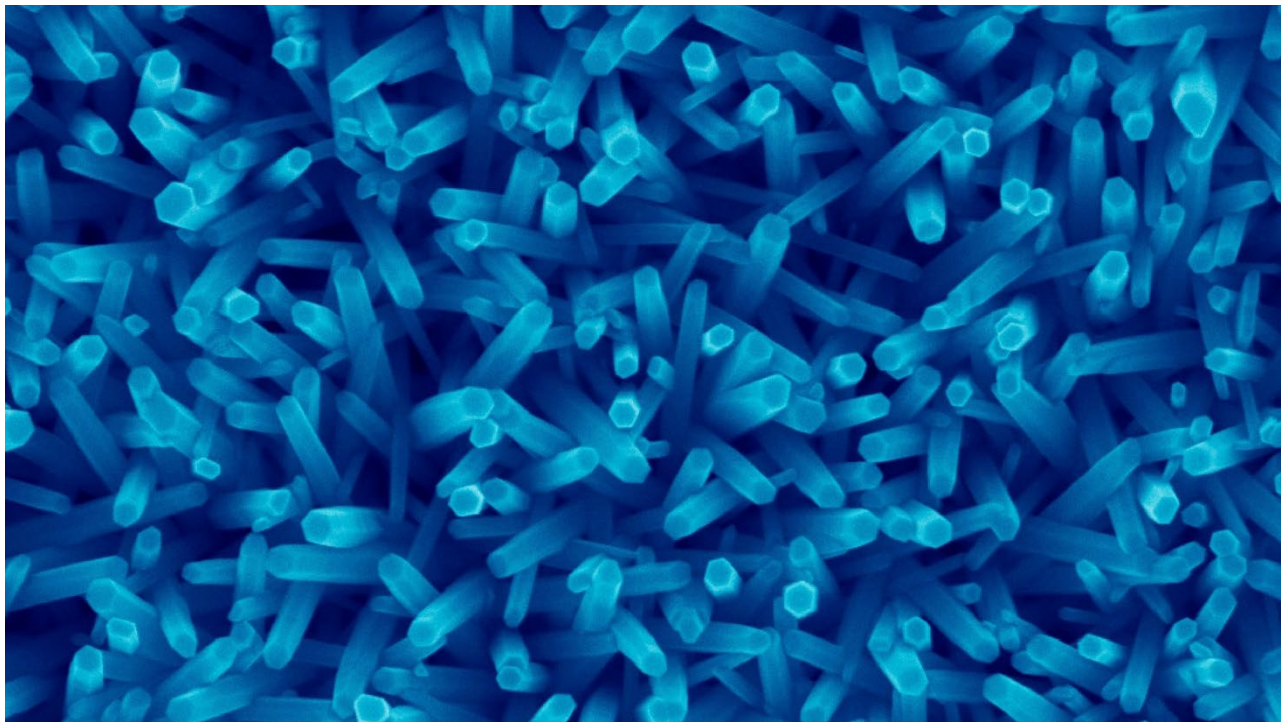
BLACK CARBON AND EFFECTS ON MATERIALS



Research Institutes of Sweden

DIVISION Material o produktion

Contents

- Recent experience from UNESCO studies
- Report 71 The effect of black carbon on soiling of materials
- The relationship between elemental carbon concentration and haze measurements deposited mass on glass
- Inventory of BC/EC measurements performed at ICP Materials sites
- Summary / gaps of knowledge

UNESCO report

Table 20. Cost due to air pollution above the background scenario for the materials constituting the artifacts.

Name of the cultural object	Material (risk)				
	Limestone (corrosion)	Limestone (soiling)	Copper (corrosion)	Glass (soiling)	Other stone materials (soiling)
Cathedral of Saint Domnius	Low	Medium		Low	Low
Aachen Cathedral	Medium	Low		Low	Medium
Speyer Cathedral			Medium	Low	High
Würzburg Residence	Medium	Medium		Medium	High
Porta Nigra			Low		Medium
Town Hall of Bremen			Medium	Low	Medium
Wartburg Castle (palace and keep)	Low	Low	Low	Low	Medium
Hercules Monument			Low		High
The Gatehouse of Lorsch Abbey	Low	Low			Low
The Colosseum	High	High/Very high			
The Tower of Pisa	High	High			
Palazzo Madama	Medium	High		Low	High
Ghirlandina Tower	Medium	Medium/High			Low
Royal Palace of Caserta	Very high	High/Very high		Medium/High	High/Very high
Hydroparken				Low	Low
Nidarosdomen	Low	Low	Low	Low	Low
Drottningholm Palace Theatre				Low	Low
Nederluleå church			Low	Low	Low
Wall of the Hanseatic Town of Visby	High/Very high	Very high			High
Towers of the cathedral of the Abbey of St. Gall	Low	Low	Low		Low
Bern Minster	Low	Low		Low	Medium

Note: low = hundreds or thousands of Euro/year; medium = tens of thousands of Euro/year; high = hundreds of thousand Euro/year; very high = approaching or exceeding one million Euro/year.

- costs due to the soiling of materials from air pollution represent on average 35% of the total cost for the soiling of the limestone and 33% for the soiling of glass.

Report 71

- Since BC is related directly to the absorption of light, and soiling of materials is measured as loss of reflectance, it is self-evident and long since established that BC contributes to the soiling of materials.
- Soiling for transparent (glass by haze) and non-transparent materials (painted steel, stone by reflectance) follow different mechanisms and are evaluated by different parameters.
- Thresholds are given for non-transparent materials (35% reflectance) but not for transparent materials where it has to be established for haze.

Aestethic threshols (Bromblecombe and Grossi, 2005)

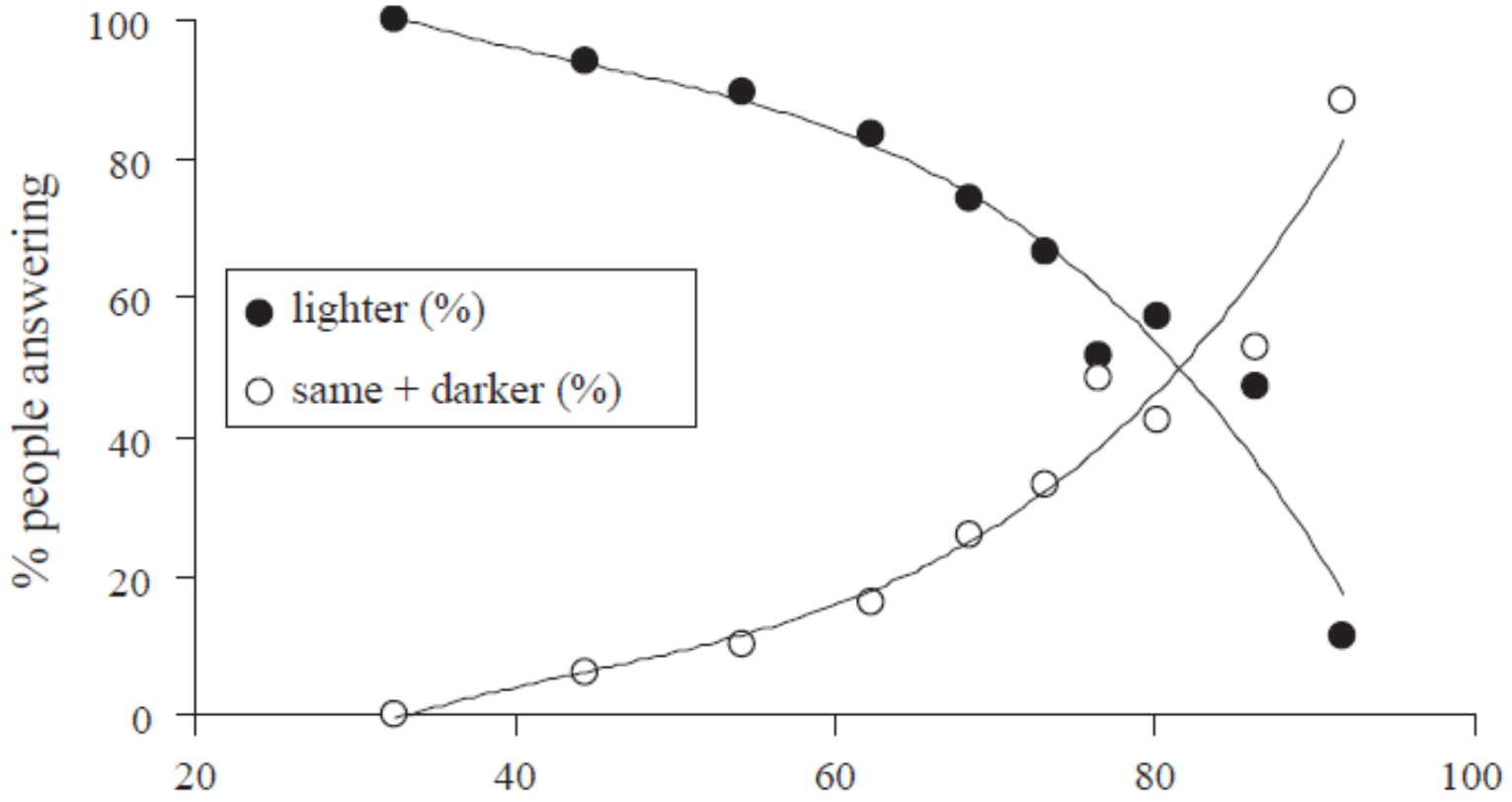


Fig. 5. The proportion of respondents wanting the building to have a lighter tone (black dots) as a function of perceived lightness L_p, along with the proportion of respondents willing to accept the tone as it is (or in just a few cases wish for a darker building) (white dots). The curves are best fit third order polynomials (see text).

- Watt et al (2008) used this to make a conservative estimate of critical reflectance, 35% (Lp=65).
- This has been used together with dose-response functions for PM10 to estimate tolerable levels of pollution and for calculation of soiling costs in i.a. Sweden
- If dose-response functions for black carbon are available the same critera could be used (for non-transparent materials)

Haze vs EC, transparant materials

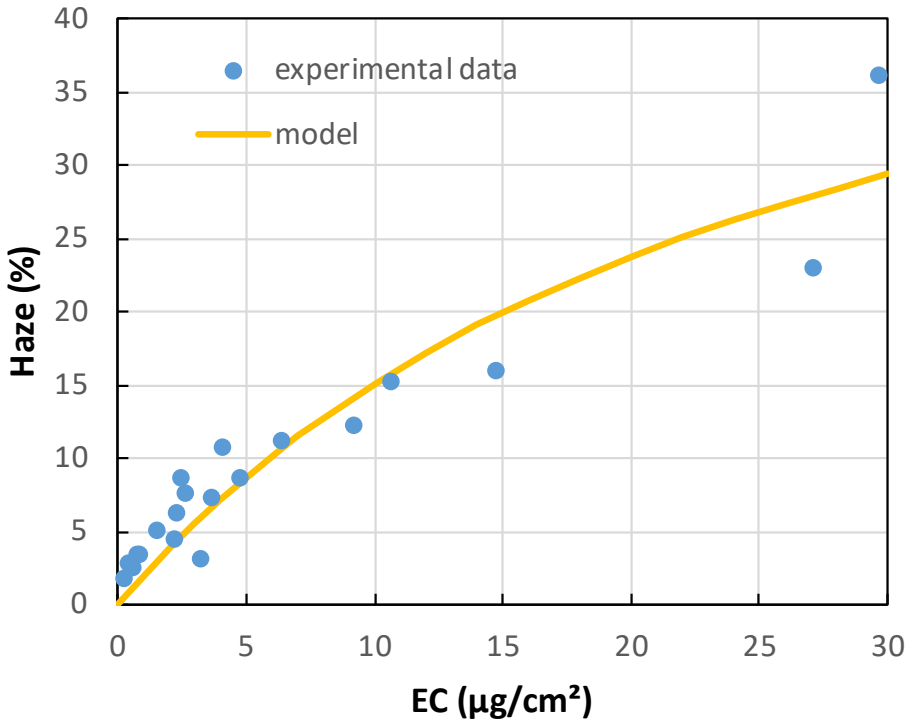


Figure 1 : Haze (%) as a function of elemental carbon concentration (µg/cm²) for data from Favez et al. (2006)

- There is a correlation between Haze and EC (literature)
- In ICP Materials there is a dose-response function for haze including PM10, SO2 and NO2 but not BC

Measurement of BC/EC at ICPM sites

Station	Measurements
1 Prague	Measurements on OC, EC, TC PYC with EUSAAR
3 Kopisty	No
10 Bottrop	No reply yet
13 Rome	No
14 Casaccia	No
15 Milan	BC since 2013 with MAAP
16 Venice	No
21 Oslo	No
23 Birkenes	EC/OC since 2010 with thermal-optical analysis
24 Stockholm	BC with aethalometer
26 Aspvreten	No
31 Madrid	No
33 Toledo	EC with thermal-optical analysis
40 Paris	Not yet but bought an aethalometer to be used soon
41 Berlin	No
44 Svanvik	No
45 Chaumont	No
50 Katowice	No
51 Athens	No
53 Vienna	No
57 Hämeenlinna	No
58 New Haven	No
59 Zilina	No
60 Split	No
61 Zagreb	No

- Only six sites with possible measurements to compare with today

Summary / gaps of knowledge

- BC results in soiling of materials and economic consequences are substantial but there is a lack of
  - Quantitative relationships including BC
  - Threshold levels for BC for transparent materials
- There is a lack of data concerning BC/EC measurements at ICP Materials test sites, which are needed to establish relationships. Current measurement methods for BC are too expensive to be practical for installment at all ICP Materials test sites.
- An interesting approach would be to compare modelling output at ICP Materials test sites with measured soiling values of transparent and non-transparent materials.
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