

European guidelines on air quality and its impact on historic buildings and monuments

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1

Acknowledgements

- EU Funded Research Contracts
 - Cult-Strat
 - Multi-Assess
 - REACH
- European Association of Historic Towns and Regions

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2

Management of the air pollution risk to heritage

- Science
- Values/resources
- 'Acceptable' levels
- Sustainability

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3

Managing the risk to our heritage

- Enormously diverse and complex task,
 - tremendous variety of history, style, art and culture.
 - many different types of monument.
 - made of many different materials, range in age over centuries.
 - located in radically different environments.

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4

Managing the risk to our heritage

- Air pollution is only one of the risks that threaten this heritage and may frequently not be the most pressing.
- In addition we have the added complication that weathering occurs naturally and indeed is often felt to contribute to a sense of age and serenity that is fundamental to the way that we value our ancient buildings.

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5

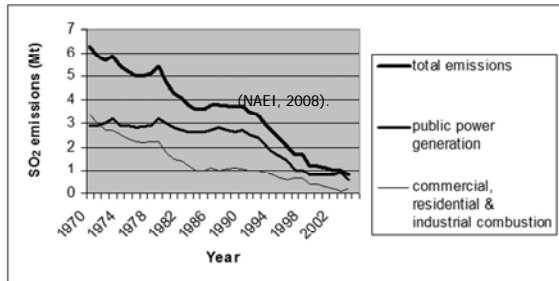
Background

- The danger to heritage from air pollution comes from two main sources –
 - gases that increase the corrosivity of the atmosphere.
 - black particles that dirty light coloured surfaces.

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6

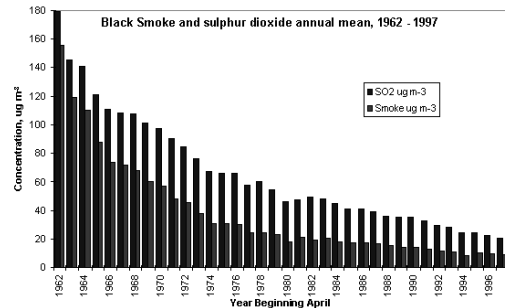
Annual emissions of SO₂ in the UK.



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(NAEI, 2008). 7

Ambient concentrations over time in UK



8

Bankside power station, London



In use

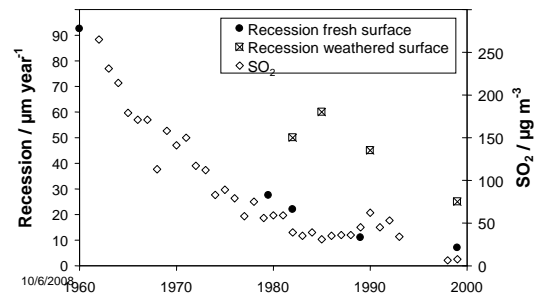


At present modern art gallery

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9

Portland Limestone, St. Paul's Cathedral, London, fresh and weathered surfaces



10

Corrosion

- SO₂ is the largest single contributing factor to decreasing corrosion trends, which was about 50% during the 8-year period 1987-1995.
- The decreasing trend of corrosion has been broken in some regions in Europe even though the SO₂ conc. are still decreasing

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11

Corrosion

- Apart from the decreasing corrosion of most materials the corrosion rates in urban areas are still considerably higher than in surrounding rural areas
- The decreasing S pollution has created a new multi-pollutant situation, where other pollutants have to be taken into account

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12

Particulate matter

- More complicated because it is a mixture rather than a single substance
- Includes dust, soot and other tiny bits of solid materials produced by many sources.
- Particulate pollution can cause increased corrosion by involvement in a number of chemical reactions
- Often more importantly, it is the source of the black matter that makes buildings dirty.

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13

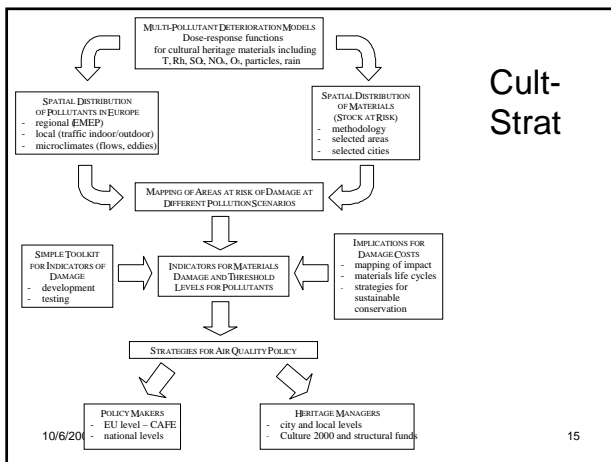
Soiling



- Soiling is a visual effect - the darkening of exposed surfaces due to air pollution – and may be said to come into the category of nuisance, and the extent of the nuisance caused by the soiling depends on the response of the observer.

10/6/

14



10/6/20

15

A soiling map for London; white painted steel, % loss in reflectance after 5 years



10/6/

16

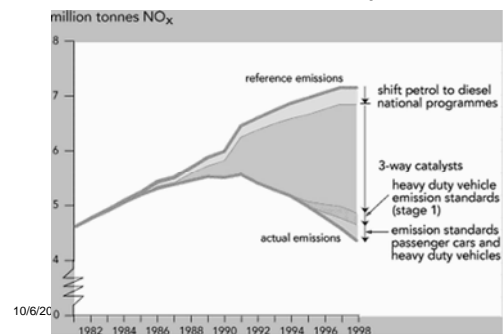
European and Nation State Policy

- **Policy instruments**
 - Ownership and operation
 - Regulation including laws for heritage protection as well as air quality
 - Funding (incentive and disincentives)
 - Information and education

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17

Contributions of policy initiatives to decreasing NOx emissions from vehicles in Europe



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18

EU limit and target values for the protection of human health

Pollutant	Concentration	Averaging Period	Legal status	Permitted Exceedances each year
Sulphur dioxide (SO ₂)	350 µgm ⁻³	1 hour	Limit value entered into force 1.1.2005	24
	125 µgm ⁻³	24 hours	Limit value entered into force 1.1.2005	3
Nitrogen dioxide (NO ₂)	200 µgm ⁻³	1 hour	Limit value entered into force 1.1.2010	18
	40 µgm ⁻³	1 year	Limit value entered into force 1.1.2010	n/a
PM ₁₀	50 µgm ⁻³	24 hours	Limit value entered into force 1.1.2005	35
	40 µgm ⁻³	1 year	Limit value entered into force 1.1.2005	n/a

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19

EU limit and target values for the protection of vegetation and ecosystems

Pollutant	Concentration	Averaging period
Nitrogen oxides (as NO ₂)	30 µgm ⁻³	Annual mean
Sulphur dioxide	20 µgm ⁻³	Annual and winter mean
Ozone	18000 µgm ⁻³	based on AOT40 for May to July.

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20

Average 'tolerable' rates for corrosion and maintenance intervals for some Cultural Heritage materials

Material	Type of surface	Corrosion depth before action (µm)	Tolerable time between maintenance (years)	Tolerable corrosion rate (µm yr ⁻¹)
Limestone/marble	Ornament Aged	100	12	8.3
	Ornament Corroded	50	6	8.3
Calcareous sandstone	Ornament Aged	100	12	8.3
	Ornament Corroded	50	6	8.3
Copper Monument	Ornament Corroded	10	20	0.5
Brass Monument	Ornament Aged	10	15	0.7
	Ornament Corroded	10	15	0.7

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21

'Acceptable' levels

- Using background corrosion rates and typical 'average' and 'urban' pollution scenarios, SO₂ concentrations for the protection of cultural heritage have been calculated (Multi-Assess 2007).
- Although drawing on a limited database, this work has estimated tolerable SO₂ concentrations for a range of materials.

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22

'Acceptable' levels

- The results suggest that a concentration of 10 µgm⁻³ would protect a broad range of heritage materials over 80% of European territory at current HNO₃ levels.
- This concentration is significantly lower than the annual mean of 20 µgm⁻³ proposed for the protection of vegetation and ecosystems.

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23

Examples of calculated tolerable levels of PM₁₀ (µgm⁻³) for a range of materials and different maintenance intervals

Material	5 years	10 years	20 years
Painted steel	40	20	10
White plastic	45	22	11
Limestone	36	18	9
Average	40	20	10

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24

Local policy

- Maintenance and preventative conservation strategies
- Scientific background for continuous maintenance strategies.
- Scientific knowledge based preventive conservation strategies

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25

Examples of policy options to reduce NO_x concentrations in a town centre

Option	Non Air quality benefits	Potential disadvantages	Knock on consequences
Increase public transport provision	More effective use of road space Reduces social exclusion for non-car owners	High level of financial commitment for infrastructure development	Increase local taxes to provide funding
Low emission zones	Long-term improvement to urban environment Encourages development of alternative technologies, fuels and mobility modes	Potential for social prejudice against owners of older vehicles Enforcement difficulties and resource cost	Potential for no overall emissions decrease for urban area as a whole Potential displacement of vehicles to other locations
Pedestrian town centre	Reduced risk of accidents Longer-term potential for increased trade and economic activity Improved overall town environment with lower noise levels Encourages healthier lifestyle Encourages social interaction Protects heritage	Reduced accessibility Short-term loss of trade Limited vehicle access may compromise situation Accessibility provision for the disabled	Need to improve public transport access to the area Potential displacement of traffic to elsewhere in the vicinity Increased out of hours commercial deliveries

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26

Conclusions

- Dose-Response functions have been created for a number of heritage materials
- These can be used to:
 - Map risk
 - Calculate costs
 - Calculate 'tolerable' levels if 'tolerable' corrosion or soiling rates can be set

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27

Conclusions

- Guidelines for heritage protection will:
 - Relate material damage to ambient concentrations
 - Present 'tolerable' levels context for local discussion
 - Develop 'acceptable' levels debate
 - Facilitate engagement with the public
 - Be an aid to developing policy and evaluate cost/benefit choices

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28