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Urban pollution and climate impacts on soiling of stone historical buildings

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This presentation analyses and compares the impact of air pollution and future climate on the soiling of stone historical buildings. Urban air pollution from coal smoke blackened and sulphated architectural surfaces at the beginning of the 20^{th} century, but a century later they appear to be discoloured by diesel soot and attacked by nitrogen deposition from combustion sources in cities. In terms of porous stone surfaces this has led to a transition from gypsum rich crusts through to more organic layers and a concomitant potential for greater biological activity. The present century offers the promise of even more dramatic changes through new climate regimes, most particularly changes in humidity stress, time of wetness and wind driven rain. These will further alter the way in which pollutants attack historical buildings e.g. changing rainfall will redistribute soot and the reaction products of pollutants across building surfaces in ways that disfigure the facades. Predictions of the future environment impact on soiling need to balance accumulation and redistribution. The accumulation is mostly influenced by atmospheric elemental carbon concentrations, surface roughness and time of wetness. The redistribution is dominated by wind driven rain, precipitation amount and wind direction. Studies on "aesthetics of soiling" show a complex relationship between blackening and architectural perception. Sometimes soiling can be aesthetically beneficial as many old buildings, which have darkened over long periods, display a patina that enhances the appeal. However, blackening of light coloured fabric eventually reaches a point where it becomes publicly unacceptable and raises pressure for cleaning. Perception of blackening depends strongly on the individual and on general conditions of the local environment. Typically people are more sensitive to the blackening effect in relatively clean environments than in industrial areas, so ironically standards for cleanliness generally increase when pollution levels decrease. The

redistribution of soiling by rain and wind results in different soiling patterns that also affect public soiling perception. Patterns with less soiling and those which create shadowing effects were found to be more acceptable. Others cause strong negative reaction, more generally those that obscure architectural forms, especially where there is vertical streaking, lumpiness and to some extent the fractal dimension of the feature (where > 1). Converting these observations into air pollution standards implies a translation from physics and chemistry aspects to the world of values which presents considerable challenge. This was attempted using a relationship found between the perceived lightness of a building and the opinion that it was dirty to establish potential levels of blackening. These aesthetic thresholds can suggest limit values for elemental carbon in the air, such that significant buildings do not become unacceptably discoloured. Developments of this kind contribute to the regulation of non health aspects of air pollution and aid decision making in the management of significant buildings.