

Austrian project on health effects of particulates¹

Helger Hauck

1. Overview

AUPHEP is a research project carried out by the Clean Air Commission of the Austrian Academy of Sciences in cooperation with the following institutions: Institute of Experimental Physics of the University of Vienna, Institute of Environmental Health and University Children's Hospital of the Medical University of Vienna, Institute for Chemical Technology and Analytics of the Vienna University of Technology, Institute for Meteorology of the University of Natural Resources and Applied Life Sciences, Vienna, Pulmonary Center of the city of Vienna, Office for Youth and Family Affairs of the City of Linz, Federal Environment Agency, Vienna, Air Quality Departments of the Federal Austrian States, City of Vienna – MA-22 (chemical laboratory). The project was started in 1998 and was completed in 2004 (Hauck et al. 2004a).

The project was funded by the Federal Ministry for Science and Traffic, the Federal Ministry of Environment, Youth and Family Affairs, and the Austrian Academy of Sciences. Additional financial support came from the Ambient Air Monitoring Networks of the Federal Austrian States, the Federal Environment Agency, as well as several companies.

In the middle of the last century high concentrations of particulate air pollution (PM – particulate matter) were a serious menace to human health (e.g. London smog episodes). Extensive technical and regulatory measures taken in the industrialized countries led to a considerable reduction of PM concentration. Nevertheless, epidemiological studies (e.g. "Six Cities Studies" in the USA) demonstrated that even at relatively low PM concentrations (varying around air quality standards) there is a positive statistical association between PM concentrations and adverse health effects. Especially the fine fractions with diameters smaller than 2.5 µm proved critical; they affect the respiratory tract and the cardio-vascular system particularly in susceptible groups such as children, the elderly, and individuals with pre-existing diseases. Although intense research was carried out in this field during the last 25 years, the causal links between PM burden and adverse health effects could not be determined unambiguously. The latest research findings provide convincing evidence that even at very low PM concentrations there is a relationship between health effects (increased mortality and more frequent disorders of the respiratory tract

1 Reprint from AUPHEP-Endbericht, Kommission für Reinhaltung der Luft, Österreichische Akademie der Wissenschaften, Wien 2004 (http://www.oeaw.ac.at/krl/publikation/documents/AUPHEP_EB.pdf).

and the circulation system) and PM-burdens. The causal agent (mass concentration, number concentration, surface, composition etc.) could not be identified with certainty to date.

2. Monitoring programs

The purpose of the Austrian project was to give an overview on the ambient air quality situation with special emphasis on PM; the monitoring sites were selected in an effort to reflect the typical Austrian situation. The interaction of the different PM-parameters and the characteristic chemical composition of the aerosol with respect to the current meteorological situation could thus be evaluated. At four sampling sites where SO_2 , NO/NO_2 , TSP, and O_3 and the most important meteorological parameters were already being monitored, continuous measurements were carried out for TSP (total suspended particles) PM10, PM2.5, PM1.0, and particle number concentration. Implementation of various measurement techniques allowed investigation of the equivalence of these results also with respect to aerosol composition (Hauck et al 2004b).

The 12 months monitoring series demonstrate only a weak variability between summer and winter in the mass concentrations of all fractions in Vienna and Streithofen (NÖ), the sites in Linz and Graz – having higher concentrations in general – indicate a clear maximum in winter. At all urban sites the particle number concentrations are higher, peaking in winter; the rural site at Tullnerfeld has nearly equal concentrations in both seasons. Trajectory analyses revealed that these sites are well suited in most (but not all) cases to serve as background stations for Vienna (Gomišček et al. 2004a). In general, higher PM concentrations above the current standards are more common in winter due to the unfavorable weather conditions (e.g. low mixing layer: Gomišček et al. 2004b).

The PM10- and PM2.5- fractions were also collected as diurnal sample by means of a high volume sampler and underwent thorough chemical analysis. The analytical measurement program included ions, trace metals, soot, and organic carbon. The chemical analysis revealed the influence of aerosol sources. Due to the parallel sampling at the urban station in Vienna (AKH) and the background station at Streithofen it was possible to detect metropolitan influences in the aerosol formation processes. The metropolitan contribution to the PM10 concentration at the AKH site showed an annual mean of 22% (Puxbaum et al. 2004). During monitoring campaigns (in summer and winter) using specially designed high resolution impactors soluble ions and a number of heavy metals within different size-modes could be identified (Berner et al. 2004).

3. Health effects studies

The data derived from these monitoring series are the basis for the subsequent studies on health effects of particulates. They are compiled in a database and are collected on a CD-ROM, thus made available.

The effects of particulate air pollution on the lung function of children were investigated in an epidemiological survey conducted with two cohorts (PM effects on the lung function of one- and two-year old children, PM effects on the lung function of elementary school children: Horak et al. 2000, Neuberger et al. 2002, Moshhammer et al. 2006). In another study, time-series analyses were carried out using health data from Vienna, Tullnerfeld, Linz, and Graz including exposure data collected in these areas. Morbidity data (hospital discharges with relevant diagnosis recorded around the monitoring stations) and mortality data due to respiratory and cardiovascular diseases were linked with the exposure and weather data (Neuberger et al. 2005).

The relationship between the two causal pollutants SO₂ and suspended particles on the one side and premature deaths due to bronchitis/asthma on the other observed in previous time-series studies in Vienna, could no longer be found in the years 1999–2001, a benefit from improved air quality (emission control in industry and domestic heating). A rise in fine mode concentrations (PM_{2.5}) of 10 µg/m³ is commonly linked to an increase in hospitalization of persons older than 65 years for bronchitis/asthma, i.e. 5.5% in men, and 5.6% in women. But not only the elderly are affected, hospitalization of children goes up too, of preschool girls by 8%, of school girls by 6%. A rise in carbonaceous fine particles (e.g. as caused by diesel-powered vehicles) in Vienna was associated with adverse respiratory effects in kindergarten children. First responses to a rise in fine particles burden are characterized by discrete, sub-clinical lung function disorders in children followed by symptoms of adverse effects in susceptible subpopulations living near the monitoring site and increased hospital admissions with attributable diagnosis in the whole metropolitan area. Some hours after an increase in active surface recorded at a monitoring station in Linz, an examination of children of a nearby primary school revealed a slight increase in respiratory resistance and a slight decrease in peak flow (Moshhammer and Neuberger 2003). In the city of Vienna, however, a significant increase in hospital admissions for bronchitis/asthma triggered by a rise in PM_{2.5} occurred two or more days after the event: in men over 65 years after 2 days, in women over 65 years after 3 days, in schoolgirls after 2 days, in pre-schoolgirls after 4 days (see this compendium, pp. 103 ff). A second peak in hospitalizations was observed in persons over 65 years 10 days after a rise in fine dust concentration. One day after the event, a significant increase in specific mortality due to ischemic heart disease (myocardial infarction) in persons older than 65 years – independent of temperature – could be observed. Lung disorders occurred after an increase in PM_{2.5} and PM₁₀, but an increase in

ischemic heart disorders could only be found after a rise in fine particle concentration (PM_{1.0}, PM_{2.5}, PM_{2.5}-PM_{1.0}). Due to the short latency interval it must be supposed that premature deaths due to heart disease are a direct consequence of the penetration of fine particles into the blood via the lung, impairing the coagulation mechanism and interacting directly with the heart.

In a longitudinal PM exposure study carried out with schoolchildren in Vienna, Tullnerfeld, and Linz a total of 2 913 children of the second and third grade from seven schools in Vienna and Tullnerfeld respectively and from 10 schools in Linz was examined. The children's parents filled out a questionnaire four times (one per season), the children were directly interviewed. Current and previous respiratory disorders along with allergic responses and chronic diseases of the child and his family, the life style of the child, and demographic features were recorded. The main points of the examination were the overall evaluation of the respiratory health as judged by the parents together with an asthma score derived from the present symptoms and the medication. The influence of the PM burden was analyzed using a mixed regression model, with the time-activity parameters being the PM fraction and the climate data of the last four weeks preceding the personal interviews. The age of the child at the beginning of the inquiry, gender, allergies of the child and his family, asthma of the family, passive smoking, truck traffic in the residential area, general traffic density in the residential area, domestic cooking or heating with gas and the presence of moulds in the home were included as fixed variables.

Associations with the asthma score proved weak or non-existent. The variability of medium-term PM burden is generally not linked with the variability of asthma symptoms. In Tullnerfeld however, the findings showed a systematic correlation between the PM_{1.0} fraction, to a certain extent also the PM_{2.5} fraction, and the severity of the symptoms. A clear relationship was found between the fine dust concentration during the reference period and the overall evaluation of the lung condition. High PM_{2.5} concentrations were linked with an aggravated risk for impending lung injuries. The analysis strongly suggested that this increase was due to the PM fraction ranging from 1.0 to 2.5 μm . The two impactor campaigns carried out in summer and winter clearly demonstrate that the mass concentration in this area varies with the fine and coarse fraction and is therefore an indicator of the physical aerosol processes which play an active role in the accumulation and fractioning of particles. Since truck frequency in the residential area of the children is an important factor of the incidence of respiratory disorders, diesel soot seems to be one of the causal agents of occurrence and severity of the symptoms.

In summary, compared to former years, these time-series studies indicate an improvement in air quality but still give evidence of a prevailing high fine dust concentration. This is a serious hint that further research is urgently needed

H. Hauck

for the protection of human health in general and of susceptible subpopulations in particular.

4. References

- Berner, A., Galambos, Z., Ctyroky, P., Frühauf, P., Hitzenberger, R., Gomišček, B., Hauck, H., Preining, O., and H. Puxbaum. 2004. "On the correlation of atmospheric aerosol components of mass size distributions in the larger region of a central European city." *Atmospheric Environment* 38: 3959–3970.
- Gomišček, B., Frank, A., Puxbaum, H., Stopper, S., Preining, O., and H. Hauck. 2004a. "Case Study Analysis of PM Burden at the Urban and Rural Site During the AUPHEP-Project." *Atmospheric Environment* 38: 3935–3948.
- Gomišček, B., Hauck, H., Stopper, S., and O. Preining. 2004b. "Spatial and Temporal Variations of PM_{1.0}, PM_{2.5}, PM₁₀ and Particle Number Concentration during the AUPHEP-Project." *Atmospheric Environment* 38: 3917–3934.
- Hauck, H., Berner, A., Frischer, T., Gomišček, B., Kundi, M., Neuberger, M., Puxbaum, H., Preining, O., and AUPHEP-Team. 2004a. "AUPHEP – Austrian Project on Health Effects of Particulates – General Overview." *Atmospheric Environment* 38: 3905–3915.
- Hauck, H., Berner, A., Gomišček, B., Stopper, S., Puxbaum, H., Kundi, M., and O. Preining. 2004b. "Equivalence of Measuring Methods for PM." *Journal of Aerosol Science* 35: 1135–1149.
- Horak, F. jr., Frischer, T., Studnicka, M., Gartner, C., Seyda, B., Amoako-Mensah, T., and H. Hauck. 2000. "Calibrated Inductance-Plethysmography (RESPI-TRACE) as a means to assess lung function in preschool children in epidemiologic studies." *European Respiratory Journal* 16 Suppl 13, 299s.
- Moshhammer H., Hutter, H-P., Hauck, H., and M. Neuberger. 2006. "Low levels of air pollution induce changes of lung function in a panel of school children." *European Respiratory Journal* 27: 1138–1143.
- Moshhammer, H., and M. Neuberger. 2003. "The active surface of suspended particles as a predictor of lung function and pulmonary symptoms in Austrian school children." *Atmospheric Environment* 37: 1737–1744.
- Neuberger, M., Horak, F. jr., Frischer, T., Kundi, M., Puxbaum, H., Studnicka, M., Hauck, H., and O. Preining. 2002. "Austrian project on health effects of particulates: First results on lung function changes in children." *Pollution Atmospherique* 175: 383–386.
- Neuberger M., Moshhammer, H., Hauck, H., Kundi, M., Rabczenko, D., and M.G. Schimek. 2005. "Zeitreihenstudie zur atmosphärischen Feinstaubbelastung und spezifischen Mortalität und Morbidität in Österreich." *Österreichisches Forum Arbeitsmedizin*, 5-7.
- Neuberger, M., Schimek, M.G., Horak, F. jr., Moshhammer, H., Kundi, M., Frischer, T., Gomišček, B., Puxbaum, H., Hauck, H., and AUPHEP-Team. 2004. "Acute effects of particulate matter on respiratory diseases, symptoms and

functions. Epidemiological results of the Austrian Project on Health Effects of Particulate Matter (AUPHEP)." *Atmospheric Environment* 38: 3971–3981.

Puxbaum, H., Gomišček, B., Kalina, M., Bauer, H., Salam, A., Stopper, S., Preining, O., and H. Hauck. 2004. "A dual site study of PM_{2.5} and PM₁₀ aerosol chemistry in the larger region of Vienna, Austria." *Atmospheric Environment* 38: 3949–3958.

Address of the Author:

ao. Univ.-Prof. Dr. Helger Hauck
Käferkreuzgasse 2-8/8/1, A-3400 Klosterneuburg