



UNIVERSITY
of SOPRON

11th Hardwood Conference

30-31 May 2024
Sopron

11TH HARDWOOD CONFERENCE PROCEEDINGS

Róbert Németh, Christian Hansmann, Holger Militz, Miklós Bak, Mátyás Báder



11TH HARDWOOD CONFERENCE PROCEEDINGS

Sopron, Hungary, 30-31 May 2024

**Editors: Róbert Németh, Christian Hansmann, Holger Militz,
Miklós Bak, Mátyás Báder**



UNIVERSITY OF SOPRON PRESS

SOPRON, 2024

11TH HARDWOOD CONFERENCE PROCEEDINGS

Sopron, Hungary, 30-31 May 2024

Editorial board

Prof. Dr. Róbert Németh

Dr. Christian Hansmann

Prof. Dr. Holger Militz

Dr. Miklós Bak

Dr. Mátyás Báder

[University of Sopron](#) – Hungary

[FATE - Scientific Association for Wood Industry](#) – Hungary

[Wood K Plus](#) – Austria

[Georg-August University of Göttingen](#) – Germany

[University of Sopron](#) – Hungary

[University of Sopron](#) – Hungary

[FATE - Scientific Association for Wood Industry](#) – Hungary

Scientific committee

Prof. Dr. Dr. h.c. Peter Niemz

Prof. Dr. Dr. h.c. Alfred Teischinger

Prof. Dr. George I. Mantanis

Prof. Dr. Bartłomiej Mazela

Prof. Dr. Julia Mihailova

Prof. Dr. Joris Van Acker

Prof. Dr. Ali Temiz

Prof. Dr. Henrik Heräjärvi

Prof. Dr. Andreja Kutnar

Prof. Dr. Goran Milić

Dr. Vjekoslav Živković

Dr. Rastislav Lagana

Dr. Milan Gaff

Dr. Lê Xuân Phương

Dr. Peter Rademacher

Dr. Emilia-Adela Salca

Dr. Galina Gorbacheva

[ETH Zürich](#) – Switzerland / [Luleå University of Technology](#) – Sweden

[BOKU University Vienna](#) – Austria

[University of Thessaly](#) – Greece

[Poznań University of Life Sciences](#) – Poland

[University of Forestry](#) – Bulgaria

[Ghent University](#) – Belgium

[Karadeniz Technical University](#) – Turkey

[Natural Resources Institute Finland \(LUKE\)](#) – Finland

[InnoRenew CoE](#) – Slovenia

[University of Belgrade](#) – Serbia

[University of Zagreb](#) – Croatia

[TU Zvolen](#) – Slovak Republic

[Mendel University Brno](#) – Czech Republic

[Vietnam National University of Forestry](#) – Vietnam

[Eberswalde University for Sustainable Development](#) – Germany

[“Transilvania” University of Brasov](#) – Romania

[Bauman Moscow State Technical University](#) – Russian Federation

Cover design

Ágnes Vörös

[University of Sopron](#) – Hungary

Webservices

Dr. Miklós Bak

[11th Hardwood Conference official website](#)

[University of Sopron](#) – Hungary

ISBN 978-963-334-518-4 (pdf)

DOI <https://doi.org/10.35511/978-963-334-518-4>

ISSN 2631-004X (Hardwood Conference Proceedings)

Constant Serial Editors: Prof. Dr. Róbert Németh, Dr. Miklós Bak

Cover image based on the photograph of Dr. Miklós Bak, 2024

The manuscripts have been peer-reviewed by the editors and have not been subjected to linguistic revision.

In the articles, corresponding authors are marked with an asterisk (*) sign.

[University of Sopron Press](#), 2024 (Bajcsy-Zsilinszky 4, 9400 Sopron, Hungary)

Responsible for publication: Prof. Dr. Attila Fábián, rector of the [University of Sopron](#)

Creative Commons license: CC BY-NC-SA 4.0 DEED



Nevezd meg! - Ne add el! - Így add tovább! 4.0 Nemzetközi
Attribution-NonCommercial-ShareAlike 4.0 International

Sponsors: [University of Sopron](#), Hungary; [Wood K Plus](#), Austria; [Georg-August University of Göttingen](#), Germany; [Scientific Association for Wood Industry](#), Hungary



UNIVERSITY
of SOPRON

WOOD
KPLUS



FATE

Content

Preface to the 11TH HARDWOOD CONFERENCE

Róbert Németh..... 9

Plenary Session - Keynotes of the 11TH HARDWOOD CONFERENCE

- The role of black locust (*Robinia pseudoacacia*) in Czechia
Ivan Kuneš, Martin Baláš, Přemysl Šedivka, Vilém Podrázský 11
- Engineered wood products for construction based on beech and poplar resources in Europe
Joris Van Acker, Liselotte De Ligne, Tobi Hallez, Jan Van den Bulcke 23
- The situation in the hardwood sector in Europe
Maria Kiefer-Polz, Rainer Handl 60

Session I - Silvicultural aspects and forest management of hardwoods

- Monitoring xylogenesis as a tool to assess the impact of different management treatments on wood formation: A study case on *Vitis vinifera*
Angela Balzano, Maks Merela, Meta Pivk, Luka Krže, Veronica De Micco 62
- The History of Forests - Climate Periods of the Middle Ages and Forestry
Emese Berzsenyi, Dóra Hegyesi, Rita Kattein-Pornói, Dávid Kazai..... 63
- Climate change mitigation aspects of increasing industrial wood assortments of hardwood species in Hungary
Éva Király, Zoltán Börzsök, Attila Borovics..... 71
- Uncovering genetic structures of natural Turkey oak populations to help develop effective climate change strategies for forestry
Botond B. Lados, László Nagy, Attila Benke, Csilla É. Molnár, Zoltán A. Köbölkuti, Attila Borovics, Klára Cseke..... 78
- Ash dieback: infection biology and management
Nina E. Nagy, Volkmar Timmermann, Isabella Børja, Halvor Solheim, Ari M. Hietala..... 86
- The Role of Industrial Hardwood Production Plantations and Long-Term Carbon Sequestration in a Circular Economy via the New *Robinia pseudoacacia* ‘Turbo Obelisk’ Varieties
Márton Németh, Kálmán Pogrányi, Rezső Solymos..... 95
- Initial growth of native and introduced hardwoods at the afforested agricultural lands – preliminary results
Vilém Podrázský, Josef Gallo, Martin Baláš, Ivan Kuneš, Tama Abubakar Yahaya, Miroslav Šulitka
 102

Poster Session

- Light response curve analysis of juvenile Püspökladányi and Üllői black locust
Tamás Ábri, Zsolt Keserű, József Csajbók..... 111
- Revealing the optimum configuration of heat-treated wood dowel joints by means of Artificial Neural Networks and Response Surface Methodology
Bogdan Bedeleian, Cosmin Spîrchez..... 115
- Artificial neural networks as a predictive tool for thrust force and torque during drilling of wood-based composites
Bogdan Bedeleian, Mihai Ispas, Sergiu Răcășan 121

Research on the value retention of hardwood products in the spirit of sustainability <i>Daniel Bodorkós, József Zalavári, Péter György Horváth</i>	126
Abrasive Water Jet Cutting vs. Laser Jet Cutting of Oak Wood Panels <i>Camelia Cosereanu, Gheorghe Cosmin Spirchez, Antonela Lungu, Sergiu-Valeriu Georgescu, Alexandru Catalin Filip, Sergiu Racasan</i>	131
Polyphenol content of underutilized wood species from Hungary <i>Tamás Hofmann, Haruna Seidu, Kibet Tito Kipkoror</i>	136
Wood quality evaluation of 32 grafted clone linages of Keyaki (<i>Zelkova serrata</i>) plus trees 12 years after planting <i>Kiyohiko Ikeda, Shigehiro Yamamoto</i>	141
Influence of the number of belts over vibrations of the cutting mechanism in woodworking shaper <i>Georgi Kovatchev, Valentin Atanasov</i>	146
The impact of litter forest fires on the internal structure of wood from stem of beech trees <i>Elena-Camelia Musat, Costin-Ovidiu Vantoiu, Emilia-Adela Salca</i>	153
Analysing innovative wood joints crafted by laser cut spline curves <i>László Németh, József Garab, Péter György Horváth</i>	158
Dynamic fatigue tests of hardwoods <i>Gábor Orbán, Antal Kánnár</i>	163
Restoration of an old painted oak boardsign - A case study <i>Gabriel Calin Canalas, Emilia-Adela Salca, Elena-Camelia Musat</i>	168
Some physical properties of native and thermo-treated <i>Fraxinus excelsior</i> timber <i>Cosmin Spirchez, Aurel Lunguleasa, Alin Olărescu, Camelia Coşereanu, Bogdan Bedelea</i>	173
The surface morphology of sanded curly maple in comparison with straight grain maple selected for musical instruments <i>Mariana Domnica Stanciu, Lidia Gurau, Florin Dinulica, Catalin Constantin Roibu, Cristian Hiciu, Andrei Mursa, Marian Stirbu</i>	178
Analysis of changes in the composition of beech as an important industrial raw material in Hungary <i>Katalin Szakálosné Mátyás, Attila László Horváth</i>	183
Investigation of old hardwood structure element <i>Fanni Szőke, Antal Kánnár</i>	187
An investigation of the influence of coating film thickness on the light induced colour changes of clear coated maple (<i>Acer pseudoplatanus</i>) wood surfaces with natural aspect <i>Mihai-Junior Torcătoru, Maria Cristina Timar</i>	192
Composite Material Manufacturing from Plantation Paulownia Wood with Using Microwave Technology: Technical and Cost Analyses <i>Grigory Torgovnikov, Peter Vinden, Alexandra Leshchinskaia</i>	198
Thermal modification of wood as a tool for changing the colour of hardwoods <i>Vidholdová Zuzana</i>	203
High termite resistance of kempas (<i>Koompassia malaccensis</i>) hardwood protected with a novel vegetal extracts-cypermethrin wood preservative under outdoor aboveground tropical environment <i>Messaoudi Daouia, Wong Andrew H.H.</i>	209
Comparison of wood properties of pedunculate oak and non-native northern red oak from an anthropogenic site <i>Aleš Zeidler, Vlastimil Borůvka</i>	214
Acoustic Parameters of Pioneer Wood Species <i>Petr Horák, Vlastimil Borůvka</i>	219
Determination of Elastic Parameters of Birch and Oak Wood Using Optical Method <i>David Novák, Vlastimil Borůvka, Petr Horák, Tomáš Kytka</i>	224

Preliminary study on climate change impacts on annual wood growth development in Hungary <i>Péter Farkas, Zsolt György Tóth, Huba Komán</i>	230
Combustion characteristics of Russian olive (<i>Elaeagnus angustifolia</i> L.) <i>Szabolcs Komán, Krisztián Töröcsi</i>	236
Withdrawal capacity of Green ash (<i>Fraxinus pennsylvanica</i> Marsh.) and Box elder (<i>Acer negundo</i> L.) <i>Szabolcs Komán, Boldizsár Déri</i>	241
Formaldehyde emission from wood and wood-based products <i>Szabolcs Komán, Csilla Czók, Tamás Hofmann</i>	246
Finite element analysis of heat transfer of Turkey oak (<i>Quercus cerris</i>) <i>Sándor Borza, Gergely Csiszár, József Garab, Szabolcs Komán</i>	250
Possible alternative to creosote treated railway sleepers, Fürstenberg-System Sleeper (FSS) <i>Szabolcs Komán, Balogh Mátyás Zalán, Sándor Fehér</i> ,.....	255
Investigation of bendability characteristics of wood-based polymer composites <i>S. Behnam Hosseini, Milan Gaff</i>	260
Comparing the blossoming and wood producing properties of selected black locust clones <i>Alexandra Porcsin, Katalin Szakálosné Mátyás, Zsolt Keserű</i>	266
The influence of two different adhesives on structural reinforcement of oak-wood elements by carbon and glass fibres <i>Andrija Novosel, Vjekoslav Živković</i>	271
Investigating Kerf Topology and Morphology Variation in Native Species After CO ₂ Laser Cutting <i>Lukáš Štefančin, Rastislav Igaz, Ivan Kubovský, Richard Kminiak</i>	272
Comparison of fluted-growth and cylindrical hornbeam logs from Hungarian forests <i>Mátyás Báder, Maximilián Cziczzer</i>	279
Thermal modification affects the dynamic vapor sorption of tree of heaven wood (<i>Ailanthus altissima</i> , Mill.) <i>Fanni Fodor, Lukas Emmerich, Norbert Horváth, Róbert Németh</i>	285
How conditions after application affect the depth of penetration of gel wood preservative in oak <i>Jan Baar, Štěpán Bartoš, Anna Oberle, Zuzana Paschová</i>	290
The weathering of the beech wood impregnated by pigmented linseed oil <i>Jakub Dömény, Jan Baar</i>	294
Examination of the durability of beeswax-impregnated wood <i>Miklós Bak, Ádám Bedők, Róbert Németh</i>	299
Preparation of pleated oak samples and their bending tests at different moisture contents <i>Pál Péter Gecseg, Mátyás Báder</i>	304
Bending test results of small-sized glued laminated oak timber consisting of 2, 3 and 5 layers <i>Dénes Horváth, Sándor Fehér</i>	308
Homogenized dynamic Modulus of Elasticity of structural strip-like laminations made from low-grade sawn hardwood <i>Simon Lux, Johannes Konnerth, Andreas Neumüller</i>	314
Impact of varnishing on the acoustic properties of sycamore maple (<i>Acer pseudoplatanus</i>) panels <i>Aleš Straže, Jure Žigon, Matjaž Pavlič</i>	319
The effect of wood and solution temperatures on the preservative uptake of Pannonia poplar and common spruce – preliminary research <i>Luca Buga-Kovács, Norbert Horváth</i>	325

Session II - Hardwood resources, product approaches, and timber trade

Birch tar – historic material, innovative approach <i>Jakub Brózdowski, Monika Bartkowiak, Grzegorz Cofta, Grażyna Dąbrowska, Ahmet Erdem Yazici, Zbigniew Katolik, Szymon Rosołowski, Magdalena Zborowska</i>	330
Beech Wood Steaming – Chemical Profile of Condensate for Sustainable Applications <i>Goran Milić, Nebojša Todorović, Dejan Orčić, Nemanja Živanović, Nataša Simin</i>	336
Towards a complete technological profile of hardwood branches for structural use: Case study on Poisson's ratio <i>Tobias Nennung, Michael Grabner, Christian Hansmann, Wolfgang Gindl-Altmutter, Johannes Konnerth, Maximilian Pramreiter</i>	342
Low-value wood from non-native tree species as a potential source of bioactive extractives for bio-based preservation <i>Viljem Vek, Ida Poljanšek, Urša Osolnik, Angela Balzano, Miha Humar, Primož Oven</i>	349
Hardwood Processing - do we apply appropriate technologies? <i>Alfred Teischinger</i>	357

Session III - Surface coating and bonding characteristics of hardwoods

Influence of pretreatments with essential oils on the colour and light resistance of maple (<i>Acer pseudoplatanus</i>) wood surfaces coated with shellac and beeswax <i>Emanuela Carmen Beldean, Maria Cristina Timar, Dana Mihaela Pop</i>	365
Oak timber cross-cutting based on fiber orientation scanning and mechanical modelling to ensure finger-joints strength <i>Soh Mbou Delin, Besseau Benoit, Pot Guillaume, Viguiet Joffrey, Marcon Bertrand, Milhe Louis, Lanvin Jean-Denis, Reuling Didier</i>	376
From Phenol-Lignin Blends towards birch plywood board production <i>Wilfried Sailer-Kronlachner, Peter Bliem, Hendrikus van Herwijnen</i>	386
Flatwise bending strength and stiffness of finger jointed beech lamellas (<i>Fagus sylvatica</i> , L.) using different adhesive systems and effect of finger joint gap size <i>Hannes Stolze, Adefemi Adebisi Alade, Holger Militz</i>	395
Mode I fracture behaviour of bonded beech wood analysed with acoustic emission <i>Martin Capuder, Aleš Straže, Boris Azinović, Ana Brunčič</i>	402

Session IV - Hardwood structure and properties

Compression strength perpendicular to grain in hardwoods depending on test method <i>Marlene Cramer</i>	410
Compensatory Anatomical Studies on <i>Robinia</i> , <i>Sclerocarya</i> and <i>Ulmus</i> <i>Fath Alrhman A. A. Younis, Róbert Németh, Mátyás Báder</i>	420
The influence of the type of varnish on the viscous-elastic properties of maple wood used for musical instruments <i>Roxana Gall, Adriana Savin, Mariana Domnica Stanciu, Mihaela Campean, Vasile Ghiorghe Gliga</i>	426
XRF investigation of subfossil oak (<i>Quercus</i> spp) wood revealing colour - iron content correlation <i>Nedelcu Ruxandra, Timar Maria Cristina, Beldean Emanuela Carmen</i>	435
Investigating the Development of Heartwood in <i>Quercus robur</i> in Denmark <i>Andrea Ponzeccchi, Albin Lobo, Jill Katarina Olofsson, Jon Kehlet Hansen, Erik Dahl Kjær, Lisbeth Garbrecht Thygesen</i>	445

Modelling tensile mechanical properties of oak timber from fibre orientation scanning for strength grading purpose <i>Guillaume Pot, Joffrey Viguier, Benoit Besseau, Jean-Denis Lanvin, Didier Reuling</i>	452
Green oak building – small diameter logs for construction <i>Martin Huber, Franka Brüchert, Nicolas Hofmann, Kay-Uwe Schober, Beate Hörnel-Metzger, Maximilian Müller, Udo H. Sauter</i>	461
An evaluative examination of oak wood defect detection employing deep learning (DL) software systems. <i>Branimir Jambreković, Filip Veselčić, Iva Ištok, Tomislav Sinković, Vjekoslav Živković, Tomislav Sedlar</i>	466
Comparison of surface roughness of milled surface of false heartwood, mature wood, and sapwood within beech wood <i>Lukáš Adamčík, Richard Kminiak, Adrián Banski</i>	467

Session V - Hardwoods in composites and engineered materials

Developing Laminated Strand Lumber (LSL) based on underutilized Hungarian wood species <i>László Bejő, Tibor Alpár, Ahmed Altaher Omer Ahmed</i>	475
Feasibility study on manufacturing finger-jointed structural timber using <i>Eucalyptus grandis</i> wood <i>Adefemi Adebisi Alade, Hannes Stolze, Coenraad Brand Wessels, Holger Militz</i>	481
A novel approach for the design of flame-retardant plywood <i>Christian Hansmann, Georg Baumgartner, Christoph Preimesberger</i>	486
The use of beech particles in the production of particleboards based on recycled wood <i>Ján Iždinský, Emilia Adela Salca, Pavlo Bekhta</i>	493
Thermal properties of highly porous wood-based insulation material <i>Kryštof Kubista, Přemysl Šedivka</i>	501

Session VI - Modification & functionalization

Quantitative and qualitative aspects of industrial drying of Turkey oak lumber <i>Iulia Deaconu, Bogdan Bedeleian, Sergiu Georgescu, Octavia Zeleniuc, Mihaela Campean</i>	508
Changes in properties of maple by hygrothermally treatment for accelerated ageing at 135-142°C <i>Tobias Dietrich, Herwig Hackenberg, Mario Zauer, Holger Schiema, André Wagenführ</i>	518
Change of chemical composition and FTIR spectra of Turkey oak and Pannonia poplar wood after acetylation <i>Fanni Fodor, Tamás Hofmann</i>	525
Change of cellulose crystal structure in beech wood (<i>Fagus sylvatica</i> L.) due to gaseous ammonia treatment <i>Herwig Hackenberg, Tobias Dietrich, Mario Zauer, Martina Bremer, Steffen Fischer, André Wagenführ</i>	535
Evaluation of weathering performance of acetylated hardwood species <i>Rene Herrera Diaz, Jakub Sandak, Oihana Gordobil, Faksawat Poohphajai, Anna Sandak</i>	539
Unlocking a Potential Deacetylation of Acetylated Beech (<i>Fagus sylvatica</i> L.) LVL <i>Maik Slabohm, Holger Militz</i>	544
Fork and flying wood tests to improve prediction of board stress development during drying <i>Antoine Stéphane, Patrick Perré, Clément L'Hostis, Romain Rémond</i>	549
Modification of different European hardwood species with a bio-based thermosetting resin on a semi-industrial scale <i>Christoph Hötte, Holger Militz</i>	557

The effect of wood and solution temperatures on the preservative uptake of Pannonia poplar and common spruce – preliminary research

Luca Buga-Kovács¹, Norbert Horváth²

^{1,2} University of Sopron, Institute of Basic Sciences, Bajcsy-Zs. Str. 4, Sopron, Hungary, 9400

E-mail: kovacs.luca@phd.uni-sopron.hu; norbert.horvath@uni-sopron.hu

Keywords: prolonged immersion, Pannonia poplar, common spruce, temperature differences, copper-sulphate

ABSTRACT

Our research aimed to compare the effect of wood and solution temperatures on the preservative uptake of Pannonia poplar and common spruce. The choice of the wood species was motivated by the followings. Poplar trees are less used wood species in the Hungarian construction industry. Some hybrids have similar characteristics to the commonly used spruce. Among them, the properties of the hybrid Hungarian Pannonia poplar are the focus of much research nowadays, because a significant amount of Hungarian Pannonia poplar trees are maturing to cutting age. Imported spruce is a common structural timber used in the Hungarian construction industry. According to CEN EN 14734, a copper sulphate solution was used to evaluate the prolonged immersion treatment. The temperature of the wood samples was 20 °C for both tests. The temperature of the copper sulphate solution in the control test was the same as that of the wood materials at 20 °C, while in the other test the materials were soaked in a solution at 12 °C. The preservative uptake graph, the mass of the copper sulphate solution taken up and the calculated mass of copper-sulphate after 3 hours of prolonged immersion were determined. We found that Pannonia poplar can take up more solution than spruce. For both species, the uptake of preservative at the initial stage was higher for the 12 °C solution than for the room temperature solution.

INTRODUCTION

The present study focuses on Pannonia poplar, an abundant poplar hybrid in Hungary and common spruce, for several reasons. Spruce is frequently utilized as structural timber in the Hungarian construction industry. As it is found in small quantities (1%) in Hungarian forests, it is the most important imported timber (Molnár 2004). Poplar hybrids are the subject of much research nowadays among other things because of their structural potential. Additionally, the two species exhibit nearly identical physical-mechanical properties (Molnár, 2004).

Resistance to insects and decay fungi is also a major determinant of the performance of structural timber, which can be based on treatment with preservatives. According to the Hungarian building regulations, both the low-durability Pannonia poplar and the pine species used in the construction industry until now have to undergo additional chemical wood preservative treatment before installation. In Hungary, prolonged immersion treatment is the most common method of wood protection. The question arises to what extent the differences in temperature during the soaking of the two species of wood promote the absorption of the preservative. According to CEN EN 14734, a copper sulphate solution was used to evaluate the prolonged immersion.

The prolonged immersion is when the wood is immersed for a longer period of time in the liquid preservative or its solution. The liquid penetrates into the wood by means of capillary action and possibly further seepage. The effectiveness of the prolonged immersion and the depth of penetration, depends on the anatomical structure of the wood, its moisture status, the material of the preservative, the concentration of the preservative solution and the duration of the soaking (Gyarmati et al. 1964). The amount and extent of penetration of the preservative solution is influenced more by temperature than by duration (Bálint 1967).

The water in the wood freezes well below 0 °C. In the soaking tub the protective agent can freeze, although this can and should be avoided by using a heating rod or heating blanket in modern equipment to make the technology work. The movement of the bonded water in the wood is faster the higher the temperature.

A distinction has to be made between the temperature of the wood and the outside environment, as it is often the case (in spring, after snow melt) that the daily peak temperature is already around 20 °C, but the inside of the beam to be soaked or saturated is still frozen. In summary, the higher is the temperature of the wood, the faster is the movement of the water inside. The speed of water movement is also related to its density. Water is most dense at + 4 °C. The higher the temperature, the lower the density and surface tension of the water. The properties of water affect the properties of the solution also. In summer, the soaking wood preservation technology can be used without any particular constraints, as both the soaking liquid and the wood are at the right temperature. If the wood or the preservative solution is cooled below +5 °C, the effectiveness of the soaking process is severely impaired, and so the use of soaking technology is often a problem in winter. However, heating the preservative and/or the wood should be strongly considered as it is a very energy intensive operation and rarely economical (Király and Csupor 2013).

MATERIALS AND METHODS

The tested bulk samples originated from Hungarian growing areas. All the specimens had a lying annual ring position. A total of 8 spruce and 8 Pannonia poplar samples were tested. The specimens were cut from a board along the grain. Half of the test specimens served as control samples for both species. A 5% copper sulphate solution and frozen ice cubes prepared from it were used for the test to evaluate the prolonged immersion, as prescribed in CEN EN 14734. The frozen solution provided cooling and ensured that the solution did not dilute.

For the control samples, the temperature of the solution and the specimens was maintained at 20 °C (Figure 1, left). The initial temperature of the other group of samples was the same as the control samples, but in this case the copper sulphate solution was continuously cooled with frozen copper sulphate solution "ice cubes". The solution temperature was 12 °C during the test (Figure 1, right). The temperatures of the solutions and samples were determined for the reasons described above.



Figure 1: Prolonged immersion in room temperature solution (left) and with copper-sulphate "ice-cubes" cooled solution (right)

Weights were measured before adding to the solution (m_b). As the freshly immersed wood absorbs the liquid more quickly at first, the masses were measured more frequently in the initial stage. The masses were measured 7 times in both cases. The preservative uptake curves were determined from these mass measurements per sample groups.

The times of the mass measurements are summarised in the following table (Table 1).

Table 1: Times of the mass measurements

Measurement	1	2	4	4	5	6	7	8
Time (min.)	5	10	15	35	55	75	95	180

The last 8th measurement was taken 3 hours after immersion in the solution, from which the mass of the copper sulphate solution taken up was determined. The mass of the specimens was measured before (m_b) and after (m_a) the prolonged immersion. The mass of the copper sulphate solution taken up (Δm) was calculated from the difference between their weights (Eq. 1).

$$\Delta m = m_a - m_b \text{ [g]} \quad (1)$$

Δm – the mass of the copper sulphate solution taken up
 m_a – the measured mass after the treatment
 m_b – the measured mass before the treatment

$$m_{CuSO_4} = \Delta m \cdot 0,05 [g] \quad (2)$$

m_{CuSO_4} – the calculated mass of copper-sulphate

RESULTS AND DISCUSSION

The curves illustrates the average preservative uptakes of the sample groups are depicted in Figure 2. The first three measurements were taken every 5 minutes. The highest uptake of preservative is observed within the first 5 minutes at the beginning of the soak for all sample groups, as indicated by the slope of the curves. During this time the Pannonia poplar samples soaked in a 12 °C solution absorbed the most protective agent on average. Spruce specimens soaked in 12 °C and 20 °C solutions did not exhibit significant differences in average preservative uptake, but more preservative was absorbed by the room temperature solution on average. Weights were measured every 20 minutes subsequently. The uptake of Pannonia poplar samples immersed in room temperature preservative surpassed that of spruce samples by the 6th measurement. After 95 minutes of prolonged immersion, the Pannonia poplar samples absorbed more preservative than the spruce samples in both cases.

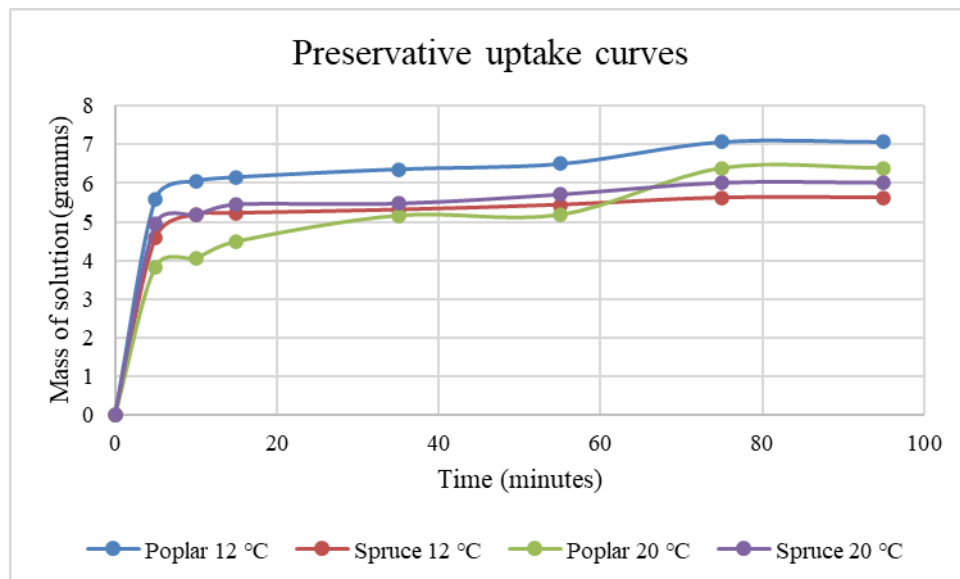


Figure 2: Preservative uptake curves during 95 minutes of prolonged immersion

Figure 3 illustrates the average preservative uptake of the sample groups after 3 hours of prolonged immersion. The Pannonia poplar specimens soaked in a cold solution at 12 °C absorbed an average of 7.11 grams of preservative, while the spruce specimens absorbed an average of 6.65 grams after three hours of prolonged immersion. The Pannonia poplar samples soaked in room temperature preservative were able to take up an average of 6.98 grams of preservative in the same time frame, while the spruce specimens absorbed an average of 6.89 grams. While in the case of Pannonia poplar, the samples soaked in the 12 °C solution exhibited a higher average uptake of preservative, in the case of spruce samples, those soaked in the 20 °C solution displayed a higher average mass of preservative. However, significant differences in preservative uptake were observed at the initial stage rather than after 3 hours of soaking.

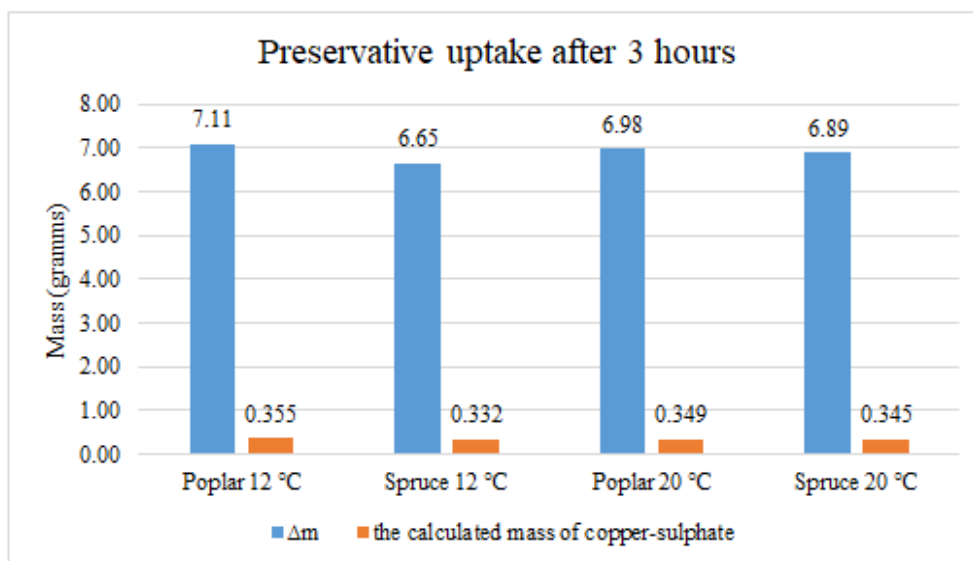


Figure 3: Preservative uptake after 3 hours of prolonged immersion

CONCLUSIONS

The prolonged immersion of Pannonia poplar has been demonstrated to be superior to that of spruce. The poplar hybrid species absorbed more of the solution at both liquid temperatures than spruce after 95 minutes of soaking. The uptake efficiency of Pannonia poplar samples is better in the 12 °C solution at the initial stage than in specimens soaked in preservative at room temperature. The Pannonia poplar samples absorbed more copper sulphate solution from both the cold and room temperature solutions after 3 hours. The differences between the groups of samples were much smaller than at the initial stage of soaking.

Overall, Pannonia poplar proved to be easier to treat with prolonged immersion than spruce, which is an important consideration for industrial protective treatment practices. Easier handling results in a higher durability class for treated wood. Pannonia Poplar can be classified in a higher durability class due to its easier prolonged immersion.

REFERENCES

- Bálint, Gyula (1967): Protection of buildings. (Épületek védelme) Műszaki Könyvkiadó Budapest. (in Hungarian) p. 180
- CEN EN 14734:2022 (MAIN): Durability of wood and wood-based products - Determination of treatability of timber species to be impregnated with wood preservatives - Laboratory method
- Gyarmati, Béla; Igmándy, Zoltán; Pagony, Hubert (1964): Wood protection. (Faanyagvédelem) Mezőgazdasági Kiadó Budapest (in Hungarian) p. 235
- Király, Béla; Csupor, Károly (2013): Materials and mixtures for chemical wood and fire protection. (A kémiai faanyag- és tűzvédelem anyagai és keverékei) Textbook. PALATIA Nyomda és Kiadó Kft. (in Hungarian) pp. 131-132
- Molnár, Sándor (2004): Wood material knowledge (Faanyagismeret). Szaktudás Kiadó Ház Zrt (in Hungarian) pp. 330, 390-391