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Influence of the environmental pollution on the chemical composition of bark and wood of trunk, branches and main roots of birch (*Betula pendula* Roth.)

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Abstract: *Influence of the environmental pollution on the chemical composition of bark and wood of trunk, branches and main roots of birch (Betula pendula* Roth.*).* Contents of extractives, mineral substances, cellulose, 1% NaOH soluble substances and lignin were examined. Analysis were made for wood and bark of trunk (butt-end, half-height, three-quarters of height and top part in pith adjacent and perimeter adjacent sections) as well as for the main roots and branches (wood and bark). Samples were gained from about 45-years old birch (*Betula pendula* Roth.) which was grown in Mazovia-Podlasie region in the range of 21 km from "Kozienice" heat and power plant. There was stated the influence of the environmental pollution on the distribution of extractives in wood and bark along the stem centre line and mineral substances on cross-sections of the stem. Environmental pollution influences also the distribution of 1%NaOH soluble substances on trunk cross-sections and along the stem, as well as distribution of lignin on the cross-sections and its content in bark.

Keywords: birch, extractives, mineral substances, cellulose, 1% NaOH soluble substances, lignin

INTRODUCTION

Birch is an important species from the early primary and secondary succession. This is the pioneer species which grows fast and easy adapt to settle former agrarian and former industrial soils. Its requirements for climate and soil wealth is the leas among other species. Birch is acknowledged as the species natural resistant for industrial emissions acting.

Substances which, being present in the air, may harmfully act for animals and plants are classified as air pollutants. These are dusts, soots, liquids in the shape of vapour and gases.

Harmfully acting of dusts is dependent on fall volume, pulverization degree, chemical composition and water solubility. Dust acting result is more dangerous as the pulverization degree increases. Large quantity of falling dusts influences the soil pH and inhibits nutrients collecting by trees (especially nitrogen, potassium and microelements, Kopcewicz et al., 1998).

Kozienicki district is the one which participation in dust emission to the atmosphere is the highest in Mazowieckie province. Heat and power plant "Kozienice" is located there. It introduces to the atmosphere 23% of dusts pollutants and 36% of gas pollutants (nitrogen oxides, sulphur (IV) oxide, carbon (II) oxide. It is the highest volume in relation to other districts of Mazowieckie province. However, constant decrease of dusts and gases emission must be emphasized.

The aim of this paper is to analyze the influence of environmental pollution on the chemical composition of wood and bark of birch (*Betula pendula* Roth.) depending on the sample location on cross-sections of different trunk heights, as well as in the wood and bark of main roots and branches.

MATERIALS AND METHODS

Samples were gained from cca. 45-years old trunk of birch which were grown in Swierże Górne forest district in Mazovia-Podlasie region, in the range of 21 km from heat and power plant “Kozienice”. Disks of about 200 mm height were cut from the butt-end, half height, three-quarters and top part of the stem. Samples of bark and wood from outer-, middle- and pith adjacent wood were collected. Main roots and branches were also sampled.

Wood samples were gained using drill, disintegrated in laboratory mill and sieved. Sawdust with cca. 0.5 mm diameter was used for most of analyses, only mineral substance content was examined in dusty fraction.

Bark samples were first disintegrated using wood chisel, then with laboratory mill and finally sieved. Most of analyses were performed on the fraction with diameter of cca. 0.5 mm, only the mineral substances content was examined in dusty fraction.

Extractives content was determined in Soxhlet apparatus, using ethanol-toluene mixture (1:1v) (Krutul 2002). Mineral substances content in samples with known humidity was analyzed using muffle oven in 600˚C, until the constant mass was reached (Kačik & Solar, 1999). Kürschner-Hoffer method was used for cellulose content analysis, PN-74/P50092 standard was applied to determine lignin content, 1% NaOH soluble substances were also examined (Krutul 2002). The results were calculated in relation to sawdust dry mass.

RESULTS AND DISCUSSION

Extractives content on the cross-sections of birch wood decreases in direction from pith to perimeter, apart from the stem height. It is presented in the Fig. 1. This content in pith adjacent wood is higher than in outer wood. It is 10% higher in the butt-end section, 45% higher in the half-height, 35% in three-quarters height and 25% in the top part of the stem. Wood of main roots and branches contains similar to pith adjacent wood amount of extractives.

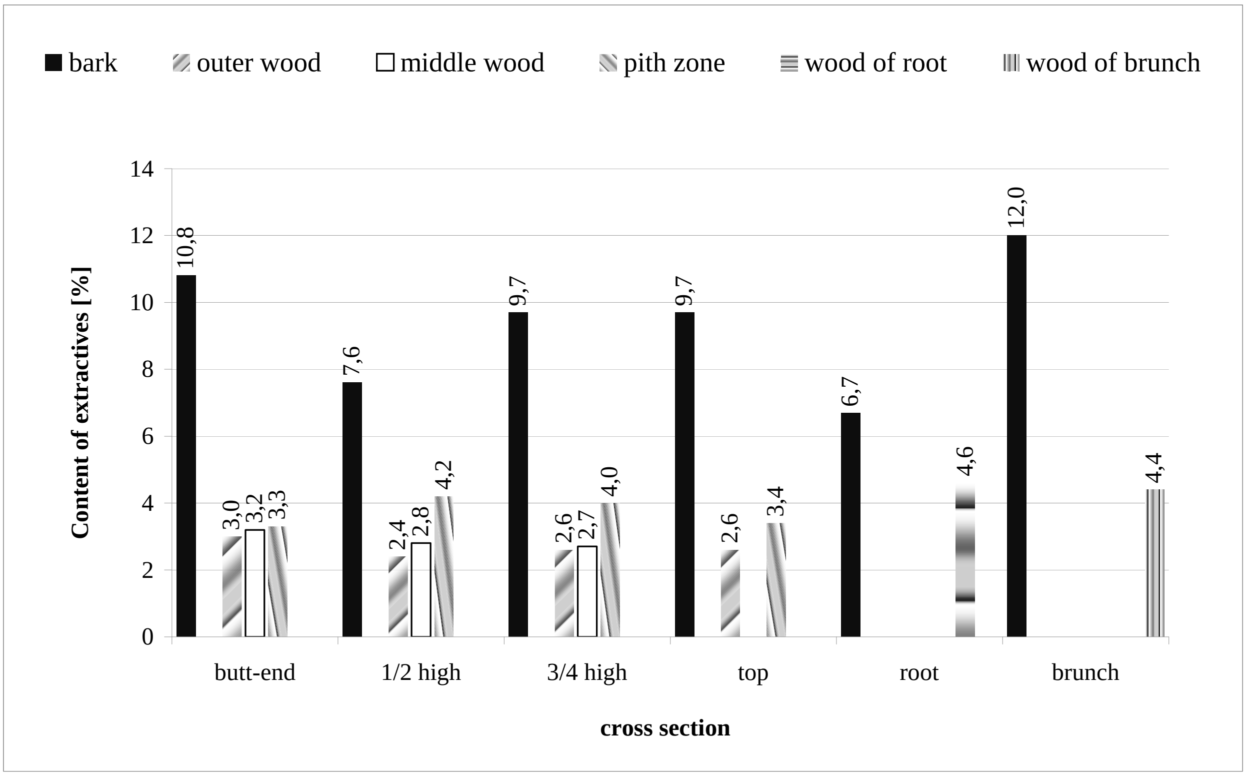

Fig. 1. Content of extractives in the wood, bark, brunch and root of birch (*Betula pendula* Roth.)

Extractives content in bark is several times higher in relation to wood taken from the stem, as well as from roots and branches.

According to Krutul & Buzak (1986), oak wood (*Quercus petraea* Liebl.) from about 80 years old stem (unpolluted environment) contains more extractives in half height and top part of the stem in relation to butt-end section. Extractives content in outer- and middle wood from butt-end section is higher in relation to other sections (half-height, three-quarters and top-part). This content in pith adjacent wood is higher in wood from half- and three quarters height of the stem in comparison to butt-end and top section. It leads to the conclusion that environmental pollution influences distribution of extractives along the stem centre line.

Main branches and roots contain respectively 4.4 and 4.6% of extractives and this value is higher than extractives content in stem heartwood. Bark of main roots contains lower amount of extractives than bark of main branches (the highest extractives content) and trunk.

According to Krutul & Sacharczuk (1997), extractives content in bark of oak (*Quercus robur* L.) changes from 6.1 to 15.2% and it is lower in wood from lower parts of the stem.

Data presented in the Fig. 1 shows that extractives content in bark from butt-end section is 30% higher in relation to bark taken from half-height and 10% higher from bark gained from three-quarters and top part of the stem. The statement that environmental pollution influences the extractives content distribution in bark along the stem centre line, is then justified.

Mineral substances content on the cross-section is constant, what is presented in the Fig. 2. However it rises with the stem height and in top part of the stem is 30% higher in outer wood and 45% in middle wood in relation to butt-end section.

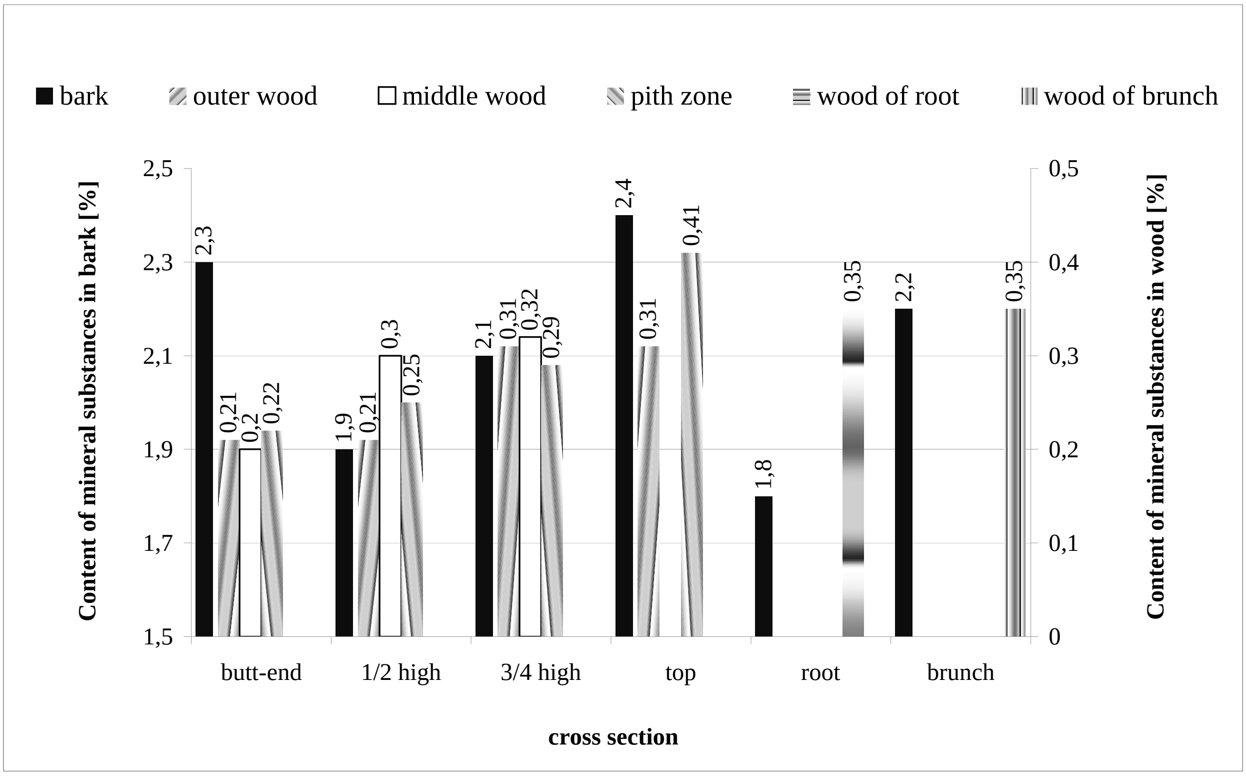

Fig. 2. Content of mineral substances in the wood, bark, brunch and root of birch (*Betula pendula* Roth.)

Mineral substances content is higher in oak sapwood and heartwood (*Quercus robur* L. and *Quercus petraea*) from top part of the stem, according to Krutul & Sacharczuk (1997) and Krutul (1995, 1997). These results are compatible to data presented in the Fig. 2. However, environmental pollution influences the distribution of mineral substances on the cross-section. Oak sapwood gained from unpolluted environment contains more mineral substances in relation to heartwood (Krutul & Makowski, 2004).

Mineral substances content in bark of birch stem changes from 1.9 to 2.4%. It is 10 times higher in comparison to wood (Fig. 2). These results are consistent with data presented by Krutul & Sacharczuk, who examined bark of oak (*Quercus robur* L.). Bark of main roots and branches contains, respectively, 1.8 and 2.2% of mineral substances and this values are 5 and 6 times higher in relation to wood.

Cellulose content in bark and wood on the cross-sections along the stem centre line and in bark and wood of main roots and branches is presented in the Fig. 3. In outer wood it is higher than in middle wood. In outer wood from butt-end and half-height section cellulose content is 3% higher, from three-quarters – 6% and from top part of the stem – 5% higher in relation to middle wood. Similar relations were obtained for 90-years old oak wood gained from unpolluted environment (Krutul, 1998).

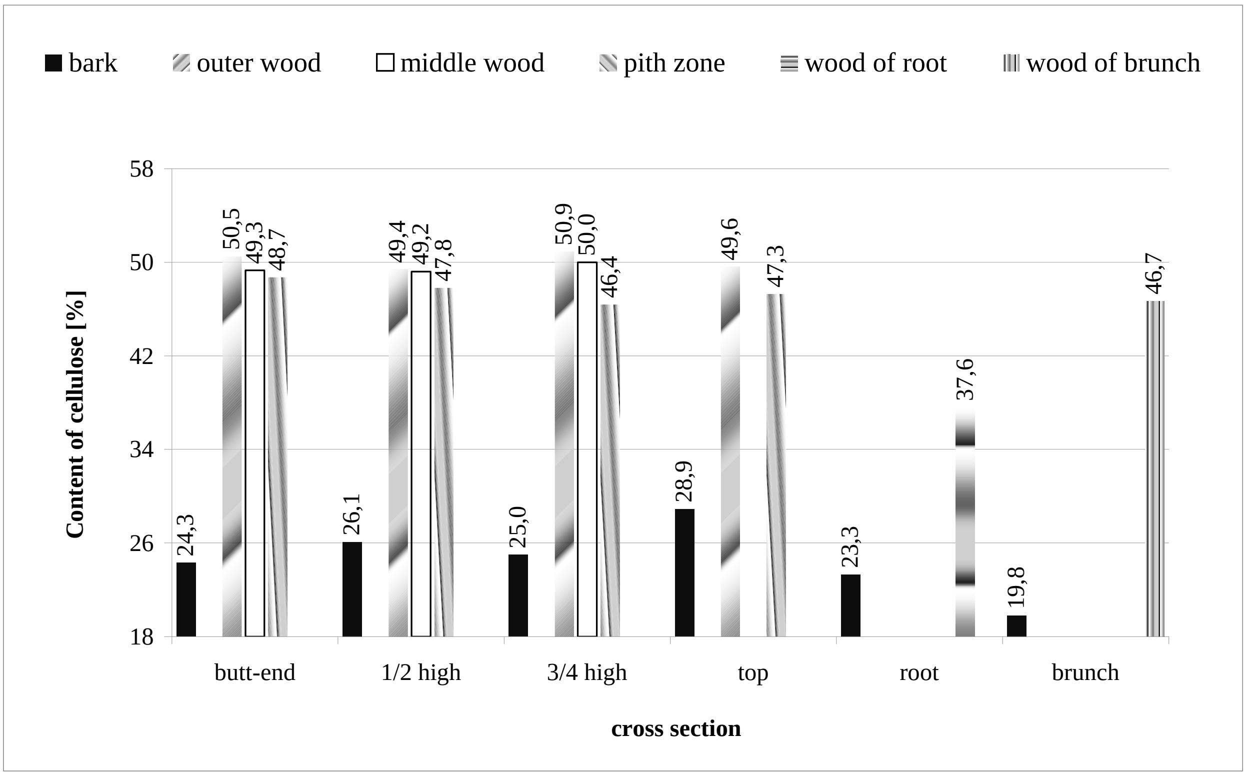

Fig. 3. Content of cellulose in the wood, bark, brunch and root of birch (*Betula pendula* Roth.)

Cellulose content in particular zones along the stem does not change. In branches wood it equals 46.7% and is similar to cellulose content in stem middle wood. Wood of main roots contains 37.6% of cellulose and this value is cca. 25% and 20% lower in relation to, respectively, outer and middle wood.

Cellulose content in bark is about 50% lower in outer and middle wood from butt-end section, and 40% lower in top part of the tree. In bark from main roots cellulose content is equal to 23.3% and is similar to the value obtained for bark from butt-end section. Content of cellulose in bark of main branches is the lowest – 19.8%.

Summarizing, the environmental pollution does not influence distribution of cellulose in wood and bark on the cross-section and along the stem.

1% NaOH soluble substances content in bark and wood of analyzed birch is presented in the Fig. 4. Basing on these results, changes in this content both on the cross-section and along the stem are insignificant. In outer wood it changes from 24.0 to 26.1%, in middle wood – from 25.0 to 26.1%. Content of 1% NaOH soluble substances in oak sapwood (*Quercus* *robur* L.) changes from 19.5 to 22.7% and in heartwood – from 21.8 to 26.1%. It increases with the stem height and on the cross-section in direction from perimeter to pith.

Bark of the stem, main roots and branches contains about 21% of 1% NaOH soluble substances, it is less in relation to analyzed wood zones.

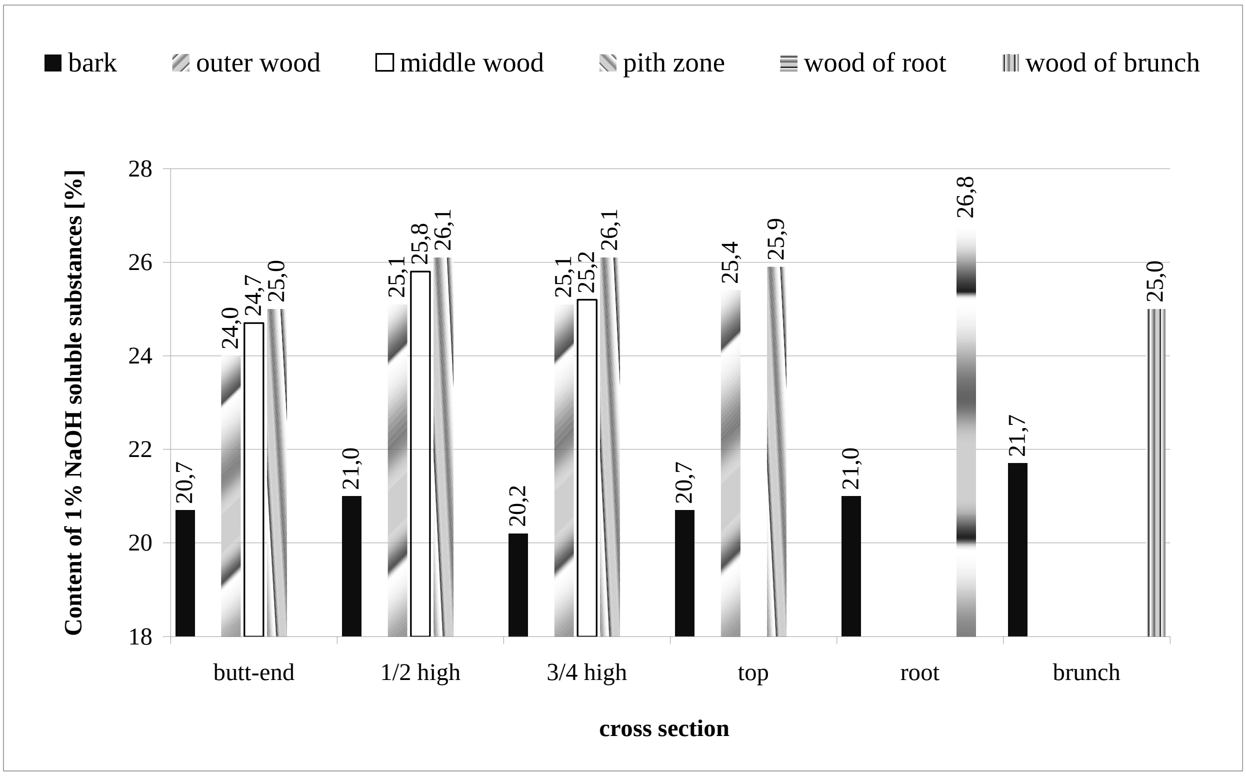

Fig. 4. Content of 1% NaOH soluble substances in the wood, bark, brunch and root of birch (*Betula pendula* Roth.)

According to Prosiński (1984), total pentosans and hexosans content in bark of birch equals about 11.8%. Significant difference between this value and results obtained in this paper may be caused not only by raw material diversity and disintegration degree, but also by different analytical methods. Obtained results are similar to data given by Fengel & Wegener (1984) for pine bark, where 1%NaOH soluble substances content is equal to 23.1%.

Summarizing, environmental pollution influenced distribution of 1% NaOH soluble substances in birch wood on the cross-section and along the stem.

Fig. 5 presents data concerning lignin content in wood and bark of the stem, main branches and roots. It does not change on the cross-section and along the stem. As it arises from former paper of Krutul (1998), lignin content on the cross-section of scots pine wood (*Pinus sylvestris* L.) decreases in the direction from pith to perimeter. Krutul et al. (2004, 2010) stated that oak wood (*Quercus robur*) from pith adjacent zone contains more lignin in relation to outer wood. Presented results show that environmental pollution influenced distribution of lignin on the stem cross-section.

Lignin content in bark of the stem and main branches and roots is more than a twice higher in relation to wood. It equals 46.0% in bark from the top part of the stem, 47.9% in the butt-end section, 48.0% in bark from main branches and 49.0% in bark from main roots.

According to Prosiński (1994), lignin content in inter bark of birch is equal to 20.2%. Krutul et al. (2007) determined this content in oak bark (*Quercus petraea*) on the level of 35.6%.

Summarizing, there is a visible influence of the environmental pollution on lignin content in bark.

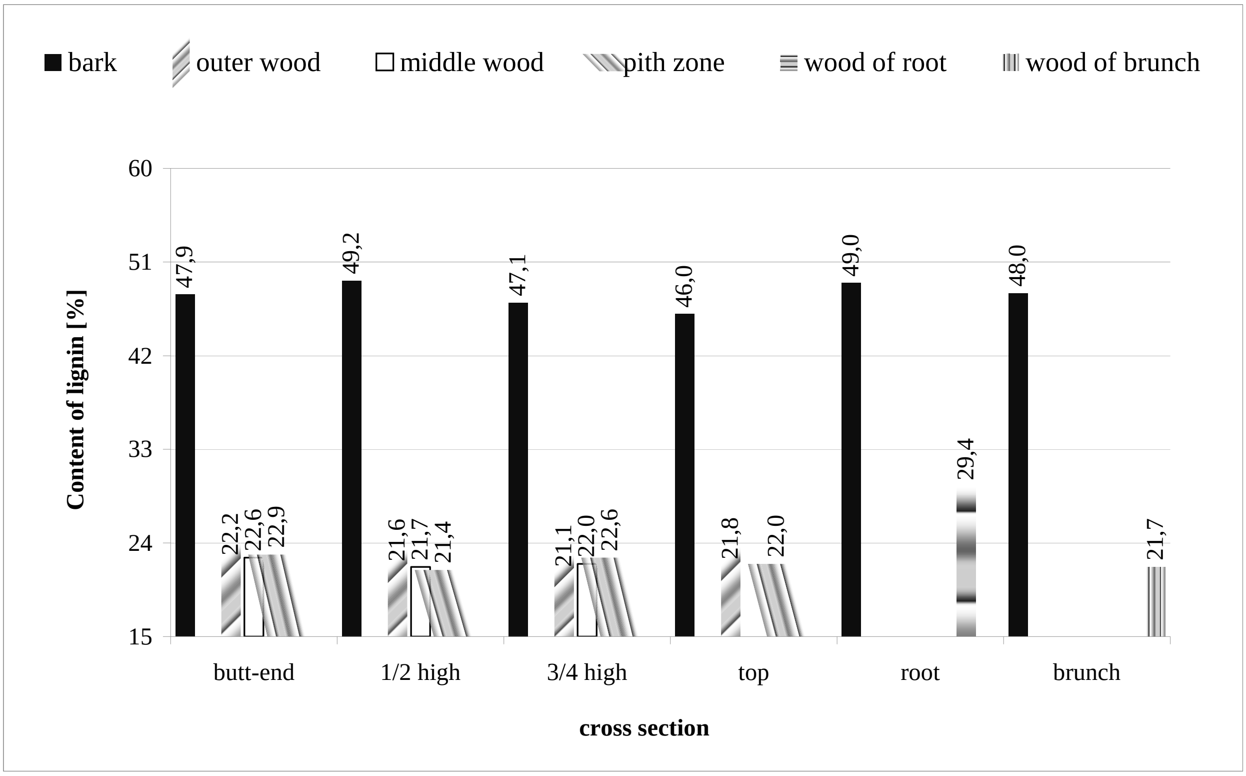

Fig. 5. Content of lignin in the wood, bark, brunch and root of birch (*Betula pendula* Roth.)

CONCLUSION

Environmental pollution influences distribution of extractives in wood and bark of birch along the stem centre line, distribution of mineral substances on the stem cross-section, 1% NaOH soluble substances in wood on the cross-section and along the stem centre line. There is also significant influence of the environmental pollution on the content of lignin in bark and its distribution on the stem cross-section..

There is no visible influence of the environmental pollution on content and distribution of cellulose in wood and bark.

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Streszczenie: *Wpływ skażenia środowiska na skład chemiczny kory i drewna pnia, gałęzi i głównych korzeni brzozy gruczołkowatej (Betula pendula* Roth.*).* Przeprowadzono oznaczenia zawartości substancji ekstrakcyjnych, mineralnych oraz celulozy i substancji rozpuszczalnych w 1% NaOH, a także ligniny w drewnie pnia w strefach przyrdzeniowej, środkowej i przyobwodowej oraz w korze w krążkach pobranych w części odziomkowej, ½, ¾ i w części wierzchołkowej, jak również w głównych gałęziach i korzeniach w drewnie i korze. Badania przeprowadzono w ok. 45-letniej brzozie pozyskanej z Krainy Mazowiecko-Podlaskiej w odległości 21 km od elektrociepłowni Kozienice. Na podstawie uzyskanych wyników stwierdzono, że skażenie środowiska wywarło wpływ na rozmieszczenie substancji ekstrakcyjnych w drewnie i w korze na przekroju wzdłuż wysokości pnia. W drewnie strefy przyobwodowej i środkowej zawartość tych substancji jest większa w odniesieniu do ½ i ¾ wysokości pnia, natomiast w drewnie strefy przyrdzeniowej odwrotnie. Skażenie środowiska wywarło wpływ na rozmieszczenie substancji mineralnych na przekrojach poprzecznych pnia, ponieważ w badanych strefach drewna ich zawartość jest jednakowa. Natomiast nie stwierdzono wpływu skażenia środowiska na zawartość i rozmieszczenie celulozy w korze i drewnie badanego pnia. Skażenie środowiska wywarło wpływ na rozmieszczenie substancji rozpuszczalnych w 1% NaOH na przekrojach poprzecznych jak i na przekroju wzdłuż wysokości pnia, jak również wywarło wpływ na zwiększoną zawartość ligniny w korze.

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