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Soiling of window glass of building façades: a new Dose-Response Function based on the mass of deposited particles

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Materials used in building façades are subject to different types of weathering, an important one being soiling. The material studied here is the silica-soda-lime glass, used for windows and contemporaneous façades. Glass weathering in a polluted environment, sheltered from rain, is dominated by soiling. This phenomenon can be expressed either by an optical parameter, the haze, or by the mass of Deposited and Neoformed Particles by unit of glass surface (DNPs). By contrast to the haze, which is an optical parameter requiring an expensive technology (spectrophotometry), measuring DNPs is much simpler: the glass sample is weighed before and after exposure and the result, divided by the sample surface.

After the development of a previous Dose-Response Function (DRF) expressing soiling evolution through haze, this study focuses on the development of a new DRF for soiling expressed in terms of DNPs mass, sheltered from rain.

The development of this DRF follows a statistical approach. The general form proposed for the DRF is:

DNPs=A(dose1, dose2, …., dosen).g(t)

where g(t) represents the temporal trend obtained from standardized data. Data standardization has been employed in order to obtain a general trend independent of the environmental characteristics of the monitoring site. According to previous studies and physical considerations, the analytical form of the temporal trend g(t) was expressed by a function admitting an horizontal asymptote: the saturation level of soling. Ten monitoring campaigns (performed at different European sites) were used; the longest one runs up to 2102 days and the shortest ones, up to 365 days, with 14 to 5 records, respectively. Two different models were fitted by a non-linear regression: the Hill's model and a decreasing exponential model. Both models performed well (R^2 ranging from 0.73 to 0.76) and they were further tested in order to get the final form of the DRF.

The amplitude function A was considered as a linear combination of the different doses. A multiple linear regression was then applied to doses multiplied by the temporal trend function g permitting to obtain the regression coefficients of the amplitude function A. Another database was used, containing the monitoring values for SO_2, NO_2 and PM10 concentrations, as well as temperature and relative humidity, monitored at 19 European sites. The correlation between pollution concentrations was taken into account and led to a selection of pollutants in order to avoid numerical instability in the regression procedure. The meteorological parameters didn't have a statistical impact, so they were not considered as doses.

A DRF for DNPs could be established using SO_2 and PM10 concentrations and the Hill model for the g(t) trend with a determination coefficient of $\sim$0.7.

This DRF was then used to plot the annual DNPs evolution from 1500 to 2100 in Paris and compared to the same curve expressed in terms of Haze for the same period. The obtained evolution is comparable and reveals an important peak corresponding to the industrial period.