

# Mold Formation in Cathedral Ceilings: Hygrothermal Analysis and Solutions

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**Prof. Dr. Sedlbauer & Dr. Hartwig Künzel**

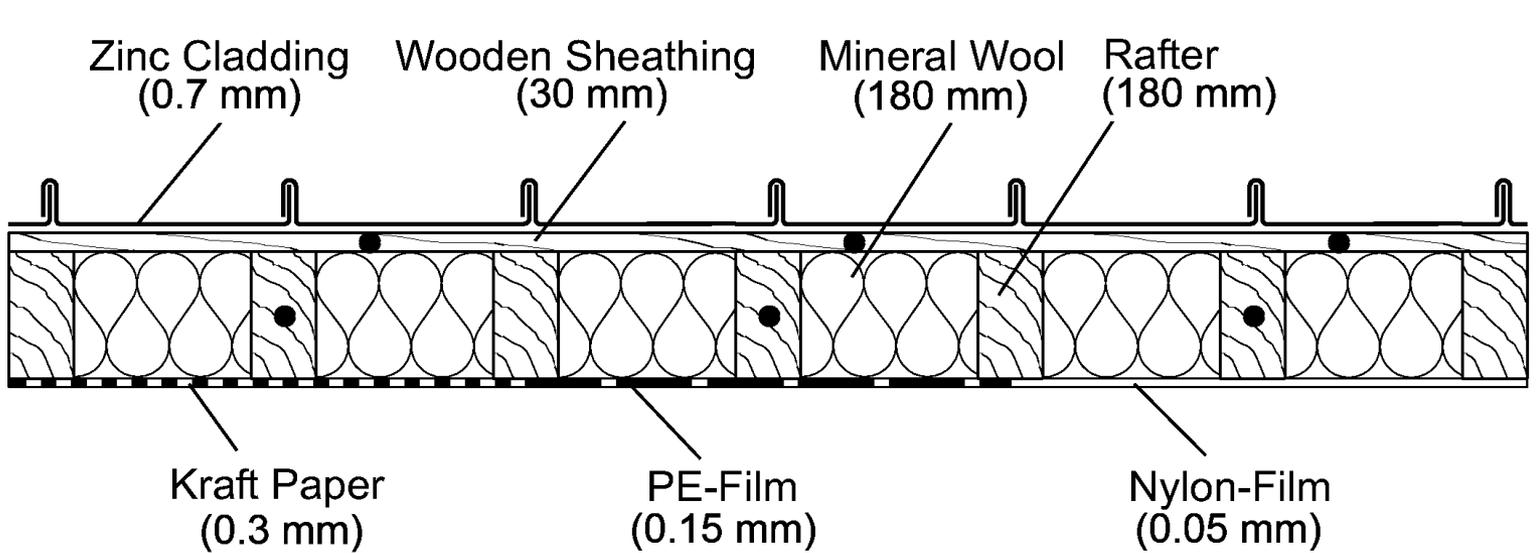
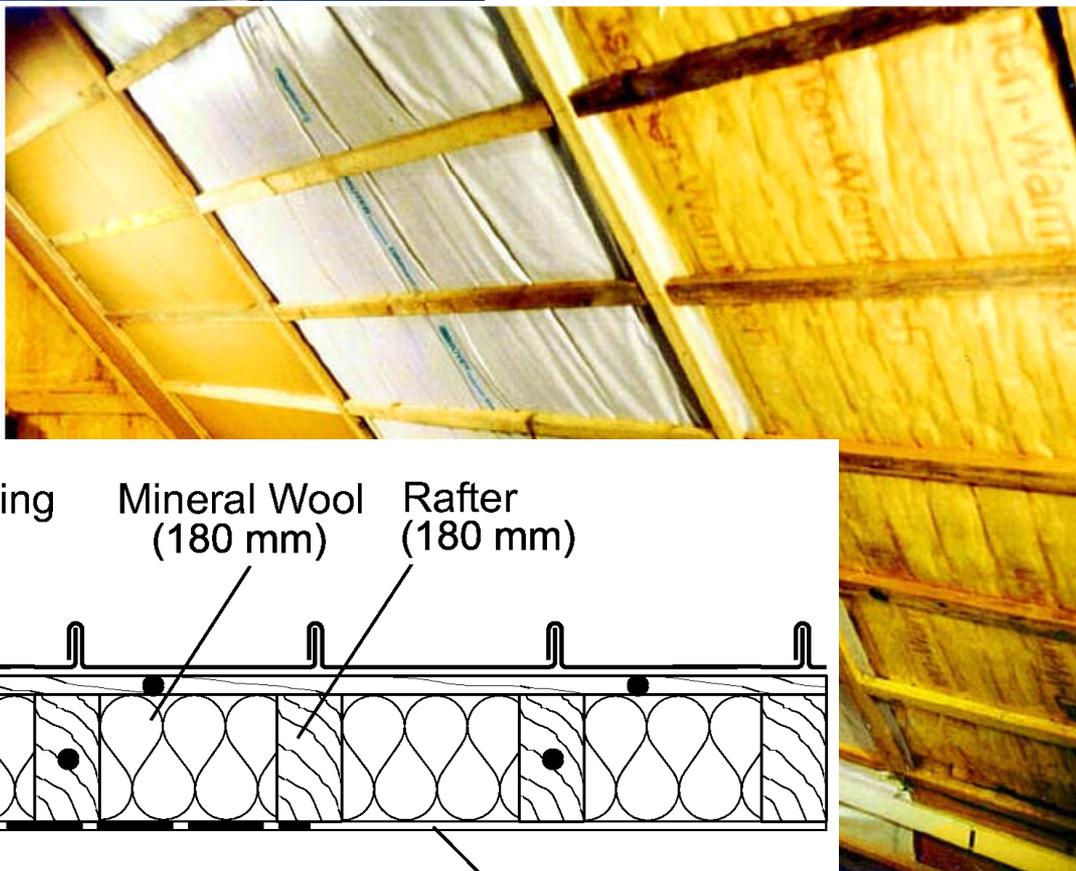
**Fraunhofer-Institut for Building Physics  
Holzkirchen, Germany**

- Problem: mold detected during a field test
- Analysis of the hygrothermal conditions
- Biohygrothermal model for mold prediction
- Conclusions

# Field Test Site in Holzkirchen



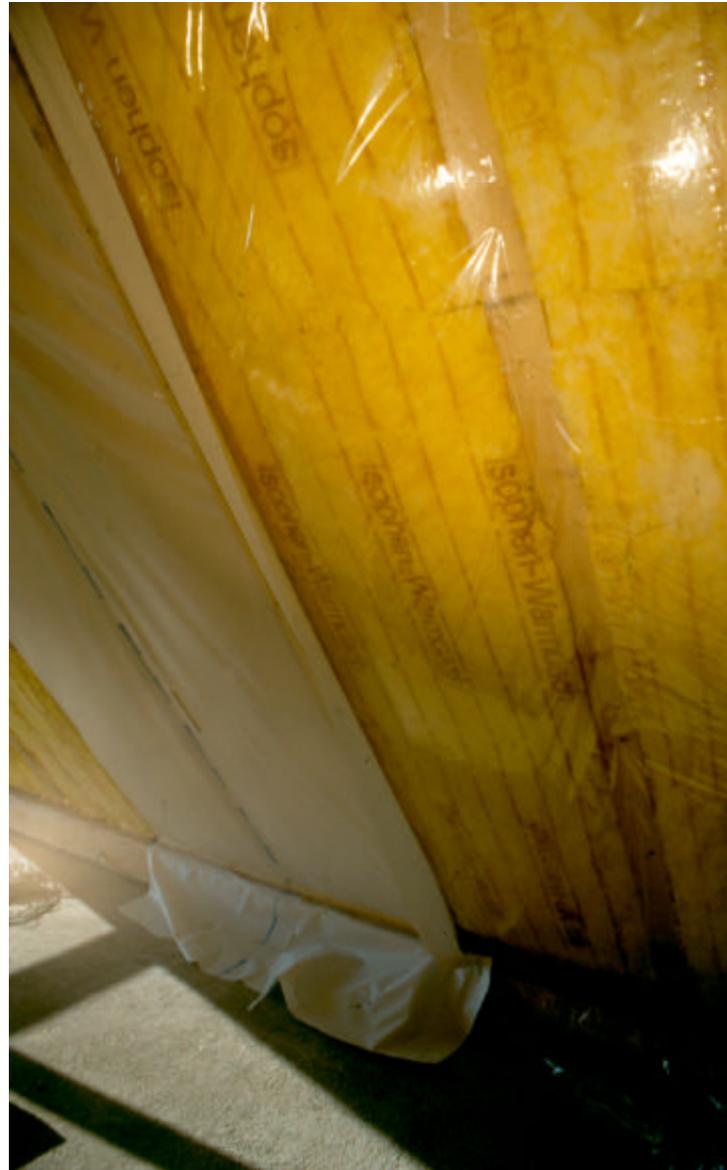
# Cathedral Ceiling with Metal Sheet Covering



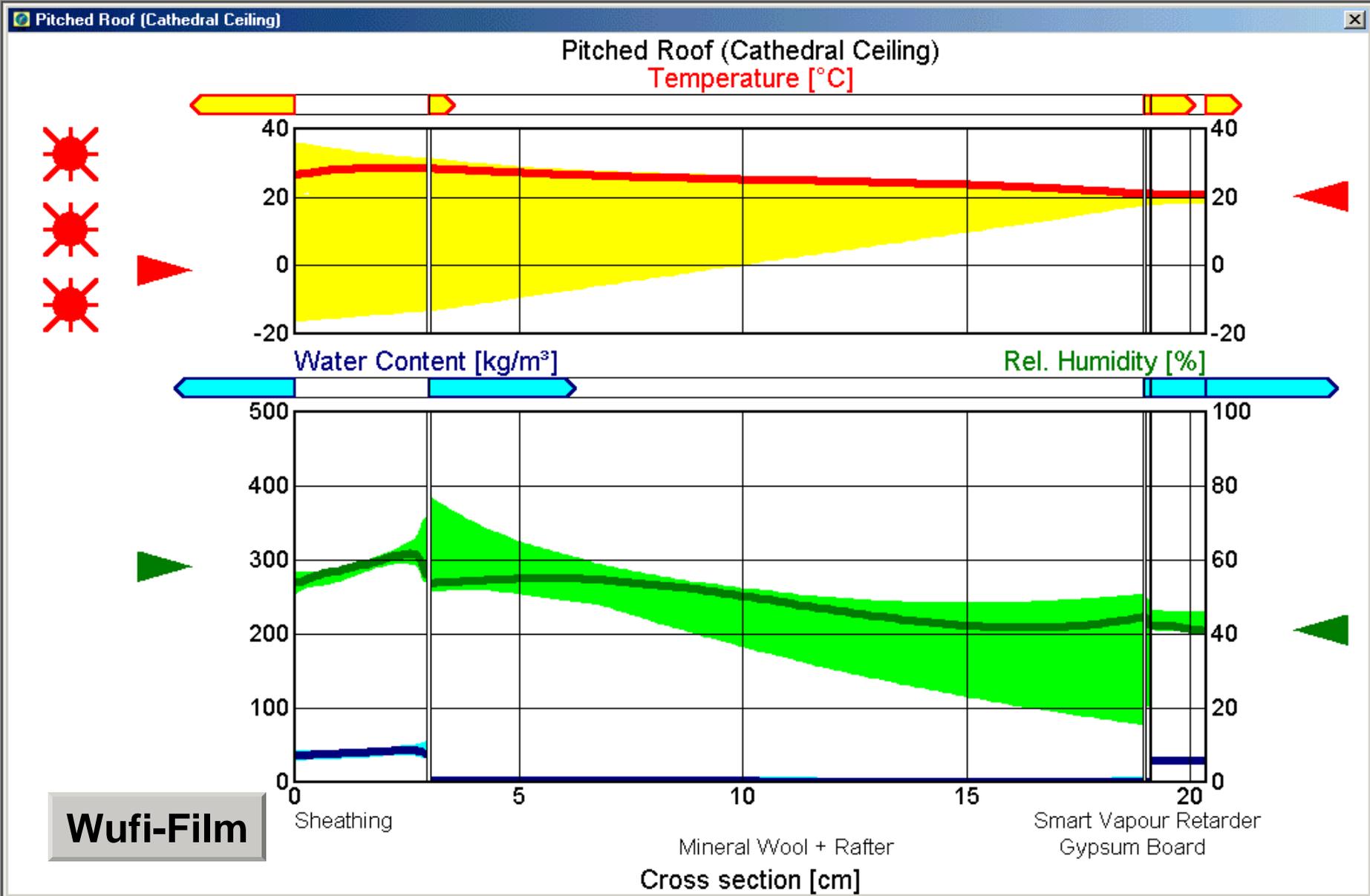
**Mold growth due to summer condensation**



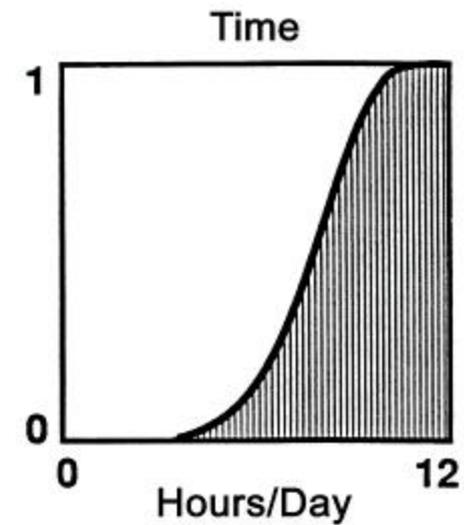
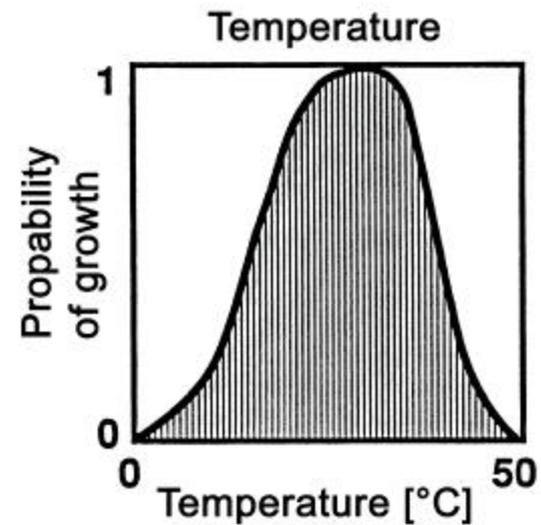
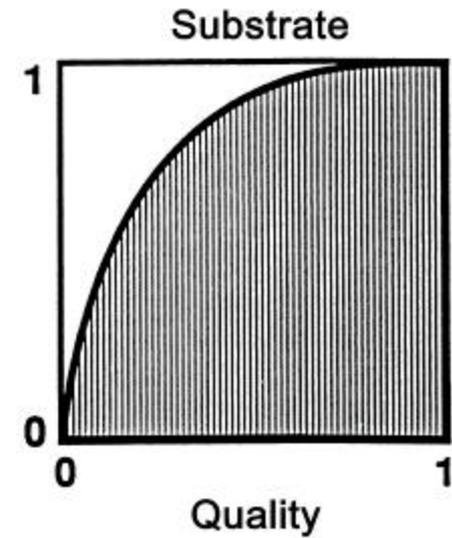
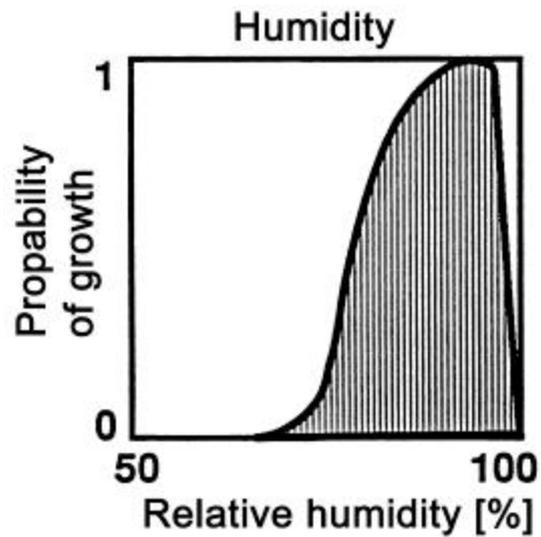
**No Mold growth  
on PA-Film**



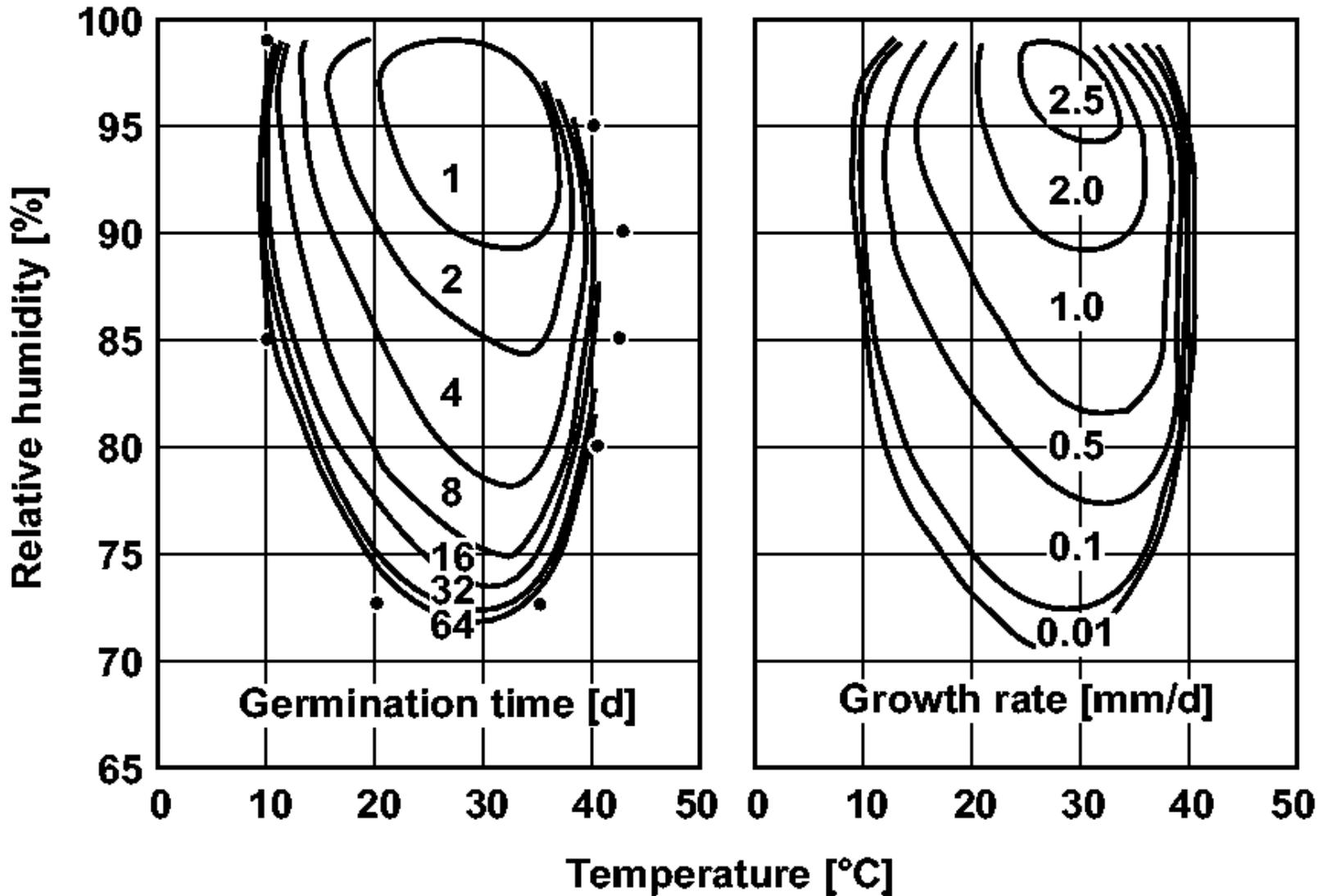
# Computational Analysis of the Hygrothermal Conditions



# Factors Favoring Mold Growth

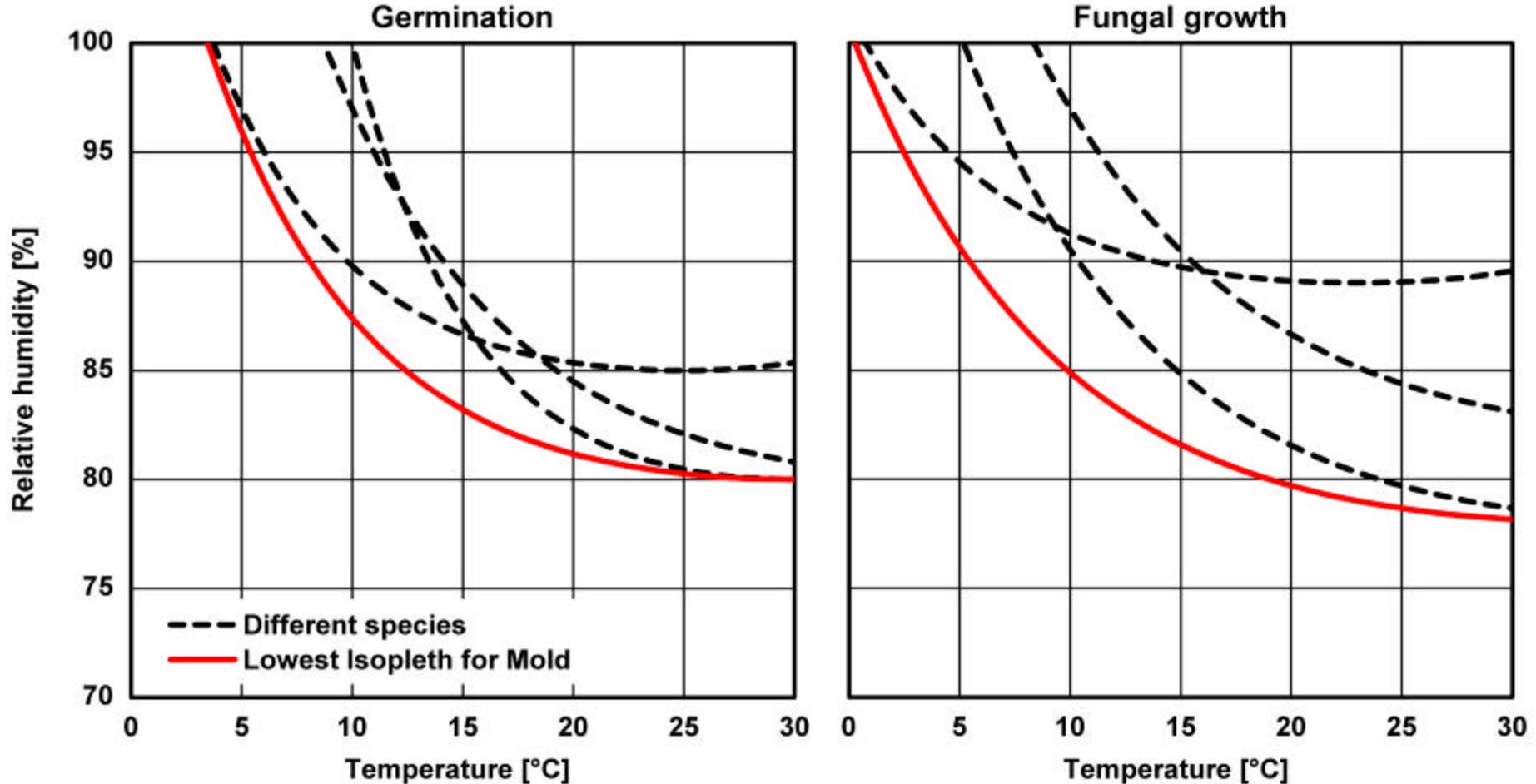


## Aspergillus restrictus (Smith)

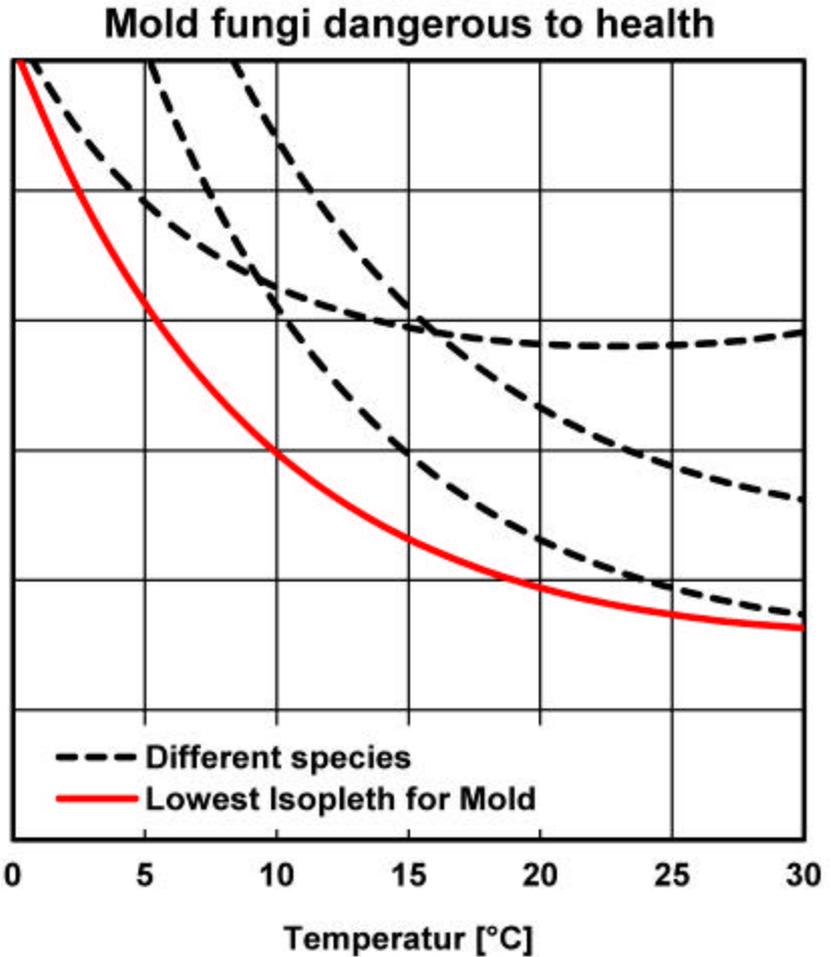
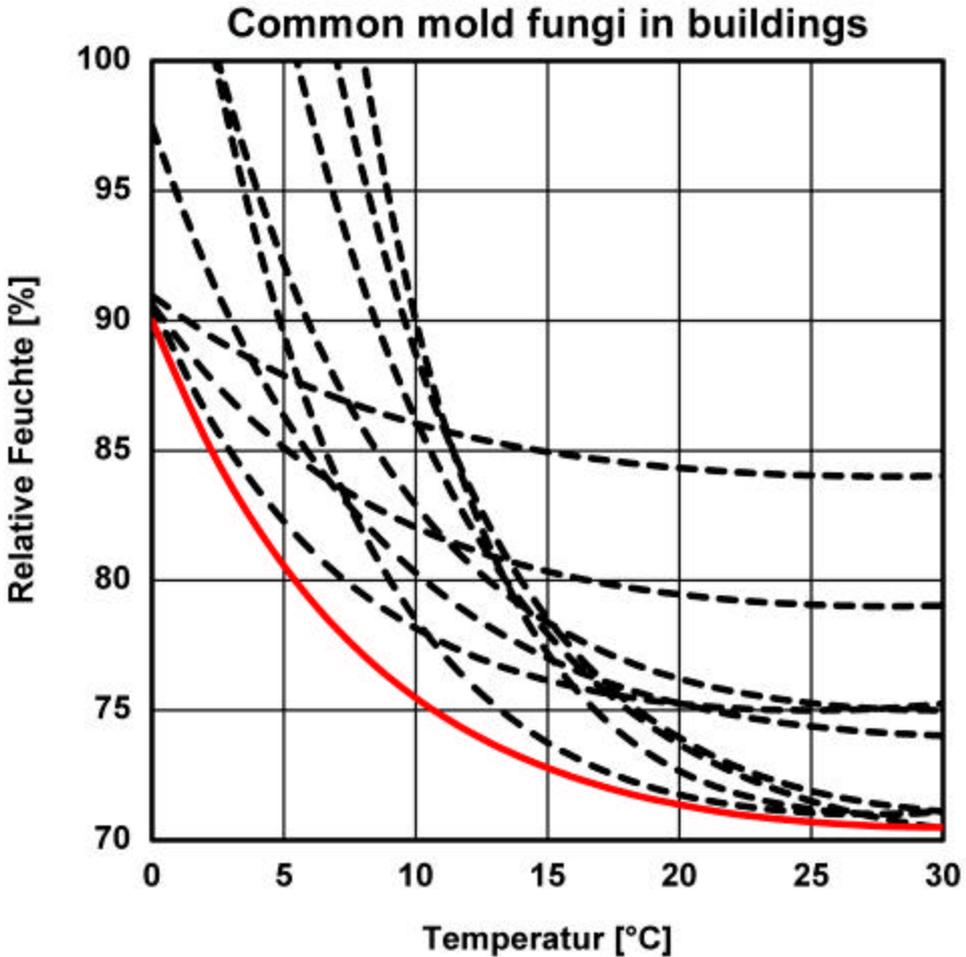


# Development of the Lowest Isoleth for Mold

Mold fungi considered as dangerous to health:  
(*Aspergillus fumigatus*, *Aspergillus flavus*, *Stachybotrys chartarum*)

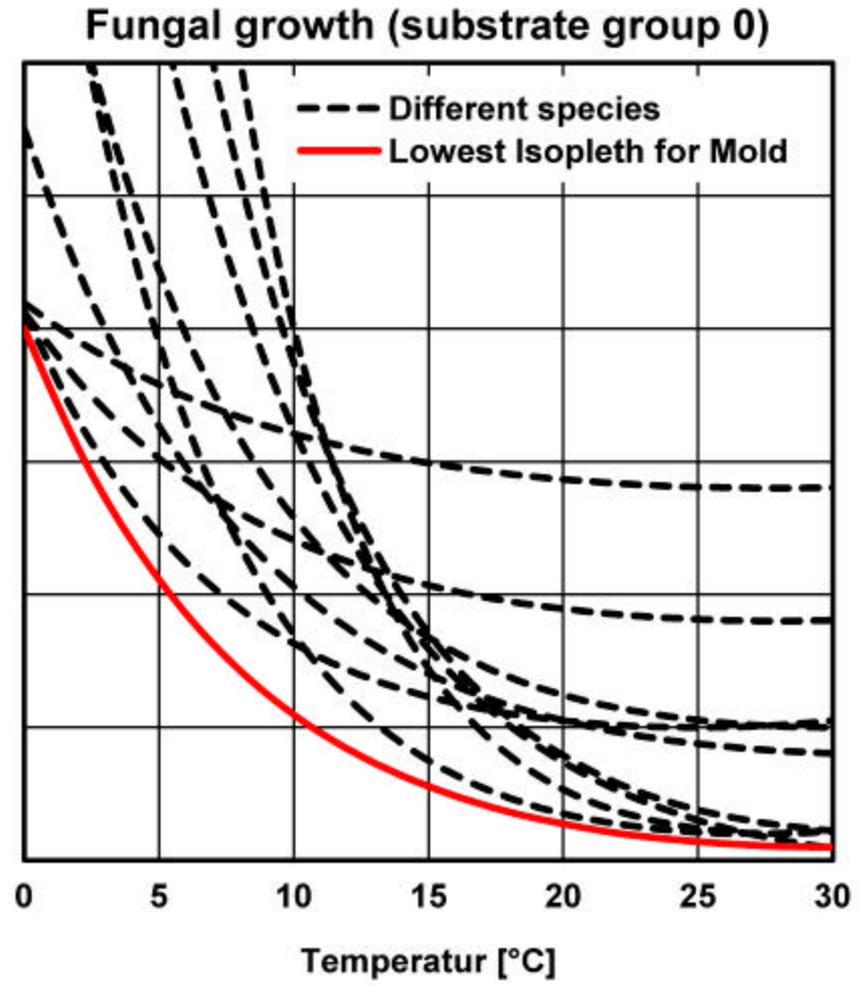
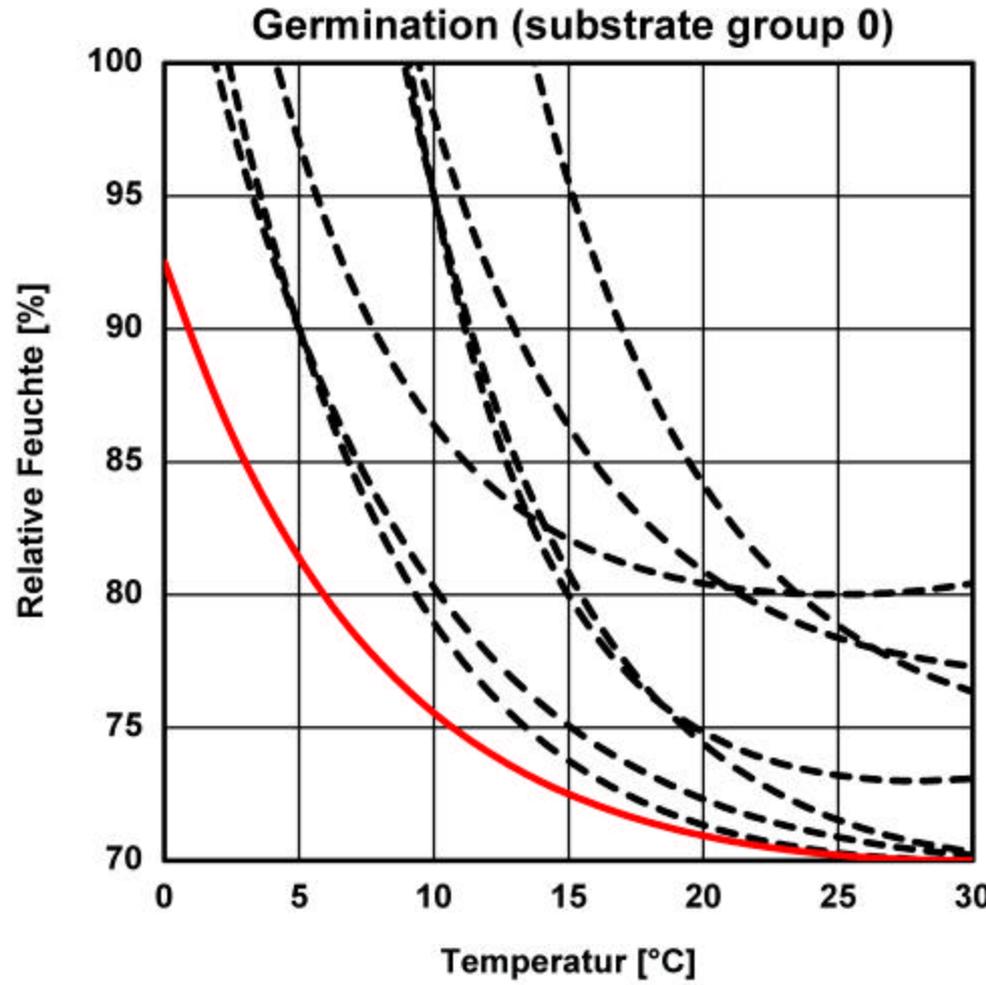


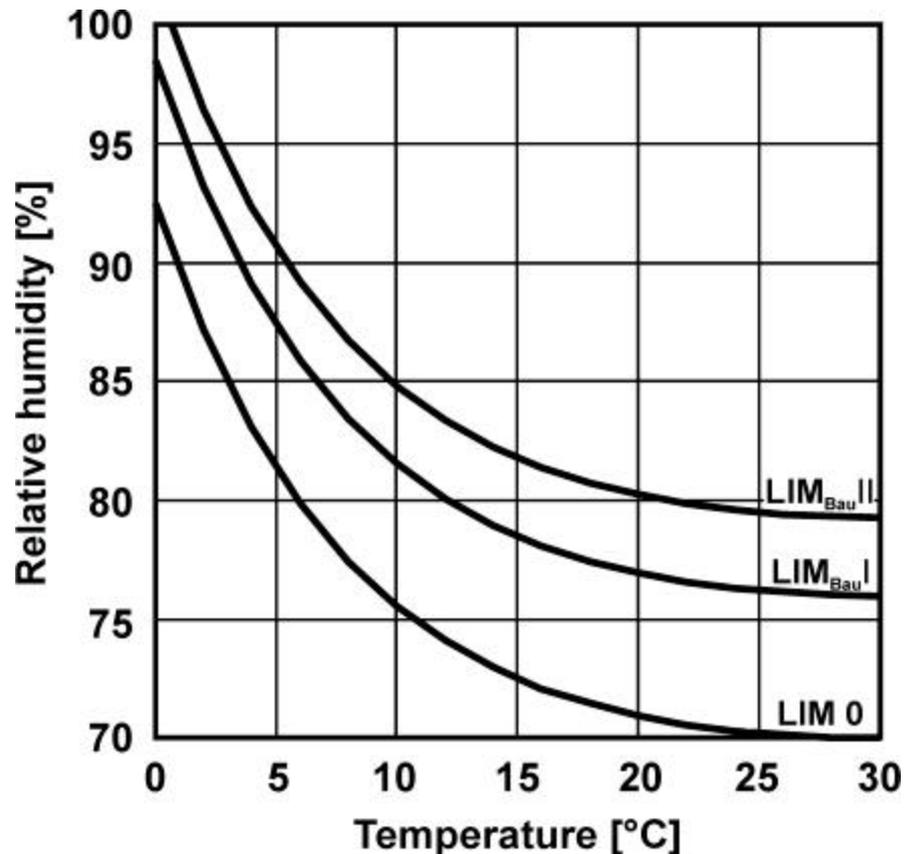
# Development of the Lowest Isopleth for Mold



**Fortunately higher humidity necessary for mold with health risk**

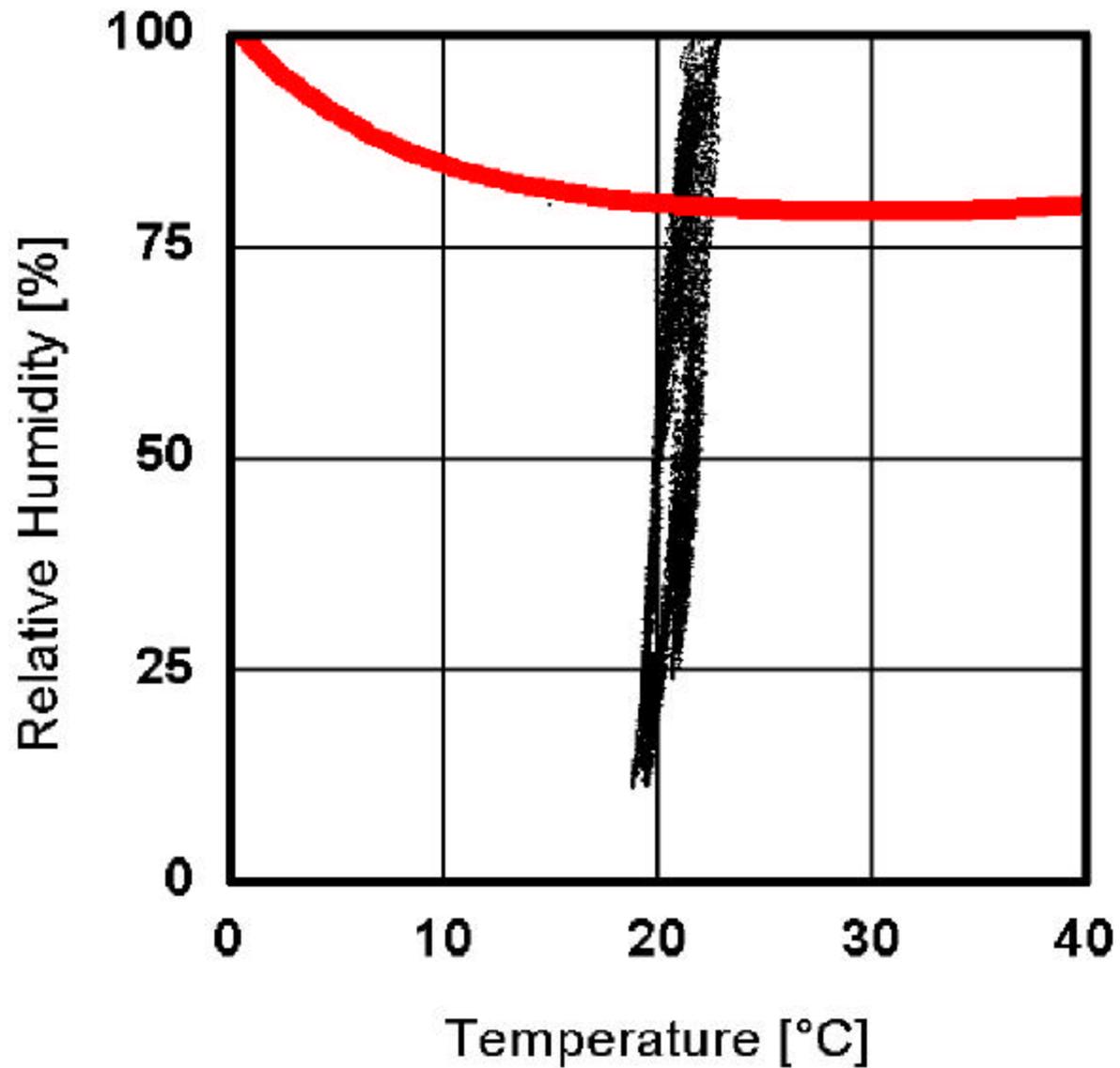
# Development of the Lowest Isoleth for Mold



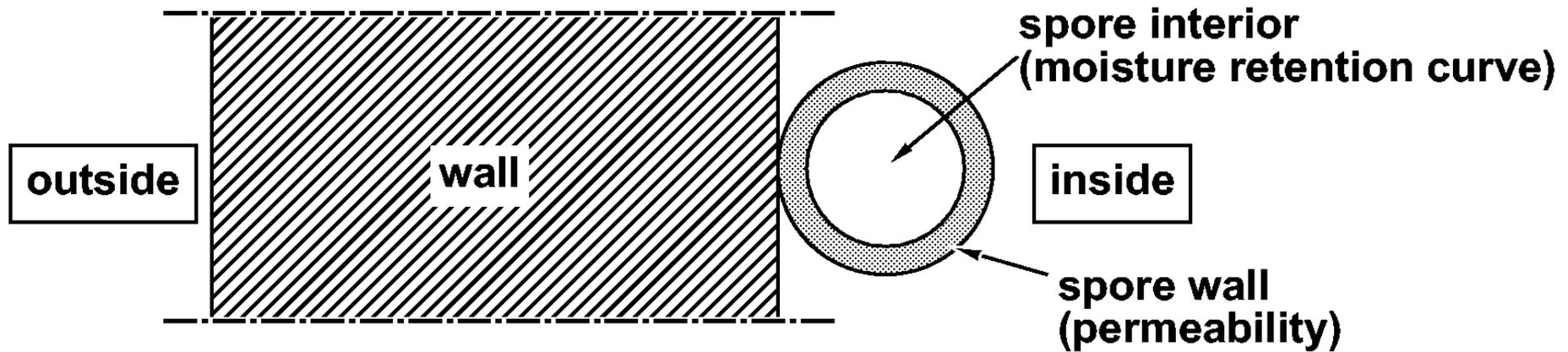


## Substrate group:

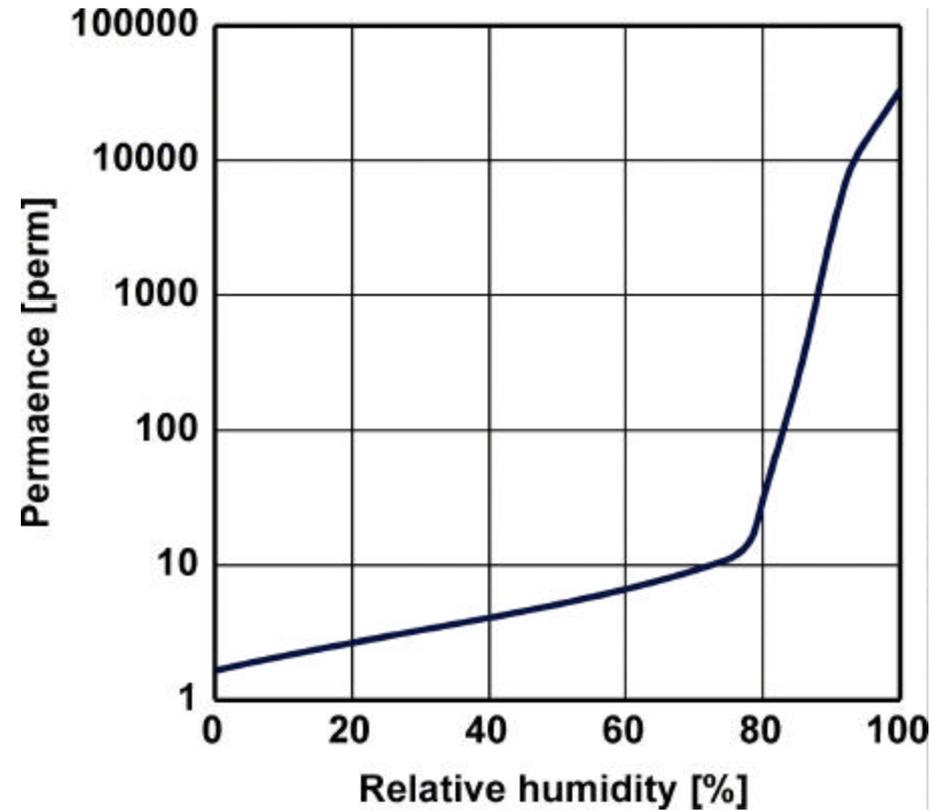
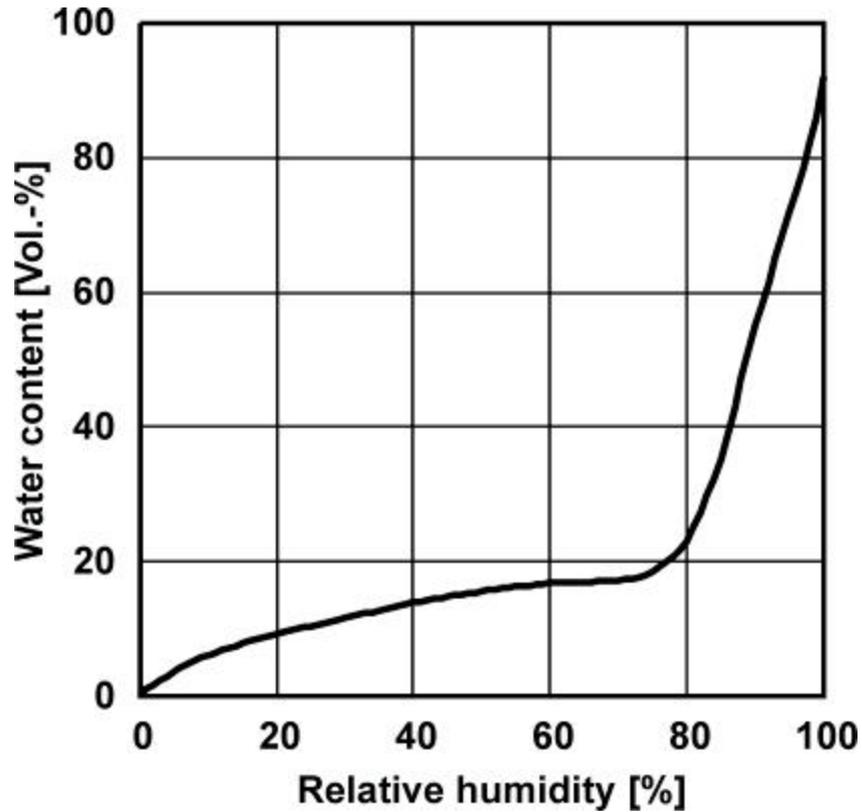
- 0 optimum substrate  
(biological full medium)
- I biodegradable substrates  
(wood, wall paper, ...)
- II non biodegradable substrates  
(mineral building materials)



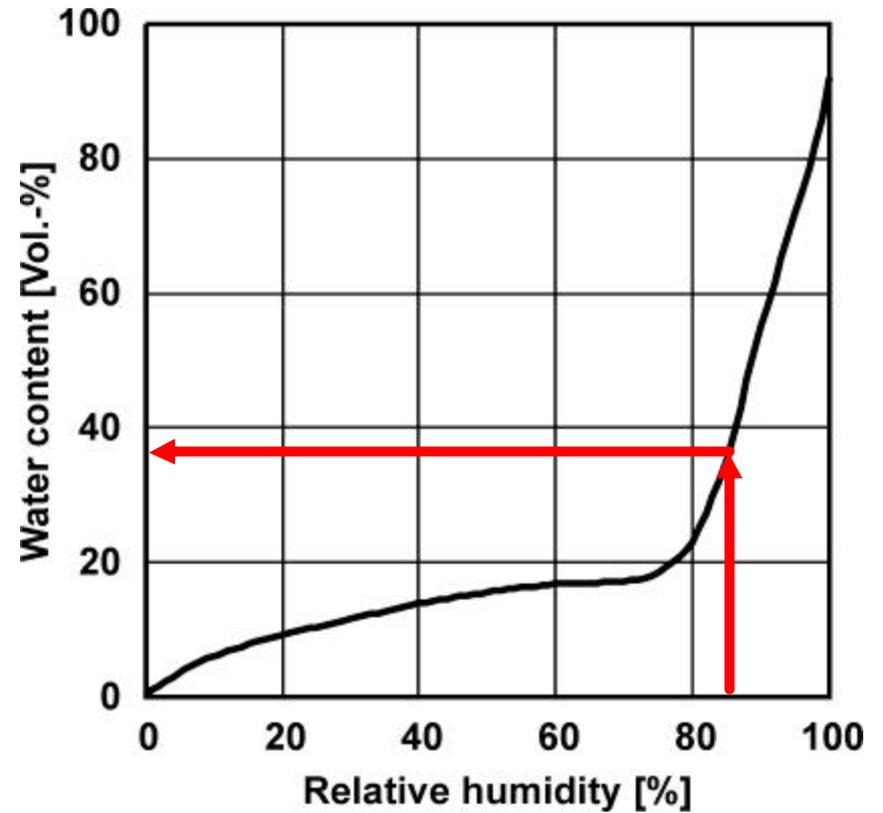
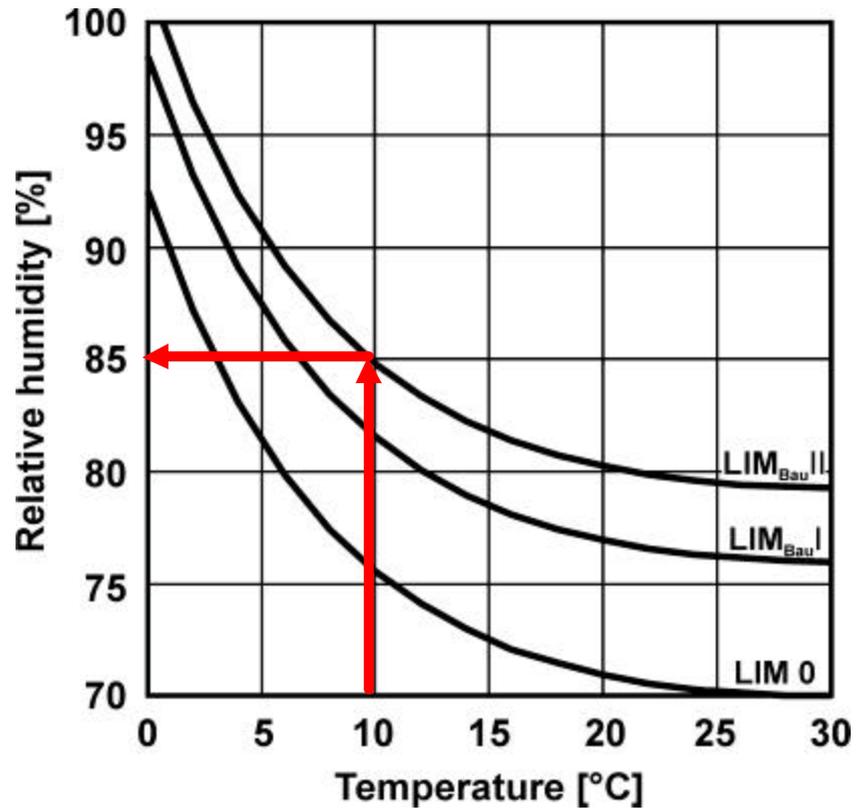
## model spore

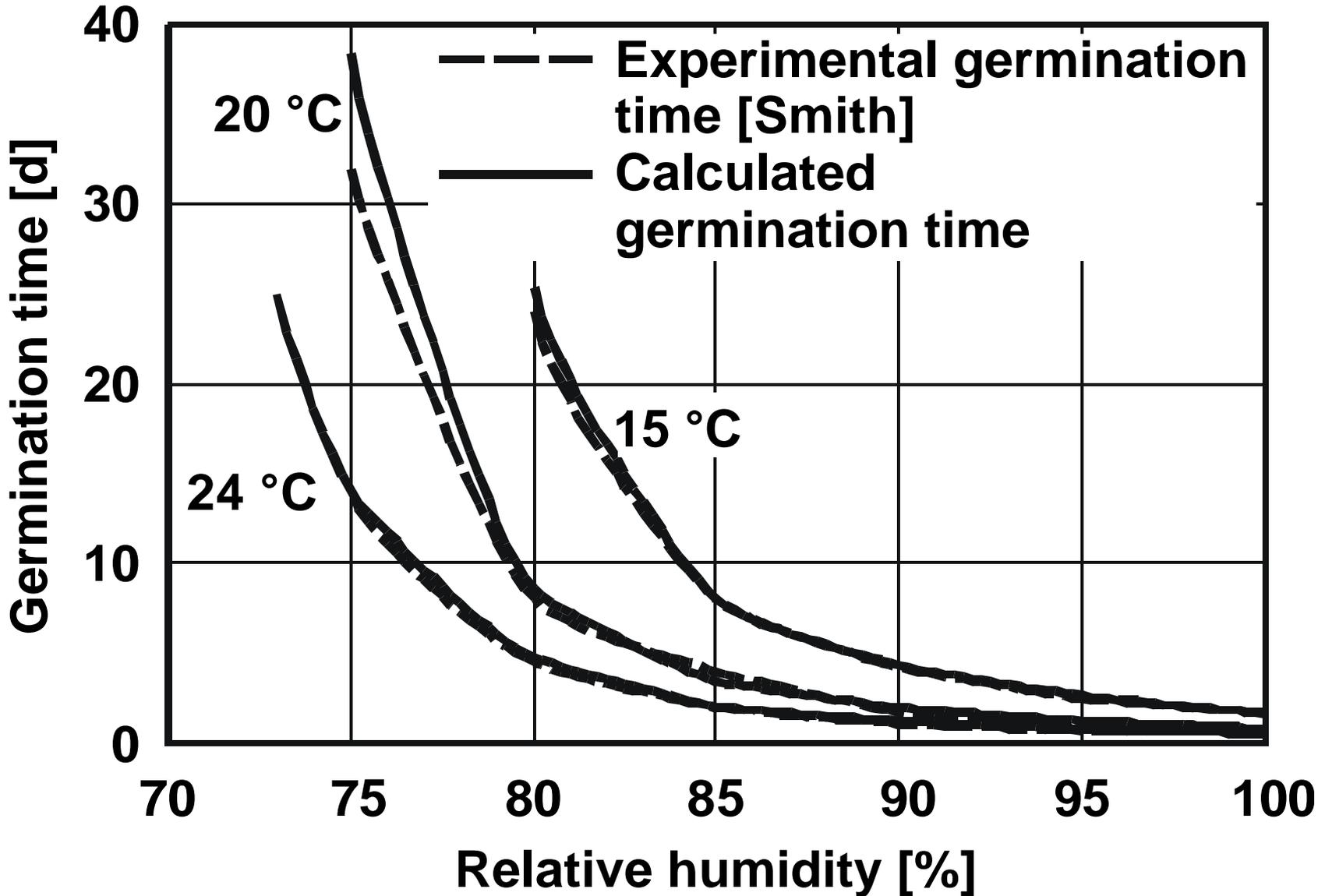


# Hygrothermal Characteristics of the Model Spore

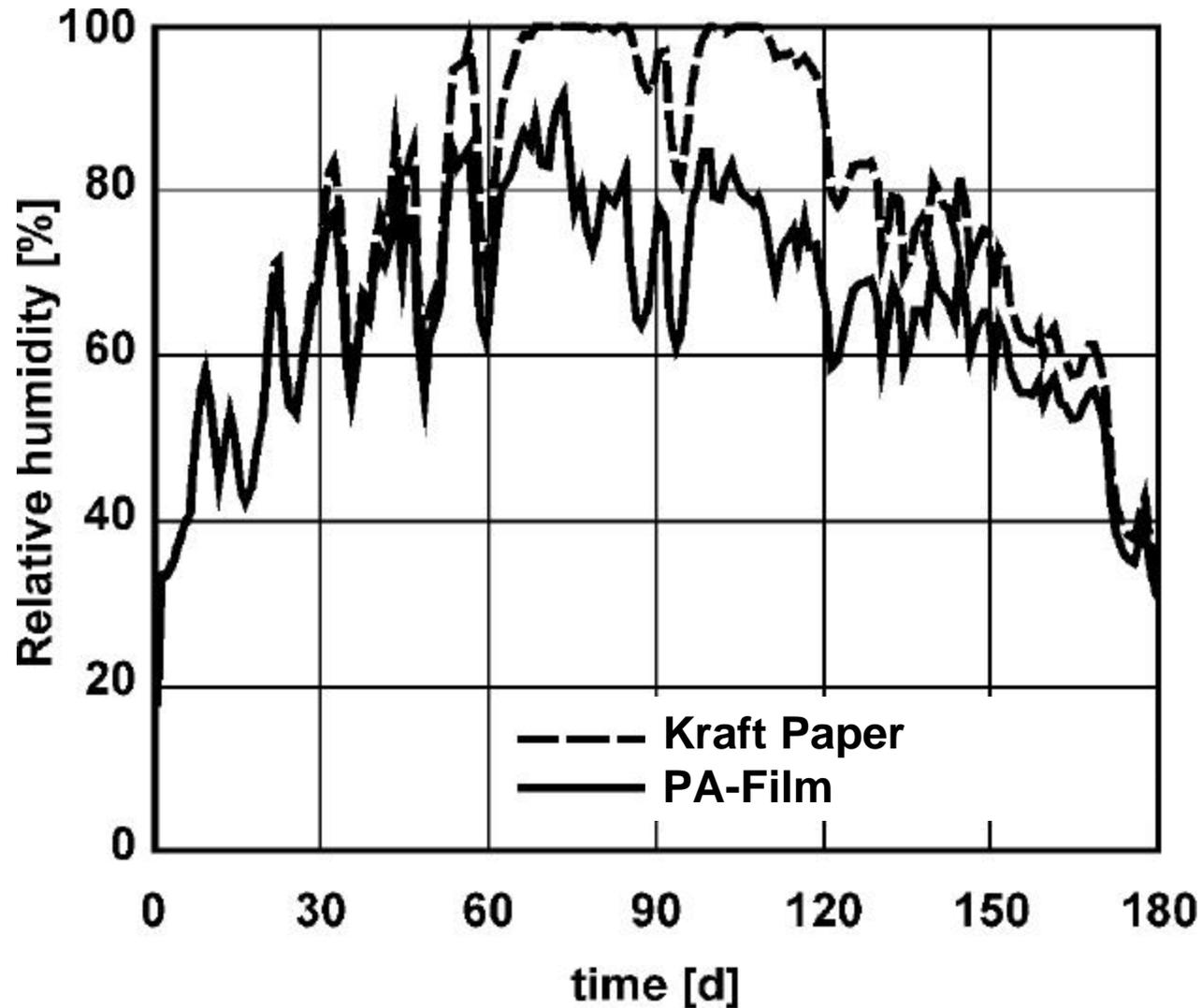


# Hygrothermal Characteristics of the Model Spore

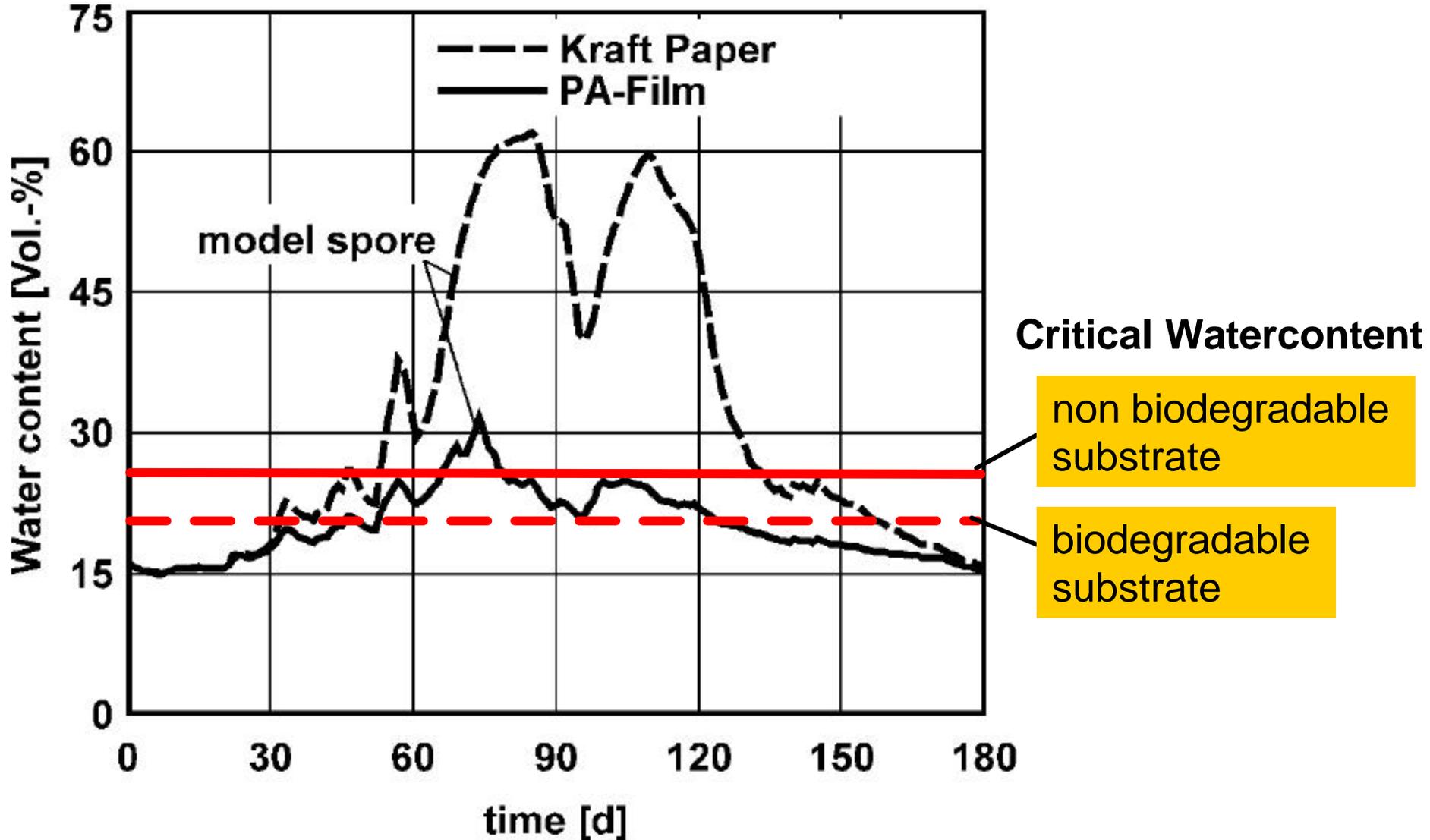




### Humidity Behind the Vapor Retarder



### Water Content of the Model Spore



Summer condensation may lead to mold formation in the building envelope

### Remedies:

- reduce moisture intrusion
- enhance drying potential
- avoid biodegradable materials in condensation planes

### Mold growth predictions for fluctuating hygrothermal conditions

- new biohygrothermal model looks promising
- more research necessary to validate this model

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Biohygrothermal model WUFI-Bio (only in German)