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# LAMPIRAN

**Lampiran 1.** Data Kadar Fe pada Slag Nikel Periode 3 Mei 2023 – 11 Juni 2023

| Sampel | Tanggal | Shift | Kadar Slag Fe |
|---|---|---|---|
| 1 | 03 Mei 2023 | A | 18,30 |
| 2 | | B | 19,70 |
| 3 | | C | 21,40 |
| 4 | 04 Mei 2023 | A | 20,70 |
| 5 | | B | 20,90 |
| 6 | | C | 20,40 |
| 7 | 05 Mei 2023 | A | 19,50 |
| 8 | | B | 19,50 |
| 9 | | C | 19,90 |
| 10 | 06 Mei 2023 | A | 20,70 |
| 11 | | B | 21,00 |
| 12 | | C | 21,20 |
| 13 | 07 Mei 2023 | A | 20,80 |
| 14 | | B | 20,50 |
| 15 | | C | 20,30 |
| 16 | 08 Mei 2023 | A | 21,00 |
| 17 | | B | 21,30 |
| 18 | | C | 20,90 |
| 19 | 09 Mei 2023 | A | 20,80 |
| 20 | | B | 19,10 |
| 21 | | C | 19,10 |
| 22 | 10-Mei-2023 | A | 19,80 |
| 23 | | B | 19,70 |
| 24 | | C | 19,50 |
| 25 | 11 Mei 2023 | A | 19,30 |
| 26 | | B | 18,60 |
| 27 | | C | 19,50 |
| 28 | 12 Mei 2023 | A | 19,80 |
| 29 | | B | 20,60 |
| 30 | | C | 21,60 |
| 31 | 13 Mei 2023 | A | 22,20 |
| 32 | | B | 22,50 |
| ⋮ | ⋮ | ⋮ | ⋮ |
| 118 | 11 Juni 2023 | A | 20,40 |
| 119 | | B | 20,40 |
| 120 | | C | 19,80 |

**Lampiran 2.** Uji Normalitas

```
> library(nortest)
> setwd("D:/coolyah")
> data = read.csv('data1.csv', header = TRUE, sep = ';')
> lillie.test(data$Fe)
```

```
  Lilliefors (Kolmogorov-Smirnov) normality test

data:  data$Fe
D = 0.067826, p-value = 0.1925
```

**Lampiran 3**. *Average Run Length Exponentially Weighted Moving Average*

```
> library(spc)
> l1 <- 0.1
> l2 <- 0.25
> l3 <- 0.5
> l4 <- 0.75
> cE1 <- 2.824
> cE2 <- 3
> cE3 <- 3.072
> cE4 <- 3.088
> mu <- (0:40)/20
> arl1 <- sapply(mu,l=l1,cE=cE1,sided="two",xewma.arl)
> arl2 <- sapply(mu,l=l2,cE=cE2,sided="two",xewma.arl)
> arl3 <- sapply(mu,l=l3,cE=cE3,sided="two",xewma.arl)
> arl4 <- sapply(mu,l=l4,cE=cE4,sided="two",xewma.arl)
> round(cbind(mu,arl1,arl2,arl3,arl4),digits=5)
        mu      arl1      arl2      arl3      arl4
 [1,] 0.00 513.34728 502.89517 501.54153 500.92606
 [2,] 0.05 450.25373 469.86048 484.18487 490.50465
 [3,] 0.10 327.47939 391.32235 438.12779 461.46175
 [4,] 0.15 223.18906 303.73187 376.90085 419.38615
 [5,] 0.20 152.90010 228.61761 313.39150 370.88008
 [6,] 0.25 108.02912 171.09265 255.51354 321.53727
 [7,] 0.30  79.19662 128.97808 206.42264 275.07636
 [8,] 0.35  60.18063  98.53950 166.38581 233.43233
 [9,] 0.40  47.24170  76.49179 134.38459 197.25818
[10,] 0.45  38.15839  60.37624 109.03504 166.44434
[11,] 0.50  31.59089  48.45303  89.00413 140.50321
[12,] 0.55  26.71178  39.51305  73.15516 118.80737
[13,] 0.60  22.99662  32.71761  60.57109 100.71917
[14,] 0.65  20.10434  27.48175  50.53180  85.65219
[15,] 0.70  17.80750  23.39383  42.47887  73.09437
[16,] 0.75  15.95090  20.16118  35.98149  62.61143
[17,] 0.80  14.42623  17.57342  30.70752  53.84122
[18,] 0.85  13.15639  15.47761  26.40042  46.48467
[19,] 0.90  12.08539  13.76136  22.86141  40.29607
[20,] 0.95  11.17191  12.34114  19.93586  35.07406
[21,] 1.00  10.38490  11.15427  17.50292  30.65374
[22,] 1.05   9.70072  10.15316  15.46770  26.89997
[23,] 1.10   9.10110   9.30137  13.75531  23.70186
[24,] 1.15   8.57171   8.57071  12.30637  20.96826
[25,] 1.20   8.10124   7.93917  11.07356  18.62408
[26,] 1.25   7.68061   7.38943  10.01898  16.60732
[27,] 1.30   7.30248   6.90770   9.11211  14.86664
[28,] 1.35   6.96086   6.48297   8.32830  13.35944
[29,] 1.40   6.65081   6.10634   7.64748  12.05026
[30,] 1.45   6.36824   5.77056   7.05330  10.90952
[31,] 1.50   6.10971   5.46971   6.53233   9.91246
[32,] 1.55   5.87233   5.19890   6.07351   9.03832
[33,] 1.60   5.65366   4.95407   5.66769   8.26963
[34,] 1.65   5.45162   4.73185   5.30725   7.59166
[35,] 1.70   5.26439   4.52937   4.98584   6.99194
[36,] 1.75   5.09045   4.34424   4.69814   6.45991
[37,] 1.80   4.92844   4.17441   4.43967   5.98660
```

**Lampiran 3**. *Average Run Length Exponentially Weighted Moving Average*
(Lanjutan)

| | | | | | |
|---|---|---|---|---|---|
| [38,] | 1.85 | 4.77721 | 4.01815 | 4.20664 | 5.56435 |
| [39,] | 1.90 | 4.63572 | 3.87395 | 3.99583 | 5.18663 |
| [40,] | 1.95 | 4.50309 | 3.74053 | 3.80450 | 4.84782 |
| [41,] | 2.00 | 4.37853 | 3.61677 | 3.63032 | 4.54314 |

**Lampiran 4**. *Average Run Length Cumulative Sum*

```
> k <- 0.5
> h <- 5
> mu <- (0:40)/20
> arl1 <- sapply(mu, k=k, h=h, sided="two", xcusum.arl)
> round(cbind(mu, arl1), digits=5)
       mu      arl1
 [1,] 0.00 465.44351
 [2,] 0.05 430.10196
 [3,] 0.10 348.64968
 [4,] 0.15 262.01063
 [5,] 0.20 191.28119
 [6,] 0.25 139.49369
 [7,] 0.30 103.06180
 [8,] 0.35  77.65076
 [9,] 0.40  59.82080
[10,] 0.45  47.14881
[11,] 0.50  37.99614
[12,] 0.55  31.26731
[13,] 0.60  26.22902
[14,] 0.65  22.38686
[15,] 0.70  19.40404
[16,] 0.75  17.04833
[17,] 0.80  15.15753
[18,] 0.85  13.61680
[19,] 0.90  12.34369
[20,] 0.95  11.27818
[21,] 1.00  10.37597
[22,] 1.05   9.60391
[23,] 1.10   8.93686
[24,] 1.15   8.35554
[25,] 1.20   7.84495
[26,] 1.25   7.39328
[27,] 1.30   6.99117
[28,] 1.35   6.63109
[29,] 1.40   6.30692
[30,] 1.45   6.01368
[31,] 1.50   5.74722
[32,] 1.55   5.50412
[33,] 1.60   5.28149
[34,] 1.65   5.07692
[35,] 1.70   4.88833
[36,] 1.75   4.71396
[37,] 1.80   4.55230
[38,] 1.85   4.40202
[39,] 1.90   4.26200
[40,] 1.95   4.13124
[41,] 2.00   4.00887
```

**Lampiran 5**. *Average Run Length Mixed Exponentially Weighted Moving Average-Cumulative Sum*

```
> x=c(); Z=c(); sdp=c(); Kz=c(); Hz=c(); Mp=c(); Mn=c(); rl=c(); k=0.5;
> h=37.42; ld=0.1
> mus <- (0:40) / 20
> sig <- 1
> results <- c()
>
> for (mu in mus) {
+   for (j in 1:50000) {
+     for (i in 1:1000000) {
+       x[i] <- rnorm(1, mu, sig)
+       if (i == 1) {
+         Z[i] <- ld * x[i] + (1 - ld) * mu
+       } else {
+         Z[i] <- ld * x[i] + (1 - ld) * Z[i - 1]
+       }
+       sdp[i] <- sqrt((ld / (2 - ld)) * (1 - (1 - ld)^(2 * i)))
+       Kz[i] <- k * sdp[i]
+       Hz[i] <- h * sdp[i]
+       if (i == 1) {
+         Mp[i] <- max(0, Z[i] - Kz[i])
+       } else {
+         Mp[i] <- max(0, Z[i] - Kz[i] + Mp[i - 1])
+       }
+       if (i == 1) {
+         Mn[i] <- max(0, -Z[i] - Kz[i])
+       } else {
+         Mn[i] <- max(0, -Z[i] - Kz[i] + Mn[i - 1])
+       }
+       if (Mp[i] > Hz[i] | Mn[i] > Hz[i]) {
+         rl[j] <- i
+         break
+       } else {
+         rl[j] <- 0
+       }
+     }
+   }
+   results <- c(results, mean(rl))
+ }
>
> results
```

```
 [1]  500.17656  391.09318  237.58058  148.29944   98.79304
70.79226  53.47932
 [8]  42.22010  34.47268  28.96032  24.67360  21.51868  18.99906
16.97064
```

**Lampiran 5**. *Average Run Length Mixed Exponentially Weighted Moving Average-Cumulative Sum* (Lanjutan)

```
[15]  15.28540  13.92684  12.71404  11.73546  10.83448  10.07666
9.39332
[22]   8.81212   8.24700   7.76166   7.32260   6.93464   6.56102
6.23430
[29]   5.92342   5.64170   5.38374   5.14416   4.91876   4.70450
4.49742
[36]   4.31450   4.16118   4.03140   3.90280   3.75242   3.58554
```

```
> x=c(); Z=c(); sdp=c(); Kz=c(); Hz=c(); Mp=c(); Mn=c(); rl=c(); k=0.5;
> h=20.18; ld=0.25
 > mus <- (0:40) / 20
 > sig <- 1
 >
 > results <- c()
 >
 > for (mu in mus) {
 +   for (j in 1:50000) {
 +     for (i in 1:1000000) {
 +       x[i] <- rnorm(1, mu, sig)
 +       if (i == 1) {
 +         Z[i] <- ld * x[i] + (1 - ld) * mu
 +       } else {
 +         Z[i] <- ld * x[i] + (1 - ld) * Z[i - 1]
 +       }
 +       sdp[i] <- sqrt((ld / (2 - ld)) * (1 - (1 - ld)^(2 * i)))
 +       Kz[i] <- k * sdp[i]
 +       Hz[i] <- h * sdp[i]
 +       if (i == 1) {
 +         Mp[i] <- max(0, Z[i] - Kz[i])
 +       } else {
 +         Mp[i] <- max(0, Z[i] - Kz[i] + Mp[i - 1])
 +       }
 +       if (i == 1) {
 +         Mn[i] <- max(0, -Z[i] - Kz[i])
 +       } else {
 +         Mn[i] <- max(0, -Z[i] - Kz[i] + Mn[i - 1])
 +       }
 +       if (Mp[i] > Hz[i] | Mn[i] > Hz[i]) {
 +         rl[j] <- i
 +         break
 +       } else {
 +         rl[j] <- 0
 +       }
 +     }
 +   }
 +   results <- c(results, mean(rl))
 + }
 > results
```

**Lampiran 5**. *Average Run Length Mixed Exponentially Weighted Moving Average-Cumulative Sum* (Lanjutan)

```
[1] 501.42114 415.49922 274.00748 173.20146 115.81726  82.84114
61.46440
 [8]  48.01640  39.08552  32.30204  27.47172  23.86846  20.98142
18.69410
[15]  16.80428  15.26592  13.99206  12.83248  11.89336  11.09568
10.36936
[22]   9.77792   9.20730   8.70686   8.26342   7.86660   7.50614
7.16118
[29]   6.85078   6.56958   6.29862   6.06832   5.83984   5.63980
5.44526
[36]   5.25608   5.08954   4.93754   4.77516   4.64292   4.51072
```

```
> x=c(); Z=c(); sdp=c(); Kz=c(); Hz=c(); Mp=c(); Mn=c(); rl=c(); k=0.5;
> h=11.2; ld=0.5
> mus <- (0:40) / 20
> sig <- 1
>
> results <- c()
>
> for (mu in mus) {
+   for (j in 1:50000) {
+     for (i in 1:1000000) {
+       x[i] <- rnorm(1, mu, sig)
+       if (i == 1) {
+         Z[i] <- ld * x[i] + (1 - ld) * mu
+       } else {
+         Z[i] <- ld * x[i] + (1 - ld) * Z[i - 1]
+       }
+       sdp[i] <- sqrt((ld / (2 - ld)) * (1 - (1 - ld)^(2 * i)))
+       Kz[i] <- k * sdp[i]
+       Hz[i] <- h * sdp[i]
+       if (i == 1) {
+         Mp[i] <- max(0, Z[i] - Kz[i])
+       } else {
+         Mp[i] <- max(0, Z[i] - Kz[i] + Mp[i - 1])
+       }
+       if (i == 1) {
+         Mn[i] <- max(0, -Z[i] - Kz[i])
+       } else {
+         Mn[i] <- max(0, -Z[i] - Kz[i] + Mn[i - 1])
+       }
+       if (Mp[i] > Hz[i] | Mn[i] > Hz[i]) {
+         rl[j] <- i
+         break
+       } else {
+         rl[j] <- 0
+       }
+     }
```

**Lampiran 5**. *Average Run Length Mixed Exponentially Weighted Moving Average-Cumulative Sum* (Lanjutan)

```
+   }
+   results <- c(results, mean(rl))
+ }
>
> results
```

```
 [1]   505.95090   437.76800   315.81696   210.98594   140.98548
98.27370  71.81112
 [8]  55.36096  43.67736  35.75374  29.72312  25.52736  22.00990
19.44252
[15]  17.35402  15.55700  14.13052  12.92960  11.93480  11.07234
10.31618
[22]   9.68068   9.06638   8.52386   8.08858   7.68394   7.29836
6.95182
[29]   6.64742   6.35916   6.11252   5.88446   5.67598   5.45580
5.27750
[36]   5.08890   4.93728   4.78832   4.63418   4.51232   4.39414
```

```
 > x=c(); Z=c(); sdp=c(); Kz=c(); Hz=c(); Mp=c(); Mn=c(); rl=c(); k=0.5;
 > h=7.32; ld=0.75
 > mus <- (0:40) / 20
 > sig <- 1
 >
 > results <- c()
>
> for (mu in mus) {
+   for (j in 1:50000) {
+     for (i in 1:1000000) {
+       x[i] <- rnorm(1, mu, sig)
+       if (i == 1) {
+         Z[i] <- ld * x[i] + (1 - ld) * mu
+       } else {
+         Z[i] <- ld * x[i] + (1 - ld) * Z[i - 1]
+       }
+       sdp[i] <- sqrt((ld / (2 - ld)) * (1 - (1 - ld)^(2 * i)))
+       Kz[i] <- k * sdp[i]
+       Hz[i] <- h * sdp[i]
+       if (i == 1) {
+         Mp[i] <- max(0, Z[i] - Kz[i])
+       } else {
+         Mp[i] <- max(0, Z[i] - Kz[i] + Mp[i - 1])
+       }
+       if (i == 1) {
+         Mn[i] <- max(0, -Z[i] – Kz[i])
+       } else {
+         Mn[i] <- max(0, -Z[i] - Kz[i] + Mn[i - 1])
+       }
```

**Lampiran 5**. *Average Run Length Mixed Exponentially Weighted Moving Average-Cumulative Sum* (Lanjutan)

```
+      if (Mp[i] > Hz[i] | Mn[i] > Hz[i]) {
+        rl[j] <- i
+        break
+      } else {
+        rl[j] <- 0
+      }
+    }
+  }
+  results <- c(results, mean(rl))
+ }
> results
```

```
[1] 504.06816 457.89220 343.31642 242.95732 170.37154 120.72918
87.23636
 [8]  65.22140  50.58666  40.60580  32.95230  27.56270  23.49550
20.56204
[15]  17.96516  16.03644  14.56262  13.11624  12.02926  11.06530
10.28724
[22]   9.58244   8.94876   8.41944   7.92950   7.52162   7.15238
6.78826
[29]   6.46854   6.17204   5.93336   5.67972   5.48016   5.24612
5.06440
[36]   4.89764   4.73678   4.57614   4.45220   4.30620   4.18528
```

**Lampiran 6.** Peta kendali EWMA fase I

```
> setwd("D:/coolyah")
> data <- read.csv('data1.csv', header = TRUE, sep = ';')
> data_subset <- data$Fe[1:96]
>
> EWMA <- function(data_subset, miu0, lambda, L, plot_title) {
+   n <- length(data_subset)
+   sigma <- sd(data_subset)
+   Zi <- numeric(n + 1)
+   BKA <- numeric(n)
+   GT <- numeric(n)
+   BKB <- numeric(n)
+   keterangan <- character(n)
+
+   Zi[1] <- miu0
+   for (i in 1:n) {
+     Zi[i + 1] <- lambda * data_subset[i] + (1 - lambda) * Zi[i]
+     BKA[i] <- miu0 + ((L * sigma) * sqrt((lambda / (2 - lambda)) * (1 - (1 -
lambda)^(2 * i))))
+     GT[i] <- miu0
+     BKB[i] <- miu0 - ((L * sigma) * sqrt((lambda / (2 - lambda)) * (1 - (1 -
lambda)^(2 * i))))
+
+     if (Zi[i + 1] <= BKA[i] && Zi[i + 1] >= BKB[i]) {
+       keterangan[i] <- "Terkendali"
+     } else {
+       keterangan[i] <- "TIDAK TERKENDALI"
+     }
+   }
+
+   sampel <- 1:n
+
+   result <- data.frame(
+     Sampel = sampel,
+     Zi = Zi[2:(n + 1)],
+     BKA= BKA,
+     GT = GT,
+     BKB= BKB,
+     keterangan = keterangan
+   )
+   print(result)
+
+   windows()
```

**Lampiran 6.** Peta kendali EWMA fase I (Lanjutan)

```
+   plot(Zi[2:(n + 1)], type = "o", col = "blue", xlab = "Observasi ke-", ylab = "Zi",
+       main = plot_title, ylim = range(c(BKB, BKA, Zi[2:(n + 1)])))
+   lines(BKA, type = "l", col = "red")
+   lines(BKB, type = "l", col = "green")
+   lines(GT, type = "l", col = "black")
+   points(which(result$keterangan == "TIDAK TERKENDALI"),
Zi[which(result$keterangan == "TIDAK TERKENDALI") + 1], col = "red", pch =
19)
+   legend("topright", legend = c("BKA", "BKB", "GT"),
               col = c("red", "green", "black"), lty = 1)
+   return(result)
+ }
> EWMA_InControl <- function(data, miu0, lambda, L) {
+   iterasi <- 0
+   sd_iterasi <- numeric()
+   repeat {
+     sd_iterasi <- c(sd_iterasi, sd(data))
+     plot_title <- paste("Peta Kendali EWMA Fase I Iterasi", iterasi + 1)
+     hasil_EWMA <- EWMA(data, miu0, lambda, L, plot_title)
+     iterasi <- iterasi + 1
+     if (!any(hasil_EWMA$keterangan == "TIDAK TERKENDALI")) {
+       cat("Total iterasi untuk mencapai kontrol:", iterasi, "\n")
+       break
+     }
+     data <- data[hasil_EWMA$keterangan == "Terkendali"]
+   }
+   iterasi_df <- data.frame(
+     Iterasi = 1:iterasi,
+     SD = sd_iterasi
+   )
+   print(iterasi_df)
+   return(list(hasil_EWMA = hasil_EWMA, iterasi_df = iterasi_df))
+ }
```

```
> hasil_EWMA <- EWMA_InControl(data_subset, 20, 0.1, 2.824)
  Sampel       Zi      BKA GT      BKB       keterangan
1      1 19.83000 20.31735 20 19.68265       Terkendali
2      2 19.81700 20.42694 20 19.57306       Terkendali
3      3 19.97530 20.49835 20 19.50165       Terkendali
4      4 20.04777 20.54943 20 19.45057       Terkendali
```

**Lampiran 6.** Peta kendali EWMA fase I (Lanjutan)

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | 5 | 20.13299 | 20.58756 | 20 | 19.41244 | Terkendali |
| 6 | 6 | 20.15969 | 20.61672 | 20 | 19.38328 | Terkendali |
| 7 | 7 | 20.09372 | 20.63936 | 20 | 19.36064 | Terkendali |
| 8 | 8 | 20.03435 | 20.65713 | 20 | 19.34287 | Terkendali |
| 9 | 9 | 20.02092 | 20.67118 | 20 | 19.32882 | Terkendali |
| 10 | 10 | 20.08883 | 20.68235 | 20 | 19.31765 | Terkendali |
| 11 | 11 | 20.17994 | 20.69126 | 20 | 19.30874 | Terkendali |
| 12 | 12 | 20.28195 | 20.69840 | 20 | 19.30160 | Terkendali |
| 13 | 13 | 20.33375 | 20.70413 | 20 | 19.29587 | Terkendali |
| 14 | 14 | 20.35038 | 20.70873 | 20 | 19.29127 | Terkendali |
| 15 | 15 | 20.34534 | 20.71244 | 20 | 19.28756 | Terkendali |
| 16 | 16 | 20.41081 | 20.71543 | 20 | 19.28457 | Terkendali |
| 17 | 17 | 20.49973 | 20.71784 | 20 | 19.28216 | Terkendali |
| 18 | 18 | 20.53975 | 20.71979 | 20 | 19.28021 | Terkendali |
| 19 | 19 | 20.56578 | 20.72137 | 20 | 19.27863 | Terkendali |
| 20 | 20 | 20.41920 | 20.72264 | 20 | 19.27736 | Terkendali |
| 21 | 21 | 20.28728 | 20.72367 | 20 | 19.27633 | Terkendali |
| 22 | 22 | 20.23855 | 20.72450 | 20 | 19.27550 | Terkendali |
| 23 | 23 | 20.18470 | 20.72518 | 20 | 19.27482 | Terkendali |
| 24 | 24 | 20.11623 | 20.72572 | 20 | 19.27428 | Terkendali |
| 25 | 25 | 20.03460 | 20.72616 | 20 | 19.27384 | Terkendali |
| 26 | 26 | 19.89114 | 20.72652 | 20 | 19.27348 | Terkendali |
| 27 | 27 | 19.85203 | 20.72681 | 20 | 19.27319 | Terkendali |
| 28 | 28 | 19.84683 | 20.72704 | 20 | 19.27296 | Terkendali |
| 29 | 29 | 19.92214 | 20.72723 | 20 | 19.27277 | Terkendali |
| 30 | 30 | 20.08993 | 20.72739 | 20 | 19.27261 | Terkendali |
| 31 | 31 | 20.30094 | 20.72751 | 20 | 19.27249 | Terkendali |
| 32 | 32 | 20.52084 | 20.72761 | 20 | 19.27239 | Terkendali |
| 33 | 33 | 20.66876 | 20.72769 | 20 | 19.27231 | Terkendali |
| 34 | 34 | 20.70188 | 20.72776 | 20 | 19.27224 | Terkendali |
| 35 | 35 | 20.78169 | 20.72781 | 20 | 19.27219 | TIDAK TERKENDALI |
| 36 | 36 | 20.84353 | 20.72786 | 20 | 19.27214 | TIDAK TERKENDALI |
| 37 | 37 | 20.98917 | 20.72789 | 20 | 19.27211 | TIDAK TERKENDALI |
| 38 | 38 | 21.11026 | 20.72792 | 20 | 19.27208 | TIDAK TERKENDALI |
| 39 | 39 | 21.24923 | 20.72794 | 20 | 19.27206 | TIDAK TERKENDALI |
| 40 | 40 | 21.39431 | 20.72796 | 20 | 19.27204 | TIDAK TERKENDALI |
| 41 | 41 | 21.45488 | 20.72798 | 20 | 19.27202 | TIDAK TERKENDALI |
| 42 | 42 | 21.51939 | 20.72799 | 20 | 19.27201 | TIDAK TERKENDALI |
| 43 | 43 | 21.43745 | 20.72800 | 20 | 19.27200 | TIDAK TERKENDALI |
| 44 | 44 | 21.38370 | 20.72801 | 20 | 19.27199 | TIDAK TERKENDALI |
| 45 | 45 | 21.28533 | 20.72801 | 20 | 19.27199 | TIDAK TERKENDALI |
| 46 | 46 | 21.14680 | 20.72802 | 20 | 19.27198 | TIDAK TERKENDALI |
| 47 | 47 | 20.98212 | 20.72802 | 20 | 19.27198 | TIDAK TERKENDALI |
| 48 | 48 | 20.79391 | 20.72803 | 20 | 19.27197 | TIDAK TERKENDALI |
| 49 | 49 | 20.59452 | 20.72803 | 20 | 19.27197 | Terkendali |
| 50 | 50 | 20.61507 | 20.72803 | 20 | 19.27197 | Terkendali |
| 51 | 51 | 20.69356 | 20.72803 | 20 | 19.27197 | Terkendali |
| 52 | 52 | 20.72420 | 20.72803 | 20 | 19.27197 | Terkendali |
| 53 | 53 | 20.74178 | 20.72804 | 20 | 19.27196 | TIDAK TERKENDALI |
| 54 | 54 | 20.74760 | 20.72804 | 20 | 19.27196 | TIDAK TERKENDALI |
| 55 | 55 | 20.72284 | 20.72804 | 20 | 19.27196 | Terkendali |
| 56 | 56 | 20.69056 | 20.72804 | 20 | 19.27196 | Terkendali |
| 57 | 57 | 20.58150 | 20.72804 | 20 | 19.27196 | Terkendali |
| 58 | 58 | 20.43335 | 20.72804 | 20 | 19.27196 | Terkendali |
| 59 | 59 | 20.28002 | 20.72804 | 20 | 19.27196 | Terkendali |
| 60 | 60 | 20.21202 | 20.72804 | 20 | 19.27196 | Terkendali |
| 61 | 61 | 20.27081 | 20.72804 | 20 | 19.27196 | Terkendali |
| 62 | 62 | 20.28373 | 20.72804 | 20 | 19.27196 | Terkendali |
| 63 | 63 | 20.29536 | 20.72804 | 20 | 19.27196 | Terkendali |
| 64 | 64 | 20.37582 | 20.72804 | 20 | 19.27196 | Terkendali |
| 65 | 65 | 20.26824 | 20.72804 | 20 | 19.27196 | Terkendali |
| 66 | 66 | 20.24142 | 20.72804 | 20 | 19.27196 | Terkendali |

**Lampiran 6.** Peta kendali EWMA fase I (Lanjutan)

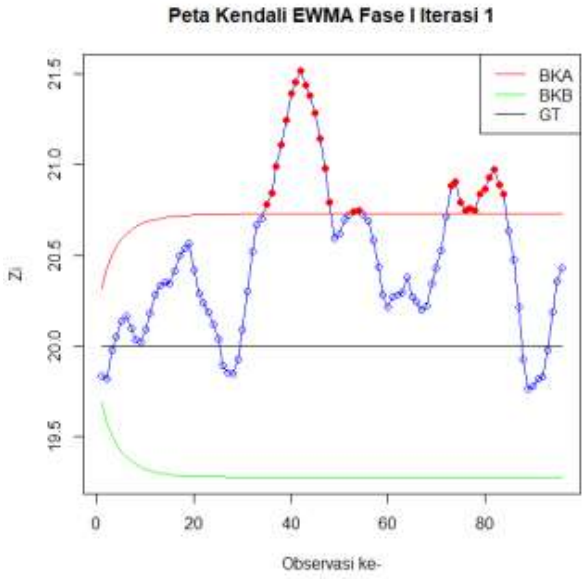
| | | | | | | |
|---|---|---|---|---|---|---|
| 67 | 67 | 20.19728 | 20.72804 | 20 | 19.27196 | Terkendali |
| 68 | 68 | 20.21755 | 20.72804 | 20 | 19.27196 | Terkendali |
| 69 | 69 | 20.34579 | 20.72804 | 20 | 19.27196 | Terkendali |
| 70 | 70 | 20.43121 | 20.72804 | 20 | 19.27196 | Terkendali |
| 71 | 71 | 20.52809 | 20.72804 | 20 | 19.27196 | Terkendali |
| 72 | 72 | 20.71528 | 20.72804 | 20 | 19.27196 | Terkendali |
| 73 | 73 | 20.88375 | 20.72804 | 20 | 19.27196 | TIDAK TERKENDALI |
| 74 | 74 | 20.90538 | 20.72804 | 20 | 19.27196 | TIDAK TERKENDALI |
| 75 | 75 | 20.79484 | 20.72804 | 20 | 19.27196 | TIDAK TERKENDALI |
| 76 | 76 | 20.74536 | 20.72804 | 20 | 19.27196 | TIDAK TERKENDALI |
| 77 | 77 | 20.76082 | 20.72804 | 20 | 19.27196 | TIDAK TERKENDALI |
| 78 | 78 | 20.74474 | 20.72804 | 20 | 19.27196 | TIDAK TERKENDALI |
| 79 | 79 | 20.84027 | 20.72804 | 20 | 19.27196 | TIDAK TERKENDALI |
| 80 | 80 | 20.86624 | 20.72804 | 20 | 19.27196 | TIDAK TERKENDALI |
| 81 | 81 | 20.92962 | 20.72804 | 20 | 19.27196 | TIDAK TERKENDALI |
| 82 | 82 | 20.97665 | 20.72804 | 20 | 19.27196 | TIDAK TERKENDALI |
| 83 | 83 | 20.88899 | 20.72804 | 20 | 19.27196 | TIDAK TERKENDALI |
| 84 | 84 | 20.84009 | 20.72804 | 20 | 19.27196 | TIDAK TERKENDALI |
| 85 | 85 | 20.63608 | 20.72804 | 20 | 19.27196 | Terkendali |
| 86 | 86 | 20.47247 | 20.72804 | 20 | 19.27196 | Terkendali |
| 87 | 87 | 20.21523 | 20.72804 | 20 | 19.27196 | Terkendali |
| 88 | 88 | 19.92370 | 20.72804 | 20 | 19.27196 | Terkendali |
| 89 | 89 | 19.76133 | 20.72804 | 20 | 19.27196 | Terkendali |
| 90 | 90 | 19.77520 | 20.72804 | 20 | 19.27196 | Terkendali |
| 91 | 91 | 19.81768 | 20.72804 | 20 | 19.27196 | Terkendali |
| 92 | 92 | 19.82591 | 20.72804 | 20 | 19.27196 | Terkendali |
| 93 | 93 | 19.97332 | 20.72804 | 20 | 19.27196 | Terkendali |
| 94 | 94 | 20.18599 | 20.72804 | 20 | 19.27196 | Terkendali |
| 95 | 95 | 20.35739 | 20.72804 | 20 | 19.27196 | Terkendali |
| 96 | 96 | 20.43165 | 20.72804 | 20 | 19.27196 | Terkendali |

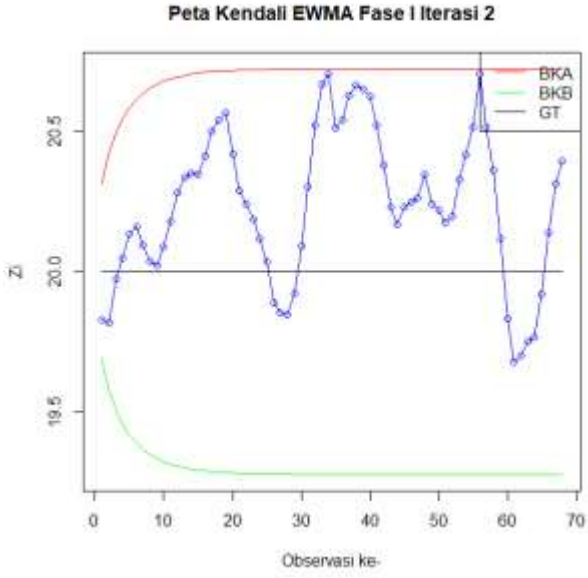
| | Sampel | Zi | BKA | GT | BKB | keterangan |
|---|---|---|---|---|---|---|
| 1 | 1 | 19.83000 | 20.31456 | 20 | 19.68544 | Terkendali |
| 2 | 2 | 19.81700 | 20.42320 | 20 | 19.57680 | Terkendali |
| 3 | 3 | 19.97530 | 20.49398 | 20 | 19.50602 | Terkendali |
| 4 | 4 | 20.04777 | 20.54462 | 20 | 19.45538 | Terkendali |
| 5 | 5 | 20.13299 | 20.58241 | 20 | 19.41759 | Terkendali |
| 6 | 6 | 20.15969 | 20.61131 | 20 | 19.38869 | Terkendali |
| 7 | 7 | 20.09372 | 20.63376 | 20 | 19.36624 | Terkendali |
| 8 | 8 | 20.03435 | 20.65137 | 20 | 19.34863 | Terkendali |
| 9 | 9 | 20.02092 | 20.66530 | 20 | 19.33470 | Terkendali |
| 10 | 10 | 20.08883 | 20.67637 | 20 | 19.32363 | Terkendali |
| 11 | 11 | 20.17994 | 20.68520 | 20 | 19.31480 | Terkendali |
| 12 | 12 | 20.28195 | 20.69228 | 20 | 19.30772 | Terkendali |
| 13 | 13 | 20.33375 | 20.69795 | 20 | 19.30205 | Terkendali |
| 14 | 14 | 20.35038 | 20.70252 | 20 | 19.29748 | Terkendali |
| 15 | 15 | 20.34534 | 20.70620 | 20 | 19.29380 | Terkendali |
| 16 | 16 | 20.41081 | 20.70916 | 20 | 19.29084 | Terkendali |
| 17 | 17 | 20.49973 | 20.71155 | 20 | 19.28845 | Terkendali |
| 18 | 18 | 20.53975 | 20.71348 | 20 | 19.28652 | Terkendali |
| 19 | 19 | 20.56578 | 20.71504 | 20 | 19.28496 | Terkendali |
| 20 | 20 | 20.41920 | 20.71630 | 20 | 19.28370 | Terkendali |
| 21 | 21 | 20.28728 | 20.71732 | 20 | 19.28268 | Terkendali |
| 22 | 22 | 20.23855 | 20.71815 | 20 | 19.28185 | Terkendali |
| 23 | 23 | 20.18470 | 20.71882 | 20 | 19.28118 | Terkendali |
| 24 | 24 | 20.11623 | 20.71936 | 20 | 19.28064 | Terkendali |
| 25 | 25 | 20.03460 | 20.71980 | 20 | 19.28020 | Terkendali |
| 26 | 26 | 19.89114 | 20.72015 | 20 | 19.27985 | Terkendali |
| 27 | 27 | 19.85203 | 20.72044 | 20 | 19.27956 | Terkendali |
| 28 | 28 | 19.84683 | 20.72067 | 20 | 19.27933 | Terkendali |
| 29 | 29 | 19.92214 | 20.72086 | 20 | 19.27914 | Terkendali |
| 30 | 30 | 20.08993 | 20.72101 | 20 | 19.27899 | Terkendali |
| 31 | 31 | 20.30094 | 20.72113 | 20 | 19.27887 | Terkendali |

**Lampiran 6.** Peta kendali EWMA fase I (Lanjutan)

```
32     32 20.52084 20.72123 20 19.27877 Terkendali
33     33 20.66876 20.72131 20 19.27869 Terkendali
34     34 20.70188 20.72138 20 19.27862 Terkendali
35     35 20.51169 20.72143 20 19.27857 Terkendali
36     36 20.54053 20.72147 20 19.27853 Terkendali
37     37 20.62647 20.72151 20 19.27849 Terkendali
38     38 20.66383 20.72154 20 19.27846 Terkendali
39     39 20.64744 20.72156 20 19.27844 Terkendali
40     40 20.62270 20.72158 20 19.27842 Terkendali
41     41 20.52043 20.72159 20 19.27841 Terkendali
42     42 20.37839 20.72161 20 19.27839 Terkendali
43     43 20.23055 20.72162 20 19.27838 Terkendali
44     44 20.16749 20.72162 20 19.27838 Terkendali
45     45 20.23074 20.72163 20 19.27837 Terkendali
46     46 20.24767 20.72163 20 19.27837 Terkendali
47     47 20.26290 20.72164 20 19.27836 Terkendali
48     48 20.34661 20.72164 20 19.27836 Terkendali
49     49 20.24195 20.72165 20 19.27835 Terkendali
50     50 20.21776 20.72165 20 19.27835 Terkendali
51     51 20.17598 20.72165 20 19.27835 Terkendali
52     52 20.19838 20.72165 20 19.27835 Terkendali
53     53 20.32854 20.72165 20 19.27835 Terkendali
54     54 20.41569 20.72165 20 19.27835 Terkendali
55     55 20.51412 20.72165 20 19.27835 Terkendali
56     56 20.70271 20.72165 20 19.27835 Terkendali
57     57 20.51244 20.72165 20 19.27835 Terkendali
58     58 20.36119 20.72166 20 19.27834 Terkendali
59     59 20.11507 20.72166 20 19.27834 Terkendali
60     60 19.83357 20.72166 20 19.27834 Terkendali
61     61 19.68021 20.72166 20 19.27834 Terkendali
62     62 19.70219 20.72166 20 19.27834 Terkendali
63     63 19.75197 20.72166 20 19.27834 Terkendali
64     64 19.76677 20.72166 20 19.27834 Terkendali
65     65 19.92010 20.72166 20 19.27834 Terkendali
66     66 20.13809 20.72166 20 19.27834 Terkendali
67     67 20.31428 20.72166 20 19.27834 Terkendali
68     68 20.39285 20.72166 20 19.27834 Terkendali
Total iterasi untuk mencapai kontrol: 2
  Iterasi       SD
1       1 1.123745
2   2 1.113892
```

**Lampiran 6.** Peta kendali EWMA fase I (Lanjutan)



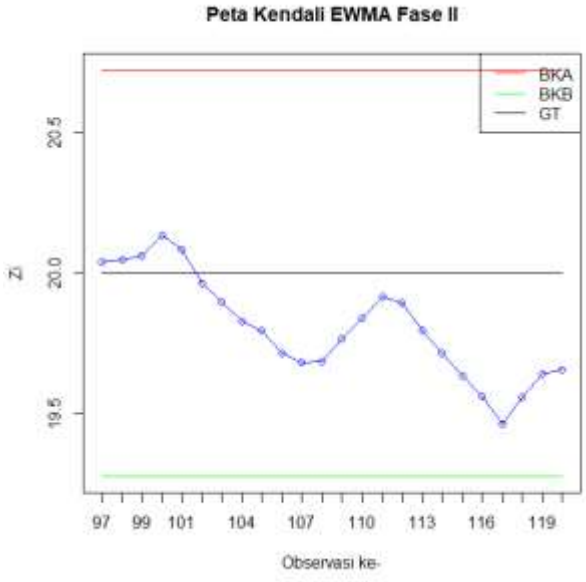
**Lampiran 7.** Peta kendali EWMA fase II

```
> setwd("D:/coolyah")
> new_data <- read.csv('data1.csv', header = TRUE, sep = ';')
> new_data_subset <- tail(new_data$Fe, 24)
> BKA <- rep(20.72166, 24)
> BKB <- rep(19.27834, 24)
> EWMA <- function(data, miu0, lambda, BKA, BKB, plot_title) {
+   n <- length(data)
+   Zi <- numeric(n + 1)
+   GT <- numeric(n)
+   keterangan <- character(n)
+
+   Zi[1] <- miu0
+   for (i in 1:n) {
+     Zi[i + 1] <- lambda * data[i] + (1 - lambda) * Zi[i]
+     GT[i] <- miu0
+
+     if (Zi[i + 1] <= BKA[i] && Zi[i + 1] >= BKB[i]) {
+       keterangan[i] <- "Terkendali"
+     } else {
+       keterangan[i] <- "TIDAK TERKENDALI"
+     }
+   }
+   filter_data <- data[keterangan == "Terkendali"]
+   filter_sd <- sd(filter_data)
+   df_hasil <- data.frame(
+     Sampel = 97:120,
+     Zi = Zi[2:(n + 1)],
+     BKA = BKA[1:n],
+     GT = GT[1:n],
+     BKB = LCL[1:n],
+     keterangan = keterangan
+   )
+   print(df_hasil)
+   windows()
+
+   plot(Zi[2:(n + 1)], type = "o", col = "blue", xlab = "Observasi ke-", ylab = "Zi",
+        main = plot_title, ylim = range(c(BKB, BKA, Zi[2:(n + 1)])), xaxt = "n")
+
+   axis(1, at = 1:n, labels = 97:120)
+   lines(BKA, type = "l", col = "red")
+   lines(BKB, type = "l", col = "green")
+   lines(GT, type = "l", col = "black")
+   points(which(df_hasil$keterangan == "TIDAK TERKENDALI"), Zi[which(df_ha
sil$keterangan == "TIDAK TERKENDALI") + 1], col = "red", pch = 19) +
+   legend("topright", legend = c("BKA", "BKB", "GT"),
+          col = c("red", "green", "black"), lty = 1)
+   return(list(df_hasil = df_hasil, filter_sd = filter_sd))
+ }
```

**Lampiran 7.** Peta kendali EWMA fase II (Lanjutan)

```
> ewma_result <- EWMA(new_data_subset, miu0=20, lambda = 0.1,
BKA = BKA, BKB = BKB, plot_title="Peta Kendali EWMA Fase II")
```

| Sampel | | Zi | BKA | GT | BKB | keterangan |
|---|---|---|---|---|---|---|
| 1 | 97 | 20.04000 | 20.72166 | 20 | 19.27834 | Terkendali |
| 2 | 98 | 20.04600 | 20.72166 | 20 | 19.27834 | Terkendali |
| 3 | 99 | 20.06140 | 20.72166 | 20 | 19.27834 | Terkendali |
| 4 | 100 | 20.13526 | 20.72166 | 20 | 19.27834 | Terkendali |
| 5 | 101 | 20.08173 | 20.72166 | 20 | 19.27834 | Terkendali |
| 6 | 102 | 19.96356 | 20.72166 | 20 | 19.27834 | Terkendali |
| 7 | 103 | 19.89720 | 20.72166 | 20 | 19.27834 | Terkendali |
| 8 | 104 | 19.82748 | 20.72166 | 20 | 19.27834 | Terkendali |
| 9 | 105 | 19.79474 | 20.72166 | 20 | 19.27834 | Terkendali |
| 10 | 106 | 19.71526 | 20.72166 | 20 | 19.27834 | Terkendali |
| 11 | 107 | 19.68374 | 20.72166 | 20 | 19.27834 | Terkendali |
| 12 | 108 | 19.68536 | 20.72166 | 20 | 19.27834 | Terkendali |
| 13 | 109 | 19.76683 | 20.72166 | 20 | 19.27834 | Terkendali |
| 14 | 110 | 19.84014 | 20.72166 | 20 | 19.27834 | Terkendali |
| 15 | 111 | 19.91613 | 20.72166 | 20 | 19.27834 | Terkendali |
| 16 | 112 | 19.89452 | 20.72166 | 20 | 19.27834 | Terkendali |
| 17 | 113 | 19.79506 | 20.72166 | 20 | 19.27834 | Terkendali |
| 18 | 114 | 19.71556 | 20.72166 | 20 | 19.27834 | Terkendali |
| 19 | 115 | 19.63400 | 20.72166 | 20 | 19.27834 | Terkendali |
| 20 | 116 | 19.56060 | 20.72166 | 20 | 19.27834 | Terkendali |
| 21 | 117 | 19.46454 | 20.72166 | 20 | 19.27834 | Terkendali |
| 22 | 118 | 19.55809 | 20.72166 | 20 | 19.27834 | Terkendali |
| 23 | 119 | 19.64228 | 20.72166 | 20 | 19.27834 | Terkendali |
| 24 | 120 | 19.65805 | 20.72166 | 20 | 19.27834 | Terkendali |



**Lampiran 8**. Peta kendali CUSUM fase I

```
> data <- read.csv('data1.csv', header = TRUE, sep = ';')
> data_subset <- data$Fe[1:96]
> CUSUM <- function(data_subset, miu0, h, k, standar = TRUE) {
+   n <- length(data_subset)
+   sigma <- sd(data_subset)
+   K <- k * sigma
+   BKA <- h * sigma
+   BKB <- -h * sigma
+   Cplus <- numeric(n + 1)
+   Cmin <- numeric(n + 1)
+   Cplus[1] <- 0
+   Cmin[1] <- 0
+
+   hasil <- character(n)
+
+   for (i in 1:n) {
+     Cplus[i + 1] <- max(0, (data_subset[i] - (miu0 + K) + Cplus[i]))
+     Cmin[i + 1] <- max(0, ((miu0 - K) - data_subset[i] + Cmin[i]))
+
+     if ((Cplus[i + 1] <= BKA) && (Cmin[i + 1] <= BKA)) {
+       hasil[i] <- "Terkendali"
+     } else {
+       hasil[i] <- "Tidak Terkendali"
+     }
+   }
+
+   sampel <- 1:n
+   result <- data.frame(
+     Sampel = sampel,
+     Cplus = Cplus[2:(n + 1)],
+     Cmin = Cmin[2:(n + 1)],
+     BKA = rep(BKA, n),
+     BKB = rep(BKB, n),
+     Keterangan = hasil
+   )
+   plot(result$Cplus, col = "blue", type = "b", main = "Peta Kendali CUSUM", ylim
= c(min(result$Cmin, result$BKB), max(result$Cplus, result$BKA)), ylab = "Ci",
xlab = "Observasi ke-")
+   lines(result$Cmin, col = "red", type = "b", lwd = 1)
+   abline(h = result$BKA[1], col = "black", lwd = 2)
+   abline(h = result$BKB[1], col = "black", lwd = 2)
```

**Lampiran 8**. Peta kendali CUSUM fase I (Lanjutan)

```
+   legend("topleft", legend = c("C+(Cplus)", "C-(Cmin)", "BKA", "BKB"),
+          col = c("blue", "red", "black", "black"), pch = c(NA, NA, NA, NA), lty = 1,
cex = 0.5)
+   print(result)
+   return(result)
+ }
> recalculate_control <- function(data, miu0 = 20, h, k, standar = TRUE) {
+   iterasi <- 0
+   sd_iterasi <- numeric()
+
+   repeat {
+     sd_iterasi <- c(sd_iterasi, sd(data))
+     controls <- CUSUM(data, miu0, h, k, standar)
+     iterasi <- iterasi + 1
+     if (!any(controls$Keterangan == "Tidak Terkendali")) {
+       cat("Total iterasi untuk mencapai kontrol:", iterasi, "\n")
+       break
+     }
+     data <- data[controls$Keterangan == "Terkendali"]
+   }
+   iterasi_stats <- data.frame(
+     Iterasi = 1:iterasi,
+     SD = sd_iterasi
+   )
+   print(iterasi_stats)
+
+   return(list(controls = controls, iterasi_stats = iterasi_stats, update_data =
data))
+ }
> result <- recalculate_control(data_subset, miu0 = 20, h = 5, k = 0
.5, standar = FALSE)
   Sampel       Cplus       Cmin      BKA       BKB       Keterangan
1       1  0.00000000 1.13812754 5.618725 -5.618725       Terkendali
2       2  0.00000000 0.87625509 5.618725 -5.618725       Terkendali
3       3  0.83812754 0.00000000 5.618725 -5.618725       Terkendali
4       4  0.97625509 0.00000000 5.618725 -5.618725       Terkendali
5       5  1.31438263 0.00000000 5.618725 -5.618725       Terkendali
6       6  1.15251017 0.00000000 5.618725 -5.618725       Terkendali
7       7  0.09063772 0.00000000 5.618725 -5.618725       Terkendali
8       8  0.00000000 0.00000000 5.618725 -5.618725       Terkendali
9       9  0.00000000 0.00000000 5.618725 -5.618725       Terkendali
10     10  0.13812754 0.00000000 5.618725 -5.618725       Terkendali
11     11  0.57625509 0.00000000 5.618725 -5.618725       Terkendali
12     12  1.21438263 0.00000000 5.618725 -5.618725       Terkendali
13     13  1.45251017 0.00000000 5.618725 -5.618725       Terkendali
14     14  1.39063772 0.00000000 5.618725 -5.618725       Terkendali
```

**Lampiran 8**. Peta kendali CUSUM fase I (Lanjutan)

| | | | | | | |
|---|---|---|---|---|---|---|
| 15 | 15 | 1.12876526 | 0.00000000 | 5.618725 | -5.618725 | Terkendali |
| 16 | 16 | 1.56689280 | 0.00000000 | 5.618725 | -5.618725 | Terkendali |
| 17 | 17 | 2.30502034 | 0.00000000 | 5.618725 | -5.618725 | Terkendali |
| 18 | 18 | 2.64314789 | 0.00000000 | 5.618725 | -5.618725 | Terkendali |
| 19 | 19 | 2.88127543 | 0.00000000 | 5.618725 | -5.618725 | Terkendali |
| 20 | 20 | 1.41940297 | 0.33812754 | 5.618725 | -5.618725 | Terkendali |
| 21 | 21 | 0.00000000 | 0.67625509 | 5.618725 | -5.618725 | Terkendali |
| 22 | 22 | 0.00000000 | 0.31438263 | 5.618725 | -5.618725 | Terkendali |
| 23 | 23 | 0.00000000 | 0.05251017 | 5.618725 | -5.618725 | Terkendali |
| 24 | 24 | 0.00000000 | 0.00000000 | 5.618725 | -5.618725 | Terkendali |
| 25 | 25 | 0.00000000 | 0.13812754 | 5.618725 | -5.618725 | Terkendali |
| 26 | 26 | 0.00000000 | 0.97625509 | 5.618725 | -5.618725 | Terkendali |
| 27 | 27 | 0.00000000 | 0.91438263 | 5.618725 | -5.618725 | Terkendali |
| 28 | 28 | 0.00000000 | 0.55251017 | 5.618725 | -5.618725 | Terkendali |
| 29 | 29 | 0.03812754 | 0.00000000 | 5.618725 | -5.618725 | Terkendali |
| 30 | 30 | 1.07625509 | 0.00000000 | 5.618725 | -5.618725 | Terkendali |
| 31 | 31 | 2.71438263 | 0.00000000 | 5.618725 | -5.618725 | Terkendali |
| 32 | 32 | 4.65251017 | 0.00000000 | 5.618725 | -5.618725 | Terkendali |
| 33 | 33 | 6.09063772 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 34 | 34 | 6.52876526 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 35 | 35 | 7.46689280 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 36 | 36 | 8.30502034 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 37 | 37 | 10.04314789 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 38 | 38 | 11.68127543 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 39 | 39 | 13.61940297 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 40 | 40 | 15.75753052 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 41 | 41 | 17.19565806 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 42 | 42 | 18.73378560 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 43 | 43 | 18.87191315 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 44 | 44 | 19.21004069 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 45 | 45 | 19.04816823 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 46 | 46 | 18.38629577 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 47 | 47 | 17.32442332 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 48 | 48 | 15.86255086 | 0.33812754 | 5.618725 | -5.618725 | Tidak Terkendali |
| 49 | 49 | 14.10067840 | 0.97625509 | 5.618725 | -5.618725 | Tidak Terkendali |
| 50 | 50 | 14.33880595 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 51 | 51 | 15.17693349 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 52 | 52 | 15.61506103 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 53 | 53 | 15.95318858 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 54 | 54 | 16.19131612 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 55 | 55 | 16.12944366 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 56 | 56 | 15.96757121 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 57 | 57 | 15.00569875 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 58 | 58 | 13.54382629 | 0.33812754 | 5.618725 | -5.618725 | Tidak Terkendali |
| 59 | 59 | 11.88195383 | 0.87625509 | 5.618725 | -5.618725 | Tidak Terkendali |
| 60 | 60 | 10.92008138 | 0.71438263 | 5.618725 | -5.618725 | Tidak Terkendali |
| 61 | 61 | 11.15820892 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 62 | 62 | 10.99633646 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 63 | 63 | 10.83446401 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 64 | 64 | 11.37259155 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 65 | 65 | 10.11071909 | 0.13812754 | 5.618725 | -5.618725 | Tidak Terkendali |
| 66 | 66 | 9.54884664 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 67 | 67 | 8.78697418 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 68 | 68 | 8.62510172 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 69 | 69 | 9.56322926 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 70 | 70 | 10.20135681 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 71 | 71 | 11.03948435 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 72 | 72 | 12.87761189 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 73 | 73 | 14.71573944 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 74 | 74 | 15.25386698 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 75 | 75 | 14.49199452 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 76 | 76 | 14.23012207 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |

**Lampiran 8**. Peta kendali CUSUM fase I (Lanjutan)

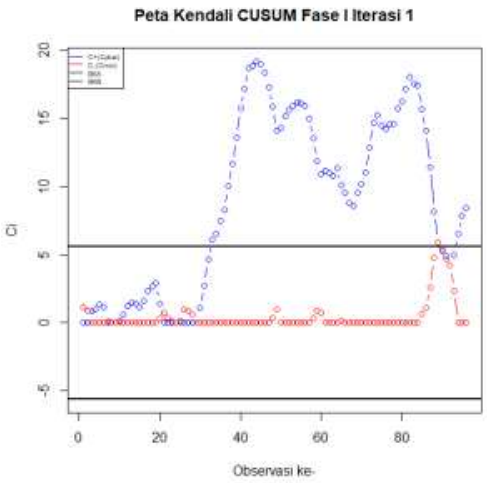
| | | | | | | |
|---|---|---|---|---|---|---|
| 77 | 77 | 14.56824961 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 78 | 78 | 14.60637715 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 79 | 79 | 15.74450469 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 80 | 80 | 16.28263224 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 81 | 81 | 17.22075978 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 82 | 82 | 18.05888732 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 83 | 83 | 17.59701487 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 84 | 84 | 17.43514241 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 85 | 85 | 15.67326995 | 0.63812754 | 5.618725 | -5.618725 | Tidak Terkendali |
| 86 | 86 | 14.11139750 | 1.07625509 | 5.618725 | -5.618725 | Tidak Terkendali |
| 87 | 87 | 11.44952504 | 2.61438263 | 5.618725 | -5.618725 | Tidak Terkendali |
| 88 | 88 | 8.18765258 | 4.75251017 | 5.618725 | -5.618725 | Tidak Terkendali |
| 89 | 89 | 5.92578013 | 5.89063772 | 5.618725 | -5.618725 | Tidak Terkendali |
| 90 | 90 | 5.26390767 | 5.42876526 | 5.618725 | -5.618725 | Terkendali |
| 91 | 91 | 4.90203521 | 4.66689280 | 5.618725 | -5.618725 | Terkendali |
| 92 | 92 | 4.24016275 | 4.20502034 | 5.618725 | -5.618725 | Terkendali |
| 93 | 93 | 4.97829030 | 2.34314789 | 5.618725 | -5.618725 | Terkendali |
| 94 | 94 | 6.51641784 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 95 | 95 | 7.85454538 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |
| 96 | 96 | 8.39267293 | 0.00000000 | 5.618725 | -5.618725 | Tidak Terkendali |

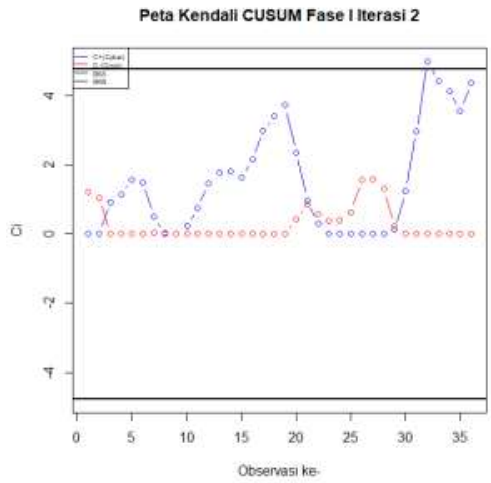
| | Sampel | Cplus | Cmin | BKA | BKB | Keterangan |
|---|---|---|---|---|---|---|
| 1 | 1 | 0.0000000 | 1.2230304 | 4.769696 | -4.769696 | Terkendali |
| 2 | 2 | 0.0000000 | 1.0460608 | 4.769696 | -4.769696 | Terkendali |
| 3 | 3 | 0.9230304 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 4 | 4 | 1.1460608 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 5 | 5 | 1.5690912 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 6 | 6 | 1.4921216 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 7 | 7 | 0.5151520 | 0.0230304 | 4.769696 | -4.769696 | Terkendali |
| 8 | 8 | 0.0000000 | 0.0460608 | 4.769696 | -4.769696 | Terkendali |
| 9 | 9 | 0.0000000 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 10 | 10 | 0.2230304 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 11 | 11 | 0.7460608 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 12 | 12 | 1.4690912 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 13 | 13 | 1.7921216 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 14 | 14 | 1.8151520 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 15 | 15 | 1.6381824 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 16 | 16 | 2.1612128 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 17 | 17 | 2.9842432 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 18 | 18 | 3.4072736 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 19 | 19 | 3.7303040 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 20 | 20 | 2.3533344 | 0.4230304 | 4.769696 | -4.769696 | Terkendali |
| 21 | 21 | 0.9763648 | 0.8460608 | 4.769696 | -4.769696 | Terkendali |
| 22 | 22 | 0.2993952 | 0.5690912 | 4.769696 | -4.769696 | Terkendali |
| 23 | 23 | 0.0000000 | 0.3921216 | 4.769696 | -4.769696 | Terkendali |
| 24 | 24 | 0.0000000 | 0.4151520 | 4.769696 | -4.769696 | Terkendali |
| 25 | 25 | 0.0000000 | 0.6381824 | 4.769696 | -4.769696 | Terkendali |
| 26 | 26 | 0.0000000 | 1.5612128 | 4.769696 | -4.769696 | Terkendali |
| 27 | 27 | 0.0000000 | 1.5842432 | 4.769696 | -4.769696 | Terkendali |
| 28 | 28 | 0.0000000 | 1.3072736 | 4.769696 | -4.769696 | Terkendali |
| 29 | 29 | 0.1230304 | 0.2303040 | 4.769696 | -4.769696 | Terkendali |
| 30 | 30 | 1.2460608 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 31 | 31 | 2.9690912 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 32 | 32 | 4.9921216 | 0.0000000 | 4.769696 | -4.769696 | Tidak Terkendali |
| 33 | 33 | 4.4151520 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 34 | 34 | 4.1381824 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 35 | 35 | 3.5612128 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |
| 36 | 36 | 4.3842432 | 0.0000000 | 4.769696 | -4.769696 | Terkendali |

| | Sampel | Cplus | Cmin | BKA | BKB | Keterangan |
|---|---|---|---|---|---|---|
| 1 | 1 | 0.0000000 | 1.25487232 | 4.451277 | -4.451277 | Terkendali |
| 2 | 2 | 0.0000000 | 1.10974463 | 4.451277 | -4.451277 | Terkendali |
| 3 | 3 | 0.9548723 | 0.00000000 | 4.451277 | -4.451277 | Terkendali |
| 4 | 4 | 1.2097446 | 0.00000000 | 4.451277 | -4.451277 | Terkendali |

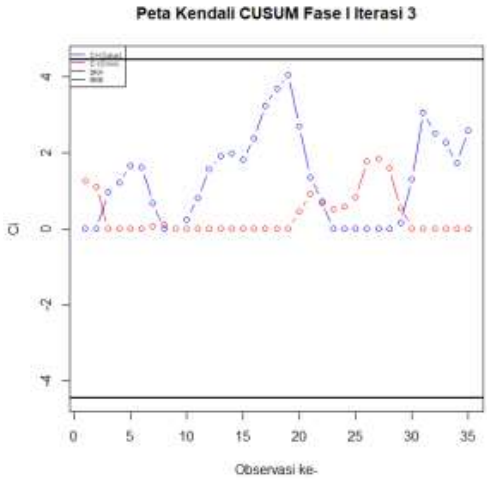
**Lampiran 8**. Peta kendali CUSUM fase I (Lanjutan)

```
5        5 1.6646169 0.00000000 4.451277 -4.451277 Terkendali
6        6 1.6194893 0.00000000 4.451277 -4.451277 Terkendali
7        7 0.6743616 0.05487232 4.451277 -4.451277 Terkendali
8        8 0.0000000 0.10974463 4.451277 -4.451277 Terkendali
9        9 0.0000000 0.00000000 4.451277 -4.451277 Terkendali
10      10 0.2548723 0.00000000 4.451277 -4.451277 Terkendali
11      11 0.8097446 0.00000000 4.451277 -4.451277 Terkendali
12      12 1.5646169 0.00000000 4.451277 -4.451277 Terkendali
13      13 1.9194893 0.00000000 4.451277 -4.451277 Terkendali
14      14 1.9743616 0.00000000 4.451277 -4.451277 Terkendali
15      15 1.8292339 0.00000000 4.451277 -4.451277 Terkendali
16      16 2.3841062 0.00000000 4.451277 -4.451277 Terkendali
17      17 3.2389785 0.00000000 4.451277 -4.451277 Terkendali
18      18 3.6938508 0.00000000 4.451277 -4.451277 Terkendali
19      19 4.0487232 0.00000000 4.451277 -4.451277 Terkendali
20      20 2.7035955 0.45487232 4.451277 -4.451277 Terkendali
21      21 1.3584678 0.90974463 4.451277 -4.451277 Terkendali
22      22 0.7133401 0.66461695 4.451277 -4.451277 Terkendali
23      23 0.0000000 0.51948926 4.451277 -4.451277 Terkendali
24      24 0.0000000 0.57436158 4.451277 -4.451277 Terkendali
25      25 0.0000000 0.82923389 4.451277 -4.451277 Terkendali
26      26 0.0000000 1.78410621 4.451277 -4.451277 Terkendali
27      27 0.0000000 1.83897852 4.451277 -4.451277 Terkendali
28      28 0.0000000 1.59385084 4.451277 -4.451277 Terkendali
29      29 0.1548723 0.54872316 4.451277 -4.451277 Terkendali
30      30 1.3097446 0.00000000 4.451277 -4.451277 Terkendali
31      31 3.0646169 0.00000000 4.451277 -4.451277 Terkendali
32      32 2.5194893 0.00000000 4.451277 -4.451277 Terkendali
33      33 2.2743616 0.00000000 4.451277 -4.451277 Terkendali
34      34 1.7292339 0.00000000 4.451277 -4.451277 Terkendali
35      35 2.5841062 0.00000000 4.451277 -4.451277 Terkendali
Total iterasi untuk mencapai kontrol: 3
  Iterasi        SD
1       1 1.1237449
2       2 0.9539392
3       3 0.8902554
```



**Lampiran 8**. Peta kendali CUSUM fase I (Lanjutan)



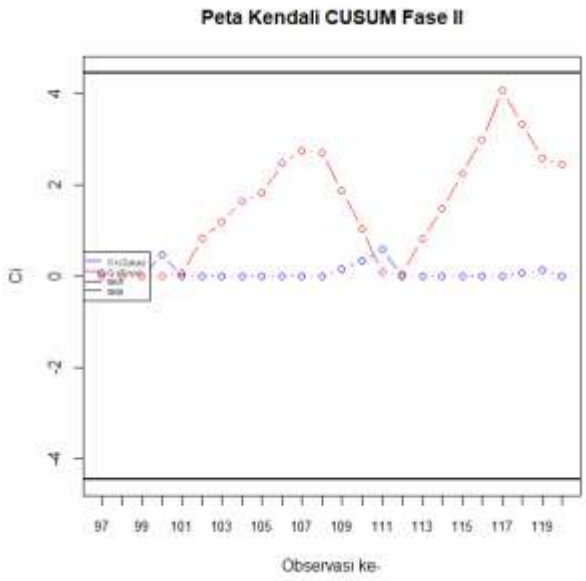
**Lampiran 9.** Peta kendali CUSUM fase II

```
> setwd("D:/coolyah")
> CUSUM_F2 <- read.csv("CUSUM_FASE1.csv", header = TRUE, sep = ';')
> BKA_F1_CUSUM <- rep(4.45128, 24)
> BKB_F1_CUSUM <- rep(-4.45128, 24)
> new_data_1 <- read.csv('data1.csv', header = TRUE, sep = ';')
> new_data_subset_1 <- tail(new_data_1$Fe, 24)
> CUSUM <- function(data_subset, miu0, k, BKA_F1_CUSUM,
BKB_F1_CUSUM, standar = TRUE) {
+   n <- length(data_subset)
+   data <- data_subset
+   if (standar == TRUE) {
+     data <- (data - mean(data)) / sd(data)
+   }
+   sigma <- sd(data)
+   K <- k * sigma
+   x <- numeric(n)
+   Cplus <- numeric(n + 1)
+   Cmin <- numeric(n + 1)
+   hasil <- character(n)
+   for (i in 1:n) {
+     x[i] <- data[i]
+     Cplus[i + 1] <- max(0, (x[i] - (miu0 + K) + Cplus[i]))
+     Cmin[i + 1] <- max(0, ((miu0 - K) - x[i] + Cmin[i]))
+
+     BKA <- BKA_F1_CUSUM[i]
+     BKB <- BKB_F1_CUSUM[i]
+
+     if ((Cplus[i + 1] <= BKA) && (Cmin[i + 1] <= BKA)) {
+       hasil[i] <- "Terkendali"
+     } else {
+       hasil[i] <- "Tidak Terkendali"
+     }
+   }
+   sampel <- 97:120
+   result <- data.frame(
+     Sampel = sampel,
+     Cplus = Cplus[2:(n + 1)],
+     Cmin = Cmin[2:(n + 1)],
+     BKA = BKA_F1_CUSUM,
+     BKB = BKB_F1_CUSUM,
+     Keterangan = hasil
+   )
+   sigma <- sd(data)
+   cat("Standard Deviasi:", sigma, "\n”)
+   print(result)
```

**Lampiran 9.** Peta kendali CUSUM fase II (Lanjutan)

```
+   windows()
+   plot(result$Cplus, col = "blue", type = "b", main = "Peta Kendali CUSUM Fase
II",
+        ylim = c(min(result$Cmin, min(result$BKB)), max(result$Cplus,
max(result$BKA))),
+        ylab = "Ci", xlab = "Observasi ke-", xaxt = "n")
+   axis(1, at = 1:length(sampel), labels = sampel, cex.axis = 0.8)
+   lines(result$Cmin, col = "red", type = "b", lwd = 1)
+   abline(h = result$BKA[1], col = "black", lwd = 2)
+   abline(h = result$BKB[1], col = "black", lwd = 2)
+
+   legend("left", legend = c("C+(Cplus)", "C-(Cmin)", "BKA", "BKB"),
+          col = c("blue", "red", "black", "black"), pch = c(NA, NA, NA, NA), lty = c(1,
1, 1, 1), cex = 0.5)
+
+   return(result)
+ }
> controls <- CUSUM(new_data_subset_1, miu0 = 20, k = 0.5, BK
A_F1_CUSUM, BKB_F1_CUSUM, standar = FALSE)
Standard Deviasi: 0.6750067
   Sampel      Cplus       Cmin     BKA      BKB Keterangan
1      97 0.06249665 0.00000000 4.45128 -4.45128 Terkendali
2      98 0.00000000 0.00000000 4.45128 -4.45128 Terkendali
3      99 0.00000000 0.00000000 4.45128 -4.45128 Terkendali
4     100 0.46249665 0.00000000 4.45128 -4.45128 Terkendali
5     101 0.00000000 0.06249665 4.45128 -4.45128 Terkendali
6     102 0.00000000 0.82499329 4.45128 -4.45128 Terkendali
7     103 0.00000000 1.18748994 4.45128 -4.45128 Terkendali
8     104 0.00000000 1.64998658 4.45128 -4.45128 Terkendali
9     105 0.00000000 1.81248323 4.45128 -4.45128 Terkendali
10    106 0.00000000 2.47497987 4.45128 -4.45128 Terkendali
11    107 0.00000000 2.73747652 4.45128 -4.45128 Terkendali
12    108 0.00000000 2.69997316 4.45128 -4.45128 Terkendali
13    109 0.16249665 1.86246981 4.45128 -4.45128 Terkendali
14    110 0.32499329 1.02496645 4.45128 -4.45128 Terkendali
15    111 0.58748994 0.08746310 4.45128 -4.45128 Terkendali
16    112 0.00000000 0.04995974 4.45128 -4.45128 Terkendali
17    113 0.00000000 0.81245639 4.45128 -4.45128 Terkendali
18    114 0.00000000 1.47495303 4.45128 -4.45128 Terkendali
19    115 0.00000000 2.23744968 4.45128 -4.45128 Terkendali
20    116 0.00000000 2.99994632 4.45128 -4.45128 Terkendali
21    117 0.00000000 4.06244297 4.45128 -4.45128 Terkendali
22    118 0.06249665 3.32493961 4.45128 -4.45128 Terkendali
23    119 0.12499329 2.58743626 4.45128 -4.45128 Terkendali
24    120 0.00000000 2.44993290 4.45128 -4.45128 Terkendali
```

**Lampiran 9.** Peta kendali CUSUM fase II (Lanjutan)



**Lampiran 10.** Peta Kendali MEC Fase I

```
> setwd("D:/coolyah")
> data <- read.csv('data1.csv', header = TRUE, sep = ';')
> data_subset <- data$Fe[1:96]
> MEC <- function(data, miu0, k, h, lambda) {
+   n <- length(data)
+   Zi <- numeric(n + 1)
+   x <- numeric(n)
+   var <- numeric(n)
+   Kz <- numeric(n)
+   BKA <- numeric(n)
+   BKB <- numeric(n)
+   Miplus <- numeric(n + 1)
+   Mimin <- numeric(n + 1)
+   hasil <- character(n)
+   tau <- (sd(data))^2
+   Zi[1] <- miu0
+   for (i in 1:n) {
+     x[i] <- data[i]
+     Zi[i + 1] <- lambda * x[i] + (1 - lambda) * Zi[i]
+     var[i] <- tau * ((lambda / (2 - lambda)) * (1 - (1 - lambda)^(2 * i)))
+     Kz[i] <- k * sqrt(var[i])
+     BKA[i] <- h * sqrt(var[i])
+     BKB[i] <- -(h * sqrt(var[i]))
+     if (i == 1) {
+       Miplus[2] <- max(0, (Zi[2] - miu0) - Kz[i])
+       Mimin[2] <- max(0, -(Zi[2] - miu0) - Kz[i])
+     } else {
+       Miplus[i + 1] <- max(0, (Zi[i + 1] - miu0) - Kz[i] + Miplus[i])
+       Mimin[i + 1] <- max(0, -(Zi[i + 1] - miu0) - Kz[i] + Mimin[i])
+     }
+     if ((Miplus[i + 1] <= BKA[i]) && (Mimin[i + 1] <= BKA[i])) {
+       hasil[i] <- "terkendali"
+     } else {
+       hasil[i] <- "tidak terkendali"
+     }
+   }
+   sampel <- 1:n
+   result <- data.frame(
+     Sampel = sampel,
+     Zi = Zi[2:(n + 1)],
+     Kz = Kz,
+     Miplus = Miplus[2:(n + 1)],
+     Mimin = Mimin[2:(n + 1)],
+     BKA = BKA,
+     BKB = BKB,
+     Keterangan = hasil
+   )
```

**Lampiran 10.** Peta Kendali MEC Fase I (Lanjutan)

```
+   print(result)
+   return(result)
+ }
> recalculate <- function(data_subset, miu0, k, h, lambda) {
+   iterasi <- 0
+   sd_iterasi <- numeric()
+
+   repeat {
+     sd_iterasi <- c(sd_iterasi, sd(data_subset))
+     terkendali <- MEC(data_subset, miu0, k, h, lambda)
+     iterasi <- iterasi + 1
+     windows()
+     plot(terkendali$Miplus, type = "o", col = "blue", xlab = "Observasi ke-", ylab =
"Mi",
+          main = paste("Peta Kendali MEC Iterasi", iterasi), ylim =
c(min(terkendali$Mimin, terkendali$BKB), max(terkendali$Miplus,
terkendali$BKA)))
+     lines(terkendali$Mimin, type = "o", col = "red")
+     lines(terkendali$BKA, type = "l", col = "green")
+     lines(terkendali$BKB, type = "l", col = "green")
+     legend("topleft", legend = c("Miplus", "Mimin", "BKA", "BKB"), col = c("blue",
"red", "green", "green"), lty = 1, cex = 0.6)
+
+     if (!any(terkendali$Keterangan == "tidak terkendali")) {
+       cat("Total iterasi untuk mencapai kontrol:", iterasi, "\n")
+       break
+     }
+     data_subset <- data_subset[terkendali$Keterangan == "terkendali"]
+   }
+   iterasi_stats <- data.frame(
+     Iterasi = 1:iterasi,
+     SD = sd_iterasi
+   )
+
+   print(iterasi_stats)
+
+   return(list(terkendali = terkendali, iterasi_stats = iterasi_stats))
+ }
> MEC_hasil <- recalculate(data_subset, miu0 = 20, k = 0.5, h = 37.42, lambda = 0.1)
   Sampel       Zi         Kz       Miplus       Mimin      BKA       BKB       Keterangan
1       1 19.83000 0.05618725  0.00000000 0.11381275 4.205053 -4.205053       terkendali
2       2 19.81700 0.07559221  0.00000000 0.22122055 5.657321 -5.657321       terkendali
3       3 19.97530 0.08823545  0.00000000 0.15768510 6.603541 -6.603541       terkendali
4       4 20.04777 0.09727927  0.00000000 0.01263583 7.280381 -7.280381       terkendali
5       5 20.13299 0.10403002  0.02896298 0.00000000 7.785606 -7.785606       terkendali
6       6 20.15969 0.10919260  0.07946408 0.00000000 8.171974 -8.171974       terkendali
7       7 20.09372 0.11320184  0.05998657 0.00000000 8.472026 -8.472026       terkendali
8       8 20.03435 0.11634809  0.00000000 0.00000000 8.707491 -8.707491       terkendali
9       9 20.02092 0.11883551  0.00000000 0.00000000 8.893649 -8.893649       terkendali
10     10 20.08883 0.12081278  0.00000000 0.00000000 9.041628 -9.041628       terkendali
11     11 20.17994 0.12239096  0.05755158 0.00000000 9.159739 -9.159739       terkendali
12     12 20.28195 0.12365451  0.21584534 0.00000000 9.254304 -9.254304       terkendali
13     13 20.33375 0.12466861  0.42493018 0.00000000 9.330199 -9.330199       terkendali
14     14 20.35038 0.12548402  0.64982427 0.00000000 9.391224 -9.391224       terkendali
15     15 20.34534 0.12614064  0.86902393 0.00000000 9.440365 -9.440365       terkendali
```

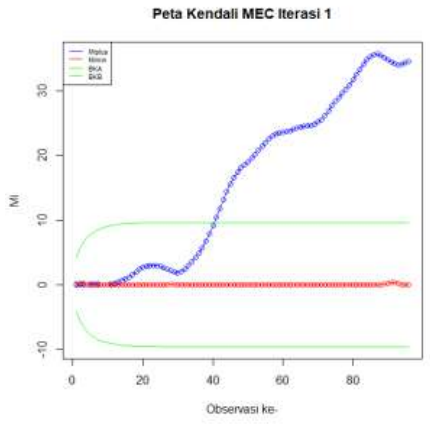
**Lampiran 10.** Peta Kendali MEC Fase I (Lanjutan)

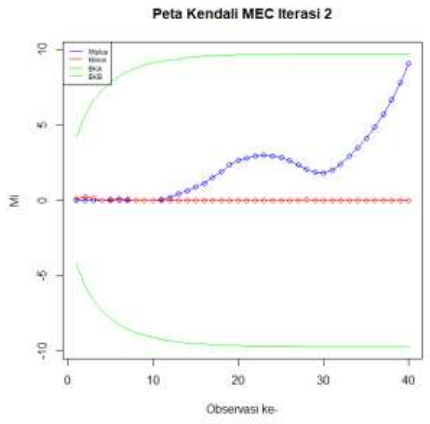
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 16 | 16 | 20.41081 | 0.12667000 | 1.15316020 | 0.00000000 | 9.479983 | -9.479983 | terkendali |
| 17 | 17 | 20.49973 | 0.12709717 | 1.52578867 | 0.00000000 | 9.511952 | -9.511952 | terkendali |
| 18 | 18 | 20.53975 | 0.12744213 | 1.93809961 | 0.00000000 | 9.537769 | -9.537769 | terkendali |
| 19 | 19 | 20.56578 | 0.12772086 | 2.37615652 | 0.00000000 | 9.558629 | -9.558629 | terkendali |
| 20 | 20 | 20.41920 | 0.12794619 | 2.66741032 | 0.00000000 | 9.575493 | -9.575493 | terkendali |
| 21 | 21 | 20.28728 | 0.12812842 | 2.82656190 | 0.00000000 | 9.589131 | -9.589131 | terkendali |
| 22 | 22 | 20.23855 | 0.12827583 | 2.93683806 | 0.00000000 | 9.600163 | -9.600163 | terkendali |
| 23 | 23 | 20.18470 | 0.12839511 | 2.99313975 | 0.00000000 | 9.609090 | -9.609090 | terkendali |
| 24 | 24 | 20.11623 | 0.12849165 | 2.98087522 | 0.00000000 | 9.616315 | -9.616315 | terkendali |
| 25 | 25 | 20.03460 | 0.12856979 | 2.88690983 | 0.00000000 | 9.622163 | -9.622163 | terkendali |
| 26 | 26 | 19.89114 | 0.12863305 | 2.64942075 | 0.00000000 | 9.626897 | -9.626897 | terkendali |
| 27 | 27 | 19.85203 | 0.12868426 | 2.37276605 | 0.01928617 | 9.630730 | -9.630730 | terkendali |
| 28 | 28 | 19.84683 | 0.12872573 | 2.09086693 | 0.04373383 | 9.633834 | -9.633834 | terkendali |
| 29 | 29 | 19.92214 | 0.12875932 | 1.88425156 | 0.00000000 | 9.636347 | -9.636347 | terkendali |
| 30 | 30 | 20.08993 | 0.12878651 | 1.84539461 | 0.00000000 | 9.638382 | -9.638382 | terkendali |
| 31 | 31 | 20.30094 | 0.12880853 | 2.01752267 | 0.00000000 | 9.640031 | -9.640031 | terkendali |
| 32 | 32 | 20.52084 | 0.12882637 | 2.40953924 | 0.00000000 | 9.641366 | -9.641366 | terkendali |
| 33 | 33 | 20.66876 | 0.12884082 | 2.94945707 | 0.00000000 | 9.642447 | -9.642447 | terkendali |
| 34 | 34 | 20.70188 | 0.12885252 | 3.52248733 | 0.00000000 | 9.643322 | -9.643322 | terkendali |
| 35 | 35 | 20.78169 | 0.12886199 | 4.17531984 | 0.00000000 | 9.644031 | -9.644031 | terkendali |
| 36 | 36 | 20.84353 | 0.12886967 | 4.88997523 | 0.00000000 | 9.644606 | -9.644606 | terkendali |
| 37 | 37 | 20.98917 | 0.12887588 | 5.75027189 | 0.00000000 | 9.645071 | -9.645071 | terkendali |
| 38 | 38 | 21.11026 | 0.12888092 | 6.73164626 | 0.00000000 | 9.645448 | -9.645448 | terkendali |
| 39 | 39 | 21.24923 | 0.12888500 | 7.85199103 | 0.00000000 | 9.645753 | -9.645753 | terkendali |
| 40 | 40 | 21.39431 | 0.12888830 | 9.11740951 | 0.00000000 | 9.646000 | -9.646000 | terkendali |
| 41 | 41 | 21.45488 | 0.12889098 | 10.44339465 | 0.00000000 | 9.646201 | -9.646201 | tidak terkendali |
| 42 | 42 | 21.51939 | 0.12889314 | 11.83389000 | 0.00000000 | 9.646363 | -9.646363 | tidak terkendali |
| 43 | 43 | 21.43745 | 0.12889490 | 13.14244475 | 0.00000000 | 9.646494 | -9.646494 | tidak terkendali |
| 44 | 44 | 21.38370 | 0.12889632 | 14.39725311 | 0.00000000 | 9.646601 | -9.646601 | tidak terkendali |
| 45 | 45 | 21.28533 | 0.12889747 | 15.55368985 | 0.00000000 | 9.646687 | -9.646687 | tidak terkendali |
| 46 | 46 | 21.14680 | 0.12889841 | 16.57159224 | 0.00000000 | 9.646757 | -9.646757 | tidak terkendali |
| 47 | 47 | 20.98212 | 0.12889916 | 17.42481379 | 0.00000000 | 9.646813 | -9.646813 | tidak terkendali |
| 48 | 48 | 20.79391 | 0.12889977 | 18.08982266 | 0.00000000 | 9.646859 | -9.646859 | tidak terkendali |
| 49 | 49 | 20.59452 | 0.12890027 | 18.55544017 | 0.00000000 | 9.646896 | -9.646896 | tidak terkendali |
| 50 | 50 | 20.61507 | 0.12890067 | 19.04160550 | 0.00000000 | 9.646926 | -9.646926 | tidak terkendali |
| 51 | 51 | 20.69356 | 0.12890100 | 19.60626391 | 0.00000000 | 9.646950 | -9.646950 | tidak terkendali |
| 52 | 52 | 20.72420 | 0.12890126 | 20.20156611 | 0.00000000 | 9.646970 | -9.646970 | tidak terkendali |
| 53 | 53 | 20.74178 | 0.12890147 | 20.81444775 | 0.00000000 | 9.646986 | -9.646986 | tidak terkendali |
| 54 | 54 | 20.74760 | 0.12890165 | 21.43315091 | 0.00000000 | 9.646999 | -9.646999 | tidak terkendali |
| 55 | 55 | 20.72284 | 0.12890179 | 22.02709345 | 0.00000000 | 9.647010 | -9.647010 | tidak terkendali |
| 56 | 56 | 20.69056 | 0.12890190 | 22.58875144 | 0.00000000 | 9.647018 | -9.647018 | tidak terkendali |
| 57 | 57 | 20.58150 | 0.12890199 | 23.04135335 | 0.00000000 | 9.647025 | -9.647025 | tidak terkendali |
| 58 | 58 | 20.43335 | 0.12890206 | 23.34580480 | 0.00000000 | 9.647031 | -9.647031 | tidak terkendali |
| 59 | 59 | 20.28002 | 0.12890213 | 23.49692083 | 0.00000000 | 9.647035 | -9.647035 | tidak terkendali |
| 60 | 60 | 20.21202 | 0.12890217 | 23.58003500 | 0.00000000 | 9.647039 | -9.647039 | tidak terkendali |
| 61 | 61 | 20.27081 | 0.12890221 | 23.72194750 | 0.00000000 | 9.647042 | -9.647042 | tidak terkendali |
| 62 | 62 | 20.28373 | 0.12890225 | 23.87677849 | 0.00000000 | 9.647044 | -9.647044 | tidak terkendali |
| 63 | 63 | 20.29536 | 0.12890227 | 24.04323613 | 0.00000000 | 9.647046 | -9.647046 | tidak terkendali |
| 64 | 64 | 20.37582 | 0.12890229 | 24.29015776 | 0.00000000 | 9.647048 | -9.647048 | tidak terkendali |
| 65 | 65 | 20.26824 | 0.12890231 | 24.42949699 | 0.00000000 | 9.647049 | -9.647049 | tidak terkendali |
| 66 | 66 | 20.24142 | 0.12890232 | 24.54201204 | 0.00000000 | 9.647050 | -9.647050 | tidak terkendali |
| 67 | 67 | 20.19728 | 0.12890233 | 24.61038535 | 0.00000000 | 9.647051 | -9.647051 | tidak terkendali |
| 68 | 68 | 20.21755 | 0.12890234 | 24.69903108 | 0.00000000 | 9.647051 | -9.647051 | tidak terkendali |
| 69 | 69 | 20.34579 | 0.12890235 | 24.91592200 | 0.00000000 | 9.647052 | -9.647052 | tidak terkendali |
| 70 | 70 | 20.43121 | 0.12890236 | 25.21823358 | 0.00000000 | 9.647052 | -9.647052 | tidak terkendali |
| 71 | 71 | 20.52809 | 0.12890236 | 25.61742377 | 0.00000000 | 9.647053 | -9.647053 | tidak terkendali |
| 72 | 72 | 20.71528 | 0.12890237 | 26.20380469 | 0.00000000 | 9.647053 | -9.647053 | tidak terkendali |
| 73 | 73 | 20.88375 | 0.12890237 | 26.95865729 | 0.00000000 | 9.647053 | -9.647053 | tidak terkendali |
| 74 | 74 | 20.90538 | 0.12890237 | 27.73513439 | 0.00000000 | 9.647053 | -9.647053 | tidak terkendali |
| 75 | 75 | 20.79484 | 0.12890237 | 28.40107353 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 76 | 76 | 20.74536 | 0.12890237 | 29.01752853 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 77 | 77 | 20.76082 | 0.12890238 | 29.64944778 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 78 | 78 | 20.74474 | 0.12890238 | 30.26528487 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 79 | 79 | 20.84027 | 0.12890238 | 30.97664802 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 80 | 80 | 20.86624 | 0.12890238 | 31.71398461 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 81 | 81 | 20.92962 | 0.12890238 | 32.51469730 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 82 | 82 | 20.97665 | 0.12890238 | 33.36244848 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 83 | 83 | 20.88899 | 0.12890238 | 34.12253431 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 84 | 84 | 20.84009 | 0.12890238 | 34.83372132 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 85 | 85 | 20.63608 | 0.12890238 | 35.34089939 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 86 | 86 | 20.47247 | 0.12890238 | 35.68446941 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 87 | 87 | 20.21523 | 0.12890238 | 35.77079219 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 88 | 88 | 19.92370 | 0.12890238 | 35.56559246 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 89 | 89 | 19.76133 | 0.12890238 | 35.19802246 | 0.10976524 | 9.647054 | -9.647054 | tidak terkendali |
| 90 | 90 | 19.77520 | 0.12890238 | 34.84431922 | 0.20566371 | 9.647054 | -9.647054 | tidak terkendali |
| 91 | 91 | 19.81768 | 0.12890238 | 34.53309607 | 0.25908210 | 9.647054 | -9.647054 | tidak terkendali |
| 92 | 92 | 19.82591 | 0.12890238 | 34.23010500 | 0.30426841 | 9.647054 | -9.647054 | tidak terkendali |
| 93 | 93 | 19.97332 | 0.12890238 | 34.07452279 | 0.20204585 | 9.647054 | -9.647054 | tidak terkendali |
| 94 | 94 | 20.18599 | 0.12890238 | 34.13160857 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |
| 95 | 95 | 20.35739 | 0.12890238 | 34.36009553 | 0.00000000 | 9.647054 | -9.647054 | tidak terkendali |

**Lampiran 10.** Peta Kendali MEC Fase I (Lanjutan)

```
96     96 20.43165 0.12890238 34.66284355 0.00000000 9.647054 -9.647054 tidak terkendali

Sampel        Zi         Kz     Miplus       Mimin       BKA        BKB Keterangan
1        1 19.83000 0.05665785 0.00000000 0.113342148 4.240274 -4.240274 terkendali
2        2 19.81700 0.07622534 0.00000000 0.220116804 5.704705 -5.704705 terkendali
3        3 19.97530 0.08897448 0.00000000 0.155842327 6.658850 -6.658850 terkendali
4        4 20.04777 0.09809405 0.00000000 0.009978276 7.341359 -7.341359 terkendali
5        5 20.13299 0.10490134 0.02809166 0.000000000 7.850816 -7.850816 terkendali
6        6 20.15969 0.11010717 0.07767820 0.000000000 8.240420 -8.240420 terkendali
7        7 20.09372 0.11414998 0.05725254 0.000000000 8.542985 -8.542985 terkendali
8        8 20.03435 0.11732259 0.00000000 0.000000000 8.780422 -8.780422 terkendali
9        9 20.02092 0.11983084 0.00000000 0.000000000 8.968140 -8.968140 terkendali
10      10 20.08883 0.12182467 0.00000000 0.000000000 9.117358 -9.117358 terkendali
11      11 20.17994 0.12341606 0.05652647 0.000000000 9.236458 -9.236458 terkendali
12      12 20.28195 0.12469020 0.21378455 0.000000000 9.331815 -9.331815 terkendali
13      13 20.33375 0.12571279 0.42182520 0.000000000 9.408345 -9.408345 terkendali
14      14 20.35038 0.12653503 0.64566828 0.000000000 9.469882 -9.469882 terkendali
15      15 20.34534 0.12719715 0.86381142 0.000000000 9.519435 -9.519435 terkendali
16      16 20.41081 0.12773095 1.14688674 0.000000000 9.559384 -9.559384 terkendali
17      17 20.49973 0.12816170 1.51845069 0.000000000 9.591621 -9.591621 terkendali
18      18 20.53975 0.12850954 1.92969422 0.000000000 9.617654 -9.617654 terkendali
19      19 20.56578 0.12879061 2.36668138 0.000000000 9.638689 -9.638689 terkendali
20      20 20.41920 0.12901783 2.65686354 0.000000000 9.655694 -9.655694 terkendali
21      21 20.28728 0.12920158 2.81494196 0.000000000 9.669446 -9.669446 terkendali
22      22 20.23855 0.12935023 2.92414372 0.000000000 9.680571 -9.680571 terkendali
23      23 20.18470 0.12947050 2.97937001 0.000000000 9.689573 -9.689573 terkendali
24      24 20.11623 0.12956785 2.96602928 0.000000000 9.696858 -9.696858 terkendali
25      25 20.03460 0.12964664 2.87098704 0.000000000 9.702755 -9.702755 terkendali
26      26 19.89114 0.12971043 2.63242056 0.000000000 9.707529 -9.707529 terkendali
27      27 19.85203 0.12976208 2.35468805 0.018208353 9.711394 -9.711394 terkendali
28      28 19.84683 0.12980390 2.07171076 0.041577845 9.714524 -9.714524 terkendali
29      29 19.92214 0.12983776 1.86401695 0.000000000 9.717058 -9.717058 terkendali
30      30 20.08993 0.12986518 1.82408132 0.000000000 9.719110 -9.719110 terkendali
31      31 20.30094 0.12988739 1.99513052 0.000000000 9.720772 -9.720772 terkendali
32      32 20.52084 0.12990538 2.38606808 0.000000000 9.722119 -9.722119 terkendali
33      33 20.66876 0.12991995 2.92490678 0.000000000 9.723209 -9.723209 terkendali
34      34 20.70188 0.12993174 3.49685782 0.000000000 9.724092 -9.724092 terkendali
35      35 20.78169 0.12994130 4.14861102 0.000000000 9.724807 -9.724807 terkendali
36      36 20.84353 0.12994904 4.86218704 0.000000000 9.725386 -9.725386 terkendali
37      37 20.98917 0.12995531 5.72140428 0.000000000 9.725855 -9.725855 terkendali
38      38 21.11026 0.12996038 6.70169919 0.000000000 9.726235 -9.726235 terkendali
39      39 21.24923 0.12996450 7.82096445 0.000000000 9.726543 -9.726543 terkendali
40      40 21.39431 0.12996783 9.08530341 0.000000000 9.726792 -9.726792 terkendali
Total iterasi untuk mencapai kontrol: 2
  Iterasi       SD
1       1 1.123745
2       2 1.133157
```



**Lampiran 11.** Peta Kendali MEC Fase II

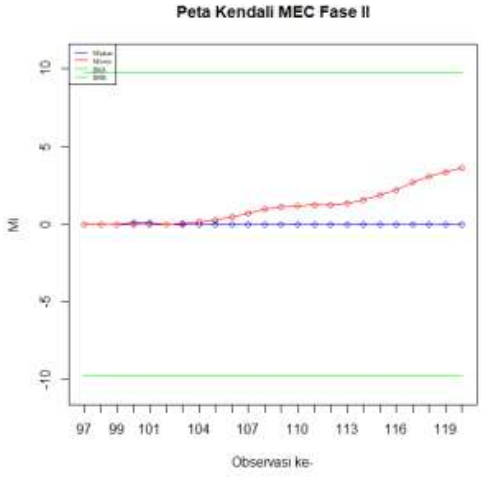
```
> setwd("D:/coolyah")
> new_data_2 <- read.csv('data1.csv', header = TRUE, sep = ';')
> new_data_subset_2 <- tail(new_data_2$Fe, 24)
> BKA_F1 <- rep(9.72679, 24)
> BKB_F1 <- rep(-9.72679, 24)
> mean <- 20
> MEC <- function(data, miu0, k, lambda, BKA, BKB) {
+   n <- length(data)
+   Zi <- numeric(n + 1)
+   x <- numeric(n)
+   var <- numeric(n)
+   Kz <- numeric(n)
+   Miplus <- numeric(n + 1)
+   Mimin <- numeric(n + 1)
+   hasil <- character(n)
+
+   tau <- (sd(data))^2
+
+   Zi[1] <- miu0
+
+   for (i in 1:n) {
+     x[i] <- data[i]
+     Zi[i + 1] <- lambda * x[i] + (1 - lambda) * Zi[i]
+     var[i] <- tau * ((lambda / (2 - lambda)) * (1 - (1 - lambda)^(2 * i)))
+     Kz[i] <- k * sqrt(var[i])
+     if (i == 1) {
+       Miplus[2] <- max(0, (Zi[2] - miu0) - Kz[i])
+       Mimin[2] <- max(0, -(Zi[2] - miu0) - Kz[i])
+     } else {
+       Miplus[i + 1] <- max(0, (Zi[i + 1] - miu0) - Kz[i] + Miplus[i])
+       Mimin[i + 1] <- max(0, -(Zi[i + 1] - miu0) - Kz[i] + Mimin[i])
+     }
+
+     if ((Miplus[i + 1] <= BKA[i]) && (Mimin[i + 1] <= BKA[i])) {
+       hasil[i] <- "terkendali"
+     } else {
+       hasil[i] <- "tidak terkendali"
+     }
+   }
+   sampel <- 97:120
+   result <- data.frame(
+     Sampel = sampel,
+     Zi = Zi[2:(n + 1)],
+     Kz = Kz,
+     Miplus = Miplus[2:(n + 1)],
+     Mimin = Mimin[2:(n + 1)],
+     BKA_F1 = BKA,
```

**Lampiran 11.** Peta Kendali MEC Fase II (Lanjutan)

```
+    BKB_F1 = BKB,
+    Keterangan = hasil
+  )
+
+  windows()
+
+  plot(Miplus[2:(n + 1)], type = "o", col = "blue", xlab = "Observasi ke-", ylab = "M
i",
+       main = "Peta Kendali MEC Fase II", ylim = c(min(BKB) - 1, max(BKA) + 1),
xaxt = "n")
+  axis(1, at = 1:n, labels = sampel)
+  lines(Mimin[2:(n + 1)], type = "o", col = "red")
+  lines(BKA, type = "l", col = "green")
+  lines(BKB, type = "l", col = "green")
+   legend("topleft", legend = c("Miplus", "Mimin", "BKA", "BKB"), col = c("blue", "r
ed", "green", "green"), lty = 1, cex = 0.5)
+
+  print(result)
+ }
```

```
> MECF2 <- MEC(new_data_subset_2, miu0 = mean, k = 0.5, lambd
a = 0.1, BKA = BKA_F1, BKB = BKB_F1)
    Sampel       Zi          Kz       Miplus       Mimin  BKA_F1   BKB_F1 Keterangan
1       97 20.04000 0.03375034 0.006249665 0.00000000 9.72679 -9.72679 terkendali
2       98 20.04600 0.04540643 0.006843232 0.00000000 9.72679 -9.72679 terkendali
3       99 20.06140 0.05300092 0.015242309 0.00000000 9.72679 -9.72679 terkendali
4      100 20.13526 0.05843333 0.092068976 0.00000000 9.72679 -9.72679 terkendali
5      101 20.08173 0.06248834 0.111314631 0.00000000 9.72679 -9.72679 terkendali
6      102 19.96356 0.06558939 0.009285844 0.00000000 9.72679 -9.72679 terkendali
7      103 19.89720 0.06799764 0.000000000 0.03479782 9.72679 -9.72679 terkendali
8      104 19.82748 0.06988752 0.000000000 0.13742622 9.72679 -9.72679 terkendali
9      105 19.79474 0.07138165 0.000000000 0.27130889 9.72679 -9.72679 terkendali
10     106 19.71526 0.07256935 0.000000000 0.48347743 9.72679 -9.72679 terkendali
11     107 19.68374 0.07351732 0.000000000 0.72622421 9.72679 -9.72679 terkendali
12     108 19.68536 0.07427631 0.000000000 0.96658559 9.72679 -9.72679 terkendali
13     109 19.76683 0.07488545 0.000000000 1.12487406 9.72679 -9.72679 terkendali
14     110 19.84014 0.07537525 0.000000000 1.20935534 9.72679 -9.72679 terkendali
15     111 19.91613 0.07576967 0.000000000 1.21745655 9.72679 -9.72679 terkendali
16     112 19.89452 0.07608764 0.000000000 1.24685270 9.72679 -9.72679 terkendali
17     113 19.79506 0.07634423 0.000000000 1.37544388 9.72679 -9.72679 terkendali
18     114 19.71556 0.07655144 0.000000000 1.58333430 9.72679 -9.72679 terkendali
19     115 19.63400 0.07671887 0.000000000 1.87261312 9.72679 -9.72679 terkendali
20     116 19.56060 0.07685422 0.000000000 2.23515681 9.72679 -9.72679 terkendali
21     117 19.46454 0.07696368 0.000000000 2.69365126 9.72679 -9.72679 terkendali
22     118 19.55809 0.07705222 0.000000000 3.05851135 9.72679 -9.72679 terkendali
23     119 19.64228 0.07712387 0.000000000 3.33910855 9.72679 -9.72679 terkendali
24     120 19.65805 0.07718186 0.000000000 3.60387566 9.72679 -9.72679 terkendali
```

**Lampiran 11.** Peta Kendali MEC Fase II (Lanjutan)



**Lampiran 12**. Riwayat Hidup Penulis

## A. DATA PRIBADI

| | |
|---|---|
| Nama | : Naaifah Putri Ramadhani |
| NIM | : H051201059 |
| Tempat, Tanggal Lahir | : Kendari, 09 November 2002 |
| Agama | : Islam |
| Jenis Kelamin | : Perempuan |
| Suku/Bangsa | : Moronene/Indonesia |
| Alamat | : BTN BATU MARUPA BLOK E2/28 |
| E-mail | : naifahhputri@gmail.com |
| No. Handphone | : 082291012808 |

## B. RIWAYAT PENDIDIKAN

1. SDN 01 Kendari (2008-2014)
2. SMPN 05 Kendari (2014-2017)
3. SMAN 4 Kendari (2017-2020)
4. S1 Program Studi Statistika FMIPA Unhas (2020-2024)