

# Microbial contamination of libraries and archives: risk assessment and contamination control

**F Bosco, M Demichela, A A Barresi and D Fissore**

**Department of Applied Science and Technology, DISAT, Politecnico di Torino**

**FLORENCE HERI-TECH 14-16 OCTOBER 2020**

# Recovery of FLOODED ARCHIVAL MATERIALS

## Documents – certificates



<http://www.sato-archivi.it>

## Cultural heritage – ancient books



<https://www.bncf.firenze.sbn.it>

## Natural flood



<http://www.arte.it/calendario-arte/firenze>

## Fire extinguishing



<http://www.mqmd.it/services>

# DRYING paper materials QUICKLY applying NON-INVASIVE methods

Prevent **BIODETERIORATION AND ILLNESS** caused by  
Microorganisms and their metabolites

Probability of microbial growth  
increases with  
water contact time

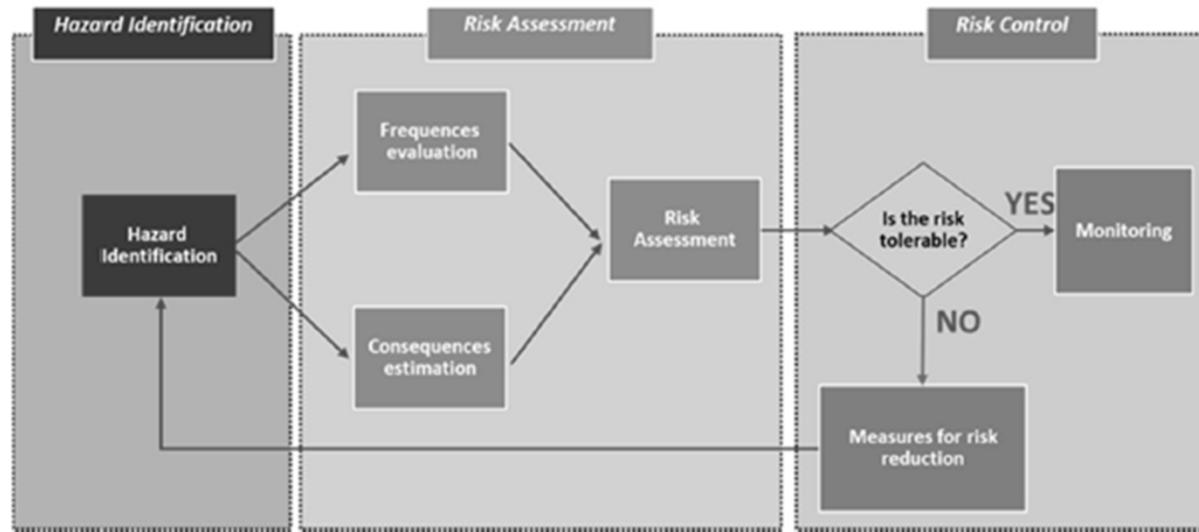
**HIGH** paper **BIORECEPTIVITY**  
*i.e.* its ability to be colonized by microorganisms.  
Cellulose could be a **primary C source**  
for paper borne microorganisms.

Different classes of microorganisms can cause  
biodeterioration and illness:

**BACTERIA, YEASTS, FILAMENTOUS FUNGI**



# RISK BASED decision making can guide the adoption of the measures to be implemented



$$R = P \times E \times M$$

**P** is the probability of occurrence of an unwanted event that could trigger the mould formation;

**E** is the exposure factor to the hazard;

**M** is the magnitude or severity of the consequences.

$$P = 1$$

The starting unwanted event is taken for granted

## EXPOSURE FACTOR, E

Exposure Factor, <i>E</i>	Librarian (h/week)	Reader (contacts/week)	Restorer (contacts/week)
4	30÷40	>10	>5
3	20÷30	7÷10	3÷5
2	10÷20	4÷7	2÷3
1	<10	<4	<2

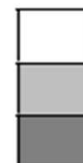
Indexes definitions and assignment are based on expert judgment

## MAGNITUDE FACTOR, M

Magnitude Factor, <i>M</i>	Description
4	High contamination with toxins production
3	Low contamination with toxins production OR high contamination with allergens production
2	Low contamination with allergens production
1	Negligible contamination

## RISK TOLERABILITY EVALUATION

<i>E</i> \ <i>M</i>	1	2	3		4
1					
2					
3					
4					



Tolerable risk. Monitoring and awareness are required.

Risk to be reduced. Reduction measures have to be planned

Risk not tolerable, requires immediate reduction measures



## EXPOSURE FACTOR, E

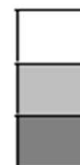
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## Case study



A flooding due to the spurious intervention of the firefighting system sprinklers has damaged a shelf containing books, with the possible formation of filamentous fungi that could spread in the air toxins in case of manipulation.

A **librarian**, who should not manipulate the books after the contamination, will not be exposed

A **restorer** will be potentially exposed.

A **reader** will be potentially exposed.

### Initial condition

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### Freeze drying + Essential Oils

#### EXPOSURE FACTOR, E

Exposure Factor, E	Librarian (h/week)	Reader (contacts/week)	Restorer (contacts/week)
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E \ M	1	2	3	4
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- Tolerable risk. Monitoring and awareness are required.
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Residual risk could be further managed using PPE

# ESSENTIAL OILS

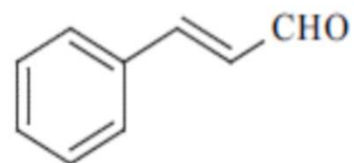
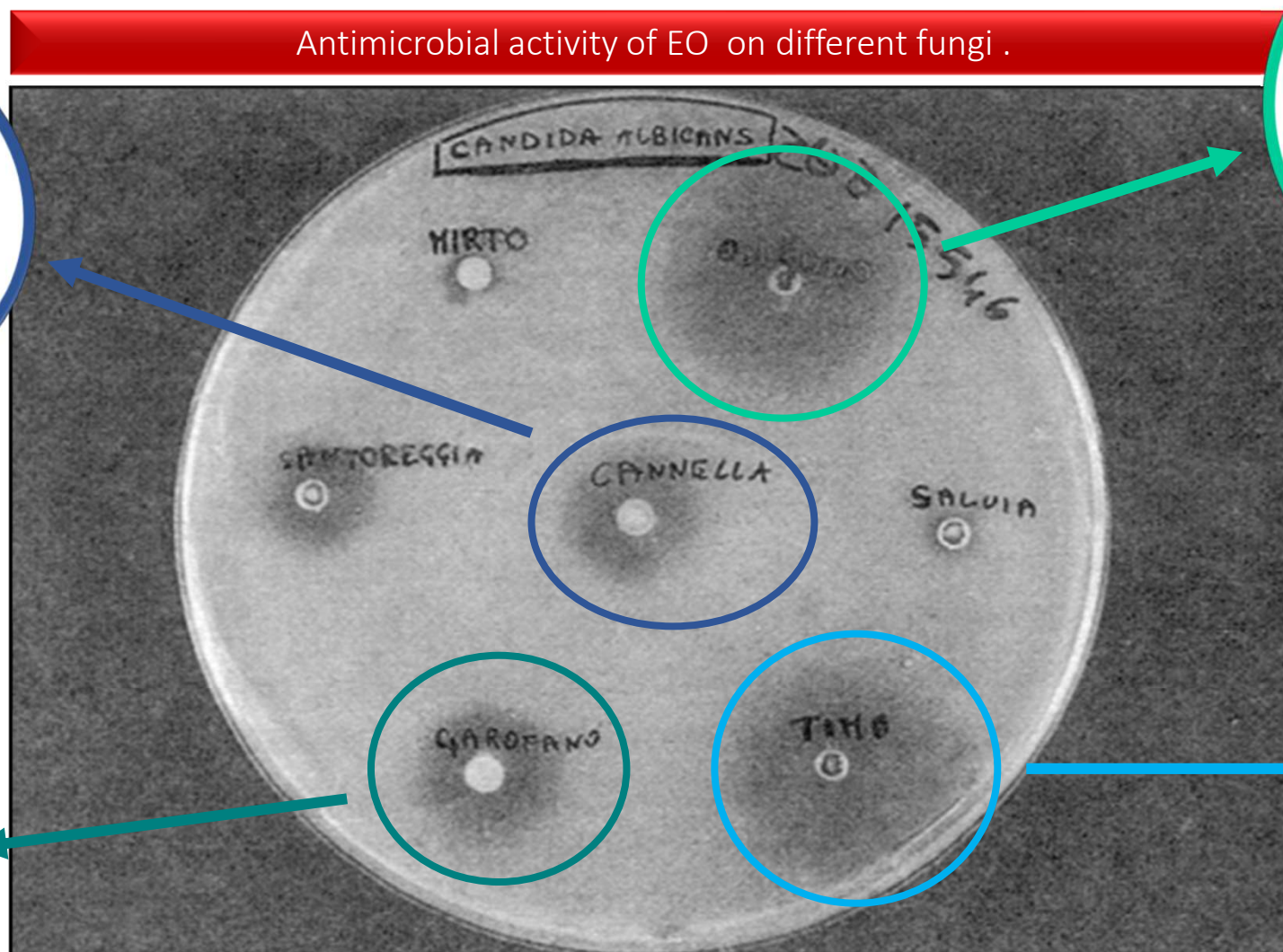
- EO are natural, volatile, complex compounds extracted from aromatic plants.
- EO antimicrobial activity is closely related to the chemical composition.



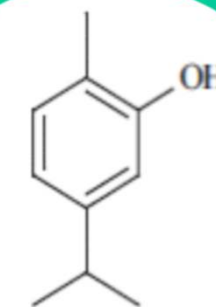


# ESSENTIAL OILS

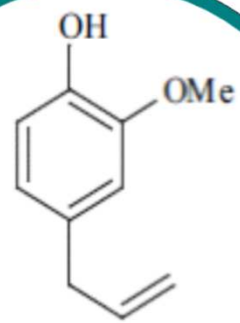
Antimicrobial activity of EO on different fungi .



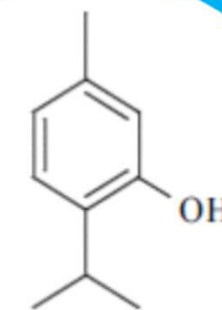
Cinnamaldehyde



Carvacrol



Eugenol



Thymol

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# EXPERIMENTAL ACTIVITY

**AIM:** Investigate the effect of EO treatment, after freeze-drying, on the growth of microorganisms contaminating the flooded archival material.

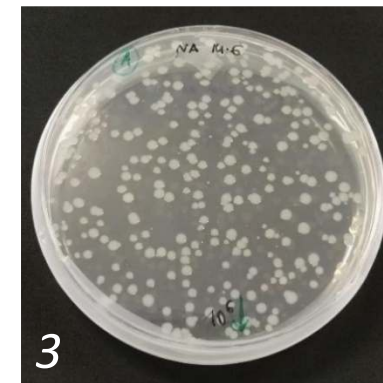
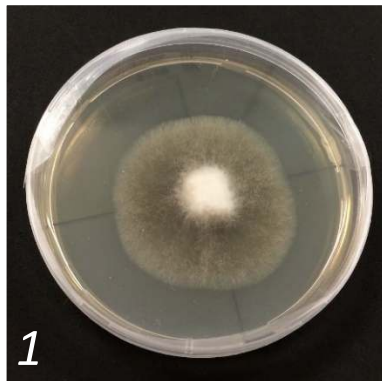
EO was applied at two different time: immediately after the drying phase (t0) or after 24 hours of incubation.

## ESSENTIAL OIL

- *Thymus vulgaris* oil

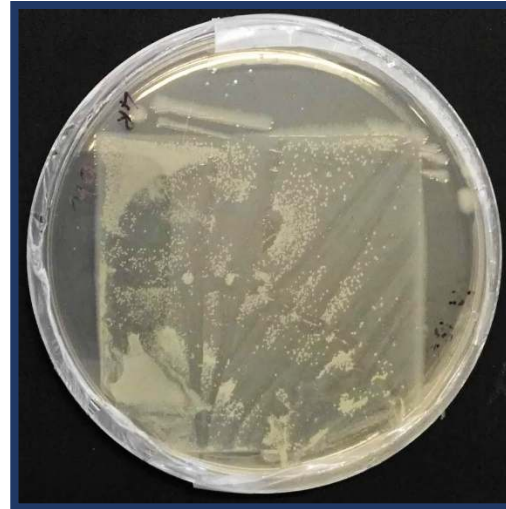
## Biodeteriogenic microorganisms

1. *Alternaria alternata* strain BNR
2. *Rhodotorula mucilaginosa*
3. *Staphylococcus epidermidis*

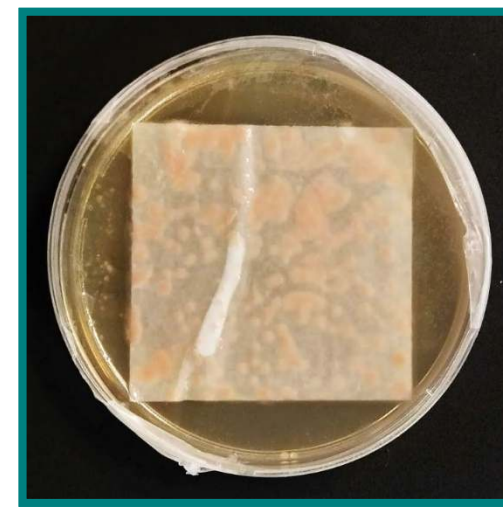
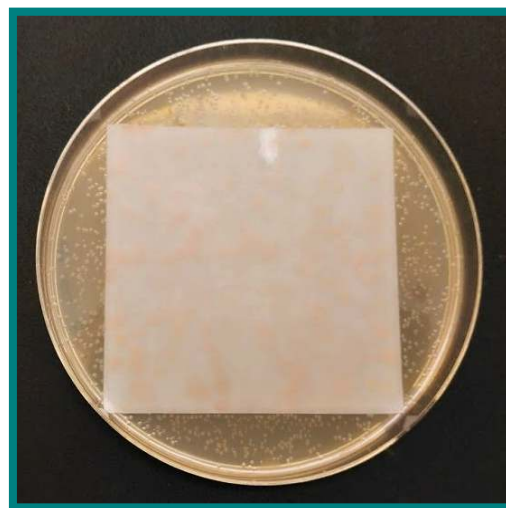
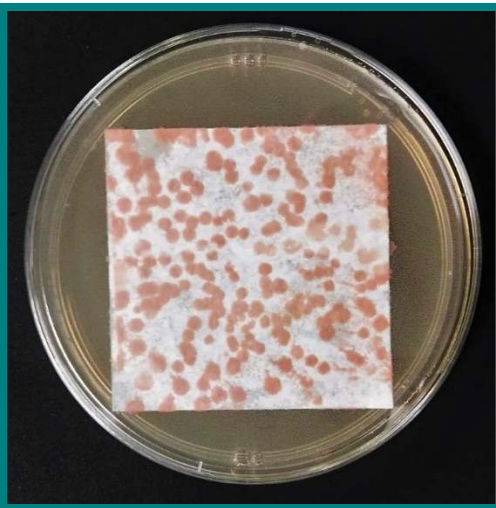


# Effect of *Thymus vulgaris* oil after freeze-drying

*S. epidermidis*



*R. mucilaginosa*



Control

Treatment at t0

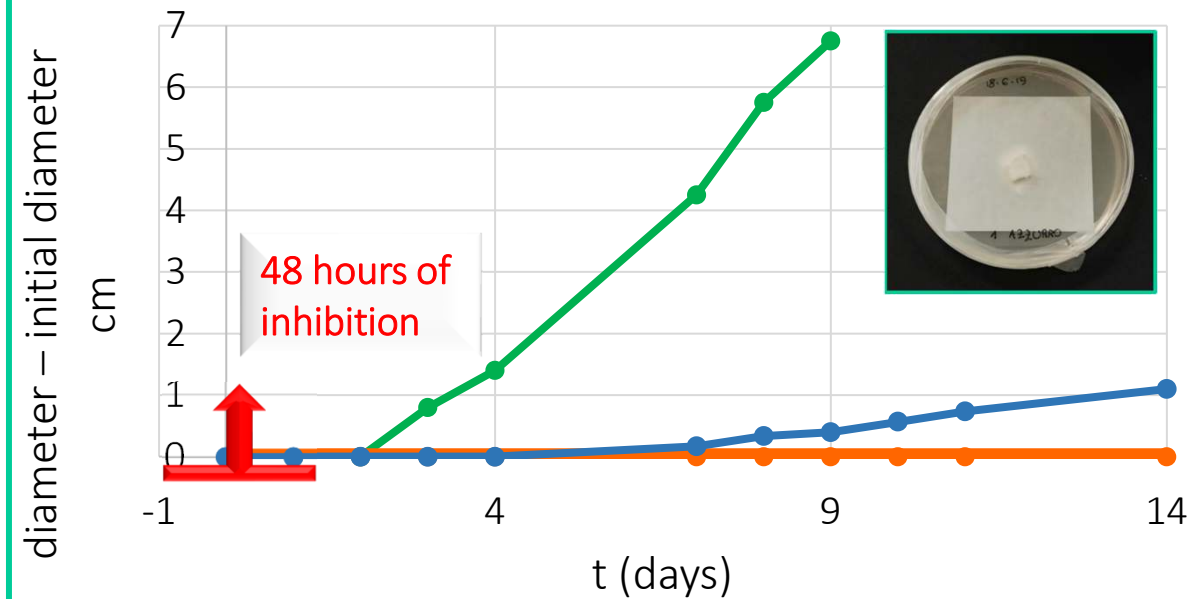
Treatment after 24 hours



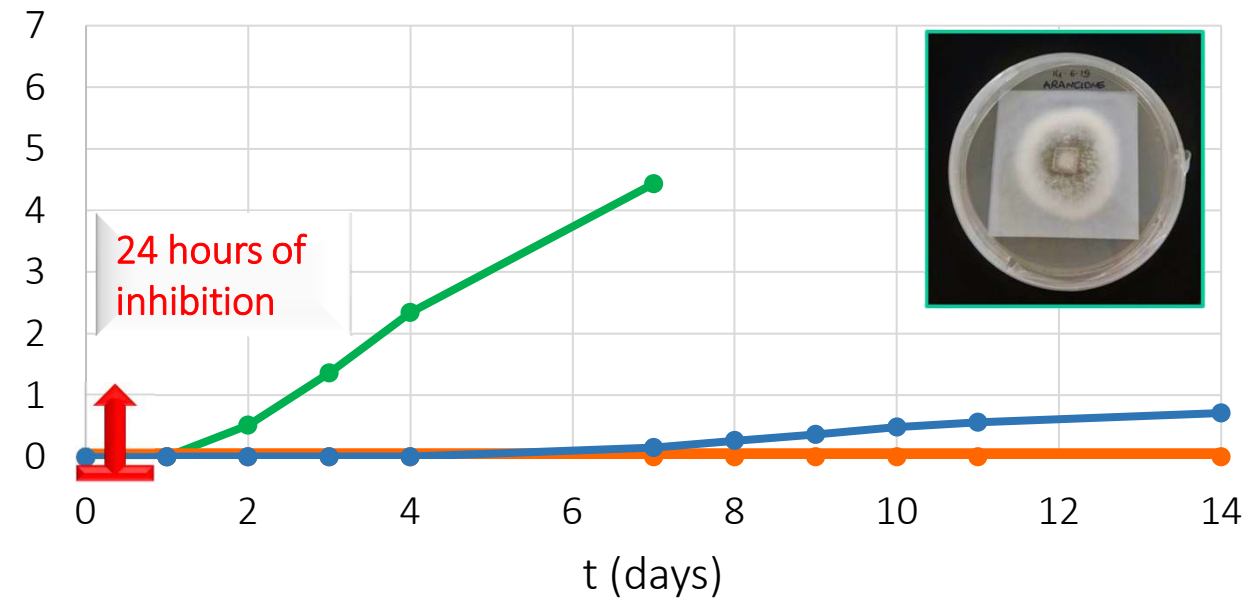
# Effect of *Thymus vulgaris* oil after freeze-drying

The mycelium of *A. alternata*, with or without sporification, treated immediately after the drying (red line), showed a total inhibition of growth

*A. alternata* not-sporified



*A. alternata* sporified



— control — treated at t0 — treated after 24 hours

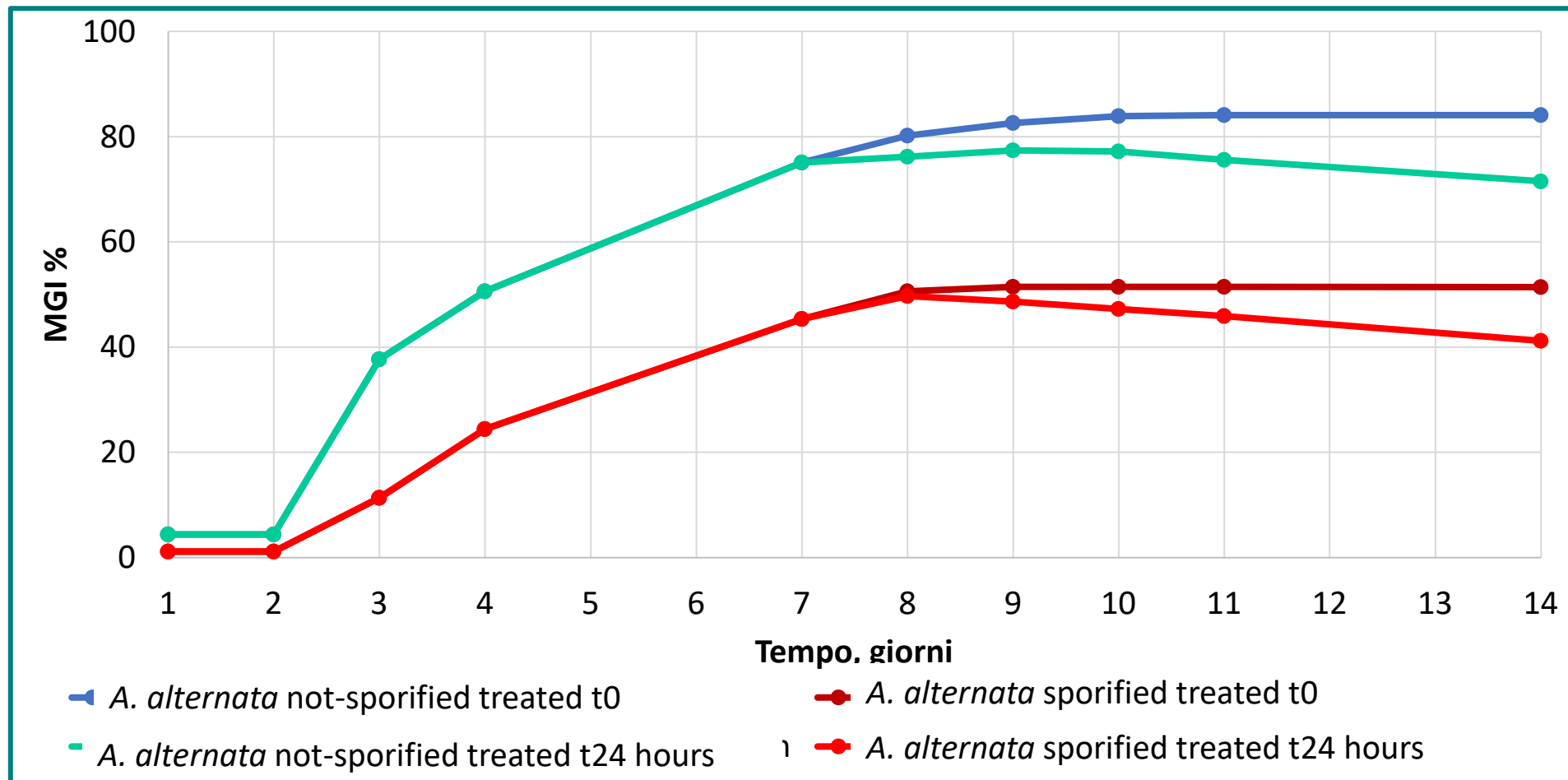


# Effect of *Thymus vulgaris* oil after freeze-drying

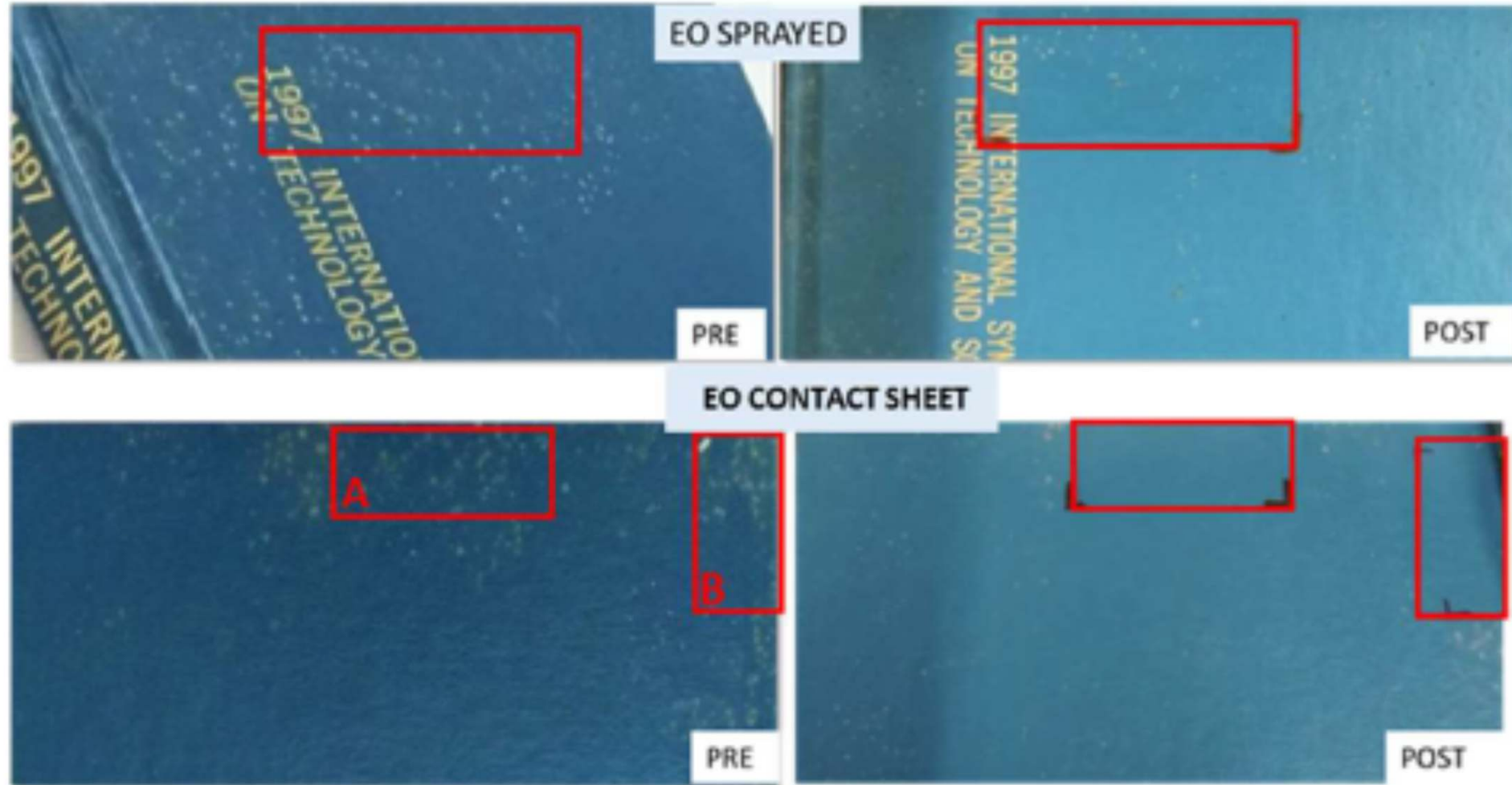
**MGI (%)** = inhibition percentage of mycelial growth

$$\frac{d_c - d_t}{d_c} \cdot 100$$

$d_c$  = colony diameter in the control;  
 $d_t$  = colony diameter in the treated sheets.



# Effect of *Thymus vulgaris* oil on contaminated book



Contaminated book treated with *Thymus vulgaris* oil: pre-treatment with EO (on the left), post-treatment with EO (on the right). EO contact time: A) 2 hours; B) 24 hours.

## CONCLUSION

- *Thymus vulgaris* oil (0.75% v/v) was able to inhibit the growth of *R. mucilaginosa* and *S. epidermidis* , after the freeze-drying process; the efficacy was higher when the oil was applied earlier.
- The mycelium of *A. alternata*, with or without sporification, treated immediately after the drying, showed a total inhibition of growth during the evaluation period; for non-sporulated mycelium a higher value of MGI% was observed.
- The inhibition effect of *T. vulgaris* oil (0,75% v/v) on contaminated book was higher in the areas where it was applied through the contact sheets. Probably, the volatile components of EO showed a higher toxicity
- *Risk based decision making* can support the choice of the preventive measures.
- The *initial risk modelling work* will have to be enriched as far as the knowledge of the effects of microorganisms on the human health and their growth and diffusion will increase. Also the influence of the storage time and storage conditions, that can significantly influence the level of contamination, and thus the Magnitude factor will be considered in further works.

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Ing. Gabriele BALDISSONE  
Dott. ssa Chiara MOLLEA

*for their precious support*

**THANK YOU FOR YOUR ATTENTION**

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