9 PŘÍLOHY

I. Chemické parametry – test normality, variance a jednostranný párový t-test

a. pH

```
> data <- data.frame(Jezero <- c('NWA', 'VWA', 'STA', 'SLA', 'SES', 'VZ', 'VTE', 'BAT'),
+ Skupina <- c("A", "A", "SA", "SA", "SA", "A", "SA", "A"),
+ pH_1988 <- c(5.84, 5.38, 4.78, 4.78, 4.82, 6.24, 4.78, 6.14),
+ pH_2011 <- c(6.69, 6.7, 5.42, 5.08, 5.39, 6.74, 5.75, 6.54))
> pH_1988_A <- data$pH_1988[data$Skupina == "A"]
> pH_2011_A <- data$pH_2011[data$Skupina == "A"]
> pH_1988_SA <- data$pH_1988[data$Skupina == "SA"]
> pH_2011_SA <- data$pH_2011[data$Skupina == "SA"]
> shapiro.test(pH_1988_A)

        Shapiro-Wilk normality test

data:  pH_1988_A
W = 0.91864, p-value = 0.5293

> shapiro.test(pH_2011_A)

        Shapiro-Wilk normality test

data:  pH_2011_A
W = 0.83871, p-value = 0.1917

> shapiro.test(pH_1988_SA)

        Shapiro-Wilk normality test

data:  pH_1988_SA
W = 0.62978, p-value = 0.001241

> shapiro.test(pH_2011_SA)

        Shapiro-Wilk normality test

data:  pH_2011_SA
W = 0.96289, p-value = 0.7971

 > var.test(pH_1988_A, pH_2011_A)

         F test to compare two variances

 data:  pH_1988_A and pH_2011_A
 F = 19.38, num df = 3, denom df = 3, p-value = 0.03636
 alternative hypothesis: true ratio of variances is not equal to 1
 95 percent confidence interval:
    1.255266 299.215704
 sample estimates:
 ratio of variances
           19.38028

> var.test(pH_1988_SA, pH_2011_SA)

         F test to compare two variances

data:  pH_1988_SA and pH_2011_SA
F = 0.0053333, num df = 3, denom df = 3, p-value = 0.00131
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.0003454414 0.0823423060
sample estimates:
ratio of variances
       0.005333333
> wilcox.test(pH_1988_A, pH_2011_A, alternative = "less", paired = TRUE)

         Wilcoxon signed rank exact test

data:  pH_1988_A and pH_2011_A
V = 0, p-value = 0.0625
alternative hypothesis: true location shift is less than 0

> wilcox.test(pH_1988_SA, pH_2011_SA, alternative = "less", paired = TRUE)

         Wilcoxon signed rank exact test

data:  pH_1988_SA and pH_2011_SA
V = 0, p-value = 0.0625
alternative hypothesis: true location shift is less than 0
```

b. Alkalinita

```
> data <- data.frame(Jezero = c('NWA', 'VWA', 'STA', 'SLA', 'SES', 'VZ', 'VTE', 'BAT'),
+ Skupina = c("A", "A", "SA", "SA", "SA", "A", "SA", "A"),
+ ANC_1988 = c(13, -5, -15, -13, -11, 27, -15, 14),
+ ANC_2011 = c(83.5, 86.4, 15.4, 10.2, 8.7, 79.4, 19.3, 67.1))
> ANC_1988_A <- data$ANC_1988[data$Skupina == "A"]
> ANC_2011_A <- data$ANC_2011[data$Skupina == "A"]
> ANC_1988_SA <- data$ANC_1988[data$Skupina == "SA"]
> ANC_2011_SA <- data$ANC_2011[data$Skupina == "SA"]
> shapiro.test(ANC_1988_A)

        Shapiro-Wilk normality test

data:  ANC_1988_A
W = 0.94653, p-value = 0.6945

> shapiro.test(ANC_2011_A)

        Shapiro-Wilk normality test

data:  ANC_2011_A
W = 0.89737, p-value = 0.4181

> shapiro.test(ANC_1988_SA)

        Shapiro-Wilk normality test

data:  ANC_1988_SA
W = 0.86337, p-value = 0.2725

> shapiro.test(ANC_2011_SA)

        Shapiro-Wilk normality test

data:  ANC_2011_SA
W = 0.93368, p-value = 0.6162

> var.test(ANC_1988_A, ANC_2011_A)

        F test to compare two variances

data:  ANC_1988_A and ANC_2011_A
F = 2.3934, num df = 3, denom df = 3, p-value = 0.4923
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  0.1550225 36.9524585
sample estimates:
ratio of variances
          2.393421


> var.test(ANC_1988_SA, ANC_2011_SA)

        F test to compare two variances

data:  ANC_1988_SA and ANC_2011_SA
F = 0.15462, num df = 3, denom df = 3, p-value = 0.1595
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.01001508 2.38727869
sample estimates:
ratio of variances
         0.1546247


> t.test(ANC_1988_A, ANC_2011_A, paired = TRUE, alternative = "less", var.equal = TRUE)

        Paired t-test

data:  ANC_1988_A and ANC_2011_A
t = -7.2727, df = 3, p-value = 0.002683
alternative hypothesis: true mean difference is less than 0
95 percent confidence interval:
      -Inf -45.21814
sample estimates:
mean difference
         -66.85

> t.test(ANC_1988_SA, ANC_2011_SA, paired = TRUE, alternative = "less", var.equal = TRUE)

        Paired t-test

data:  ANC_1988_SA and ANC_2011_SA
t = -8.0941, df = 3, p-value = 0.00197
alternative hypothesis: true mean difference is less than 0
95 percent confidence interval:
      -Inf -19.07883
sample estimates:
mean difference
          -26.9
```

c. Dusičnanový dusík

```
> data <- data.frame(Jezero = c('NWA', 'VWA', 'STA', 'SLA', 'SES', 'VZ', 'VTE', 'BAT'),
+ Skupina = c("A", "A", "SA", "SA", "SA", "A", "SA", "A"),
+ NO3_1988 = c(40.4, 50, 12.9, 0, 35.2, 51.8, 31.0, 47.1),
+ NO3_2011 = c(20.8, 22.3, 0.1, 0.5, 16.7, 17.9, 12.7, 25.2))
> NO3_1988_A <- data$NO3_1988[data$Skupina == "A"]
> NO3_2011_A <- data$NO3_2011[data$Skupina == "A"]
> NO3_1988_SA <- data$NO3_1988[data$Skupina == "SA"]
> NO3_2011_SA <- data$NO3_2011[data$Skupina == "SA"]
> shapiro.test(NO3_1988_A)

        Shapiro-Wilk normality test

data:  NO3_1988_A
W = 0.92004, p-value = 0.5372

> shapiro.test(NO3_2011_A)

        Shapiro-Wilk normality test

data:  NO3_2011_A
W = 0.99879, p-value = 0.9964

> shapiro.test(NO3_1988_SA)

        Shapiro-Wilk normality test

data:  NO3_1988_SA
W = 0.92237, p-value = 0.5503

> shapiro.test(NO3_2011_SA)

        Shapiro-Wilk normality test

data:  NO3_2011_SA
W = 0.83818, p-value = 0.1901

> var.test(NO3_1988_A, NO3_2011_A)

        F test to compare two variances

data:  NO3_1988_A and NO3_2011_A
F = 2.7075, num df = 3, denom df = 3, p-value = 0.435
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  0.175366 41.801711
sample estimates:
ratio of variances
          2.707508

> var.test(NO3_1988_SA, NO3_2011_SA)

        F test to compare two variances

data:  NO3_1988_SA and NO3_2011_SA
F = 3.7238, num df = 3, denom df = 3, p-value = 0.3088
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  0.2411891 57.4918560
sample estimates:
ratio of variances
          3.723763


> t.test(NO3_1988_A, NO3_2011_A, paired = TRUE, alternative = "greater", var.equal = TRUE)

        Paired t-test

data:  NO3_1988_A and NO3_2011_A
t = 8.0551, df = 3, p-value = 0.001998
alternative hypothesis: true mean difference is greater than 0
95 percent confidence interval:
 18.24462      Inf
sample estimates:
mean difference
         25.775

> t.test(NO3_1988_SA, NO3_2011_SA, paired = TRUE, alternative = "greater", var.equal = TRUE)

        Paired t-test

data:  NO3_1988_SA and NO3_2011_SA
t = 2.7532, df = 3, p-value = 0.03528
alternative hypothesis: true mean difference is greater than 0
95 percent confidence interval:
 1.782775      Inf
sample estimates:
mean difference
         12.275
```

d. Siřičitany

```
> data <- data.frame (Jezero = c('NWA', 'VWA', 'STA', 'SLA', 'SES', 'VZ', 'VTE', 'BAT'),
+ Skupina = c("A", "A", "SA", "SA", "SA", "A", "SA", "A"),
+ SO4_1988 = c(0, 3.5, 4.8, 4.4, 3.8, 3.2, 3.2, 4.3),
+ SO4_2011 = c(1.3, 1, 1.1, 1.2, 1.6, 1.1, 1.1, 2.7))
>
> SO4_1988_A <- data$SO4_1988[data$Skupina == "A"]
> SO4_2011_A <- data$SO4_2011[data$Skupina == "A"]
> SO4_1988_SA <- data$SO4_1988[data$Skupina == "SA"]
> SO4_2011_SA <- data$SO4_2011[data$Skupina == "SA"]
> shapiro.test(SO4_1988_A)

        Shapiro-Wilk normality test

data:  SO4_1988_A
W = 0.84164, p-value = 0.2002

> shapiro.test(SO4_2011_A)

        Shapiro-Wilk normality test

data:  SO4_2011_A
W = 0.76497, p-value = 0.0528

> shapiro.test(SO4_1988_SA)

        Shapiro-Wilk normality test

data:  SO4_1988_SA
W = 0.97865, p-value = 0.8941

> shapiro.test(SO4_2011_SA)

        Shapiro-Wilk normality test

data:  SO4_2011_SA
W = 0.76348, p-value = 0.05123

>
> var.test(SO4_1988_A, SO4_2011_A)

        F test to compare two variances

data:  SO4_1988_A and SO4_2011_A
F = 5.6848, num df = 3, denom df = 3, p-value = 0.1874
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  0.368204 87.768173
sample estimates:
ratio of variances
          5.684768

> var.test(SO4_1988_A, SO4_2011_A)

        F test to compare two variances

data:  SO4_1988_A and SO4_2011_A
F = 5.6848, num df = 3, denom df = 3, p-value = 0.1874
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  0.368204 87.768173
sample estimates:
ratio of variances
          5.684768

> var.test(SO4_1988_SA, SO4_2011_SA)

        F test to compare two variances

data:  SO4_1988_SA and SO4_2011_SA
F = 8.6471, num df = 3, denom df = 3, p-value = 0.1097
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
   0.5600723 133.5035182
sample estimates:
ratio of variances
          8.647059


> t.test(SO4_1988_A, SO4_2011_A, paired = TRUE, alternative = "greater", var.equal = TRUE)

        Paired t-test

data:  SO4_1988_A and SO4_2011_A
t = 1.4218, df = 3, p-value = 0.1251
alternative hypothesis: true mean difference is greater than 0
95 percent confidence interval:
 -0.802572       Inf
sample estimates:
mean difference
          1.225

> t.test(SO4_1988_SA, SO4_2011_SA, paired = TRUE, alternative = "greater", var.equal = TRUE)

        Paired t-test

data:  SO4_1988_SA and SO4_2011_SA
t = 7.1897, df = 3, p-value = 0.002772
alternative hypothesis: true mean difference is greater than 0
95 percent confidence interval:
 1.883497      Inf
sample estimates:
mean difference
            2.8
```

e. Vápník

```
> data <- data.frame (Jezero = c('NWA', 'VWA', 'STA', 'SLA', 'SES', 'VZ', 'VTE', 'BAT'),
+ Skupina = c("A", "A", "SA", "SA", "SA", "A", "SA", "A"),
+ Ca_1988 = c(62, 95, 56, 34, 52, 142, 54, 125),
+ Ca_2011 = c(112, 111, 27, 20, 41, 110, 38, 105))
>
> Ca_1988_A <- data$Ca_1988[data$Skupina == "A"]
> Ca_2011_A <- data$Ca_2011[data$Skupina == "A"]
> Ca_1988_SA <- data$Ca_1988[data$Skupina == "SA"]
> Ca_2011_SA <- data$Ca_2011[data$Skupina == "SA"]
>
>
> shapiro.test(Ca_1988_A)

        Shapiro-Wilk normality test

data:  Ca_1988_A
W = 0.96838, p-value = 0.8314

> shapiro.test(Ca_2011_A)

        Shapiro-Wilk normality test

data:  Ca_2011_A
W = 0.85422, p-value = 0.2401

> shapiro.test(Ca_1988_SA)

        Shapiro-Wilk normality test

data:  Ca_1988_SA
W = 0.77526, p-value = 0.06475

> shapiro.test(Ca_2011_SA)

        Shapiro-Wilk normality test

data:  Ca_2011_SA
W = 0.92793, p-value = 0.5823

> var.test(Ca_1988_A, Ca_2011_A)

        F test to compare two variances

data:  Ca_1988_A and Ca_2011_A
F = 128.07, num df = 3, denom df = 3, p-value = 0.00231
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
    8.295061 1977.280116
sample estimates:
ratio of variances
           128.069

> var.test(Ca_1988_SA, Ca_2011_SA)

        F test to compare two variances

data:  Ca_1988_SA and Ca_2011_SA
F = 1.0807, num df = 3, denom df = 3, p-value = 0.9506
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  0.06999734 16.68515148
sample estimates:
ratio of variances
          1.080702

> wilcox.test(Ca_1988_A, Ca_2011_A, paired = TRUE, alternative = "less")

        Wilcoxon signed rank exact test

data:  Ca_1988_A and Ca_2011_A
V = 5, p-value = 0.5625
alternative hypothesis: true location shift is less than 0

> t.test(Ca_1988_SA, Ca_2011_SA, paired = TRUE, alternative = "greater", var.equal = TRUE)

        Paired t-test

data:  Ca_1988_SA and Ca_2011_SA
t = 4.4096, df = 3, p-value = 0.01082
alternative hypothesis: true mean difference is greater than 0
95 percent confidence interval:
 8.160378      Inf
sample estimates:
mean difference
           17.5
```

f. Celkový reaktivní hliník

```
> data <- data.frame (Jezero = c('NWA', 'VWA', 'STA', 'SLA', 'SES', 'VZ', 'VTE', 'BAT'),
+ Skupina = c("A", "A", "SA", "SA", "SA", "A", "SA", "A"),
+ AL_1988 = c(NA, 0.01, 0.01, 0.02, 14.27, 0.14, 13.22, 0.1),
+ AL_2011 = c(0, 0, 0, 3.13, 0, 0, 0.22, 0))
> AL_1988_A <- data$AL_1988[data$Skupina == "A"]
> AL_2011_A <- data$AL_2011[data$Skupina == "A"]
> AL_1988_SA <- data$AL_1988[data$Skupina == "SA"]
> AL_2011_SA <- data$AL_2011[data$Skupina == "SA"]
> shapiro.test(AL_1988_A)

        Shapiro-Wilk normality test

data:  AL_1988_A
W = 0.95301, p-value = 0.5827

> shapiro.test(AL_2011_A)
Error in shapiro.test(AL_2011_A) : all 'x' values are identical
> shapiro.test(AL_1988_SA)

        Shapiro-Wilk normality test

data:  AL_1988_SA
W = 0.76114, p-value = 0.04884

> shapiro.test(AL_2011_SA)

        Shapiro-Wilk normality test

data:  AL_2011_SA
W = 0.67988, p-value = 0.006601

> var.test(AL_1988_A, AL_2011_A)

        F test to compare two variances

data:  AL_1988_A and AL_2011_A
F = Inf, num df = 2, denom df = 3, p-value < 2.2e-16
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 Inf Inf
sample estimates:
ratio of variances
               Inf

> var.test(AL_1988_SA, AL_2011_SA)

        F test to compare two variances

data:  AL_1988_SA and AL_2011_SA
F = 26.857, num df = 3, denom df = 3, p-value = 0.02284
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
   1.739532 414.649350
sample estimates:
ratio of variances
          26.85695

> wilcox.test(AL_1988_A, AL_2011_A, paired = TRUE, alternative = "greater")

        Wilcoxon signed rank exact test

data:  AL_1988_A and AL_2011_A
V = 6, p-value = 0.125
alternative hypothesis: true location shift is greater than 0

> wilcox.test(AL_1988_SA, AL_2011_SA, paired = TRUE, alternative = "greater")

        Wilcoxon signed rank exact test

data:  AL_1988_SA and AL_2011_SA
V = 8, p-value = 0.1875
alternative hypothesis: true location shift is greater than 0
```

g. Rozpuštěný organický uhlík

```
> data <- data.frame(Jezero = c('NWA', 'VWA', 'STA', 'SLA', 'SES', 'VZ', 'VTE', 'BAT'),
+ Skupina = c("A", "A", "SA", "SA", "SA", "A", "SA", "A"),
+ DOC_1988 = c(0.3, 0.25, 2.72, 2.38, 0.4, 0.15, 0.49, 0.15),
+ DOC_2011 = c(0.36, 0.16, 1.74, 4.02, 0.54, 0.37, 1.08, 0.16))
>
> DOC_1988_A <- data$DOC_1988[data$Skupina == "A"]
> DOC_2011_A <- data$DOC_2011[data$Skupina == "A"]
> DOC_1988_SA <- data$DOC_1988[data$Skupina == "SA"]
> DOC_2011_SA <- data$DOC_2011[data$Skupina == "SA"]
>
>
> shapiro.test(DOC_1988_A)

        Shapiro-Wilk normality test

data:  DOC_1988_A
W = 0.8494, p-value = 0.2242

> shapiro.test(DOC_2011_A)

        Shapiro-Wilk normality test

data:  DOC_2011_A
W = 0.74959, p-value = 0.03829

> shapiro.test(DOC_1988_SA)

        Shapiro-Wilk normality test

data:  DOC_1988_SA
W = 0.81098, p-value = 0.1234

> shapiro.test(DOC_2011_SA)

        Shapiro-Wilk normality test

data:  DOC_2011_SA
W = 0.8901, p-value = 0.3836


> var.test(DOC_1988_A, DOC_2011_A)

        F test to compare two variances

data:  DOC_1988_A and DOC_2011_A
F = 0.40107, num df = 3, denom df = 3, p-value = 0.4728
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.02597738 6.19218545
sample estimates:
ratio of variances
         0.4010695

> var.test(DOC_1988_SA, DOC_2011_SA)

        F test to compare two variances

data:  DOC_1988_SA and DOC_2011_SA
F = 0.63911, num df = 3, denom df = 3, p-value = 0.7219
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.04139529 9.86732621
sample estimates:
ratio of variances
         0.6391094

> wilcox.test(DOC_1988_A, DOC_2011_A, paired = TRUE, alternative = "less")

        Wilcoxon signed rank exact test

data:  DOC_1988_A and DOC_2011_A
V = 3, p-value = 0.3125
alternative hypothesis: true location shift is less than 0

> t.test(DOC_1988_SA, DOC_2011_SA, paired = TRUE, alternative = "less", var.equal = TRUE)

        Paired t-test

data:  DOC_1988_SA and DOC_2011_SA
t = -0.64028, df = 3, p-value = 0.2838
alternative hypothesis: true mean difference is less than 0
95 percent confidence interval:
      -Inf 0.9297418
sample estimates:
mean difference
        -0.3475
```

h. Volný fosfor

```
> var.test(VP_1988_SA, VP_2011_SA)

        F test to compare two variances

data:  VP_1988_SA and VP_2011_SA
F = 0.62698, num df = 3, denom df = 3, p-value = 0.7107
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.0406096 9.6800444
sample estimates:
ratio of variances
         0.6269791

> data <- data.frame (Jezero = c('NWA', 'VWA', 'STA', 'SLA', 'SES', 'VZ', 'VTE', 'BAT'),
+ Skupina = c("A", "A", "SA", "SA", "SA", "A", "SA", "A"),
+ VP_1988 = c(3, 3.1, 9.0, 13.3, 4.4, 2, 5.8, 1.9),
+ VP_2011 = c(2.7, 2.4, 7.4, 7, 3.2, 1.4, 15.1, 0.5))
> VP_1988_A <- data$VP_1988[data$Skupina == "A"]
> VP_2011_A <- data$VP_2011[data$Skupina == "A"]
> VP_1988_SA <- data$VP_1988[data$Skupina == "SA"]
> VP_2011_SA <- data$VP_2011[data$Skupina == "SA"]
>
> shapiro.test(VP_1988_A)

        Shapiro-Wilk normality test

data:  VP_1988_A
W = 0.80507, p-value = 0.1116

> shapiro.test(VP_2011_A)

        Shapiro-Wilk normality test

data:  VP_2011_A
W = 0.9358, p-value = 0.6289

> shapiro.test(VP_1988_SA)

        Shapiro-Wilk normality test

data:  VP_1988_SA
W = 0.94407, p-value = 0.6793

> shapiro.test(VP_2011_SA)

        Shapiro-Wilk normality test

data:  VP_2011_SA
W = 0.91019, p-value = 0.4834

>
> var.test(VP_1988_A, VP_2011_A)

        F test to compare two variances

data:  VP_1988_A and VP_2011_A
F = 0.40532, num df = 3, denom df = 3, p-value = 0.4777
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.0262524 6.2577417
sample estimates:
ratio of variances
         0.4053156


> t.test(VP_1988_A, VP_2011_A, paired = TRUE, alternative = "greater", var.equal = TRUE)

        Paired t-test

data:  VP_1988_A and VP_2011_A
t = 3.2225, df = 3, p-value = 0.02425
alternative hypothesis: true mean difference is greater than 0
95 percent confidence interval:
 0.2022845       Inf
sample estimates:
mean difference
           0.75

> t.test(VP_1988_SA, VP_2011_SA, paired = TRUE, alternative = "less", var.equal = TRUE)

        Paired t-test

data:  VP_1988_SA and VP_2011_SA
t = -0.015181, df = 3, p-value = 0.4944
alternative hypothesis: true mean difference is less than 0
95 percent confidence interval:
    -Inf 7.70093
sample estimates:
mean difference
          -0.05
```

i. Chlorofyl-a

```
> chl_1988_A <- data$chl_1988[data$Skupina == "A"]
> chl_2011_A <- data$chl_2011[data$Skupina == "A"]
> chl_1988_SA <- data$chl_1988[data$Skupina == "SA"]
> chl_2011_SA <- data$chl_2011[data$Skupina == "SA"]
>
>
> shapiro.test(chl_1988_A)

        Shapiro-Wilk normality test

data:  chl_1988_A
W = 0.97862, p-value = 0.8939

> shapiro.test(chl_2011_A)

        Shapiro-Wilk normality test

data:  chl_2011_A
W = 0.86754, p-value = 0.2881

> shapiro.test(chl_1988_SA)

        Shapiro-Wilk normality test

data:  chl_1988_SA
W = 0.98205, p-value = 0.9139

> shapiro.test(chl_2011_SA)

        Shapiro-Wilk normality test

data:  chl_2011_SA
W = 0.8981, p-value = 0.4217

>
> var.test(chl_1988_A, chl_2011_A)

        F test to compare two variances

data:  chl_1988_A and chl_2011_A
F = 0.012328, num df = 3, denom df = 3, p-value = 0.004546
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.000798468 0.190329510
sample estimates:
ratio of variances
        0.01232769


> var.test(chl_1988_SA, chl_2011_SA)

        F test to compare two variances

data:  chl_1988_SA and chl_2011_SA
F = 0.16359, num df = 3, denom df = 3, p-value = 0.1712
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.01059578 2.52569797
sample estimates:
ratio of variances
         0.1635901

> wilcox.test(chl_1988_A, chl_2011_A, paired = TRUE, alternative = "less")

        Wilcoxon signed rank exact test

data:  chl_1988_A and chl_2011_A
V = 0, p-value = 0.0625
alternative hypothesis: true location shift is less than 0

> t.test(chl_1988_SA, chl_2011_SA, paired = TRUE, alternative = "less", var.equal = TRUE)

        Paired t-test

data:  chl_1988_SA and chl_2011_SA
t = -1.165, df = 3, p-value = 0.1641
alternative hypothesis: true mean difference is less than 0
95 percent confidence interval:
     -Inf 4.725439
sample estimates:
mean difference
        -4.6325
```

II. Dvouvýběrový t-test -abundance, počet, diverzita 2011

```
> data <- data.frame(
+ Jezero = c('NWA', 'VWA', 'STA', 'SLA', 'SES', 'VZ', 'VTE', 'BAT'),
+ Skupina <- c("A", "A", "SA", "SA", "SA", "A", "SA", "A"),
+ Abundance_2011 = c(40, 2912, 6367, 2903, 16190, 11680, 531, 6620),
+ Pocet_2011 = c(2, 4, 3, 6, 7, 5, 1, 5),
+ Diverzita_Simp_2011 = c(0.5, 0.934, 0.490, 0.401, 0.493, 0.748, 1.0, 0.721))
```

a. Abundance

```
> abun_A <- data$Abundance_2011[data$Skupina == "A"]
> abun_SA <- data$Abundance_2011[data$Skupina == "SA"]
> shapiro.test(abun_A)

        Shapiro-Wilk normality test

data:  abun_A
W = 0.97927, p-value = 0.8977

> shapiro.test(abun_SA)

        Shapiro-Wilk normality test

data:  abun_SA
W = 0.90224, p-value = 0.4423

> var.test(abun_A, abun_SA)

        F test to compare two variances

data:  abun_A and abun_SA
F = 0.53211, num df = 3, denom df = 3, p-value = 0.6173
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.03446519 8.21541152
sample estimates:
ratio of variances
         0.5321144

> t.test(abun_A, abun_SA, var.equal = f_test$p.value > 0.05)

        Two Sample t-test

data:  abun_A and abun_SA
t = -0.27777, df = 6, p-value = 0.7905
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -11621.181   9251.681
sample estimates:
mean of x mean of y
  5313.00   6497.75
```

b. Počet druhů

```
> pocet_A <- data$Pocet_2011[data$Skupina == "A"]
> pocet_SA <- data$Pocet_2011[data$Skupina == "SA"]
> shapiro.test(pocet_A)

        Shapiro-Wilk normality test

data:  pocet_A
W = 0.82743, p-value = 0.1612

> shapiro.test(pocet_SA)

        Shapiro-Wilk normality test

data:  pocet_SA
W = 0.93927, p-value = 0.6499

> var.test(pocet_A, pocet_SA)

        F test to compare two variances

data:  pocet_A and pocet_SA
F = 0.26374, num df = 3, denom df = 3, p-value = 0.3026
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.01708227 4.07187228
sample estimates:
ratio of variances
         0.2637363

> t.test(pocet_A, pocet_SA, var.equal = f_test$p.value > 0.05)

        Two Sample t-test

data:  pocet_A and pocet_SA
t = -0.16151, df = 6, p-value = 0.877
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -4.037448  3.537448
sample estimates:
mean of x mean of y
     4.00      4.25
```

c. Diverzita

```
> div_A <- data$Diverzita_Simp[data$Skupina == "A"]
> div_SA <- data$Diverzita_Simp[data$Skupina == "SA"]
> shapiro.test(div_A)

        Shapiro-Wilk normality test

data:  div_A
W = 0.96644, p-value = 0.8193

> shapiro.test(div_SA)

        Shapiro-Wilk normality test

data:  div_SA
W = 0.76152, p-value = 0.04922

> var.test(div_A, div_SA)

        F test to compare two variances

data:  div_A and div_SA
F = 0.42517, num df = 3, denom df = 3, p-value = 0.5007
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.02753817 6.56422702
sample estimates:
ratio of variances
         0.4251668

> t.test(diversity_A, diversity_SA, var.equal = f_test$p.value > 0.05)

        Two Sample t-test

data:  diversity_A and diversity_SA
t = 0.79713, df = 6, p-value = 0.4558
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.2685375  0.5280375
sample estimates:
mean of x mean of y
  0.72575   0.59600
```

III. Dvouvýběrový párový t-test – abundance, počet, diverzita

a. Test normality

```
>  data <- data.frame(
+ Jezero = c('NWA', 'VWA', 'STA', 'SLA', 'SES', 'VZ', 'VTE', 'BAT'),
+ Skupina = c('A', 'A', 'SA', 'SA', 'SA', 'A', 'SA', 'A'),
+ Abundance_1988 = c(142, 189, 10705, 15610, 32911, 12437, 11143, 17515),
+ Abundance_2011 = c(40, 2912, 6367, 2903, 16190, 11680, 531, 6620),
+ Pocet_1988 = c(1, 2, 4, 3, 4, 3, 4, 2),
+ Pocet_2011 = c(2, 4, 3, 6, 7, 5, 1, 5),
+ Diverzita_Simp_1988 = c(1, 0.531, 0.461, 0.492, 0.637, 0.481, 0.704, 0.748),
+ Diverzita_Simp_2011 = c(0.5, 0.934, 0.490, 0.401, 0.493, 0.748, 1.0, 0.721))
> acidifikovana <- data %>% filter(Skupina == 'A')
> silne_acidifikovana <- data %>% filter(Skupina == 'SA')

> shapiro.test(acidifikovana$Abundance_1988 - acidifikovana$Abundance_2011)

        Shapiro-Wilk normality test

data:  acidifikovana$Abundance_1988 - acidifikovana$Abundance_2011
W = 0.84325, p-value = 0.205

> shapiro.test(silne_acidifikovana$Abundance_1988 - silne_acidifikovana$Abundance_2011)

        Shapiro-Wilk normality test

data:  silne_acidifikovana$Abundance_1988 - silne_acidifikovana$Abundance_2011
W = 0.97927, p-value = 0.8977

>
> shapiro.test(acidifikovana$Pocet_1988 - acidifikovana$Pocet_2011)

        Shapiro-Wilk normality test

data:  acidifikovana$Pocet_1988 - acidifikovana$Pocet_2011
W = 0.94466, p-value = 0.683

> shapiro.test(silne_acidifikovana$Pocet_1988 - silne_acidifikovana$Pocet_2011)

        Shapiro-Wilk normality test

data:  silne_acidifikovana$Pocet_1988 - silne_acidifikovana$Pocet_2011
W = 0.8494, p-value = 0.2242

>
> shapiro.test(acidifikovana$Diverzita_Simp_1988 - acidifikovana$Diverzita_Simp_2011)

        Shapiro-Wilk normality test

data:  acidifikovana$Diverzita_Simp_1988 - acidifikovana$Diverzita_Simp_2011
W = 0.93516, p-value = 0.625

> shapiro.test(silne_acidifikovana$Diverzita_Simp_1988 - silne_acidifikovana$Diverzita_Simp_2011)

        Shapiro-Wilk normality test

data:  silne_acidifikovana$Diverzita_Simp_1988 - silne_acidifikovana$Diverzita_Simp_2011
W = 0.90008, p-value = 0.4315
```

b. F-test na ověření variancí před párovým t-testem

```
> var.test(acidifikovana$Abundance_1988, acidifikovana$Abundance_2011)

        F test to compare two variances

data:  acidifikovana$Abundance_1988 and acidifikovana$Abundance_2011
F = 3.0633, num df = 3, denom df = 3, p-value = 0.3824
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  0.1984083 47.2942534
sample estimates:
ratio of variances
          3.063262

> var.test(silne_acidifikovana$Abundance_1988, silne_acidifikovana$Abundance_2011)

        F test to compare two variances

data:  silne_acidifikovana$Abundance_1988 and silne_acidifikovana$Abundance_2011
F = 2.2994, num df = 3, denom df = 3, p-value = 0.5118
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  0.1489325 35.5007827
sample estimates:
ratio of variances
          2.299395

> var.test(acidifikovana$Pocet_1988, acidifikovana$Pocet_2011)

        F test to compare two variances

data:  acidifikovana$Pocet_1988 and acidifikovana$Pocet_2011
F = 0.33333, num df = 3, denom df = 3, p-value = 0.391
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.02159009 5.14639413
sample estimates:
ratio of variances
         0.3333333


> var.test(silne_acidifikovana$Pocet_1988, silne_acidifikovana$Pocet_2011)

        F test to compare two variances

data:  silne_acidifikovana$Pocet_1988 and silne_acidifikovana$Pocet_2011
F = 0.032967, num df = 3, denom df = 3, p-value = 0.01917
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.002135284 0.508984034
sample estimates:
ratio of variances
        0.03296703

> var.test(acidifikovana$Diverzita_Simp_1988, acidifikovana$Diverzita_Simp_2011)

        F test to compare two variances

data:  acidifikovana$Diverzita_Simp_1988 and acidifikovana$Diverzita_Simp_2011
F = 1.7757, num df = 3, denom df = 3, p-value = 0.6489
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  0.1150147 27.4158566
sample estimates:
ratio of variances
          1.775732

> var.test(silne_acidifikovana$Diverzita_Simp_1988, silne_acidifikovana$Diverzita_Simp_2011)

        F test to compare two variances

data:  silne_acidifikovana$Diverzita_Simp_1988 and silne_acidifikovana$Diverzita_Simp_2011
F = 0.18092, num df = 3, denom df = 3, p-value = 0.194
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.01171832 2.79327631
sample estimates:
ratio of variances
         0.1809213
```

c. Dvouvýběrový párový test

```
> t.test(acidifikovana$Abundance_1988, acidifikovana$Abundance_2011, paired = TRUE)

        Paired t-test

data:  acidifikovana$Abundance_1988 and acidifikovana$Abundance_2011
t = 0.75854, df = 3, p-value = 0.5033
alternative hypothesis: true mean difference is not equal to 0
95 percent confidence interval:
 -7214.572 11730.072
sample estimates:
mean difference
        2257.75

> t.test(silne_acidifikovana$Abundance_1988, silne_acidifikovana$Abundance_2011, paired = TRUE)

        Paired t-test

data:  silne_acidifikovana$Abundance_1988 and silne_acidifikovana$Abundance_2011
t = 4.2931, df = 3, p-value = 0.02324
alternative hypothesis: true mean difference is not equal to 0
95 percent confidence interval:
  2870.233 19318.767
sample estimates:
mean difference
        11094.5


> t.test(acidifikovana$Pocet_1988, acidifikovana$Pocet_2011, paired = TRUE)

        Paired t-test

data:  acidifikovana$Pocet_1988 and acidifikovana$Pocet_2011
t = -4.899, df = 3, p-value = 0.01628
alternative hypothesis: true mean difference is not equal to 0
95 percent confidence interval:
 -3.2992283 -0.7007717
sample estimates:
mean difference
             -2


> t.test(acidifikovana$Diverzita_Simp_1988, acidifikovana$Diverzita_Simp_2011, paired = TRUE)

        Paired t-test

data:  acidifikovana$Diverzita_Simp_1988 and acidifikovana$Diverzita_Simp_2011
t = -0.17888, df = 3, p-value = 0.8694
alternative hypothesis: true mean difference is not equal to 0
95 percent confidence interval:
 -0.6717848  0.6002848
sample estimates:
mean difference
       -0.03575

> t.test(silne_acidifikovana$Diverzita_Simp_1988, silne_acidifikovana$Diverzita_Simp_2011, paired = TRUE)

        Paired t-test

data:  silne_acidifikovana$Diverzita_Simp_1988 and silne_acidifikovana$Diverzita_Simp_2011
t = -0.22939, df = 3, p-value = 0.8333
alternative hypothesis: true mean difference is not equal to 0
95 percent confidence interval:
 -0.3346516  0.2896516
sample estimates:
mean difference
        -0.0225
```

d. Welschova korekce pro t-test při nerovnosti rozptylů pro počet druhů

```
> t.test(silne_acidifikovana$Pocet_1988, silne_acidifikovana$Pocet_2011, var.equal = FALSE)

        Welch Two Sample t-test

data:  silne_acidifikovana$Pocet_1988 and silne_acidifikovana$Pocet_2011
t = -0.35729, df = 3.1976, p-value = 0.7432
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -4.801822  3.801822
sample estimates:
mean of x mean of y
     3.75      4.25
```

IV. DCA a CCA statistika

a. Rok 1988

Výsledky DCA pro neupravená druhová data 1988:

```
Detrended correspondence analysis with 26 segments.
Rescaling of axes with 4 iterations.
Total inertia (scaled Chi-square): NaN

                        DCA1   DCA2    DCA3    DCA4
Eigenvalues           0.9050 0.4170 0.21676 0.29630
Additive Eigenvalues  0.0000 0.0000 0.00000 0.00000
Decorana values       0.9062 0.2273 0.07314 0.03208
Axis lengths          3.1832 2.9114 0.89275 2.27379
```

Výsledky DCA pro druhová data 2011 převedená na prostý logaritmus:

```
Detrended correspondence analysis with 26 segments.
Rescaling of axes with 4 iterations.
Total inertia (scaled Chi-square): NaN

                        DCA1   DCA2     DCA3     DCA4
Eigenvalues           0.6123 0.4386 0.446259 0.440750
Additive Eigenvalues  0.0000 0.0000 0.000000 0.000000
Decorana values       0.6391 0.2357 0.005275 0.001209
Axis lengths          3.8018 2.3692 2.358356 2.359124
```

Výsledky CCA s druhovými daty převedenými na prostý logaritmus:

```
              Inertia Proportion Rank
Total           2.151      1.000
Constrained     2.151      1.000    7
Unconstrained   0.000      0.000    0
Inertia is scaled Chi-square
Some constraints or conditions were aliased because they were redundant
4 species (variables) deleted due to missingness

Eigenvalues for constrained axes:
  CCA1   CCA2   CCA3   CCA4   CCA5   CCA6   CCA7
0.6391 0.5222 0.4494 0.2806 0.1346 0.0738 0.0514
```

b. Rok 2011

Výsledky DCA pro neupravená druhová data 2011:

```
Detrended correspondence analysis with 26 segments.
Rescaling of axes with 4 iterations.
Total inertia (scaled Chi-square): 4.6641

                        DCA1   DCA2   DCA3    DCA4
Eigenvalues           0.9112 0.8868 0.7829 0.39268
Additive Eigenvalues  0.9112 0.8850 0.7643 0.37841
Decorana values       0.9222 0.3132 0.0761 0.03499
Axis lengths          4.8658 5.2922 2.9711 1.46935
```

Výsledky DCA pro druhová data 2011 převedená na prostý logaritmus:

```
Detrended correspondence analysis with 26 segments.
Rescaling of axes with 4 iterations.
Total inertia (scaled Chi-square): 2.3898

                        DCA1   DCA2     DCA3     DCA4
Eigenvalues           0.6520 0.4075 0.120658 0.171878
Additive Eigenvalues  0.6520 0.4075 0.115088 0.313466
Decorana values       0.6617 0.3754 0.008029 0.002069
Axis lengths          3.8213 2.3349 1.678003 1.658548
```

Výsledky CCA s druhovými daty převedenými na prostý logaritmus:

```
              Inertia Proportion Rank
Total            2.39       1.00
Constrained      2.39       1.00    7
Unconstrained    0.00       0.00    0
Inertia is scaled Chi-square
Some constraints or conditions were aliased because they were redundant

Eigenvalues for constrained axes:
  CCA1   CCA2   CCA3   CCA4   CCA5   CCA6   CCA7
0.6617 0.4946 0.4428 0.3239 0.2178 0.1672 0.0818
```

c. Rok 1988 a 2011 společně

Výsledky DCA pro neupravená společná druhová data 1988 a 2011:

```
Detrended correspondence analysis with 26 segments.
Rescaling of axes with 4 iterations.
Total inertia (scaled Chi-square): 5.0615

                        DCA1   DCA2   DCA3    DCA4
Eigenvalues           0.9020 0.8383 0.4996 0.35083
Additive Eigenvalues  0.9020 0.8381 0.3152 0.35640
Decorana values       0.9185 0.7836 0.1877 0.08813
Axis lengths          3.1585 3.9475 2.0188 2.07603
```

Výsledky DCA pro společná druhová data 1988 a 2011 převedená na prostý logaritmus:

```
Detrended correspondence analysis with 26 segments.
Rescaling of axes with 4 iterations.
Total inertia (scaled Chi-square): 2.3898

                        DCA1   DCA2     DCA3     DCA4
Eigenvalues           0.6520 0.4075 0.120658 0.171878
Additive Eigenvalues  0.6520 0.4075 0.115088 0.313466
Decorana values       0.6617 0.3754 0.008029 0.002069
Axis lengths          3.8213 2.3349 1.678003 1.658548
```

Výsledky CCA s druhovými daty převedenými na prostý logaritmus:

```
              Inertia Proportion Rank
Total          2.7479     1.0000
Constrained    1.7289     0.6292    7
Unconstrained  1.0190     0.3708    8
Inertia is scaled Chi-square
Some constraints or conditions were aliased because they were redundant

Eigenvalues for constrained axes:
  CCA1   CCA2   CCA3   CCA4   CCA5   CCA6   CCA7
0.5630 0.3881 0.3100 0.2185 0.1516 0.0558 0.0420

Eigenvalues for unconstrained axes:
   CA1    CA2    CA3    CA4    CA5    CA6    CA7    CA8
0.3389 0.2515 0.1473 0.1212 0.0652 0.0455 0.0353 0.0140
```