Impact of the environmental pollution originated from sulfur mining on the chemical composition of wood and bark of birch (Betula pendula Roth.)

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Abstract: Impact of environmental pollution caused by sulphur mining on the chemical composition of wood and bark of birch (Betula pendula Roth.) Content of extractives, cellulose, 1% NaOH soluble substances and lignin were examined. Samples were gained from cca. 70-year old birch (Betula pendula Roth.) grown in the environment polluted by sulfur mining industry. 200mm height disks were cut in the butt-end, middle and top section of the trunk. Disk from the main branch was also collected. Bark was collected from butt-end section. On the cross-section from butt-end and middle part of the trunk following zones were marked: outer, center and pith adjacent wood. On the cross-section from the top part wood was divided into outer and pith adjacent. Only one zone was marked in branch.

Results show that environmental pollution caused by sulfur mining industry influences the content and distribution of extractives on the cross- and longitudinal sections. It also causes the increase of extractives content in bark. Content and distribution of 1% NaOH soluble substances are also changed on both cross-sections. Environmental pollution decreased lignin content in wood and increased this content in bark from butt-end section.

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

INTRODUCTION

Sulfur mining industry, regardless of the processing method, causes the pollution of both atmosphere and soil. Studies on the influence of sulfur mining on the environment are most often regarded to soils placed on mining fields. As it arises from Sołek-Podwika and Ciarkowska (2006), the reclamation of degraded areas of “Grzybów” mines after sulfur exploitation, did not result in suitable effect. Large areas stayed without any growing plants what testifies of the destruction of biological life. Soils, studied in 1966-1996, were placed on the area of sulfur mines, where sulfur was mined with underground melting method. They were covered with light quartz sand without organic substance and soil aggregates (Martyn et al. 2002). According to Sołek-Podwika and Ciarkowska (2012), pH of soils in the area of sulfur storage is between 2.35 and 4.0. It is assumed that on the industrial area decrease of pH below the value of 5.0 is caused by the presence of strong acids (such as $H_2SO_4$), which act harmfully for plants and other soil organisms (Wylupek et al. 2006).

Opencast methods of sulfur mining cause the pollution of the atmosphere by sulfur dusts, sulfur dioxide and trioxide, as well as hydrogen sulfide (Lęcka-Pilaszek and Siuta 1991). Some trees of Scots pine (Pinus sylvestris L.) are characterized with different sort at places with strong sulfur pollution. Their branches are in the shape of many short sprouts growing horizontally (Niewęgłowska-Guzik 1995). Moreover, in branches wood numerous lens areas occur, which are of differentiate shape. Distorted coils are of izodiametrical shape and form folds and loops.
Studies of the influence of environmental pollution on forests are performed on Scots pine trees because they do not dump needles for winter and changes in annual increments and coils may be observed.

Birch plays significant role in early stages of primary and secondary succession. This is the pioneer species, fast growing and fast adaptive to settle on former agricultural soils and industrial wasteland. Its requirements regarding to climate and soil wealth are the lowest among other domestic species. It is also believed to be the species resistance for industrial emissions impact.

The aim of this paper is to determine the influence of environmental pollution caused by sulfur mining industry on the chemical composition of trunk and branch wood and bark of birch (Betula pendula Roth.)

MATERIALS AND METHODS

Tree of cca. 70-year old birch (Betula pendula Roth.) was sampled. The tree was grown in Stale forestry in Małopolska region. Disks of about 200mm height were cut from butt-end, middle and top section of the trunk, as well as from the main branch. On the cross-section from butt-end and middle part of the trunk following zones were marked: outer, center and pith adjacent wood. On the cross-section from the top part wood was divided into outer and pith adjacent. Only one zone was marked in branch, because of short diameter. Bark for analysis was collected from the butt-end section. Drill was used to collect the samples, then material was disintegrated and fractioned by sieves. Fraction with the diameter of about 0.5 mm was taken for studies. The analysis of wood density was performed according to the standard PN-77D-04101 “Wood – density determination”. Extractives content in samples of known moisture content was determined in Soxhlet apparatus using ethanol-benzene (1:1) (Krutul 2002). Kürschner-Hoffer method was used for cellulose content analysis, PN-74/P50092 standard was applied to determine lignin content. Substances soluble in 1% NaOH were also examined (Krutul 2002). The results were calculated in relation to sawdust dry mass.

RESULTS AND DISCUSSION

Density of birch wood in butt-end section (12% of moisture content) varies from 690 to 716 kg/m³. The average from five measurements equals 700 kg/m³. It is shown in the Fig. 1. Wood density is similar in middle and top section and the mean value equals 645 kg/m³, while in branch this value is lower (630 kg/m³). According to Krzysik (1984), birch wood density (15% of moisture content) varies from 510 to 830 kg/m³, and mean value equals 650 kg/m³. Obtained results are then similar to the data from the literature.
Extractives content on the cross-section of birch wood decreases in the direction from pith to outer wood, regardless of the trunk height (Fig. 2). This content in pith adjacent wood is higher in comparison to outer wood - 28% higher in butt-end section, 50% higher in half-height and 45% in the top part of the trunk. Amount of extractives in main branch is similar to pith adjacent wood.

According to Krutul and Buzak (1986) oak wood (*Quercus petraea* Liebl.) from cca. 80-year old trunk (unpolluted environment) contains more extractives in half height and top section in relation to butt-end. Krutul et al. (2011) stated that birch wood (*Betula pendula* Roth.) gained 21 km from “Kozienice” heat and power plant contains more extractives in upper parts of the trunk (middle, three quarters and top sections) in comparison to butt-end section.

In butt-end section analyzed outer wood contains 35% more extractives in relation to outer wood collected from half height and 25% more in comparison to top part of the trunk. Extractives content in wood taken from main branch is similar to extractives content in pith adjacent wood in the trunk (Fig. 2).
Bark from butt-end section contains 5 times more extractives than outer wood, from middle and top part – 7 times more. Extractives content in bark is 3.5 times higher than in pith adjacent wood and 3 times higher in relation to wood gained from the main branch (Fig. 2).

According to Krutul et al. (2011), extractives content in bark of birch (*Betula pendula* Roth.) equals 10.8% and is about 20% lower in comparison to bark from butt-end section from currently analyzed trunk. The statement that environmental pollution influences the extractives content distribution in wood along the trunk centre line, is the justified.

Cellulose content in bark and wood on the cross-section along the trunk centre line and wood of main branch is presented in the Fig. 3. On the basis of presented results, cellulose content is higher in outer wood than in wood from centre zone and pith adjacent. In outer wood from butt-end section cellulose content is cca. 6% higher, half height – 4.6% higher and top part of the trunk – 4% higher in relation to pith adjacent wood.

**Figure 2.** Extractives content in wood from trunk and branch as well as in bark of birch
Figure 3. Cellulose content in wood from trunk and branch as well as in bark of birch

Obtained results are consistent with earlier data presented by Krutul et al. (2011) which referred to the cellulose content in the 45-year old trunk of birch gained on the area 21 km from “Kozienice” heat and power plant.

Cellulose content in wood of particular zones along the trunk does not change. This result is similar to 45-year old birch analyzed by Krutul et al. (2011).

In branch cellulose content equals 47.3%. This value is similar to pith adjacent wood from half height and top part of the trunk.

Bark contains cca. 65% less cellulose in comparison to wood gained from the trunk and main branch.

The environmental pollution originated from sulfur mining industry causes the decrease of cellulose content of about 30% in bark from butt-end section in relation to bark from butt-end section of a trunk gained 21 km from “Kozienice” heat and power plant (Krutul et al. 2011).

Content of 1% NaOH soluble substances in bark and wood of analyzed stem is presented in the Fig. 4. On the basis of presented data it may be stated that changes in 1% NaOH soluble substances are irregular both on the cross- and longitudinal section of the trunk. As for butt-end section, these substances content in pith adjacent wood is 6% higher in comparison to outer and center wood. In the middle and top section of the trunk opposite relation was observed – outer wood contains 3-6% more of 1% NaOH soluble substances than pith adjacent wood.
According to Krutul et al (2011), content of 1% NaOH soluble substances in 45-year old birch varies from 24 to 25.4% in outer wood, from 24.7 to 25.8% in center wood and from 25 to 26.1% in pith adjacent wood. Moreover, wood from the top part of the trunk contains more of these substances in relation to butt-end, half- and three quarters height.

Content of 1% NaOH soluble substances in branch equals 29.1 and is cca. 14% higher in comparison to branch gained from 45-year old birch (Krutul et al. 2011).

Bark from butt-end section contains 35% 1% NaOH soluble substances, what is 40% more than these substances content in bark from 45-year old trunk.

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

Fig. 5 shows data concerning lignin content in wood from trunk and branch and as well as in bark. It may be observed that analyzed parameter does not change on the cross- and longitudinal section.
Figure 5. Lignin content in wood from trunk and branch as well as in bark of birch

As it arises from former papers of Krutul (2004, 2010), oak wood from pith adjacent zone contains more lignin in relation to outer wood. Krutul et al. (2011) stated that in 45-year old birch trunk lignin content in pith adjacent wood is about 4% higher in comparison to outer wood and only in top part of the trunk this value is similar for all zones.

Lignin content in analyzed outer wood is cca. 20% lower in relation to the value obtained for this zone gained from 45-year old trunk, 23% lower in middle section and about 24% lower in pith adjacent wood. Lignin content in branch is similar to the value obtained for the trunk and equals 19.4%.

Bark contains 34.8% of lignin what is twice higher in comparison to wood. Bark from analyzed trunk contains about 40% more lignin in relation to 45-year old trunk from Krutul et al. (2011).

According to Prosiński (1984) lignin content in inter bark of birch equals 20.2%. Krutul et al. (2007) determined this value in oak bark (Quercus petraea Liebl.) on the level of 35.6%.

Summarizing, there is a visible influence of the environmental pollution on distribution of lignin in wood on cross-section and along the trunk and in bark, especially in butt-end section of the trunk.

CONCLUSION

On the basis of presented results following conclusions were formulated:

There is the influence of the environmental pollution on the content and distribution of extractives in wood on the cross- and longitudinal section of the trunk as well as on this content in bark.

Environmental pollution caused the decrease of cellulose content in butt-end section and influenced the distribution of 1% NaOH soluble substances on the cross-section and along the trunk.
Lignin content in wood was observably changed. Significant changes in lignin content in bark from butt-end section were also denoted.

REFERENCES
Streszczenie: Wpływ skażenia środowiska przez przemysł górnicty siarki na skład chemiczny drewna i kory brzozy brodawkowatej (Betula pendula Roth.) Próbki do badań pozyskano z ok. 70-letniego pnia brzozy brodawkowatej (Betula pendula Roth.) wyrosłej w środowisku skażonym przez przemysł górniczy siarki. Krążki o wysokości ok. 200mm wycięto w części odziomkowej, na wysokości ½ i w części wierzchołkowej pnia, jak również pobrano krążek z głównej gałęzi. Na przekroju poprzecznym w części odziomkowej i w połowie długości pnia wyznaczono strefę drewna przyobwodową, środkową i przyrdzeniową, a w części wierzchołkowej dwie strefy: przyobwodową i przyrdzeniową, natomiast w gałęzi ze względu na niewielką średnicę, wyznaczono tylko jedną strefę. Korę pobrano w części odziomkowej pnia.

Na podstawie uzyskanych wyników stwierdzono, że skażenie środowiska spowodowane przez przemysł górniczy siarki wywarło wpływ na zawartość i rozmieszczenie substancji ekstrakcyjnych na przekroju poprzecznym i na przekroju wzdłuż wysokości pnia, jak również spowodowało zwiększenie zawartości tych substancji w korze.

Skażenie środowiska wpłynęło również na zawartość celulozy w drewnie w części odziomkowej pnia (zmniejszenie zawartości), jak również wywarło wpływ na zawartość i rozmieszczenie na przekroju poprzecznym i na przekroju wzdłuż wysokości pnia substancji rozpuszczalnych w 1% NaOH. Skażenie środowiska spowodowało również zmniejszenie zawartości ligniny w drewnie, a zwiększenie jej zawartości w korze w części odziomkowej pnia.

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