

**Pollutant Type:**                      **Particulate Matter**

**Pollutant/Metric Name:**   **Non-carbonaceous elemental composition**

**Description of the metric**

Particulate matter is composed mainly of the three fractions: elemental carbon, organic carbon and inorganic compounds. The latter fraction comprises inorganic molecules (water) and molecule ions (ammonium, silicate, sulphate, nitrate, phosphate), elemental non-metal ions (mainly chloride) as well as many metal elements in form of their ions or various compounds (oxides, sulphides). Several of the heavy metals and their compounds are known to be health relevant. Consequently, for some of the heavy metals (Pb, As, Cd, Ni) EU-wide limit or target values exist. Other elements like chromium are considered additionally in most environmental impact assessments.

The elemental composition of particulate matter at a given location strongly depends on the sources contributing to the particulate load. It reflects natural as well as anthropogenic sources. Therefore the analysis of elemental composition is an important step in most source apportionment studies. Some elements can be considered as rather specific indicator or tracer components which help to identify and quantify source contributions, e.g. vanadium (heavy/crude fuel oil combustion in refineries and oversea ships, frequently associated with nickel), antimony (brake wear particles, together with copper and barium), potassium (biomass combustion).

Most metal elements are present in form of chemical compounds and various states of oxidation. However, exact speciation is a difficult task demanding a high analytical effort. Hence, the analysis of elemental composition is mainly based on methods delivering concentrations for the elements. For mass closure purpose a stable oxide is assumed for metallic elements to best represent the actual species.

Of the various metals Fe (assumed to be present as FeO or Fe<sub>2</sub>O<sub>3</sub>) is the major contributor with typical urban background concentrations of several hundred ng/m<sup>3</sup>. In absence of specific sources most other elements are present in the lower ng/m<sup>3</sup> concentration range.

**Health Relevance**

There is evidence that the toxicity of particles is different across geographical locations pointing to differential toxicity according to particle sources and mixtures. Recent research indicated that the adverse health effects of ambient particulate matter vary between specific chemical compositions. Among particle non-carbonaceous elemental components, metals have been identified as particular candidates for toxicity. Lead neurotoxicity has been well studied and there is accumulated evidence on the reduction of cognitive and mental development, especially in children (Grandjean 2010; Jakubowski 2011). It should be noted that lead intake does not happen exclusively via air inhalation. Several other metal compounds of PM, especially nickel and vanadium have been identified to be associated with cardiopulmonary diseases (Hsu et al. 2011; Zhang et al. 2009; Zanobetti et al. 2009; Patel et al. 2009; Ito et al. 2011; Chen et al. 2009), even in children (Patel et al. 2009), and heart rate vulnerability (Hsu et al. 2011). Other metals that have been associated with adverse effects include arsenic in association with diabetes morbidity, lead and chromium for cardiopulmonary effects. The biological mechanisms through which these effects occur are under investigation in toxicological studies, with initial results pointing toward DNA damage and pro-inflammatory responses (Zhong et al. 2010; Perrone et al. 2010; Cameron et al. 2011) and modification of micro RNAs (Bollati et al. 2010).



## Background Information on Air Pollutants and Air Quality Metrics

Compound	Toxicological Information	References	Epidemiological information	References
Pb	Neurotoxicity; Modification of microRNAs in peripheral blood leukocytes	Grandjean 2010; Jakubowski 2011; Bollati et al. 2010	Affects cognitive functions; reduces IQ levels, esp in children. Affects cardiopulmonary disease occurrence.	Grandjean 2010; Jakubowski 2011; Chen & Lippmann 2009
As			Increase in emergency admissions for MI and diabetes	Zanobetti et al. 2009
Cd	Modification of microRNAs in peripheral blood leukocytes	Bollati et al. 2010		
Ni	Genotoxicity-carcinogenicity	Cameron et al. 2011	Effects on heart rate; cardiopulmonary effects	Hsu et al. 2011; Zhang et al. 2009; Zanobetti et al. 2009; Patel et al. 2009; Ito et al. 2011; Chen & Lippmann 2009
Cr			Increase in emergency admissions for myocardial infarction	Zanobetti et al. 2009
V			Increase in cardiopulmonary diseases	Zhang et al. 2009; Patel et al. 2009; Ito et al. 2011; Chen & Lippmann 2009
Fe	Oxidative injury, cytotoxicity, pro-inflammatory responses, DNA damage	Zhong et al. 2010; Perrone et al. 2010		

### EC legislation, limit values

Lead (Pb) is the only heavy metal element for which a limit value has been set in the EU Air Quality directive 2008/50/EC. In case of As, Cd, and Ni target values have been defined in the 4<sup>th</sup> daughter directive 2004/107/EC. In the EU countries national regulations and procedures may be applied to other elements as well, e.g. in environmental impact assessments.

Element	Time basis	Limit value (human health)	Target value	Dimension	Ref.
Pb	calendar year	0.5		$\mu\text{g}/\text{m}^3$	2008/50/EC
As	calendar year		6	$\text{ng}/\text{m}^3$	2004/107/EC
Cd	calendar year		5	$\text{ng}/\text{m}^3$	2004/107/EC
Ni	calendar year		20	$\text{ng}/\text{m}^3$	2004/107/EC

### Reference method for determination of the metric

The elemental composition is determined manually by multi-element analytical methods, like Atomic Absorption spectrometry (AAS), inductively-coupled plasma with atomic emission spectrometry (ICP-AES) or mass spectroscopy (ICP-MS) from filter samples after acidic digestion of the collected material.

An alternative method is X-ray fluorescence spectrometry directly applied to filters without further sample treatment; this method requires collection of PM on a suitable filter material (PTFE) as well as well-defined calibration filters.

### References

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