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Soil microbial biomass and functional diversity in urban forest parks and suburban forests of various biomes in European Russia

Nadezhda Ananyeva[1], Ruslan Khatit[1], Sofia Sushko[1,2,3], Anna Buyvolova[4], Andrey Dolgikh[5], Anna Zhuravleva[1], Alexandra Selezneva[1], Viacheslav Vasenev[2], and **Kristina Ivashchenko**[1,2]

[1]Institute of Physicochemical and Biological Problems in Soil Science, RAS, Pushchino, Moscow region, Russia (ananyeva@rambler.ru)

[2]Department of Landscape Design and Sustainable Ecosystems, Agrarian-Technological Institute, Peoples' Friendship University of Russia, Moscow, Russia

[3]Agrophysical Research Institute, Saint- Petersburg, Russia

[4]Lomonosov Moscow State University, Moscow, Russia

[5]Institute of Geography, Moscow, Russia

Forest parks play an important role in the sustainable functioning of urban ecosystems. In contrast to natural forests, urban forests are under continuous anthropogenic pressure, affecting the soil microbial community functioning and its capacity to provide many ecosystem services. Moreover, another significant factor determining such functioning is bioclimatic conditions, i.e., city geographic location. Our study aims to examine the effect of urbanization on soil microbial biomass and functional diversity along a latitudinal gradient of European Russia. Urban forest parks (UFP) were chosen in Moscow, Tula, and Belgorod cities located in mixed coniferous-broadleaved forests, deciduous forests, and forest-steppe biomes of European Russia, respectively (17 sites). Outside of the cities the reference suburban forests (SUF) were selected (12 sites). When selecting sites, we considered the following criteria: i) same soil reference group within the biome (Retisols, Luvisols, Phaeozems in mixed coniferous-broadleaved forests, deciduous forests, and forest-steppe, respectively), ii) loam parent materials, and iii) forest aged ≥60 years. In each UFP and SUF, five spatially distributed plots were chosen, in which soil samples were taken from the upper 10 cm layer without litter (totally 85 and 60 for UFP and SUF). For freshly collected soil samples, microbial biomass carbon content (MBC, substrate-induced respiration method) and basal respiration (BR; rate of CO_2 release) were measured, then the ratio BR / MBC = qCO_2 was calculated. The community level physiological profile of soil microorganisms (CLPP, MicroResp^{TM} technique) indicating the microbial ability to utilize different organic substrates (carbohydrates, acids: amino, carboxylic, phenolic, 14 totally) was tested. CLPP data were used to calculate the Shannon–Wiener diversity index (H_{CLPP}).

It was found that soil BR decreased on average from SUF to USP in all studied biomes, while the MBC content did not change significantly. A significant increase of MBC in USP and SUF soils was observed from north to south (from mixed coniferous-broadleaved forests to forest-steppe), and for qCO_2 – decreasing. The CLPP of the studied soils were dominated by microorganisms consuming carboxylic acids (ascorbic and citric) and carbohydrates (glucose, fructose, galactose).

Cluster analysis identified two groups that differed by soil CLPP: i) mixed coniferous-broadleaved forests and deciduous forests (Moscow, Tula) and ii) forest-steppe (Belgorod). Soil H_{CLPP} index didn't significantly differ between SUF and UFP in all studied biomes. Two-way ANOVA showed that soil MBC, qCO_2, and H_{CLPP} changes were more associated with bioclimatic conditions (18-47% of explained variance, $P < 0.05$) than urbanization ($P > 0.05$). On contrary, soil BR was more sensitive to urbanization (4% of explained variance, $P < 0.05$) than to the change of bioclimatic conditions ($P > 0.05$). Notably, driving factors of spatial variation for the studied soil microbial properties within each city (53-92% unexplained variance) have yet to be identified.

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