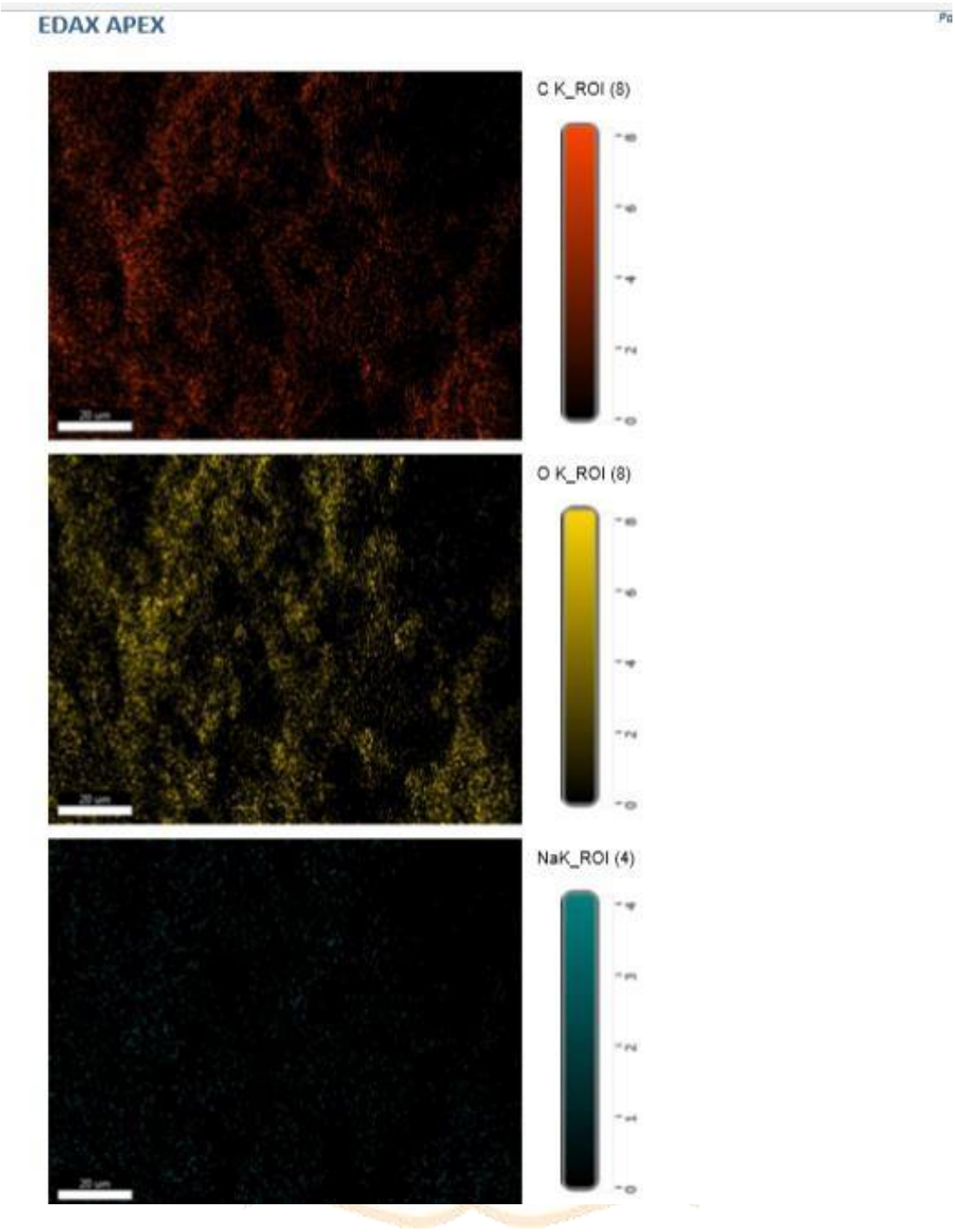
Image

PhaseROI 2

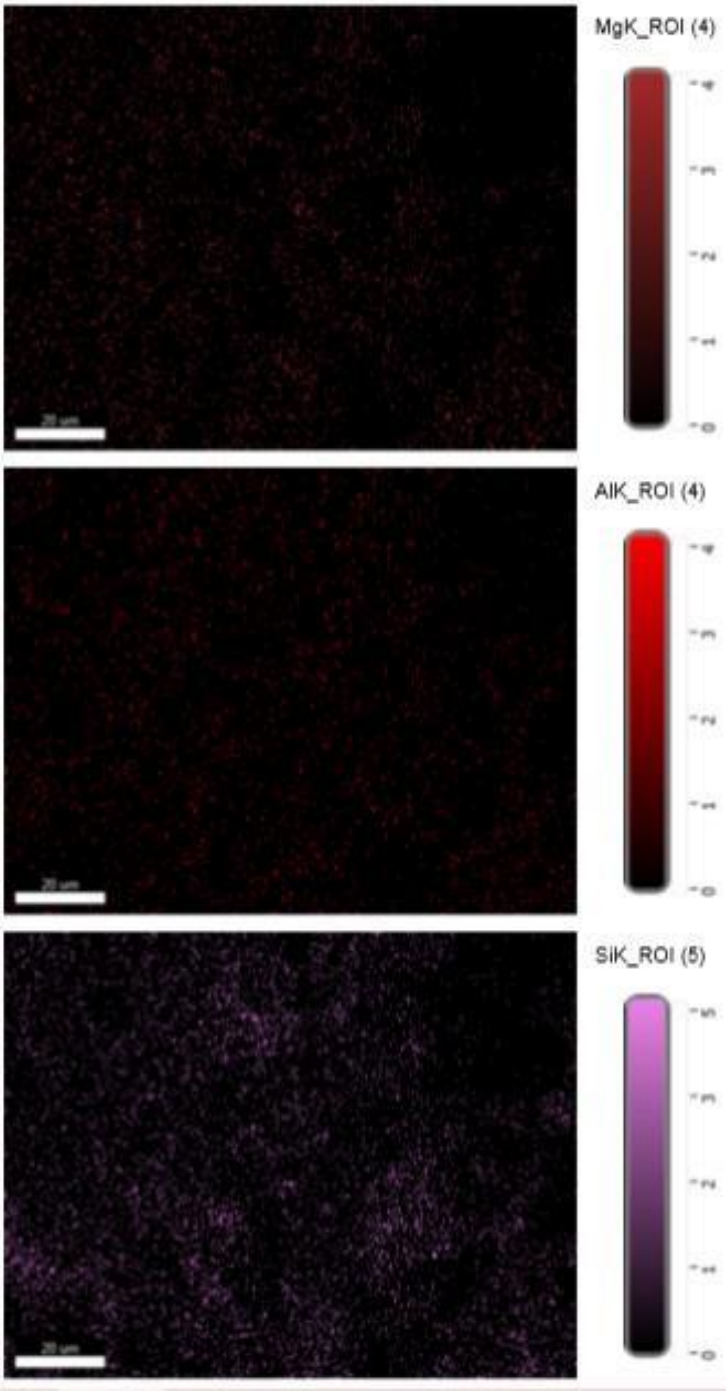
ElementOverlay

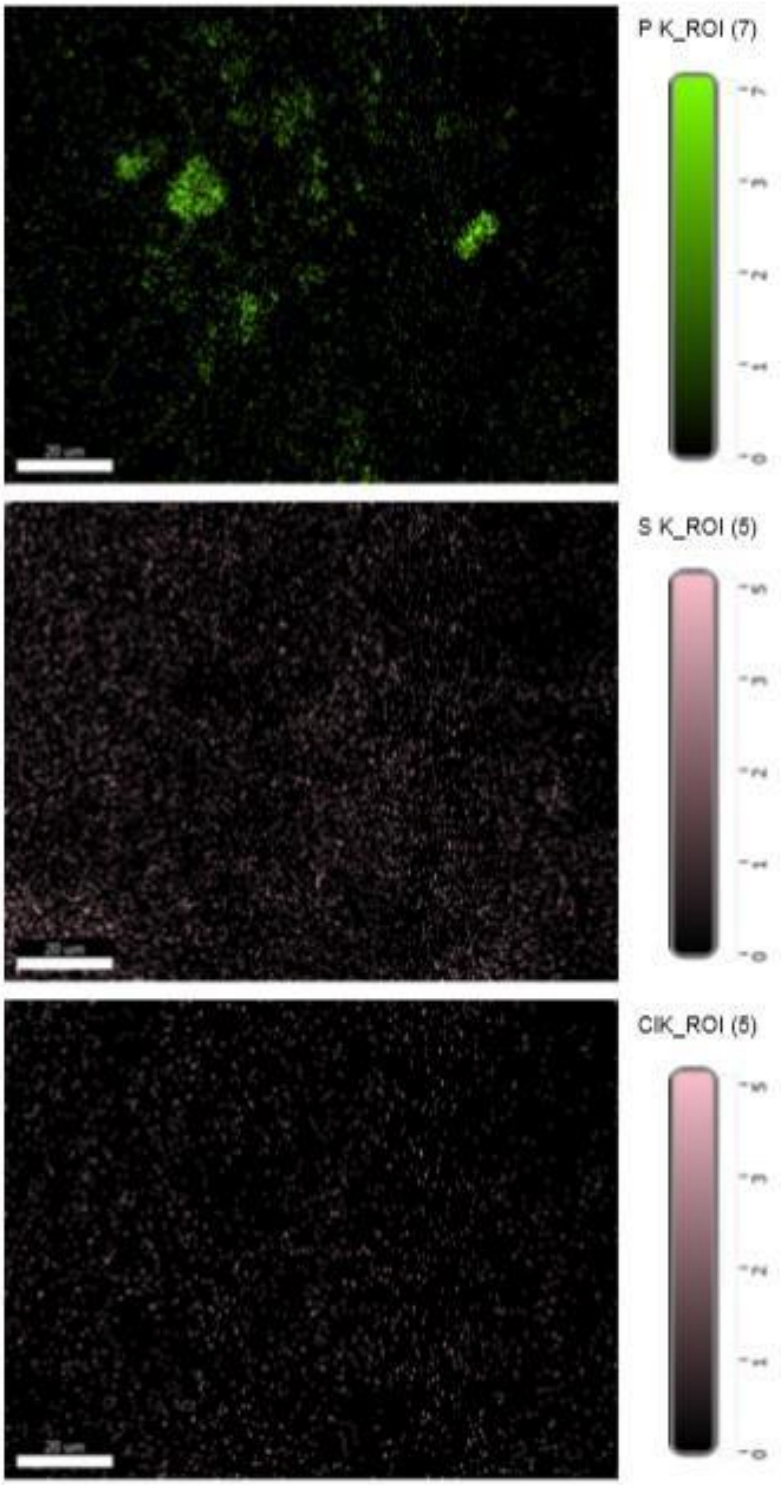


14% C K
14% O K
2% NaK
3% MgK
2% AlK
7% SiK
4% P K
9% S K
2% ClK
6% K K
36% CaK


EDAX APEX
C K_ROI (8)
O K_ROI (8)
NaK_ROI (4)

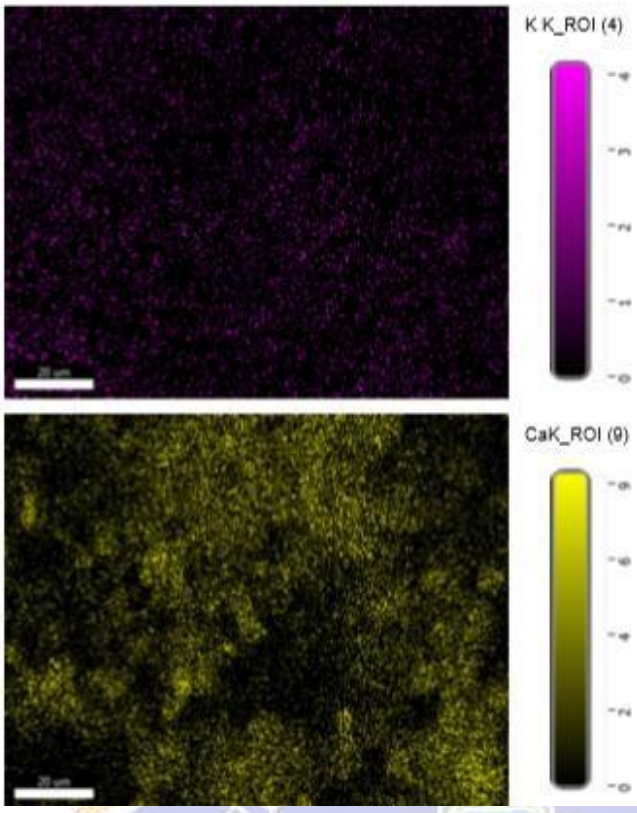
EDAX APEX




P K_ROI (7)
S K_ROI (5)
ClK_ROI (5)

EDAX APEX

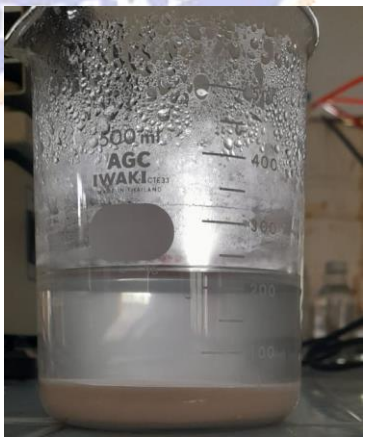
Page 5



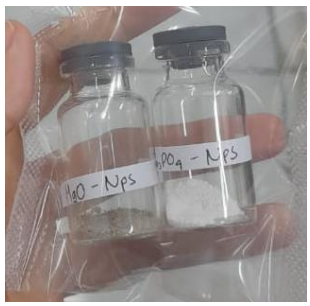
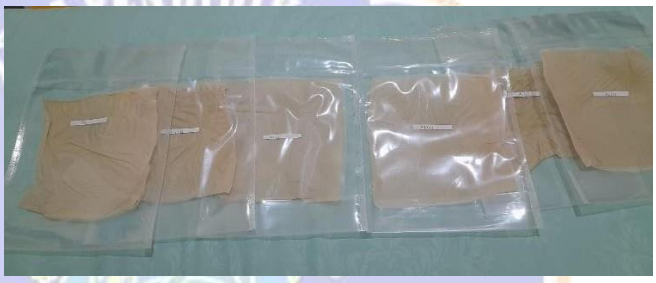

**Smart Quant Results**

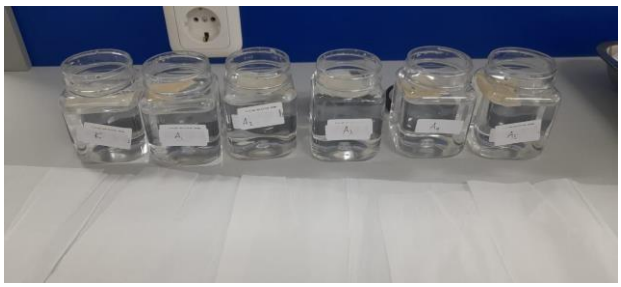
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| C K | 29.14 | 41.88 | 207.16 | 8.98 | 0.0989 | 1.0679 | 0.3179 | 1.0000 |
| O K | 40.21 | 43.39 | 224.02 | 10.33 | 0.0546 | 1.0227 | 0.1328 | 1.0000 |
| NaK | 0.88 | 0.66 | 11.57 | 14.06 | 0.0025 | 0.9294 | 0.3086 | 1.0015 |
| MgK | 1.17 | 0.83 | 28.76 | 9.42 | 0.0051 | 0.9454 | 0.4621 | 1.0027 |
| AlK | 0.29 | 0.18 | 9.12 | 16.81 | 0.0016 | 0.9106 | 0.6089 | 1.0049 |
| SiK | 1.95 | 1.20 | 78.05 | 5.73 | 0.0136 | 0.9306 | 0.7413 | 1.0074 |
| P K | 1.15 | 0.64 | 39.76 | 5.46 | 0.0086 | 0.8939 | 0.8231 | 1.0117 |
| S K | 2.92 | 1.57 | 107.86 | 3.66 | 0.0240 | 0.9116 | 0.8881 | 1.0152 |
| ClK | 0.35 | 0.17 | 11.63 | 17.72 | 0.0028 | 0.8672 | 0.9163 | 1.0238 |
| K K | 1.67 | 0.74 | 50.01 | 5.62 | 0.0148 | 0.8631 | 0.9818 | 1.0485 |
| CaK | 20.28 | 8.73 | 502.99 | 1.75 | 0.1777 | 0.8789 | 0.9906 | 1.0066 |

**Lampiran 6** Dokumentasi

| Aktivitas | Dokumentasi |
|---|---|
| **Sintesis $Ca_3(PO_4)_2$-NPs** Furnace bubuk tulang sapi |  |
| Penambahan $H_3PO_4$ |  |
| Pengendapan hasil sintesis |   |

| | |
|---|---|
| Pencucian dengan NaOH |  |
| **Sintesis MgO-NPs**<br>Pemanasan bubuk daun kelor |  |
| Penambahan bioreduktor dan prekursor |  |
| Sentrifuse sampel |  |

| | |
|---|---|
| Hasil nanopartikel |  |
| Pencetakan Bioplastik |  |
| Bioplastik |  |
| Pengujian kuat tarik |  |
| Pengujian biodegradasi |  |

| | |
|---|---|
| Pengujian daya serap air |  |

**Lampiran 7** Riwayat Hidup

Lidya Tiara lahir di Bolu pada tanggal 3 Juni 2003. Penulis lahir dari pasangan suami istri Bapak Matius Kamma' dan Ibu Arni Palindang. Penulis berkebangsaan Indonesia dan beragama Kristen. Kini penulis beralamat Jalan Busirih Ujung, Kecamatan Mimika, Kabupaten Mimika, Provinsi Papua Tengah. Penulis menyelesaikan pendidikan dasar di SD Tabita Sion dan lulus pada tahun 2015. Kemudian penulis melanjutkan di SMP Batu Karang dan lulus pada tahun 2018. Pada tahun 2021, penulis lulus dari SMA Katolik Rajawali dan melanjutkan ke Strata 1 Jurusan Kimia di Universitas Pendidikan Ganesha. Pada semester akhir tahun 2025 penulis telah menyelesaikan Skripsi yang berjudul "Pengaruh Penambahan Nano Kalsium Fosfat dan Magnesium Oksida Terhadap Karakteristik Bioplastik Dari Rumput Laut (*Eucheuma spinosum)*". Selanjutnya, mulai tahun 2025 sampai dengan penulisan skripsi ini, penulis masih terdaftar sebagai mahasiswa Program S1 Kimia di Universitas Pendidikan Ganesha.