Soil microbial respiration (CO_2) of natural and anthropogenically-transformed ecosystems in Moscow region, Russia

Kristina Ivashchenko [a, b], Nadezhda Ananyeva [a], Sofia Rogovaya [a], Vyacheslav Vasenev [b]

[a] Institute of Physicochemical and Biological Problems in Soil Science, RAS, Pushchino, Moscow region, Russia

[b] Institute of Agrotechnology, Peoples' Friendship University of Russia, Moscow, Russia

e-mail: ivashchenko-kv@rambler.ru

Introduction

The CO_2 concentration in modern atmosphere increases and one of the most reasons of it is land use changing. It is related not only with soil plowing, but also with growing urbanization and, thereby, forming the urban ecosystems. The soil CO_2 efflux mainly supplies by soil microorganisms respiration (contribution ~ 70%) and plant roots respiration. Soil microbial respiration (MR) is determined in the field (*in situ*) and laboratory (*in lab*) conditions. The measurement of soil MR *in situ* is labour-consuming, therefore it is difficult carried at the regional scale. We suggest to measure the MR of the upper highest active 10 cm mineral soil layer (*in lab*) followed by calculation of the CO_2 production for area of different ecosystems. *The aim of our investigation* is assess the portion of soil microbial CO_2 (biogenic) production of different land uses in the highly-urbanized region of Russia.

Approaches for microbial CO_2 production measurement

Lab

SOIL (2 g) + H_2O (0.2 mL) → 22ºC, 24 h thermostat

Microbial respiration (µg CO_2-C g^{-1} soil h^{-1})

Advantages

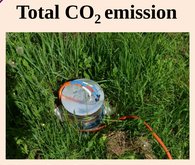
-easy to measure (less time and labour-consuming)
-analysis of huge number of samples

Limitations

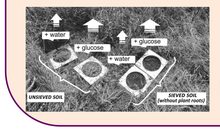
- standard hydrothermal soil condition (potential soil microbial respiration)

Field

Total CO_2 emission



Microbial CO_2 emission



g CO_2 m^{-2} d^{-1}

Advantages

-indicates the real processes in the soil (actual respiration)

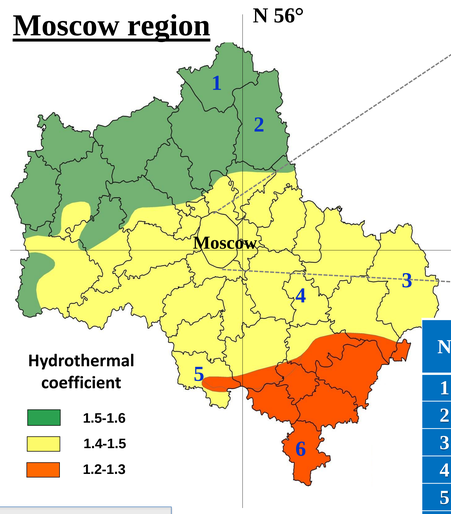
Limitations

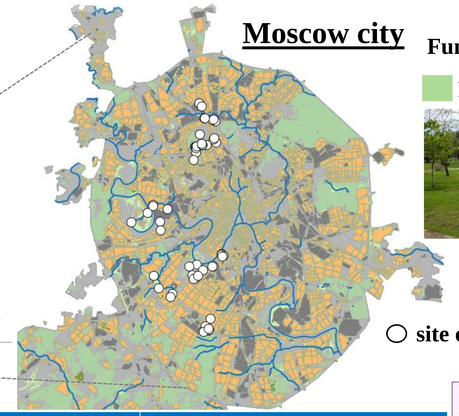
- more time and labour-consuming
-limited number of studied sites
- no standard technique for separation of plant root and microbial respiration

Reference

Ananyeva N.D., Rogovaya S.V., Ivashchenko K.V., Vasenev V.I., Sarzhanov D.A., Ryzhkov O.V., Kudeyarov V.N. Carbon dioxide emission and soil microbial respiration activity of Chernozems under anthropogenic transformation of terrestrial ecosystems // Eurasian Journal of Soil Science. 2016. V. 5. N 2. pp. 146-154.

Object of study and soil sampling





Functional zones (unsealed territories, km²)

Recreational (247.6)

Residential (201.9)

Industrial (42.0)

○ site of soil sampling

N	Administrative district of Moscow region	Ecosystems (Area, km²)			
		Forest	Meadow	Arable	Urban
1	Taldomskiy	766	108	ND*	147
2	Sergievo-Posadskiy	987	74	457	174
3	Shatursky	1283	90	213	53
4	Voskresenskiy	286	62	212	184
5	Serpukhovsky	512	46	296	34
6	Serebriano-Prudsky	ND*	107	581	16

*ND, no data

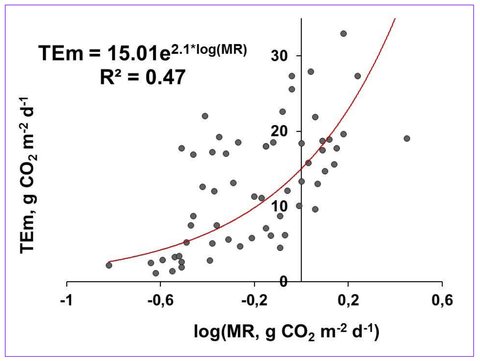
Soil sampling

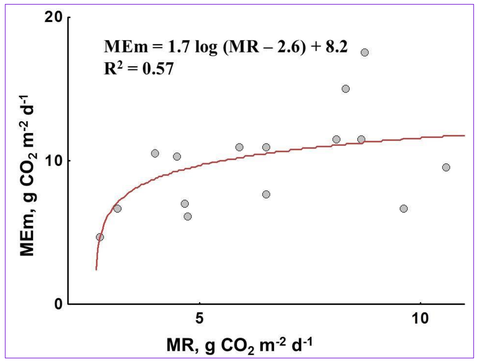
Spatially distributed plots (randomly)
Moscow region, 3-5 in each ecosystem (total 156)
Moscow, 14-20 in each functional zone (total 52)
✓ 10 cm upper layer (litter excluded)
✓ August - September
✓ Pre-incubation of soil samples (7 d, 22°C, 60% WHC)

CO_2 measuring *in situ* (Moscow)

✓ Recreational and industrial zones in 5 spatial replicas at each plot in August and October (Li-820 infrared gas analyzer)

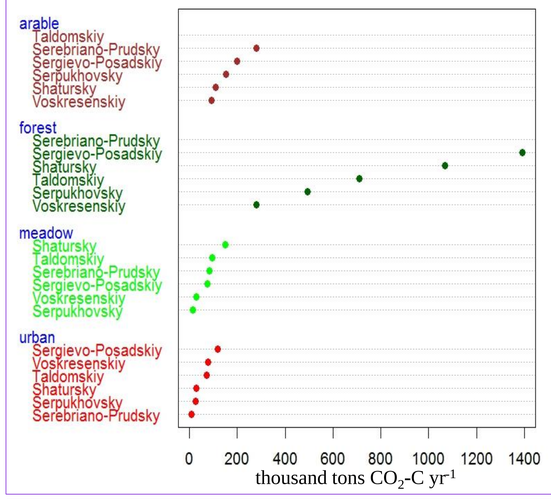
***Relationship** between soil microbial respiration (MR, in lab) and soil total (TEm) or microbial CO_2 emission (MEm) (in situ) (see details Ananyeva et al., 2016)*





Moscow region ⟵ *Results* ⟶ Moscow city

Soil microbial respiration (0-10 cm) for area of different ecosystems in studied administrative districts of Moscow region



Soil CO_2 emission and microbial respiration (0-10 cm) in recreational (forest park) and industrial (near highway) zones. The values with different letters significantly ($p < 0.05$) differ for each localization separately, t-test

Zone	Total emission (*in situ*), g CO_2 m^{-2} d^{-1}	Microbial respiration, MR (*in lab*)	
		µg CO_2-C g^{-1} h^{-1}	g CO_2 m^{-2} d^{-1}
01.08.2014 (n=5 for each site)			
Recreational	11.9 ± 3.3 *b*	0.7 ± 0.3 *a*	6.4 ± 2.6 *a*
Industrial	28.6 ± 5.8 *a*	0.6 ± 0.1 *a*	4.8 ± 1.1 *a*
29.10.2014 (n=5 for each site)			
Recreational	7.3 ± 4.1 *a*	0.5 ± 0.3 *a*	4.4 ± 2.4 *a*
Industrial	10.7 ± 3.7 *a*	0.5 ± 0.2 *a*	4.0 ± 1.8 *a*

MR (in lab) < Total CO_2 emission (in situ) (in average 2 times)

MR, CO_2 ton d^{-1} (S, km^2 × MR)

Soil MR in Moscow

~1042 thousand tons CO_2-C yr^{-1}

Conclusion. **The approach allows us to compare soil MR (main biogenic CO_2 source) of different ecosystems (Moscow region) and functional zones (Moscow city). The urban soils might be significant source of CO_2, therefore they should be taken into account for calculation of carbon cycle balance and basically at regional level. It might be useful for assessment of soil microbial CO_2 efflux, soil ecological monitoring and prediction of soil CO_2 efflux within wide range of ecosystems. Soil MR in Moscow city exceeds the anthropogenic CO_2 emission (transport) in average by 18 times.**