

CHEMICAL COMPOSITION AND CONTENT OF SELECTED HEAVY METALS IN THE WOOD OF COMMON SEA BUCKTHORN (*HIPPOHAË RHAMNOIDES* L.) GROWING IN THE COASTAL REGIONS OF THE BALTIC SEA

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Abstract. The investigations were carried out on the common sea buckthorn (*Hippohaë rhamnoides* L.) growing in the coastal areas of the Baltic Sea. The performed analyses comprised the determination of the basic chemical composition and selected heavy metals. For comparative purposes, investigations were also conducted on wood of the common sea buckthorn growing in urban conditions, namely in the city of Poznań. On the basis of the performed experiments it was found that the content of cellulose in the examined material ranged from 33.6 to 39.3% with the highest values determined in the wood of bushes growing in urban conditions. In addition, considerable differences were also observed in the lignin content in the compared samples, whereas the concentration of pentosans remained at the level of 18% irrespective of the place of sample collection. Concentrations of the examined heavy metals did not exceed levels dangerous for the growth and development of the examined bushes.

Key words: common sea buckthorn (*Hippohaë rhamnoides* L.), chemical composition, heavy metals

INTRODUCTION

The common sea buckthorn (*Hippohaë rhamnoides* L.) belongs to the family of oleaster (*Elaegnaceae*) and can be found in its natural habitat in Europe, Caucasus, Siberia, as well as in Minor and Central Asia. In Poland, it can be found growing in its natural conditions on sandy coastal dunes. The largest communities of the common sea buckthorn occur in the western part of the Baltic coast between Świnoujście and Niechorze, as well as in the neighbourhood of Jastrzębia Góra and cliff coasts of the

Wolin Island and along the coast of the Puck Bay [Sobczak 1996]. It can also be found planted artificially all over Poland.

The common sea buckthorn is employed widely especially to strengthen sea cliffs and to secure and consolidate dunes due to its exceptionally well-developed root system which, thanks to deep rooting and numerous lateral roots, can bind strongly and permanently the coastal belt [Grochowski 1983]. The climatic conditions prevailing in the seaside zone encourage spontaneous renewal and spreading of the buckthorn plants and the development of separate bush communities. It is the common sea buckthorn that is responsible for plant successions on bare cliffs. It is a species that takes over sward phytocoenoses but, at the same time, helps other arboreous plants to settle sea cliffs [Piotrowska 2003]. In addition, the symbiosis of the common sea buckthorn with bacteria fixing atmospheric nitrogen results in the fertilisation of the soil poor in nitrogen compounds and, by doing so, it prepares the soil for more demanding plants. Last but not least, its low soil requirements and high resistance to atmospheric contamination makes this plant a very good plant species which can be used as a pioneer plant for the reclamation of industrial sites [Grochowski 1983].

In 1994 investigations were carried out on raw material obtained from the coastal area of the Baltic Sea differing climatically and geographically [Prądzyński et al. 1996]. The results of those studies revealed that the content of cellulose in the wood of the examined common sea buckthorn (*Hippohaë rhamnoides* L.) ranged from 40.3 to 44.4% and showed a decreasing tendency in plants derived from the west to east coast (from Świnoujście to Niechorze).

The aim of this study was to verify the basic chemical composition and the content of heavy metals in the wood of common sea buckthorn growing in the coastal areas of the Baltic Sea differing climatically and geographically.

MATERIAL AND RESEARCH METHODOLOGY

The material for experiments was collected from bushes growing in the technical zone of:

- Szczecin Lagoon – Nowe Warpno, Brzóska, Trzebież
- Hel Peninsula – Władysławowo
- Gdańsk Bay – Sopot.

In addition, for comparative purposes, investigations were also carried out on the material collected from inland areas, i.e. from the urban agglomeration of Poznań.

Prior to chemical analyses, the experimental material was ground. First the obtained wood was cut into 1 cm long pieces using for this purpose pruning scissors. Then, after drying them to air dry state, the pieces were ground in a mill using a 4 mm mesh plate. The obtained sawdust was sieved through analytical sieves in order to obtain the required fraction of 0.5-1.0 mm.

The analysis of the obtained raw material comprised:

- determination of wood basic chemical composition (percentage content of cellulose, pentosans and lignin, mineral substances as well as substances soluble in cold and hot water, in organic solvents and 1% NaOH solution); all analyses were carried out in accordance with the PN-92 P50092 standard

- determination of selected heavy metals (Cu, Cd, Pb) in wood; all analyses were carried out in accordance with the PN-91 R0401 standard.

RESULTS

The investigation results of the percentage content of the principal wood constituents of the common sea buckthorn are presented in Table 1. The cellulose content in the wood of the sea buckthorn obtained from the eastern part of the coast ranged from 38.4% from Władysławowo to 36.6% from the Sopot municipality. These values are higher in comparison with those determined in the material collected from the zone of Szczecin Lagoon in which the average content of this wood constituent was approximately 34%. The highest values exceeding 39% were observed in the result of analysis of the sea buckthorn growing along the dual carriage-way in Poznań. The analysis of the next principal wood constituent – lignin – revealed that its content in the examined materials varied and was contained in the interval ranging from 26.5% to 35.3%. In the case of the sea buckthorn growing in the zone of Szczecin Lagoon, the average lignin content amounted to 28.1%. The content of lignin determined in the material obtained from Władysławowo and Sopot as well as from Poznań, was higher exceeding 30% with the highest values of 35.3% determined in the wood growing along the Hel Peninsula. Considerably smaller variations in the percentage content of principal wood constituents in the examined materials were determined in the case of low-polymerized carbohydrate constituents – pentosans. In all the examined materials, the pentosan content fluctuated between 17-18%.

Table 1. Percentage content of the principal constituents in the wood of sea buckthorn derived from the coastal parts of the Baltic Sea and from Poznań

Tabela 1. Zawartość procentowa głównych składników chemicznych drewna rokitnika wzrastającego w strefie nadbrzeżnej Morza Bałtyckiego oraz w Poznaniu

Material Materiał		Cellulose Celuloza	Lignin Lignina	Pentosans Pentozany
		%		
Gdańsk Bay Zatoka Gdańska	Sopot	36.6	35.3	18.0
Hel Peninsula Półwysep Helski	Władysławowo	38.4	33.6	16.8
Szczecin Lagoon Zalew Szczeciński	Nowe Warpno	33.6	28.3	18.3
	Brzózki	34.4	29.5	18.2
	Trzebież	34.3	26.5	17.1
Agglomeration of Poznań Aglomeracja miejska	Poznań	39.3	33.4	18.4

Table 2 collates the results of determination of the secondary constituents of the examined wood. The highest contents of substances soluble in organic solvents were determined in the material obtained from the Szczecin Lagoon, on average 6.1%. The proportion of this constituent in the wood of the sea buckthorn obtained from Trzebież amounted to 5.3%, from Brzózki – to 6.4% and from Nowe Warpno – to 6.6%. Similar proportions of substances soluble in organic solvents were determined in the wood of sea buckthorn obtained from the Gdańsk Bay and Hel Peninsula. Its proportion determined in the material obtained from Władysławowo reached 6.6%, whereas in that collected in Sopot slightly less – 5.3%. Sea buckthorn wood was found to contain relatively high contents of substances soluble in cold and hot water; the highest levels of these substances, 9.9 and 14.1%, respectively, were determined in the wood obtained from bushes growing on the Szczecin Lagoon in the neighbourhood of Nowe Warpno. The content of water soluble substances in the wood obtained from the remaining locations was slightly lower but it always exceeded the results recorded for the wood obtained from Poznań agglomeration. Moreover, the wood obtained from bushes growing along the sea coast was characterized by high levels of substances soluble in 1% solution of NaOH which were considerably higher in comparison with the wood derived from Poznań (18.9%). The levels of these substances in samples from the Szczecin Lagoon were similar and averaged about 26%, while the wood obtained from Sopot and Władysławowo contained lower quantities of substances soluble in sodium hydroxide solution amounting to about 20%.

Table 2. Percentage proportion of secondary wood constituents in the wood of common sea buckthorn growing in the coastal zone of the Baltic Sea and in Poznań

Tabela 2. Zawartość procentowa ubocznych składników chemicznych drewna rokitnika wzrastającego w strefie nadbrzeżnej Morza Bałtyckiego oraz w Poznaniu

Material	Material	Substances soluble in: Substancje rozpuszczalne w:			
		organic solvents rozpuszczalnikach organicznych	cold water zimnej wodzie	hot water gorącej wodzie	1% NaOH solution roztworze 1-procentowym NaOH
%					
Gdańsk Bay Zatoka Gdańska	Sopot	5.3	6.6	10.1	20.6
The Hel Peninsula Półwysep Helski	Władysławowo	6.6	9.8	8.1	19.7
Szczecin Lagoon Zalew Szczeciński	Nowe Warpno	6.6	9.9	14.1	25.8
	Brzózki	6.4	8.9	13.6	26.4
	Trzebież	5.3	6.3	12.9	26.0
Agglomeration of Poznań Agglomeracja miejska	Poznań	5.6	4.2	6.0	18.9

The content of selected heavy metals (Table 3) was determined in order to assess the impact of environmental contamination on the chemical composition of the sea buckthorn wood growing in coastal zones of the Baltic Sea. On the basis of the obtained results, it was found that the highest concentration of copper in the analysed experimental materials occurred in the wood of sea buckthorn growing in the Szczecin Lagoon. In the case of the material obtained from Nowe Warpno, Brzózki and Trzebież, the average amount of this element was determined at the level of 2.43 ppm. Bearing in mind the content of copper in plants according to Kabata-Pendias and Pendias [1999] – 4.00-5.00 ppm, the level of copper determined in this experiment was relatively low indicating shortage of this element in the examined plants. Even less copper (0.18 ppm on average) was determined in the wood of the sea buckthorn derived from the eastern coast. Also the cadmium content determined in the examined wood did not exceed allowable standards for the over ground plant parts according to Kabata-Pendias and Pendias [1999] – 0.05-0.20 ppm. The highest levels reaching 0.17 ppm were determined again in the wood of sea buckthorn growing on the western coast in Trzebież. In the case of the eastern coast, both in the case of sea buckthorn growing near Sopot as well as near Władysławowo, the concentration of this element amounted to 0.10 ppm. Despite considerable variations in the concentration of lead determined in the wood of sea buckthorn growing in the Gdańsk Bay and Hel Peninsula, its acceptable levels were not exceeded. The content of this element determined in the wood obtained from Sopot was two times higher in comparison with the wood derived from Władysławowo.

Table 3. Content of selected heavy metals in the wood of sea buckthorn growing in the coastal zone of the Baltic Sea and in Poznań

Tabela 3. Zawartość wybranych metali ciężkich w drewnie rokitnika wzrastającym w strefie nadbrzeżnej Morza Bałtyckiego oraz w Poznaniu

Material Material		Cu	Cd	Pb	Total Suma
ppm					
Gdańsk Bay Zatoka Gdańska	Sopot	0.16	0.10	1.28	1.54
Hel Peninsula Półwysep Helski	Władysławowo	0.20	0.10	0.54	0.84
Szczecin Lagoon Zalew Szczeciński	Nowe Warpno	2.51	0.13	0.73	3.37
	Brzózki	2.26	0.14	0.89	3.39
	Trzebież	2.51	0.17	1.08	3.76
Agglomeration of Poznań Agglomeracja miejska	Poznań	0.07	0.04	0.74	0.85

RECAPITULATION

Differences were found in the content of principal and secondary wood constituents which can probably be attributed to different climatic-natural conditions prevailing in the western and eastern parts of the sea coast. The content of cellulose in the examined material ranged from 33.6 to 39.3% with the highest values determined in the wood of bushes growing in urban conditions. In addition, considerable differences were also observed in the lignin content in the compared samples, whereas the concentration of pentosans remained at the level of 18% irrespective of the place of sample collection. The common sea buckthorn collected from the western coast grew in the vicinity of the Szczecin Lagoon water region bearing the hallmarks of both land and sea reservoir. The other sea buckthorn collected from the eastern coast developed in a sea environment. Consequently, the influence of different environments found its reflection in differences in the determined chemical composition.

On the basis of the performed investigations, relatively low levels of heavy metals were determined in all the experimental materials, irrespective of the place of sample collection. The obtained results confirmed satisfactory ecological-environmental conditions existing in the coastal regions of the Baltic Sea.

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SKŁAD CHEMICZNY I ZAWARTOŚĆ WYBRANYCH METALI CIĘŻKICH W DREWIE ROKITNIKA (*HIPPOHAË RHAMNOIDES* L.) ROSNĄCEGO W STREFIE NADBRZEŻNEJ MORZA BAŁTYCKIEGO

Streszczenie. W pracy omówiono zawartość procentową głównych i ubocznych składników drewna rokitnika zwyczajnego (*Hippohaë rhamnoides* L.) rosnącego w strefie nadbrzeżnej Morza Bałtyckiego. Dodatkowo w celu określenia wpływu zanieczyszczeń śro-

dowiska zbadano zawartość wybranych metali ciężkich w drewnie. Ze względu na różnicowanie warunków klimatyczno-geograficznych badania przeprowadzono na próbkach drewna pozyskanych z zachodniej i wschodniej części wybrzeża. Otrzymane rezultaty zestawiono z danymi uzyskanymi dla drewna rokitnika rosnącego w aglomeracji miejskiej Poznania. Na podstawie wyników stwierdzono, że zawartość celulozy w badanych próbkach wahała się w przedziale od 33,6 do 39,3%, przy czym wartości najwyższe uzyskano dla drewna krzewów rosnących w aglomeracji miejskiej. Zaobserwowano również znaczne różnice w zawartości ligniny w porównywanych próbkach, a zawartość pentozanów utrzymywała się na poziomie około 18%, niezależnie od miejsca pobrania próbek materiału. Udział badanych metali ciężkich nie przekraczał zawartości niebezpiecznych dla wzrostu i rozwoju badanych krzewów.

Słowa kluczowe: rokitnik zwyczajny (*Hippohaë rhamnoides* L.), skład chemiczny, metale ciężkie

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