

AIR & CULTURAL HERITAGE

The cost of the deterioration of building materials due to air pollution is huge and seriously endangers our cultural heritage.

The Milan Duomo, Saint Paul's in London and Notre Dame in Paris are great icons of European culture. Yet these monuments, and many others, are heavily affected by air pollutants which attack the calcareous materials these buildings are built with. For over two centuries, the development of industry, transport and heating resulted in significant emissions of sulphur, nitrogen compounds and carbon. These compounds are either gases or particulates. They build up over the years on the surface of the buildings. The walls - made mainly of stone, bricks, cement, glass, wood

and ceramic - become discoloured and suffer material loss, structural failure and soiling [1]. Of particular importance is soiling caused by particles, and corrosion caused by chemicals (mostly sulphur and nitrogen oxides as well as carbon dioxide), which decrease the pH of rainwater (acidification). Many different damage patterns are involved in chemical decay such as pulverisation, black crusts, soluble salts efflorescence and particulate matter deposits [2]. The cost of air pollution damage to building materials is enormous but difficult to estimate with great precision.

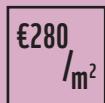
EU legislation

- Article 128 of the European Union Treaty says that actions by the Community shall be aimed at supporting conservation and safeguarding of cultural heritage of European significance.
- The Ambient Air Quality and National Emissions Ceilings (NEC) Directives are two major EU instruments to control air pollution in order to protect human health and the environment. However, they do not specifically address impacts on historic and cultural monuments and buildings.
- The Convention on Long-Range Transboundary Air Pollution (CLRTAP), to which the EU is a party, defines the term of "acceptable levels" of air pollutants damaging materials and cultural heritage and proposes the rates for certain materials [3].
- The indicators used by the European Environment Agency (EEA) for their "Integrated Assessment of Air Pollution and Climate Change" includes impacts on sea level, ecosystems, water resources and health. The impacts on cultural heritage are however not mentioned.

FACTS AND FIGURES



HISTORICAL buildings and monuments situated in EU cities are affected by air pollution. The costs of losing our precious cultural heritage forever through damage caused by air pollution would be huge.



CLEANING NATURAL STONE from soot and damage caused by SO₂ may cost on average €280 per square metre. This could add up to billions of euros to be spent cleaning affected surfaces [4].



POLYCYCLIC ORGANIC HYDROCARBONS (PAH), which are byproducts of coal, diesel and wood combustion, can cause significant degradation to buildings and monuments.



HEAVY METAL POLLUTION may accelerate the kinetic decay of construction materials.



Raised atmospheric **CARBON DIOXIDE** (CO₂) is a major cause of corrosion of limestone facades of buildings [5].



MATERIALS used for culturally valuable objects are also the most vulnerable to air pollution. This is the case of bronze, nickel, zinc, unalloyed and galvanised steel, mortar and natural stone.



STAINED GLASS present in many European cathedrals is being damaged by polluted rain and depositions of soot. Elevated levels of sulphur and nitrogen compounds cause glass to lose its transparency.



AIR POLLUTION AFFECTS INDOOR AIR QUALITY AND WORKS OF ART

Krakow is still one of the most polluted cities in Europe. This has an impact not only on human health but also on the works of art and historical buildings that this Polish city is famous for. A study of pollutants in the chambers of the Wawel Royal Castle found that the concentration of dust in

winter reaches $130 \mu\text{g}/\text{m}^3$ [6]. These particles spoil the artefacts, their texture, provoke chemical reactions and pose microbiological hazards. This prompts more intense cleaning and treatment activities that adversely affect the works of art. The presence of sulphate and soot particles can cause the fading of paintings.



AIR QUALITY MANAGEMENT IN CITIES

Most of Europe's precious historical and modern cultural heritage is located in the heart of big cities or capitals. This is usually also where the highest concentrations of air pollutants occur, as shown by the EEA reports on air quality. However, there is a lot which can be done to improve air quality in cities, as demonstrated by several initiatives which have been implemented in recent years. Air quality management can include Low Emission Zones (LEZ), better land-use planning, congestion charges, parking management and improving public transport [7]. All of this could help protect human health and cities' most precious sights.



BETTER UNDERSTANDING HOW AIR POLLUTION DAMAGES BUILDINGS



More research is needed to better understand the extent of the damage caused by air pollution to our cultural heritage. Some research is already taking place in Paris where, on the top of the north tower of the church of Saint-Eustache, experiments are trying to determine the damage air pollution is causing [8]. Samples of Parisian limestone and glass are exposed, some sheltered from rain and some not. They are regularly analysed (sulfation and carbonation, weight gain or loss, darkening, loss of transparency) according to the different doses of pollutants measured on the site.

For footnotes, please refer to separate reference sheet and to the EEB website.

RECOMMENDATIONS

- Adopt ambitious emission reduction commitments in the revised National Emissions Ceilings Directive. Emission reduction commitments must go beyond the Gothenburg Protocol and aim to achieve the health and environmental objectives of the EU's 6th and 7th Environment Action Programmes by 2030.
- Control emissions from medium combustion installations by setting limits in line with current best available techniques, ensure their rapid entry into force and an adequate permitting and monitoring regime.
- Adopt sector legislation to cut emissions from all major sources of air pollution. Surveillance of compliance is also critical, as shown with road vehicles.
- Ensure that air pollution's impacts on cultural heritage are better researched and understood, including the costs associated with the damages.
- Consider specific levels for the protection of sensitive materials based on the latest research.

More information:

- Global Climate Change Impact on Built Heritage and Cultural Landscapes:
<http://noahsark.isac.cnr.it/>
- Conservation, restoration and maintenance of Indoor and Outdoor Monuments, D. Camuffo, Elsevier, 2013
- International Co-operative Programme on Effects on Materials including Historic and Cultural Monument:
<http://www.corr-institute.se/ICP-Materials/web/page.aspx>
- The Effects of Air Pollution on Cultural Heritage, J. Watt et al, 2009
- The enhanced deterioration of the cultural heritage monuments due to air pollution, C. Varotsos, C. Tzanis, A. Cracknell, 2009