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THE RESISTANCE TO BROWN ROT FUNGI OF SPRUCE WOOD (*Picea abies* (L.) Karst.) FROM THE INDUSTRY POLLUTED AREA OF THE KARKONOSZE MOUNTAINS TO BASIDIOMYCETES[1]

by Maria Bartkowiak, Grzegorz Cofta, Bartłomiej Mazela and Kazimierz Lutomski

Institute of Chemical Wood Technology
A. Cieszkowski Agricultural University of Poznań

Spruce wood (*Picea abies* (L.) Karst.) of trees injured by industrial pollution in the Karkonosze Mountains was exposed to the influence of fungi causing brown rot of wood. The investigations were also performed for spruce wood of injured trees from the same region as well as from Pomerania and Scots pine wood (*Pinus sylvestris* L.). The estimation of wood resistance to fungi was made on the basis of mass losses after 16 days of incubation of samples.

Key words: spruce wood (*Picea abies* (L.) Karst.), Scots pine wood (*Pinus sylvestris* L.), industrial pollution, natural resistance, brown rot fungi

INTRODUCTION

Forests dying, occurring also in Poland, is the severe consequence of the development of the civilization. The different types of air polluting emissions negatively influence the development and life of different organisms including trees in forests. The evident examples are mountain stands especially in the western part of the Sudety Mountains for instance the Izerskie Mountains where significant forest areas died. Forests dying is not only a nature phenomenon but also brings significant economic loses due to the reduction of the economic potential of forestry sites and trees growth as well as the limitation of forest utilization. There is an exact relationship between the degree

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of the forest damages and the value of volume increment of the stand. The report on the condition of forests in Poland provides data that the decrease of wood increment caused by industrial emissions was equal to ca. 3 000 000 m^3 in 1986 (N.N. 1986).

According to the European Union data from 1994 the degree of the stand damage in Poland had one of the highest values in Europe and similar to that in the Czech Republic, Slovakia, Lithuania and Belarus (N.N. 1996). Forests of the west and south-west part of Poland are in the highest danger. The total death of forests occurred on the area of ca. 15 000 ha in the Sudety Mountains. The process started here in the 1980s (Gorzelak 1997). The region may be named as the area of the ecological disaster with simultaneously increasing degree of the danger in the north-eastern direction. The higher and higher damages of spruce stands are also observed in the Carpathian Mountains (Modrzyński and Jakubiszak 1997).

Discoloration of leaves and needles as well as their loss i.e. defoliation is the basic criterion of the classification of damages of stands caused by abiotic factors also including air pollution with gasses and dusts. The degree of defoliation of confers in Poland in 1997 was equal to 2.80. The highest value was noticed in the Sudety Mountains area (3.68), while the lowest in the Baltic Sea area (Budna and Grzybowska 1998). This means that the Sudety Mountains are in the area of the most intensive influences of the complex of harmful factors causing forests dying. The same source reports that in 1997 on the area of the Wrocław Regional Directorate of the State Forests 98.4% of forest stands indicated the negative influence gasses and dusts. The similar result i.e. 93.1% was obtained in the Katowice Regional Directorate of the State Forests while in the Białystok Regional Administration of the State Forests only 1.8% was noticed.

The resources of standing large diameter timber are the important indicator for forest economy. They amounted to ca. 48 000 dam^3 in Polish damaged stands in 1980 and increased to over 530 000 dam^3 during 17 years, that is they increased over 1000% (Budna and Grzybowska 1998). The resources of large diameter timber from damaged stands in the Jelenia Góra Province was estimated in 1997 as ca. 85% of the total area of productive stands. One year later i.e. in 1998 the content even increased (Budna et al. 1999).

The state of health of stands may be associated to the quality of the harvested raw wood. The sudden development of forest damages caused by emissions of gasses and dusts paid attention of timber producers as well as consumers on properties of timber from areas subjected to gases and dusts. A number of research projects were lunched to explain doubts related to the problem. The programs aimed to determine a number of properties of wood coming from damaged stands and compare them to results obtained for wood of healthy trees. The works were done and published especially in the 1980s. German authors were especially active. They investigated wood from areas polluted with industrial emissions. Liese (1987) gave the summary of their works. In 1984 there were published 700 scientific papers in this area. In the next year the number of publications increased to 900. The obtained results indicate that strength properties of wood from damaged stands did not differ significantly from properties of wood from healthy trees. There was observed the decrease of trees growth, which causes small increase of wood density. There were no observed differences in chemical composition of spruce wood from damaged and healthy stands. However, small changes in the content of wood reserved substances and soluble extractives. Aleksandrowicz (1992) investigated the influence of industrial pollution of air on anatomical composition of spruce wood. The investigations indicated the decrease of density, changes of the content of latewood and annual growth rings during 10 and 20 years as well as the decrease of the number of the growths in 1 cm. However, there was no noticed change in the length of tracheids of earlywood and latewood. The following pests easily infect spruce wood from gas polluted dying back trees: *Heterobasidion annosum*, *Gloeophyllum saepiarium*, *Ips typographus* or *Xyloterus lineatus* (Götze et al. 1985).

One of the most important wood properties is its durability. The property is usually identified as wood resistance to fungi causing decay of wood tissue (Cartwright and Fidlay 1951). Such defined resistance is influenced by a number of factors as wood density, existence of species specific extractives as well as location and conditions of a tree growth (Lutomski and Raczkowski 1963, Lutomski and Surmiński 1963). The influence of industrial emissions on durability of wood from damaged stands was investigated very rarely. However, the works of Schmidt et al. (1986) and Liese (1986) should be mentioned here. The works concern spruce and beech wood coming from stands in Bayern, Nieder Sachsen, Baden-Würtenberg, Schleswig-Holstein. Investigations on durability of wood coming from damaged stands in Poland have been not conducted and published yet.

The objective of the work was to determine wood resistance to decay caused by basidiomycetes. Wood was coming from stands damaged by industrial emissions and its resistance was compared to the resistance of wood from healthy stands. The investigations concerned spruce wood from the Sudety Mountains as the area of the highest degree of pollution and recognized as the region of ecological disaster as well as Scots pine and spruce wood from the Baltic Sea area being the region of low pollution and differing in the degree of defoliation.

MATERIALS

Wood subjected to the investigations was coming from the following locations:

1. The area of the Wrocław Regional Directorate of the State Forests – the Kamienna Góra Forest Inspectorate. Spruce wood (*Picea abies* (L.) Karst.) was harvested in the spruce stand (the high-mountain coniferous forest, the IV/III zone of danger) which was ca. 65 years old. There were cut dying trees with distinct defoliation of the third degree and scanty yellowish litter of needles. In the same stand there were also cut trees characterized as healthy, correctly developing, without visible traces of defoliation.
2. The area of the Szczecinek Regional Directorate of the State Forests – the Szczecinek Forest Inspectorate. Spruce and Scots pine (*Pinus sylvestris* L.) wood was harvested in the healthy stand without symptoms of damages.

The stand was ca. 65 years old. Wood of the both species was the control material coming from the unpolluted area. There were cut 3 trees in each species group. Next, blocks of the length of 120 cm were cut from the height of 360 cm from the butt end. The harvesting was performed in the middle of May. The selection of trees was made with the help of workers of the mentioned forest inspectorates.

The obtained material was debarked, cut along the axis into four parts from which square timber was cut. The square timber allowed obtaining samples coming from different zones of the cross section of each block. The location of square timber in the cross section is shown in Fig. 1.

The square timber was placed down on stickers and stored under a roof in the well vented place in order to obtain moisture content of ca. 20%. Next, wood was subjected to the further mechanical processing i.e. samples of the final dimensions of 15*25*50 mm were cut. All samples were stored in the climatic chamber at temperature of 20±2°C and relative air humidity of 56±5% in order to obtain the constant mass. The total time of wood seasoning from harvesting to the mycological test was 8 months.

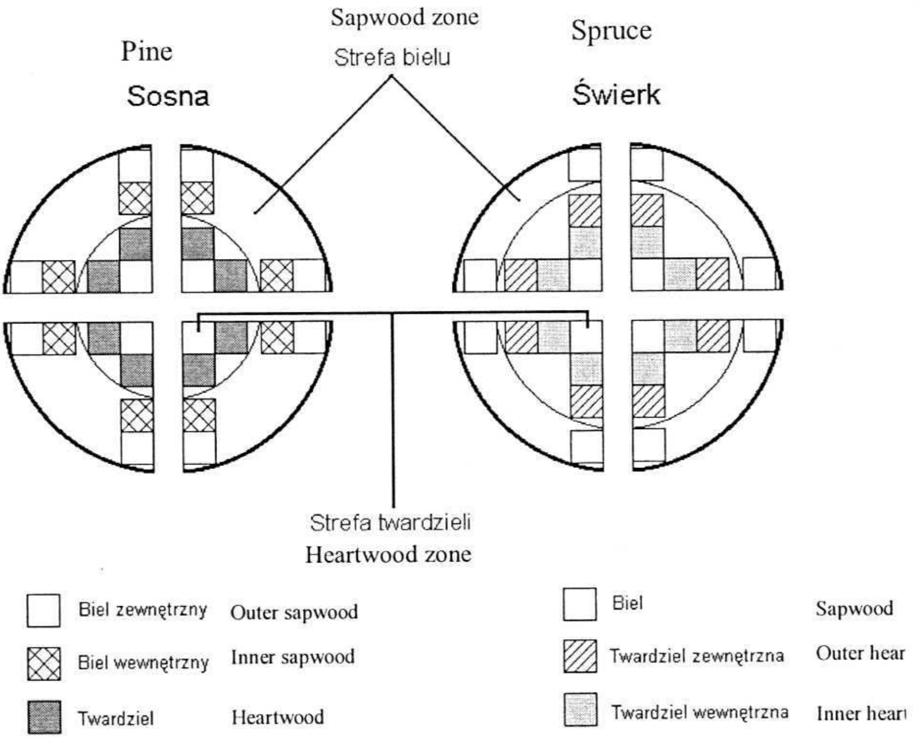


Fig. 1. Location of square timber in the transverse cross-section

Rys. 1. Rozmieszczenie na przekroju poprzecznym graniaków z których wykonano próbki do badań

METHODS

The basic method applied during the investigations was the European Standard EN 350-1/1994. The described earlier samples were measured with the accuracy of 0.01 mm and weighed with the accuracy of 0.0001 g. The samples were divided into groups taking into account samples location in the cross section of a stem and the location in the length of its axis. The method of samples separation was applied according to the Appendix A point A.3 of the standard. The control samples designed for moisture content determination of each group were dried in temperature of 103±2°C to the constant mass and weighed. The remaining samples were twice sterilized with steam of temperature of 110°C. The break between sterilization processes was 24 h. The sterilized samples were then placed in the Kolle flasks on freshly bred on the agar-malt base the following pure cultures of fungi:

- *Coniophora puteana* (Schum. ex Fries) Karst., strain BAM Ebw. 15
- *Serpula lacrymans* (Schum. ex Fries) S.F. Gray, strain BAM 315
- *Poria placenta* (Fries) Cooke sensu J. Eriksson, strain FPRL 280
- *Gloeophyllum trabeum* (Pers. ex Fries) Murrill, strain BAM Ebw.109.

Fungi cultures were coming from the MPA mycological laboratory in Eberswalde.

The flasks were stored for 16 weeks in air conditioned, sterile chamber in temperature of 21±1°C and air relative humidity of 80±5%. Then the samples were cleaned, weighed, initially air pre-dried, dried to the constant mass in temperature of 103±2°C and again weighed. The number of samples was varying from 12 to 24 in each group.

The initial mass i.e. oven dry mass of samples subjected to mycological tests was calculated taking into account the mean value of moisture content of a given group o f samples and mass of each sample in the air-dry state. The performed measurements let to determine the following values:

- density of each sample
- moisture content after 16 days of the test
- mass loss of wood caused by test fungi.

RESULTS

Density of tested wood

Density is one of the most important characteristics of wood. A number of other wood properties including the resistance to fungi depends on density. The results presented in Table 1 show that density of Scots pine wood fits to the data characteristic to that species. According to Krzysik (1974) the mean density of Scots pine (*Pinus sylvestris* L.) wood equals to 580 kg/m^3 and may vary from 330 to 890 kg/m^3. Density of spruce (*Picea abies* (L.) Karst.) wood is somewhat lower and varies from 330 to 680 kg/m^3 with the mean value of 470 kg/m^3. The density of spruce used in the reported investigations was varying from 319 to 478 kg/m^3. However, the lower values were noticed for wood coming from the Karkonosze Mountains regardless of the degree of health of trees used to prepare samples (Table 1). It is at variance with the general

Table 1
Tabela 1

Density of samples subjected to the mycological test
Gęstość drewna próbek poddanych testowi mykologicznemu

Species and wood origin Gatunek i pochodzenie drewna	Zone Strefa	Density (kg/m^3) Gęstość (kg/m^3)
Damaged spruce (*The Karkonosze Mountains*) Świerk uszkodzony *(Karkonosze)*	Sapwood Biel Outer heartwood Twardziel zewnętrzna Inner heartwood Twardziel wewnętrzna	341 – **378** – 392 329 – **382** – 404 364 – **384** - 409
Damaged spruce (*The Karkonosze Mountains*) Świerk uszkodzony *(Karkonosze)*	Sapwood Biel Outer heartwood Twardziel zewnętrzna Inner heartwood Twardziel wewnętrzna	366 – **380** – 392 357 – **375** – 391 319 – **343** - 362
Spruce *(Pomerania)* Świerk *(Pomorze)*	Sapwood Biel Outer heartwood Twardziel zewnętrzna Inner heartwood Twardziel wewnętrzna	428 – **469** – 478 386 - **412** – 441 381 – **426** - 448
Pine *(Pomerania)* Sosna *(Pomorze)*	Sapwood Biel Outer heartwood Twardziel zewnętrzna Inner heartwood Twardziel wewnętrzna	494 - **545** – 566 415 – **535** – 558 474 - **558** - 562

opinion that wood of trees growing in harder climatic conditions, e.g. wood from mountain forests (Kollmann 1951), is usually more dense, its density is higher than for wood of trees of the same species but growing in an area of more mild climate. The investigated wood from the stand from the region of Szczecinek was coming from the area beyond the natural occurrence of spruce (Bugała 1979). It may be to some degree the reason of the differentiation of density of the investigated wood.

The observation requires confirmation in further investigations because Aleksandrowicz (1992) stated for Scots pine the decrease of density of wood from trees growing in the area of the harmful influence of industrial emissions. However, Liese (1987) indicates the insignificant increase of density of wood from trees of damaged stands and relates it with the decrease of growth.

Resistance to fungi

The decay activity of the applied test fungi plays the decisive role in mycological tests in which the basic criterion of the material evaluation is its susceptibility to fungi action. The activity is characterized by wood mass losses of the species recognized as

Table 2
Tabela 2

Mass losses of Scots pine sapwood caused by fungi
Ubytki masy bielu sosny pod wpływem grzybów

Test fungus Grzyb testowy	Tested samples Próbki badane	Requirements acc. to PN-EN 113 Wymagania wg PN-EN 113
	Mass losses (%) Ubytki masy	
Coniophora puteana	52.7 – **59.19** – 63.4	min. 20
Poria placenta	30.9 – **35.60** – 38.5	min. 20
Serpula lacrymans	19.7 – **23.20** – 28.1	-
Gloeophyllum trabeum	18.5 – **24.94** – 27.4	min. 20

the standard one. Scots pine wood of undamaged trees from The Szczecinek Forest Inspectorate (The Baltic Sea area) was used in the research as the standard material.

Table 2 presents mass losses of the species caused by fungi. The results were compared to mass losses given in the standard PN-EN 113 (2000) as the minimum values for fungi causing decay.

It results from data in Table 2 that the applied strains of testing fungi had good activity of pine sapwood decay. The activity was exceeding the minimum requirements. It allows for positive evaluation of the investigations in this area. The most active fungus was *Coniophora puteana*, which caused decay of almost 60% of wood substance in 16 weeks. The high activity of *Coniophora puteana* confirms the decision of including the fungus to the set of test fungi. The fungus is not included in the group of fungi designed for laboratory tests of natural resistance of solid wood according to the standard EN-350-1. The reasons of that are unknown for the authors. The high ease of culture and confirmed by other authors (Van Acker, Militz and Stevens 1999) high ability of decay of pine sapwood and wood of other softwood and hardwood species suggests that *C. puteana* is one of the most dangerous house fungi and should be taken into consideration during tests of wood natural durability. It should be also noticed that *Serpula lacrymans* is not included in the set of test fungi used in investigations of fungicidal properties of impregnants. Ważny (1959) performed broad investigations on the influence of fungi on physical and mechanical properties of wood. After 4 months of tests he obtained ca. 32% of mass loss of pine sapwood caused *S. lacrymans*. Thus the values were higher than mass losses noticed in this work. It shows not only differences in properties of investigated wood but also differences in strains of testing fungi (Gersonde 1958).

Moisture content of samples after tests

The moisture contents of samples after tests on wood resistance to fungi, which are presented in Table 3 are the typical values for the fungi species used during investigations. The highest values were obtained for *C. puteana*, which decays wood at higher moisture contents, e.g. in cellars. The lower moisture content, not exceeding 56% after

Table 3
Tabela 3

Moisture content of samples after the mycological test
Wilgotność próbek po zakończeniu testu mykologicznego

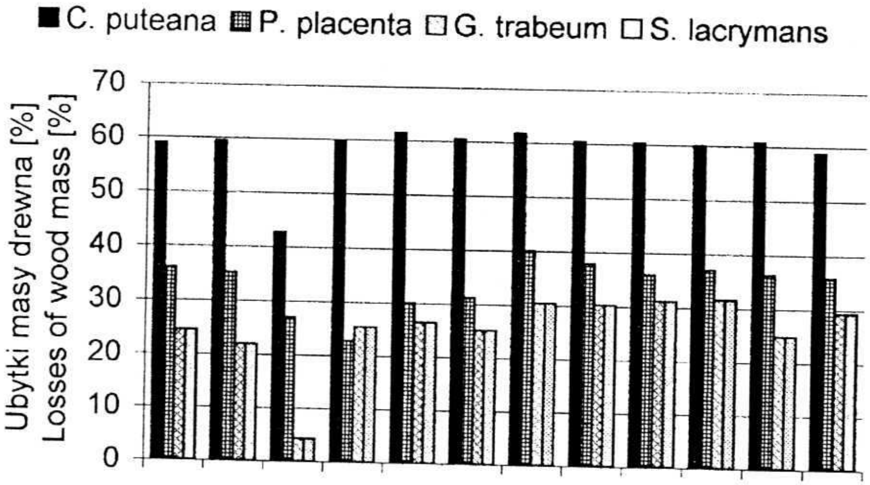
Species and wood origin Gatunek i pochodzenie drewna	Zone Strefa	Test fungus Grzyb testowy			
		Coniophora puteana	*Poria placenta*	*Serpula lacrymans*	*Gloeophyllm trabeum*
		Moisture content of samples (%) Wilgotność próbek (%)			
Damaged spruce (*The Karkonosze Mountains)* Świerk uszkodzony *(Karkonosze)*	Sapwood Biel	77 – **87** – 98	59 – **65** – 82	44 – **53** – 75	51 – **69** – 80
	Outer heartwood Twardziel zewnętrzna	75 – **84** – 92	57 – **64** – 79	47 – **52** – 81	54 – **64** – 78
	Inner heartwood Twardziel wewnętrzna	71 – **85** – 91	52 – **65** – 74	40 – **44** – 58	57 – **65** – 72
Healthy spruce *(The Karkonosze Mountains)* Świerk zdrowy *(Karkonosze)*	Sapwood Biel	74 – **82** – 99	64 – **66** – 75	49 – **56** – 61	57 – **67** – 80
	Outer heartwood Twardziel zewnętrzna	78 – **81** – 92	54 – **61** – 68	48 – **52** – 59	59 – **64** – 74
	Inner heartwood Twardziel wewnętrzna	81 – **87** – 96	58 – **62** - 70	45 – **55** – 64	59 – **62** – 69
Spruce *(Pomerania)* Świerk *(Pomorze)*	Sapwood Biel	81 – **91** –100	51 – **61** – 70	47 – **53** – 58	51 – **64** – 71
	Outer heartwood Twardziel zewnętrzna	79 – **95** – 99	54 – **62** – 72	39 – **41** – 47	61 – **66** – 80
	Inner heartwood Twardziel wewnętrzna	85 – **96** – 105	58 – **63** – 71	34 – **38** – 42	62 – **65** – 79

16 weeks of testing, was obtained for samples subjected to *S. lacrymans*. The species does not require high moisture content of wood during its decay (Andersen 1992). While, samples subjected to *P. placenta* and *G. trabeum* had similar moisture contents after 16 weeks of decay and their values were intermediate in comparison to the values reported earlier.

The values of moisture contents of wood after tests which being characteristic for applied fungi are another evidence of proper conditions in which investigations were performed. The obtained results together with appropriate ability of fungi to decay wood may be recognized as fully reliable.

Resistance of pine wood

Pine wood coming from the Baltic Sea area (Pomerania) has the diverse resistance to fungi because of samples location in the transverse cross-section as well as applied test species (Fig. 2). The differences in mass losses of sapwood and heartwood of the species subjected to *C. puteana* reach ca. 17% while subjected to *P. placenta* the losses are lower. For *S. lacrymans* and *G. trabeum* the differences in mass losses of sapwood



BZ	BW	T	B	TZ	TW	B	TZ	TW	B	TZ	TW
Healthy trees Drzewa zdrowe									Damaged trees Drzewa uszkodzone		
Pomerania Pomorze						The Karkonosze Mountains Karkonosze					
Pine Sosna			Spruce Świerk								

Fig. 2. Mass losses of wood subjected to test fungi
B – sapwood, BZ – outer sapwood, BW – inner sapwood, T – heartwood, TW – inner heartwood, TZ – outer heartwood
Rys. 2. Ubytki masy drewna poddanego działaniu grzybów testowych
B – biel, BZ – biel zewnętrzny, BW – biel wewnętrzny, T – twardziel, TW – twardziel wewnętrzna, TZ – twardziel zewnętrzna

and heartwood exceed 20%. However, the relatively low mass losses of heartwood should be noticed. The sensitivity of *S. lacrymans* to substances included in pine heartwood are generally known (Cartwright and Findlay 1951). It was also experimentally identified by Schulz (1957) and Ważny (1959). The identified, in the carried out investigations, low activity of *G. trabeum* in pine heartwood decay (the mass losses of 2.70% after 4 months) can be explained similarly as for *S. lacrymans* with individual behavior of the applied strain of the species. *G. trabeum* is the specific species for the decay of softwoods. In the discussed investigations mass losses of pine sapwood and spruce wood (both sapwood and heartwood) reached 30%.

Spruce wood resistance to decay

It results from data presented in Fig. 2 that spruce wood of healthy trees subjected to four species of fungi causing brown rot revealed similar mass losses as pine wood which depended on the species of the test fungus. *C. puteana* has decayed spruce wood only insignificantly more than pine sapwood. The similarly low differences occurred for the other test fungi.

In order to better present the obtained results, the mass losses of spruce wood from trees damaged by industrial emissions in the Karkonosze Mountains were compared to mass losses of wood of healthy trees from the Karkonosze Mountains and Pomerania. The mass losses of wood of healthy trees were assumed to be equal to 100%. The results of calculations are presented in Table 4. The resistance of spruce sapwood of damaged trees in comparison to pine sapwood is approximately comparable for *C. puteana*, *P. placenta* and *G. trabeum*. However, spruce sapwood is more susceptible to *S. lacrymans*. The susceptibility of wood with the 3^{rd} and 4^{th} degree of defoliation from the Karkonosze Mountains is comparable to the susceptibility of spruce wood from healthy trees from the same region. The assumed method of comparison with reference to *G. trabeum* indicates however, that sapwood and inner heartwood of spruce trees damaged by industrial emissions was less decayed than spruce wood from trees without symptoms of defoliation. Schmidt et al. (1986) suggest that it may be caused by settling dying trees with antagonistic bacteria and fungi which slow down the development of test fungi.

In order to check the significance of differences of mass losses of spruce wood form damaged stands from the Karkonosze and mass losses of wood of healthy trees from the same region as well as spruce and pine from Pomerania the obtained results were statistically analysed. The standard deviation and significance of differences of mass losses were calculated. The last task was performed by the Pearson test because of the different number of samples in the compared groups. The standard deviation of the arithmetic means of mass losses was varying from ±1.82 to ±5.31%. It shows the low concentration around the arithmetic mean and their lower spread. The performed calculations also indicate that the significance of differences was confirmed for cases of high mass losses exceeding ±18% of mass losses of wood being the reference. The bold font emphasized these cases in Table 4.

The highest differences were noticed when comparing spruce wood with pine heartwood. It is justified by the high susceptibility of test fungi on the presence of specific substances in the wood, e.g. pinosilvine. Such high susceptibility characterizes *S. lacrymans* and *G. trabeum*, which cause very low mass losses of pine heartwood. The differences in mass losses of spruce wood of damaged trees from the Karkonosze Mountains and wood of trees without symptoms of defoliation were in most cases small. Moreover, there was even noticed the increase of the resistance to fungi of damaged trees in comparison to wood of healthy trees.

The results suggesting the drop of the wood resistance to fungi are the most important data from the point of view of the basic objective of the investigations. The statistically proven drop was noticed for *P. placenta* and *S. lacrymans* when compared the resistance of damaged wood from the Karkonosze Mountains to the healthy wood from Pomerania. Spruce wood of damaged trees from the Karkonosze Mountains and spruce wood of trees recognized as healthy i.e. without symptoms of defoliation have practically the same resistance to the applied test fungi. The observation suggested that

Table 4
Tabela 4

Spruce wood resistance from the Karkonosze Mountains compared to the resistance of spruce and pine wood from Pomerania
Odporność drewna świerka z Karkonoszy w porównaniu do odporności drewna świerka i sosny z Pomorza.

Zone of the transverse cross-section Strefa przekroju poprzecznego	Group of samples subjected to the comparison Grupa próbek poddana porównaniu	Test fungus / Grzyb testowy											
		Coniophora puteana			*Poria placenta*			*Serpula lacrymans*			*Gloeophyllum trabeum*		
		Mass losses of spruce wood from the Karkonosze Mountains in comparison to wood of: (%) Ubytki masy próbek drewna świerka z Karkonoszy w porównaniu do drewna: (%)											
		healthy spruce świerka zdrowego		pine sosny	healthy spruce świerka zdrowego		pine sosny	healthy spruce świerka zdrowego		pine sosny	healthy spruce świerka zdrowego		pine sosny
		Pomorze	Karkonosze		Pomorze	Karkonosze		Pomorze	Karkonosze		Pomorze	Karkonosze	
Sapwood Biel	Damaged spruce from the Karkonosze Świerk uszkodzony Karkonosze	100	97	101	**162**	92	104	**125**	104	**136**	**83**	82	93
	Healthy spruce from the Karkonosze Świerk zdrowy Karkonosze	103	-	104	**175**	-	112	**119**	-	**124**	100	-	113
Inner heartwood Twardziel zewn.	Damaged spruce from the Karkonosze	99	100	**140**	**121**	96	135	94	**82**	**576**	99	105	**1099**
	Healthy spruce from the Karkonosze	98	-	**141**	**124**	-	140	114	-	**700**	94	-	**1049**
Outer heartwood Twardziel wewn.	Damaged spruce from the Karkonosze	97	97	**138**	115	99	133	117	94	**678**	**82**	86	**899**
	Healthy spruce from the Karkonosze	99	-	**141**	115	100	133	123	-	**718**	96	-	**1049**

(The bold font emphasizes the statistically proved differences of mass losses of samples)
(Pogrubioną czcionką zaznaczono stwierdzoną statystycznie istotność różnic ubytków masy próbek)

the noticed differences of the resistance of wood of trees with defoliation from the Karkonosze Mountains compared to the resistance of wood of healthy trees may be caused not by the influence of emissions but by the different forest site conditions of spruce growing in the Karkonosze Mountains and Pomerania. Therefore, the similar comparison as described above was also performed for mass losses of wood of fully health trees from the Karkonosze Mountains and spruce and pine wood from Pomerania. The results are presented in Table 4 and indicate the same tendency as earlier described when discussed wood of damaged trees. It clearly results from the Table that the resistance to basidiomycetes of spruce wood from the Karkonosze Mountains with spots of defoliation is similar in comparison to wood without defoliation.

The results presented in Table 4 also indicate that the resistance of wood from the Karkonosze Mountains regardless of the degree of health is clearly lower than the resistance of the tested spruce wood from Pomerania. It especially concerns sapwood subjected to *P. placenta* and *S. lacrymans*. The differences are statistically proved. The probable cause of the differences may be mainly, mentioned earlier, differences of density of wood from both regions. The density is also listed among different factors deciding on the natural resistance of wood to fungi (Cartwright and Findlay 1951). The wood of trees growing in the Karkonosze Mountains, which underwent defoliation, and without their symptoms did not indicate the significant differences in the resistance. From the point of view of the resistance to basidiomycetes of wood of damaged and healthy trees but coming from the same region has the value. It confirmed the results of investigations on the lack of the influence of gasses and dusts on wood resistance to decay fungi, which were conducted by Schulz (1984), Liese (1986) and Schmidt et al. (1986).

DISCUSSION

The already published results on the influence of industrial emissions on different wood properties of wood do not let to obtain the clear opinion. Grosser, Schulz and Utschig (1985) stated the reduction of yearly growths caused by the dust and gas emissions with simultaneous lack of visible changes in anatomic elements of the wood. The similar results obtained Aleksandrowicz (1992) for pine wood stating also the decrease of the wood density with the increase of degree of damage of stands. The negative influence of industrial emissions on wood of trees growing in an area of the influence was noticed by Sprawa-Neyman et al. (1988). It results from their investigations that Scots pine (*Pinus sylvestris* L.) wood growing for ca. 40 years in the polluted area has ca. 10% lower compression strength and 15% lower modulus of elasticity. The works of German authors (Liese 1987) prove however, the lack of significant differences in the number of strength properties of wood from damaged stands in comparison to healthy trees.

The higher conformity is observed during the estimation of the influence of dusts and gasses on trees growing in the range of the emissions. However, the higher content of bacteria and some fungi is observed in wood of damaged trees (Bauch and Frühwald 1983, Schmidt 1985), but it does not cause the significant decrease of the resistance to decay fungi from the class of *Basidiomycetes*. It is even observed lower losses of such wood in comparison to healthy trees (Schmidt et al. 1986).

The results obtained in these investigations indicating the lack of significant differences in the resistance to basidiomycetes of wood with symptoms of defoliation from the Karkonosze mountains area and wood of healthy trees are in the agreement with opinions of other authors.

RECAPITULATION

The conducted investigations prove that emissions of gasses and dusts in the Karkonosze Mountains, manifesting in defoliation of growing spruce trees, do not reduce spruce wood resistance to basidiomycetes. The resistance to the decay caused by *Coniophora puteana*, *Poria placenta*, *Serpula lacrymans* and *Gloeophyllum trabeum* of spruce wood from the studied region is comparable to the resistance of wood of healthy trees from the Karkonosze Mountains as well as from Pomerania. The observed, regardless of the degree of tree health, lower degree of the spruce heartwood resistance is caused by the high sensibility of *S. lacrymans* and *G. trabeum* on substances present in that area of pine wood. The limited number of test fungi in the investigations on the wood natural resistance may lead to mistaken conclusions. The set of fungi should also contain *Coniophora puteana*, which is characterized by high activity in wood decay including pine heartwood.

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ODPORNOŚĆ NA DZIAŁANIE GRZYBÓW PODSTAWCZAKÓW DREWNA ŚWIERKA (*PICEA ABIES* (L.) KARST.) Z TERENU OBJĘTEGO EMISJAMI PRZEMYSŁOWYMI W KARKONOSZACH

Streszczenie

Drewno świerka (*Picea abies* (L.) Karst.) pochodzące z drzew wykazujących wysoki stopień defoliacji i drzew zdrowych z terenu objętego emisjami przemysłowymi w Karkonoszach poddano w kontrolowanych warunkach laboratoryjnych działaniu grzybów rozkładu brunatnego (*Coniophora puteana, Poria placenta, Serpula lacrymans, Gloeophyllum trabeum*). Takiemu samemu testowi poddano drewno świerka i sosny (*Pinus sylvestris* L.) pochodzące z drzewostanów zdrowych z rejonu Szczecinka (Pomorze).

Po 16 tygodniach działania grzybów określono ubytki masy próbek. Stwierdzono, że odporność drewna świerka drzew uszkodzonych emisjami przemysłowymi nie wykazuje istotnych zmian wobec użytych grzybów testowych w porównaniu do drewna drzew zdrowych.

Niezależnie od stopnia zdrowotności drzew, stwierdzono mniejszą odporność na działanie *P. placenta* i *S. lacrymans* drewna świerkowego z Karkonoszy w porównaniu do drewna tego samego gatunku z Pomorza.

Authors' address:
inż. Maria Bartkowiak
mgr inż. Grzegorz Cofta
prof. dr hab. Kazimierz Lutomski
dr inż. Bartłomiej Mazela
Akademia Rolnicza im. A. Cieszkowskiego w Poznaniu
Instytut Chemicznej Technologii Drewna
60-637 Poznań, ul. Wojska Polskiego 38/42
POLAND