Air pollution and cancer in Switzerland

Peter Straehl, PhD, MPH, Swiss Agency for the Environment, Berne, Switzerland

In this study the carcinogenic effects of air pollution on public health in Switzerland were assessed. In addition, the extent of the necessary emission reductions to protect public health was determined, and possible risk reduction measures identified.

Risk assessments were carried out on the basis of the exposure of the population to the pollutants PM2.5 (fine particles with a diameter ≤ 2.5µm) and benzene. Exposure levels were determined with the help of empirical dispersion models and assumptions concerning typical Swiss weather patterns. In 2000, the population weighted annual average of ambient PM2.5 concentrations across Switzerland was 16.5 µg/m^3, while benzene concentrations averaged around 3.8 µg/m^3. By 2010, as a result of measures already adopted or approved in principle, the population weighted mean concentrations will be reduced to approx. 14.5 µg/m^3 PM2.5 and 2 µg/m^3 benzene. On the basis of significant, epidemiologically proven PM2.5 risk increments (500'00 people examined and followed up to 20 years) and recognized methods of calculation, the study concludes that in Switzerland approx. 300 (100–450) cases of cancer per year are attributable to excessive air pollution. Particulate pollutants account for 270 cases of lung cancer, while gaseous air pollutants are responsible for 30 cases of leukaemia. The calculations indicate that the risk of getting cancer as a result of breathing air pollutants is relatively high. Some 10% of all cases of lung cancer in Switzerland are to be attributed to excessive air pollution. Ranking well behind active smoking, exposure to polluted air is an important risk factor for lung cancer. From a public health perspective, there is a major need for action to reduce the risk.

In the year 2000, approx. 24'300 tonnes of primary PM10 particulates were emitted in Switzerland. Although no confirmed figures are yet available for PM2.5 particulates, these emissions are likely to account for around 75% of the PM10 emissions. Of the 24'300 tonnes of PM10, approx. 4600 tonnes are fine soot particles from combustion processes, mainly from diesel engines. Benzene emissions totalled around 1400 tonnes per year (2000). If the protection of the population guaranteed by the Constitution is to be assured, soot emissions will need to be reduced by approx. 30-fold to a maximum level of 150 (100–200) tonnes per year, while benzene emissions should not exceed 100 tonnes/year. If the ambitious – but in public health terms legitimated – emission targets for soot and benzene are ultimately attained, annual average concentrations of these two carcinogenic substances in outdoor air should no longer exceed 0.3–0.5 µg/m^3.

In 2000, two thirds of PM10 emissions were derived from either industrial/trade (36%) or transport (31%) sources, while around 28% came from the agricultural/forestry sector. In the same year, approx. 1600 tonnes of soot were emitted in exhaust gases from road traffic, which is thus the main source of soot emissions in Switzerland. Significant contributions of around 1000 tonnes each per year derive from the construction sector (machines) and agriculture (tractors, machinery). Aviation is responsible for the emission of approx. 600 tonnes of soot, with 400 tonnes deriving from other sources (e.g. heating systems, wood burning, other off road activities in household and trade). Exhaust gases from motor vehicles (mainly petrol-driven engines) accounted for 75% of all benzene emissions.

In reducing emissions of particulate matter and soot, particulate traps clearly play a key role. With these systems, around 90% (mass) to 99.9% (number) of particles can be filtered out of exhaust streams. The carcinogenic potential of exhaust gases is reduced by more than 90%. If all heavy duty vehicles, construction machines, tractors and diesel-powered passenger cars are once fitted with particulate traps, several hundred cases of lung cancer could be prevented in the coming years. Each year 15–20 cases of lung cancer could be prevented merely by equipping all heavy duty vehicles in Switzerland with particulate traps. These measures are also worthwhile from an economic viewpoint, as the cost/benefit ratio is highly favourable. For example, fitting particulate traps to construction machines at a cost of CHF 1 billion in the next years would produce public health cost savings of around CHF 4 billion by 2020. The benefits thus outstrip the costs by a factor of 4.

Air Pollution and Cancer in Switzerland

Peter Straehl[1] and Ursula Ackermann-Liebrich[2]

[1]Swiss Agency for the Environment , CH-3003 Berne Switzerland

[2]Institute for Social and Preventive Medicine University Basel, CH-4051 Basel, Switzerland

Introduction

- The aim of this study was the assessment of the carcinogenic effects of air pollution on public health in Switzerland.
- The need and extent of the necessary emission reductions of carcinogenic air pollutants to protect the health of the population were determined.
- The 5 year survival rate of lung cancer is still very low (5%). Active smoking is responsible of about 70-80% of all lung cancer cases in Switzerland. To filter out the cases caused by air pollutants raises some methodological problems.

Methods

- The carcinogenic effects of particulate and gaseous air pollution were calculated wit the help of PM2.5 (small particles with a diameter <2.5µm) and benzene respectively as indicator substances.
- The lung cancer mortality associated with particulate air pollution was calculated with the method of the "attributable cases" based on relative risks derived from linear exposure-effect relationships from a large US cohort epidemiologic study. For the additive calculations the following formula was used:

$$N_{RR} = \frac{RR_{10} - 1}{10\ \mu g/m^3} \times I_{tar} \times P \times C_{av}$$

N_{RR} is the number of deaths caused by lung cancer in Switzerland based on the relative risk RR_{10} of the examined population in the United States of America. I_{tar} is the lung cancer incidence (mortality) in Switzerland, P is the percentage of the population older than 30 years in Switzerland, and C_{av} is the population weighted annual average of the PM2.5 concentrations in Switzerland.

The results of the US-ACS cohort study - 500'000 participants in 156 regions followed up to 20 years - are shown in table 1. If the PM2.5 concentration increases by 10 µg/m³ (annual average), the number of deaths caused by lung cancer is increased by 14% (RR_{10}=1.14).

Cause of mortality	1979-1983	1999-2000	Average
All-cause	1.04 (1.01-1.08)	1.06 (1.02-1.10)	1.06 (1.02-1.11)
Cardiopulmonary	1.06 (1.02-1.10)	1.08 (1.02-1.14)	1.09 (1.03- 1.16)
Lung cancer	1.08 (1.01-1.16)	1.13 (1.04 -1.22)	1,14 (1.04 -1.23)

Tab. 1

- The cancer cases (mainly leukaemia) caused by gaseous air pollutants were calculated with the unit risk method (WHO unit risk for benzene). A linear exposure-effect relationship without no-effect level was used. The unit risk for benzene proposed by WHO is: 6 x 10^{-6}, meaning that 6 persons out of 1 million are at risk to get a leukaemia if they breathe 1 µg/m³ of benzene during their whole life (70 years).

Population exposure

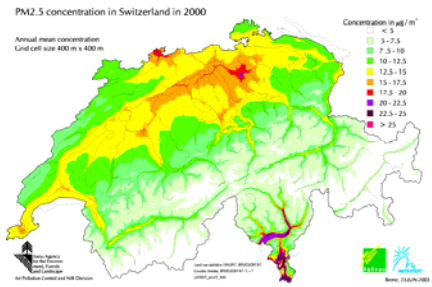

Fig. 1: PM 2.5

In 2000 the population weighted annual average of ambient PM2.5 concentrations across Switzerland was 16.5 µg/m³ ,while benzene concentrations averaged around 3.8 µg/m³. By 2010 - as a result of measures already adopted or approved in principle – the population weighted PM2.5 and benzene concentrations will be reduced to approx. 14.5 µg/m³ and 2 µg/m³ respectively. With additional, not yet approved measures, the PM2.5 burden could be lowered to 11.5 µg/m³ by 2010.

The PM2.5 and benzene population exposures in the year 2000 were determined in a 400 x 400 m grid cell with the help of empirical dispersion models based on a Gaussian approach and using typical Swiss meteorological data inputs (fig. 1 and 2).

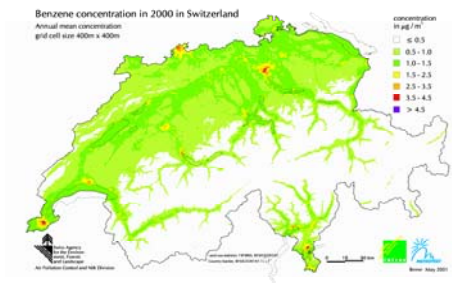

Fig. 2: Benzene

Ambient air contributes only to about 50% to the personal benzene burden. This burden is also influenced by the residence time in certain microenvironments and the profession.

Result: Cancer risk associated with air pollution

- ***Lung cancer associated with fine PM air pollution***

In Switzerland 2650 lung cancer death cases per year had been registered (mean of the last 2 years). This corresponds to a lung cancer incidence rate of about 37 cases per 100'000 person years (I_{tar}). Around 66% of all inhabitants are more than 30 years old (P=0.66). Only the effects over a PM2.5 reference concentration of 5.5 µg/m³ had been quantified. This results in a population weighted annual PM2.5 mean concentration (C_{av}) of 11 µg/m³ (16.5-5.5). Following the formula:

$$\frac{1.14 - 1}{10} \times 37 \times 0.66 \times 11 = 3.8$$

It can be concluded, that the excessive PM2.5 air pollution is responsible for about 3.8 cases per 100'000 person years. This means approx. **270** (130-420) **lung cancer deaths per year** can be attributed to the fine PM air pollution

- ***Leukaemia and gaseous air pollutants***

Following calculations based on a population weighted benzene annual mean concentration of 3.8 µg/m³, a population of 7.3 Mio. inhabitants and the WHO unit risk of 6 x 10^{-6} it can be stated, that about 167 persons in Switzerland are at risk to get a leukaemia in the next 70 years (calculation: 3.8 x 7.3 x 6). This means about 2 (1-3) leukaemia cases per year.

Calculations based on unit risks can underestimate the real risk by about a factor of 10 and if benzene is taken as an indicator for the risk associated with the whole gaseous air pollution it can be concluded that about **30 cancer cases per year** (mainly leukaemia) can be attributed to excessive air pollution by gaseous pollutants.

Conclusions

- Breathing polluted air can cause cancer. In Switzerland about **300 cancer deaths per year** can be attributed to air pollution.. Combustion related fine particulate matter is the main risk factor. The population protection criteria of the Swiss federal law relating to the protection of the environment are not met by far.
- Compared with 2000 the emissions of carcinogenic air pollutants as (diesel) soot and benzene must be lowered by a factor of 15-30 not exceeding 150 tons (soot) resp. 100 tons (benzene) per year.

- ***Particulate traps play a key role***

With particulate traps around 90% (mass) to 99.9% (number) of the fine carcinogenic soot particles can efficiently filtered out of exhaust streams. If all heavy duty vehicles, construction machines, tractors and diesel-powered passenger cars are once fitted with particulate traps, several hundred cases of lung cancer could be prevented in Switzerland in the coming years. The cost/benefit ratio of this measures is highly favourable as the public health cost savings can outstrip the costs of the filters up to a factor of 4.