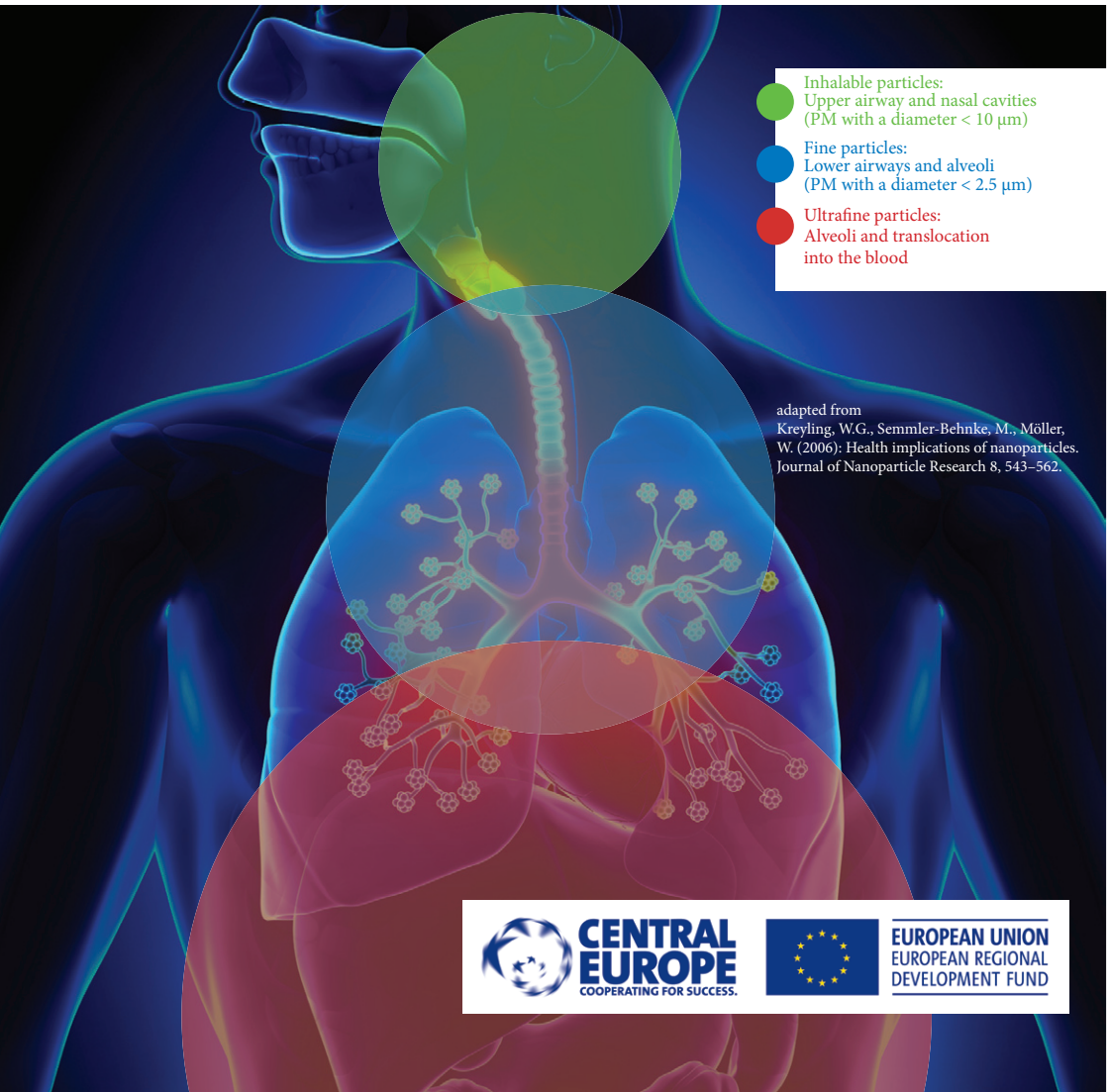
UFIREG

Ultrafine particles – cooperation with environmental and health policy

Ultrafine particles - too small to see, too big to ignore: What can regional and European environmental and health policy do?

Summary for Policymakers and Stakeholders



CENTRAL EUROPE
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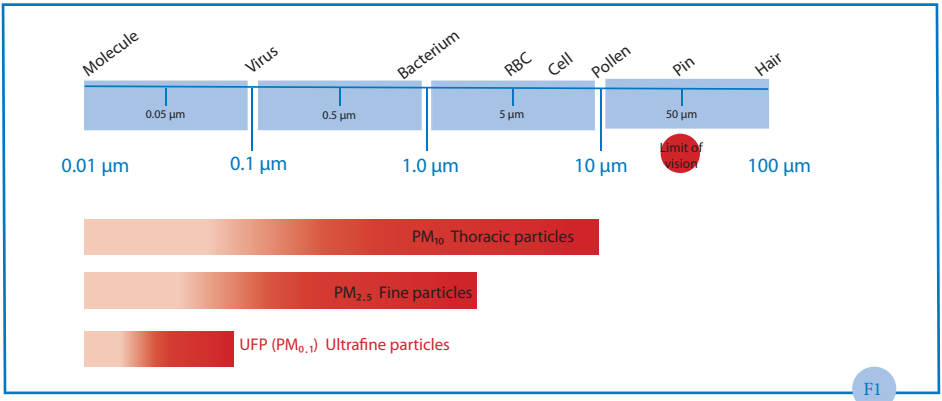
Invisible to our eyes, but detrimental to our health - Why it is important to measure ultrafine particles (UFP)?

Ultrafine particles (UFP) are the smallest constituents of airborne particulate matter: they are smaller than 0.1 micrometres and invisible to our eyes (F1). Yet, their potential adverse effects on human health are of great concern because of their specific properties and acting mechanisms (B1). Size governs the transport and removal of particles from the air and their deposition within the respiratory system and it is partly associated with the chemical composition and the source. UFP have little mass but high number and surface area concentration and a high content of elemental and organic carbon. Ambient UFP are built from gases or originate from combustion processes.

In urban areas, they are emitted mostly by anthropogenic sources like traffic, domestic heating, and industrial processes. Epidemiological studies have shown that particulate matter (PM) is associated with adverse health effects[1], especially in vulnerable population groups (F2). The health effects of UFP are in part different from the effects of larger particles such as $PM_{2.5}$ or PM_{10}[2]. However, evidence on short-term health effects of UFP is still limited. No epidemiological studies of long-term exposures to ambient UFP have been conducted yet.

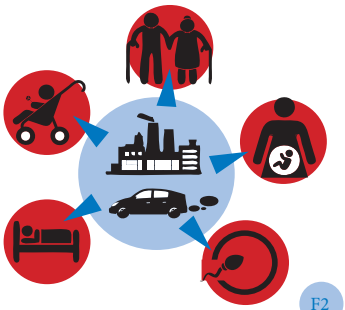


F1

UFP [1-3-4]

B1

- deposit deeply in the lung.
- are not well recognized and cleared by the immune system in the alveolar space.
- injure cells, cause oxidative stress, inflammation, mitochondrial exhaustion, and damage to protein and DNA.
- penetrate the lung membranes, reach the bloodstream and can be transported to different organs such as heart, liver, kidneys and brain.
- reach the brain via the olfactory nerve.



adapted from Rückerl et al., 2001 [1]

F2

[1] *Rückerl, R., Schneider, A., Breitner, S. et al. (2011): Health Effects of Particulate Air Pollution - A Review of Epidemiological Evidence. Inhalation Toxicology 23(10), 555 - 592.*

[2] *WHO Regional Office for Europe (2013): Review of evidence on health aspects of air pollution – REVIHAAP project. Technical report. Copenhagen, Denmark (available at: http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf; accessed 22 October 2014)*

[3] *Brook, R.D., Franklin, B., Cascio, W. et al. (2004):Air pollution and cardiovascular disease – A statement for healthcare professionals from the expert panel on population and prevention science of the American Heart Association. Circulation 109, 2655-2671*

[4] *Health Effects Institute (HEI) (2013): Understanding the Health Effects of Ambient Ultrafine Particles, HEI Review Panel on Ultrafine Particles, HEI Perspectives 3, Insights from HEI's research, Boston, USA (available at: http://pubs.healtheffects.org/getfile.php?u=893; accessed 5 November 2014)*

The UFIREG project

The project "Ultrafine particles – an evidence based contribution to the development of regional and European environmental and health policy" (UFIREG) aimed to improve the knowledge base on possible health effects of ultrafine particles and to raise overall awareness of environmental and health care authorities and the population. Five cities in four European countries participated in the study (F3).

The project started in July 2011 and ended in December 2014. It was implemented through the CENTRAL EUROPE Programme, co-financed by the ERDF.

The project was structured in two main areas:
Assessment of exposure to UFP and other air pollutants in five European cities: To investigate the exposure of the population to UFP, UFIREG partners have established standardised UFP measurements in five cities. Based on the data generated through UFIREG measurements, they have determined the temporal variation of these very small particles in each study location and performed a comprehensive comparison on the air pollution situation between the cities. Whereas the main focus lied on the implementation and harmonisation of UFP measurements in the project cities as a basis for epidemiological studies, it also aimed to develop long-term strategies for regular measurements of UFP.
Epidemiology of short-term health effects: Statistical analyses have assessed the short-term effects of these particles on human mortality and morbidity, especially in relation to cardiovascular and respiratory diseases.

F3

UFIREG
Ultrafine particles – cooperation with environmental and health policy

Ultrafine Particles – an evidence based contribution to the development of regional and European environmental and health policy (UFIREG)

INTERREG IV B CENTRAL EUROPE
Project number: 3CE288P3
Duration: 7/2011 – 12/2014
Website: www.ufireg-central.eu

How variable is the exposure in the five UFIREG cities?

To investigate the exposure of the population to UFP, UFIREG partners have established standardised UFP measurements using custom-made mobility particle size spectrometers in five cities located in Germany (Augsburg and Dresden), the Czech Republic (Prague), Slovenia (Ljubljana) and Ukraine (Chernivtsi) (F4). All of the UFIREG measurement stations were located at an urban or suburban background site which was representative for a large part of the urban population and had no roads with heavy traffic in immediate vicinity. To achieve high and comparable data quality, UFIREG established an extensive quality assurance program.

Selected Results

The temporal variation of UFP was determined at one fixed monitoring site in each of the five project cities. Overall, the particle number concentration (PNC) of 10-100 nm particles varied between the five cities from May 2012 to April 2014 (F5). In summer, there was a considerable influence of new particle formation due to high global radiation and precursor gases, especially in Dresden and Prague. The results demonstrate that PNC in urban areas strongly depends on various factors such as meteorological conditions, cityscape and the activity of different particle sources (traffic, domestic heating, long-range transport, etc.) whereby the everyday life of people plays an important role.

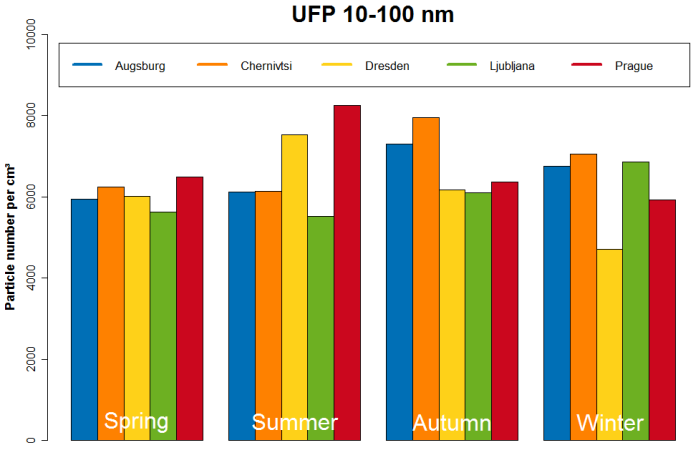
Consequences

High quality measurements of size-resolved PNC and integration into routine monitoring networks are still a challenge.

The deviance (+/- 20%) due to the PNC measurement principle in general is larger than for other air pollution measurements. For epidemiological studies, the deviance needs to be continuously monitored. Determination of the total PNC could be an alternative for UFP measurements. However, the information of size-resolved PNC data has an additional value for defining sources of air pollution and human exposure assessment.

Appropriate instruments show particle number size distributions, which means they indicate how many particles of a defined size between 10 and 800 nm are in one cubic centimetre air at a certain time. The function of the instrument is based on charging particles, followed by segregation of particles in an electrical field according to their diameter and charge. In a last step, the classified particles are counted by a particle counter.

F4



F5

What is the evidence for health effects in the five UFIREG cities?

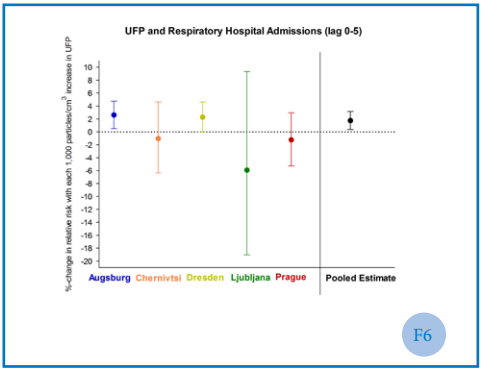
Epidemiological studies in the frame of the UFIREG project have assessed the short-term effects of UFP on human mortality and morbidity, especially in relation to cardiovascular and respiratory diseases (B2).

Official statistics were used to determine the association between air pollution concentration and daily (cause-specific: respiratory and cardiovascular) hospital admissions and mortality. Associations of UFP levels and health effects were analyzed for each city by use of Poisson regression models adjusting for a number of confounding factors, such as time trend, day of the week, holiday, vacation periods, influenza epidemics, air temperature and relative humidity. Time lags were included to identify immediate effects (2-day average: lag 0-1), delayed effects (average of lag 2-5) and prolonged effects (6-day average: lag 0-5). City-specific effect estimates were pooled using meta-analyses methods.

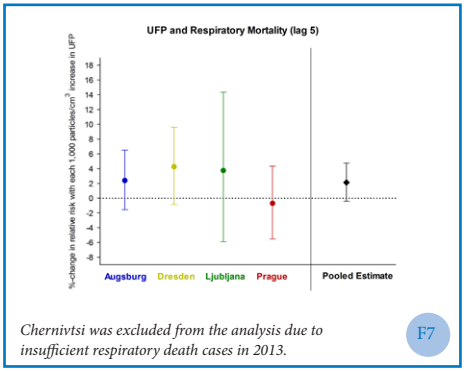
B2

Selected Results

Results on morbidity and mortality effects of UFP are heterogeneous across the five European cities investigated. Overall, an increase in respiratory hospital admissions and mortality can be detected for increases in UFP concentrations (F6, F7). Results on cardiovascular health were less conclusive. Although there is a growing body of scientific literature that addresses the health effects related to UFP (and UFIREG helped improving the knowledge base for the impact of traffic emissions on health), it is not sufficient to draw definite conclusions about the specific health consequences of exposure to UFP.



F6



Chernivtsi was excluded from the analysis due to insufficient respiratory death cases in 2013.

F7

Gaps

There is still (a) limited epidemiological evidence on the effect of short-term exposure to ultrafine particles on health; (b) insufficient understanding of whether the effects of UFP are independent of those of $PM_{2.5}$ and PM_{10}; (c) no evidence on the effects of long-term exposure to UFP on health, and (d) little evidence showing which size ranges or chemical characteristics of UFP are most significant to health[5].

[5] *WHO Regional Office for Europe (2013): Review of evidence on health aspects of air pollution – REVIHAAP project. Technicalreport. Copenhagen, Denmark (available at: http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf; accessed 22 October 2014)*

Where do we go from here? - What can environmental and health policymakers contribute?

So far, no directives for the regulation of UFP in ambient air and almost no official measurements sites which routinely measure UFP exist. Usually, research results are used to formulate recommendations and guidelines, e.g. the WHO Air Quality Guidelines[6], which support policymakers in setting thresholds of air pollution constituents for national and European policy on air quality control such as the EU Air Quality Directive[7].

Current data and studies on the levels of UFP and their health effects do not allow firm conclusions on exposure limits and respective health effects to be considered in European air quality guidelines. On the other hand, to date, UFP are not included in routine measurements of air quality monitoring stations. This in turn explains the lack of data for epidemiological studies.

At this stage, policymakers and stakeholders are called upon for supporting routine measurements and research efforts to resolve this chicken-egg situation (B3).

B3

What policymakers and stakeholders can contribute

- Continue efforts to routinely monitor UFP and generate data for epidemiological studies: Larger and more specific multi-centre studies and long study periods are needed to produce powerful results. The creation of so-called supersites or special sites should be considered[8].
- Support multi-pollutant approaches as so far pollutants are mostly assessed independently.
- Foster the conduct of epidemiological studies to assess the association between UFP levels and adverse health effects; concentration–response functions need to be established for UFP and for newly identified health outcomes. This will also require the generation of large data sets on these exposure metrics [8].
- Facilitate studies for evidence that may allow defining limit values for daily concentrations of UFP.
- Develop and implement measures to reduce UFP emissions, particularly from transport and domestic heating/biomass burning. Measures may include:
  - ✓ Encourage mass public transit and alternative energy sources for vehicles (electric and hybrid technologies)
  - ✓ Encourage fewer road traffic journeys and more physically active transport
  - ✓ Support concept of low emission zones (incl. shipping traffic in cities)
  - ✓ Support urban planning measures that help control hot spots such as near road microenvironments
  - ✓ Support reliable filter systems for heavy duty vehicles (construction machinery), ships, heating systems.
- Help protect people from UFP and soot particles also at occupational sites (e.g. construction sites).
- Strengthen communication and awareness raising for professionals and the public in relation to air pollution and particulate matter, including UFP.

The project consortium is suggesting to further pursue open research questions (B4):

- Are the short-term health effects of UFP comparable in cities across Europe? (more multicentre time-series studies including meta-analysis are needed)
- What are the health effects of personal short-term exposures to UFP?
- What are the health effects of pollutant mixtures and together with individual activities i.e. in a tunnel or during physical activity?
- Are the health effects of UFP independent of the health effects of black carbon and/or other criteria air pollutants?
- What are the long-term health effects of UFP and their components?
- Are population groups spending more time near traffic more at risk compared to other groups?
- How effective are measures implemented for increasing air quality in urban settings?
- Which are the main sources of UFP and how to estimate the health effect impact of specific UFP sources?

B4

For further details please consult the UFIREG handbook and other documents on the UFIREG webpage at: http://www.ufireg-central.eu/. On this webpage you also find a link to a film explaining the background to the UFIREG project.

[6] *WHO (2005): Air quality guidelines, global update 2005. Geneva, Switzerland (available at: http://www.euro.who.int/__data/assets/pdf_file/0005/78638/E90038.pdf?ua=1; accessed 23 October 2014)*

[7] *European Commission (2008): Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe (available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF; accessed 27 October 2014)*

[8] *WHO Regional Office for Europe (2013): Review of evidence on health aspects of air pollution – REVIHAAP project. Technical report. Copenhagen, Denmark (available at: http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf; accessed 22 October 2014)*

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The UFIREG project is implemented through the CENTRAL EUROPE Programme co-financed by the ERDF

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