



Advancing Worker Health Protection

9th - 13th June | Aviva Stadium | Dublin

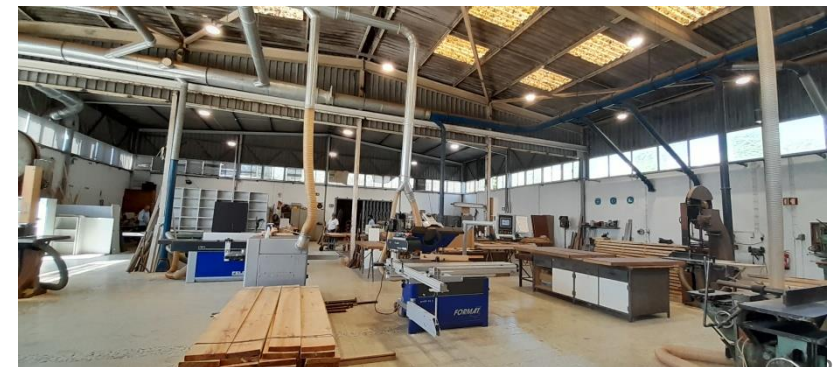
Sampling protocol to assess occupational exposure to microbial contamination in wood working environments

Marta Dias, Pedro Pena, Bianca Gomes, Renata Cervantes, Sara Gonçalves, Susana Viegas, **Carla Viegas***





- The sawmill market is driven by **rising construction demand** and it is foreseen an increase due to need to overcome the lack of housing through Europe [1].
- Workers in the sawmill industry may be **exposed to wood derivatives, microorganisms, and their products** [1,2].
- Wood products can cause **health effects** such as decreased lung function, bronchial hyperresponsiveness, and various respiratory disorders [1,2].
- Exposure to **wood dust infected with microorganisms**, particularly fungi, can lead to allergic alveolitis and asthma in woodworkers [1,2].



- There is a knowledge gap in the field of microbial occupational exposure assessment in sawmills [1].
- The importance of an accurate assessment and risk management should be emphasized.

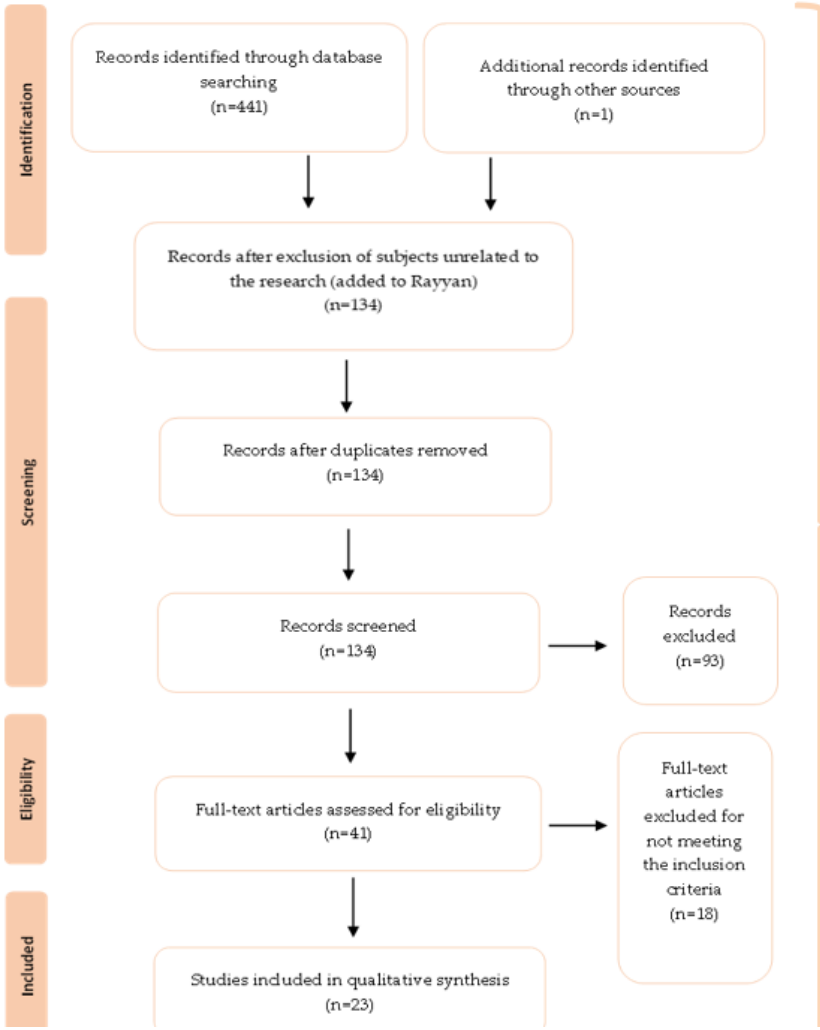


The aim of this study is to define a protocol that allows a proper assessment of microbial contamination in woodworking environments.







The sampling protocol was developed by performing a review concerning exposure assessments done in the same setting.



- The most used sampling method was air sampling, being impaction the most common method
- Morphological identification of fungi and bacteria was the most frequent analytical procedure
- Screening for fungal susceptibility to azoles was performed in 2 studies
- 4 studies applied molecular tools
- High fungal and bacterial levels were frequent
- *Penicillium* as the most frequent genera followed by *Aspergillus* sp.
- Mycotoxins were not assessed in any of the analyzed studies



	Active Sampling Methods	Passive Sampling Methods
	<ul style="list-style-type: none"> • Impaction sampling allows us to rely on the microbial composition to draw conclusions regarding the inflammatory potential variation [6,7]. • Most diversified fungal contamination [1]. 	<ul style="list-style-type: none"> • Can collect contamination over a longer period [1]. • Settled dust reservoirs can anticipate microbial levels in indoor air [1]. • EDCs and E-cloths electrostatic properties may aid in attracting smaller particles than gravity alone [4,5]. • Surface swabs are an affordable, quick, and do not require extensive collection time [4,5]. • In PPE (FRPD and MPG) humidity of the material increases, providing favorable conditions for microorganism's growth [4,5].
	<ul style="list-style-type: none"> • Indoor air is not homogeneous in space or time [8]. • Microbial load can be underestimated, due to the high velocity of the airflow that may result in microorganisms' cell damage [9,10]. 	<ul style="list-style-type: none"> • Vacuumed dust does not provide the age of the collected dust sample [4,5]. • In EDCs and E-cloths it is difficult to elute particles from the collection material. May lose charge over time [4,5]. • Surface swabs collection efficiency may vary between surface materials and applied swabbing pressure during collection [4,5]. • Lack of replacement/bad storage of the PPE can be a source of microorganisms, which can impose sample bias [4,5].




Active and passive sampling methods combined, increase the sensitivity of the assessment and eliminate the described disadvantages of the impaction samplers.









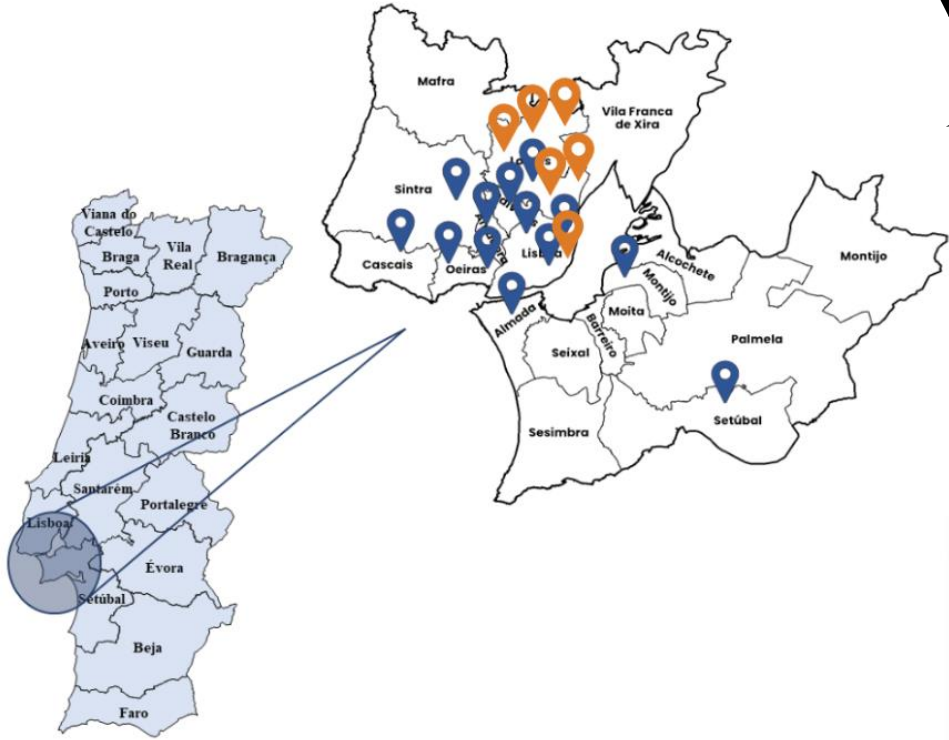
The protocol was applied in sampling campaigns developed in “Do It Yourself” (DIY) stores with a wood cutting section and in **sawmills**.


Active Sampling Methods

		
MAS-100	Andersen six-stage	Personal Air Sampler

Passive Sampling Methods

					
EDC	Surface Swabs	E-cloth	Settled Dust + Filter	FRPD	MPG



13 

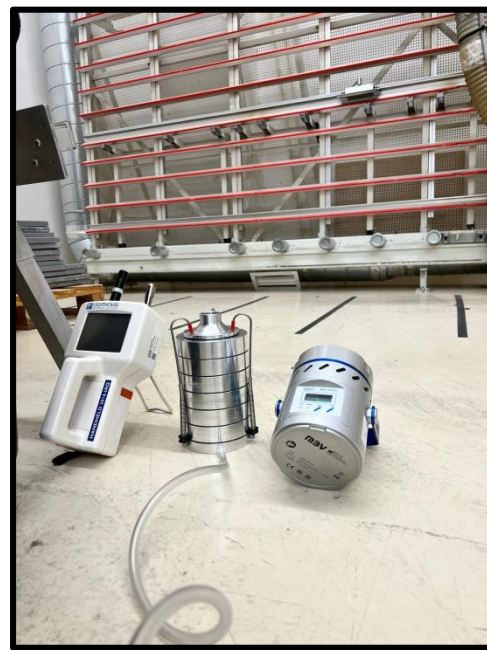


6 



IOHA 2024

Advancing Worker Health Protection
9th - 13th June | Aviva Stadium | Dublin





DIY Stores							Sawmills							
Active Sampling Methods				Passive Sampling Methods			Active Sampling Methods				Passive Sampling Methods			
<i>Alternaria</i> sp.	<i>Chrysosporium</i> sp.	<i>Mucor</i> sp.	<i>Syncephalastrum racemosum</i>	<i>Alternaria</i> sp.	<i>Cladosporium</i> sp.	<i>Paecilomyces</i> sp.	<i>Alternaria</i> sp.	<i>Chrysosporium</i> sp.	<i>Penicillium</i> sp.	<i>Trichoderma</i> sp.	<i>Acremonium</i> sp.	<i>Chrysonilia</i> sp.	<i>Paecilomyces</i> sp.	<i>Stemphylium</i> sp.
<i>Aspergillus</i> sp.	<i>Cladosporium</i> sp.	<i>Paecilomyces</i> sp.	<i>Trichoderma</i> sp.	<i>Aspergillus</i> sp.	<i>Fusarium</i> sp.	<i>Penicillium</i> sp.	<i>Aspergillus</i> sp.	<i>Cladosporium</i> sp.	<i>Phoma</i> sp.	<i>Tricothecium roseum</i>	<i>Alternaria</i> sp.	<i>Chrysosporium</i> sp.	<i>Penicillium</i> sp.	<i>Trichoderma</i> sp.
<i>Aureobasidium</i> sp.	<i>Fusarium</i> sp.	<i>Penicillium</i> sp.	<i>Ulocladium</i> sp.	<i>Aureobasidium</i> sp.	<i>Geomyces</i> sp.	<i>Rhizopus</i> sp.	<i>Aureobasidium</i> sp.	<i>Fusarium</i> sp.	<i>Rhizopus</i> sp.	<i>Ulocladium</i> sp.	<i>Aspergillus</i> sp.	<i>Cladosporium</i> sp.	<i>Phoma</i> sp.	<i>Tricothecium roseum</i>
<i>C.sitophila</i>	<i>Lichtheimia</i> sp.	<i>Phoma</i> sp.		<i>C.sitophila</i>	<i>Leichimia</i> sp.	<i>Trichoderma</i> sp.	<i>C.sitophila</i>	<i>Mucor</i> sp.	<i>Stachybotrys</i> sp.	<i>Stemphylium</i> sp.	<i>Aureobasidium</i> sp.	<i>Fusarium</i> sp.	<i>Rhizopus</i> sp.	<i>Ulocladium</i> sp.
<i>Chaetomium</i> sp.	<i>Monascus ruber</i>	<i>Rhizopus</i> sp.		<i>Chrysosporium</i> sp.	<i>Mucor</i> sp.	<i>Ulocladium</i> sp.	<i>Chrysonilia</i> sp.	<i>Paecilomyces</i> sp.	<i>Stemphylium</i> sp.		<i>C.sitophila</i>	<i>Mucor</i> sp.	<i>Stachybotrys</i> sp.	

The complement between sampling methods allowed us to identify different species in active and passive sampling methods





- Species from the WHO-FPPL were found in different sampling methods from each woodworking environment.
- The high and critical species found highlight the need for both methods to be used in complement.



Example: DIY Stores

Active Sampling Methods: MAS-100				Passive Sampling Methods: Settled Dust		
Alternaria sp.	Chrysosporium sp.	Aspergillus section Fumigati	Paecilomyces sp.	Ulocladium sp.	C.sitophila	Paecilomyces sp.
Aspergillus section Aspergilli	Aspergillus section Circumdati	Fusarium sp.	Penicillium sp.		Chrysosporium sp.	Penicillium sp.
Aureobasidium sp.	Cladosporium sp.	Mucor sp.	Phoma sp.		Cladosporium sp.	Rhizopus sp.
C.sitophila	F.verticilloides	Aspergillus section Nidulantes	Rhizopus sp.		Fusarium verticilloides	Trichoderma sp.
Chaetomium sp.	Aspergillus section Flavi	Aspergillus section Nigri	Trichoderma sp.		Aspergillus section Nigri	



Example: Sawmills

Active Sampling Methods: MAS-100				Passive Sampling Methods: Settled Dust		
Alternaria sp.	Chrysosporium sp.	Mucor sp.	Rhizopus sp.	Alternaria sp.	Aspergillus section Nigri	
Aspergillus section Aspergilli	Cladosporium sp.	Aspergillus section Nigri	Trichoderma sp.	Aureobasidium sp.	Paecilomyces sp.	
Aureobasidium sp.	Fusarium graminearum	Paecilomyces sp.	Tricobotecium rosatum	Cladosporium sp.	Penicillium sp.	
C.sitophila	Fusarium verticilloides	Penicillium sp.	Ulocladium	Aspergillus section Fumigati	Trichoderma sp.	
Chrysonilia sp.	Fusarium graminearum	Phoma sp.		Mucor sp.	Ulocladium sp.	

Critical group

	<i>Cryptococcus neoformans</i>
	<i>Candida auris</i>
	<i>Aspergillus fumigatus</i>
	<i>Candida albicans</i>

High group

	<i>Nakaseomyces glabrata (Candida glabrata)</i>
	<i>Histoplasma spp.</i>
	Eumycetoma causative agents
	Mucorales
	<i>Fusarium spp.</i>
	<i>Candida tropicalis</i>
	<i>Candida parapsilosis</i>

Medium group

	<i>Scedosporium spp.</i>
	<i>Lomentospora prolificans</i>
	<i>Coccidioides spp.</i>
	<i>Pichia kudriavzevii (Candida krusei)</i>
	<i>Cryptococcus gattii</i>
	<i>Talaromyces marneffeii</i>
	<i>Pneumocystis jirovecii</i>
	<i>Paracoccidioides spp.</i>

Main Findings

- **Active and passive sampling methods used in parallel** is crucial to **overcome the constraints** of each to allow a **proper characterization of the risks** to which these workers are exposed.
- **Similar considerations should be taken to select the best lab approach.**





Thank you for your attention

Acknowledgments:

This project was supported by FCT/MCTES UIDP/05608/2020 (<https://doi.org/10.54499/UIDP/05608/2020>) and UIDB/05608/2020 (<https://doi.org/10.54499/UIDB/05608/2020>). This work is also supported by national funds through FCT/MCTES/FSE/UE, 2023.01366.BD; UI/BD/153746/2022 and CE3C unit UIDB/00329/2020 (<https://doi.org/10.54499/UIDB/00329/2020>); UI/BD/151431/2021 (<https://doi.org/10.54499/UI/BD/151431/2021>); and Instituto Politécnico de Lisboa, national support through IPL/2022/InChildhealth/BI/12M; IPL/IDI&CA2023/FoodAIIEU_ESTeSL; IPL/IDI&CA2023/ASPRisk_ESTeSL; IPL/IDI&CA2023/ARAFSawmills_ESTeSL

References

1. Dias, M.; Gomes, B.; Cervantes, R.; Pena, P.; Viegas, S.; Viegas, C. Microbial Occupational Exposure Assessments in Sawmills—A Review. *Atmosphere*. fevereiro de **2022**;13(2):266.
2. Dutkiewicz, J.; Krysińska-Traczyk, E.; Prazmo, Z.; Skońska, C.; Sitkowska, J. Exposure to airborne microorganisms in Polish sawmills. *Ann Agric Environ Med*. **2001**;8(1):71–80.
3. Manibusan, S; Mainelis, G. Passive bioaerosol samplers: A complementary tool for bioaerosol research. A review. *Journal of Aerosol Science*. Volume 163. **2022**,105992, ISSN 0021-8502, <https://doi.org/10.1016/j.jaerosci.2022.105992>.
4. Environmental Sciences—Editorial Contacts | Springer. Available online: https://www.springer.com/gp/environmentalsciences/contactus?gclid=Cj0KCQiAweaNBhDEARIsAJ5hwbfnBdU3g9WbmW82SZiL1UWITNh5X98xQXKlgPqR1IA2ymwa6znC6gaAo2FEALw_wcB (accessed on 17 Abril 2024).
5. Viegas, C.; Almeida, B.; Dias, M.; Caetano, L.A.; Carolino, E.; Gomes, A.Q.; Faria, T.; Martins, V.; Marta Almeida, S. Assessment of Children’s Potential Exposure to Bioburden in Indoor Environments. *Atmosphere* **2020**, 11, 993. [[CrossRef](#)]
6. Croston, T.L.; Nayak, A.P.; Lemons, A.R.; Goldsmith, W.T.; Gu, J.K.; Germolec, D.R.; Beezhold, D.H.; Green, B.J. Influence of *Aspergillus fumigatus* conidia viability on murine pulmonary MicroRNA and mRNA expression following subchronic inhalation exposure. *Clin. Exp. Allergy* **2016**, 46, 1315–1327. [[CrossRef](#)]
7. Dias, M.; Viegas, C. Fungal prevalence on waste industry—Literature review. In *Encyclopedia of Mycology*; Zaragoza, Ó., Casadevall, A., Eds.; Elsevier: Oxford, UK, 2021; pp. 99–106. [[CrossRef](#)]
8. International Labour Organization. *Encyclopaedia of Occupational Health and Safety*; International Labour Organization: Geneva, Switzerland, 1998.
9. Dias, M.; Sousa, P.; Viegas, C. Occupational exposure to bioburden in portuguese ambulances. In *Occupational and Environmental Safety and Health III*; Arezes, P.M., Baptista, J.S., Carneiro, P., Castelo Branco, J., Costa, N., Duarte, J., Guedes, J.C., et al., Eds.; *Studies in Systems, Decision and Control*; Springer International Publishing: Cham, Switzerland, 2022; pp. 167–173. [[CrossRef](#)]
10. Mao, J.; Tang, Y.; Wang, Y.; Huang, J.; Dong, X.; Chen, Z.; Lai, Y. Particulate matter capturing via naturally dried ZIF-8/Graphene aerogels under harsh conditions. *iScience* **2019**, 16, 133–144. [[CrossRef](#)] [[PubMed](#)]

