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HOW DO BIOTIC AND ABIOTIC FACTORS COMBINE TO AFFECT THE WEATHERING OF WOOD SURFACES?

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Abstract:
The paper presents the aim and objectives of a research project concerned with the weathering processes of oak (Quercus robur.) and douglas fir (Pseudotsuga menziesii). The project deals with the identification of any synergistic effects between biotic factors such as aerobic bacteria, Basidiomycota, Ascomycota and abiotic factors such as light, temperature and moisture on the weathering of wood surfaces in durability class 3.

Key words: *abiotic factors; fungi; bacteria; artificial accelerated weathering; outdoor weathering.*

INTRODUCTION

Exterior wood applications are used for example in the building industry, for outdoor furniture and various wooden structures. When wood is used as a facade material it changes colour, cracks and rots after several years in service. In general, customers seek materials that need low maintenance and retain a homogeneous surface for a long period of time. Nevertheless, not only wood but also concrete, metal, glass and plaster are in need of cleaning, repainting and repairing after several years in service. It is proposed that if economic methods that minimise the maintenance required of wood then this environmental friendly material would be used more often. The use of wood as a renewable raw material is normally considered to be CO_2 neutral and more ecological than some of the materials mentioned above, as shown in a life cycle assessment by Salazar and Meil (2009). According to Börjesson and Gustavsson (2000), where the life cycle assessment of a wood building construction, was compared to a concrete building, the use of wood products can reduce the greenhouse gas emissions drastically.

Wood, like all materials, is degraded by abiotic factors, e.g. UV light, hydrolysis, physical erosion, etc. In addition, because it is an organic material, it can also be susceptible to biological degradation, i.e. biotic factors, especially by micro-organisms. This project will investigate the existence of any synergistic effects between biotic and abiotic factors during the weathering of wood surfaces. If a better understanding of which factors affect wood in which manner and in which combination biotic and abiotic factors interact to degrade the wood, it might be possible to develop techniques that increase the life-span of wood, but, which have minimal environmental impacts. This approach will facilitate the design of stable wooden facades that require little maintenance over a long period of time.

DEGRADATION OF NATURAL WOOD

Extensive research on the decay of wood in water or soil contact has already been carried out. There is a lack of knowledge concerning the degradation process of wood in end-use class 3 through microorganisms but also through abiotic factors such as light, temperature and moisture and especially the interaction of all factors.

Research on bacterial communities on sunken wood in the Mediterranean Sea revealed that in an anaerobic environment, a high diversity of microbial communities exist (Fagervold et al. 2014). Most likely in anaerobic as well as in aerobic environments the diversity of microbial communities is very high.

The wood degrading action bacteria, and thus aerobic bacteria have been studied for example by Daniel (1994) and are reported to degrade lignocellulose preparations with the help of the lignin peroxidases enzyme. Schmidt and Liese (1994) mention however, that only few bacteria show activity towards lignin. Schmitz (1919) reported first that a mix of bacteria and fungi populations caused a greater deterioration in wood compared to decay by the basidiomycetes alone. He moreover found that some bacteria produce ammonia which increases the pH value. Hervé et al. (2016) found by conducting a microcosm experiment, that fungal growth was significantly lower when soil bacteria was present. These changes on the growth environment caused by bacteria may have an influence on the ability of fungal development. Bacteria appear primarily with parenchymatous tissues and thus they often accumulate in rays and resin ducts. Moreover an affinity towards the S3 layer in softwood tracheids and hardwood fibres and vessels could be detected (Wilcox 1970). According to multiple studies such as Greaves (1969), Eriksson et al. (1990) and Fengel and Wegener (1989) there are three different kind of attacks on pit borders caused by bacteria: Tunnelling, erosion and cavitation. These researches make it particularly interesting to situate the following hypothesis: Bacteria, deriving in an aerobic environment have an influence on the degradation process of wood without ground or direct water contact.

The variation of the surface wetting is very different from one wood species to another and plays an important role in the degradation process of wood. Thus the sample size, orientation and alignment of the weathering samples have to be considered carefully. Studying the surface wetting of different wood species during weathering, Oberhofnerová and Pánek (2016) found a large fall in the contact angle between 6 and 12 months. In a study by Oberhofnerová et al. (2017) on the effects of natural weathering of wood, the roughness, colour and the formation of cracks changed more rapidly during the first months of weathering. According to George et al. (2005) the chromatic coordinates of irradiated oak sapwood and heartwood evolve in opposite directions after only short irradiation times. Pursuant to these findings the process of wood weathering is very fast at the beginning and thus the degradation process has to be monitored more precisely during the initial stages.

The aim of this thesis is to identify any synergistic effects between biotic factors, such as bacteria, fungi and moulds as well as abiotic factors, such as light, temperature and moisture on the weathering of wood surfaces in durability class 3.

OBJECTIVES

Accelerated and outdoor weathering experiments will be carried out to see if and how environmental conditions and in particular, the presence of micro-organisms, influence the weathering of wood.

One of the research objectives is to study the interactions between abiotic and biotic factors in a laboratory environment and therefore an artificial accelerated weathering experiment will be conducted. A study by Kataoke et al. (2007) shows that the depth of photodegradation is greater than indicated by other researchers such as Hon and Chang (1984), because visible light was found to penetrate 540 µm below the surface. Moreover the study shows that blue light can cause bleaching of the wood. Due to these findings and the fact that UV light is known to be an effective disinfectant, for this artificial accelerated weathering test the light source which is proposed to use by standards such as ASTM G0154 (2016) and ISO 16474-1 (2014) will be modified.

Another objective is to study the interactions between abiotic and biotic factors in natural conditions. An outdoor weathering experiment will be conducted in western France as well as in Italy. Meteorological data will be precisely recorded, consequently the degradation process of wood in two different regions can be compared to each other. This realistic experiment will allow researchers but also industry to understand the degradation process of the specific wood species.

Microbiological and molecular biology methods will be used to identify and quantify bacteria, moulds and fungi present in degraded wood facades in western France and Italy. A microcosm-scale experiment may reveal if certain bacteria have an influence on the growth rate of certain fungi and moulds or vice versa.

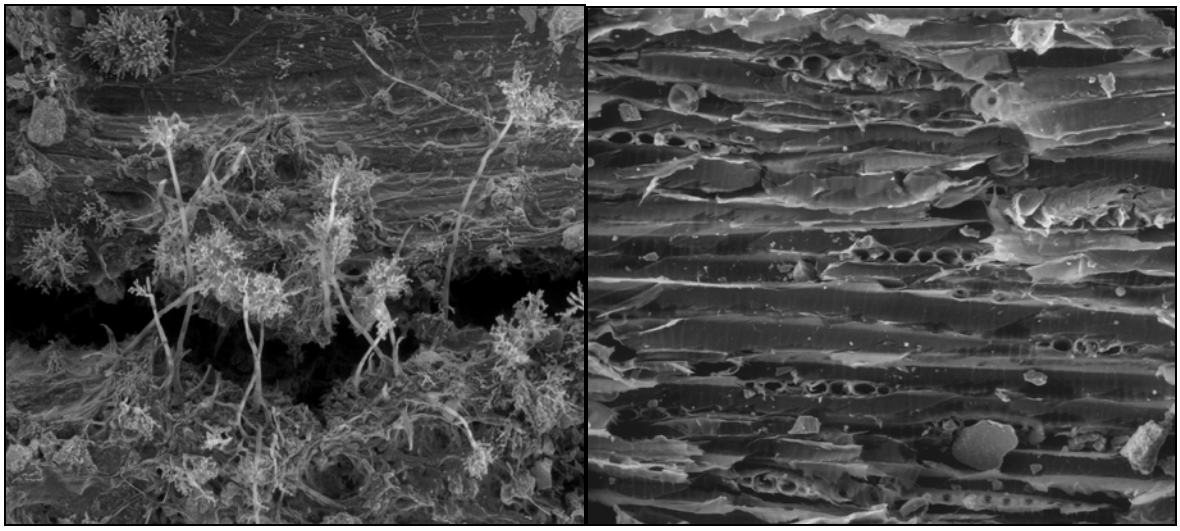

Fig. 1.
Left: Oak wood stored in water for 4 days, fungi development. Right: Douglas fir wood naturally weathered for 4 weeks.

MATERIAL AND METHODS

Douglas fir (*Pseudotsuga menziesii*) and oak (*Quercus robur*) will be examined due to the fact that these two species are commonly used for exterior applications in Europe. Moreover this choice allows the comparison between softwood and hardwood.

Several methods will be used to analyse the anatomical (ESEM, light microscope), chemical (FTIR/ATR), and visual (colorimeter, roughness testing) changes in the degraded wood as well as a surface contact test, counting the CFU will help to classify the fungi and bacteria. The focus however is on the change in visual appearance of the weathered wood surface.

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