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XVIII International WoodEMA 2025 Scientific Conference

WOOD FOR THE FUTURE: INTEGRATING SUSTAINABILITY ACROSS INDUSTRIES

Ohrid, North Macedonia

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Title of the paper: Economic Calculation of Health Risks in Long-Term Storage and Use of Biomass

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- This article builds upon the research presented at last year's WoodEMA conference in Sofia, where we explored the topic *Selected Economic and Health Risks in the Process of Production and Storage of Biomass for Energy Purposes*.
- We presented a proposal for applying model financial data **to calculate the risks of occupational diseases** and their consequences - such as **severance payments or compensation for illness-related damages for employees** of forestry and wood-processing companies working with biomass.
- In the event of an **occupational disease, it is necessary to account for a 2.8% increase in the selling price** as part of the cost calculation.
- This adjustment reflects the potential **financial impact of compensation payments**, ensuring that the pricing structure adequately **covers health-related risks associated with biomass production**.

THE ECONOMIC RISKS ARISING FROM HEALTH DAMAGE IN BIOMASS PRODUCTION AND STORAGE... - CALCULATION

The frequency of occurrence and the risk of financial compensation for an occupational disease can vary for each company and may not align with proposed calculated values (CR_{SP} and CR_{PD}). From our perspective, it is necessary to calculate these risks of occupational disease at the level 1%) = € 34,000/year.

This fact needs to be incorporated into the overhead cost calculation proposal

model cost structure:

direct cost €800,000 = allocation base, overhead cost €400,000, profit €50,000

profit margin based on Return on Cost = ROC 4.17%, overhead cost surcharge % OCS = 50%).

$$\Delta OCS = \frac{\text{Differ in overhead cost by calculation risks}}{\text{Allocation base}} \times 100 (\%)$$

$$\Delta OCS = 4,25\%$$

$$\Delta PM = \Delta OCS \times ROC / 100 = 0,177 \%$$

$$\Delta SP = \frac{\frac{\Delta OCS + \Delta PM}{100} \times \text{allocation base}}{\text{selling price}} \times 100 = 2,8\%$$

mark-up method of calculation :

Direct cost (materials, wages, others direct cost)

+ **Overhead cost** (% surcharge with using of ΔOCS)

= Total own cost

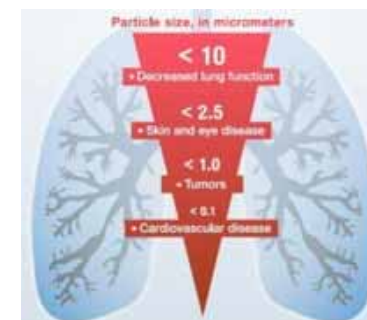
+ **Profit margin** (with using of % ROS and ΔPM)

= **Selling price without VAT** (with determination ΔSP)

Risk 1% = in the calculation, it is necessary to add **2,8 eurocents** for every €1 of the selling price



- When biomass is used as a renewable energy source, most facilities are located close to the end users of the generated thermal or electrical energy, often directly within urban areas.
- The most significant threats to human health are posed by fungal and mold activity within the chip piles, resulting from natural biological processes, and the inhalation of wood dust during chip handling.
- Biological processes associated with natural biological degradation also cause heating of the inner layers of biomass, which is stored mainly in large-volume piles. These facts significantly increase the risk of fire, which can cause damage to property and human health.
- The aim of the work is also the economic calculation of the mentioned risks (especially the burden of PM 2.5 and PM 10 dust particles and phytopathogens), especially from the perspective of the burden on the health and social system, due to the occurrence of occupational diseases and long-term respiratory diseases in the Slovak healthcare system.





METHODOLOGY

- For the analysis of the environmental impacts of biomass storage, an urban-type heating plant located in the built-up area of the town of Hriňová, in the Banská Bystrica Self-Governing Region, was selected.
- Long-term measurements of particulate matter (PM) with diameters of $2.5\text{ }\mu\text{m}$ (PM_{2.5}) and $10\text{ }\mu\text{m}$ (PM₁₀) were conducted from May 29 to June 23, 2024.
- This period was deliberately chosen outside the heating season to eliminate the influence of biomass combustion emissions and to isolate dust particles generated exclusively from biomass storage and handling activities.
- According to the World Health Organization (WHO, 2021), the recommended average annual concentration limit for PM_{2.5} is $5\text{ }\mu\text{g}/\text{m}^3$, and for **PM₁₀**, $15\text{ }\mu\text{g}/\text{m}^3$.
- The recommended average daily concentrations should not exceed $15\text{ }\mu\text{g}/\text{m}^3$ for **PM_{2.5}** and $45\text{ }\mu\text{g}/\text{m}^3$ for **PM₁₀**. For the measurements, an AirNore device from Blue was used.



2005 V.S. 2021 WHO air quality guidelines (AQGs)
Preventable PM2.5 deaths avoided if new AQGs met globally: +65% Source: WHO

Pollutant	Averaging Time	2005 AQGs	2021 AQGs
PM2.5 $\mu\text{g}/\text{m}^3$	Annual 24-hour	10 25	5 15
PM10 $\mu\text{g}/\text{m}^3$	Annual 24-hour	20 50	15 45
Ozone O ₃ $\mu\text{g}/\text{m}^3$	Peak Season* 8-hour**	- 100	60 50
Nitrogen dioxide NO ₂ $\mu\text{g}/\text{m}^3$	Annual 24-hour	40 -	10 25
Sulfur dioxide SO ₂ $\mu\text{g}/\text{m}^3$	24-hour	20	40
Carbon monoxide CO $\mu\text{g}/\text{m}^3$	24-hour	-	4



METHODOLOGY

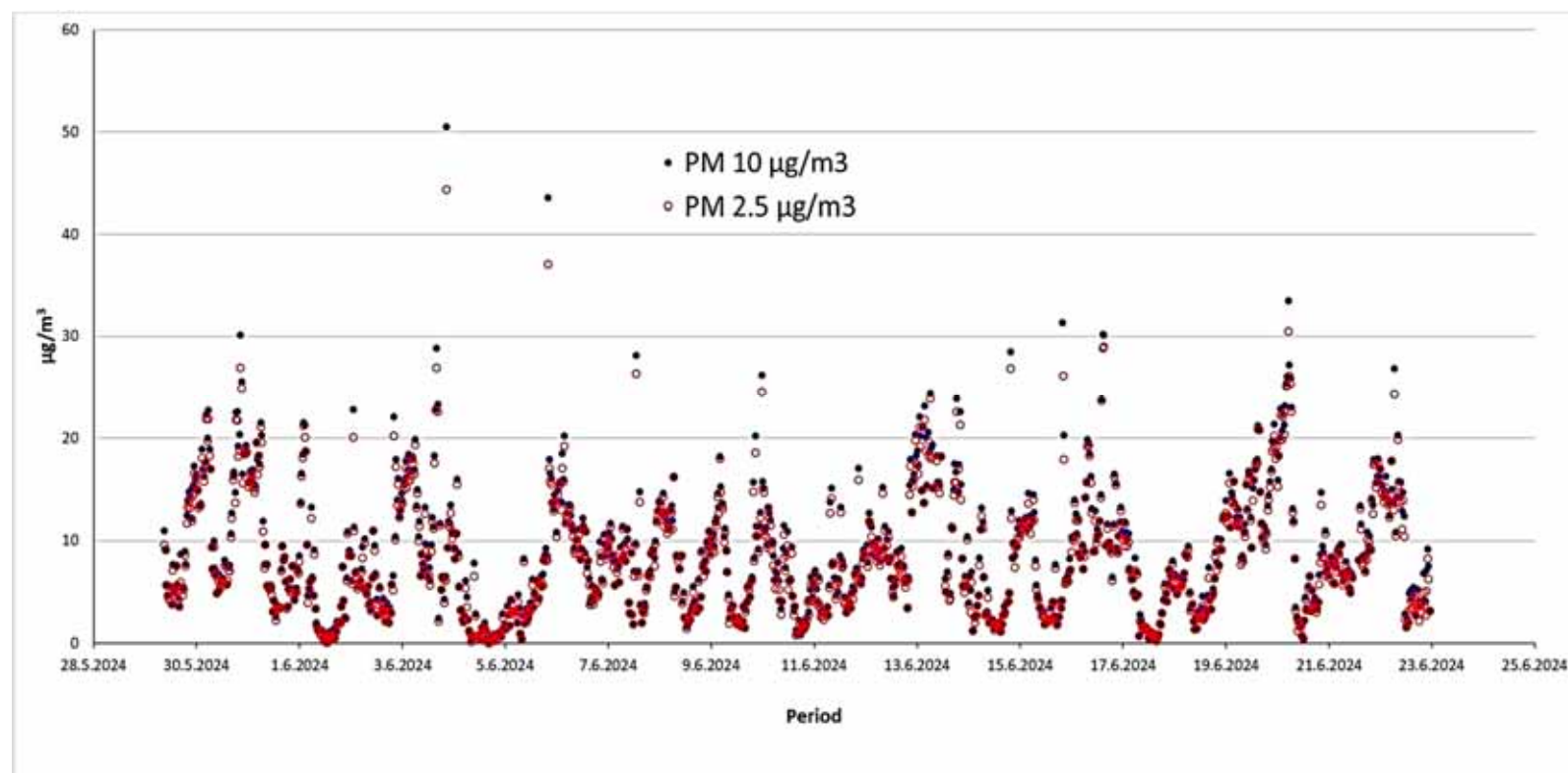
- At the selected facility, biomass samples were collected between 2019 and 2024 to analyze the presence of phytopathogens. For each sampling period, three samples were taken from the surface of the pile at different locations.
- All samples were subjected to microbial analysis for phytopathogenic presence at the accredited laboratory of the Regional Public Health Office in Poprad.
- The economic analysis focused primarily on allergic and immunodeficiency-related respiratory diseases, which may develop during the logistical processes of biomass production and handling. Specifically, data on patient visits to immunoallergology outpatient clinics and the number of hospitalized patients, regardless of age, were examined for the period 2013–2023 in the Banská Bystrica Self-Governing Region. In addition, data on the number of reported occupational diseases in the relevant category were analyzed.
- The economic assessment of these diseases was based on valid legislation (Act No. 437/2004 Coll.), databases from the National Health Information Centre (NCZI), and regulations issued by the Social Insurance Agency. Economic data from previous research were also incorporated (Gejdoš & Potkány, 2024).





RESULTS

Particulate Matter analysis



During the monitoring period, the WHO-recommended daily limit for PM10 was exceeded only once. However, the limit for PM2.5 was exceeded on several occasions, specifically in more than 14% of the recorded cases.



RESULTS

Fungi spores analysis

Year	Sample 1	Sample 2	Sample 3	Total
2019	110 000	34 000	7 700	151 700
2020	12 000	5 800	11 000	28 800
2021	12 000	50	920 000	932 050
2022	46 000	350 000	3 100 000	3 496 000
2023	31 007 500	167 650	43 010 850	74 186 000
2024	50 000	26 000	358 350	434 350

Table 1. Number of phytopathogen spores in analysed samples from wood chip pile surface in heating plant storage during period 2019-2024 (in CFU.g⁻¹)

The most frequently identified genera were *Penicillium* and *Aspergillus*. Both are known to cause serious respiratory conditions, including respiratory and skin allergies, pulmonary diseases, and potentially even carcinogenic effects.



RESULTS

Burden of the health and social system

Year	Nr. of visits Immunology and Allergology Surgery	Nr. of specific diseases connected with air quality	Nr. of new patients with specific immunotherapy admitted to treatment
2013	106 105	88 443	4473
2014	125 129	110 395	3141
2015	132 715	83 505	3375
2016	127 396	94 650	3371
2017	125 866	84 715	3288
2018	124 106	84 011	3392
2019	124 467	82 853	3266
2020	113 430	77 455	3125
2021	110 514	73 153	3230
2022	120 431	75 303	3369
2023	109 178	68 496	3468

Table 2. Number of Cases in imunology and allergology treatment in Banská Bystrica Self-Governing Region for years 2013-2023 (NHIC, 2025)

The average reimbursement for an extended and controlled examination at an immunoallergological outpatient clinic, according to the largest Slovak health insurance provider, is €10.72. Over the period 2014–2023, the total burden on the healthcare system due to poor air quality in the Banská Bystrica Self-Governing Region exceeded €9 million. In the most recent year analyzed, 2023, this burden amounted to over €734,000.



RESULTS

Burden of the health and social system

Based on the identified risks associated with the production, storage, and use of biomass, the following diseases—classified according to the national system for occupational illnesses and health damage—were selected for analysis: 1. Allergic respiratory diseases; 2. Occupational dermatoses.

The economic values associated with these diseases were derived from Slovak legislation and are detailed in our previous study (Gejdoš & Potkány, 2024) (see Table 3).

Year/Dis.	2023	2022	2021	2020	2019	2018	Together	Costs in €
1	1				2	2	5	260,800
2				1	1		2	83,456
Together	1	0	0	1	3	2	7	344,256

Table 3. Registered diseases in the Slovak Republic in the agriculture, forestry, and wood processing sector in 2019-2023 and their economic value in €

Table 3 shows that over the past 7 years, the selected diseases with the greatest economic impact were allergic respiratory diseases, recognized occupational diseases in the forestry and timber sector. This fact is, of course, influenced mainly by increased dustiness in processing operations during the production of sawn timber and further mechanical processing of wood.



CONCLUSIONS AND FUTURE WORK

In addition to the production of phytopathogens and molds, resulting from biological processes in stored biomass, air quality in the vicinity of storage sites is adversely affected not only by biomass combustion but also by its handling (including chipping, which sometimes occurs directly within heating plant premises).

These activities significantly increase the concentration of solid particulate matter in the air, even outside the heating season, as confirmed by our study.

Demonstrating a direct correlation between air pollution and human health remains challenging, primarily because the health effects typically manifest over long-term exposure periods.

Moreover, the process is influenced by a variety of additional factors, including meteorological and topographical conditions, proximity to other emission sources, traffic intensity, and local heating practices in family homes and apartment buildings.

Current legislation primarily focuses on industrial-scale processes and does not adequately account for the negative exposure experienced by populations living near biomass-related operations





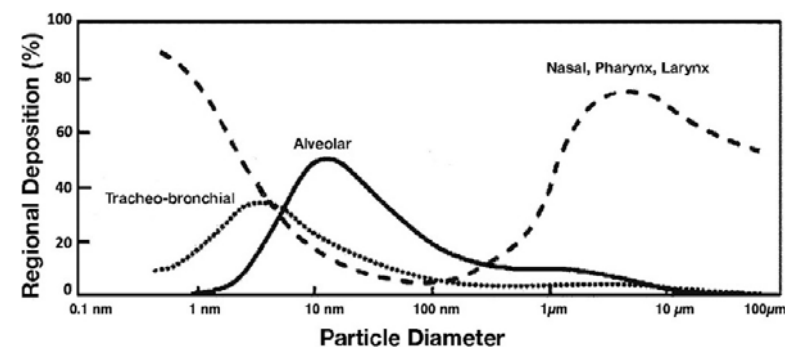
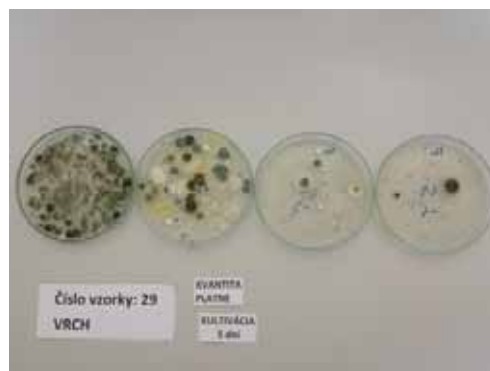
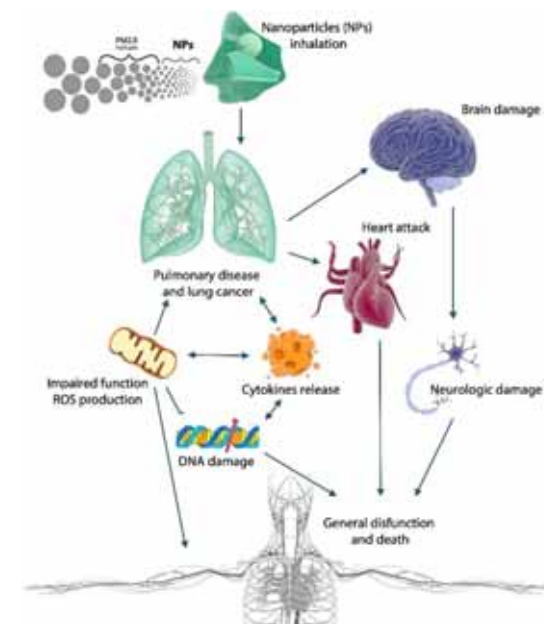
CONCLUSIONS AND FUTURE WORK

Nano-Particulate Matter Measurement (2025) in Heating Plant – Hriňová

Measurements conducted at outdoor and indoor workplaces under different atmospheric conditions; in cooperation with the Faculty of Ecology and Environmental Sciences – Department of Environmental Engineering.

Continuous Wood Chip Sampling in 3 Municipal Heating Plants (Hriňová, Hnúšť'a, Poltár)

Next sampling scheduled for November 2025, in cooperation with the Regional Public Health Office in Poprad – accredited laboratory.





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INVITATION

CENTRAL EUROPEAN FORESTRY JOURNAL

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SPECIAL ISSUE: The forest-based sector's path to the digital future

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„The forest-based sector's path to the digital future“

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The journal is indexed in a variety of databases including Web of Science and SCOPUS

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1.4	21	Q2	0.401

Cite Score Trend:

Special Issue Editors:

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Special Issue Information

Dear Colleagues,

This special issue "The forest-based sector's path to the digital future" is published in order to inform readers about the possibilities of developing innovative technologies and the results achieved. The forest-based processes, valuable renewable raw material wood, it is a natural material that has a unique property that every tree, every piece of wood is unique. This property greatly complicates the introduction of automation and digitalization into production processes. As a result, the sector shows signs such as low labor productivity, low competitiveness, logistical problems, etc. Currently, new technologies such as artificial intelligence are coming to the fore. This technology can be the answer to many problems in the sector. The special issue focuses on a number of topics such as innovative scanning technologies, automation, the use of neural networks, objectification in assessing the quality of wood and wood products. The ambition is to capture trends in research into the application of new innovative technologies that will move the sector into a new age.

Keywords: forest, wood products, digitalization, innovative technologies, economy, quality, artificial intelligence

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Manuscripts should be submitted online at https://web.nrcsk.org/?page_id=4524 by registering and logging in to this website: <https://www.editorialmanager.com/forestryjournal/default.aspx>. Once you are registered, click here to go to the submission form. If any problem, contact responsible person for the journal online system: Dr. Michal Bolesta (michal.bolesta@tiscali.sk). Manuscript can be submitted until the **deadline (December, 10th 2025)**. Exclusively research articles and review articles are invited. Submitted manuscripts should not have been published previously, nor be under consideration for publication elsewhere (except conference proceedings papers).

All manuscripts are thoroughly refereed through a single-blind peer-review process. A guide for authors and other relevant information for submission of manuscripts is available on the instructions for Authors page: https://web.nrcsk.org/?page_id=4650. Submitted papers should be well formatted, using good English.

Accepted papers will be published in electronic form as soon as accepted as online first (see also https://web.nrcsk.org/?page_id=4677), then in a paper format in 2026 within the issue 3 (autumn). Hard copy of the journal will be posted to each co-author of published papers. There are not any article processing charges for publication in this open access.





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THANKS FOR PAYING ATTENTION!

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