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DATA ON THE ELEMENTS OF CARBON CYCLE IN A SOLONETZ AND SOLONCHAK SOIL

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Introduction

Carbon, being the most important element for life is also a major component of soils. Since soil is the greatest sink of carbon, soil carbon content and its transformation are extremely important processes (Németh, 1996). CO_2 is the most important compound of carbon, basic material for buildup of organic matter, assimilation and final product of the disintegration of organic matter, i.e. dissimilation. Due to the importance of the atmospheric CO_2 concentration in controlling the so-called "greenhouse-effect" the knowledge of its concentration in soils is not only important for soil processes, but also has far-reaching consequences in global climate processes.

In the characterization of carbon balance we focused on two parameters, soil CO_2 concentration and soil surface CO_2 flux.

Additionally data on carbon stable isotopes in groundwater were also interpreted. Carbon stable isotopes are helpful in distinguishing sources of CO_2 in the soil. The isotopic compositions of the upper soil gas are similar to that of atmospheric values close to the surface and change to match those of biological sources with increasing depth. These changes in the isotopic composition are a function of the mixing with the atmospheric CO_2. Stable carbon isotope composition of the soil CO_2 affects the stable carbon isotope composition of the groundwater as well.

Our objective was to describe the elements of the carbon cycle in two native grasslands at two strictly protected salt-affected areas, Apaj and Zabszék.

Methods

Soil CO_2 concentration was measured when the flux measurements were made. A hollow stemmed rod with a perforated end was forced to different soil depths at 10 cm increments with a sliding hammer. Air was pumped from the rod to the LI-COR CO_2 analyzer. CO_2 concentration was measured in parts per million (ppm).

Soil CO_2 flux (or soil respiration) was measured with a box having its open-side-down placed securely onto the soil surface. The atmosphere inside the box was recirculated through the CO_2 analyzer, which was used to measure the accumulation of CO_2 as a function of time. The slope of the graph produced by the concentration accumulation as a function of time is *dx/dt*. Flux is calculated as

$$F=A^{-1}\ [\ (PV)/(RT)\ ]\ [dx/dt]$$

Where A is the footprint area of the box and P, V, and T are pressure, volume and temperature inside the box. Flux was expressed in units of grams per square meter per day ($g\ m^{-2}\ d^{-1}$).

Isotopic methods used are described by Tóth et al. 2001 and Fórizs et al. 2005.

The native vegetation at Apaj is a result of gradual drying and groundwater sinking. The official nomenclature of the present plant association is **Artemisio santonici–Festucetum pseudovinae Soó (1933) 1947 corr. Borhidi 1996** (Molnár and Borhidi, 2003). Its characteristics are described under the code of F1a by Molnár et al. (2003) and can be summarized as: a) Typical soil is Solonetz (Table 1), the soil is affected by shallow groundwater and surface waterlogging as well. b) There are no shrubs or trees among the grasses, neither tall grasses. c) They occur in an elevation zone between **Pannonic Puccinellia limosa hollow** (lower neighbor, same as the vegetation at Zabszék site) and slightly saline **Grassy saline puszta** or nonsaline **Pannonic loess steppic grasslands** (upper neighbor). At present the site is grazed by sheep.

The native vegetation at Zabszék is the result of continuous drying of the lake and the shifting of lake margin towards the bottom of the lake. The official nomenclature of the plant association is **Lepidio crassifolii–Puccinellietum limosae Soó 1947 - puccinellietosum**. Its characteristics are described under the code of F4 by Bagi and Molnár (2003) and can be summarized as: a) Typical soil is Solonchak (characteristic data in Table 1). A condition of its occurrence is shallow saline groundwater and repeated waterlogging, typical on the bank of saline lakes. The spring and late summer aspects might be very different. b) Physiognomy is determined by waterlogging. If there is no waterlogging the *Puccinellia limosa* is small, on wet places it grows high, forms tussocky patches. c) They occur in the neighborhood of saline lakes. d) Regenerative potential is very good. At present the only major grazing animals are wild geese at the site.

Results and discussion

Table 2 shows that evaporation caused moderate enrichment in ^{18}O of groundwater ($\delta^{18}O$ -8.27 to -8.58‰) compared to atmospheric precipitation (mean $\delta^{18}O$ is -9.1‰ [Deák J. 1995]). The $\delta^{13}C$ values of the dissolved inorganic carbonate (DIC) of groundwater differ at the two sites. There is an opportunity to explain the differences based on the Soil Organic Matter, and $CaCO_3$ and CO_2 content and flux (Fig 1.). We hypothesize that the $\delta^{13}C_{DIC}$ value of -14.1‰ at Apaj is more negative compared to the -10.1‰ value at Zabszék, because of the larger concentration of SOM ($\delta^{13}C$ value ca -26 $\delta^{13}C$) and of soil CO_2 (ca -23 $\delta^{13}C$), see Table 2. Also a contributing fact can be that the concentration of soil $CaCO_3$, a component rich in ^{13}C, is less (ca -5 to -10 $\delta^{13}C$) at Apaj than at Zabszék.

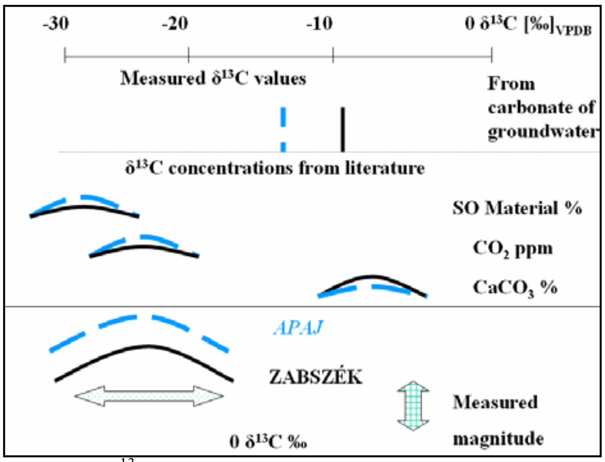

Figure 1. The measured $\delta^{13}C$ values of dissolved carbonate in the groundwater, and approximate $\delta^{13}C$ values and comparative magnitude (see Table 2) of Soil Organic Matter, and soil $CaCO_3$.

Table 1. Abiotic characteristics of the studied native grasslands

Site	Apaj	Zabszék
Coordinates Latitude	N 47° 05'14.0''	N 46° 50' 34.8''
Coordinates Longitude	E 19° 05' 54.7''	E 19° 10' 37.1''
Soil type	Solonetz	Solonchak
Soil clay % in 0-40 cm depth	30	34
Soil sand % in 0-40 cm depth	13	8
Soil $CaCO_3$ content-%	12	32
Exchangeable Na %	23	39
pH	8.3	8.5
Electrical conductivity of saturation extract - mS/cm	1.8	5.3

Table 2. Characteristic measured parameters of the two sites

	Groundwater parameters			Soil parameters			
Site	$\delta^{13}C$ of dissolved carbonate	$\delta^{18}O$ of groundwater	EC	$CaCO_3$ 0-100 cm	Soil organic matter	CO_2 flux	CO_2 conc.
Dimension	$[‰]_{VPDB}$	$[‰]_{VSMOW}$	mS/cm	%	%	mole/m^2/day	ppm
Apaj solonetz grassland	-14.1	-8.58	3.9	32	1.94	3-14	3570-3600
Apaj nonsaline cropland	-11.4	-8.27	2.8				
Zabszék solonchak grassland	-10.1	-8.4	3.1	41	0.77	0.14	3367
Zabszék non-saline cropland	-9.1	-8.41	3.1				

Conclusions

Carbon cycle at the studied salt-affected sites shows close relationship between vegetation (plant cover), soil composition and groundwater. The larger plant cover at Apaj resulted in greater soil CO_2 concentration and flux, and SOM. All these components are depleted in ^{13}C, therefore the $\delta^{13}C$ value of DIC at Apaj is significantly more negative than at Zabszék.

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References

Bagi, I. and Zs. Molnár. 2003. Habitat F4 in „Comparative survey and evaluation of the vegetation of Hungary" Working Group for data quality. Manual of habitats 2.0 Editors: Bölöni, J., A. Kun, and Zs. Molnár. Vácrátót. (in Hungarian)

Deák J. 1995. Determination of recharge of groundwaters in the Great Hungarian Plain by isotopic techniques. VITUKI Report, Budapest.

Fórizs, I., T. Berecz, Z. Molnár, and M. Süveges 2005. Origin of shallow groundwater of Csepel Island (south of Budapest, Hungary, Danube River): isotopic and chemical approach. Hydrological Processes (in press).
Molnár Zs. and A. Borhidi. 2003. Hungarian alkali vegetation: Origins, landscape history, syntaxonomy, conservation. Phytocoenologia 33:377-408
Molnár, Zs., I. Bagi, and G. Tímár. 2003. Habitat F1a in „Comparative survey and evaluation of the vegetation of Hungary" Working Group for data quality. Manual of habitats 2.0 Editors: Bölöni, J., A. Kun, and Zs. Molnár. Vácrátót. (in Hungarian)
Németh, T. 1996. Organic Matter and Nitrogen Content of Soils. RISSAC. Budapest. (in Hungarian).
Tóth, T., L. Kuti, I. Fórizs, S. Kabos. 2001.Change of soil salt concentration in the study site of "Nyírőlapos", Hortobágy. Agrokémia és Talajtan, 50:409-426.