**Pollutant Type:** Particulate matter

**Pollutant Name:** Elemental carbon (EC)

**Description of the metric**
The metric elemental carbon (EC) is defined as elemental carbon concentration measured in particulate matter (PMx). Measurement values are related to mass concentrations and usually reported in µg/m³. Elemental carbon is a primary aerosol and is emitted directly from incomplete combustion processes, such as fossil fuel combustion or biomass burning. The main EC emission sources are road traffic (mainly diesel motor vehicles), energy production, specific industrial processes, biomass combustion and residential and domestic activities. EC is mainly present in the fine grain-size fractions, frequently in the size range <0.1 µm (Harrison and Yin, 2008).

**Health Relevance**
Epidemiological studies on the health effects of elemental carbon have also used, apart from EC measurements, optically measured black carbon (BC) as a surrogate measure of elemental carbon. Most of the evidence to date comes from controlled exposure studies and short-term health effect studies. Maynard et al. (2007) found a statistically significant 2.3% increase in all-cause mortality associated with an inter-quartile range of increase in BC in Boston, and larger increases of 3.7% and 4.4% for respiratory and stroke mortality respectively. Zhou et al. (2011) did not find a statistically significant association with mortality outcomes when considering the effects over all seasons, but did find an effect on total and cardiovascular mortality during the cold season in Seattle, USA. On the other hand BC has been systematically associated with increased hospital admissions for cardiovascular and respiratory outcomes (Peng et al. 2009; Bell et al. 2009), as well as with decreases in lung function (Suglia et al. 2008). Stronger effects have been identified in susceptible populations such as children (where associations with respiratory symptoms and cognitive function have been found, (Suglia et al. 2008a; Patel et al. 2009)), the elderly (increased blood pressure (Suglia et al. 2008b, Mordukhovich et al. 2009) and disturbances of autonomic control of the heart (Schwartz et al. 2005)) or myocardial infarction survivors (von Klot et al. 2009).

Human studies using EC in Concentrated Ambient Particles (CAP), found an effect on the brachial artery diameter (Brook et al 2002; Urch et al 2004) and lipid peroxidation in human bronchial epithelial cells from CAPs in Taiwan (Huang et al 2003).

Toxicological studies have used BC nanoparticles to investigate this PM component’s health effects and have identified alteration in cytokine/chemokine gene expression (Ovrevik et al 2009) and in vivo reduction in cardiac contractility (Tankersley et al. 2008)). Recent studies have indicated increased elastase production that contributes to pulmonary destruction following black carbon exposure (Chang et al. 20011) as well ROS generation in lung epithelial cells (Diabaté et al. 2011).
### Background Information on Air Pollutants and Air Quality Metrics

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**EC legislation, limit values (EU Directive 2008/50/EC)**

Concentration levels of elemental carbon are not regulated in the EU Directive 2008/50/EC. In order to collect information on the background pollution levels the directive requires to measure EC in PM2.5 samples taken at rural/regional background sites.
Reference method for determination of the metric

Currently there is no EU-wide harmonised reference method. A CEN working group to define a corresponding standard has been founded.

Atmospheric elemental carbon concentrations may be determined directly from collected filter samples by thermal desorption techniques. In Europe, several different protocols have been used, leading to different splits of the total carbon into elemental and organic carbon fractions. A common problem of all thermal techniques is charring of organic carbon which may lead to an overestimation of elemental carbon. To correct for this bias, optical transmittance (TOT, Birch and Cary, 1996) and thermal-optical reflectance (TOR, Chow et al., 2004) techniques were developed. Specific thermal protocols must be applied for the analysis of elemental carbon using either of the techniques (TOT or TOR). Elemental carbon determination is most widely performed with offline laboratory instruments. An online EC monitor exists as well. However, most online measurements of related to elemental carbon in PM are carried out by surrogate measurement technologies based on light absorption/scattering principles.

References
Ovrevik J, Låg M, Holme JA, Schwarze PE, Refsnes M. Cytokine and chemokine expression patterns in lung epithelial cells exposed to components characteristic of particulate air pollution. Toxicology. 2009 May 2;259(1-2):46-53.


Urch B, Brook JR, Wasserstein D, Brook RD, Rajagopalan S, Corey P, Silverman F. Relative contributions of PM2.5 chemical constituents to acute arterial vasoconstriction in humans. Inhalation Toxicology 2004 Jun;16(6-7):345-52.


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