RESEARCH ARTICLE

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Chemical composition of a dead wood biomass in beech communities

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ABSTRACT

Dead plant biomass provides and returns different chemical elements to the cycle of nutrients. Information about the dynamics of the elements of mineral nutrition is used as an explanation of possible stress in forest ecosystems and establishing the requirements of plant species to environmental conditions. Recently dead wood biomass is seen as essential depot and carbon pool. The beech forests are among the most common forests in Bulgaria. They have great economic and environmental importance for the country and for this reason were chosen for the subject of this study. The content of macronutrients: Ca, K, C, N, P, Mg, Zn in different fractions of dead wood biomass (standing and logs) were determined. Following order of elements was established: C, N, Ca, K, Mg, P, Zn. The data obtained showed that Ca and K from metals were presented in the highest concentrations.

Key words: chemical elements, dead wood biomass, beech stands

Introduction

The dead trees play an important role in the functioning and the productivity of the forests ecosystems through influence over biological diversity, the accumulation of carbon dioxide, nutrient turnover and energy flux, hydrological processes, protection of the soils and regeneration of the tree species. The dead wood assures important habitats for invertebrates species, for small vertebrate species, fishes, birds as well as many lichen, mosses and fungi species (Dudley & Vallauri, 2004).

Dead wood plays an important role in the functioning of river ecosystems as well, by supporting the retention of water and sediments; retain and facilitate the distribution of organic matter to feed aquatic invertebrates, creates heterogeneity in water flows by forming pools, cliffs and rapids and improves the structure of the habitats of fish, amphibians and other aquatic organisms (Lazarov et al., 2012).

Dead wood passes through several stages of decomposition – population, decay and transformation into humus, that take from 30 to 50 years depending on the tree species. Sometimes this period may be extended significantly, for example in areas with colder climates (Dudley & Vallauri, 2004). Other authors pointed as key stages of decomposition of dead biomass, incl. wood – fragmentation, humification and slow mineralization of humus and humus-like substances. The first stage involved mezofauna organisms, including a great number of small organisms – protozoans, soil mites, collembolans, nematodes poliheti, insect larvae and many others (Lyubenova, 2009). Their importance is exclusively for increasing the active surface of detritus, deposit of substances that stimulate the development of bacterial and fungal populations (real destructors). On a scale of Bazilevich these phases take place within 1.6 to 20 years, with 50 years in the tundra (Lyubenova, 2009).

In historical aspect for many years, the dead wood was removed from the stands as measure for protection against insects and fungi, which are perceived as threat for the healthy forest status. This leads to reduction of the quantity of the dead wood in the forest ecosystems to critical low levels which are not enough for maintaining vital populations of many forest species. The protection of these species and forest habitats became a priority and require a new perception of the meaning of the dead wood with establishment of the European ecological network Natura 2000.

Many writers focus their attention on dead biomass. It is seen as essential depot biomass and carbon pool (Arthur & Fahey, 1992; Bradford et al., 2009; Domke et al., 2011) that need to be considered in inventories and evaluated under the Framework Convention for climate change. Kueppers et al. (2004) studied the dead wood biomass and the rate of decay in altitude and gradient suggest that global warming will lead to loss of carbon included in the dead wood of subalpine forests. According Oswalt & Brandeis (2008) dead wood is also an important share of the total biomass and as such should be considered when assessing carbon stocks.

Dead plant biomass provides and returns different chemical elements to the cycle of nutrients. Information about the dynamics of the elements of mineral nutrition is used as an explanation of possible stress in forest ecosystems and establishing the requirements of plant species to environmental conditions (Mihov, 1979; Markert, 1993; Schulze et al., 2005). The content of macro- and microelements in different fractions phytomass is the subject of various studies at home and abroad (Marschner, 1995; Lyubenova et al., 1998; 2000, Ivanova et al., 2014). Some authors studied mostly content of chemical elements in a litter, as a dynamic fraction (Lyubenova & Dimitrova, 2011). Subject of discussion are tree species such as common beech (*Fagus sylvatica* L.) (Damyanova et al., 2014), plain chestnut (*Castanea sativa* Mill.) (Bengt, 1972; Dimitrova et al., 2009), *Pinus sylvestris* L. (Mihov, 1979), Norway spruce (Velizarova, 2006) and willow (Dimitrova, 2014). Other studies focus not only on the chemical composition of the wood, but other factions, such as leaves, twigs, flowers, fruits, and in rare cases and roots (Dimitrova et al., 2014). Part of publishing makes the connection between the content of the studied elements in plant factions and the elements in the soil by the coefficient of biological absorption or bioaccumulation. Mainly those elements are C, N, P, K, Ca, and from microelements – Pb, Zn, Mn, Fe, Cu. Inorganic elements are tested very often as a component of ashes remaining after burning wood (Obernberger, 1998; Vassilev et al., 2010). Overall, the number of publications related to the elemental composition of a dead biomass and its role as their natural reservoir ecosystem is negligible.

Beech forests are among the most common forests in Bulgaria. They have great economic and environmental importance for the country and for this reason have been chosen for the subject of this study.

The purpose of the study was to investigate the dead forest biomass as a depot of chemical elements.

Materials and Methods

Objectives

The present investigation was carried out at Western Balkan Mountain. Four sample plots varying in an altitude, age and ratio between live and dead wood were chosen. *Fagus sylvatica* L. was a study wood species as the common one at the region. Characteristics of the sample plots are given in Table 1.

Methods for chemical analysis

Mean samples of standing dead biomass and logs were grinded, homogenized and dried at 105ºC to determine

Table 1. *Characteristics of sample plots.*

Sample plots	Altitude, m	Age, year	Canopy	Height, m
SP 1	700	150	0.4	29
SP 2	900	35	0.9	10
SP 3	1050	160	0.6	29
SP 4	1500	130	0.8	27

following chemical elements: Ca, K, C, N, P and micro elements: Mg, Zn.

Determination of organic carbon: oxidative decomposition of the samples with a mixture of concentrated sulfuric acid and potassium dichromate and subsequent titration.

Determination of nitrogen: method of Keldal – automatic distillation and subsequent titration using automatic Keltek-Tectator device.

Determination of phosphor and metals: samples were wet digested with a mixer of concentrated nitric acid and hydrogen peroxide in microwave oven at different irradiation modes. The elements were measured using emission optical spectroscopy in inductively coupled plasma (ICP - OES).

Results and Discussion

The dead biomass in the investigated sample plots varied between 3 and 8% approximately (Table 2). The higher amount is presented in the youngest and oldest beech stands. The lowest and highest situated sites have similar ratio between dead and live wood.

Table 2. *Percentage ratio between dead and live wood at sample plots.*

Sample plots / Type of biomass (%)	SP 1	SP 2	SP 3	SP 4
Standing dead wood	3.2	7.7	6	3.5
Standing live wood	96.8	92.3	94	96.5

The results of chemical analysis of samples of a dead standing wood and logs are presented in Table 3. Data obtained for organic carbon content were very close in their values for standing wood and logs at the same plots and amongst all investigated plots as well. They varied between 37.5 and 43.5% as the lowest values are determined for both standing wood and logs at site situated at highest altitude. Those results were expected because of the fact that the common carbon content in a live wood is about 50% and can reach higher values in roots (Dimitrova et al., 2014) and by the other hand, the decomposition processes are needed more than 20 – 30 years (Dudley & Vallauri, 2004; Lyubenova, 2009).

The chemical element nitrogen in a dead wood showed a tendency to twice greater content in logs than the content in standing biomass for all study plots. Values varied from 0.17 to 0.52%, which was very close to results reported for N-content in young beech trees for the same region of Western Balkan Mountain (Damyanova et al., 2014).

Phosphor content showed twice greater amount in logs than the one in standing biomass such as nitrogen, nevertheless the results for sample plot 2 contained young trees, were very close for logs and standing wood. There were an exception for sample plot 4, where relationship was vice versa.

Table 3. *Chemical elements in a dead standing wood and logs at sample plots in 2016 year.*

Sample plots	Chemical elements						
	C, %	N, %	P, $mg.kg^{-1}$	Ca, $mg.kg^{-1}$	K, $mg.kg^{-1}$	Mg, $mg.kg^{-1}$	Zn, $mg.kg^{-1}$
SP 1 standing wood	42.37	0.17	202	1986	9145	426	7.4
SP 1 logs	43.57	0.45	593	3387	3947	744	29.4
SP 2 standing wood	38.97	0.22	248	7514	722	519	42.1
SP 2 logs	42.75	0.40	273	11206	550	981	14.1
SP 3 standing wood	41.57	0.20	142	4359	2337	482	11.0
SP 3 logs	41.87	0.42	276	5354	1645	830	29.4
SP 4 standing wood	37.49	0.30	619	13995	2554	795	93.9
SP 4 logs	38.63	0.52	419	4991	770	535	44.8

The ecosystem biogenic migration is determined by two leading elements that run a nutrient turnover and supporting elements taking part in accumulation of biomass. Comparing the ratio of the different chemical elements in a dead wood it could be concluded that Ca and K from metals were presented in the highest concentrations. This is common chemical metabolism for broadleaved wood (Lyubenova, 2009). The chemical element Ca is a main structural metal for cells and one of component determining their strength. Its content commonly is higher in young trees than oldest (Velizarova, 2006). The variation of Ca amount is very large but for 3 of the study sample plots was found higher content in logs than standing dead wood (Table 3). Exception was detected for the highest situated site. Probably it is due to low mobility of that element.

K is one of the most mobile chemical elements both in plants and in the soil. Probably that was an explanation of finding that its content in the standing biomass was higher than one in logs for all study sample plots. It was found an increase amount of K in dead wood with age increase. For 3 of study plots were found tendency for higher Ca content than K one with exception for the lowest situated sample plot 1, where relation was vice versa. Data for content of the both elements in fine roots (< 1 cm) of different trees' species (Dimitrova et al., 2014) have shown twice higher amount of Ca than K for deciduous trees.

Exchangeable chemical element Mg and Ca showed a similar behaviour. The content of Mg in a standing dead wood was higher than one in logs with exception for the highest situated sample plot 4. Those data are similar to values reported for roots (Dimitrova et al., 2014) but higher than those reported for live young beech trees (Damyanova et al., 2014).

Element Zn is an essential for organisms as a cofactor for main enzyme complexes and at the same time toxic in high concentration. It was found the highest content (several times) for sample plot 4 at 1500 a.s.l. and lowest content for the lowest situated plot. Zn amount were higher in a standing wood than logs for 2 of study sites and the opposite tendency were determined for another 2 sites.

Conclussions

The research determined following content of analysed chemical elements in a dead wood biomass: C, Ca, N, K, Mg, P, Zn. The data obtained for organic carbon content varied between 37.5 and 43.5%, as the lowest values were found for both standing wood and logs at site situated at highest altitude.

Ca and K from metals were presented in the highest concentrations. It was found a higher K content in standing wood than logs. Elements Ca and Mg showed similar distribution an opposite behaviour – higher content in logs than in standing wood. No tendency was found for essential element Zn but its concentration was highest for the highest sample plot.

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