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IMPACT OF FIRING TEMPERATURE AND CLAY TYPE ON ALGAL SUSCEPTIBILITY

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Abstract

Observations of algal deterioration of building facades in the Netherlands appear to indicate an increase in recent years. Obviously, algal defacement may even occur within a time period shortly after completion of the building, leading to early green defacement. It causes unexpected and considerable cost of maintenance. Material properties are among many suggested causes of this phenomenon. In a research project initiated by TNO a test method was developed simulating circumstances under which algal growth occurs in practice. The impact on algal susceptibility of clay type and firing temperature of bricks was studied. This laboratory research indicates that algal susceptibility is a product related property. The final results of the research project should explain how to sustainable control and prevent growth of algae on building materials. Progressive research is initiated to relate lab results and the actual appearance of algal defacement in practice and to further focus on the causes of algal defacement.

Key Words

algal susceptibility, material properties, defacement.

1 Introduction

Cost of maintenance play an increasing role in the design of buildings. Although structural degradation, caused by physical or chemical processes, is the most obvious reason for maintenance, esthetical degradation is becoming increasingly dominant. Esthetical degradation can be results from deposition of aerosols, or growth of biological organisms, like lichens, mosses or algae. Observations of algal deterioration of building facades in the Netherlands appear to indicate an increase in recent years. Obviously, algal defacement may even occur within a time period shortly after completion of the building, leading to early green defacement. It causes unexpected and considerable cost of maintenance, conflicts with considerable financial impact and

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decrease of the economic value in terms of selling price or rental value. Conflicts originate from the lack of knowledge about the causes of algal defacement. Building design, changes in environmental conditions or environmental legislation, changes in material properties, new building products, and effects of workmanship or other factors in the building process are often suggested as causes of this phenomenon. There are more technical questions than answers (Adan 2003).

TNO initiated a research project that aims to sustainable control and prevent growth of algae on building materials. The project consortium includes both industrial partners and maintenance services. The project has been outlined in successive stages of case-studies, laboratory research on influential factors and evaluation in terms of practical implications. In preliminary laboratory research the impact on algal susceptibility of firing temperature and clay type of bricks have been studied. This paper outlines the susceptibility test principle and presents preliminary results on the impact of material properties on algal growth.

2 On influential factors

Moisture is a universal requirement for life. Algae need liquid water and are highly resistant against periods without moisture. Algae can grow on almost every building material, as long as it meets their needs for moisture and other minimal requirements are fulfilled (nutrients, alkalinity, temperature). The appearance of algae on facades is often related to the building design, such as inadequate drains or leaking pipes (figure 1).

Figure 1 Inadequate building details leading to local algal defacement

The observed increase in algal problems in the built environment does not refer to such local problems, in these cases green defacement often covers the entire facade (figure 2). A screening survey in the Netherlands (Adan and Van Hees 1997) not only showed that algal occurrence preferably is associated with north oriented facades, but that algae may also be found on fully sunlit surfaces. An investigation of houses in the Netherlands (van Hal 2001) indicated that residues of cleaning acids to remove mortar might affect algal susceptibility. In twelve cases a single specific species, Apatococcus lobatus, appeared to be predominant on brick masonry facades (van Hal 2001).

Figure 2 Algal defacement of entire facade

From the same study it has been suggested that algal susceptibility might be related to the mineral composition of brick and mortar, their hydrophilic properties and their porosity, as well as the use of acids and increased surface roughness, resulting from cleaning acids application. Porosity and pore size distribution determine moisture uptake and drying behaviour and therefore prolongation of humidity conditions (time of wetness).

3 Material and method

3.1 Material and material parameters

As stated above moisture is essential for algal growth. The pore size distribution (moisture uptake and evaporation) of a brick affects the time the material meets the conditions of algal growth. The used clay, moulding process and firing temperature, defines the pore size distribution. This study examines the effect of the type of clay and the firing temperature on algal susceptibility. Therefore the following bricks are used:

Table 1 Tested materials

Clay type (defined by colour and source)	Firing temperature [˚C] (as produced for this study)
white	1100
white	1160
white	1200
red river	1020
red river	1050
red river	1080
red loess	not known (commercially produced bricks)

3.2 Principle of test

Comparing and assessing the effect of material properties on algal susceptibility only should be done under lab conditions, as (well defined and controlled) circumstances provide a basis for required reproducibility and repeatability. Until now such lab testing is often based on the so-called vermiculite bed method, using steady state moisture conditions as the starting point (anonymous, 1989). In this case the material considered is placed on a supersaturated bed of vermiculite, introducing bottom-up

moistening of the material, whereas an algal suspension is on the top-side. In actual circumstances the moisture load usually takes place through rain wash of the surface, i.e. at the outer surface. Furthermore it is obvious that intermitting process of moistening and drying clearly relates to increased risks of algal discolouration.

Considering this TNO developed a standard test procedure that simulates this process using acid rain. In addition to this an intermittent spectral selective lighting is applied. The acidity of rainwater, the period of rain and drying and the amount of water can be set. A previous pilot application on different categories of materials (e.g. Sanders, 2002) defined reproducibility, repeatability and resolution of the transient test method. Algal defacement is not only restricted to masonry.

Both the new method and the vermiculite bed method are used simultaneously in the laboratory research.

3.3 Analysis of growth

Analysis of growth is based o the entire growth pattern as a function of time, including all stages of growth. The analysis of growth includes the following successive steps. First of all, assessment of fungal growth with the naked eye at repeated intervals during the period of test using the BS 3900 (anonymous 1998) numerical scale (table 1).

Table 2 Numerical scale to assess coverage area

Rating	Appearance
0	no growth
1	coverage ≤ 1%
2	1%< coverage ≤ 10%
3	10% <coverage ≤ 30%
4	30% < coverage ≤ 70%
5	70% < coverage

Secondly mathematical modelling of the growth pattern is applied (Adan 1994), based on a logistic model, deriving the estimated final coverage area α [-] and the moment of highest growth rate δ [days]. Growth analysis and material comparison is performed on the basis of estimators of these response variables.

4 Results and discussion

The following figures depict the development of coverage area α in time of two bricks (different clay type) for the vermiculite bed method (figure 3) and the new standard (figure 4). The new method gives a delay in growth and more discrimination between the different types of bricks than the present standard. This suggests that interaction between moistening and drying affects algal growth.

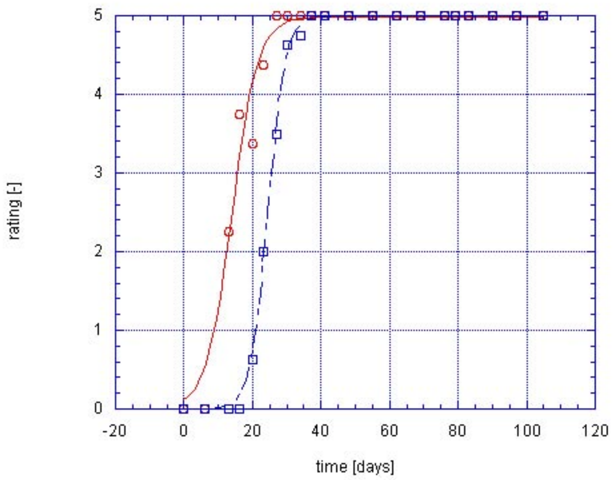

Figure 3 Coverage area of two bricks, varying clay type, assessed by vermiculite bed method

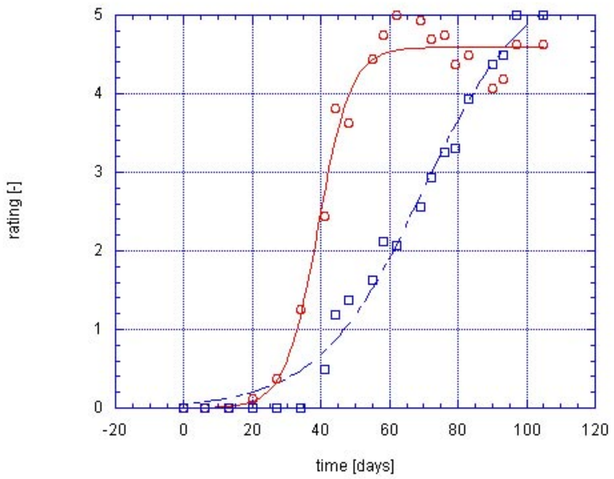

Figure 4 Coverage area of two bricks, varying clay type, assessed by new method

Bricks of the same clay type, but with varying firing temperature, did not show clear distinction in growth pattern (figure 5).

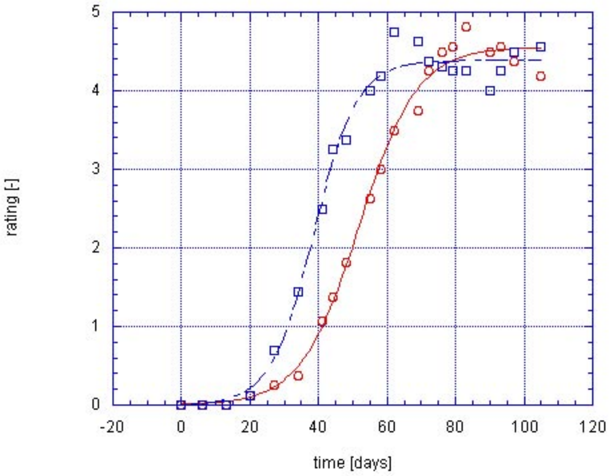

Figure 5 Coverage area of two bricks, one clay type, varying firing temperature, assessed by new method

Bricks of one clay type showed a significant higher susceptibility than bricks of another clay type (figure 6). The effect of clay composition appears to have significant effects on algal susceptibility.

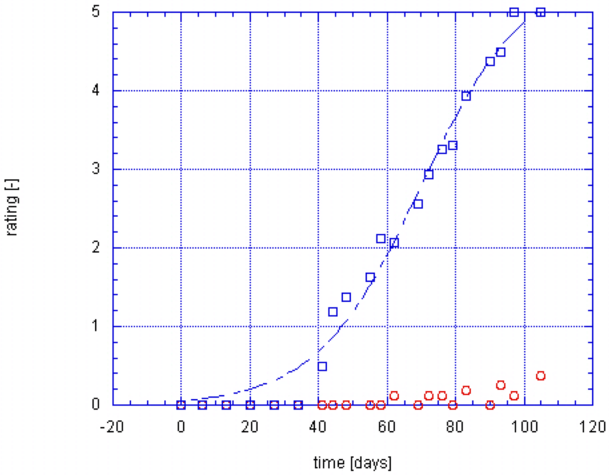

Figure 6 Coverage area of two bricks, varying clay type, assessed by new method

The total porosity (determined by analysis of pore size distribution) of the bricks of varying clay type and firing temperature showed a small variation. Table 3 gives the pore size distribution of the bricks of figure 6 (two clay types). This variation cannot yet be related to the distinct algal susceptibility.

Table 3 Pore size distribution of the bricks

	total porosity %	% <0.5 μm	% 0.5-1 μm	% >1 μm
red river	27	2	1	24
red loess	*23*	*3*	*2*	*19*

5 Conclusions

A sustainable control and prevention strategy of algal growth on building materials should consider the role of building materials. This study indicates that algal susceptibility should be considered as a product based property. The algal susceptibility is not directly related to defined material properties, as pore size distribution or water uptake.

The results of this study are in line with former research (Van Hal 2001, Sanders 2002).

In order to come to a sustainable strategy, this product based property should be further defined. This study indicates that the new test method is applicable for assessment of algal growth.

Further assessment of algal susceptibility will lead to insight in the causes of algal deterioration. Combination of the laboratory research with experimental exposition in practice should grade the test method and verify the laboratory results. Finally this will lead to insight in how to sustainable cure or prevent algal growth.

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