Composition of woody plant litter in urbanized plant communities

Oxana Tsandekova*

The Federal Research Center of Coal and Coal Chemistry of SB RAS, 10, Leningradsky Prospekt, Kemerovo, 650065, Russia

Abstract. The article presents the analysis results of the litter composition of woody plants growing in urbanized plant communities. The research object was plant litter sampled under the canopy of such woody plants as *Acer negundo* L., *Betula pendula* Roth, *Padus avium* Mill. We determined the phytomass reserve and the level of nitrogen and phosphorus content in the litter of these tree species. The *A. negundo* litter had the most intense mineralization due to higher phytomass, nitrogen, and phosphorus accumulation in comparison with trees of the other species. The woody plants under study can be arranged in the following order as the analyzed indicators decrease: boxelder maple > bird cherry > silver birch. The experimental data can be used for biomonitoring studies of natural communities.

1 Introduction

Plant litter serves as the main source of nutrients for plants. Its formation and decomposition depend on the stand structure, species composition, and forest growth conditions. A significant amount of litter is formed annually under the crowns of woody plants. With this litter, chemical compounds return to the soil [1–3]. At the initial period of litter destruction, easily soluble organic compounds decompose. Their high content promotes rapid plant litter mineralization [4–6]. During the growing season, a significant part of the nitrogen and phosphorus accumulated by plants in their phytomass returns to the soil with litter [7, 8]. Leaf litter rich in nitrogen and phosphorus can quickly decompose [9, 10]. Despite the existence of ideas about the environmental factors that determine the content of chemical compounds in plants, the issue of their variability in the litter of woody plants in urbanized areas remains unclear.

The study aims to analyze the composition of woody plant litter in urbanized phytocenoses.

* Corresponding author: zandekova@bk.ru

2 Materials and Methods

The object of research was plant litter collected under the canopy of such woody plants as boxelder maple (*Acer negundo* L.), silver birch (*Betula pendula* Roth), and bird cherry (*Padus avium* Mill.) growing in the urbanized areas of Kemerovo. The quadrats were located within the projection of tree species crowns; the control sites were plots located outside the projection of tree crowns. The stands were assigned to the first category of life state according to V. A. Alekseyev's scale. The model trees were 25–30 years old. The living ground cover on the sample plots is formed by a mixed forb-gramineous community dominated by *Urtica dioica* L., *Elytrigia repens* (L.) Nevski., *Humulus lupulus* L., with a total projective cover of 20–90%.

Samples were collected in May, July, and September 2022–2023. The growing season was characterized by sharp hydrothermal differences. Very warm weather with minimal precipitation prevailed in May. The average monthly air temperature was +14–+16 °C, which is 4–5 °C above normal. Precipitation amounted to 11–17 mm (47% of the norm). Unstable weather with sharp temperature fluctuations and heavy precipitation was observed in July and September. The average monthly air temperature was 1–2 °C below normal, and precipitation was 92–174% of the norm.

Woody plant litter samples were collected using a 30x60 cm frame and transported to the laboratory. The litter was dried to an air-dry state in a laboratory setting. After that, we weighed and determined absolutely dry phytomass, as well as nitrogen and phosphorus from one weighed sample after wet ashing. Nitrogen was determined by the Kjeldahl method, phosphorus – according to the Murphy-Riley method [11]. The samples were analyzed in three replications. The data are presented as arithmetic mean values and their standard errors. The statistical processing of the obtained data and graph plotting were performed using the standard software package StatSoft STATISTICA 8.0. for Windows and Microsoft Office Excel 2007.

3 Results and Discussion

Horizontal differentiation of the plant cover was observed under the canopy of the studied woody plants within the quadrats. The total projective cover in the forest stands was 30–90% with the dominance of *Urtica dioica* L., *Poa pratensis* L., *Elytrigia repens* (L.) Nevski., *Humulus lupulus* L., *Phleum pratense* L. Most plants belonged to meadow species. Their share amounted to about 30–50%. The phytomass reserve under the tree canopy varied on average from 3.1 to 5.1 t/ha of air-dry mass. In terms of phytomass, the experimental samples were inferior to the control ones by an average of 1.1–1.6 times. In the forest floor composition, the upper layer plant residues accounted for up to 40% of the total forest floor mass. The predominant forest floor (FF) layer in the tree stands was the fermentation layer which consisted of incompletely decomposed, morphologically identifiable plant residues. Its share was 52% of the FF mass. The almost completely decomposed mass of plant residues of the humification layer did not exceed 8% of the total FF reserve on all plots under study. A distinctive characteristic of the plant litter on the plot with boxelder maple was a high level of its phytomass, which was 1.2–1.5 times higher than that of the other tree species.

In the process of leaf senescence and plant litter formation, nitrogen- and phosphorus-containing compounds are reutilized by the plant. The content of nitrogen and phosphorus in the litter is higher at the end of the growing season than at the initial growth stages. Our data showed that the amount of nitrogen in the litter of the analyzed samples exceeded the amount of phosphorus during the growing season. It averaged 2.2–2.4%, which is 1–1.2 times lower than in the control samples. We determined that the nitrogen concentration level decreased in the middle of the growing season (up to 1.4%) in the samples under study, and at the end of the growing season it increased (up to 2.7%). On all plots, an autumn maximum of nitrogen accumulation was observed due to the supply of fresh plant litter. The experimental samples in the quadrats showed the highest levels of nitrogen content in September (2.4–2.6%). The nature of phosphorus concentration changes in the litter varied across the quadrats. Thus, in May and September, tree samples showed a substantial increase in phosphorus levels from 0.14 to 0.27%, while in July there was a decrease to 0.11% compared to the control samples. The reason may be that plants have a high growth rate at the beginning of the growing season and, therefore, need to consume large amounts of nitrogen and phosphorus, while the soil cannot provide enough plant nutrients. Increased nutrient demand causes a decrease in the nitrogen and phosphorus content of mature leaves, which leads to a decrease in nitrogen and phosphorus nutrients in the litter. Towards the end of the growing season, tree growth rate slows down resulting in lower nutrient demand, which leads to nitrogen and phosphorus accumulation in the litter. In the quadrats, the nitrogen and phosphorus reserves in the litter decreased from less to more productive stands due to their phytomass decrease. The greatest amount of nitrogen and phosphorus was observed in the litter of boxelder maple compared to the other tree species.

Thus, the composition of woody plant litter in urbanized phytocenoses depends on their species. The litter of *A. negundo* had the most intense mineralization due to a higher accumulation of phytomass, nitrogen, and phosphorus in comparison with trees of the other species. The woody plants under study can be arranged in the following order as the analyzed indicators decrease: boxelder maple > bird cherry > silver birch. The data obtained can be used for biomonitoring studies of natural communities.

Acknowledgments. The work was carried out within the framework of state task No. 0286-2024-0022 of The Federal Research Center of Coal and Coal Chemistry of SB RAS.

References

1. A. M. Grodzinsky, Allelopathy in the life of plants and their communities: Fundamentals of chemical interaction of plants (Naukova Dumka, Kiev, 1965)
2. A. A. Ovcharenko, A. M. Kuzmichev, The role of biologically active secretions of woody plants in the formation of the ecological environment of phytocenoses of the middle Prikhopery region. Bulletin of Tambov State University. **18**, 3 (2013).
3. M. E. Lucas-Borja, J. Hedo de Santiago, Y. Yang, Y. Shen, D. Candel-Pérez, Nutrient, metal contents and microbiological properties oflitter and soil along a tree age gradient in Mediterraneanforest ecosystems. Science of the Total Environment. **650** (2019). https://doi.org/10.1016/j.scitotenv.2018.09.079
4. L. Vesterdal, I. K. Schmidt, I. Callesen, L. O. Nilsson, P. Gundersen, Carbon and nitrogen in forest floor and mineral soil under six common European tree species. Forest Ecology and Management. **255** (2008). https://doi.org/10.1016/j.foreco.2007.08.015
5. Ch. Walela, H. Daniel, B. Wilson, P. Lockwood, A. Cowie, S. Harden, The initial lignin:nitrogen ratio of litter from above and below ground sources strongly and negatively influenced decay rates of slowly decomposing litter carbon pools. Soil Biology and Biochemistry. **77** (2014). https://doi.org/10.1016/j.soilbio.2014.06.013
6. K. Husmann, S. Rumpf, J. Nagel, Biomass functions and nutrient contents of European beech, oak, sycamore maple and ash and their meaning for the biomass supply chain.

Journal of Cleaner Production. **172** (2018). https://doi.org/10.1016/j.jclepro.2017.03.019

7. N. C. Tashe, M. G. Schmidt, The impact of vine maple on site fertility of coastal temperate forests. Forest Ecology and Management. **147**, 2 (2001). https://doi.org/ 10.1016/S0378-1127(00)00468-0
8. G. L. Vourlitis, O. B. Pinto, H. J. Dalmagro, P. E. Zanella, F. A. Lobo, Nitrogen and phosphorus pools and fluxes in upland and seasonally flooded forests and woodlands of the Cerrado-Pantanal transition of Brazil. Trees, Forests and People. **12** (2023). https://doi.org/ 10.1016/j.tfp.2023.100383
9. O. Polyakova, N. Billor, Impact of deciduous tree species on litterfall quality, decomposition rates and nutrient circulation in pine stands. Forest Ecology and Management. **253**, 1 (2007). https://doi.org/10.1016/j.foreco.2007.06.049
10. W. Han, J. Fang, D. Guo, Y. Zhang, Leaf nitrogen and phosphorus stoichiometry across 753 terrestrial plant species in China. New Phytologist. **168**, 2 (2005). https://doi.org/ 10.1111/j.1469-8137.2005.01530.x
11. Practicum course in agrochemistry / Edited by V. G. Mineyev (MSU, Moscow, 2001)