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Original article

# Incompatibility risk assessment procedure for the cleaning of built heritage

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ABSTRACT

A procedure is proposed to assess the compatibility of cleaning actions to be carried out upon built heritage. This procedure was designed as a semi-quantitative (in)compatibility risk assessment, where the vulnerability of the substrate to cleaning, the aggressiveness of the cleaning method and the substrate/method synergies are factors considered to determine the likelihood of damage occurring, whereas the impact on the significance of the object measures the consequences of damage occurring. Rating these factors of likelihood and consequences of damage allows a cleaning risk matrix to be proposed for the evaluation of the risk levels implicated by different cleaning methods. Furthermore, planning components entirely contingent of their specific actors, and therefore inherently difficult to grade, such as operator skills or control adequacy, are included as quality components, which work as multiplying parameters of the overall risk. The procedure was conceived to assist in and frame the planning of built heritage cleaning actions. A Delphi Panel of conservation experts was convened to validate this proposal.


## 1. Research aims

The research presented herein proposes a procedure to assess the compatibility of cleaning actions on built heritage. The proposal departs from the compatibility-based approach for the assessment of conservation actions proposed by Delgado Rodrigues and Grossi [1], which focused largely on the compatibility of materials and presented no guidelines for cleaning interventions. The main research goal was to operationalize a cleaning assessment procedure based on the concept of compatibility.

The procedure intends to constitute a support tool for the planning of built heritage cleaning interventions by framing the assessment of several key factors, so that subjectivity in decision-making is reduced. Although primarily designed for planning, the procedure may also serve as an evaluation or knowledge tool for the analysis of past interventions.

## 2. Introduction

Whenever deposits are believed to be actually or potentially damaging to the significance of a given heritage object, and/or when necessary conservation treatments call for a deposit removal, a cleaning intervention may be decided upon [2,3]. Cleaning operations may seem deceptively straightforward, but they are potentially harmful and always irreversible interventions and therefore adequate planning is crucial to achieve satisfactory results [4]. Several recommendations for the cleaning of stone heritage have been proposed in the past decades (see, for example, [2,3,5]) and methods for the assessment of stone cleaning results have been debated as well [6–8]. Nevertheless, objective acceptability criteria are generally difficult to put forward, either due to onsite testing/sampling limitations [8], availability and/or sensitivity of the testing methods [9], lack of a common approach [7,9] or the diversity of substrate/deposit/environment combinations [9]. Furthermore, in conservation practice, budgetary constraints may preclude scientific consultation or testing in the planning of conservation actions and therefore simple and integrating methodologies may bring relevant contributions at this stage.

This paper presents a procedure that aims to provide some simple planning guidelines on how to choose and plan for the less incompatible option of removing undesirable deposits from a built heritage surface. 'Compatibility' is a widely accepted heritage conservation principle that was operationalized into an assessment tool by Delgado Rodrigues and Grossi [1]. The procedure described herein was designed to complement this compatibility-based assessment tool, which does not cover cleaning actions.

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It should be emphasized that the procedure described below does not allow for deciding whether or not to clean. The intention of cleaning is presupposed and the procedure solely concerns its planning phase. Even if the planner concludes that the cleaning risks are too high, there is no form of comparing the results with the non-cleaning option, which would require analysing the impact of different deposits both on the significance and on the material condition of the object.

The effectiveness of the cleaning method in deposit removal is also presupposed, with reference to the assessment procedure proposed by Delgado Rodrigues and Grossi [1].

The idea is that, given the deposits and the target surface, a group of cleaning methods should be selected as potentially effective alternatives, which can then be assessed in terms of cleaning compatibility by using the current procedure.

This proposal borrows the definition of compatibility from the CEN Standard EN 15898:2011, but extends it to include 'actions'; compatibility is thus defined as the "extent to which one material [or action] can be used with another material without putting significance or stability at risk" [10,p. 10]. A cleaning compatibility analysis should therefore ascertain how cleaning actions would impact on the significance and stability of the heritage object.

This proposal furthermore postulates that a compatibility analysis may be achieved via an (in)compatibility risk assessment. In this context, damage is defined as "alteration that reduces significance or stability" [10,p. 9], which in cleaning interventions may result from the following incompatibility risks:

- undesirable mass loss;
- discolouration;
- indirect damage (e.g. caused by clay swelling, soluble-salt mobilization, infiltrations, etc).

## 3. Cleaning incompatibility risk factors

Risk is defined as the multiplication of the likelihood of damage occurring and the consequences of that occurrence. There are several factors of risk in a heritage cleaning intervention, influencing both classes in this equation. For the current procedure, these factors were divided into 'hard' and 'soft': the 'hard' factors correspond to items that may be parameterized and semi-quantitatively evaluated, whereas the 'soft factors', due to their strong human component, are more difficult to translate into gradable parameters.

'Hard' factors are dealt with in the first sections of this assessment procedure: (A) the vulnerability of the target surface to cleaning, (B) the aggressiveness of the cleaning method, (C) the synergistic effects that may occur with specific method/substrate combinations, leading to a risk increment, and (D) the impact on the significance of the object. The first three factors are considered to influence the likelihood of damage occurring (L), whereas the consequences of such damage are assessed via the evaluation of the ensemble of values, i.e. the significance, of the object (D). Analytically, using a simple aggregation rule:

$$IR = L \times D$$

where: IR = incompatibility risk

$$L = A \times B \times C \text{ (likelihood of damage)}$$

$$D = \text{Consequences of damage}$$

Computing the different factor, assessments should therefore permit the planner to obtain an insight on the level of risk involved in the choice of each cleaning method.

The 'soft factors' are related to components, such as 'conservation team skills' or 'control', and are dealt with in the 'Quality components' section. These 'soft factors' are sources of risk that also influence the likelihood of damage occurring, and their effect must be acknowledged, even if their assessment is somewhat less defined.

## 4. Assessment procedure

The procedure starts after selecting the target surface intended for the concerned object, as well as which cleaning methods will effectively reach that target surface; the procedure may then be applied to choose the method that will minimize the risks of damage.

As previously highlighted, this risk assessment starts with the analysis of four factors: the "Vulnerability" of the target surface; the "Aggressiveness" of the method; the "Synergies" between substrate and method; and the "Impact on the significance" of the object. The analysis of these factors should refer to the risks listed earlier: (i) mass loss; (ii) discolouration; (iii) indirect damage.

Two of these factors depend uniquely on the object at hand: the "Vulnerability" of the surface, as well as the "Impact on Significance", follow from the evaluation of the conservation object, and therefore, once assessed, should be taken as fixed values. What may vary, within this procedure, is the choice of method, and therefore repeating the procedure with different methods allows comparing between the different cleaning risks involved.

When preparing to apply the procedure, it is important to observe if there are differences within the object in terms of "Vulnerability" and/or of "Significance":

- are there areas with localized increased cleaning difficulties?
- are there any particularly fragile areas?
- are there areas with features of different significance?
- etc.

If the answer to any of these questions is yes, then different representative areas should be defined – a risk assessment will be needed for each one. Then, the cleaning methods that will prove effective for each area should be selected; it is advisable to resort to experience, bibliography and/or expert consultation and cleaning tests in small-secluded areas. The cleaning incompatibility assessment procedure may then be applied to analyse each of the selected methods for each representative area.

In the assessment of the four different ('hard') factors, evaluation scales are used that vary according to the need for distinguishing between the parameters that define each factor: "Vulnerability" and "Impact on significance" both have their parameters rated between 1 (lower risk) and 5 (higher risk), whereas for the "Aggressiveness" parameters it was found that classifications between 1 (lower risk) and 10 (higher risk) would allow for a more accurate discrimination of the different methods; finally, the "Synergies" are considered risk increments that should be classified between 1 (minimum increment) and 2 (maximum increment). In the end, the aggregation of the different factors is achieved via a simple multiplication, to give an idea of the potential risk level involved.

Throughout this risk assessment process, any number, integer or fraction/decimal, within the proposed classification ranges, can be chosen, according of course to the situation at hand. A proposal for determining the ratings for each factor is elaborated throughout the following sections.