MOULDING AND GEOMETRY OF BUILDING SHELL

A. Zöld
Technical University Budapest
E.K. Novák
Institut of Public Health
Hungary

1. WALL MOULDING AS AN ECOLOGY PHENOMENON

Ecesis of a microbe on a surface has two essential factors: accessibility and proper living conditions for elements of the microbe able to grow. In the case of fungi, viable elements are, on one hand, germinative reproductive elements /spores, conidia/, on the other hand, threads able to grow/hyphae/. These fungus bodies occur in air more or less profusely. Proper living conditions mean both availability of nutrients, and tolerance to surrounding /physical, chemical and biological/ conditions. Both aspects involve complex groups of interrelated factors. Availability of nutrients means harmonizing occurrence of nutrient components, subject to Liebig's law of minimum principle, stating that the chance of survival, growth or proliferation depends on the quantity of minimum nutrient. Though, Shelford's rule of tolerance to surrounding conditions states that any of surrounding conditions /temperature, atmosphere, reaction, etc./ has to be within the tolerance limits of the given being - different between species of fungi. These factors have a complex action, "interacting" with the former group.

The wealth of fungi comprises hundreds of thousands of species, decomposing organic matter of other beings or of artificial origin, absorbing a part in their bodies, while they absorb nutrients only in aqueous solution.

With a view on the presence of germinable elements, nutrients, living conditions involving temperature, light, atmosphere, it can be stated that because of the rather different tolerances between fungi, no real surrounding comprising the factors above can be created such as to exclude some types of mould. The only factor to be influenced by building structure and user's behaviour is moisture.

2. THE IMPORTANCE OF WATER

Water in fluid state is a material indispensable for living beings; living processes are biochemical reactions taking place in a moist medium. Therefore any living organism is only viable with a definite water content in its body. Water loss, drying out is "dangerous to life", survived by certain beings alone, but only at the cost of suspending their vital functions /anabiosis/, and continuing to live only after being in possession of the needed water quantity.

Accordingly, all the living beings, hence also fungi, need given, different quantities of water in their surroundings, closer, in their substrata. Part of surrounding water is needed to maintain the water content in their bodies,hence also atmospheric moisture reducing their evaporation is of importance, partly supplemented by water of fluid state absorbed from the surroundings. Though, chilotrophic nutrient absorption by fungi always required fluid water in the surroundings, namely they can only absorb nutrients in aqueous solution. Remind, however, that fluid water from outside is not only required for nutrient absorption, but in case of macromolecular nutriens also for digestion beginning outside the cell - since partly these are in no solution, and partly they are larger them to pass the cell membrane. Namely in this case so-called primary decomposing enzymes have to leave the cell again requiring fluid water in the surroundings, while water is both medium, and one reagent of reactions /hydrolysis/. All these point to the complexity of the "water problem", still aggravated by that of the water quantity a fungus is able to absorb from some surroundings. In this respect, water content in the surroundings or substratum is not critical alone. Vital processes being biochemical reactions involving solutions, obviously, also physico-chemical effects prevail. Thereby so-called free - rather than overall - water content of solutions is what counts. Molecules or ions of the dissolved material reduce not only water evaporation but also the quantity of "free" water to be absorbed by a living being, actually, a fungus. As a matter of fact, the numerical ratio between particles in solution, and water molecules is what counts. This is normally indicated by water activity /WA/ of solutions and aqueous substrata. Water activity is namely relative humidity percentage of air space to be kept in balance by the aqueous solution or the object with a water content.

Micro-organisms, hence also mould fungi, as aqueous systems, have a water potential or water activity. At the same time, also surroundings of the mould fungi /atmospheric humidity, fluid or solid matter/ have definite water potentials, water activities. Provided moulds have a lower water potential, water activity than that of the surroundings, the microorganism takes water from its environment, and if this is sufficient to start vital functions, the microorganism starts growing. In the oppo - site case, if water potential, water activity of the medium is lower, the microba looses water to its surrounding, its growth stops, at a marked exsiccation mould micelia may perish.

Fungi decisive in house moulding have several defense mechanisms preventing them to perish if the surroundings get dried out.

3. MACRO- AND MICROGEOMETRY OF THE BUILDING SHELL

Geometry conditions of the building shell affect moisture distribution in the structure.

If not with this very wording, but this is essentially the problem in examining parts of the building shell constituted by other than plane parallel slabs /corners, joints, thermal bridges/. Without omitting at all the importance of this paramount problem another, not less important microgeometric problem has to be pointed out, namely, pore structure of the inner surface layer.

According to traditional conception, moulding is due to surface condensation. In theoretical and laboratory investigations /1,2/ as well as in monitoring inhabited buildings /3,4/, it has become clear that capillary condensation in inner surface layers is a sufficient moisture condition of moulding. /According to later information by K. Gertis and Zs. Herbach, the same results are expected from actual tests actually made in the Institut für Bauphysik Laboratory./ These observations impose a new approach to mould tests.

Capillary condensation proceeds in dependence of air R.H. and of the material - surface layer - porosity. Material characteristics appear from the sorption isotherm, exhibiting monomolecular and polymolecular water absorption, and intervals of capillary condensation, and that is related to the distribution function of pore diameters.

As concerns accessible water affecting fungus growth, it is still of interest, how much surface materials, that is, the capillary walls, are hydrophilous, how they bind the thin - maybe monomolecular - water film, how this is helped, or just hampered, by materials dissolved from them.

These materials create micro-environments with different pH values and pH buffer capacities, that may definitely forward or prevent vital functions of fungi.

An important part of room linings are based on lime, hence contain calcium. In these materials, different calcium compounds get chemically transformed and the material hardens. This transformation is, however, incomplete, the process is not complete even after years. Its consequence is that the condensate water penetrating the material dissolves the alkaline calcium compound i.e. calcium hydroxide.

Alkalinization may affect living conditions of fungi, namely alkali neutralized acid metabolites, pointing out the high importance, in addition of the pH value, of the buffer capacity of the arising solution, that is, its neutralizing ability.

Another problem of importance is the capillary size distribution of the surfacing materials, whether they grant hyphae steric access to the contained water or not. In addition to the capillary size distribution, it also requires the knowledge of size distribution of hyphae of potential fungi /meeting other environmental conditions/. Since, however, this problem did not yet emerge from other aspects, and in identifying fungi, dimensions are of importance only for the formulae of proliferation, little else than some sparse data are found in the literature, referring to laboratory culture media rather than to natural substrata.

From the available scarce data it can, however, be stated that hyphae sizes range from some tenths of μm to some μm enabling them to penetrate such and wider capillaries, where water in fluid state is available. This latter may result from capillary condensation in the permeated capillary, or from capillaries anastomosing to the permeated cavity. Presence of hyphae in the cavities modifies, of course, geometry conditions - in the "constricted" space left between hypha and cavity wall, conditions of capillary condensation are altered, condensation comes about at a lower R.H.

Also capillaries impenetrable to hyphae are of importance. Namely, these "harmless" capillaries are able to bind and discharge much water on inner wall surfaces, of importance for taking up and discharging timely variable moisture loads, for its buffering action relieving outer walls.

4. ANTIMICROBIAL AGENTS

Presence of some materials in the surface layer may inhibit fungi from settling there. Namely, there are several natural or artificial materials /compounds, molecules/, able to inhibit vital function or some process of it of one or more representants of some groups /metabolism, growth, proliferation/ or to destroy them. In this respect there are significant differences between groups or species of living beings, the knowledge of which is of interest for the actual scope, since, on one hand, by incorporating antifungi in the surfaces, moulding may be prevented for a while, on the other hand, in reconstructing already moulded surfaces, the fungi in ecesis have to be destroyed. This requires, however, two aspects to be reckoned with: tolerance of fungi, and of man!

Remind that fungicides are of timely effect, since if they do not dissolve in water, then they don't act on fungi either, but if they do, then they get leached out of the surface by moistening, main cause of moulding /let alone decomposition/, while residua of some decontaminants may just act as nutrients.

5. CONCLUSIONS

Moulding does not require surface condensation, water present in capillaries in fluid state is sufficient.

Presence of water is determined by microgeometry, porosity of the inner surface layer. Inner walls and furniture should be such that have possible small-size capillaries safe from moulding are able to absorb and discharge much of water, enabling them to buffer timely variable moisture development.

In case of outer walls - because of lower surface temperature and higher R.H. - cavities still penetrable to hyphae, and water accumulating in them, are of importance. Because of the scarcity of data available, stil lengthy investigations are needed to establish distribution functions of pore and hypha diameters, underlying selection or even development of surfacings of the proper microgeometry. To then, relying on this qualitative description, supporting data, and practical poofs, to prevent moulding, air at 75% R.H. and at the same temperature as that of the surface has to be provided for by way of proper design and user's behaviour.

REFERENCES

1 Zöld,A.: Energieeinsparung und/oder Feuchteschutz. Heizung, Lüftung, Haustechnik, Vol.39 N°11 pp. 26-28

2 Zöld,A: Moisture balance: a problem of building shell, ventilation, users behaviour CIB 89, Paris

3 Balázs,K. Kecskeméti penészes lakások helyszini vizsgálata /Monitoring Report, 1989, in Hungarian/

4 Balázs,K.-Zöld,A.: Scgimmelpiltzbildung in praktischen Test. Heizung, Lüftung, Haustechnik, Vol.41.. No.6.