

Comparison of treatments - CH₄, NH₃, CO₂

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Purpose

Compare different slurry handling systems in terms of methane emission.

Prep

```
rm(list = ls())

source('../functions/rbindf.R')
source('../functions/dfcombos.R')
source('../functions/ggsave2x.R')

library('DescTools')
library('dplyr')
library('tidyr')
library('readxl')
library('multcomp')
library('ggplot2')
library('FSA')
```

Measurement data

Get stacked data with high-resolution measurements. Calculate mean emission rate by period.

```
dat <- read.csv('../data/dat_stacked.csv')

emis_dat <- summarise(group_by(dat, period, treatment),
                      mean_CH4_barn = mean(CH4_rate/pigs, na.rm = T),
                      mean_CH4_slurry = mean(CH4_emis_rate/pigs, na.rm = T),
                      mean_NH3_barn = mean(NH3_emis_rate/pigs, na.rm = T),
                      mean_CO2_barn = mean(CO2E, na.rm = T),
                      mean_CO2_slurry = mean(CO2_emis_rate, na.rm = T))

## `summarise()` has grouped output by 'period'. You can override using the
## `.groups` argument.

emis_dat$treatment <- factor(emis_dat$treatment)
```

Analysis

Loop through all variables, fit models, print results. Crude and a lot of pages. . .

```

for (y in c('mean_CH4_barn', 'mean_CH4_slurry', 'mean_NH3_barn', 'mean_CO2_barn', 'mean_CO2_slurry')) {
  cat('\n')
  cat('\n', rep(c(y, '\n'), 4), '\n')
  cat('\n', rep(c(y, '\n'), 4), '\n')
  cat('\n', rep(c(y, '\n'), 4), '\n')
  cat('\n')

  emis_dat$y <- emis_dat[, y, drop = TRUE]

  p1 <- ggplot(emis_dat, aes(period, y, colour = treatment)) +
    geom_line() +
    labs(y = y)

  p2 <- ggplot(emis_dat, aes(treatment, y)) +
    geom_boxplot()

  print(p1)
  print(p2)

  m1 <- aov(y ~ factor(period) + treatment, data = emis_dat)
  d1 <- glht(m1, linfct = mcp(treatment = "Dunnett"))

  m2 <- aov(log10(y) ~ factor(period) + treatment, data = emis_dat)
  d2 <- glht(m2, linfct = mcp(treatment = "Dunnett"))

  m3 <- aov(log10(y) ~ treatment, data = emis_dat)
  d3 <- glht(m3, linfct = mcp(treatment = "Dunnett"))

  cat('\n', rep(c(y, '\n'), 4), '\n')
  cat('Non-transformed aov summary:\n')
  print(summary(m1))
  cat('\n', rep(c(y, '\n'), 4), '\n')
  cat('Non-transformed lm summary:\n')
  print(summary.lm(m1))
  cat('\n', rep(c(y, '\n'), 4), '\n')
  cat('Non-transformed Dunnett s test:\n')
  print(summary(d1))
  cat('\n', rep(c(y, '\n'), 4), '\n')
  cat('Non-transformed confidence intervals:\n')
  print(confint(m1))

  cat('\n', rep(c(y, '\n'), 4), '\n')
  cat('Transformed aov summary:\n')
  print(summary(m2))
  cat('\n', rep(c(y, '\n'), 4), '\n')
  cat('Transformed lm summary:\n')
  print(summary.lm(m2))
  cat('\n', rep(c(y, '\n'), 4), '\n')
  cat('Transformed Dunnetts test:\n')
  print(summary(d2))
  cat('\n', rep(c(y, '\n'), 4), '\n')
  cat('Transformed confidence intervals:\n')
  print(100 * (10^confint(m2) - 1))

```

```

cat('\n', rep(c(y, '\n'), 4), '\n')
cat('Transformed aov summary without period:\n')
print(summary(m3))
cat('\n', rep(c(y, '\n'), 4), '\n')
cat('Transformed lm summary without period:\n')
print(summary.lm(m3))
cat('\n', rep(c(y, '\n'), 4), '\n')
cat('Transformed Dunnetts test without period:\n')
print(summary(d3))
cat('\n', rep(c(y, '\n'), 4), '\n')
cat('Transformed confidence intervals without period:\n')
print(100 * (10^confint(m3) - 1))

cat('\n', rep(c(y, '\n'), 4), '\n')
cat('Transformed relative reduction (coef):\n')
print(round(100 * (10^coef(m2)[-1:-2] - 1), 1))

cat('\n', rep(c(y, '\n'), 4), '\n')
cat('Transformed relative reduction without period (coef):\n')
print(round(100 * (10^coef(m3)[-1] - 1), 1))

cat('\n', rep(c(y, '\n'), 4), '\n')
cat('Non-transformed diagnostic plots:\n')
plot(m1, ask = FALSE)

cat('\n', rep(c(y, '\n'), 4), '\n')
cat('Transformed diagnostic plots:\n')
plot(m2, ask = FALSE)

cat('\n', rep(c(y, '\n'), 4), '\n')
cat('Transformed diagnostic plots without period:\n')
plot(m3, ask = FALSE)

cat('\n', rep(c(y, '\n'), 4), '\n')
cat('\n\n')
cat('\n', rep(paste('end', y), 3), '\n')
cat('\n', rep(paste('end', y), 3), '\n')
cat('\n', rep(paste('end', y), 3), '\n')
cat('\n')
}

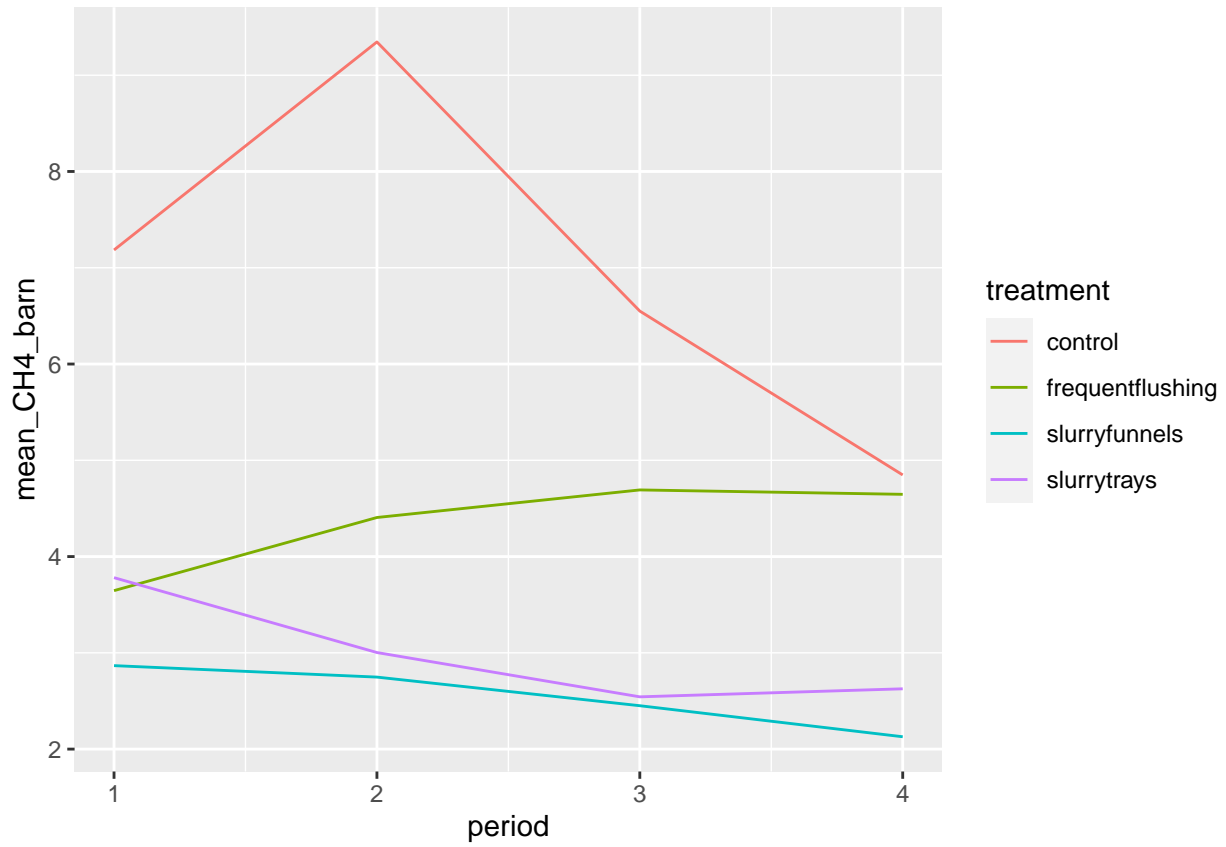
```

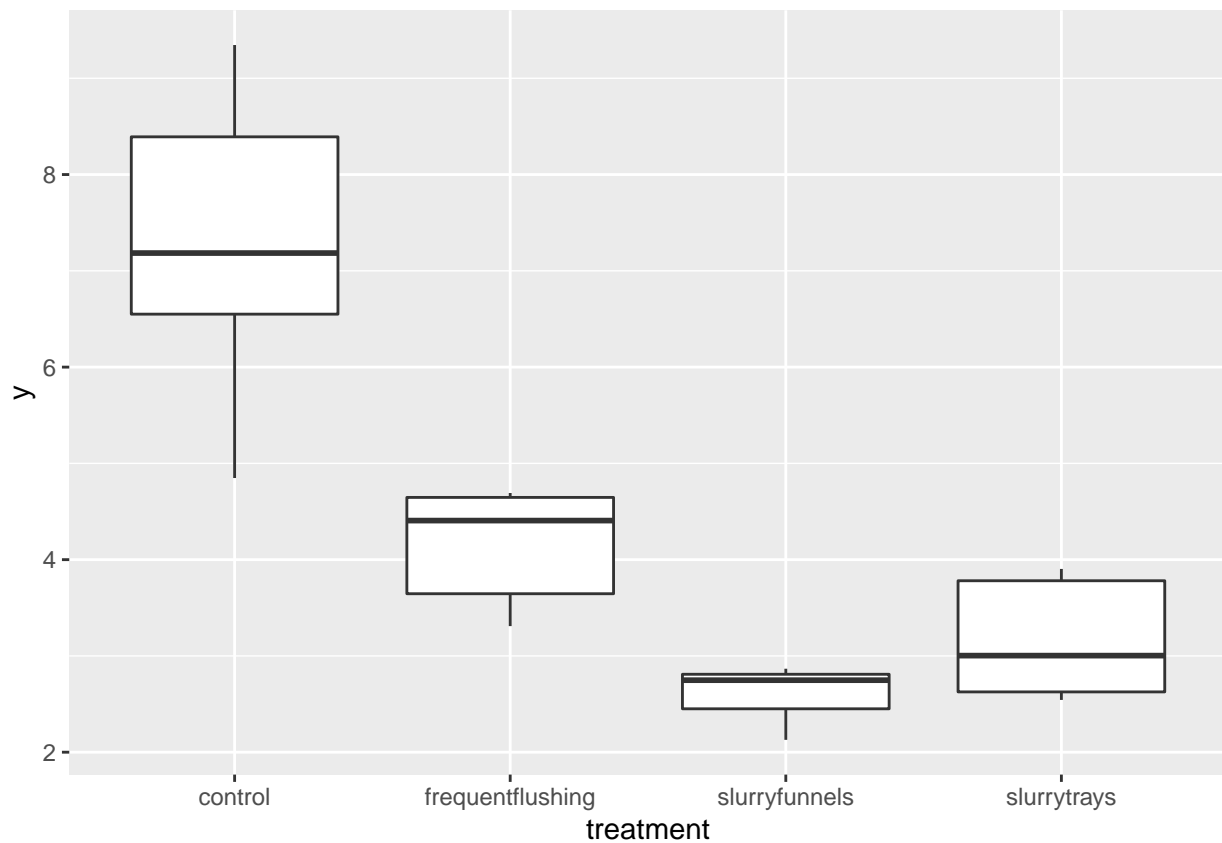
```

##
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
##
## mean_CH4_barn
## mean_CH4_barn

```

```
## mean_CH4_barn
## mean_CH4_barn
##
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Warning: Removed 4 row(s) containing missing values (geom_path).
```





```
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Non-transformed aov summary:
##           Df Sum Sq Mean Sq F value    Pr(>F)
## factor(period) 3   3.64    1.214    1.254 0.346848
## treatment      3  47.83   15.943   16.465 0.000536 ***
## Residuals      9   8.71    0.968
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 4 observations deleted due to missingness
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Non-transformed lm summary:
##
## Call:
## aov(formula = y ~ factor(period) + treatment, data = emis_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
```

```

## -1.47980 -0.49486 0.05473 0.34478 1.70454
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      7.1351     0.6509  10.963 1.66e-06 ***
## factor(period)2    0.5059     0.6958   0.727 0.485635
## factor(period)3   -0.3107     0.6958  -0.447 0.665718
## factor(period)4   -0.8075     0.6958  -1.161 0.275692
## treatmentfrequentflushing -2.6345     0.6958  -3.786 0.004307 **
## treatmentslurryfunnels  -4.4337     0.6958  -6.372 0.000129 ***
## treatmentslurrytrays   -3.9939     0.6958  -5.740 0.000280 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.984 on 9 degrees of freedom
## (4 observations deleted due to missingness)
## Multiple R-squared:  0.8552, Adjusted R-squared:  0.7587
## F-statistic: 8.86 on 6 and 9 DF, p-value: 0.002325
##
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Non-transformed Dunnett s test:
##
## Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = y ~ factor(period) + treatment, data = emis_dat)
##
## Linear Hypotheses:
##              Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0  -2.6345     0.6958  -3.786 0.0112 *
## slurryfunnels - control == 0    -4.4337     0.6958  -6.372 <0.001 ***
## slurrytrays - control == 0      -3.9939     0.6958  -5.740 <0.001 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
##
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Non-transformed confidence intervals:
##              2.5 %      97.5 %
## (Intercept)    5.662801  8.6074933
## factor(period)2 -1.068075  2.0799333
## factor(period)3 -1.884746  1.2632625

```

```

## factor(period)4          -2.381496  0.7665122
## treatmentfrequentflushing -4.208553 -1.0605448
## treatmentslurryfunnels    -6.007728 -2.8597195
## treatmentslurrytrays      -5.567873 -2.4198645
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Transformed aov summary:
##           Df Sum Sq Mean Sq F value    Pr(>F)
## factor(period)  3 0.0276  0.00919    1.649    0.246
## treatment       3 0.4397  0.14657   26.295 8.71e-05 ***
## Residuals       9 0.0502  0.00557
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 4 observations deleted due to missingness
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Transformed lm summary:
##
## Call:
## aov(formula = log10(y) ~ factor(period) + treatment, data = emis_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.102154 -0.039526 -0.002392  0.032105  0.091454
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      0.86010    0.04938   17.417 3.06e-08 ***
## factor(period)2      0.01949    0.05279    0.369  0.72057
## factor(period)3     -0.04276    0.05279   -0.810  0.43886
## factor(period)4     -0.08831    0.05279   -1.673  0.12869
## treatmentfrequentflushing -0.19613    0.05279   -3.715  0.00481 **
## treatmentslurryfunnels  -0.42879    0.05279   -8.122 1.96e-05 ***
## treatmentslurrytrays    -0.36226    0.05279   -6.862 7.37e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.07466 on 9 degrees of freedom
## (4 observations deleted due to missingness)
## Multiple R-squared:  0.9031, Adjusted R-squared:  0.8384
## F-statistic: 13.97 on 6 and 9 DF, p-value: 0.0004169
##
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn

```

```

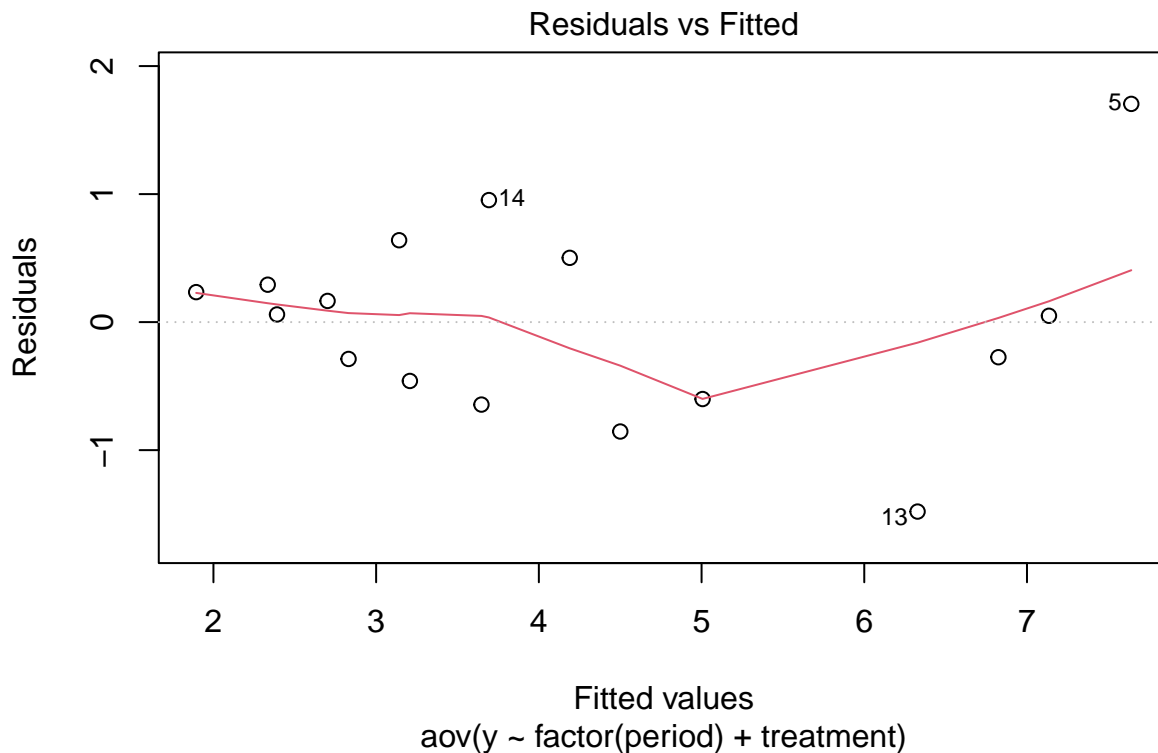
## mean_CH4_barn
##
## Transformed Dunnetts test:
##
## Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = log10(y) ~ factor(period) + treatment, data = emis_dat)
##
## Linear Hypotheses:
##
##              Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0 -0.19613    0.05279  -3.715  0.0122 *
## slurryfunnels - control == 0    -0.42879    0.05279  -8.122  <0.001 ***
## slurrytrays - control == 0     -0.36226    0.05279  -6.862  <0.001 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
##
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Transformed confidence intervals:
##
##              2.5 %      97.5 %
## (Intercept)    460.25781 837.156197
## factor(period)2 -20.55591 37.693033
## factor(period)3 -31.16405 19.306934
## factor(period)4 -38.01840 7.426925
## treatmentfrequentflushing -51.64433 -16.189624
## treatmentslurryfunnels -71.69999 -50.950230
## treatmentslurrytrays -67.01512 -42.830377
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Transformed aov summary without period:
##
##              Df Sum Sq Mean Sq F value Pr(>F)
## treatment      3 0.5453  0.1818   26.75 1.8e-06 ***
## Residuals     16 0.1087  0.0068
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Transformed lm summary without period:

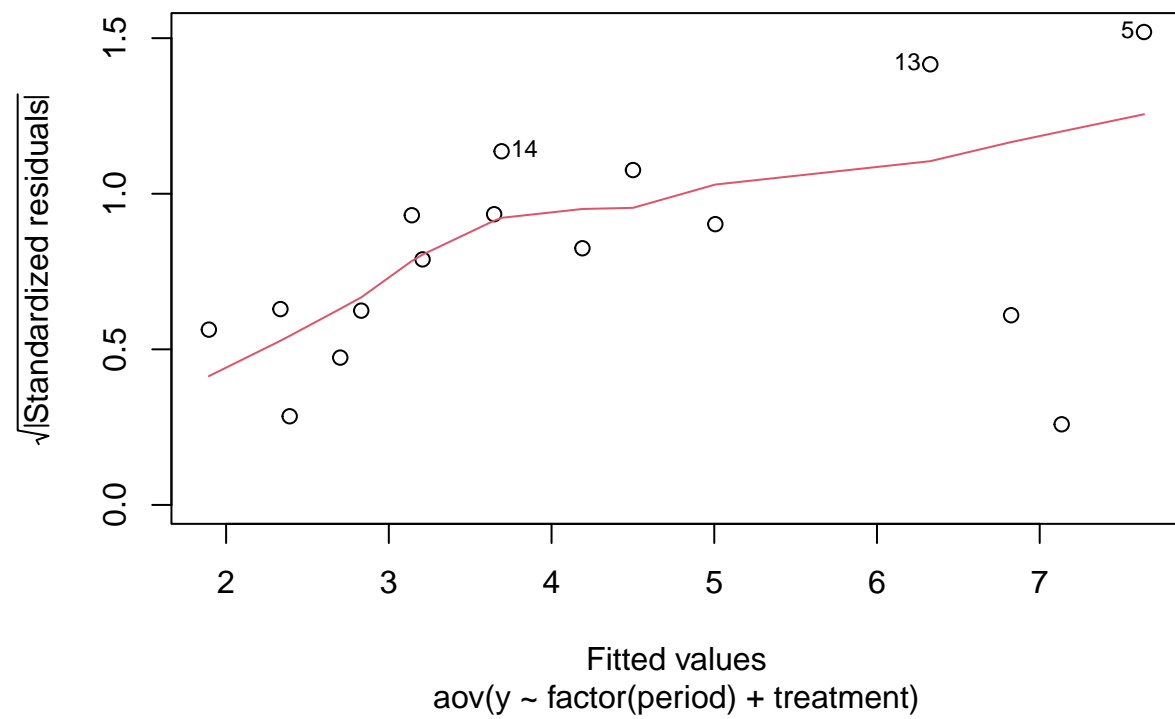
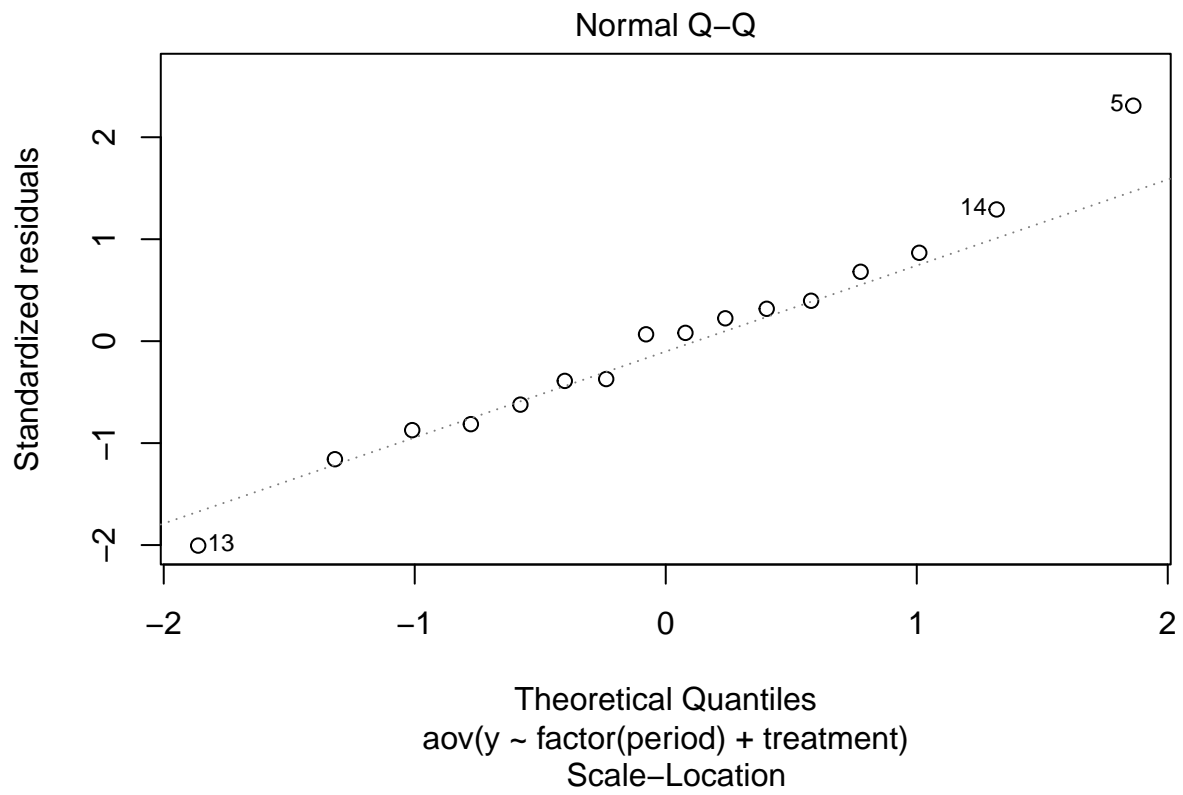
```

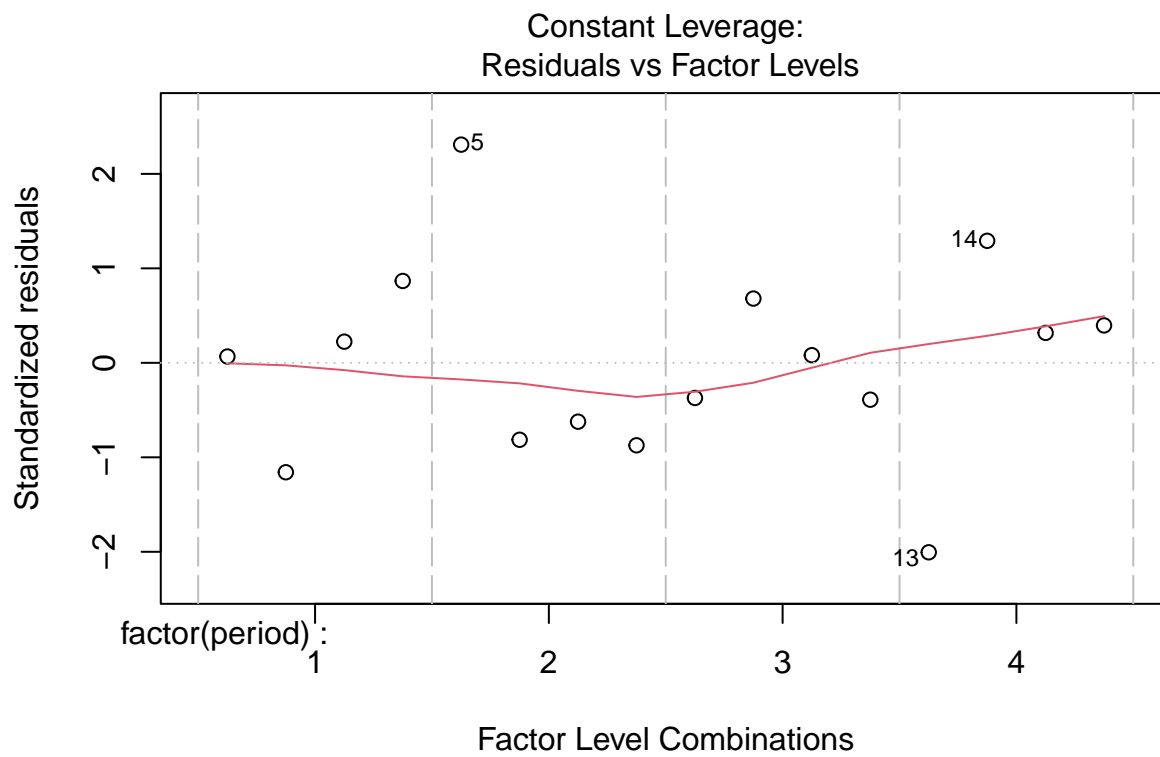


```
##
## Call:
## aov(formula = log10(y) ~ treatment, data = emis_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.16498 -0.05698  0.01621  0.05536  0.12008
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      0.85053    0.03687   23.071 1.05e-13 ***
## treatmentfrequentflushing -0.23772    0.05214   -4.559 0.000322 ***
## treatmentslurryfunnels -0.43808    0.05214   -8.403 2.92e-07 ***
## treatmentslurrytrays -0.35629    0.05214   -6.834 4.02e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.08244 on 16 degrees of freedom
## Multiple R-squared:  0.8338, Adjusted R-squared:  0.8026
## F-statistic: 26.75 on 3 and 16 DF,  p-value: 1.798e-06
##
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Transformed Dunnetts test without period:
##
## Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = log10(y) ~ treatment, data = emis_dat)
##
## Linear Hypotheses:
##              Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0 -0.23772    0.05214   -4.559  <0.001 ***
## slurryfunnels - control == 0 -0.43808    0.05214   -8.403  <0.001 ***
## slurrytrays - control == 0 -0.35629    0.05214   -6.834  <0.001 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
##
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Transformed confidence intervals without period:
##              2.5 %    97.5 %
## (Intercept)    492.07950 748.56706
```

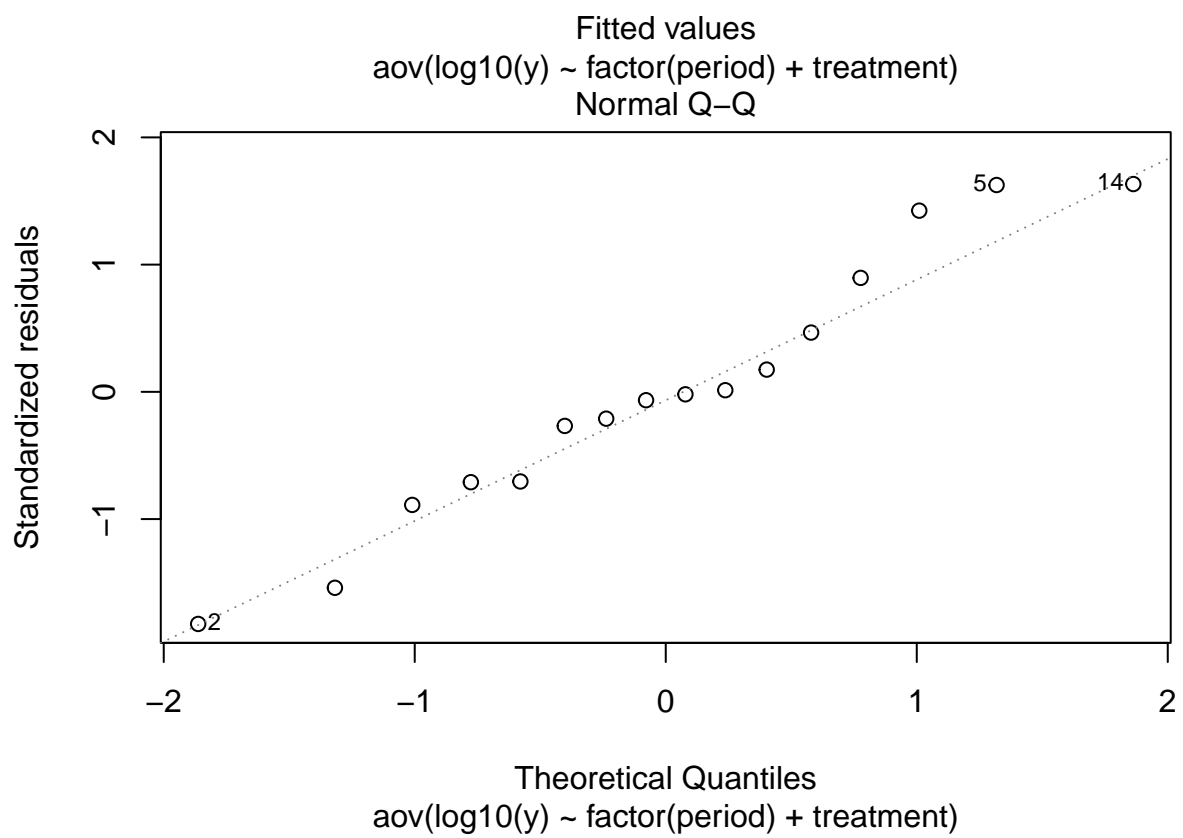
```
## treatmentfrequentflushing -55.15044 -25.38803
## treatmentslurryfunnels -71.72555 -52.96248
## treatmentslurrytrays -65.86590 -43.21434
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Transformed relative reduction (coef):
##          factor(period)3          factor(period)4 treatmentfrequentflushing
##                -9.4                -18.4                -36.3
## treatmentslurryfunnels treatmentslurrytrays
##                -62.7                -56.6
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Transformed relative reduction without period (coef):
## treatmentfrequentflushing treatmentslurryfunnels treatmentslurrytrays
##                -42.2                -63.5                -56.0
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Non-transformed diagnostic plots:
```

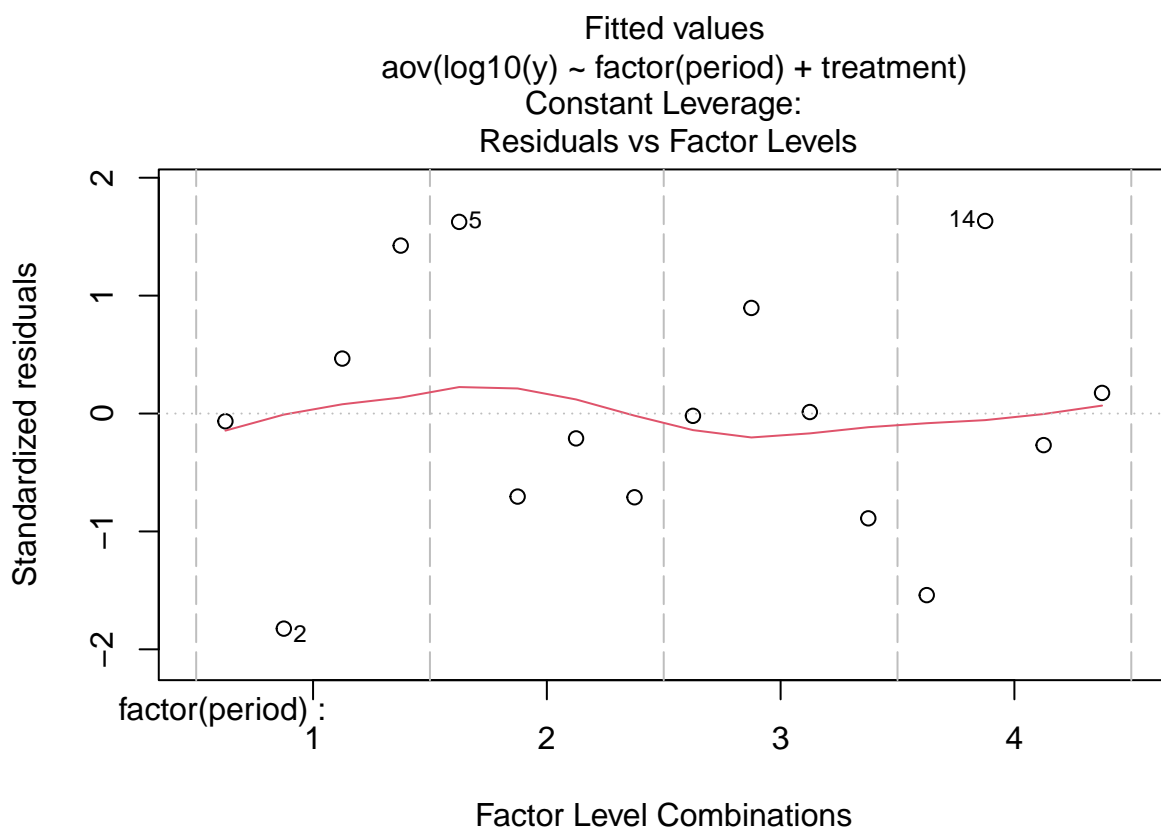
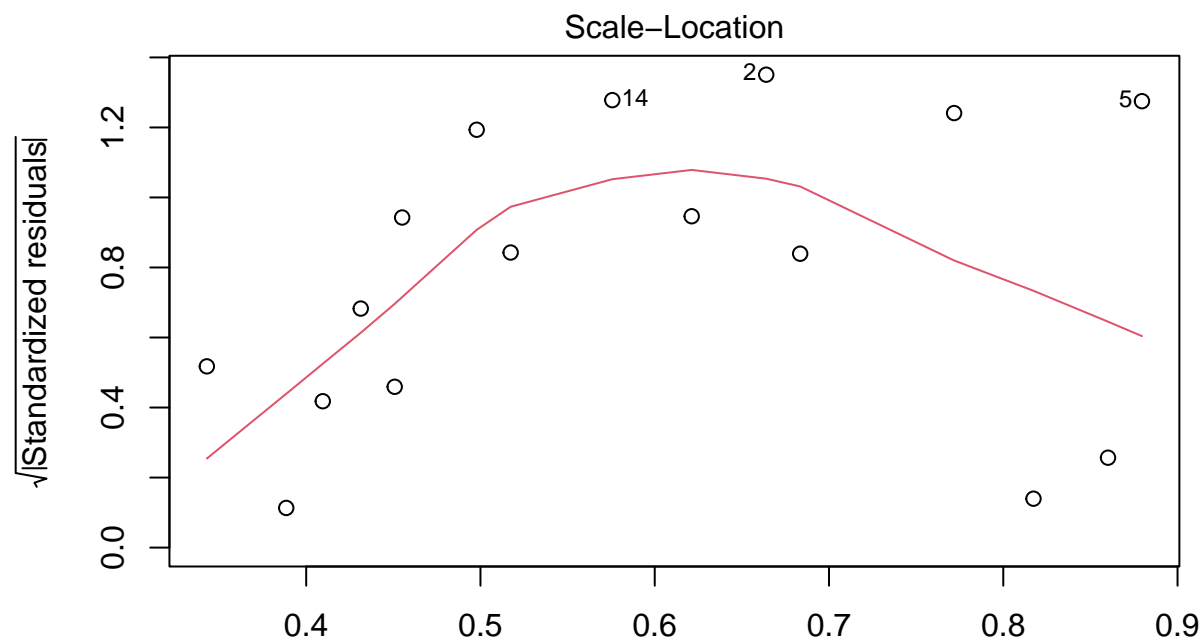




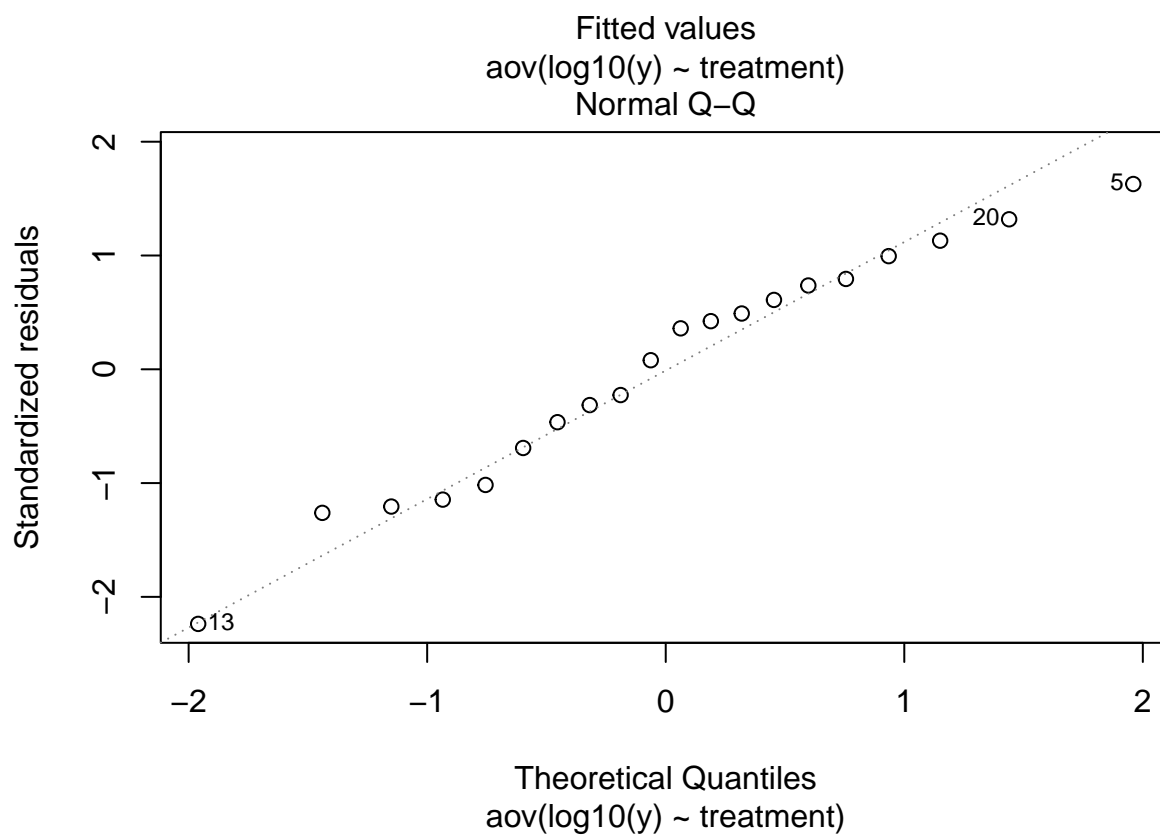
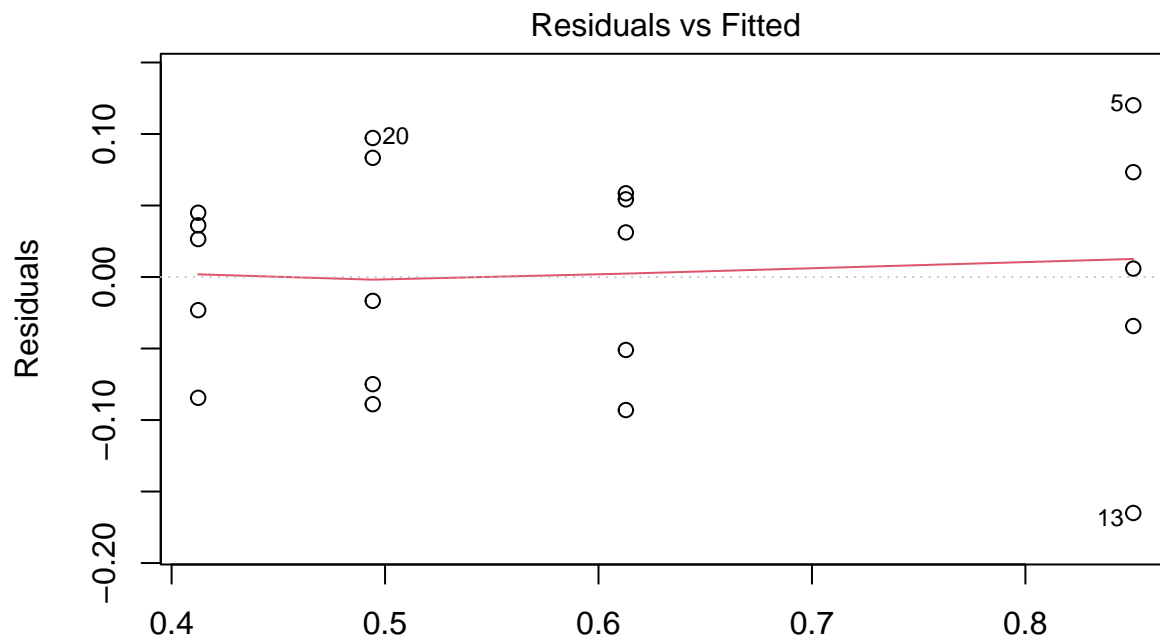


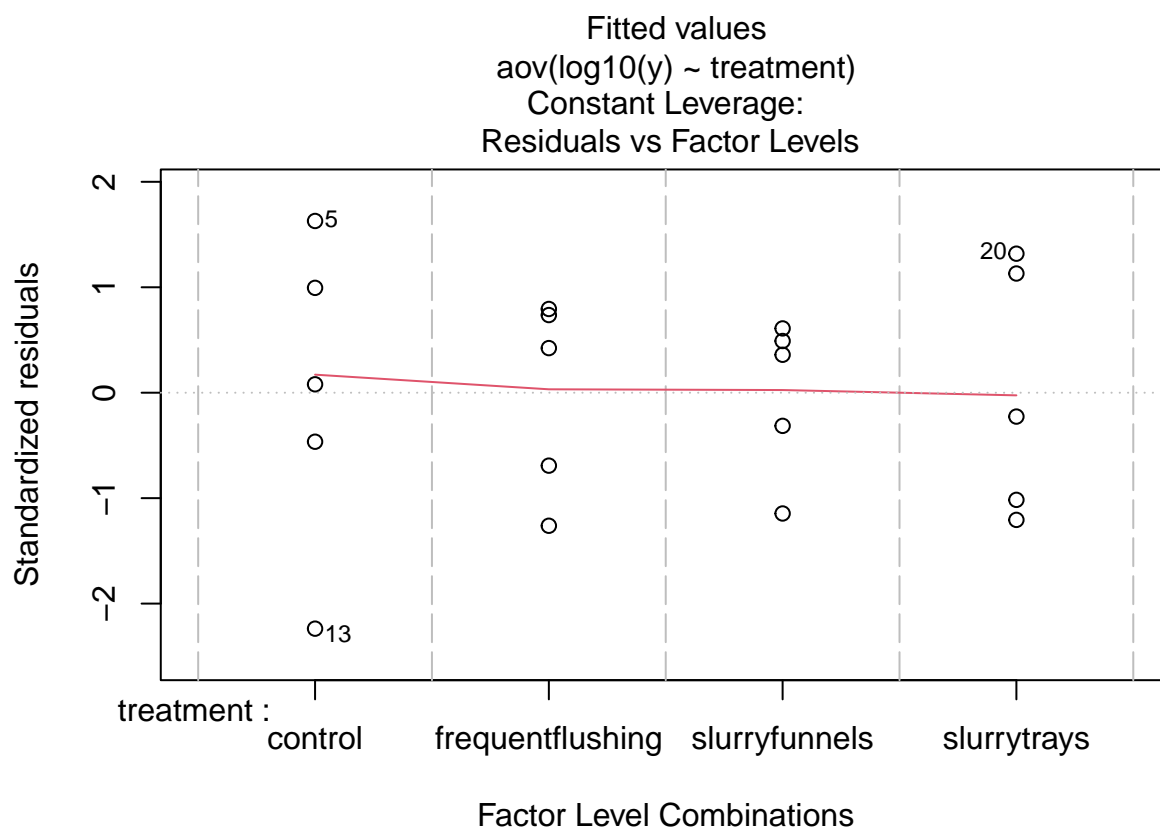
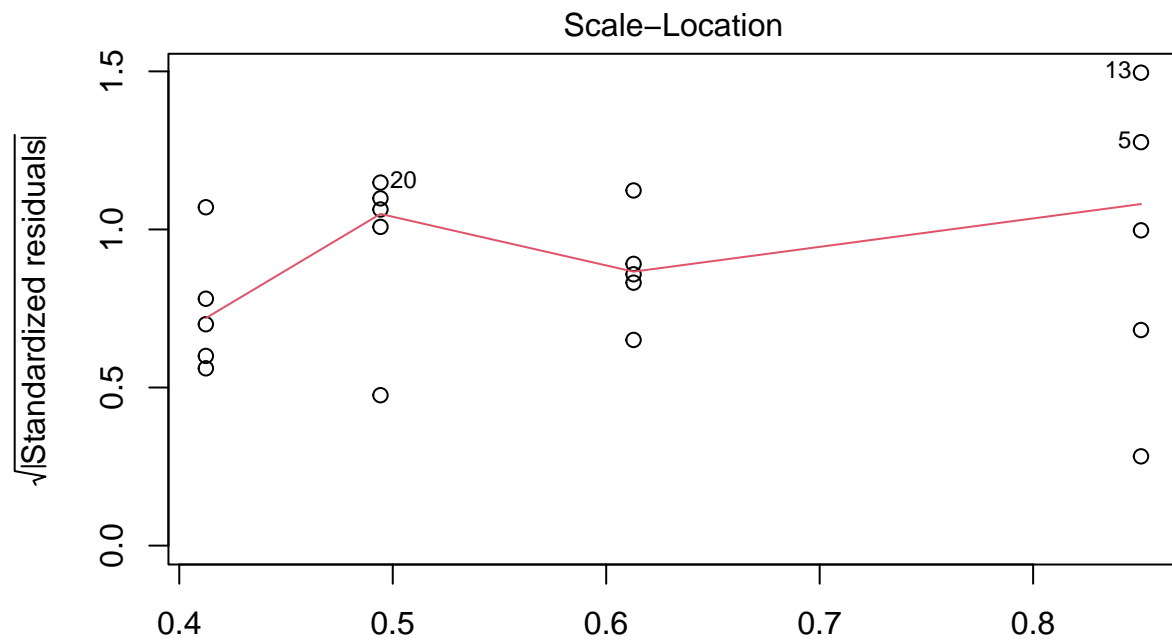
```
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Transformed diagnostic plots:
```





```
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
## Transformed diagnostic plots without period:
```





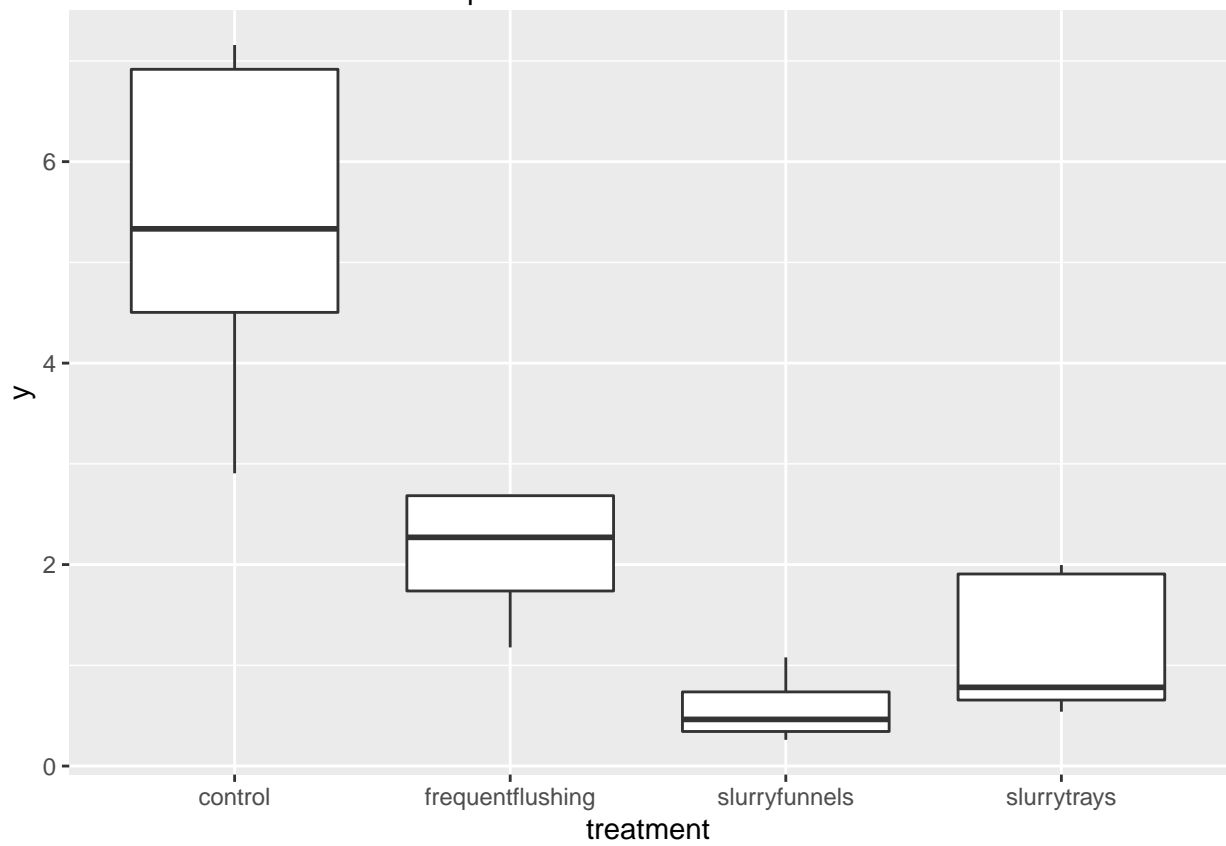
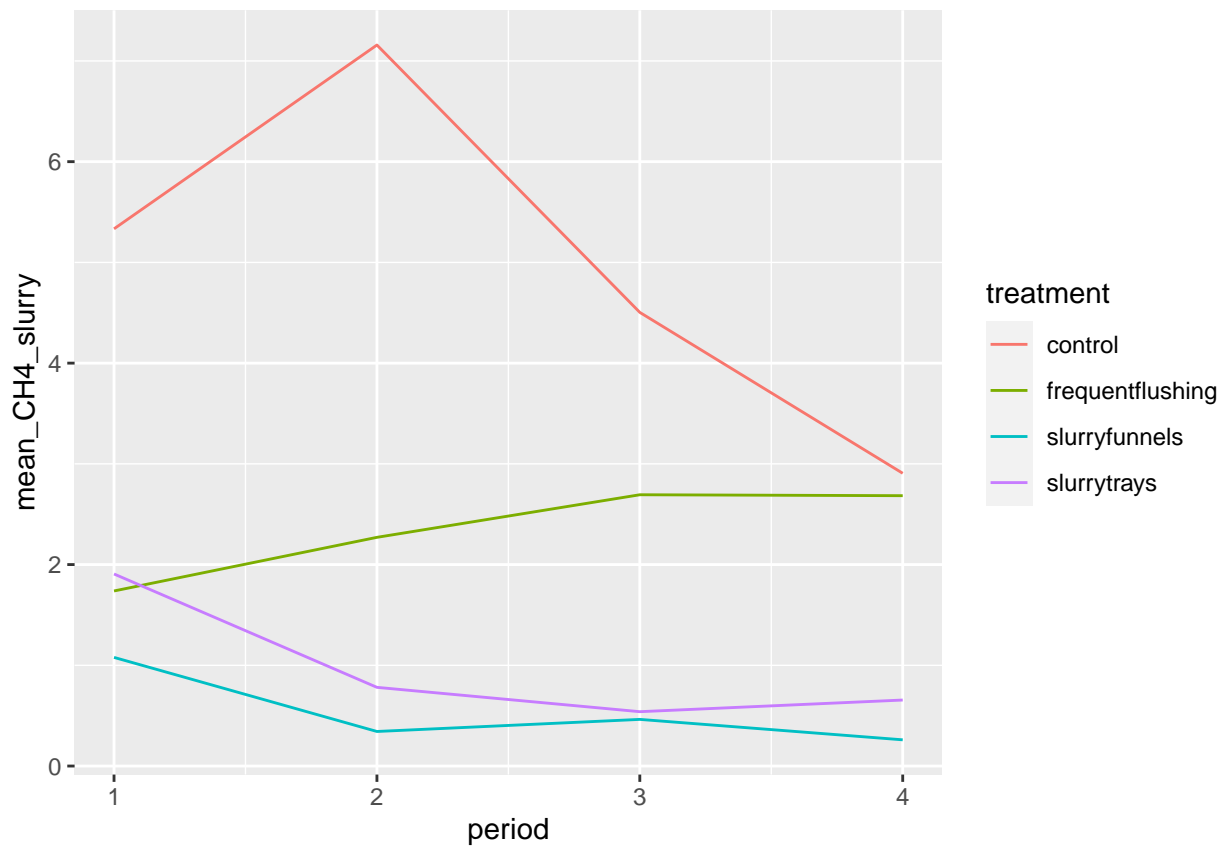
```
##
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
## mean_CH4_barn
##
##
```



```

##
##
## end mean_CH4_barn end mean_CH4_barn end mean_CH4_barn
##
## end mean_CH4_barn end mean_CH4_barn end mean_CH4_barn
##
## end mean_CH4_barn end mean_CH4_barn end mean_CH4_barn
##
##
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Warning: Removed 4 row(s) containing missing values (geom_path).

```



##

```

## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Non-transformed aov summary:
##           Df Sum Sq Mean Sq F value    Pr(>F)
## factor(period) 3   2.57   0.856   0.851 0.500103
## treatment      3  48.01  16.004  15.918 0.000608 ***
## Residuals      9   9.05   1.005
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 4 observations deleted due to missingness
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Non-transformed lm summary:
##
## Call:
## aov(formula = y ~ factor(period) + treatment, data = emis_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.48831 -0.53546  0.06752  0.35460  1.75175
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      5.2822    0.6632   7.964 2.29e-05 ***
## factor(period)2    0.1242    0.7090   0.175 0.864819
## factor(period)3   -0.4641    0.7090  -0.655 0.529080
## factor(period)4   -0.8877    0.7090  -1.252 0.242140
## treatmentfrequentflushing -2.6289    0.7090  -3.708 0.004861 **
## treatmentslurryfunnels  -4.4391    0.7090  -6.261 0.000148 ***
## treatmentslurrytrays   -4.0046    0.7090  -5.648 0.000314 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.003 on 9 degrees of freedom
## (4 observations deleted due to missingness)
## Multiple R-squared:  0.8483, Adjusted R-squared:  0.7471
## F-statistic: 8.385 on 6 and 9 DF, p-value: 0.002834
##
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Non-transformed Dunnett s test:
##
## Simultaneous Tests for General Linear Hypotheses

```

```

##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = y ~ factor(period) + treatment, data = emis_dat)
##
## Linear Hypotheses:
##
##          Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0   -2.629      0.709   -3.708   0.0123 *
## slurryfunnels - control == 0      -4.439      0.709   -6.261   <0.001 ***
## slurrytrays - control == 0        -4.005      0.709   -5.648   <0.001 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
##
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Non-transformed confidence intervals:
##
##          2.5 %    97.5 %
## (Intercept)    3.781902  6.782514
## factor(period)2   -1.479693  1.728097
## factor(period)3   -2.068034  1.139756
## factor(period)4   -2.491553  0.716237
## treatmentfrequentflushing -4.232826 -1.025037
## treatmentslurryfunnels   -6.043017 -2.835227
## treatmentslurrytrays    -5.608542 -2.400753
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Transformed aov summary:
##
##          Df Sum Sq Mean Sq F value    Pr(>F)
## factor(period)  3 0.1753   0.0584    1.645 0.247169
## treatment       3 2.4274   0.8091   22.784 0.000154 ***
## Residuals      9 0.3196   0.0355
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 4 observations deleted due to missingness
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Transformed lm summary:
##
## Call:
## aov(formula = log10(y) ~ factor(period) + treatment, data = emis_dat)

```

```

##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.286000 -0.112487  0.001559  0.122449  0.208276
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      0.8369     0.1246   6.714 8.71e-05 ***
## factor(period)2    -0.1602     0.1333  -1.202 0.259872
## factor(period)3    -0.1996     0.1333  -1.498 0.168306
## factor(period)4    -0.2891     0.1333  -2.169 0.058165 .
## treatmentfrequentflushing -0.3109     0.1333  -2.333 0.044532 *
## treatmentslurryfunnels  -1.0124     0.1333  -7.597 3.34e-05 ***
## treatmentslurrytrays   -0.7443     0.1333  -5.586 0.000341 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1885 on 9 degrees of freedom
## (4 observations deleted due to missingness)
## Multiple R-squared:  0.8906, Adjusted R-squared:  0.8177
## F-statistic: 12.21 on 6 and 9 DF, p-value: 0.0007015
##
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Transformed Dunnetts test:
##
## Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = log10(y) ~ factor(period) + treatment, data = emis_dat)
##
## Linear Hypotheses:
##              Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0  -0.3109     0.1333  -2.333   0.106
## slurryfunnels - control == 0     -1.0124     0.1333  -7.597 <0.001 ***
## slurrytrays - control == 0       -0.7443     0.1333  -5.586 <0.001 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
##
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Transformed confidence intervals:
##              2.5 %      97.5 %

```

```

## (Intercept)                258.87112 1214.877588
## factor(period)2            -65.45962   38.424082
## factor(period)3            -68.45616   26.415149
## factor(period)4            -74.32747    2.885282
## treatmentfrequentflushing -75.58357   -2.148699
## treatmentslurryfunnels    -95.14531  -80.544331
## treatmentslurrytrays      -90.99974  -63.930546
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Transformed aov summary without period:
##           Df Sum Sq Mean Sq F value    Pr(>F)
## treatment   3  2.7619   0.9206   20.23 1.08e-05 ***
## Residuals  16  0.7281   0.0455
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Transformed lm summary without period:
##
## Call:
## aov(formula = log10(y) ~ treatment, data = emis_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.28793 -0.17282 -0.00916  0.13592  0.32960
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.7077    0.0954   7.418 1.46e-06 ***
## treatmentfrequentflushing -0.4025    0.1349  -2.983  0.00878 **
## treatmentslurryfunnels    -1.0045    0.1349  -7.446 1.39e-06 ***
## treatmentslurrytrays     -0.7034    0.1349  -5.214 8.53e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2133 on 16 degrees of freedom
## Multiple R-squared:  0.7914, Adjusted R-squared:  0.7523
## F-statistic: 20.23 on 3 and 16 DF,  p-value: 1.081e-05
##
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Transformed Dunnetts test without period:

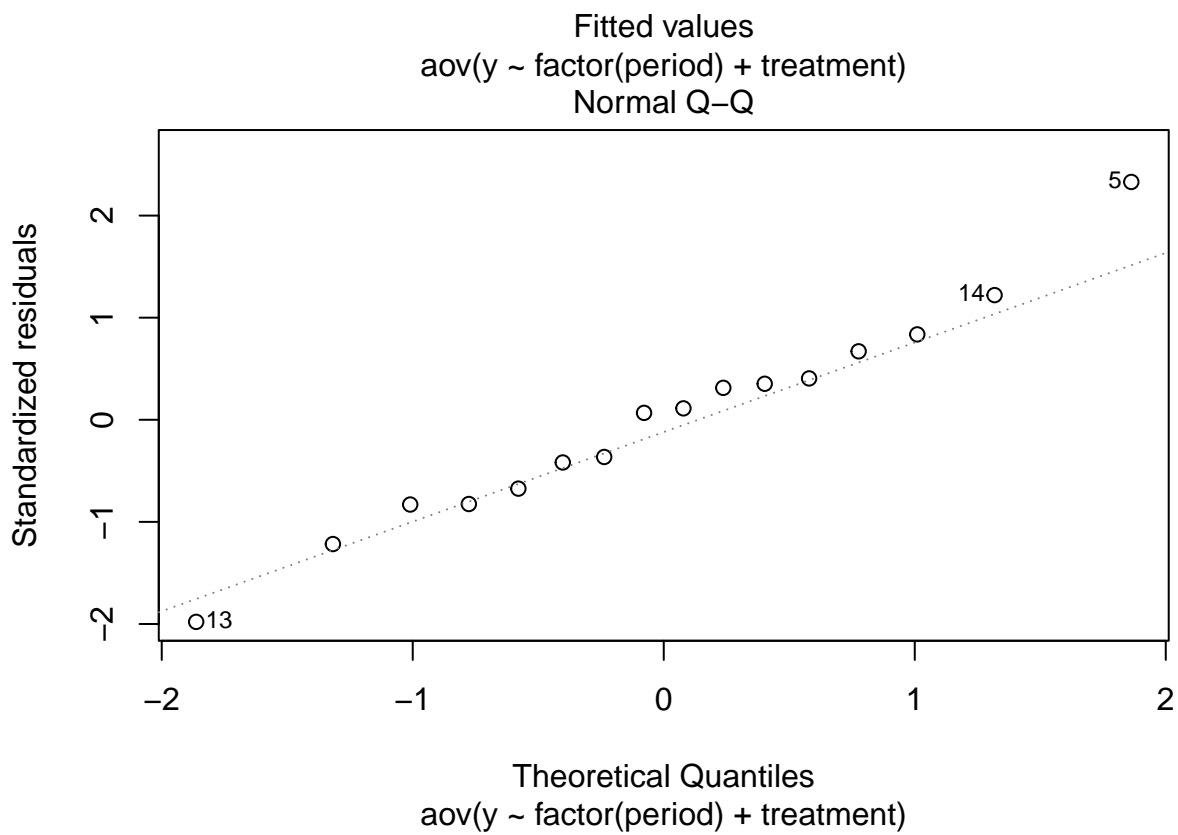
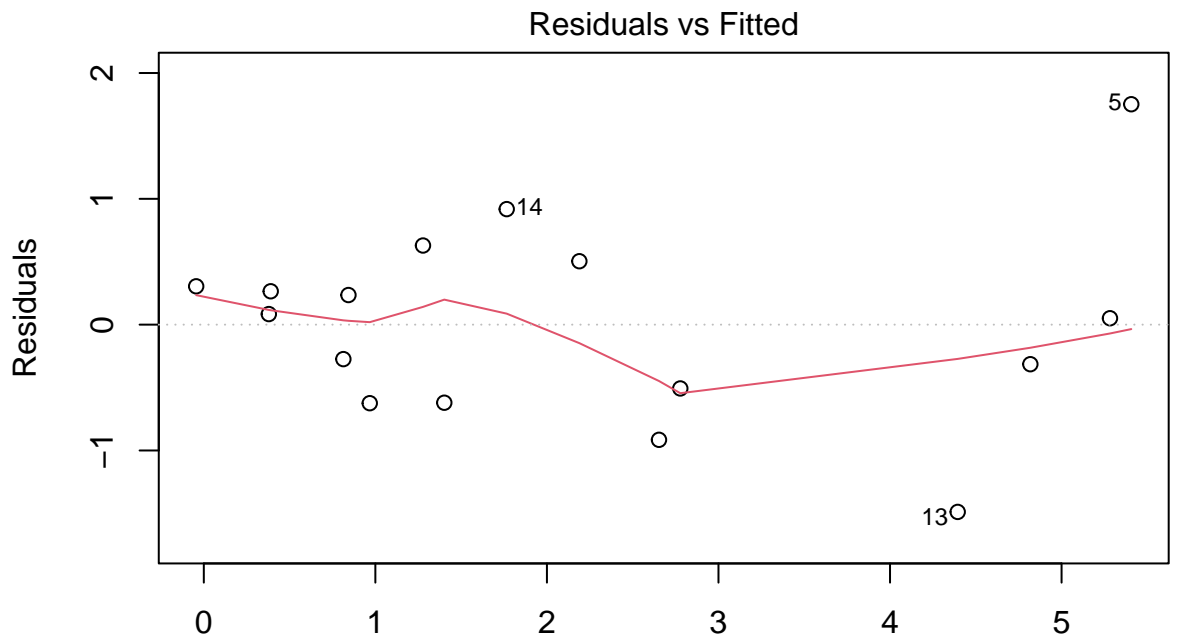
```

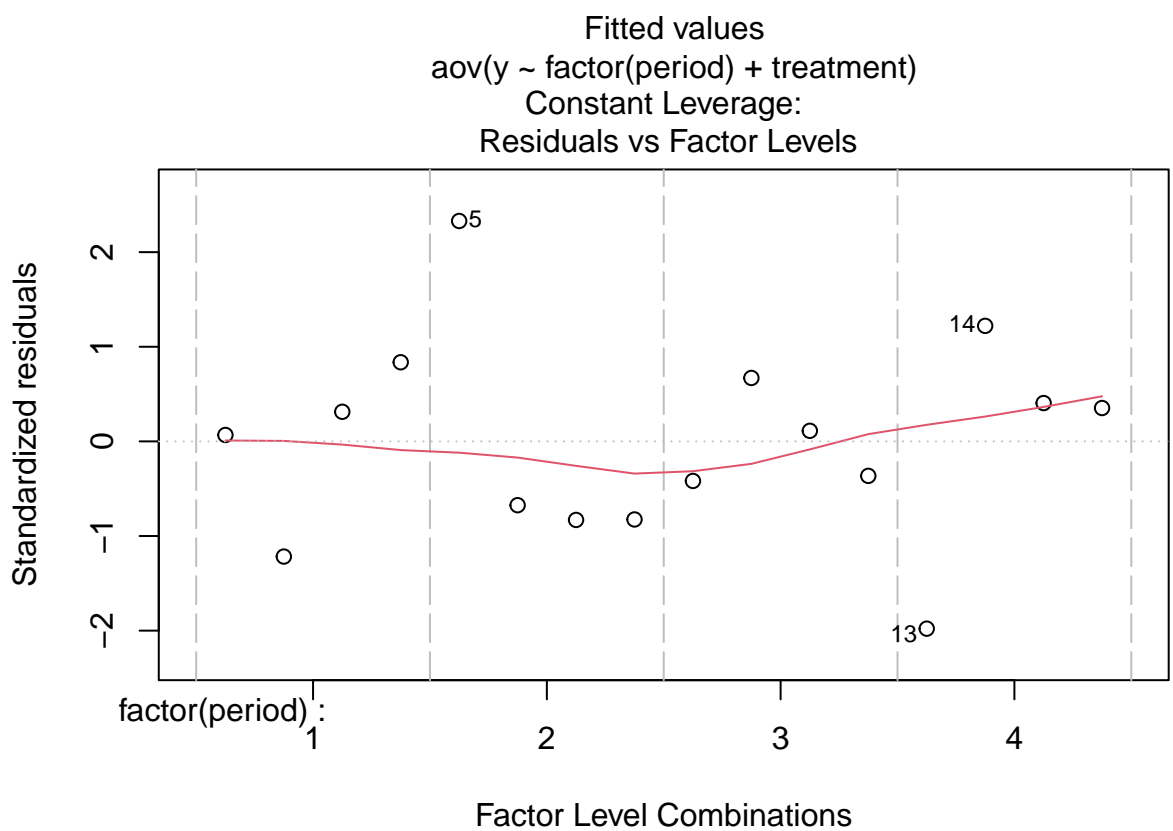
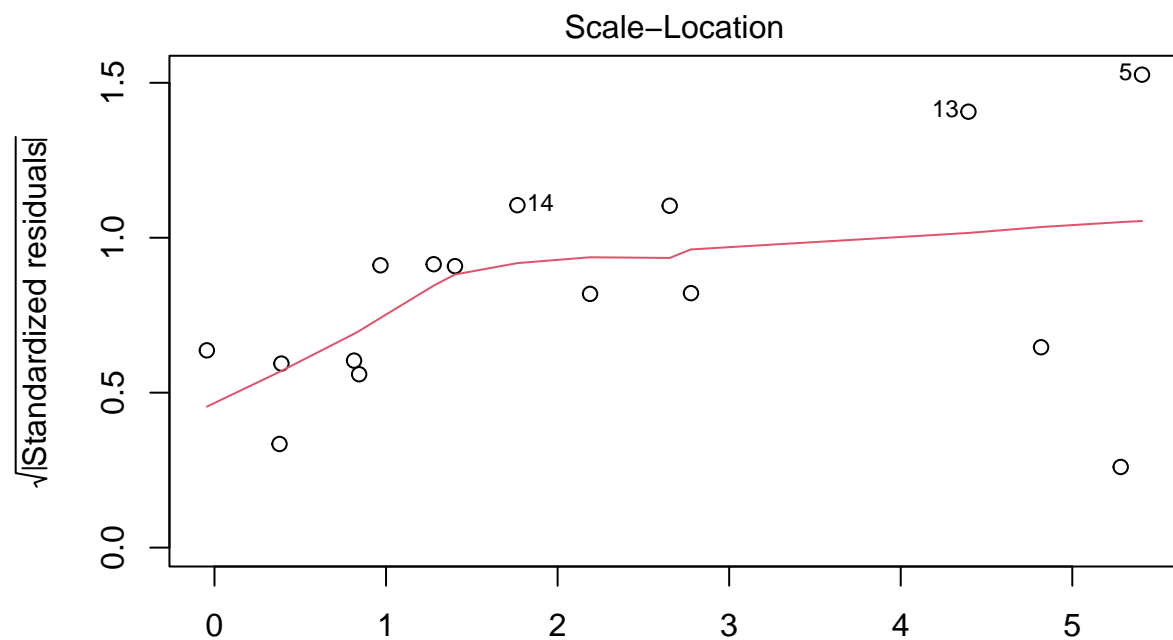
```

##
## Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = log10(y) ~ treatment, data = emis_dat)
##
## Linear Hypotheses:
##
##          Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0  -0.4025      0.1349  -2.983   0.0229 *
## slurryfunnels - control == 0     -1.0045      0.1349  -7.446   <0.001 ***
## slurrytrays - control == 0       -0.7034      0.1349  -5.214   <0.001 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
##
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Transformed confidence intervals without period:
##          2.5 %    97.5 %
## (Intercept)      220.24457 712.75327
## treatmentfrequentflushing -79.51100 -23.52181
## treatmentslurryfunnels   -94.87767 -80.88014
## treatmentslurrytrays    -89.75360 -61.75381
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Transformed relative reduction (coef):
##          factor(period)3          factor(period)4 treatmentfrequentflushing
##                -36.9                -48.6                -51.1
## treatmentslurryfunnels treatmentslurrytrays
##                -90.3                -82.0
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Transformed relative reduction without period (coef):
## treatmentfrequentflushing treatmentslurryfunnels treatmentslurrytrays
##                -60.4                -90.1                -80.2
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry

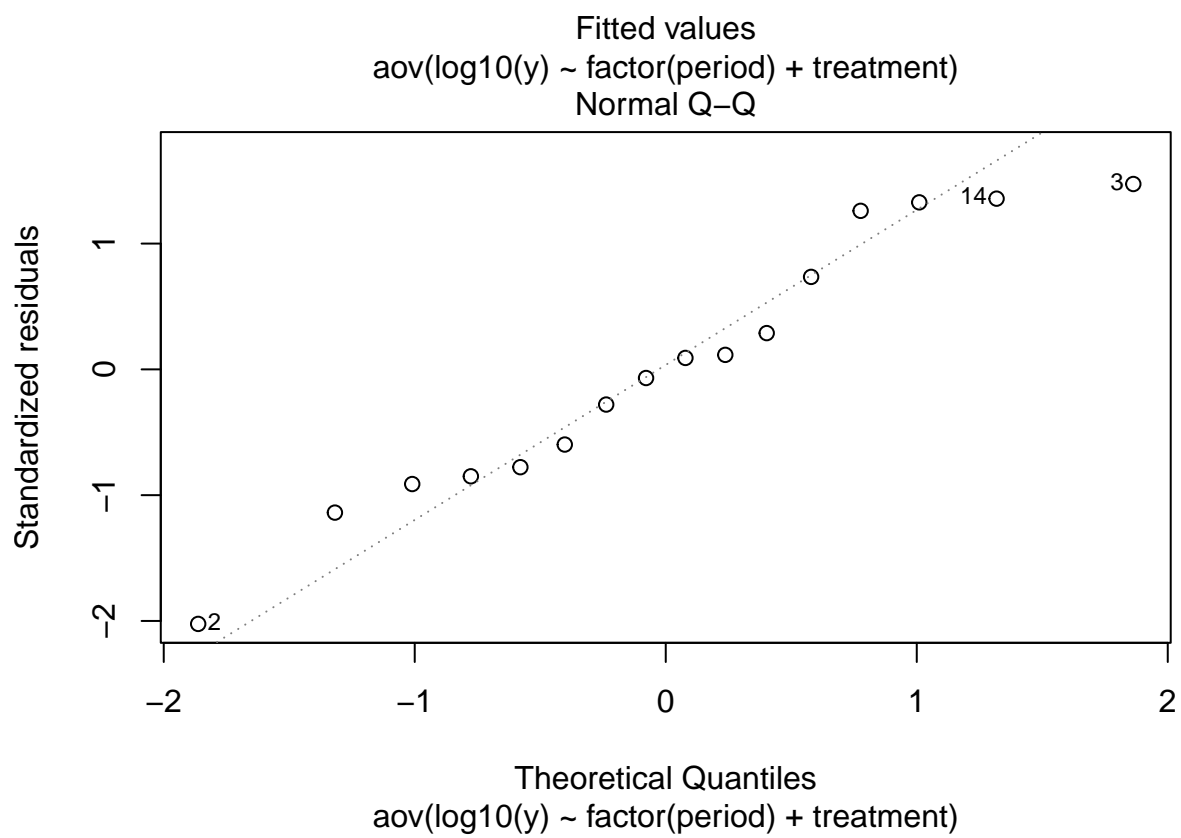
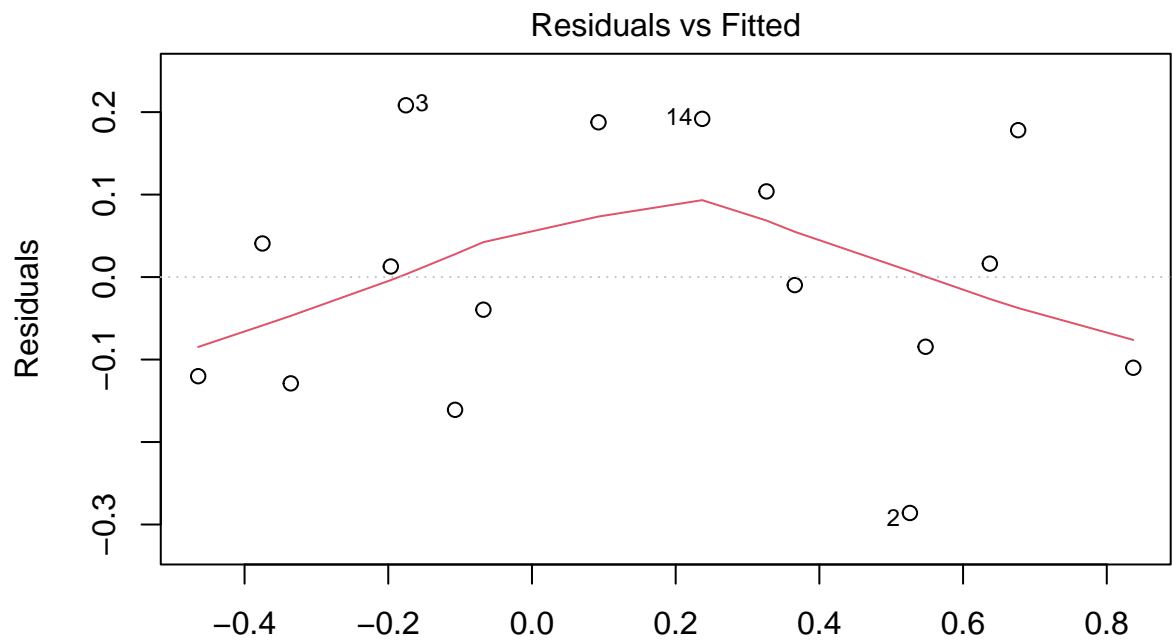
```

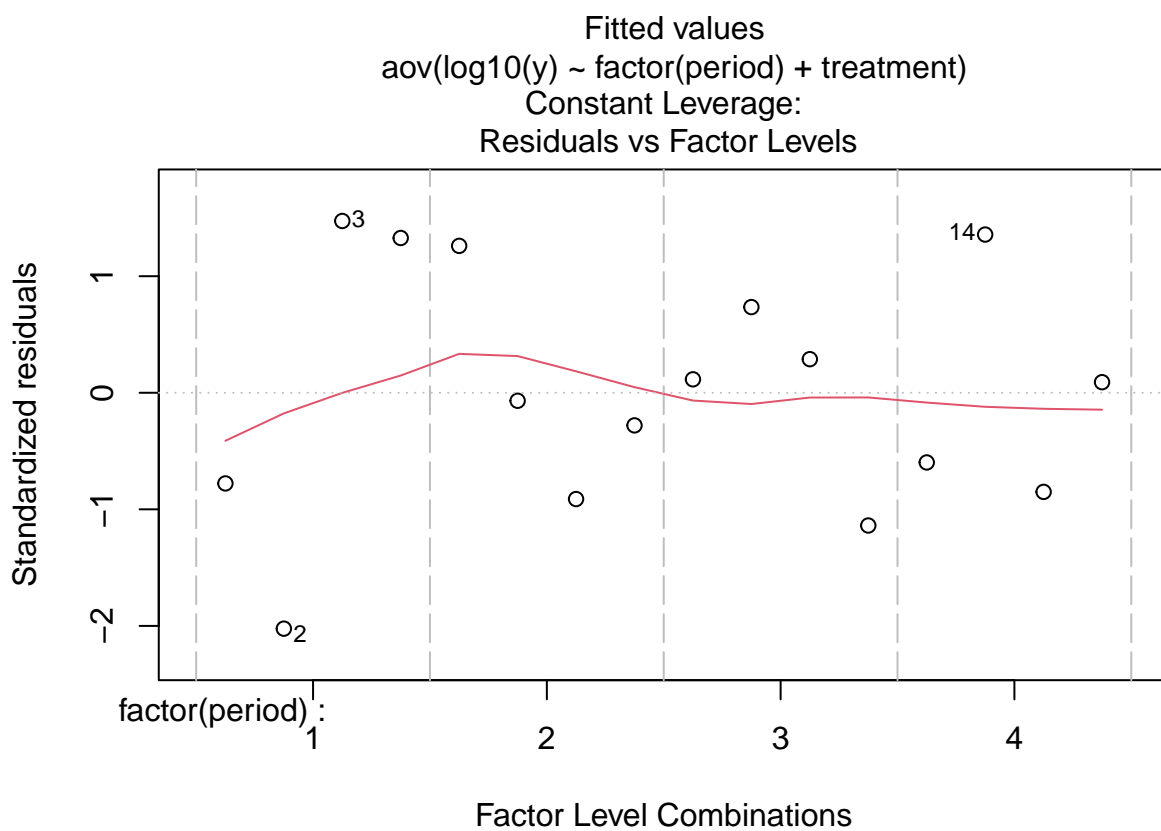
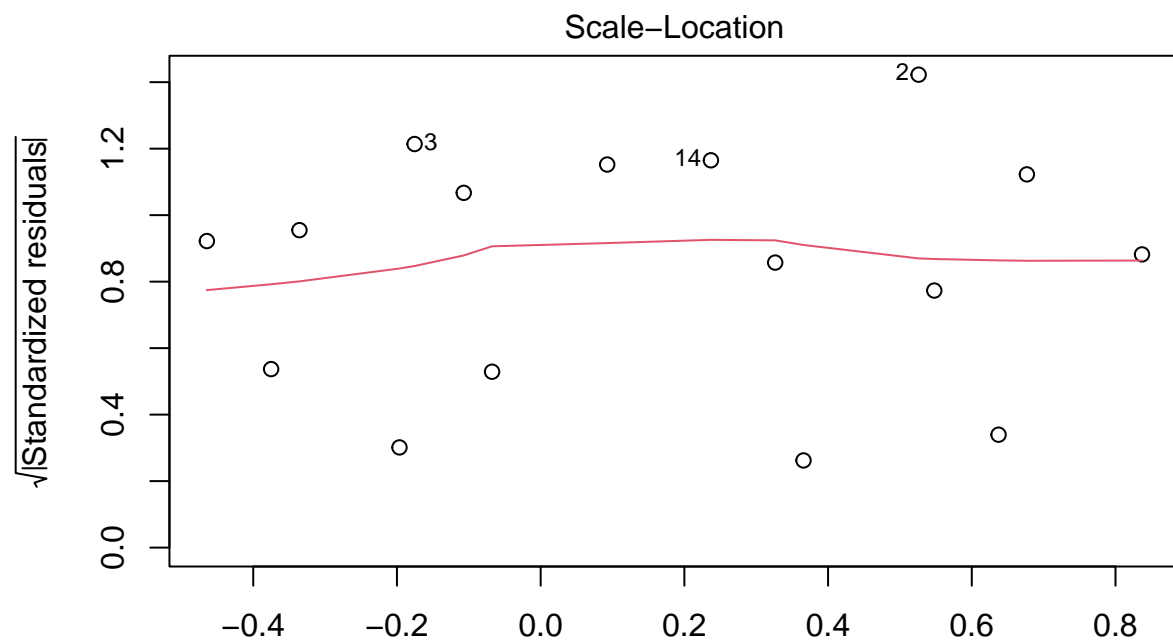
```
##
## Non-transformed diagnostic plots:
```



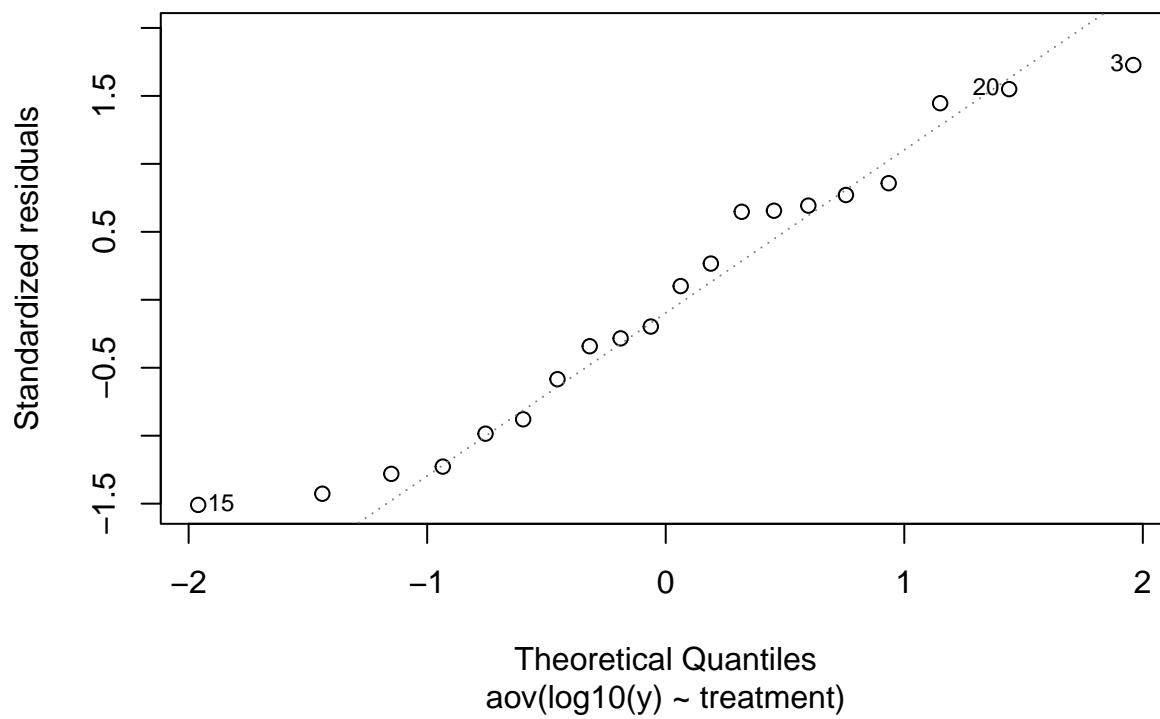
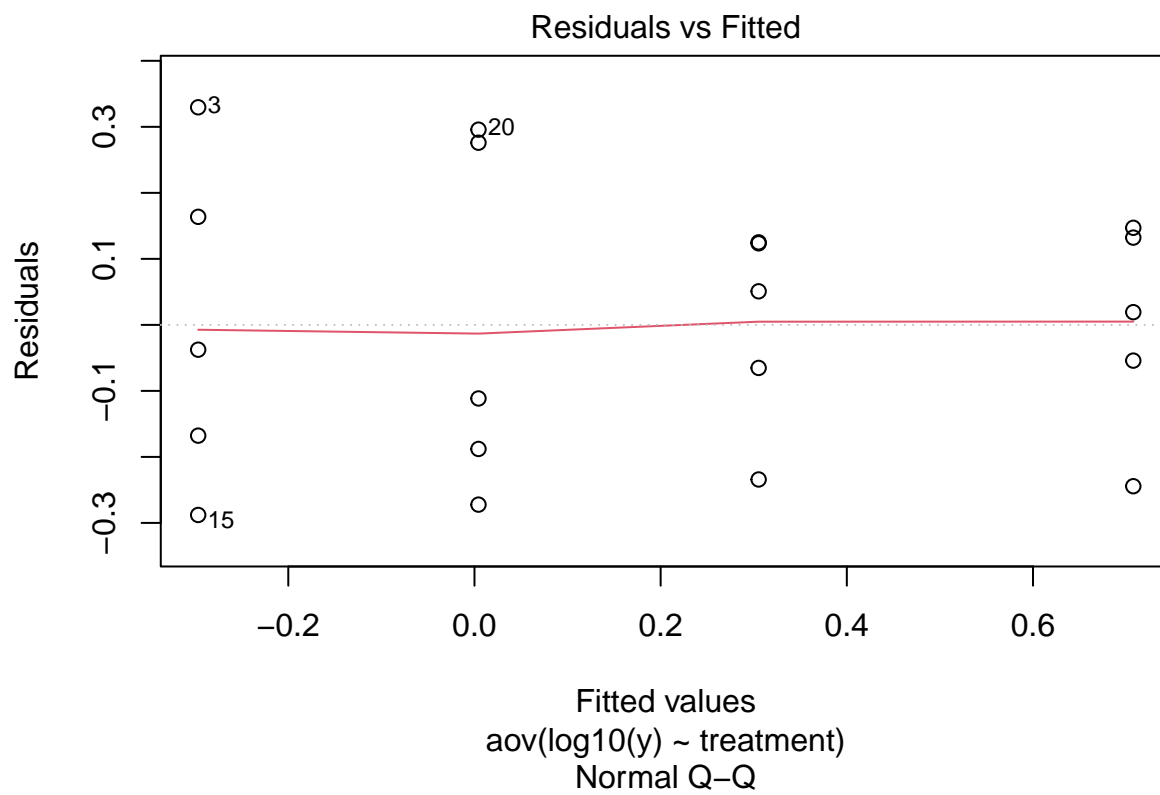


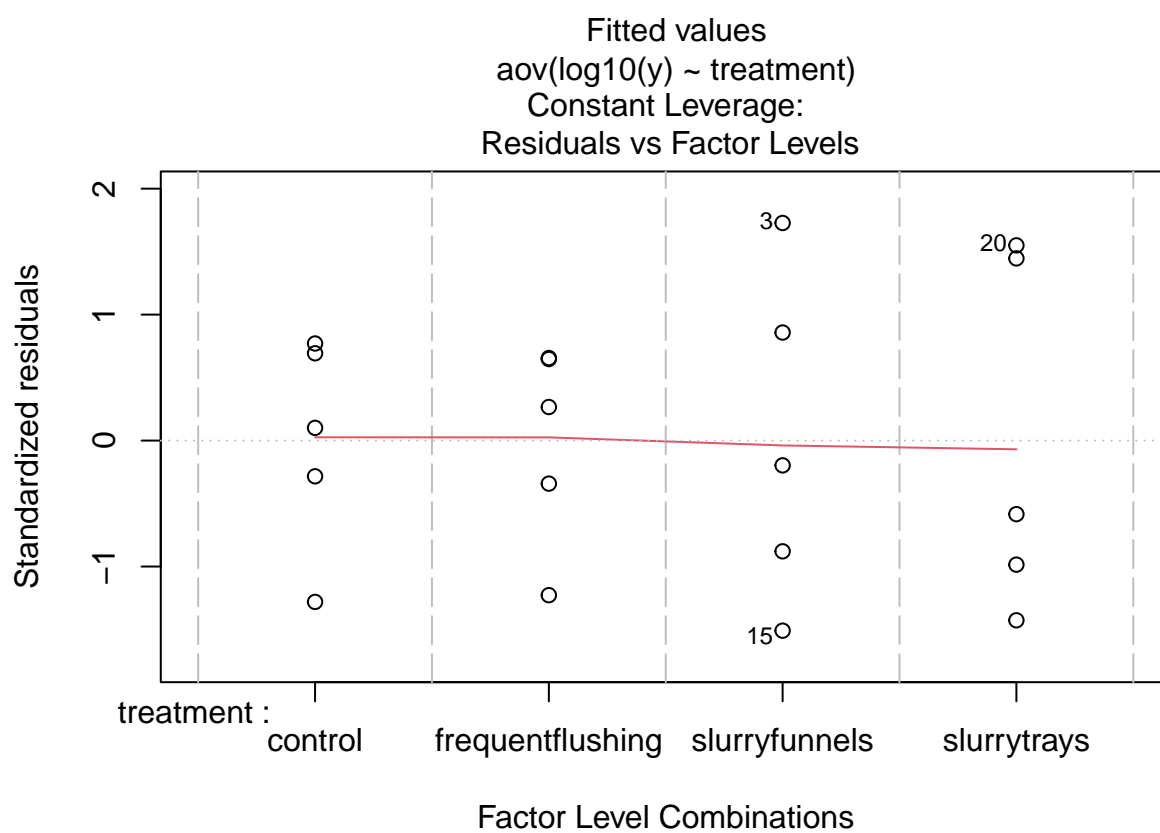
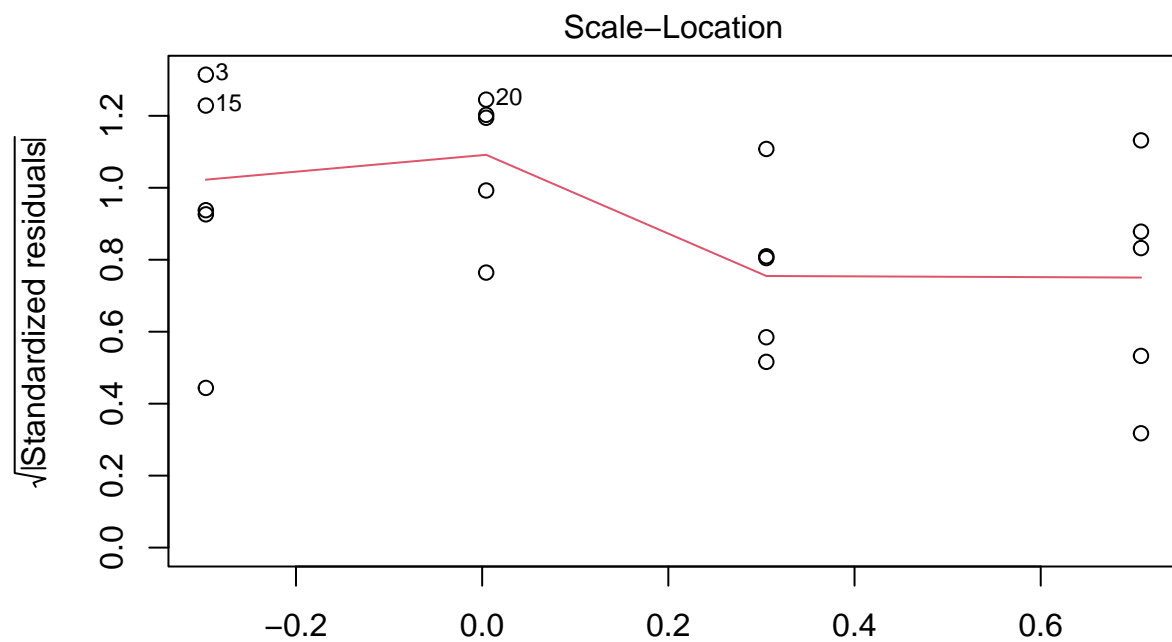
```
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Transformed diagnostic plots:
```





```
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
## Transformed diagnostic plots without period:
```



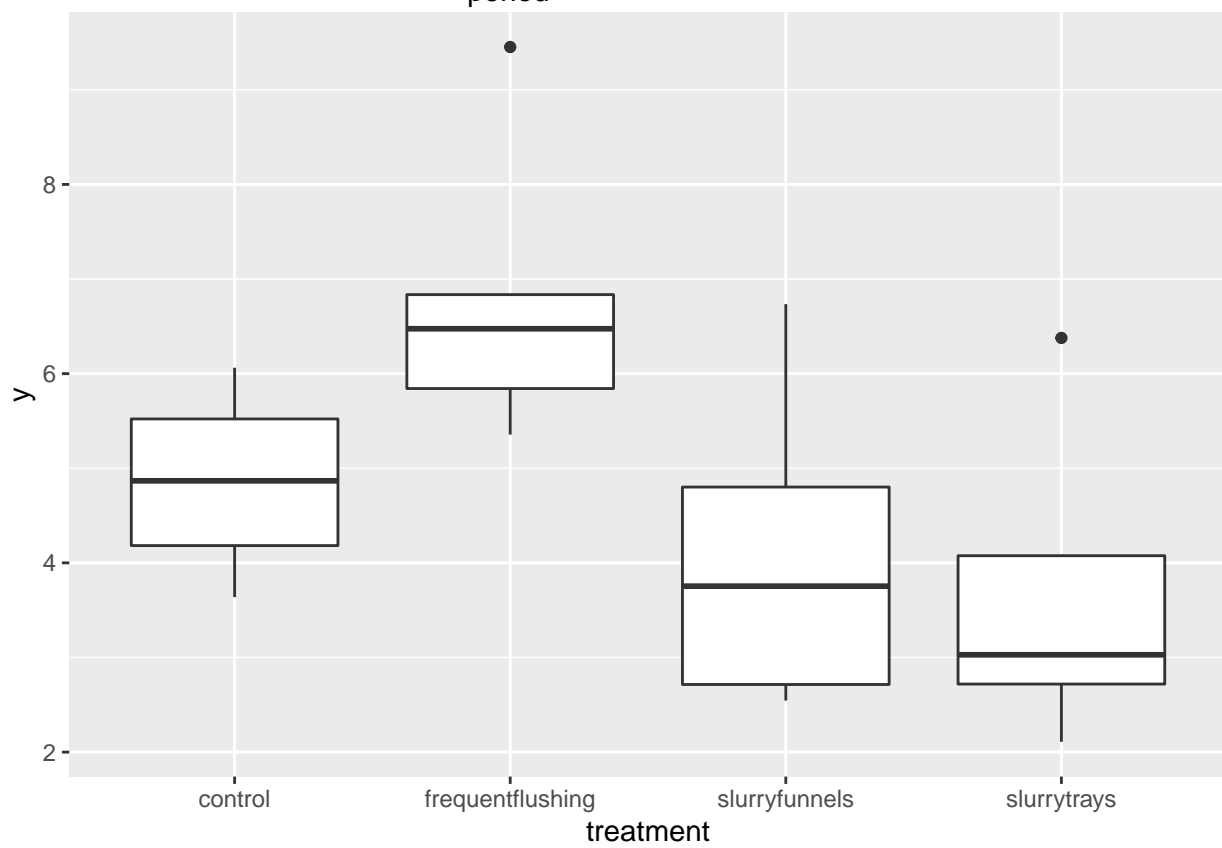
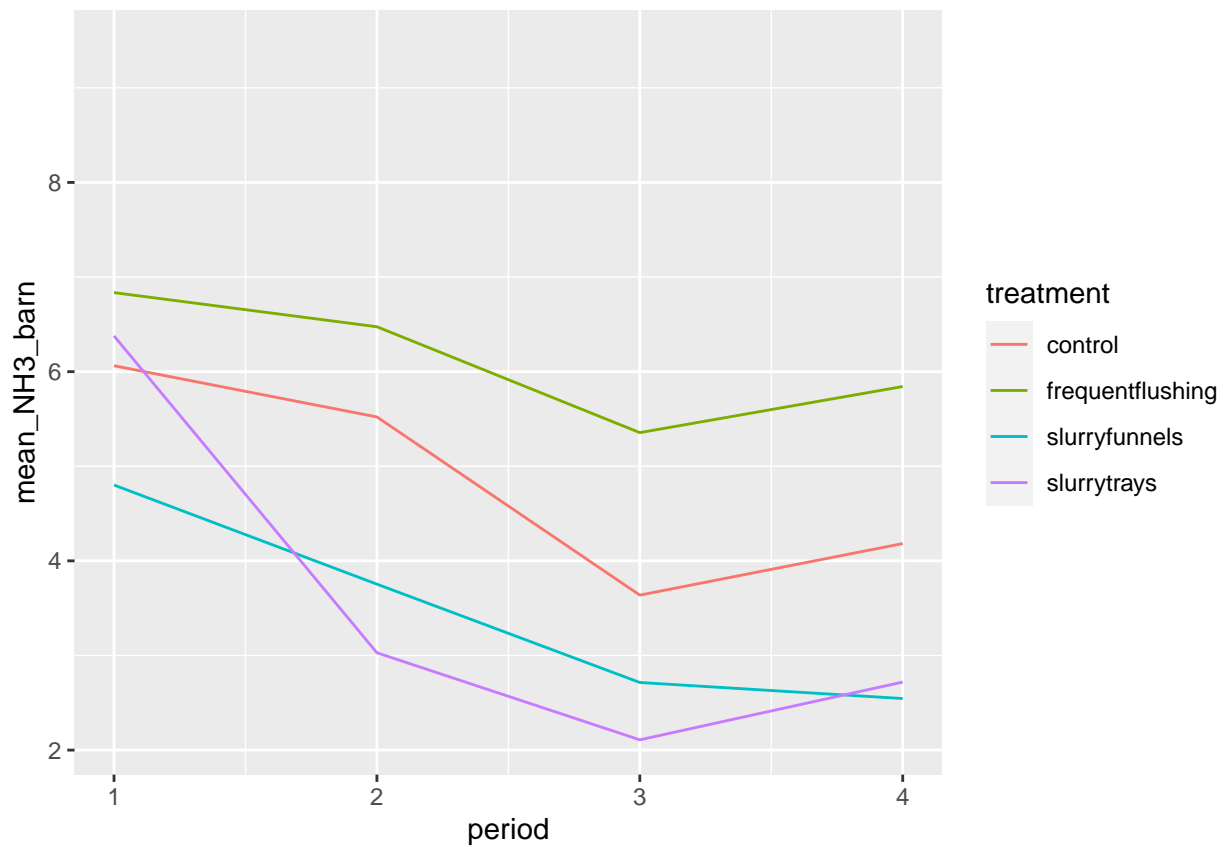


```
##
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
## mean_CH4_slurry
##
##
```

```

##
##
## end mean_CH4_slurry end mean_CH4_slurry end mean_CH4_slurry
##
## end mean_CH4_slurry end mean_CH4_slurry end mean_CH4_slurry
##
## end mean_CH4_slurry end mean_CH4_slurry end mean_CH4_slurry
##
##
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Warning: Removed 4 row(s) containing missing values (geom_path).

```



##

```

## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Non-transformed aov summary:
##           Df Sum Sq Mean Sq F value    Pr(>F)
## factor(period)  3 15.595   5.198   12.15 0.001622 **
## treatment      3 19.007   6.336   14.80 0.000795 ***
## Residuals      9  3.852   0.428
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 4 observations deleted due to missingness
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Non-transformed lm summary:
##
## Call:
## aov(formula = y ~ factor(period) + treatment, data = emis_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.81318 -0.25284 -0.07859  0.28003  1.29752
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)         6.3727    0.4327  14.727 1.32e-07 ***
## factor(period)2      -1.3246    0.4626  -2.863 0.018678 *
## factor(period)3      -2.5650    0.4626  -5.545 0.000359 ***
## factor(period)4      -2.1969    0.4626  -4.749 0.001046 **
## treatmentfrequentflushing  1.2758    0.4626   2.758 0.022187 *
## treatmentslurryfunnels   -1.3975    0.4626  -3.021 0.014456 *
## treatmentslurrytrays    -1.2927    0.4626  -2.794 0.020901 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.6542 on 9 degrees of freedom
## (4 observations deleted due to missingness)
## Multiple R-squared:  0.8998, Adjusted R-squared:  0.833
## F-statistic: 13.47 on 6 and 9 DF, p-value: 0.0004802
##
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Non-transformed Dunnett s test:
##
## Simultaneous Tests for General Linear Hypotheses

```



```

##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = y ~ factor(period) + treatment, data = emis_dat)
##
## Linear Hypotheses:
##
##          Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0    1.2758     0.4626   2.758   0.0544 .
## slurryfunnels - control == 0     -1.3975     0.4626  -3.021   0.0359 *
## slurrytrays - control == 0       -1.2927     0.4626  -2.794   0.0514 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
##
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Non-transformed confidence intervals:
##
##          2.5 %    97.5 %
## (Intercept)    5.3938497  7.3516478
## factor(period)2 -2.3710978 -0.2781235
## factor(period)3 -3.6115274 -1.5185532
## factor(period)4 -3.2433721 -1.1503978
## treatmentfrequentflushing  0.2293446  2.3223188
## treatmentslurryfunnels    -2.4440163 -0.3510421
## treatmentslurrytrays     -2.3392145 -0.2462402
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Transformed aov summary:
##
##          Df  Sum Sq Mean Sq F value  Pr(>F)
## factor(period)  3  0.16370  0.05457    9.378 0.00393 **
## treatment      3  0.20644  0.06881   11.826 0.00178 **
## Residuals      9  0.05237  0.00582
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 4 observations deleted due to missingness
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Transformed lm summary:
##
## Call:
## aov(formula = log10(y) ~ factor(period) + treatment, data = emis_dat)

```

```

##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.102192 -0.047033  0.001905  0.026331  0.141972
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      0.82837    0.05045   16.418 5.14e-08 ***
## factor(period)2    -0.12362    0.05394   -2.292 0.047632 *
## factor(period)3    -0.26402    0.05394   -4.895 0.000854 ***
## factor(period)4    -0.21883    0.05394   -4.057 0.002855 **
## treatmentfrequentflushing  0.10859    0.05394    2.013 0.074939 .
## treatmentslurryfunnels   -0.15296    0.05394   -2.836 0.019534 *
## treatmentslurrytrays    -0.16569    0.05394   -3.072 0.013315 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.07628 on 9 degrees of freedom
## (4 observations deleted due to missingness)
## Multiple R-squared:  0.8761, Adjusted R-squared:  0.7934
## F-statistic: 10.6 on 6 and 9 DF, p-value: 0.0012
##
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Transformed Dunnetts test:
##
## Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = log10(y) ~ factor(period) + treatment, data = emis_dat)
##
## Linear Hypotheses:
##              Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0  0.10859    0.05394    2.013  0.1723
## slurryfunnels - control == 0    -0.15296    0.05394   -2.836  0.0478 *
## slurrytrays - control == 0      -0.16569    0.05394   -3.072  0.0329 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
##
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Transformed confidence intervals:
##              2.5 %      97.5 %

```

```

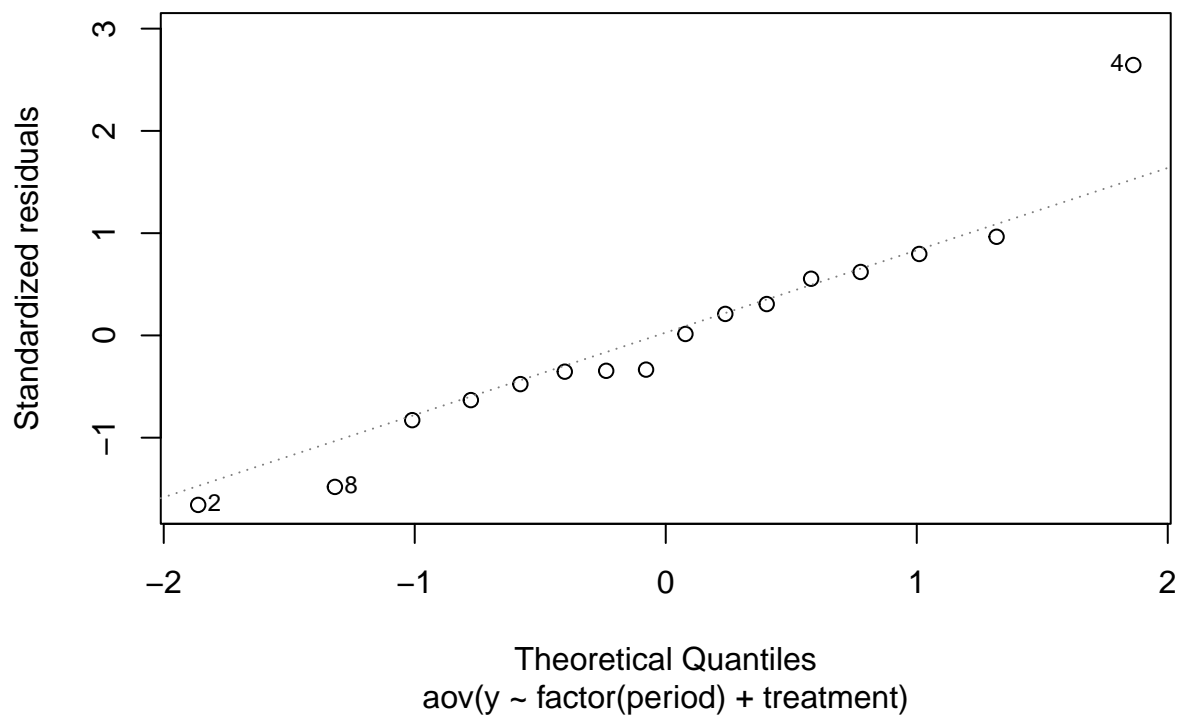
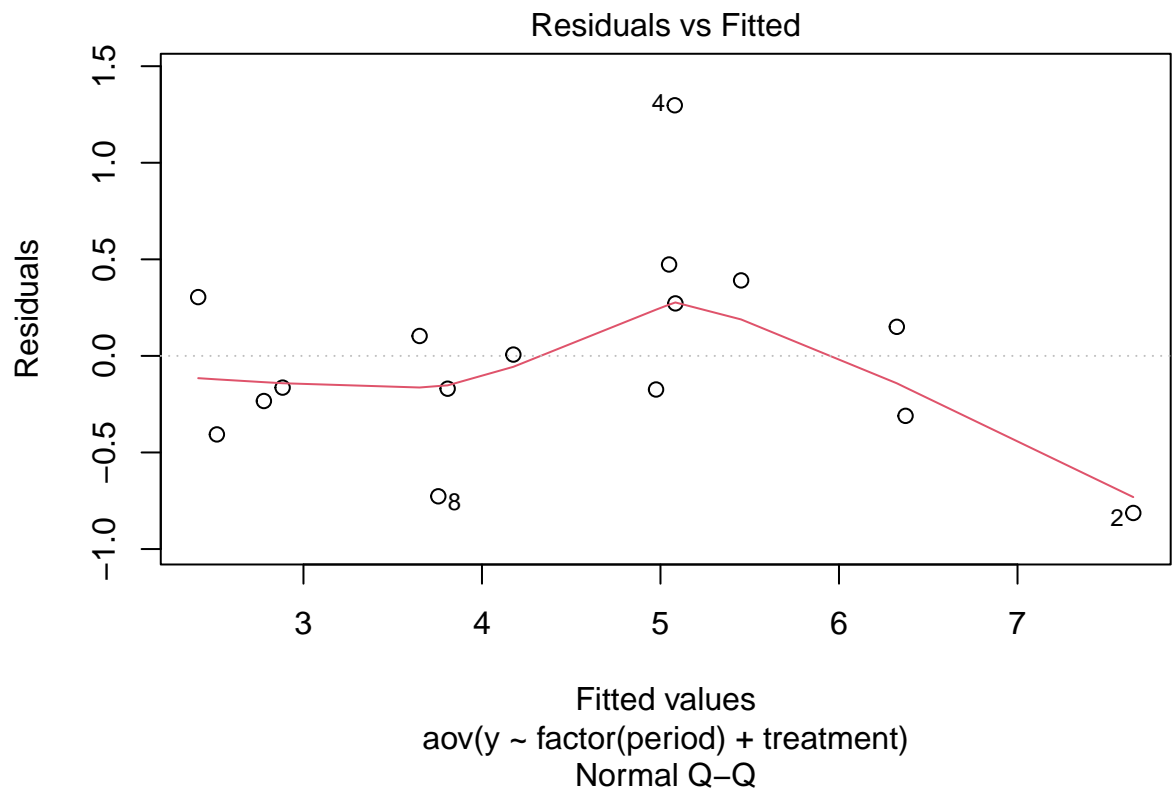
## (Intercept)          417.885106 775.9997430
## factor(period)2      -43.197429 -0.3678551
## factor(period)3      -58.888805 -27.8906482
## factor(period)4      -54.379605 -19.9814771
## treatmentfrequentflushing -3.044584 70.0605452
## treatmentslurryfunnels -46.908680 -6.8774177
## treatmentslurrytrays -48.441838 -9.5665877
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Transformed aov summary without period:
##           Df Sum Sq Mean Sq F value Pr(>F)
## treatment    3  0.2463  0.08211    4.016 0.0262 *
## Residuals   16  0.3271  0.02045
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Transformed lm summary without period:
##
## Call:
## aov(formula = log10(y) ~ treatment, data = emis_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.20693 -0.09506 -0.01121  0.08364  0.27376
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.67886    0.06395  10.616 1.19e-08 ***
## treatmentfrequentflushing 0.14452    0.09044   1.598   0.130
## treatmentslurryfunnels -0.09416    0.09044  -1.041   0.313
## treatmentslurrytrays -0.14797    0.09044  -1.636   0.121
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.143 on 16 degrees of freedom
## Multiple R-squared:  0.4295, Adjusted R-squared:  0.3226
## F-statistic: 4.016 on 3 and 16 DF, p-value: 0.02625
##
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Transformed Dunnetts test without period:

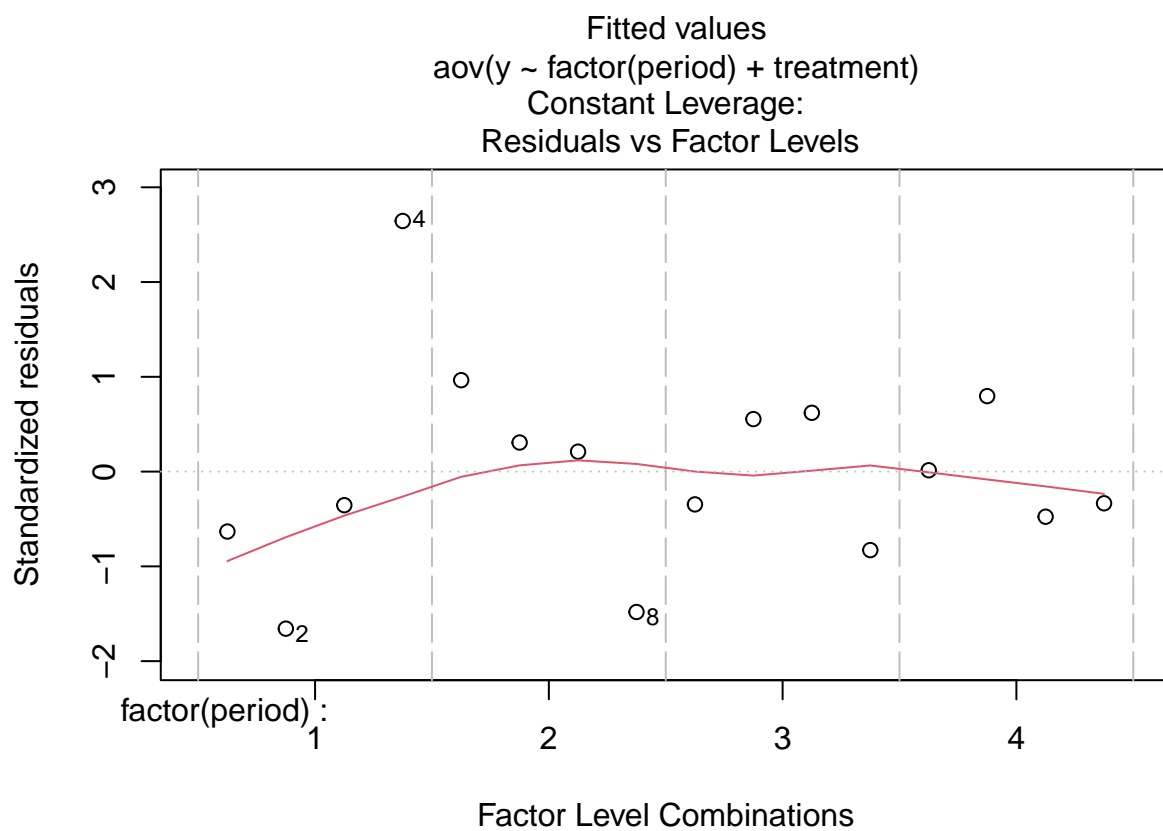
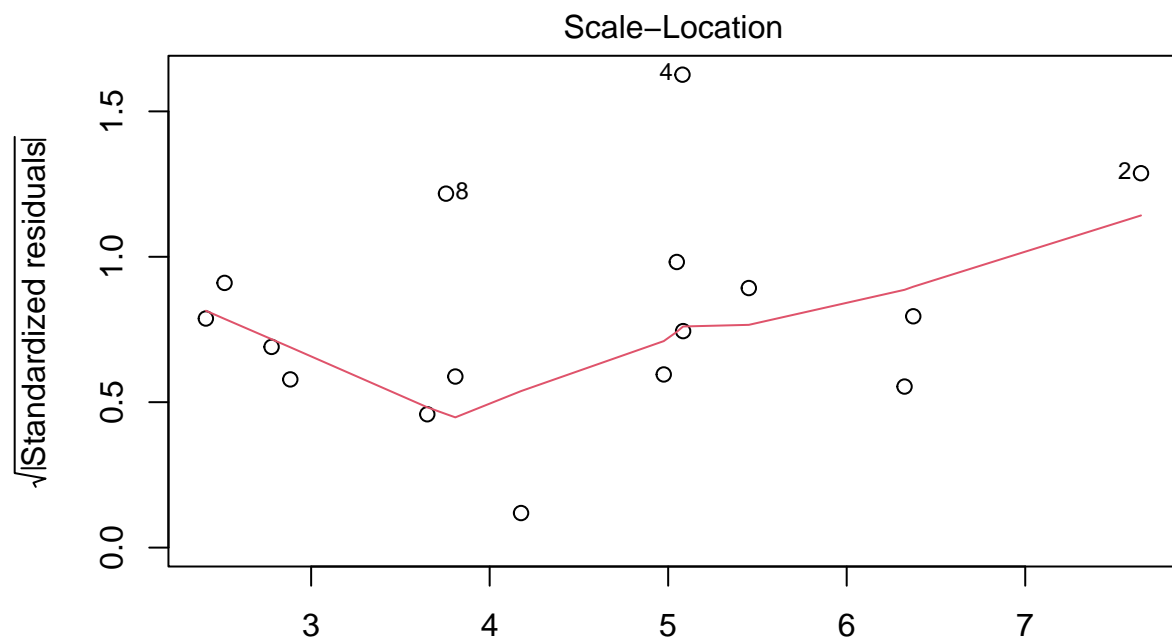
```

```

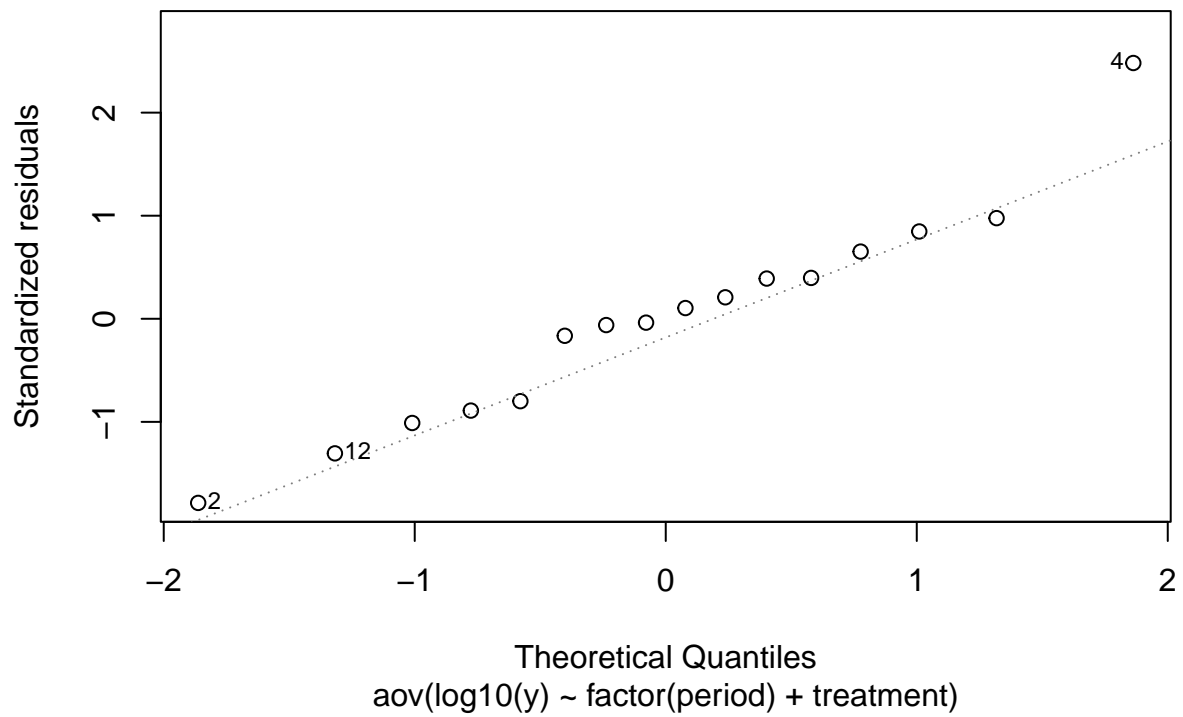
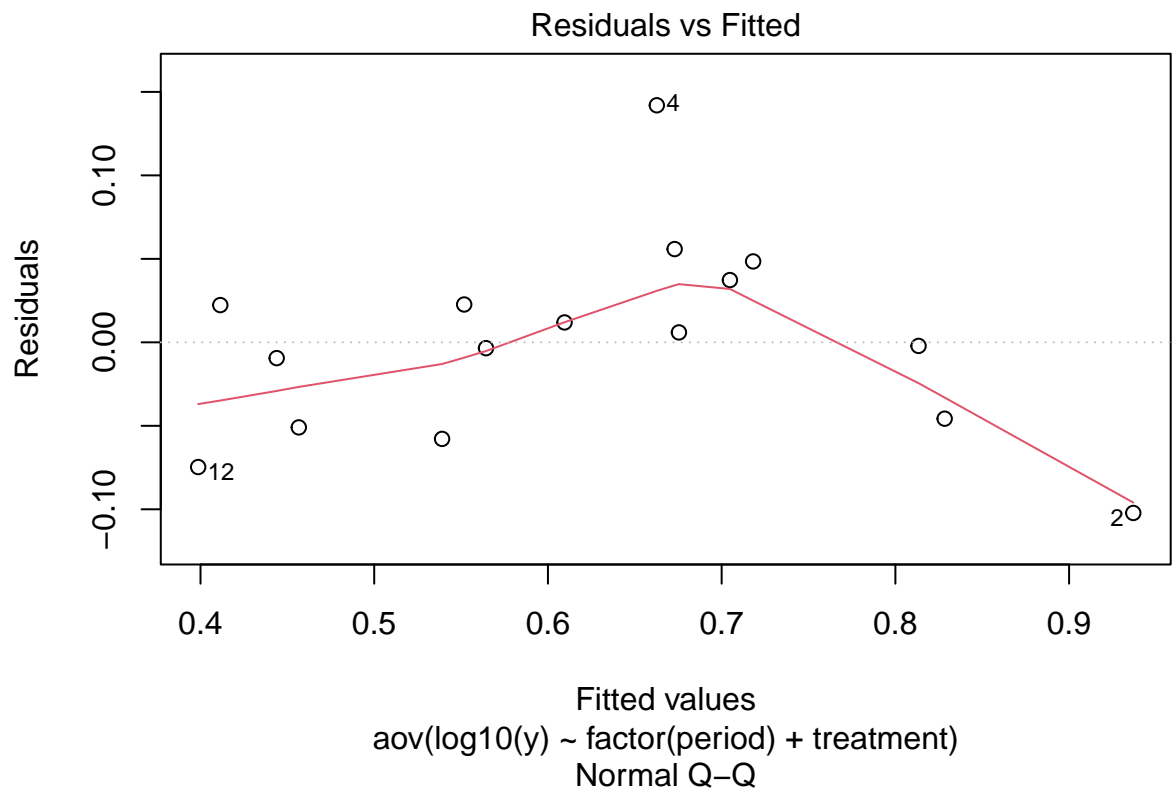
##
## Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = log10(y) ~ treatment, data = emis_dat)
##
## Linear Hypotheses:
##
##          Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0  0.14452    0.09044   1.598   0.290
## slurryfunnels - control == 0   -0.09416    0.09044  -1.041   0.607
## slurrytrays - control == 0    -0.14797    0.09044  -1.636   0.274
## (Adjusted p values reported -- single-step method)
##
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Transformed confidence intervals without period:
##          2.5 %    97.5 %
## (Intercept)      249.37949 552.26685
## treatmentfrequentflushing -10.29766 116.88850
## treatmentslurryfunnels   -48.22489  25.18542
## treatmentslurrytrays    -54.25835  10.59731
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Transformed relative reduction (coef):
##          factor(period)3          factor(period)4 treatmentfrequentflushing
##                -45.6                -39.6                28.4
## treatmentslurryfunnels treatmentslurrytrays
##                -29.7                -31.7
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Transformed relative reduction without period (coef):
## treatmentfrequentflushing treatmentslurryfunnels treatmentslurrytrays
##                39.5                -19.5                -28.9
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Non-transformed diagnostic plots:

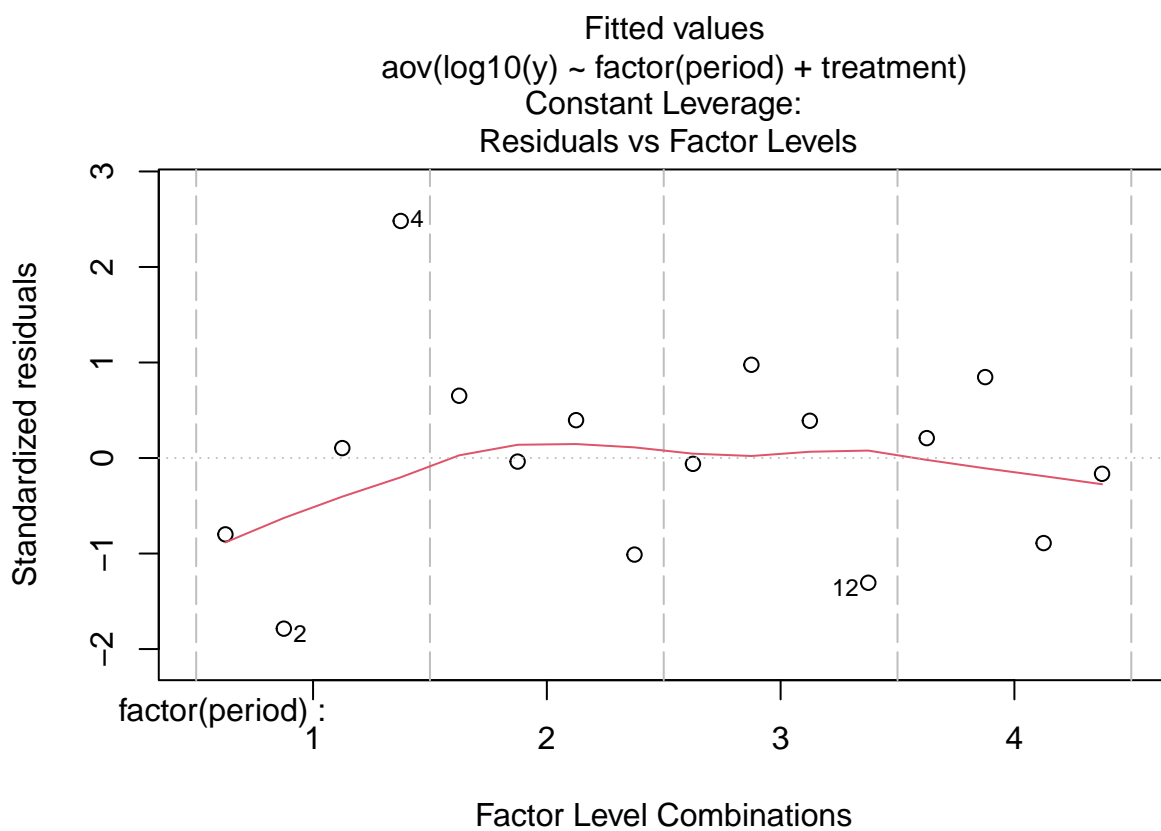
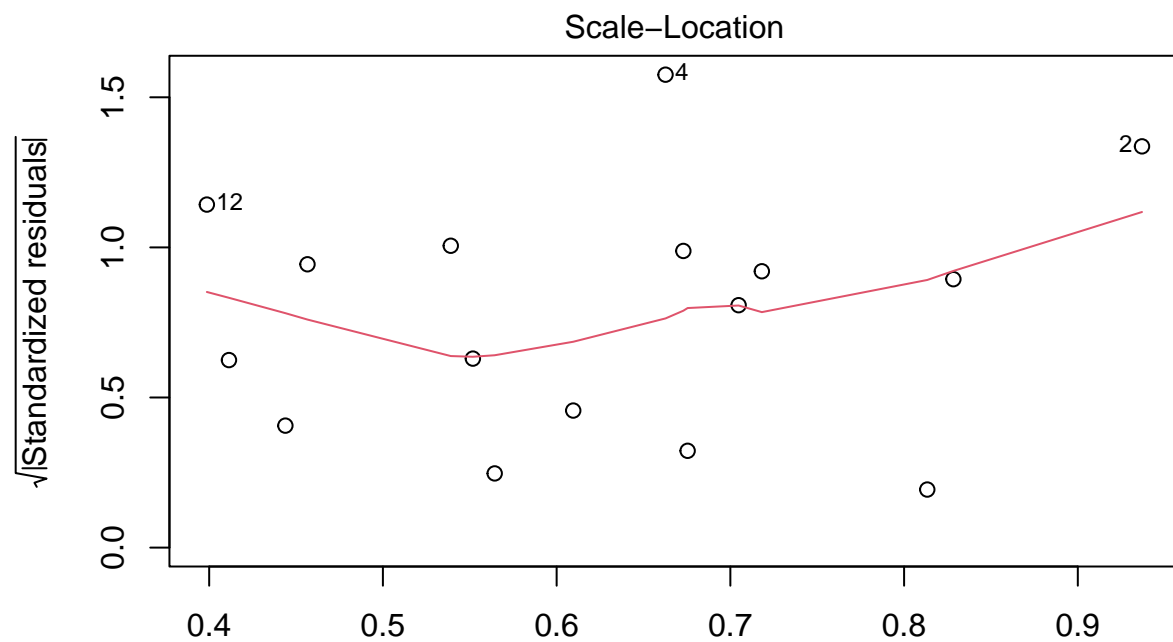
```



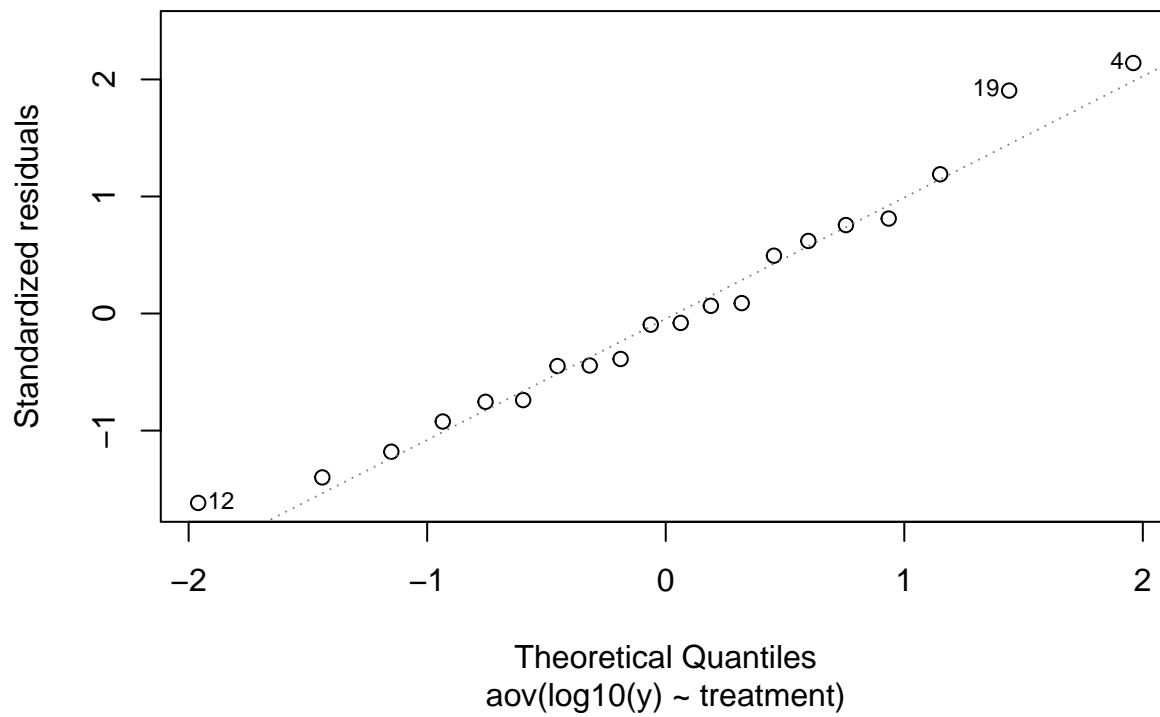
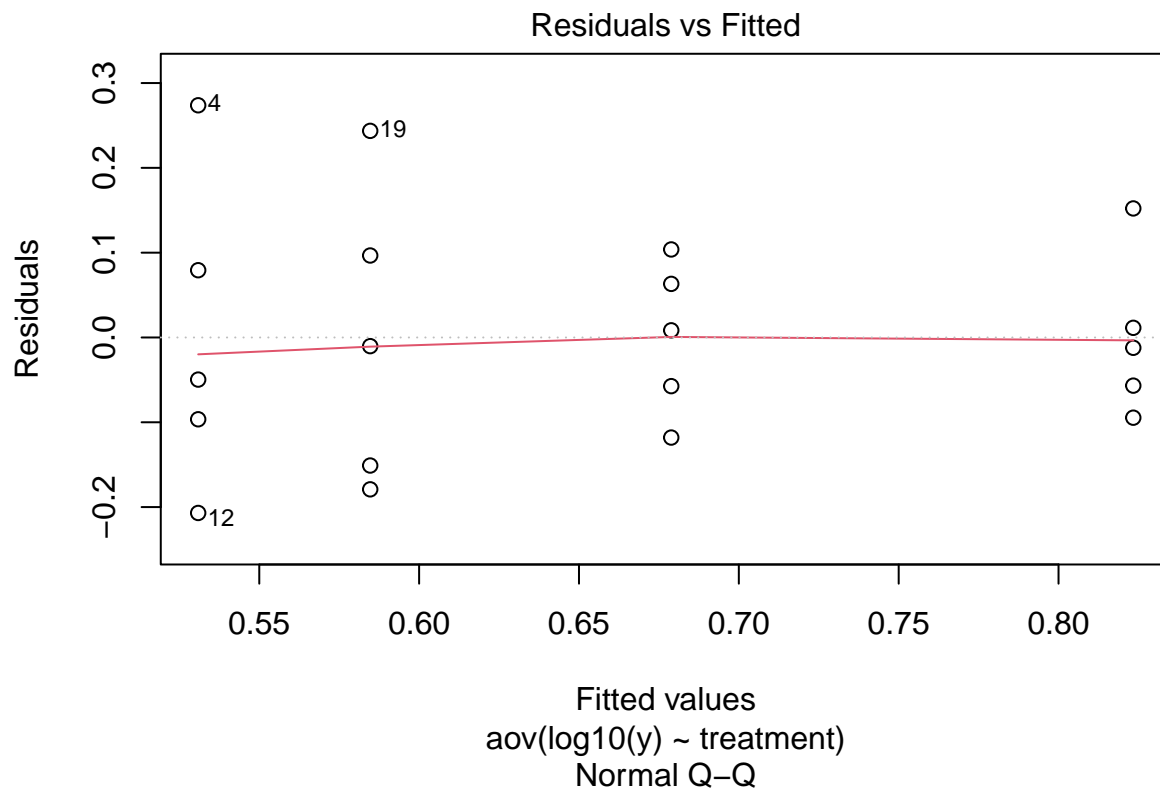


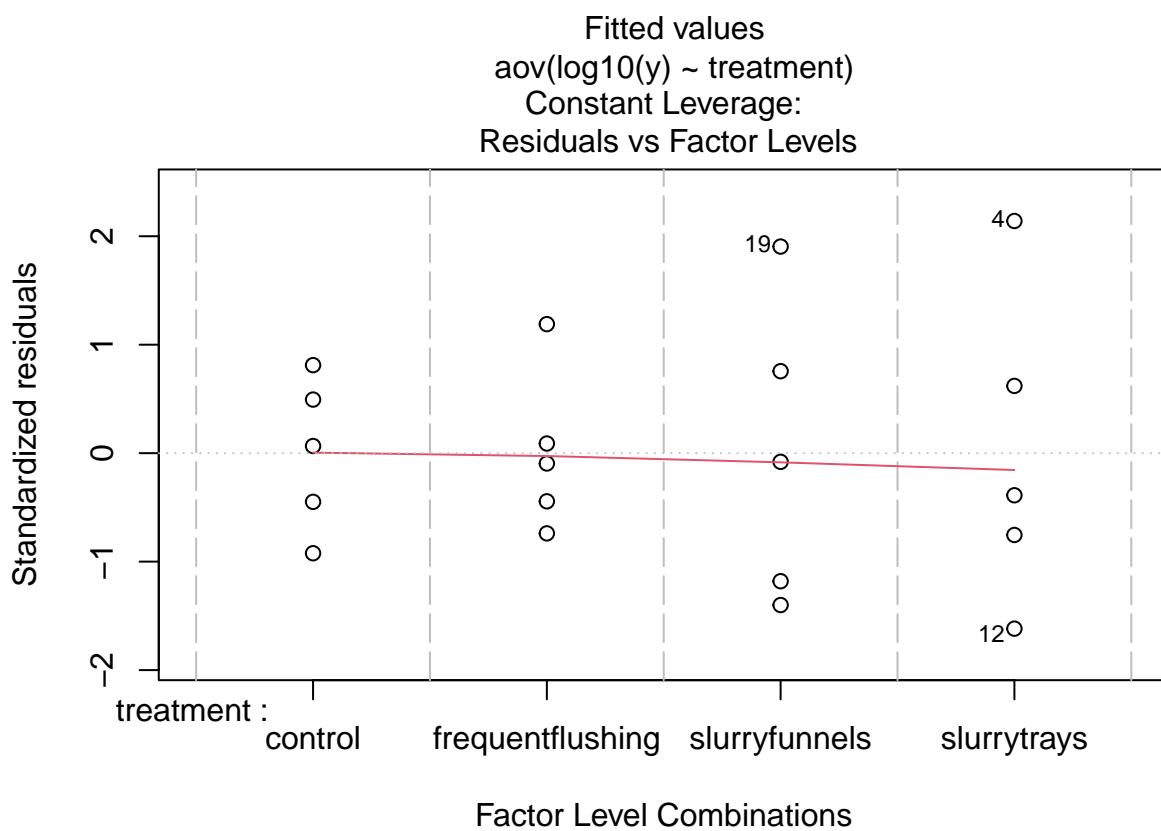
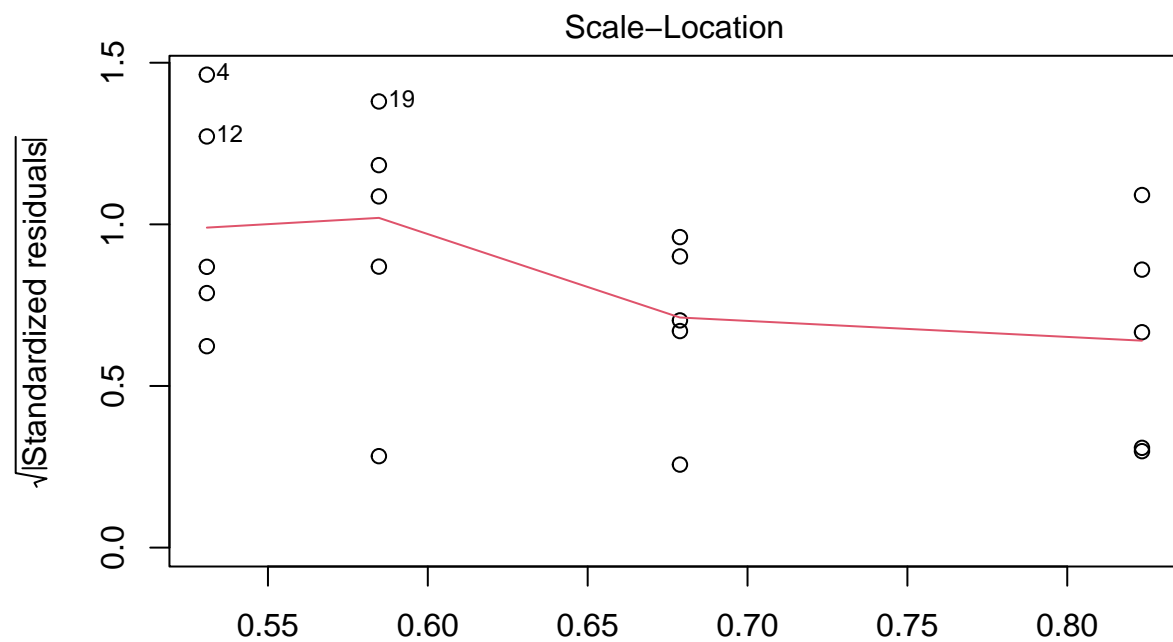
```
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Transformed diagnostic plots:
```





```
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
## Transformed diagnostic plots without period:
```

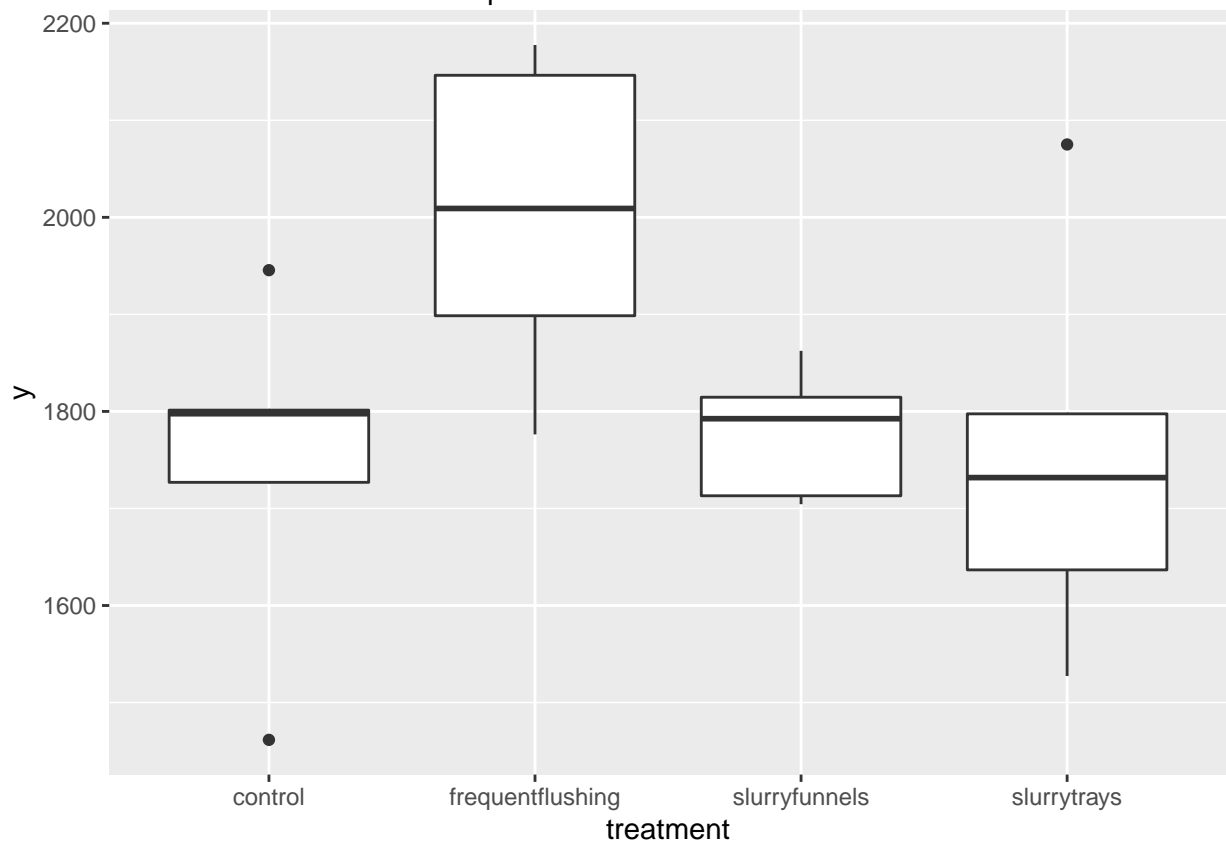
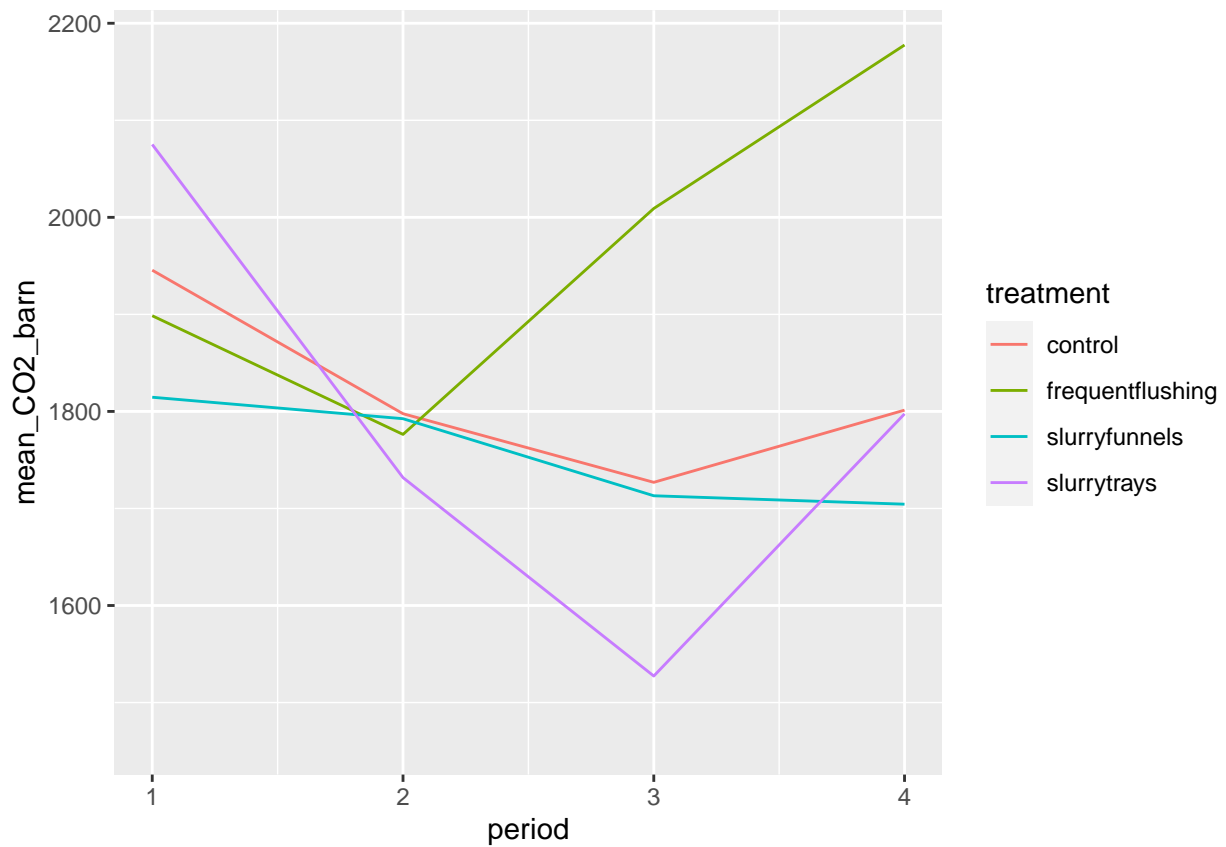


```
##
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
## mean_NH3_barn
##
##
```

```

##
##
## end mean_NH3_barn end mean_NH3_barn end mean_NH3_barn
##
## end mean_NH3_barn end mean_NH3_barn end mean_NH3_barn
##
## end mean_NH3_barn end mean_NH3_barn end mean_NH3_barn
##
##
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Warning: Removed 4 row(s) containing missing values (geom_path).

```



##

```

## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Non-transformed aov summary:
##           Df Sum Sq Mean Sq F value Pr(>F)
## factor(period) 3  91073   30358   1.484  0.284
## treatment      3 104609   34870   1.704  0.235
## Residuals      9 184138   20460
## 4 observations deleted due to missingness
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Non-transformed lm summary:
##
## Call:
## aov(formula = y ~ factor(period) + treatment, data = emis_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -169.693  -64.957    0.219   55.650  189.299
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      1920.74      94.61  20.302 7.96e-09 ***
## factor(period)2     -158.90     101.14  -1.571   0.151
## factor(period)3     -189.35     101.14  -1.872   0.094 .
## factor(period)4      -63.27     101.14  -0.626   0.547
## treatmentfrequentflushing  147.55     101.14   1.459   0.179
## treatmentslurryfunnels    -61.71     101.14  -0.610   0.557
## treatmentslurrytrays     -34.94     101.14  -0.345   0.738
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 143 on 9 degrees of freedom
## (4 observations deleted due to missingness)
## Multiple R-squared:  0.5152, Adjusted R-squared:  0.192
## F-statistic: 1.594 on 6 and 9 DF, p-value: 0.254
##
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Non-transformed Dunnett s test:
##
## Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Dunnett Contrasts

```

```
##
##
## Fit: aov(formula = y ~ factor(period) + treatment, data = emis_dat)
##
## Linear Hypotheses:
##
##               Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0    147.55     101.14   1.459   0.377
## slurryfunnels - control == 0     -61.71     101.14  -0.610   0.874
## slurrytrays - control == 0      -34.94     101.14  -0.345   0.971
## (Adjusted p values reported -- single-step method)
##
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Non-transformed confidence intervals:
##
##               2.5 %      97.5 %
## (Intercept)    1706.71426 2134.76165
## factor(period)2 -387.70010   69.90180
## factor(period)3 -418.14799   39.45391
## factor(period)4 -292.06627  165.53563
## treatmentfrequentflushing -81.25136  376.35055
## treatmentslurryfunnels -290.50893  167.09298
## treatmentslurrytrays -263.74554  193.85636
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Transformed aov summary:
##
##      Df  Sum Sq Mean Sq F value Pr(>F)
## factor(period) 3 0.005206 0.001736   1.563  0.265
## treatment      3 0.005640 0.001880   1.693  0.237
## Residuals      9 0.009993 0.001110
## 4 observations deleted due to missingness
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Transformed lm summary:
##
## Call:
## aov(formula = log10(y) ~ factor(period) + treatment, data = emis_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.043025 -0.014750  0.000852  0.013497  0.043762
##
## Coefficients:
```

```

##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)      3.28390    0.02204 148.994 <2e-16 ***
## factor(period)2   -0.03678    0.02356  -1.561  0.1530
## factor(period)3   -0.04633    0.02356  -1.966  0.0808 .
## factor(period)4   -0.01587    0.02356  -0.674  0.5174
## treatmentfrequentflushing 0.03308    0.02356   1.404  0.1939
## treatmentslurryfunnels -0.01475    0.02356  -0.626  0.5468
## treatmentslurrytrays -0.01062    0.02356  -0.451  0.6628
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.03332 on 9 degrees of freedom
## (4 observations deleted due to missingness)
## Multiple R-squared:  0.5205, Adjusted R-squared:  0.2008
## F-statistic: 1.628 on 6 and 9 DF, p-value: 0.2451
##
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Transformed Dunnetts test:
##
## Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = log10(y) ~ factor(period) + treatment, data = emis_dat)
##
## Linear Hypotheses:
##               Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0  0.03308    0.02356   1.404   0.405
## slurryfunnels - control == 0    -0.01475    0.02356  -0.626   0.866
## slurrytrays - control == 0      -0.01062    0.02356  -0.451   0.941
## (Adjusted p values reported -- single-step method)
##
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Transformed confidence intervals:
##               2.5 %          97.5 %
## (Intercept)    171310.927986 2.155536e+05
## factor(period)2    -18.732086 3.877700e+00
## factor(period)3    -20.499137 1.619034e+00
## factor(period)4    -14.724380 9.000402e+00
## treatmentfrequentflushing    -4.549047 2.200665e+01
## treatmentslurryfunnels    -14.504227 9.281805e+00
## treatmentslurrytrays    -13.687076 1.032630e+01
##

```

```

## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Transformed aov summary without period:
##           Df Sum Sq Mean Sq F value Pr(>F)
## treatment   3 0.01214 0.004048   2.586 0.0892 .
## Residuals  16 0.02505 0.001566
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Transformed lm summary without period:
##
## Call:
## aov(formula = log10(y) ~ treatment, data = emis_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.075466 -0.018899  0.003403  0.016614  0.075419
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      3.240286   0.017695 183.122 <2e-16 ***
## treatmentfrequentflushing 0.059843   0.025024   2.391  0.0294 *
## treatmentslurryfunnels    0.009248   0.025024   0.370  0.7165
## treatmentslurrytrays      0.001332   0.025024   0.053  0.9582
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.03957 on 16 degrees of freedom
## Multiple R-squared:  0.3265, Adjusted R-squared:  0.2002
## F-statistic: 2.586 on 3 and 16 DF,  p-value: 0.08925
##
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Transformed Dunnetts test without period:
##
## Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Dunnett Contrasts
##
## Fit: aov(formula = log10(y) ~ treatment, data = emis_dat)
##

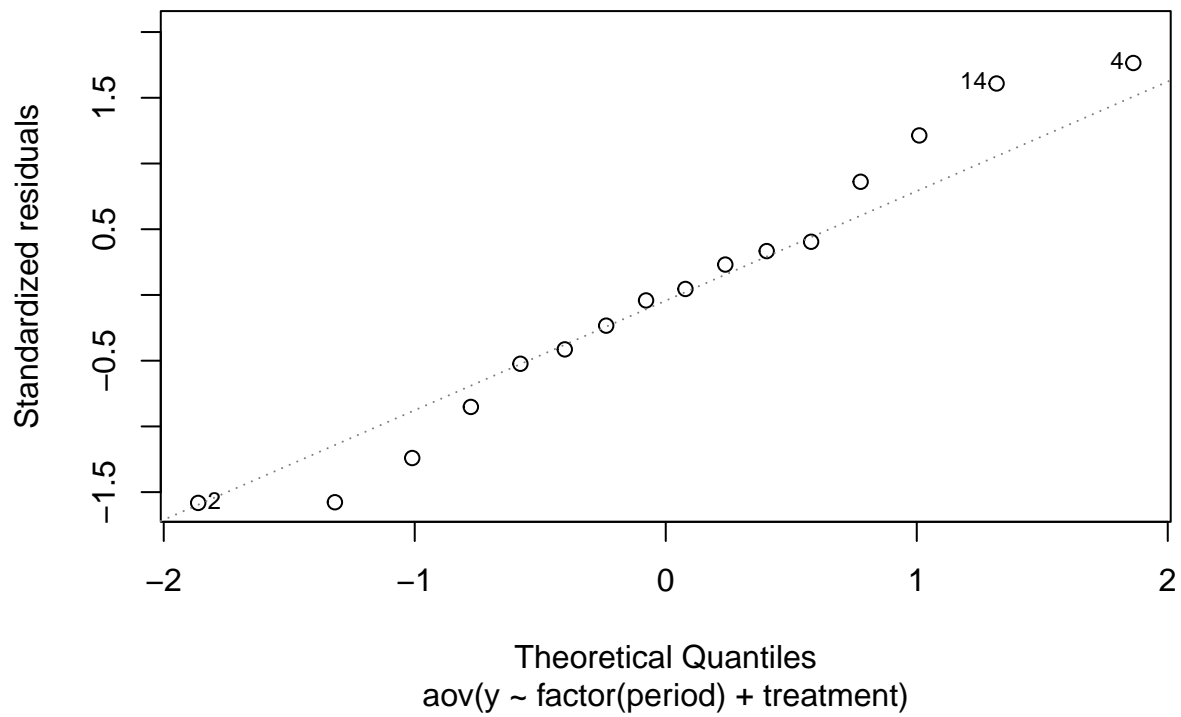
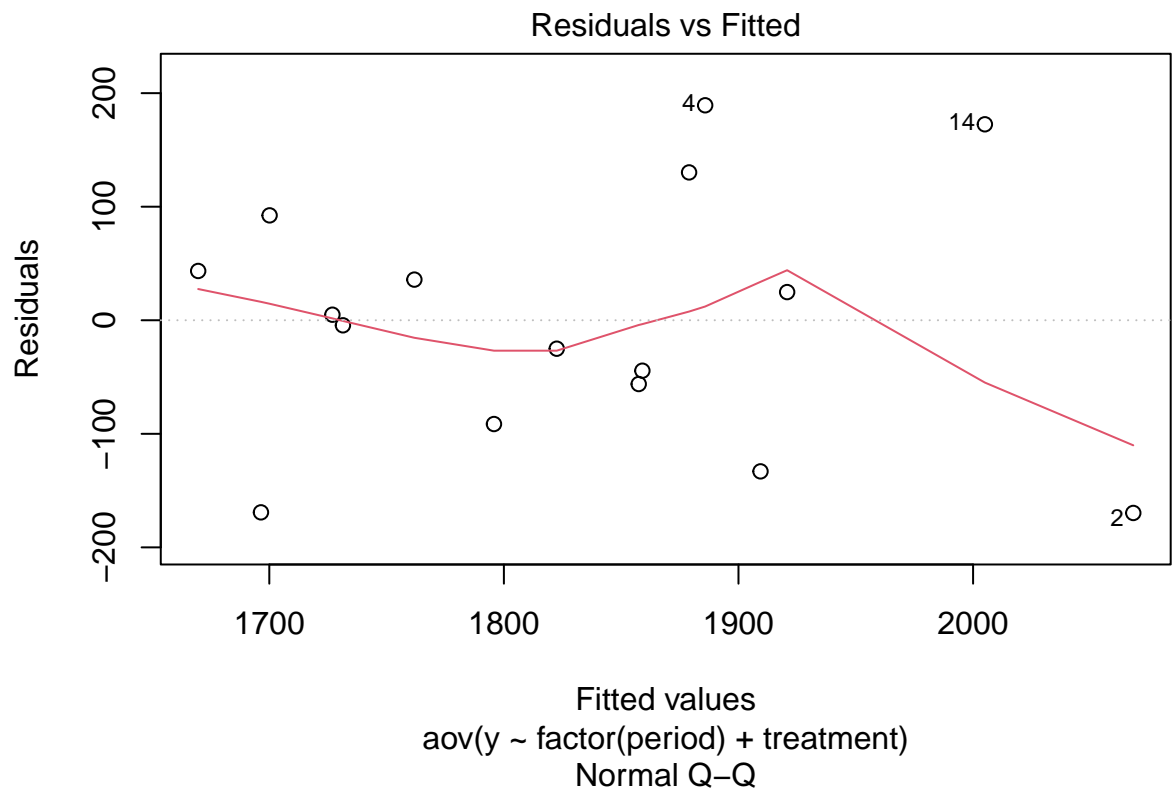
```

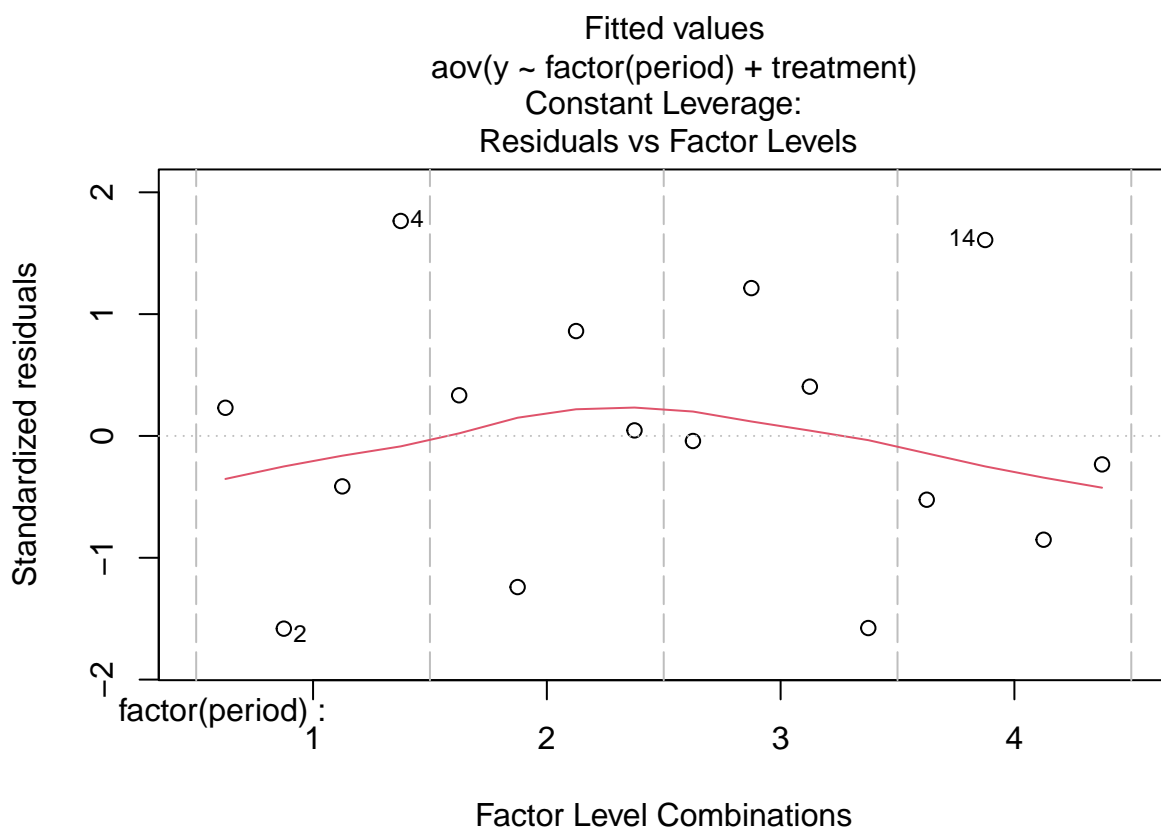
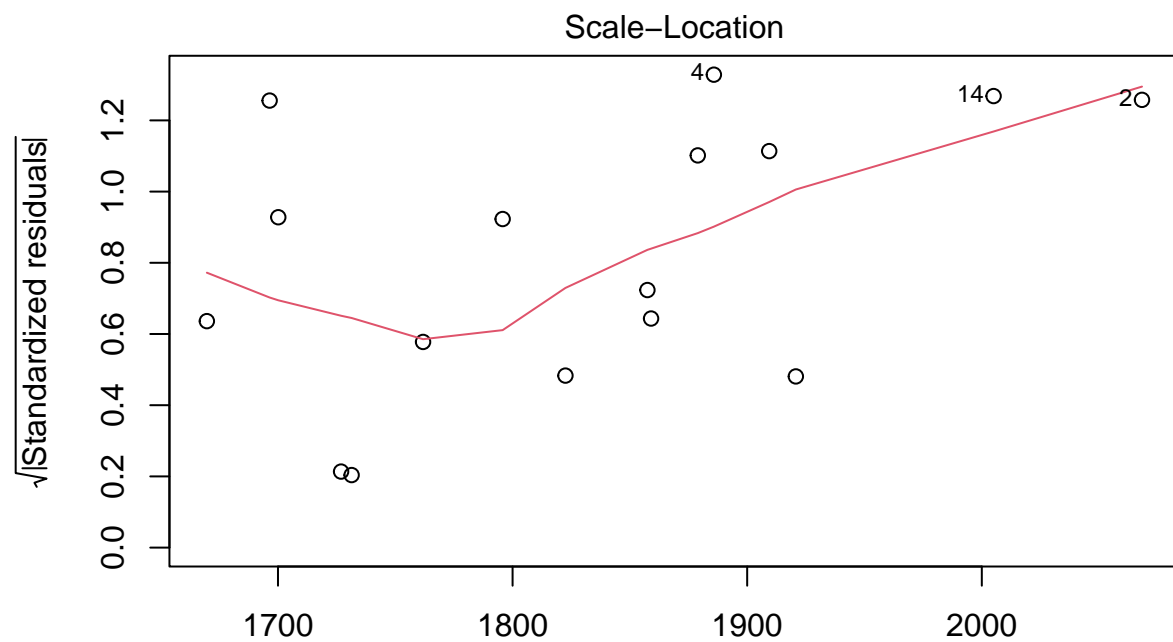


```

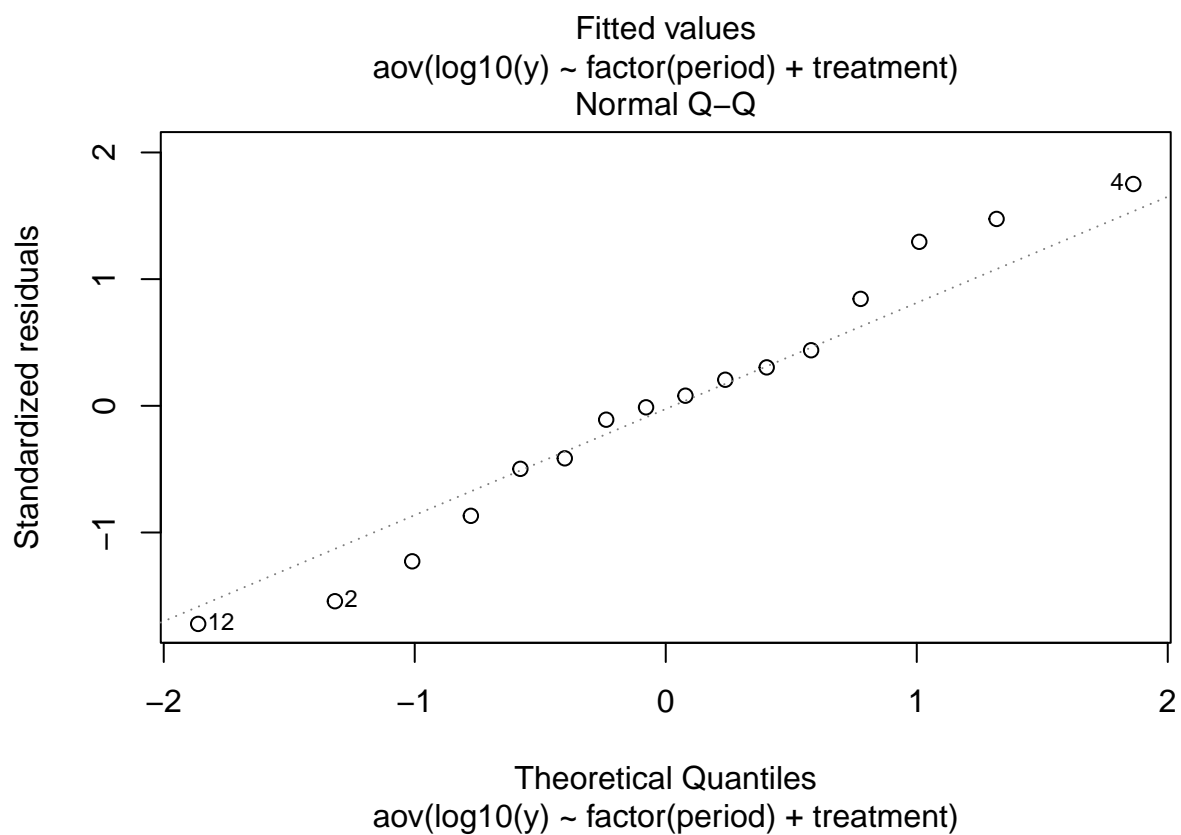
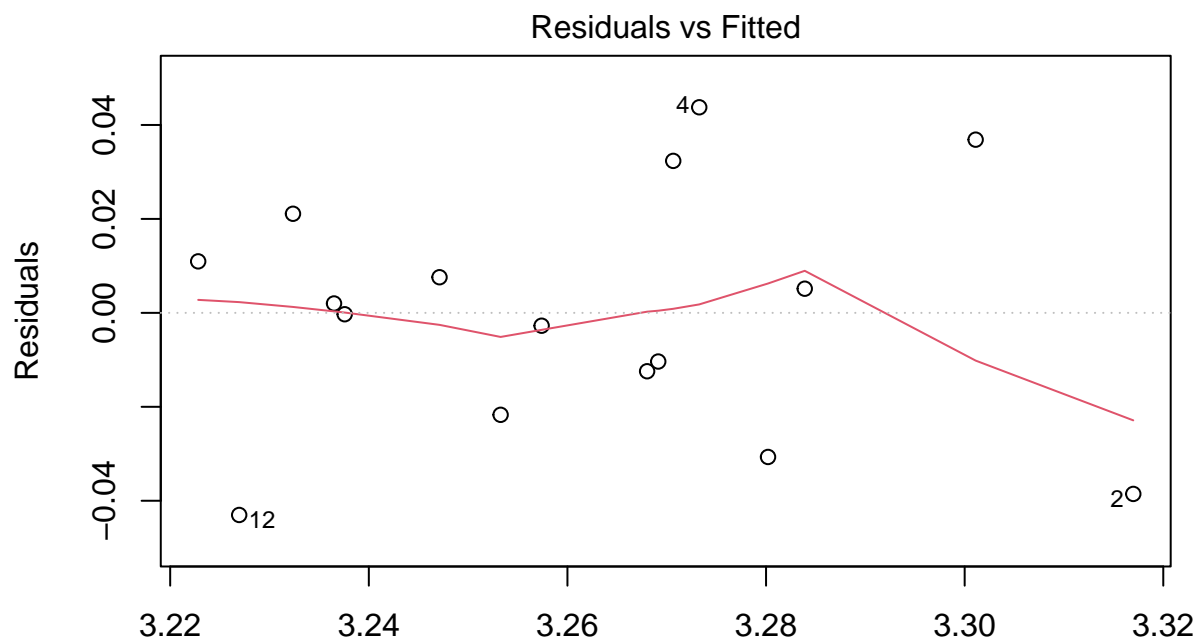
## Linear Hypotheses:
##
##          Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0 0.059843  0.025024  2.391  0.0736 .
## slurryfunnels - control == 0    0.009248  0.025024  0.370  0.9662
## slurrytrays - control == 0      0.001332  0.025024  0.053  0.9999
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
##
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Transformed confidence intervals without period:
##          2.5 %          97.5 %
## (Intercept)      159405.318999 189482.09704
## treatmentfrequentflushing      1.576806      29.68564
## treatmentsslurryfunnels      -9.593489      15.42425
## treatmentsslurrytrays      -11.226517      13.33932
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Transformed relative reduction (coef):
##          factor(period)3          factor(period)4 treatmentfrequentflushing
##                -10.1                -3.6                7.9
## treatmentsslurryfunnels treatmentsslurrytrays
##                -3.3                -2.4
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Transformed relative reduction without period (coef):
## treatmentfrequentflushing treatmentsslurryfunnels treatmentsslurrytrays
##                14.8                2.2                0.3
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Non-transformed diagnostic plots:

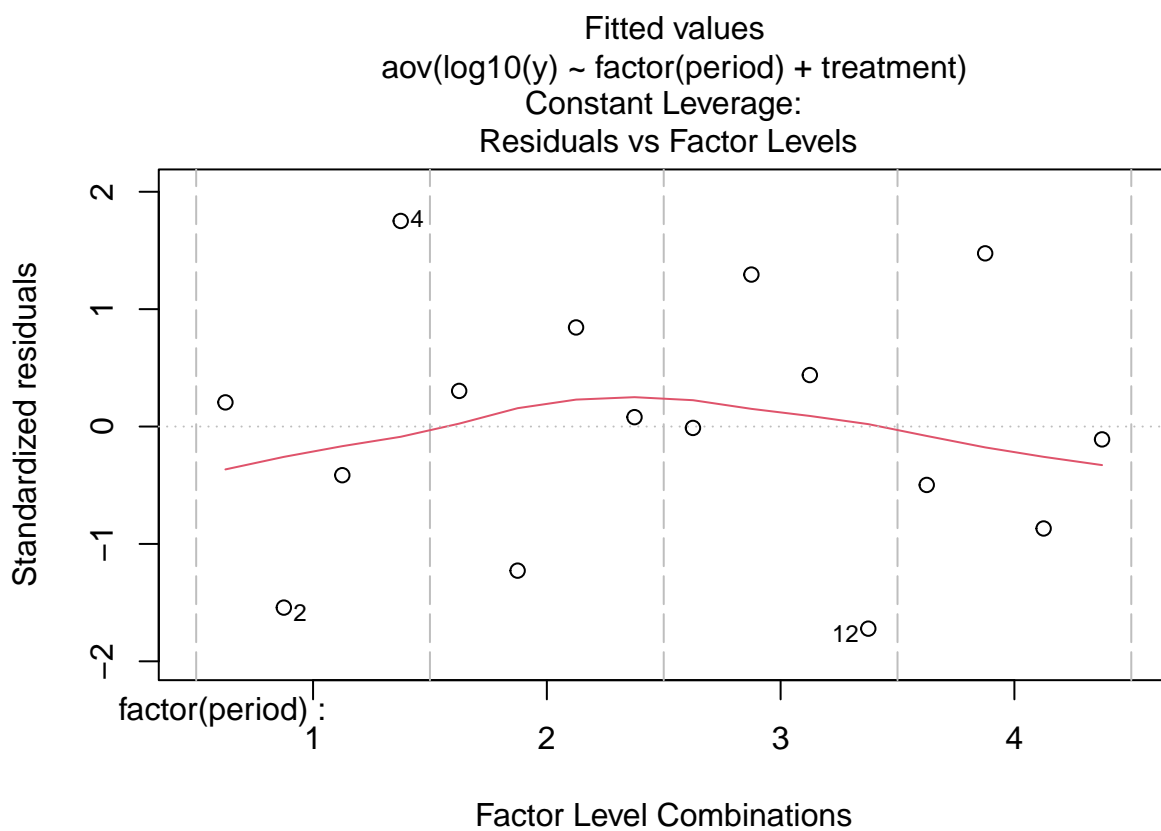
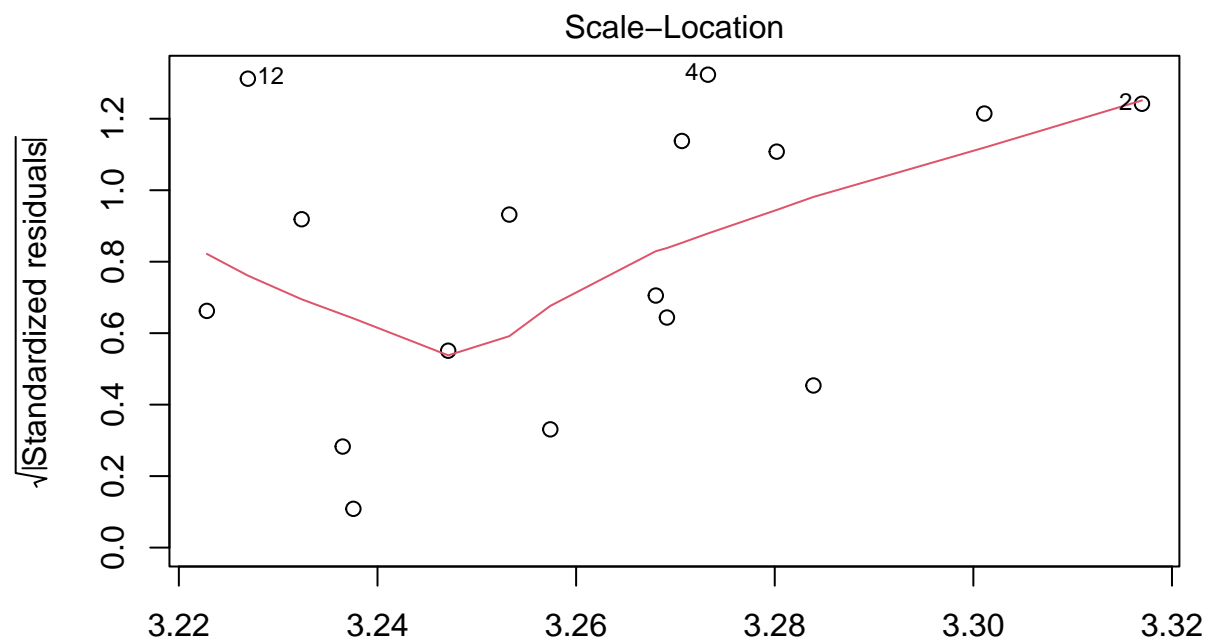
```



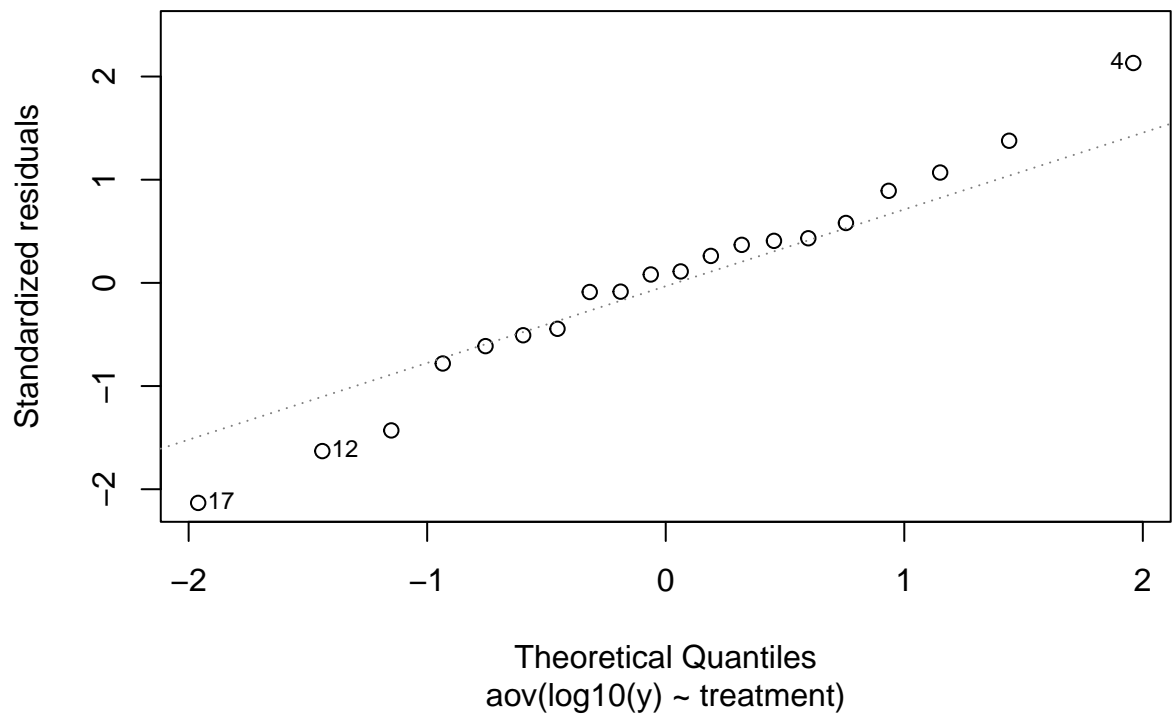
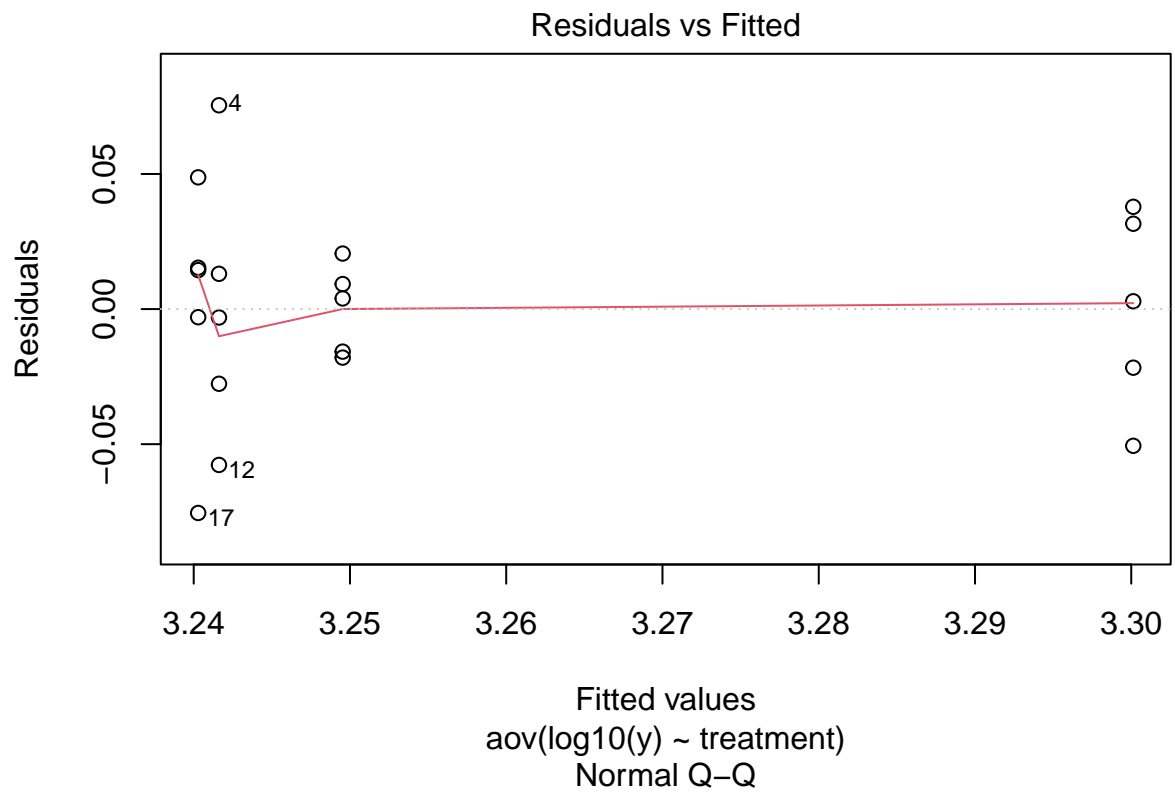


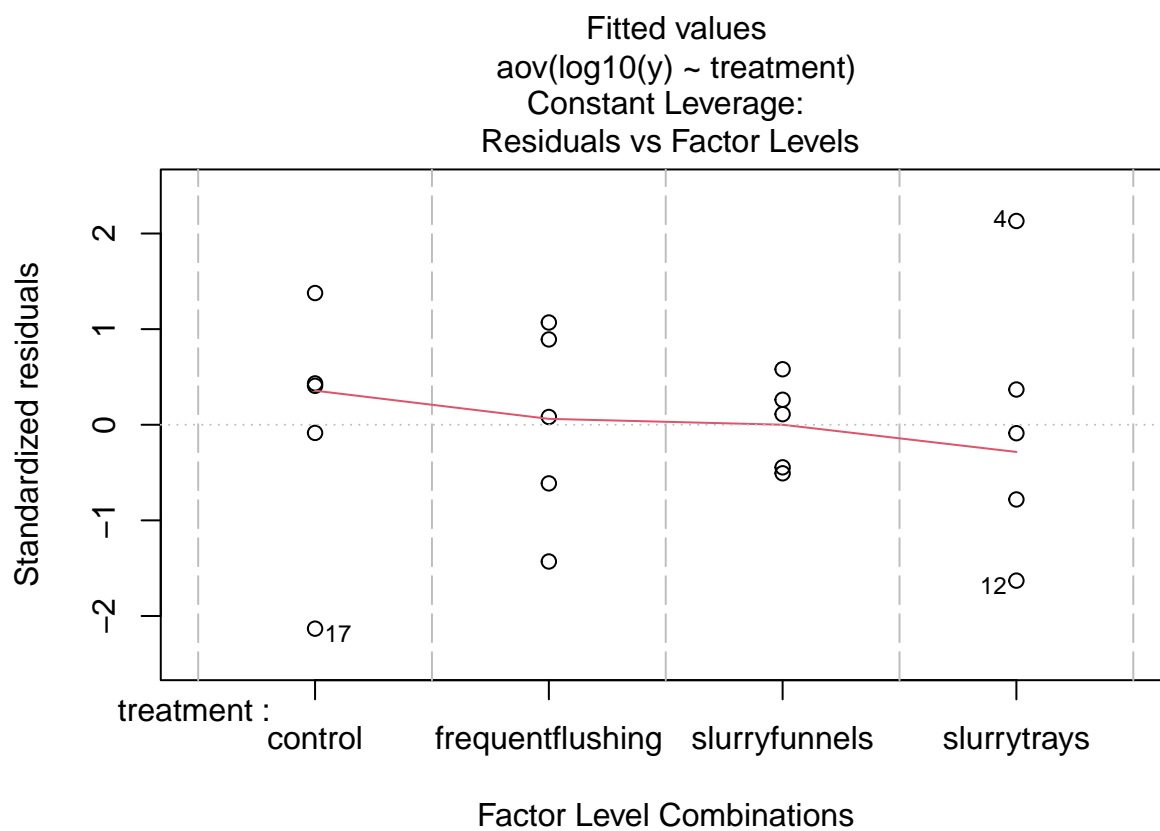
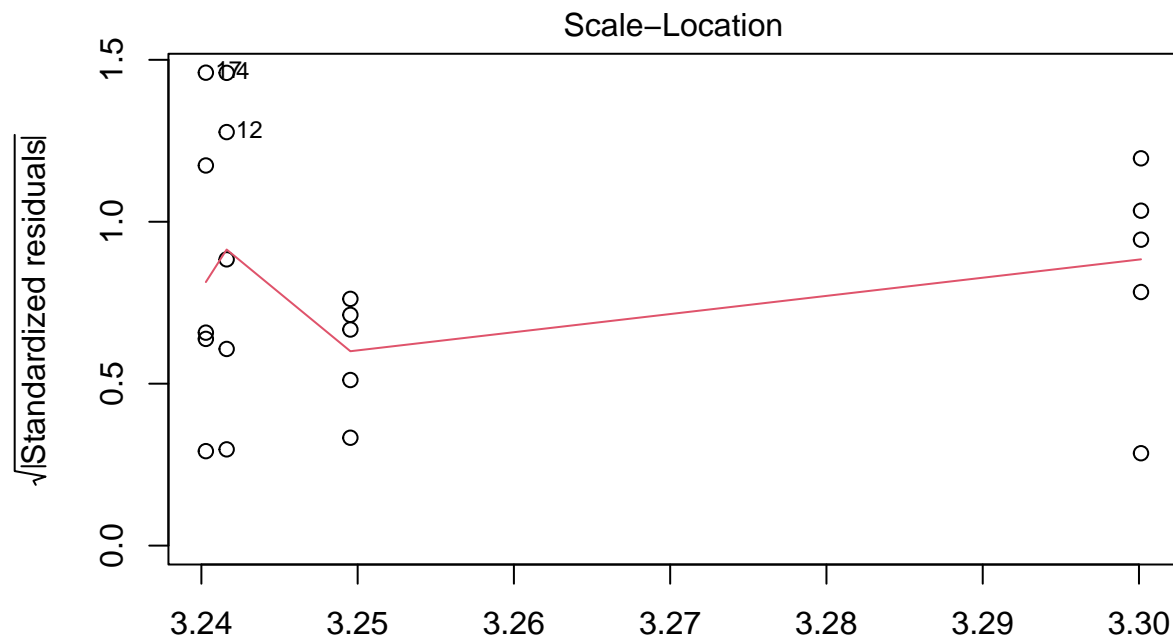
```
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Transformed diagnostic plots:
```





```
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
## Transformed diagnostic plots without period:
```



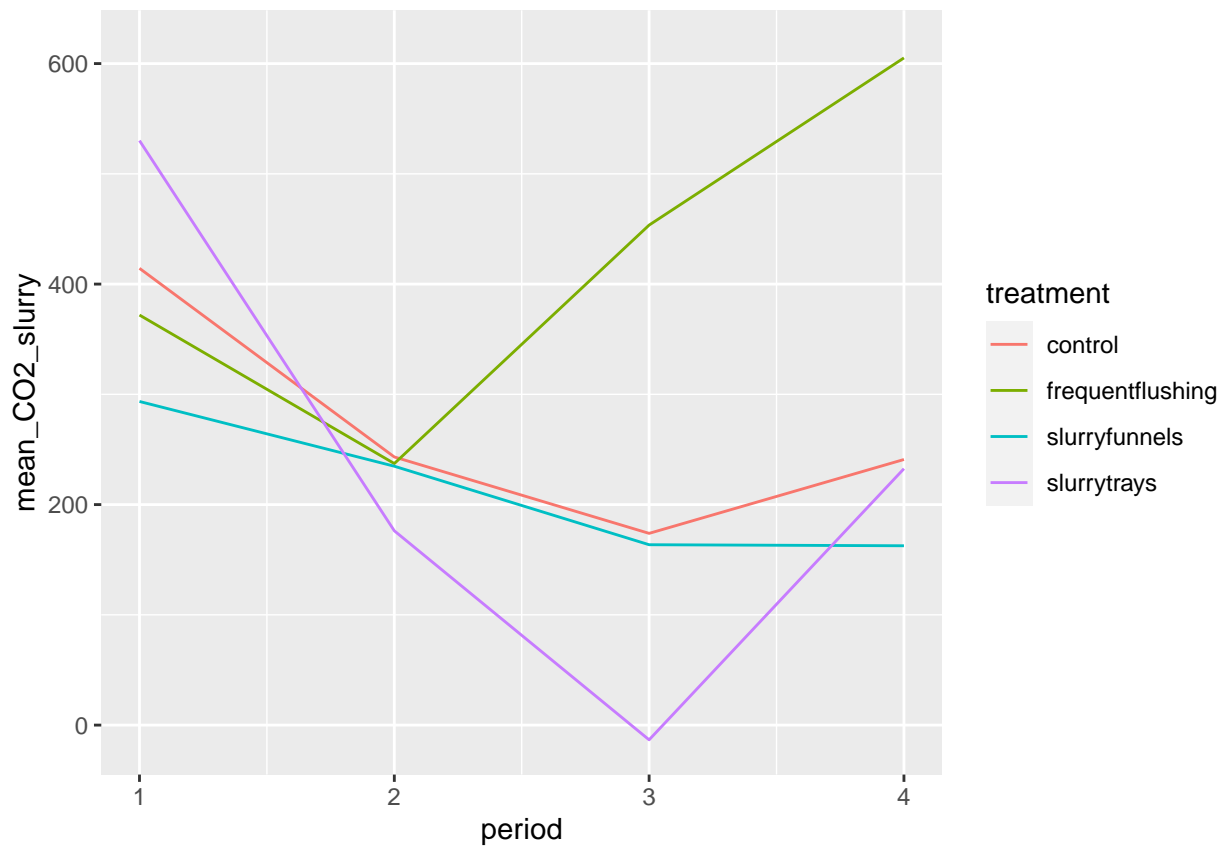


```
##
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
## mean_CO2_barn
##
##
```

```

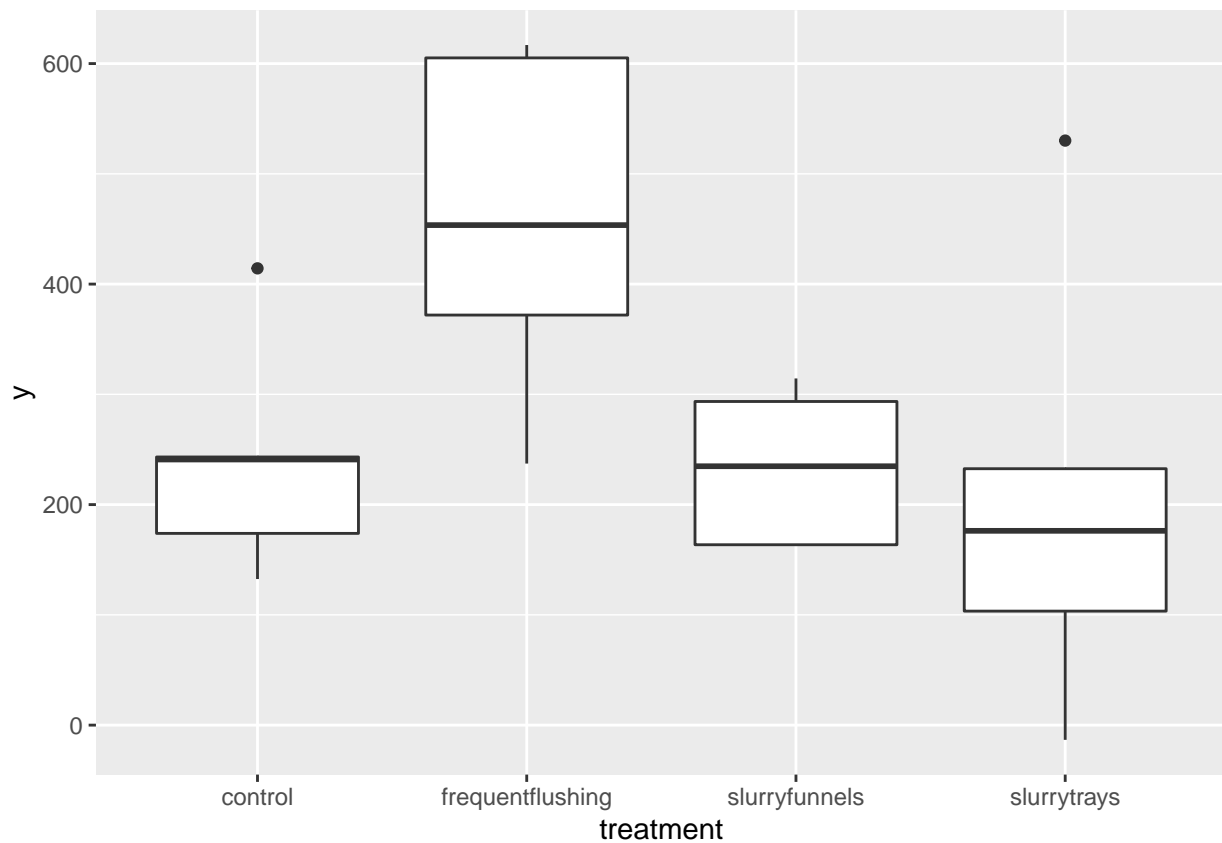
##
##
## end mean_CO2_barn end mean_CO2_barn end mean_CO2_barn
##
## end mean_CO2_barn end mean_CO2_barn end mean_CO2_barn
##
## end mean_CO2_barn end mean_CO2_barn end mean_CO2_barn
##
##
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Warning: Removed 4 row(s) containing missing values (geom_path).

```

```
## Warning in eval(predvars, data, env): NaNs produced
```

```
## Warning in eval(predvars, data, env): NaNs produced
```



```
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Non-transformed aov summary:
##           Df Sum Sq Mean Sq F value Pr(>F)
## factor(period) 3 105940   35313   1.975  0.188
## treatment      3 102555   34185   1.912  0.198
## Residuals      9 160891   17877
## 4 observations deleted due to missingness
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Non-transformed lm summary:
##
## Call:
## aov(formula = y ~ factor(period) + treatment, data = emis_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -164.986  -60.929   -0.789   48.737  178.799
##
```

```

## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)      388.03      88.44   4.388  0.00175 **
## factor(period)2   -179.62      94.54  -1.900  0.08991 .
## factor(period)3   -208.07      94.54  -2.201  0.05527 .
## factor(period)4    -92.16      94.54  -0.975  0.35513
## treatmentfrequentflushing  148.88      94.54   1.575  0.14976
## treatmentsslurryfunnels   -54.42      94.54  -0.576  0.57896
## treatmentsslurrytrays    -36.68      94.54  -0.388  0.70709
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 133.7 on 9 degrees of freedom
## (4 observations deleted due to missingness)
## Multiple R-squared:  0.5644, Adjusted R-squared:  0.2741
## F-statistic: 1.944 on 6 and 9 DF,  p-value: 0.1777
##
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Non-transformed Dunnett s test:
##
## Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = y ~ factor(period) + treatment, data = emis_dat)
##
## Linear Hypotheses:
##               Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0  148.88      94.54   1.575   0.323
## sslurryfunnels - control == 0    -54.42      94.54  -0.576   0.890
## sslurrytrays - control == 0     -36.68      94.54  -0.388   0.961
## (Adjusted p values reported -- single-step method)
##
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Non-transformed confidence intervals:
##               2.5 %      97.5 %
## (Intercept)    187.97226 588.088952
## factor(period)2 -393.48755  34.255189
## factor(period)3 -421.93793   5.804806
## factor(period)4 -306.03106 121.711680
## treatmentfrequentflushing -64.98727 362.755463
## treatmentsslurryfunnels  -268.29474 159.448000
## treatmentsslurrytrays   -250.54674 177.195996

```

```

##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Transformed aov summary:
##           Df Sum Sq Mean Sq F value Pr(>F)
## factor(period) 3 0.1472 0.04908   2.132  0.174
## treatment      3 0.1642 0.05473   2.377  0.146
## Residuals      8 0.1842 0.02302
## 5 observations deleted due to missingness
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Transformed lm summary:
##
## Call:
## aov(formula = log10(y) ~ factor(period) + treatment, data = emis_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.18531 -0.09133 -0.02469  0.10005  0.18567
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.56610    0.10115  25.370 6.24e-09 ***
## factor(period)2    -0.25049    0.10728  -2.335  0.0478 *
## factor(period)3    -0.22894    0.11861  -1.930  0.0897 .
## factor(period)4    -0.15958    0.10728  -1.487  0.1752
## treatmentfrequentflushing  0.18967    0.10728   1.768  0.1151
## treatmentslurryfunnels   -0.09050    0.10728  -0.844  0.4234
## treatmentslurrytrays     0.01625    0.11861   0.137  0.8944
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1517 on 8 degrees of freedom
## (5 observations deleted due to missingness)
## Multiple R-squared:  0.6284, Adjusted R-squared:  0.3497
## F-statistic: 2.255 on 6 and 8 DF, p-value: 0.1423
##
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Transformed Dunnetts test:
##
## Simultaneous Tests for General Linear Hypotheses
##

```

```

## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = log10(y) ~ factor(period) + treatment, data = emis_dat)
##
## Linear Hypotheses:
##
##              Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0  0.18967    0.10728   1.768   0.257
## slurryfunnels - control == 0    -0.09050    0.10728  -0.844   0.747
## slurrytrays - control == 0      0.01625    0.11861   0.137   0.998
## (Adjusted p values reported -- single-step method)
##
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Transformed confidence intervals:
##
##              2.5 %          97.5 %
## (Intercept)    21420.44495 62901.3732762
## factor(period)2    -68.22298   -0.7090119
## factor(period)3    -68.55520   10.8069763
## factor(period)4    -60.82376   22.4107036
## treatmentfrequentflushing  -12.44678  173.5701916
## treatmentslurryfunnels    -54.06948  43.5152357
## treatmentslurrytrays    -44.69744  94.8783278
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Transformed aov summary without period:
##              Df Sum Sq Mean Sq F value Pr(>F)
## treatment      3  0.3055  0.1018   2.578 0.0924 .
## Residuals     15  0.5925  0.0395
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 1 observation deleted due to missingness
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Transformed lm summary without period:
##
## Call:
## aov(formula = log10(y) ~ treatment, data = emis_dat)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.32338 -0.12382  0.02174  0.13041  0.38653

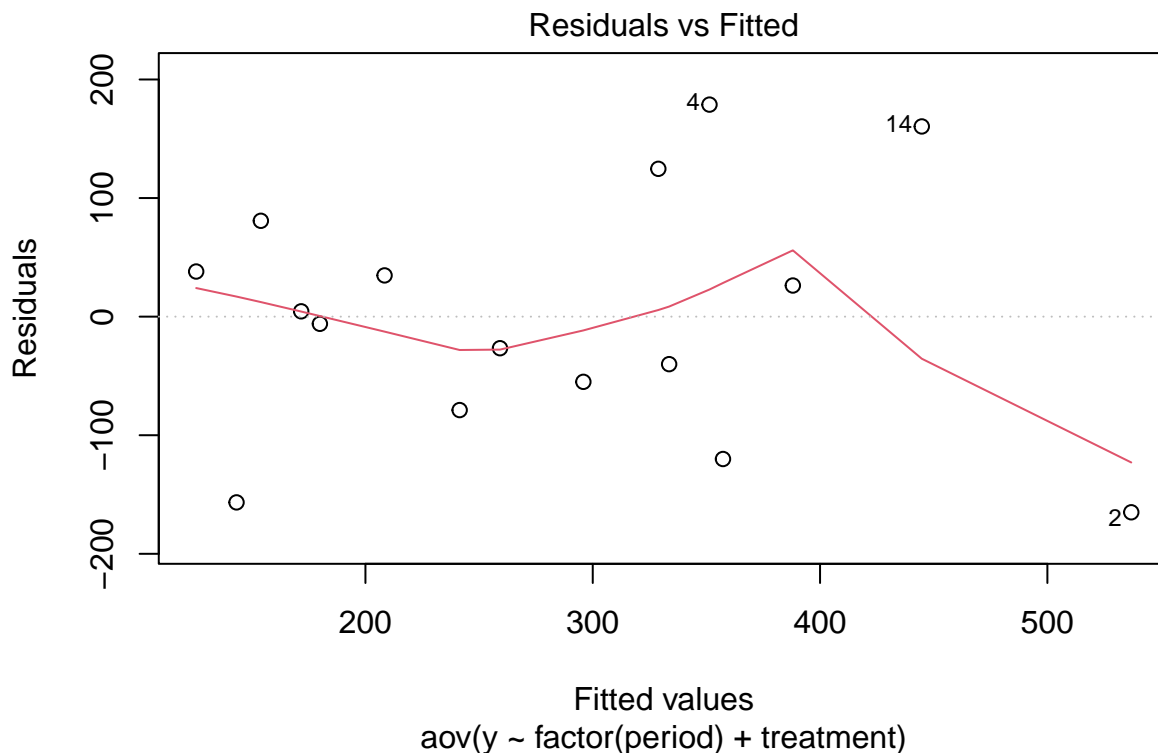
```

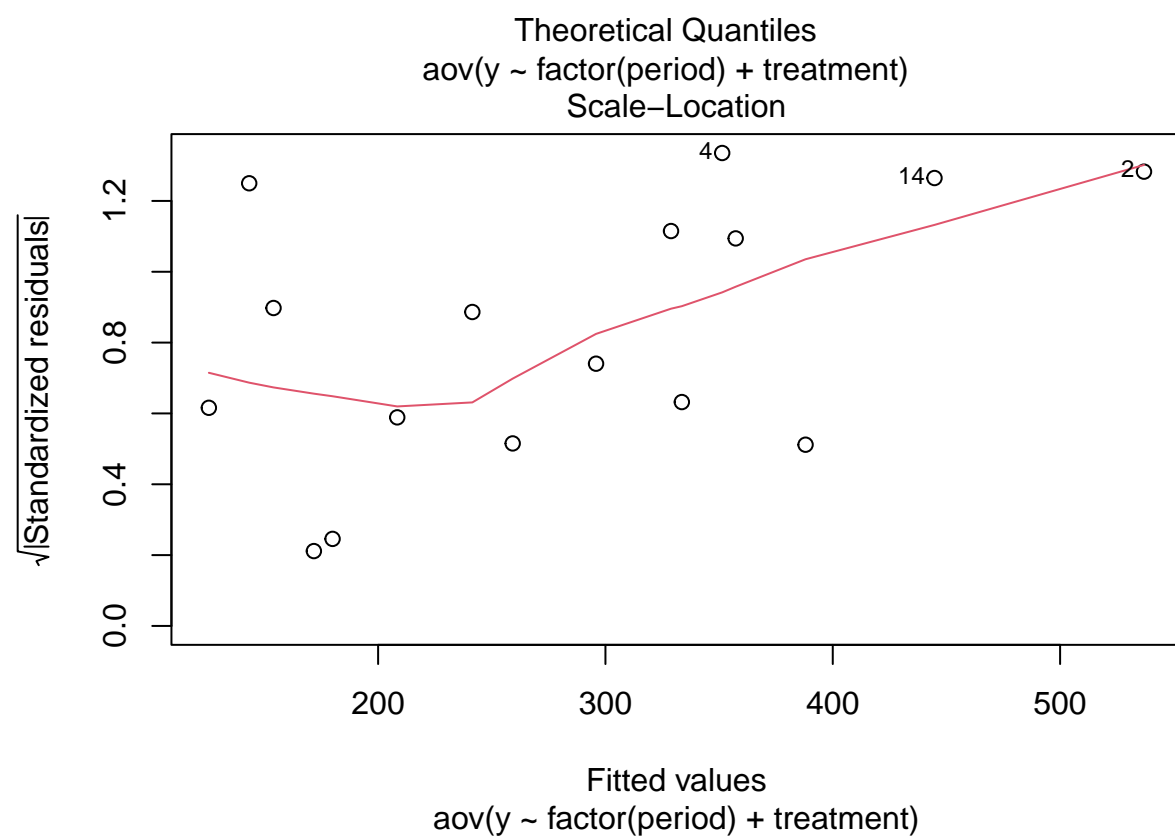
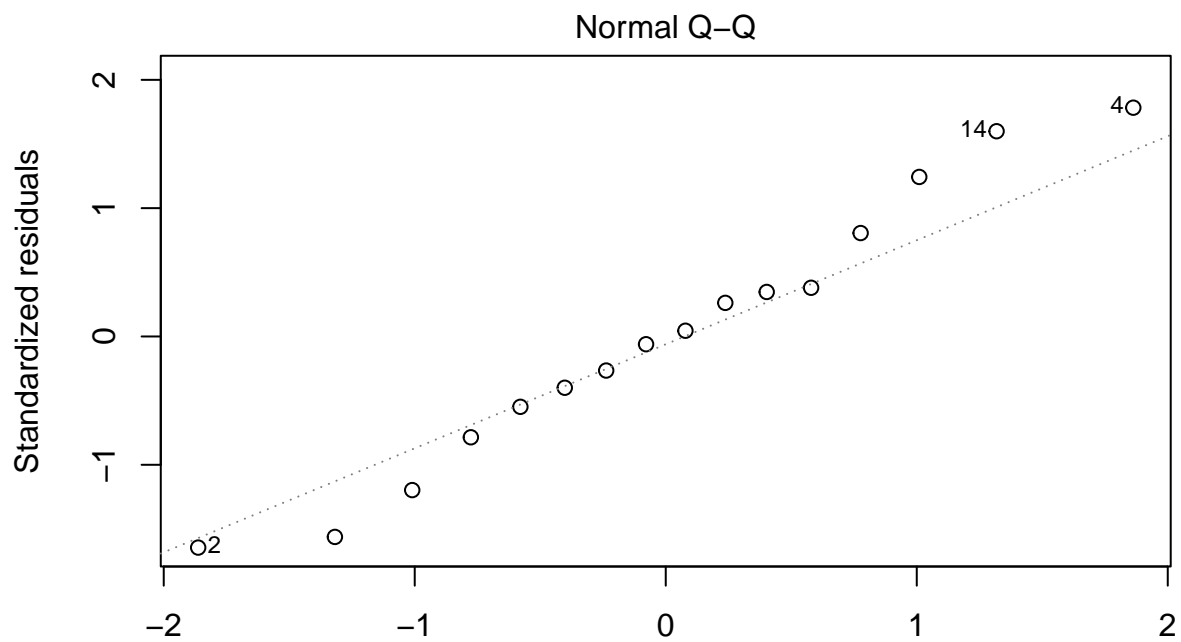
```

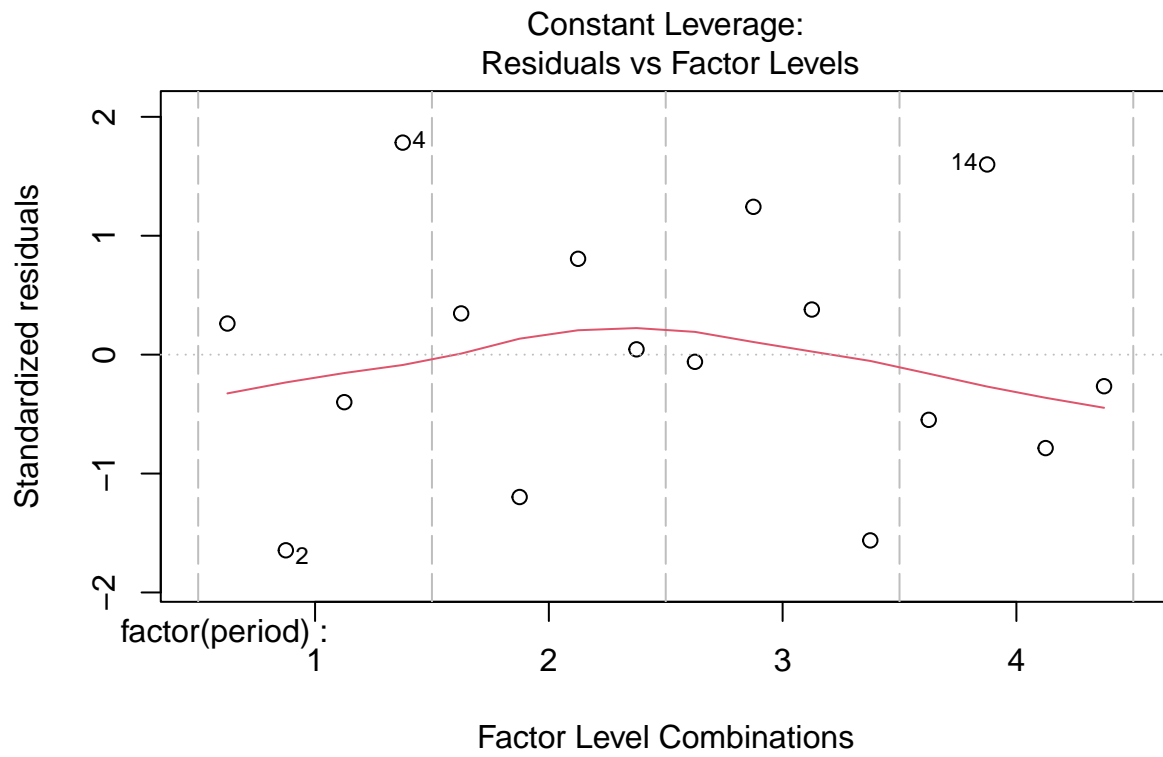
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.349517   0.088884  26.433 5.37e-14 ***
## treatmentfrequentflushing 0.285333   0.125701   2.270  0.0384 *
## treatmentsslurryfunnels   0.002664   0.125701   0.021  0.9834
## treatmentsslurrytrays    -0.011646   0.133327  -0.087  0.9315
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1988 on 15 degrees of freedom
## (1 observation deleted due to missingness)
## Multiple R-squared:  0.3402, Adjusted R-squared:  0.2082
## F-statistic: 2.578 on 3 and 15 DF,  p-value: 0.0924
##
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Transformed Dunnetts test without period:
##
## Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Dunnett Contrasts
##
##
## Fit: aov(formula = log10(y) ~ treatment, data = emis_dat)
##
## Linear Hypotheses:
##               Estimate Std. Error t value Pr(>|t|)
## frequentflushing - control == 0  0.285333   0.125701   2.270  0.0954 .
## sslurryfunnels - control == 0    0.002664   0.125701   0.021  1.0000
## sslurrytrays - control == 0     -0.011646   0.133327  -0.087  0.9995
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
##
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Transformed confidence intervals without period:
##               2.5 %      97.5 %
## (Intercept)    14356.554026 34491.52991
## treatmentfrequentflushing  4.089395  257.48601
## treatmentsslurryfunnels  -45.707728  86.46211
## treatmentsslurrytrays   -49.397111  87.29785
##
## mean_CO2_slurry
## mean_CO2_slurry

```

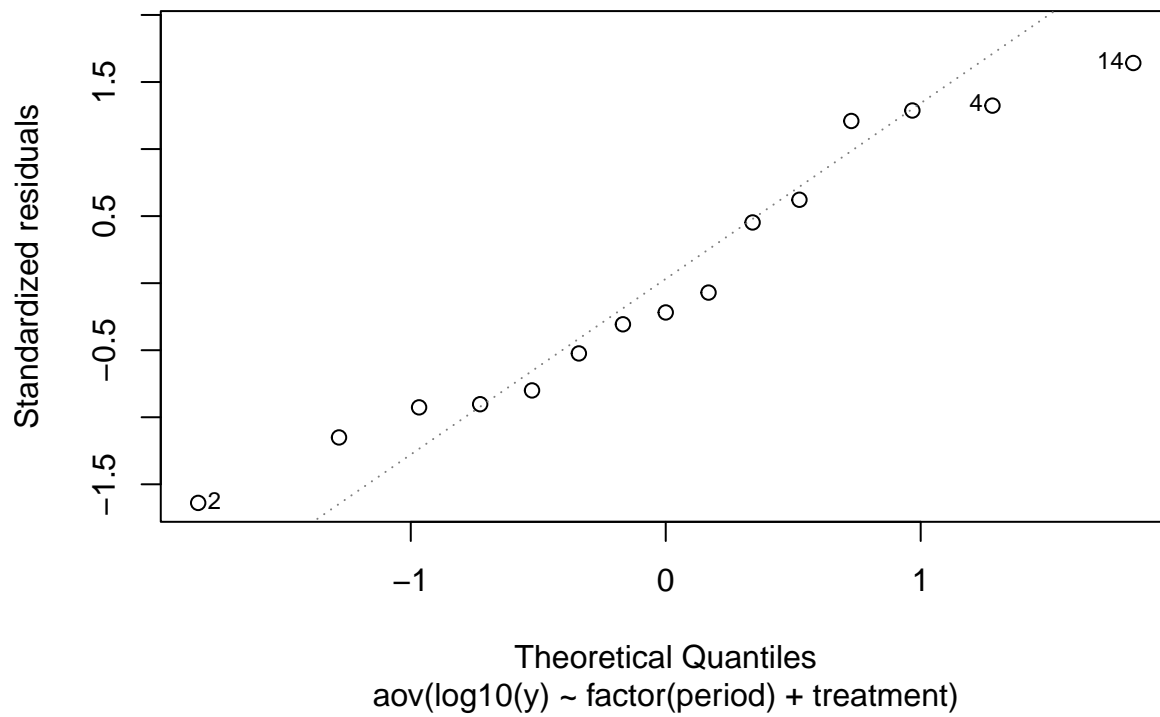
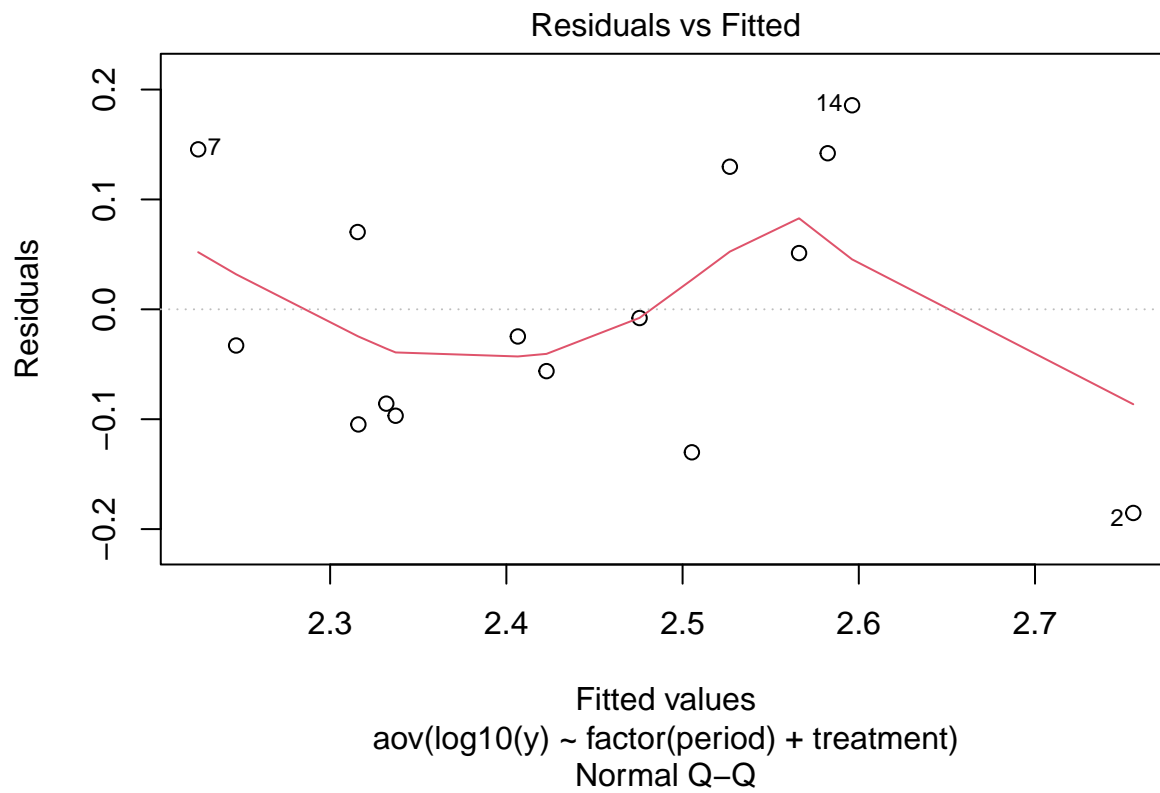
```
## mean_CO2_slurry
## mean_CO2_slurry
##
## Transformed relative reduction (coef):
##          factor(period)3          factor(period)4 treatmentfrequentflushing
##                -41.0                -30.7                    54.8
##   treatmentsslurryfunnels   treatmentsslurrytrays
##                -18.8                    3.8
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Transformed relative reduction without period (coef):
## treatmentfrequentflushing   treatmentsslurryfunnels   treatmentsslurrytrays
##                92.9                    0.6                    -2.6
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Non-transformed diagnostic plots:
```

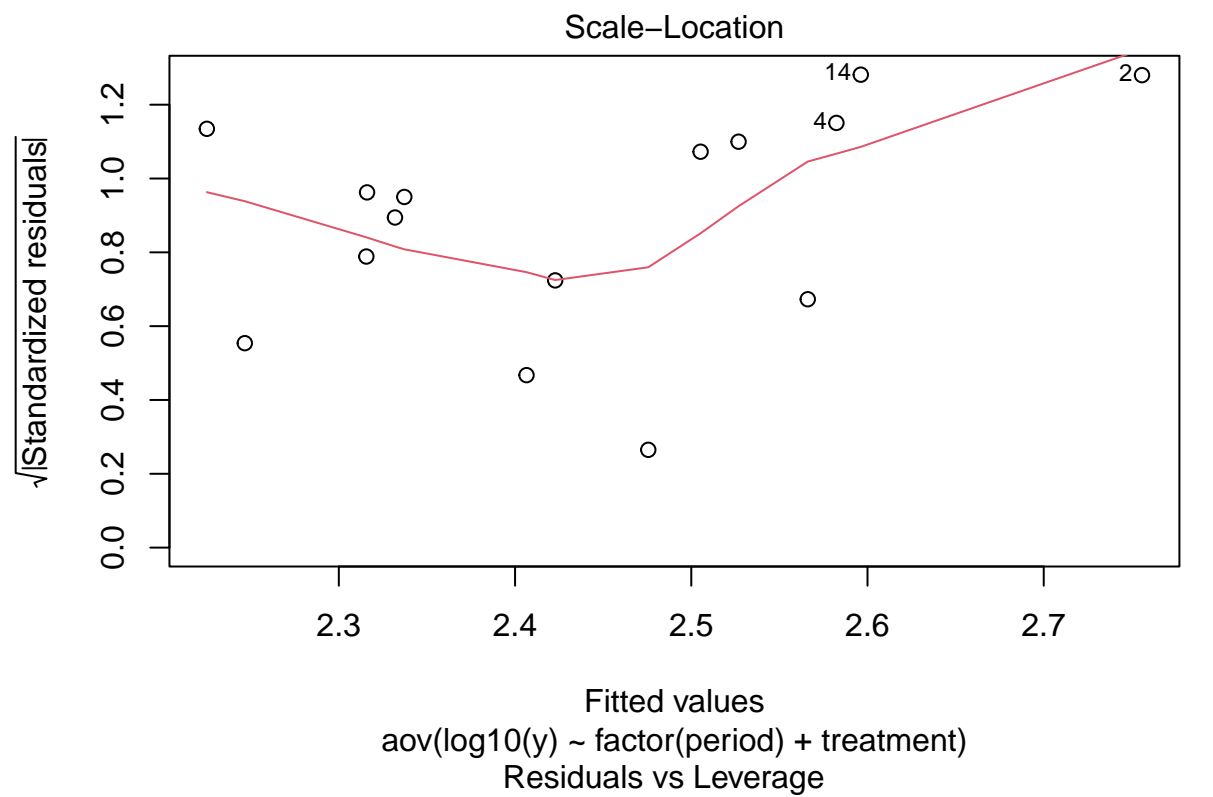






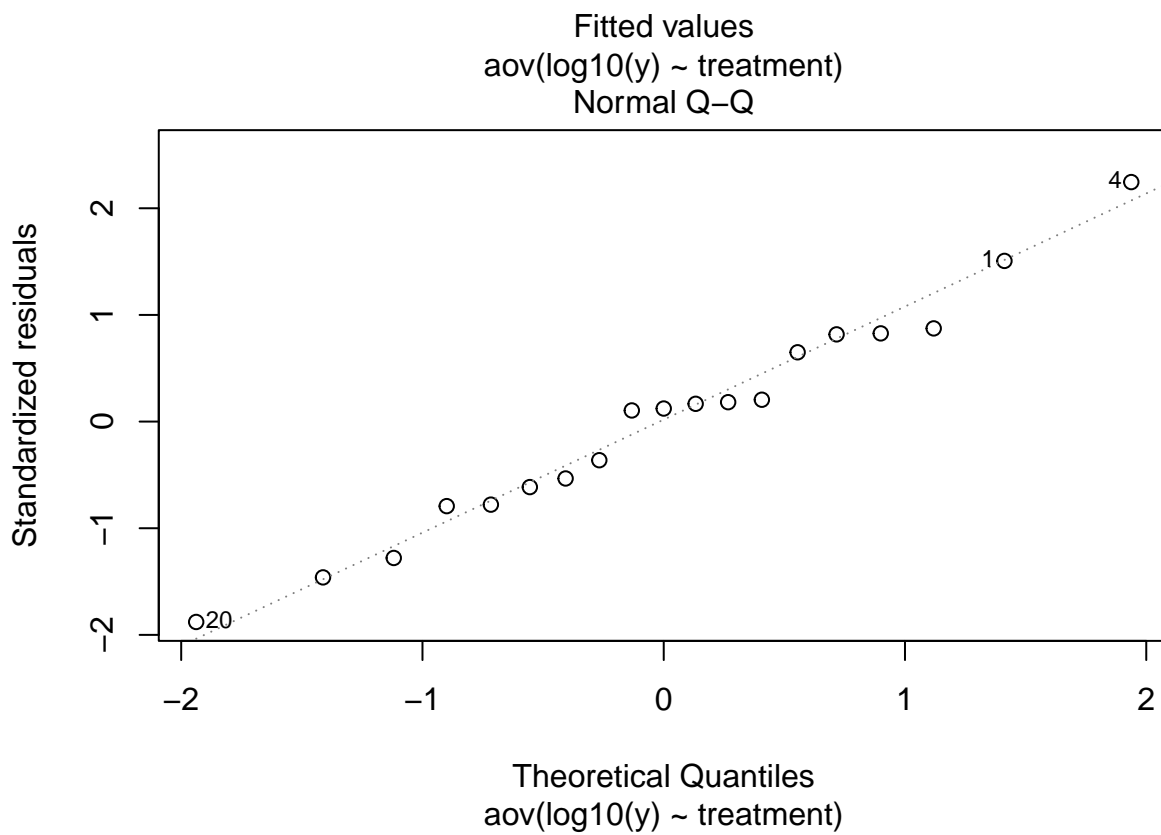
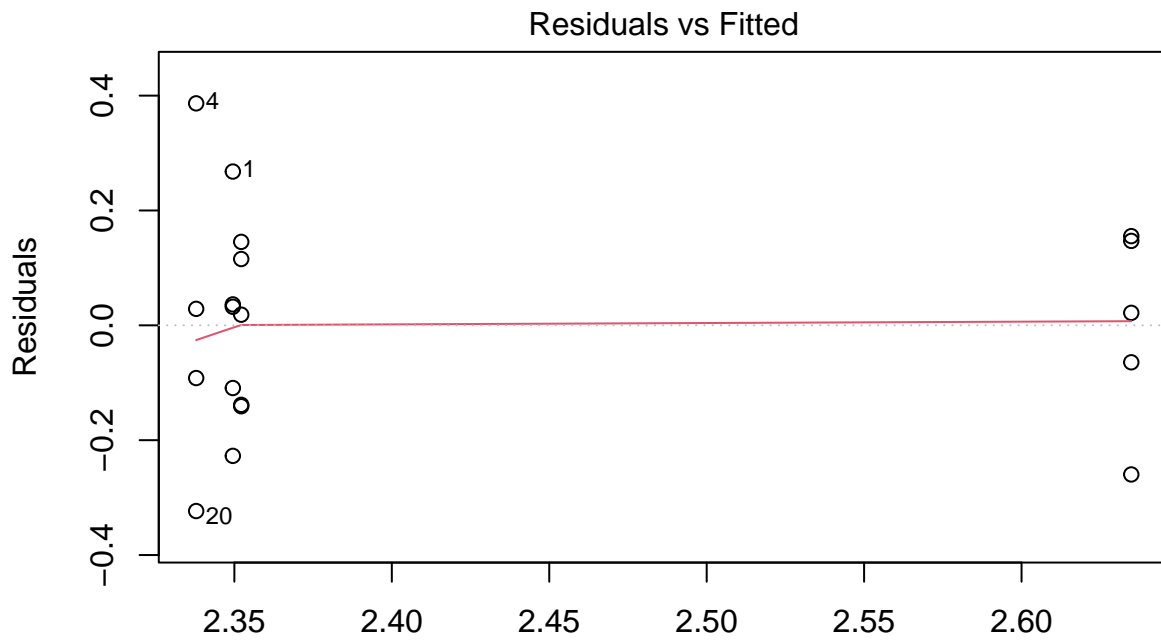
```
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
## Transformed diagnostic plots:
```

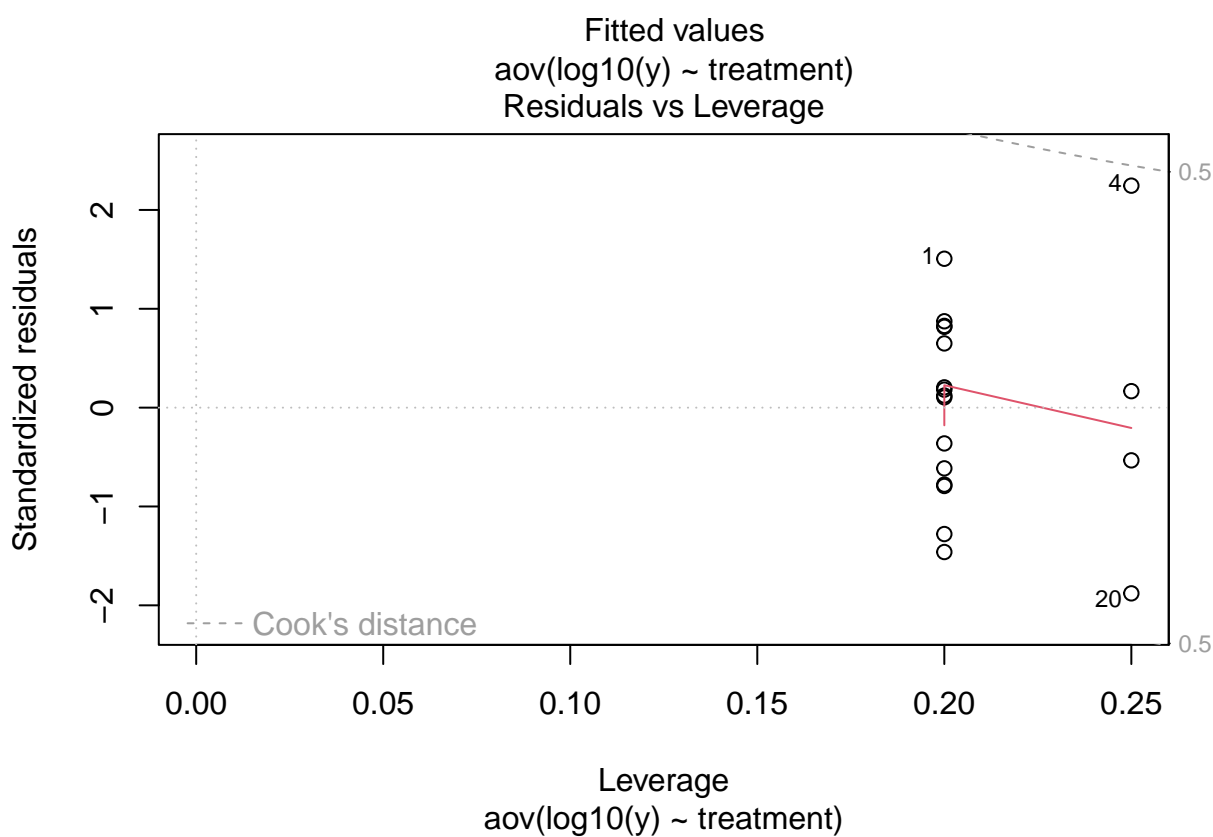
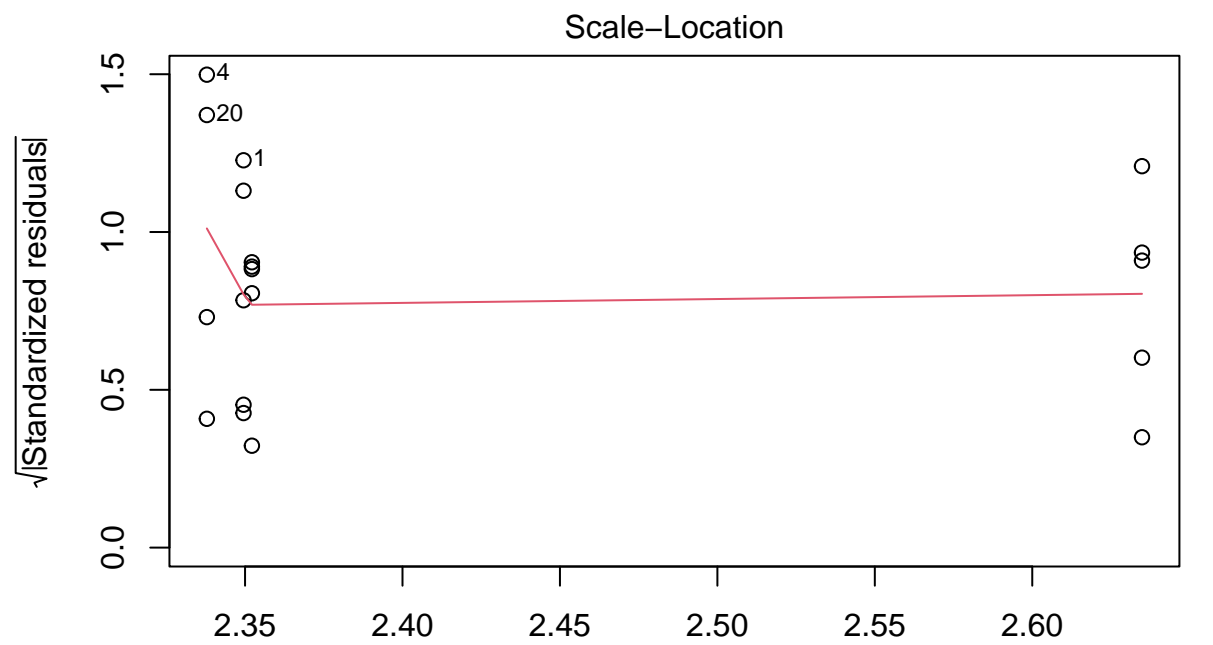




```
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
```

Transformed diagnostic plots without period:





```
##
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
## mean_CO2_slurry
##
```

```
##  
##  
##  
## end mean_CO2_slurry end mean_CO2_slurry end mean_CO2_slurry  
##  
## end mean_CO2_slurry end mean_CO2_slurry end mean_CO2_slurry  
##  
## end mean_CO2_slurry end mean_CO2_slurry end mean_CO2_slurry
```