The Evaluation of Basal Respiration for Various Soil Textures in Ecologically Sensitive Area

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Abstract. The present contribution was focused on monitoring changes in the soil basal respiration in different textures of soil in the dry polder Beša. The research was conducted between 2012 and 2014 on soil type Fluvisol locations on three soil textures: clay–loam soil, clayey soil and clay soil in three soil depths. The basal respiration (BR) has been determined by soil CO₂ production measuring from incubated soil samples in serum bottles in laboratory condition. Release CO₂ has been analysed by gas chromatography. Content of clay particles were in the range 52.18 % to 81.31%, indicating the high difference between the minimum and maximum content. By using of multiple LSD-test we recorded statistically significant impact of clay on basal respiration. Results confirm the values of basal respiration with the depth of the soil profile decreased.

1. Introduction

Ecological stability of landscape area is dynamic ability of ecosystems permanently to Ecological stability of landscape is dynamics ability of ecosystems for permanent keeping and renovate of conditions of its existence by auto-regulation mechanisms [7]. Keeping of landscape ecological stability is basic and very important conditions for its permanent sustainable development and have long-time strategy importance for society development in this region. Ecologically stable are ecosystems near to climax stadium of vegetation, and ecosystems with very high portion of biota (mainly forests, natural meadows and pastures, water ecosystems).

The problem of flooding occurs in the country long ago. Floods of agricultural land are dangerous and harmful, especially if lasting longer. In this causes no only water and airy regime of soil are changed, but also structure and properties of soil.

In recent decades on the ESL floods are increasingly. It is in connection with course of meteorological conditions in spring months, but also with very high ability of heavy soils to keep water. In this context knowledge of changes of physical and hydro-physical soil properties by effect of flooding of soil surface is important. It is known that flooding of territory causes negative changes of soil properties and create un-favourable share between water and air in soil profile. Dry polders on the East-Slovakian Lowland (ESL) were constructed for retention of flood water in Medzibodrožie.
Area of dry polder Beša is landscape compound from various ecosystems (forests, natural meadows and pastures, water ecosystems, agro-ecosystems). For these ecosystems is typical high degree of biodiversity. Ecological stability of this area is in long and no-regularly time intervals disturbed by human activities, that by mechanical saturation of polders in time of extremely floods in region of ESL. The aim of the present study was to investigate the variability of release CO2 in selected soil types and different depths in the soil profile in an ecologically sensitive area, which is disrupted by irregular flooding.

2. Materials and methods
In years 2012 – 2014 investigation of spatial variability of soil profile was realised. The experimental site dry polder Beša was situated in central part of the East Slovak Lowland and has continental climate. The study area is the dominant soil type Fluvisols with gleyic subtypes. Smaller area covers Haplic Gleysols, Haplic Luvisols, Eutric Regosols. The soils in this area can be characterized as deep and heavy soils. Widespread types of soil are clayey soil and clay less represented are clay-loam and sandy-loam soil types.

For the determination of granulometric composition, we collected samples from each experimental profile. Soil samples were taken from three soil profiles to depth 0.0 – 0.6 m from each 0.2 m (with three replications). Sampling was realized in spring time (2012 – 2014). By pipette method, we determined grain size fractions as follows [8] 1st fraction – clay, <0.001 mm; 2nd fraction – medium and fine silt, 0.001 to 0.01 mm; 3rd fraction – coarse silt, 0.01 to 0.05 mm; 4th fraction – medium and fine sand, 0.05 to 0.25 mm; 5th fraction – coarse sand, 0.25 to 2.00 mm.

The basal respiration (BR) has been determine by soil CO2 production measuring from incubated soil samples in serum bottles for 24 h. 15 g of field moist soil samples have been weighed into each of three 120-ml serum bottles that were sealed with butyl rubber stoppers and incubated at 25 °C. After 3 and 24 h 0.5 ml sample of the internal atmosphere in each bottle has been analysed by gas chromatography (Agilent Technologies 7890A GC System equipped with a thermal conductivity detector).

Respiration has been calculated from the CO2 increase during the 21 h incubation period (24–3 h). At the end of measurements, the total headspace volume for each replicate bottle has been determined by measuring the volume of water required to fill the bottle. The measured CO2 amounts have been corrected for the gas solved in the liquid phase. The results are expressed per gram of dry soil and hour [4].

For total assessment of relations between the parameters and factors under, we used mathematical-statistical methods of package STATGRAPHICS. Obtained data were tested by statistical methods using LSD-multiple test at significant level α = 0.05.

3. Results and discussion
Content of clay particles in soil profile is important information about possibilities of use land in concrete area and also water storage. Polder Beša is no-regularly overflowing area and so on majority of lands the perennial grass stands are cultivated. From table 1 it becomes clear high variability of clay particles content (<0.01 mm), when for all depth the lowest content of clay particles (in average 56.29 %) was determined in profile 1st profile, higher content (in average 68.89 %) was in profile 2nd and the highest content (in average 77.05 %) was in profile 3rd.

The contents of clay particles varied in experimental years and individual depths of soil profile. Shown results (table 1.) confirmed high spatial – horizontal and vertical – heterogeneity of soils in this landscape area. By content of clay particles in experimental soil profiles, soil in 1st profile is clay-loamy soil, in 2nd profile it is clayey soil and 3rd soil profile is clay. These results are similar as published [5] and [2] for heavy soil on the East Slovak Lowland.
Table 1. The average content of 1. category grains [%] for investigated area.

| Depth [m] | Year | Profile 1st | 2nd  | 3rd  |
|-----------|------|-------------|------|------|
| 0.0–0.2   | 2012 | 53.03       | 66.35| 77.13|
|           | 2013 | 53.87       | 66.24| 67.58|
|           | 2014 | 52.18       | 65.01| 76.59|
|           | Y    | 53.03       | 65.87| 73.77|
|           | 2012 | 54.11       | 67.97| 78.13|
| 0.2–0.4   | 2013 | 61.11       | 67.50| 78.21|
|           | 2014 | 54.77       | 68.05| 76.05|
|           | Y    | 56.66       | 67.84| 77.46|
|           | 2012 | 54.59       | 68.94| 78.89|
| 0.4–0.6   | 2013 | 61.58       | 78.12| 81.31|
|           | 2014 | 61.33       | 71.88| 79.60|
|           | Y    | 59.17       | 72.98| 79.93|
| x profile |      | 56.29       | 68.89| 77.05|
| soil texture |          | clay-loamy soil | clayey soil | clay |

Soil respiration is considered to represent the overall microbial activity reflecting mineralisation of organic matter in soil. It is the most commonly used biological variable in soil studies. Accurate prediction of the amount of CO$_2$ respired by soil is of great importance in evaluating the carbon balance of ecosystems. The intensity of respiration depends on the amount and activity of soil microflora, the quantity and quality of the organic substrate, the chemical and physical properties of the soil [6].

The values of soil basal respiration were in the range 1.2–2.3 μg C-CO$_2$ g$^{-1}$ h$^{-1}$ on clay-loam soil, 0.8 – 4.2 μg C-CO$_2$ g$^{-1}$ h$^{-1}$ in clayey soil and 3.9 – 5.9 μg C-CO$_2$ g$^{-1}$ h$^{-1}$ on clay soil. The highest values of basal respiration we found on soil textures of clay and lowest values we found on soil textures of loamy clay (figure 1).

The each soil texture has diverse quantity of microorganisms and these have also various activity. These properties primary caused the variability of basal respiration. From this fact resulting different intensity of basal respiration for individual soil types.

![Figure 1. The average values of basal respiration of the investigated area.](image)

We know about basal respiration that its values are increased at increasing temperature. The basal respiration is influenced also by other factors, as are the soil moisture, storage and quality of nutrients in the soil, soil texture, soil aeration and used methods of soil management [1]. The amount of CO$_2$-release also depends on the depth of soil profile. [3] found that with soil depth the amount of released CO$_2$ significantly decrease. Our results, obtained from investigated area, were similar and confirmed these tendency. The course of basal respiration for three experimental soil profiles is shown on figures 2–4. Data obtained from dry polder Beša were tested by means of statistical methods. Analysis of variance and LSD-multiple test were used.
Figure 2. Basal respiration at different depth of clay-loamy soil (a: 0.0 – 0.2 m; b: 0.2 – 0.4 m; c: 0.4 – 0.6 m).

Figure 3. Basal respiration at different depth of clayey soil (a: 0.0 – 0.2 m; b: 0.2 – 0.4 m; c: 0.4 – 0.6 m).

Figure 4. Basal respiration at different depth of clay soil (a: 0.0 – 0.2 m; b: 0.2 – 0.4 m; c: 0.4 – 0.6 m).

Table 2. Analysis of variance for basal respiration of the service area.

| Source of variability | Degree of freedom | Calculated F-value | P significance |
|-----------------------|-------------------|--------------------|----------------|
| soil texture          | 2                 | 815.05             | ++             |
| Year                  | 2                 | 15.16              | ++             |
| Depth                 | 2                 | 54.38              | ++             |
| Duplicating           | 3                 | 0.09               | -              |
| Residual              | 98                | 96                 | -              |
| Total                 | 107               |                    |                |

++ P < 0.01  + P < 0.05

From table 2 it becomes clear statistically significant effect of soil textures, experimental year and depth on basal respiration. The strongest effect on basal respiration had soil texture, hence content of clay particles in soil profile. From testing of obtained data by using of multiple LSD-test resulted statistically significant impact of 3rd soil texture (clay) on amount of CO$_2$-release. Similarly, the basal respiration was statistically significant effected by year 2014 and depth of soil 0.0 – 0.2 m (table 3).
Table 3. Statistical evaluation of observed basal respiration values (α = 0.05).

| Source of variability | Factor     | Basal respiration [µg C-CO$_2$ g$^{-1}$ h$^{-1}$] |
|-----------------------|------------|-----------------------------------------------|
| soil texture          | 1$^{st}$   | 2.0333a                                        |
|                       | 2$^{nd}$   | 2.16a                                          |
|                       | 3$^{rd}$   | 4.8778b                                        |
| Year                  | 2012       | 2.8922a                                        |
|                       | 2013       | 2.9022a                                        |
|                       | 2014       | 3.2767b                                        |
| Depth                 | 0.0 – 0.2 m| 3.4589c                                        |
|                       | 0.2 – 0.4 m| 2.98b                                          |
|                       | 0.4 – 0.6 m| 2.6322a                                        |

Where: 1$^{st}$ – clay-loamy soil, 2$^{nd}$ – clayey soil, 3$^{rd}$ – clay, ascenders (a, b, c) between factors suggestive of statistically significant references (α = 0.05) – LSD test

4. Conclusion
Based on the research results for observed period 2012 – 2014, we came to the following conclusions:
During the research period, soil respiration of texturally-different soils showed considerable variability. The highest values of basal respiration we noticed on clay profile and the lowest in the clay-loamy soil. The differences between experimental soil profiles were statistically significant.
The differences of soil respiration values between experimental years weren’t statistically significant. The effect of year 2014, with higher sum of precipitation, was though remarkable.
The highest values of CO$_2$-release we noticed in the upper layers of the soil profile. In depth of profiles the basal respiration was decreased.

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References
[1] Jenkins M and Adams M A 2010 Vegetation type determines heterotrophic respiration in subalpine Australian ecosystems Global Change Biol. 16 pp 209–219
[2] Kotorová D, Soltysová B and Mati R 2010 Properties of Fluvisols on the East Slovak Lowland at their different tillage (Piešťany Agroecology Research Institute) p160
[3] Martin J G and Bolstad P V 2009 Variation of soil respiration at three spatial scales: Components within measurements, intra-site variation and patterns on the landscape Soil Biol. Biochem. 41 pp 530-543
[4] Šimek M, Virtanen S, Kristufek V, Simojoki A and Yli-Halla M 2011 Evidence of rich microbial communities in the subsoil of boreal acid sulphate soil conductive to greenhouse gas emissions Agric. Ecosyst. Environ. 140 pp 113-122
[5] Šútor J, Gomboš M, Mati R, Tall A and Ivančo J 2007 Water in the aeration zone of soils in the East Slovak Lowland. (Bratislava ÚH SAV, Michalovce Agroecology Research Institute) p 279
[6] Vanhala P, Tamminen P and Fritze H 2005 Relationship between basal soil respiration rate, tree stand and soil characteristics in boreal forests Environ. Monit. Assess. 101 pp 85-92
[7] Wall D H 2005 Biodiversity Encyclopedia of soils in the environment (Oxford Elsevier Academic Press) pp 136-141
[8] Zaujec A J, Chlpík J, Nádašský J, Szombathová N and Tobiašová E 2009 Pedology and base of geology. (Slovak University of Agriculture in Nitra) p 400