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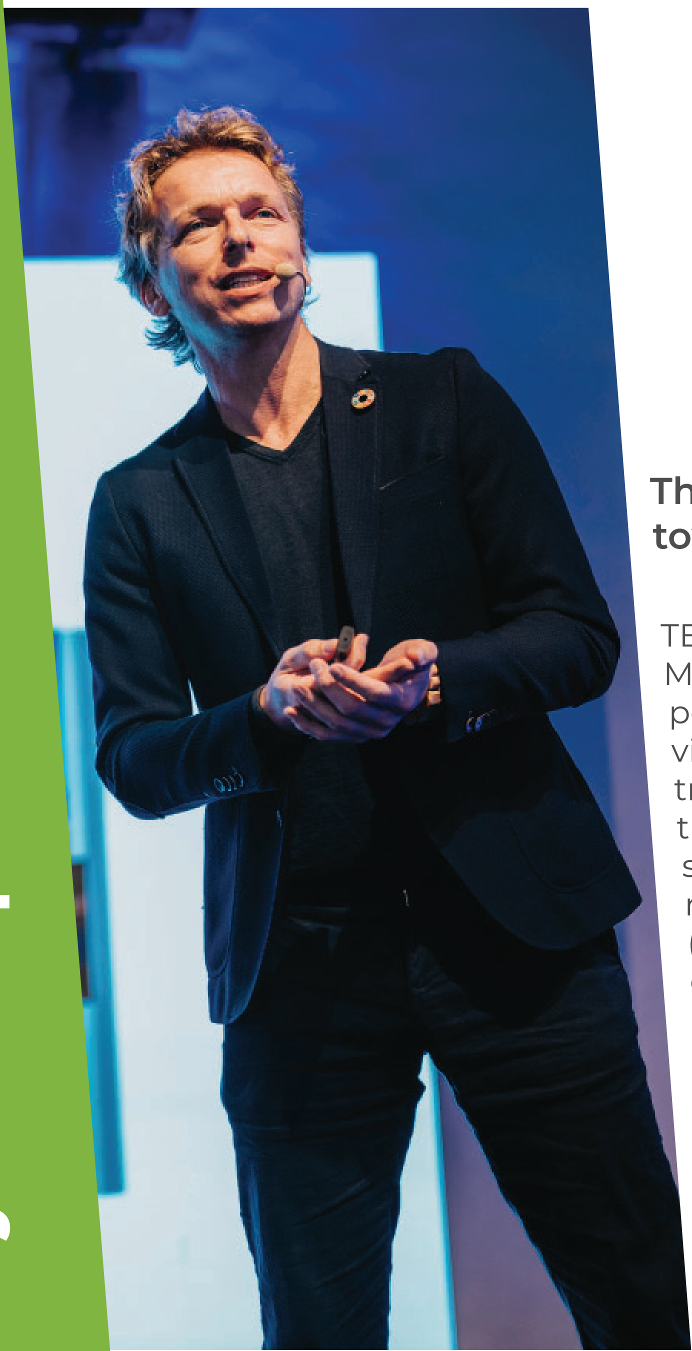
Keynote speaker

Pablo van der Lugt



The future is biobased – towards the next building revolution

TED speaker Pablo van der Lugt (PhD, MSc Eng) is a passionate advocate of high performance bio-based materials. In the vision of van der Lugt in the essential transition towards a more circular economy there are tremendous opportunities for smart biobased materials, made from renewable resources such as mass timber (CLT, Glulam, LVL, etc), modified wood and engineered bamboo, to substitute carbon intensive, high performance materials from the techno-cycle such as metals, minerals and plastics (PVC).

Van der Lugt is the author of several books on sustainable building, including the international acclaimed Tomorrow's Timber (2020) and Booming Bamboo (2017), which details the latest developments in design and architecture using bamboo and (mass) timber. Van der Lugt has published extensively in both popular magazines as scientific journals and regularly provides (keynote) presentations on this topic to stakeholders and policy makers in the building industry, including the International Climate Conference in Paris, COP 21, COP 24 and COP 26.

Innovative engineered wood products made from Thermo-hydro-mechanical densified wood with enhanced physical, mechanical, and fire performance (WoDeFi)

Lei Han [1,2], Marica Mikuljan [1,2], Matthew Schwarzkopf [1,2], Jaka Gašper Pečnik [1,2], Lea Primožič [1,2], Andreja Kutnar [1,2]*

[1] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia; Faculty of Mathematics, Natural Sciences and Information Technologies
[2] University of Primorska, Glagoljaška 8, 6000 Koper, Slovenia
* Corresponding author

In the past decade, the demand for wood applications in both residential and non-residential building construction has been on the rise. Due to increased competition from traditional and new industries that are based on renewable resources, forest resources must be considered limited. This increase in demand requires technologies to increase the life span and functionality of forest products to reduce the stress on forests. Competitive and environmentally friendly wood modification processes such as Thermo-hydro-mechanical (THM) densification have been and continue to be developed to improve the intrinsic properties of wood and ensure the desired form and functionality.

Nevertheless, wood as a natural material has some inherent features which could cause some problems. The current standards normally rate untreated mass-timber as flammable material. Hence, virgin wood products play a restrictive role in most of the built environment. This has been reinforced by some building codes and regulations through height and area limitations. The implementation of engineering processes to improve wood regarding durability or other properties should not overlook its effect on fire behavior. Therefore, the overall goal of the project is to apply wood THM densification to develop high performance engineered wood products (EWPs) with enhanced mechanical properties and fire resistance.

Keywords: EWP, fire safety, densification, timber construction

Acknowledgment: This project J4-50132 has received funding from the Slovenia Research and Innovation Agency (ARIS).

Development of thermal insulation materials from available renewables for sustainable buildings

Ramunas Tupciauskas, Andris Berzins, Gunars Pavlovichs, Martins Andzs*

Latvian State Institute of Wood Chemistry, Dzerbenes 27, 1006 Riga, Latvia, Ramunas.tupciauskas@kki.lv
* Corresponding author

Due to the evident climate change a building's eco-, energy, and hygrothermal efficiency becomes particularly important. It is already known that the building sector in Europe accounts for 40% of energy consumption and globally emits the same percentage of CO2. Insulating the building envelope significantly reduces the figures contributing to energy efficiency, sustainability, and climate stabilization (Chandhran and Elavenil, 2023). Raw materials of thermal insulation also make sense since the natural renewable resources contribute to favorable green transition and circular bioeconomy. Moreover, they have been recognized as having low environmental impact, less energy consumption, low cost, low density, scalability, biodegradability and good insulation properties (Cintura et al., 2021). Since the market for thermal insulation materials still contains up to 90% of non-biodegradable and non-renewable materials, the development of new competitive thermal insulations from available renewables is crucial.

Based on the above-mentioned key factors, the present study aims on the development of new thermal insulation materials from locally available and annually renewable lignocellulosic biomass like wheat straw, corn stalk, and reed. To develop loose-fill thermal insulation materials, the raw materials were separately processed by mechanical crushing, thermo-mechanical pulping (TMP), and steam explosion pulping (SEP). The effect of each processing and density (30–90 kg m-3) on thermal conductivity was evaluated. Besides, properties like specific heat capacity, water vapor diffusion, mold fungi resistance, fire resistance, volatile organic compounds, and settlement were investigated. In spite of mass loss of up to 30% from the initial mass of raw materials the most promising processing are both TMP and SEP providing very competitive properties of the investigated thermal insulation materials. Based on the study results, the developed materials have a high potential to enhance sustainability and energy efficiency of buildings by using environment-friendly renewable lignocellulosics.

Keywords: wheat straw, reed, corn stalk, bio-based thermal insulation materials, properties

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Fish-based bio-adhesives for healthier built environment

Mariem Zouari [1], Ingrid Bakke [2], Roland Kallenborn [2], Anders Q Nyrud [2]*

[1] InnoRenew CoE, Livade 6a 6310 Izola/Isola, mariem.zouari@innorenew.eu
[2] Norwegian University of Life Sciences, Postboks 5003 1432 Ås, ingrid.m.bakke@nmbu.no, roland.kallenborn@nmbu.no, anders.q.nyrud@nmbu.no
* Corresponding author

With increased use of glued timber products for construction, adhesives have gained significant importance in the wood industry. The sector is largely dominated by synthetic adhesives due to their convenience, high performance, and availability. Commonly used wood adhesives include phenol formaldehyde, urea formaldehyde, polyurethane, etc. (Vallée et al., 2017). The occurrence of glued wood composites in the built environment increases the risk of exposure to toxic volatile organic compounds (VOCs) potentially emitted by synthetic adhesives. In this regard, there has been a shift towards exploring the possibility of developing bio-based adhesives derived from natural and safe resources. This shift has been empowered by public awareness and legislation concerned with setting strict thresholds for VOCs in the indoor environment.

Fish protein-based adhesive represents a potential candidate as a green alternative to synthetic products. Fish glue is regarded as a sustainable and economically advantageous product given that it is derived from marine by-products, opening a promising valorization route. The application of bio-adhesives, such as fish glue, in construction timber structures may contribute to reducing human health risks given that they are less likely to emit anthropogenic VOCs.

This study aims to investigate the total VOCs emissions from various fish glue samples developed for use in glued timber structures. Samples will be kept in a controlled conditioning chamber for three days at 23 °C. Subsequently, air will be sampled on Tenax tubes, and individual VOCs will be tested using gas chromatography (TD-GC × GC-MS). Commercial glue samples will also be tested and used for comparison. The collected chromatograms will be assessed, and compounds will be identified based on a library and quantified with internal standard calibration. Moreover, the health risks associated with different glue types will be evaluated and the results will be presented.

Keywords: Bio-adhesive, fish protein, emissions, indoor air

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DENDRO-SPEC project: Spectroscopic methods for rapid phenotyping of trees reflecting their ecological resilience

Jakub Sandak [1], Edit Földvári-Nagy [1,2], Rene Herrera Díaz [1], Anna Sandak [1], Elena Cvetanoska [2], Witold Wachowiak [3], Agnieszka Jankowska [4], Włodzimierz Buraczyk [4], Paweł Kozakiewicz [4]*

[1] InnoRenew CoE, Izola, Slovenia, jakub.sandak@innorenew.eu, edit.foldvari-nagy@innorenew.eu, rene.herdiaz@innorenew.eu, anna.sandak@innorenew.eu
[2] University of Primorska, Koper, Slovenia, edit.foldvari-nagy@iam.upr.si, 89212001@student.upr.si
[3] Polish Academy of Science, Institute of Dendrology, Kornik, Poland witoldw@man.poznan.pl
[4] Warsaw University of Life Sciences, Institute of Wood Science and Furniture Making, Warsaw, Poland agnieszka_jankowska@sggw.edu.pl, wlodzimierz_buraczyk@sggw.edu.pl, pawel_kozakiewicz@sggw.edu.pl

The DENDRO-SPEC project is a comprehensive study aimed at understanding the genetic factors that influence the traits and adaptability of Scots pine trees, particularly in response to climate change. The project's main objectives are to investigate the effects of genetic variations on tree properties, analyse wood samples using near-infrared spectroscopy (NIR), and understand the genetic, morphological, and anatomical features that contribute to a tree's resilience to drought and high temperatures.

The project employs microsatellite DNA markers (SSR) and genetic association analysis, including a large database of single nucleotide site polymorphisms (SNP), to understand the genetic factors. This approach helps to uncover neutral genetic variations within and between different Scots pine populations, providing insight into the genetic basis for ecotype differences and establishing links between observable traits and genetic variations (Kozakiewicz et al., 2020).

The project aims to establish a measurement protocol for wood samples using NIR spectroscopy (Sandak et al., 2011). For this purpose, a unique set of wood samples from 50-year-old trees, representing various national Scots pine populations and all grown under the same conditions will be measured. The wood samples will be characterised using NIR spectroscopy that will indirectly assess technical characteristics and phenotypes and will balance data quality with ease of data acquisition. The ambition of the DENDRO-SPEC project is to develop a new methodology for quickly, accurately, and non-destructively predicting wood quality. By combining genetic studies with advanced spectroscopic techniques, the project aims to enhance our understanding of how trees adapt to climate change. The results could have significant implications for sustainable forest resource management and effective tree breeding programs in response to changing environmental conditions.

Keywords: Pinus sylvestris, morphological features, wood properties, spectroscopic methods, hyperspectral imaging

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Wood products manufacturing in Slovenia: overview of the data to support green transition of the forest-based value-chain

Daša Majcen [1], Andreja Kutnar [2]*

[1] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia; e-mail: dasa.majcen@innorenew.eu

[2] University of Primorska, Titov trg 4, 6000 Koper, Slovenia and InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia, andreja.kutnar@innorenew.eu

Wood products manufacturing is an important industrial sector worldwide, as well as in Slovenia. It represents a significant share of Slovenia's GDP, accounting for EUR 2.5 billion income in 2022 (SURS, 2024), which is over 8% of the total income generated by manufacturing activities. Besides its economic importance, the sector plays a crucial role in climate change mitigation as wood-based carbon storage can offset CO2 emissions in the mid-term (United Nations, 2012; Johnston et al, 2019; Cordier et al, 2022), particularly if the government encourages the production of long-lasting products (such as construction wood) as opposed to using wood for short-lived products (fuel, paper). In Slovenia, the available studies examining this potential are currently limited to the reporting obligations within the UNFCCC. The carbon pool of Harvested Wood Products (HWPs) is calculated according to the IPCC methodology, using the so-called Tier 2 method, which shows carbon stored in three categories of wood products (sawn wood, wood for boards, and wood for cellulose/pulp), which are all intermediate categories. Such a calculation does not enable an accurate prediction of long -term carbon storage.

In order to detail the existing calculation further (possibly as a Tier 3 calculation under the IPCC guidelines) and use it as a basis for policy measures, robust historical wood production data is needed for primary and secondary wood products. By acquiring reliable data of the current market situation, the flow of wood and their evolution through time can be well understood and implementation of effective sectoral measures becomes feasible. This study presents how this knowledge gap in data can serve as a basis for reviewing carbon flows within wood products manufacturing in Slovenia, similar to the state-of-the-art studies worldwide (Paluš et al, 2020; Jasinevičius et al.,2018).

Keywords: harvested wood products, forest-based value chain, carbon flow

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What if your workspace does not fit your tasks? The role of fitting and misfitting spaces on organizational culture strength and job satisfaction

Chiara Tagliaro [1], Alessandra Migliore [2]*

[1] Politecnico di Milano, Department of Architecture, Built environment and Construction engineering, via Ponzio 31, 20133, Milano, Italy, chiara.tagliaro@polimi.it
[2] Politecnico di Milano, Department of Management, Economics and Industrial Engineering, Via Lambruschini 4/b, 20156, Milano, Italy, alessandra.migliore@polimi.it
* Corresponding author

With the increase in remote work and the possibility employees have for deciding where to carry out their work tasks (e.g., at home or in places other than the office), the alignment between people's activity and workspaces has become even more important, especially when organizations aim to attract their workforce to the headquarters. However, office-activity misfit happens often when the physical layout or design of an office does not match the activities being carried out within it. This misalignment between the workspace and work tasks may reduce job satisfaction, with unwanted consequences on retention, turnover, absenteeism, and so on. At the same time, organizational values and the consensus on those values (i.e., cultural strength) may mitigate the alleged negative relationship between office-activity misfit and job satisfaction. Scientific evidence is still missing, though, to prove the extent to which office-activity misfit affects job satisfaction and whether cultural strength moderates this relationship. This study shows the preliminary results deriving from a cluster analysis based on data of a single organization located in Italy. Two groups of workers were recognized: (i) those who have a workspace that fits their tasks (i.e., fit group); (ii) those who lack a workspace that fits their tasks (i.e., misfit group). The paper compares the two groups through a mixed-method approach including (i) econometric analysis of survey data and secondary data; (ii) qualitative analysis of data from semi-structured interviews and focus groups with employees; and (iii) observations. From this preliminary analysis, organizational culture strength has been found to play a positive effect on job satisfaction only in the fit group while not in the misfit group.

Keywords: office type, work activity, office-activity misfit, job satisfaction, organizational culture

Construction and Furnishing Materials as Factors in Neighbor Noise and Dwelling Satisfaction: Evidence from Slovenian Survey Data

Ana Slavec [12], Nežka Sajinčič [1,2] and Lea Primožič [1]*

[1] InnoRenew CoE, Livade 6a, Izola, 6310 Izola, Slovenia, ana.slavec@innorenew.eu, nezka.sajincic@innorenew.eu, lea.primozic@innorenew.eu
[2] University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies, Glagoljaška 8. 6000 Koper Slovenia
* Corresponding author

Noise pollution negatively impacts human happiness, health and well-being, as shown by several observational studies (Guite et al., 2006, Maschke & Niemann 2007, Weinhold 2013). Moreover, sensor data reveals that human footsteps, movement of furniture, and dropping small items are major sources of noise in residential buildings (Park et al., 2017). The quality of sound insulation varies across different building types and material choice plays a crucial role in creating comfortable soundscapes. It is therefore important to understand the effect of various furnishing and construction materials on resident satisfaction to guide more informed design practices and enhance the well-being of communities.

In 2023, we conducted an online survey about residential renovation and furnishing with 1,009 respondents in Slovenia, which included a set of questions on dwelling satisfaction. Consistent with previous research, results indicate that neighbor noise is one of the least satisfying aspects for residents. In this contribution, we correlate various satisfaction measures with data on the presence of different construction and furnishing materials. We discuss the limitations of this observational approach and propose more experimental methodologies to confirm the causal relationship between building properties and resident well-being.

Keywords: acoustics, human wellbeing, building materials, noise, online survey

Acknowledgment: The authors acknowledge receiving funding from the Slovenian Research Agency for the project Using questionnaires to measure attitudes and behaviors of building users [Z5-1879] and from the European Cooperation in Science and Technology for the InnoRenew project [grant agreement #739574] under the H2020 Spreading Excellence and Widening Participation Horizon2020 Widespread-Teaming program.

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The effects of human activity and behavior in the office. Assessing the environmental sustainability of office buildings through the Ecological Footprint approach

Chiara Tagliaro [1], Alice Paola Pomé [2]*

[1] Politecnico di Milano, Department of Architecture, Built environment and Construction engineering, via Ponzio 31, 20133, Milano, Italy, chiara.tagliaro@polimi.it[3]
[2] Politecnico di Milano, Department of Architecture, Built environment and Construction engineering, via Ponzio 31, 20133, Milano, Italy, alicepaola.pome@polimi.it
* Corresponding author

In recent years, the rising importance of sustainability in both the international political debate and the scientific field highlighted the importance for the built environment and construction sector to increase awareness on its practices and policies. Especially, building operation and maintenance have been identified as the most relevant phase on which the sector must focus in order to decrease its environmental impact. Moreover, the Covid-19 pandemic induced more flexible ways of working which have changed the patterns in space utilization while decreasing the permanence of people in the office. In this context, it is urgent to rethink the office space through careful evaluation of users' utilization and behavior. However, there is still a gap in accurate impact assessment of in-use office buildings.

This research proposes an original calculation model to measure the environmental impact while revealing the effects of human occupation and behaviors. The model, based on the Ecological Footprint indicator, identifies eight impact sources (built-up, energy consumption, water consumption, food & drink, material consumption, mobility, waste generation, and trade-off potential). The effectiveness of the model has been demonstrated by adopting a Participatory Action Research method that allows to involve stakeholders (such as facility managers and employees) across the research development process. Calculations and results are reported from one case study of a company. This shows the potential of the model in showing the multifaceted impact of office buildings on the environment while enabling the engagement of office end-users and facility managers towards a more sustainable use of the workspace.

Besides carbon emissions and energy efficiency, the Ecological Footprint indicator can contribute to addressing the issue of effective sustainability practices within office building use by adopting more conscious utilization and behaviors.

Keywords: office utilization, human behavior, environmental sustainability

Thermal and acoustic properties of fibreboard insulation made with bark-based adhesive

Marica Mikuljan[1], Jaka Gašper Pečnik[1,2], Urban Kavka[1], Rok Prislan[1,2], Matthew Schwarzkopf [1,2]*

[1] InnoRenew CoE, Livade 6a, Izola, Slovenia; marica.mikuljan@innorenew.eu; urban.kavka@innorenew.eu
[2] Faculty of Mathematics, Natural Sciences and Information Technologies, University of Primorska, Glagoljaška 8, 6000 Koper, Slovenia; matthew.schwarzkopf@innorenew.eu; rok.prislan@innorenew.eu; jaka.pecnik@innorenew.eu
* Corresponding author

Insulation panels were made entirely from wood-derived products and their acoustic and thermal properties were determined. As part of the ForestValue, BarkBuild project that funded this study, fibreboards were manufactured with a bark-based lignin adhesive (L samples) and compared with a conventional MUF adhesive (S samples). Thermal properties were measured after the samples were exposed to different climatic conditions at 20 °C (oven dry, 65% RH, 90% RH). The thermal conductivity (λ) test was performed according to SIST EN 12664 at nine test points 10, 20, 23, 30, 40, 45, 35, 25 and 20 °C. Sample L had a lower thermal conductivity at all temperatures and relative humidities indicating better insulation properties. Specific heat was measured at seven test set points: 19, 26, 35, 42, 40, 30 and 22 °C. A lower average specific heat capacity was measured in S samples at 65% RH and 90% RH and in oven dried L samples. Thermal diffusivity α was calculated as the ratio of conductivity to the product of specific heat and density (Kan et al., 2022). Thermal diffusivity of S and L samples at 65% RH and 90% RH were similar. For oven dried samples, the thermal diffusivity of L samples was higher than that of S samples.

Sound absorption measurements were made using two specimen sizes to cover a frequency range of 50 Hz to 6400 Hz. (Cox and Antonio, 2009). Sound absorption for both types of fibreboard were relatively low with L-type α_{max} = 0.300 at 630 Hz and for S-type α_{max} = 0.143 at 6300 Hz. When measuring the sound transmission coefficient χ very large deviations were found in both fibreboard types (typically over 10 dB). This finding, along with the relatively low sound adsorption values (more reflective behaviour) indicate that this method of measurement is unsuitable for the fibreboards being tested.

Keywords: Fibreboard, bark-based adhesive, thermal properties, acoustic properties, insulation

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Timber elements – parameter monitoring during whole life cycle

*Jan Včelák [1]**

[1] ČVUT v Praze, Univerzitní centrum energeticky efektivních budov, Třinecká 1024, Buštěhrad, jan.vcelak@cvut.cz

Timber structures are commonly used for small residential projects but today also for big commercial projects such as multi-story buildings, shopping malls, sport centers, schools, and many others. Investors and developers are aware of the main risks for timber structures such as resistance to fire and moisture related problems. Timber elements offer the possibility to fully digitalize manufacturing processes and use prefabrication of elements in controlled conditions and thus limit on-site labor and reduce risk of weather-related problems during construction process.

Many timber projects already have a monitoring system which can identify moisture-related problems in the timber structure. Currently there are several types of sensors available that can be integrated into the structure to monitor increased moisture, potential leaks, condensation or other events. Prefabrication enables sensor integration where sensors become part of the timber element and measure conditions directly in it. The relevant parameters to measure would be relative air humidity, temperature, wood moisture content. By processing the data, it is possible to detect any abnormal situation to which the timber element was exposed, and the relevant data are recorded in sensor internal memory.

Using prefabrication processes allows sensor integration directly during timber elements manufacturing and prefabrication. The sensors can work in stand-alone data logging mode and monitor parameters during stocking, transportation and on-site construction. If there is no way to provide data online, they are stored in the internal memory of the sensor and once it connects with any central unit sensor it will synchronize data history with the cloud and switch to real-time monitoring. After building commissioning the same sensors will work in local network providing real-time data to facility management or building owner.

The possible system solutions for life cycle timber elements monitoring, covering all life cycle phases of the elements will be presented together with requirements for necessary data and communication infrastructure.

Keywords: timber element parameter monitoring, wood moisture content, sensor

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Green tax policies – a tool for enhancing wood and other natural materials from renewable sources used for sustainable construction

Črtomir Tavzes [1,2], Balazs David [1,2], Jaka Gašper Pečnik [1,2], Marica Mikuljan [1], Daša Majcen [1], Laszlo Hajdu [1,2], Andreja Kutnar [1,2]*

[1] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia (crtomir.tavzes@innorenew.eu, balazs.david@innorenew.eu, jaka.pecnik@innorenew.eu, marica.mikuljan@innorenew.eu, dasa.majcen@innorenew.eu, laszlo.hajdu@innorenew.eu, andreja.kutnar@innorenew.eu)
[2] University of Primorska, Titov trg 4, 6000 Koper, Slovenia
* Corresponding author

Due to the climate crisis, the construction industry is at a crucial crossroad. The choice of building materials affects the cost and efficiency of construction and plays a key role in achieving broader sustainability goals. One of the simplest and least cost-demanding ways to achieve sustainability (also measured as decreased GHG emissions) can be the increased use of (predominantly) wooden products instead of functional alternatives from other materials. Slovenia is especially well-suited for such a transition, as it has sustainably managed forests with a large stock of wood and annual increase thereof (Kuzman in Kutnar, 2015), and therefore, enough raw materials for a significant increase in the manufacture of such products. However, wooden products are often more expensive, or at least users think so (Ilgin et al., 2022). With Green Taxation, the state can create favourable market conditions for the purchase of wood products, to achieve sustainable construction (Schau et al., 2023). Several legislative packages were adopted at the global and EU level, and the member states have committed to reducing GHG emissions, also in the buildings sector.

We prepared proposals for VAT reductions on wooden products. Based on the required functionality for a single-family model house (100 m2 of usable area), we determined three alternatives (exclusively wooden, combination of wood and non-wood, and exclusively non-wood materials) for 10 building assemblies or construction products and compared the carbon footprint, amount of biogenic carbon bound in them, and price. The modelled results show that it is possible to achieve a good balance between the price and environmental impacts of the selected building assemblies. With an appropriate adjustment of the VAT rate on wooden products, they can be at least comparable if not even cheaper than non-wooden. Results offer a data-based policy foundation that, in addition to price, properly takes environmental impacts into account.

Keywords: sustainable construction, Green Tax Policies, GHG emissions, prices, wooden and non-wooden products comparison

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Biobased flame-retardant coating for wooden facades

Laetitia Marrot [1], Mariem Zouari [2,3], Ulises Rojas-Alva[1]*

[1] Slovenian National Building and Civil Engineering Institute (ZAG), Dimičeva ulica 12, 1000 Ljubljana, Slovenia, laetitia.marrot@zag.si, ulises.rojas-alva@zag.si
[2] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia, mariem.zouari@innorenew.eu
[3] Faculty of Mathematics, Natural Sciences and Information technologies; University of Primorska, Muzejski trg 2, 6000 Koper, Slovenia

As a combustible material, wood can benefit from the application of a flame-retardant coating to delay its ignition and improve its performance toward fire. Phytic acid is a non-toxic phosphorus component naturally occurring in plant tissues. Phosphorus flame retardants can form protective char layers, which affects self-extinguishing and protects the material exposed to fire from the spread of the flame. To enhance the formation of a stable aromatic char layer, a carbon source can be combined with the phosphorus containing fire retardant (Barbalini et al., 2020, Yang et al., 2018).

In this study, the fire protective effects of biobased coatings for wooden surfaces were investigated. The coatings are composed of tung oil in which different ratios of biochar/phytic acid binary blend were integrated (0, 10 and 20 wt%). A spruce substrate was selected for the application of coatings. Cone calorimetry tests were carried out on wood coated with different formulations to comprehensively study the contribution of each component (i.e., tung oil, biochar, and phytic acid) to the fire. Irradiative heat fluxes of 50, 35, and 25 kW/m^2 were used in horizontal configuration.

The introduction of tung oil delayed the ignition slightly compared to the untreated sample, which was expected as slightly more energy is required to break down the oil to gas-phase.

On the contrary, the biochar layer aided ignition given that the black surface has a higher absorptivity (close to unity) than virgin wood. Since the treatment was applied on the surface, this mostly modified the ignition behavior either negatively or positively.

Then, once the sample in-depth was involved in the (steady burning) process, the superficial treatment bore no effect on the overall burning. For the next phase, the introduction of phytic acid is expected to counteract the biochar layer's positive effect on ignition delay time.

Keywords: biobased flame retardant, wood coating, cone calorimeter, phytic acid, biochar

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Unveiling the microbiome on building materials in the coastal city of Izola

Ana Gubenšek [1,2], Anja Černoša [1], Faksawat Poohphajai [1,2,3], Wojciech Pajerski [1], Valentina Hribljan [1], Karen Butina Ogorelec [1,2], Anna Sandak [1,4]*

[1] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia, ana.gubensek@innorenew.eu, anja.cernosa@innorenew.eu, faksawat.poohphajai@innorenew.eu, wojciech.pajerski@innorenew.eu, valentina.hribljan@innorenew.eu, karen.butina@innorenew.eu, anna.sandak@innorenew.eu
[2] Andrej Marušič Institute, University of Primorska, Titov trg 4, 6000 Koper, Slovenia, ana.gubensek@iam.upr.si, faksawat.poohphajai@iam.upr.si, karen.butina@iam.upr.si
[3] Department of Bioproducts and Biosystems, School of Chemical Engineering, Aalto University, P.O. Box 16300, 00076 Aalto, Finland, faksawat.poohphajai@aalto.f
[4] Faculty of Mathematics, Natural Sciences and Information Technologies, University of Primorska, Glagoljaška 8, 6000 Koper, Slovenia, anna.sandak@famnit.upr.si
* Corresponding author

Microorganisms are ubiquitous in our environment; some of them cause deterioration of building materials, while others offer their protection. Understanding the diversity and functionality of these microorganisms is crucial for the research and development of bioinspired solutions to improve the durability and performance of building materials. As part of the ARCHI-SKIN project, environmental sampling was conducted in Izola with public engagement to collect diverse microbial samples. Three locations (Sports Ground Livade Jagodje, San Simon Bay, and the Old Town of Izola) were strategically selected for swabbing different surfaces and collecting air samples.

The aim of this work is to identify naturally occurring microorganisms, specifically fungi and bacteria, in these environments. Samples were collected using a wet-swab technique on both porous materials (wood, concrete, stone, brick) and non-porous materials (metal, plastic) at each location. The swabs were smeared on four different media types (MEACh, MEA, DG18, and LB) and incubated at 25°C. Further, 100 L of air was filtered onto the mentioned agar media at each location. After one week, photographs of the growth on petri dishes were taken, and representative fungal and bacterial cultures were purified for further analysis and identification.

The results revealed a high microbial diversity on all selected material surfaces and in the air. The collection of isolates included various bacterial species, a broad spectrum of yeasts, including *Aureobasidium* spp., and filamentous fungi, including *Cladosporium*, *Penicillium*, and *Alternaria* spp., commonly found in nature.

These findings highlight the rich microbial diversity surrounding us and emphasise the potential for utilising naturally occurring microorganisms in bioinspired approaches to more sustainable architecture.

Keywords: fungi, bacteria, materials, bioinspiration, environment

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Growth and phenotypic plasticity in *Aureobasidium pullulans* on lignin derivatives

Faksawat Poohphajai [1,2,3], Oihana Gordobil [4], Rene Herrera Diaz [1,2], Anja Černoša [1], Ana Gubenšek [1,2], Valentina Hribljan [1], Wojciech Pajerski [1], Karen Butina Ogorelec[1,2], Anna Sandak[1,2,5]*

[1] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia, faksawat.poohphajai@innorenew.eu, ana.gubensek@innorenew.eu, rene.herdiaz@innorenew.eu, anja.cernosa@innorenew.eu, valentina.hribljan@innorenew.eu, wojciech.pajerski@innorenew.eu, karen.butina@innorenew.eu, anna.sandak@innorenew.eu
[2] Andrej Marušič Institute, University of Primorska, Titov trg 4, 6000 Koper, Slovenia, faksawat.poohphajai@iam.upr.si, ana.gubensek@iam.upr.si, karen.butina@iam.upr.si, rene.herrera@iam.upr.si, anna.sandak@iam.upr.si
[3] Department of Bioproducts and Biosystems, School of Chemical Engineering, Aalto University, P.O. Box 16300, 00076 Aalto, Finland, faksawat.poohphajai@aalto.f
[4] "Materials + Technologies" Research Group, Department of Chemical and Environmental Engineering, Faculty of Engineering of Gipuzkoa, University of the Basque Country UPV/EHU, Plaza Europa 1, Donostia-San Sebastián, 20018, Spain, oihana.gordbil@ehu.eus
[5] Faculty of Mathematics, Natural Sciences and Information Technologies, University of Primorska, Glagoljaška 8, 6000 Koper, Slovenia, anna.sandak@famnit.upr.si
* Corresponding author

Phenotypic plasticity is the ability of any organism to respond to environmental signals by altering its morphology, physiological state, or behavior (West-Eberhard, 1989). *Aureobasidium pullulans* (de Bary) Arnaud (*A. pullulans*), a polymorphic black yeast-like fungus, exemplifies this capacity through its ability to modify its phenotype in response to environmental stimuli, enabling it to thrive under a wide range of climate conditions. This flexibility makes *A. pullulans* an exceptionally ideal candidate for the project "Bioinspired Living Skin for Architecture (ARCHI-SKIN)". By mimicking the natural process, the "ARCHI-SKIN" project is developing an innovative bioinspired living coating system based on fungal biofilm for protection of various building materials. To achieve the goal of this project, it is important to understand the mechanisms of fungal growth, including their ability to utilise diverse nutrients and form biofilms. This understanding is crucial for developing a technically applicable, controlled, and optimised biofilm that effectively protects substrate surfaces.

This present study aims to investigate the growth and phenotypic plasticity of *A. pullulans* on different lignin derivatives, namely vanillin, phenol, 4-hydroxybenzoic acid, and p-coumaric acid. The growth and morphologies of *A. pullulans* were visualised using a transmitted light imaging system (EVOS M7000, ThermoFisher Scientific), which captured projection images at defined time intervals. The acquired images were used for evaluating the morphological characteristics of the fungus. The obtained results revealed the variation in colony form, dimension, and morphologies of *A. pullulans* on different lignin derivatives, indicating the phenotypic plasticity of this fungus. This evaluation provides valuable insight into the dynamic interactions between *A. pullulans* and lignin breakdown products. Such insights are fundamental for optimising coating formulations, enhancing their effectiveness and durability in protecting building material surfaces, and contributing to sustainable and eco-friendly coating solutions.

Keywords: bioinspiration, living coatings, building materials, fungal growth, biofilm

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Investigation of fungal biofilms for building skin

Anja Černoša [1,], Ana Gubenšek [1,2], Valentina Hribljan [1], Wojciech Pajerski [1], Faksawat Poohphajai [1,2,3], Karen Butina Ogorelec [1,2], Anna Sandak [1,2,4]*

[1] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia; anja.cernosa@innorenew.eu, ana.gubensek@innorenew.eu, valentina.hribljan@innorenew.eu, Wojciech.pajerski@innorenew.eu, faksawat.poohphajai@innorenew.eu, karen.butina@innorenew.eu, anna.sandak@innorenew.eu
[2] Andrej Marušič Institute, University of Primorska, Titov trg 4, 6000 Koper, Slovenia; ana.gubensek@iam.upr.si, faksawat.poohphajai@iam.upr.si, karen.butina@iam.upr.si, anna.sandak@iam.upr.si
[3] Department of Bioproducts and Biosystems, School of Chemical Engineering, Aalto University, P.O. Box 16300, 00076 Aalto, Finland; faksawat.poohphajai@aalto.fi
[4] Faculty of Mathematics, Natural Sciences and Information Technologies, University of Primorska, Glagoljaška 8, 6000 Koper, Slovenia; anna.sandak@famnit.upr.si
* Corresponding author

Engineered Living Materials (ELMs) are innovative materials with living properties that offer functionalities beyond those of conventional materials. In our project "Bioinspired Living Skin for Architecture (ARCHI-SKIN)" we are developing a living fungal coating that is suitable for various architectural materials (wood, concrete, stone, brick, steel, plastic). The fungal coating not only offers an environmentally friendly alternative to current coatings, but also provides additional functions such as self-repair, UV protection, bioremediation, and antimicrobial properties. The fungus *Aureobasidium pullulans* was chosen as the ideal candidate because it can form a biofilm, grow under extreme conditions, and has antimicrobial properties. Importantly, this fungus is non-pathogenic to humans, and has been isolated from various architectural surfaces, making it a promising solution for sustainable and functional architectural coatings.

The process and mechanisms of biofilm formation by A. *pullulans* are currently under investigation. Initially, the focus was on the attachment and colonisation of *A. pullulans* cells on different types of materials, as these processes are key factors for early biofilm formation. Subsequently, the kinetics of biofilm growth and the influence of different nutrients on its development and production were investigated. An interesting feature of *A. pullulans* is its dimorphism, i.e. the fungus can form yeast cells or hyphae. The type of growth is strain dependent. Therefore, how these two morphologies influence the formation, growth and maturation of biofilms was also investigated.

Future research will not only examine the complex structure of biofilms formed by different strains of *A. pullulans* but will also explore their antagonistic interactions with other microorganisms and evaluate the overall stability of these biofilms. These results will serve as a basis for the study of biofilm formation by *A. pullulans* and contribute to the development of living coatings optimised for different types of materials, which is the main goal of the ARCHI-SKIN project.

Keywords: ELMs, fungi, biofilm, building skin

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Microbially induced mineralisation of wood for improved fire performance

Karen Butina Ogorelec [1,2], Anna Sandak [1,2,3]*

[1] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia, karen.butina@innorenew.eu, anna.sandak@innorenew.eu
[2] Andrej Marušič Institute, University of Primorska, Titov trg 4, 6000 Koper, Slovenia, karen.butina@iam.upr.si, anna.sandak@iam.upr.si
[3] Faculty of Mathematics, Natural Sciences and Information Technologies, University of Primorska, Glagoljaška 8, 6000 Koper, Slovenia, anna.sandak@famnit.upr.si
* Corresponding author

Wood is increasingly used in the building sector as it is lightweight, heat insulating, has good technical characteristics, is renewable, and acts as a carbon sink. However, a drawback of wood is its combustibility, presenting a risk in case of fire. Various approaches have been developed to mitigate this, one of them being wood mineralisation, most commonly employing calcium carbonate ($CaCO_3$). While improving fire performance, the process of mineralisation often requires expensive (supercritical CO_2) or environmentally questionable (perfusion of wood with NH_3) steps.

We aim to develop a bioinspired solution for $CaCO_3$ deposition in timber using biologically induced mineralisation by fungi. To facilitate screening for and quantification of biologically induced mineralisation, an assay will be developed. Once the best candidate is found and the optimal culturing conditions are identified, these findings will be translated into an application for wood. A formulation containing the necessary nutrients and a calcium source will be developed and applied on wood pieces prior to fungal inoculation. Various incubation times and conditions will be tested, and fungal growth as well as the extent of mineralisation will be assessed. Subsequently, the material properties of the mineralised wood, including its fire performance, will be evaluated. Based on these evaluations, the preceding steps will be optimised.

This project serves as a proof-of-concept. While it is unlikely that the manufactured material will immediately surpass existing materials, it is expected to demonstrate a novel approach that can be further refined and developed in the future.

Keywords: biologically induced mineralisation, bioinspiration, fungi

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Melanin nanoparticles – a bioinspired solution for structural coloration in architecture

Martyna Wienke [1,2], Wojciech Pajerski [1], Anna Sandak [1,3]*

[1] UInnoRenew CoE, Livade 6a, 6310 Izola, Slovenia,
[2] Faculty of Forestry and Wood Technology, Poznan University of Life Sciences, ul. Wojska Polskiego 28, 60-637 Poznan, Poland
[3] Faculty of Mathematics, Natural Sciences and Information Technologies, University of Primorska, Glagoljaška 8, 6000 Koper, Slovenia
* Corresponding author , wojciech.pajerski@innorenew.eu

Drawing inspiration from nature, structural colouration has the potential to transform the aesthetics and functionality of architectural materials. By employing bioinspired methods alongside advancements in nanotechnology, this research seeks to incorporate structural colouration into architectural surfaces, reducing the dependence on conventional chemical dyes and pigments. Our work focuses on the development and optimisation of melanin nanoparticles, with sizes ranging from 50 to 300 nm, to serve as the foundation for creating colour in coatings applicable to a variety of architectural materials, such as wood, concrete, plastic, and steel. We investigate multiple application techniques, including sonochemical methods, dip-coating, and airbrushing, to achieve surface colouration.
Expanding beyond traditional materials, our research also delves into the creation of Engineered Living Materials (ELMs). A key aspect of this study is evaluating the compatibility of these nanoparticles with the fungus *Aureobasidium pullulans*, a non-pathogenic species integral to a living coating system for architectural surfaces. Understanding how these nanoparticles interact with the fungus is critical for designing living systems that exhibit specific and desirable colour properties.

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