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Air Pollution and its health effects

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Written Declaration

I declare that I completed the submitted work individually and only used the mentioned sources and literature. Concurrently, I give my permission for this diploma/bachelor thesis to be used for study purposes.

In Prague on March 30th, 2010 Maria Slyngstad

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1.0 INTRODUCTION

This paper gives an up to date review of the health risks and complains of air pollution with focus on selected studies done in Norway and in Czech Republic on the topic. Air pollution consists of many different components including particulate matter, nitrogen dioxide and polycyclic aromatic hydrocarbons (PAH).

It is well known that with rapid industrialization, urbanization and migration, particularly in the developing world, there is a general deterioration of environmental conditions. In addition to inadequate housing, sanitation, poor water supply and malnutrition populations have been exposed to raising levels of air pollution. Despite the vast improvements in health globally over the past several decades, environmental factors remain a major cause of sickness and death in many regions of the world. (1)

The health effects caused by air pollutants may range from subtle biochemical and physiological changes to difficulty in breathing, wheezing, coughing and aggravation of existing respiratory and cardiac conditions. These effects can result in increased medication use, increased doctor or emergency room visits, more hospital admissions and premature death. The human health effects of poor air quality are far reaching, but principally affect the body's respiratory system and the cardiovascular system. Individual reactions to air pollutants depend on the type of pollutant a person is exposed to, the degree of exposure, the individual's health status and genetics. (2)

2.0 Air pollution and Health

Relationships between different types of air pollution and health have been investigated in a large number of studies. The World Health Organization (WHO) and others have published repeated knowledge summaries on the field, where it is pointed out a long number of health problems that are indicated to be related to air pollution. The evidence base is still limited, in contrast to what we, for example, have for the relationship between active smoking and health. The preliminary knowledge can only be considered reasonably robust for some connections between components of air pollution and health, and additional knowledge is necessary to form a more reliable picture of the total health burden.

Air pollution in general, and especially particulate matter, is mainly shown to be associated with death, cardiovascular and respiratory disorders. In the WHO knowledge summary, it is more in-depth shown that many studies indicate that exposure to particulate matter increases the risk of death and hospitalization among patients with COPD, cardiovascular diseases and diabetes, worsening of symptoms and increased treatment needs among patients with asthma, heart attack, pneumonia, development of atherosclerosis, infections and cancer of the airways. Some of these health damages have also been associated with other components of air pollution when these have been measured. Research also indicates that reduced lung function, various symptoms of respiratory diseases, development of asthma, the development of other risk factors for cardiovascular disease, cardiac arrhythmia, stroke, death from cancer, spontaneous abortion, premature birth, reduced birth weight and SIDS, may be associated with different components of air pollution. The knowledge on the topic is still very uncertain.

There is good documentation that the smallest particulate matter (PM 2,5) has a correlation with health effects. It can be debated how many and which components of air pollution that should be taken with the analysis of the health burden associated with air pollution. The WHO suggested that particulate matter could be used as an indicator of air pollution in general. It is uncertain how much health effects that is captured in calculating the health of PM2,5 alone, as in fact, is linked to other air pollution components, and how much health damage that is not captured in this calculation. Experimental studies on humans and animals have shown that particulate matter have effects on health independently of other components. It should be emphasized that particulate matter is not an unambiguously defined component such as, for example NO_2 (nitrogen dioxide), but it consists of many different substances and particulate components, such as carbon and mineral dust. For now, it is not identified any lower limits for the concentrations of particulate matter which can be considered secure against the negative health effects, but there is currently little knowledge about the health effects of exposure to low levels of pollution that is typical for large parts of the Norwegian population.

Both the exposure of short-and long-term seems to be associated with increased risk to health. There are however, far fewer studies on the health of the average long-term exposure than the episodes of exposure over a short time. There is reason to believe that the health of exposure over longer time can be associated with more uncertainty than exposure over a short time. Exposure over short time is described as episodes of high concentrations of air pollution in the course of hours, days or weeks, while exposure over a long period is often referred to as exposure over a year or more. (3)

The scientific literature on exposure of long time for particulate matter and negative health effects indicates risk estimates for death, and these are with the current knowledge probably only useful for exposure above a certain concentration level. Three specific risk estimates are used here for relationship between exposures to particulate matter ($PM_{2,5}$); total death, death from cardiovascular disease and respiratory diseases, and death of lung cancer (Table 1). These estimates are based on two U.S. studies that have been central to the calculations of the health burden resulting from exposure for particulate matter over a long time. The studies referenced to is the Six City Study and The American Cancer Society (ACS) Study. In the former study was an increase of 10 μg/m3 of $PM_{2,5}$ associated with an average increased risk of mortality of 13%, and an average increased risk of death from cardiovascular disease of 18%. The lowest annual exposure level in this study was over 10 μg/m3 $PM_{2,5}$ In the second study it was observed an increase in risk of death in 4% of increase of 10 μg/m3 of $PM_{2,5}$. The relative risk was 6% for cardiovascular and respiratory diseases, and 8% for lung cancer. There was an average exposure of PM2,5 at 21.1 µg/m3 for the period 1979-1983, at 14 for period 1999-2000 and an average of 17.7 for both periods. The association between particulate matter and death contains some uncertainty, and in addition, it is conceivable that the relationship is different for the conditions in Norway and the Czech Republic.

Table 1: Risk Estimates for the relationship between exposure to PM2, 5 over a long time and death

	Estimated increase in risk per 10 µg/m3
$PM_{2,5}$ All death	4 %
Death from Cardiovascular diseases	6 %
Death from Lung cancer	8 %

2.1 Historical background

The Great Smog was a severe air pollution event that affected London in December 1952. A period of cold weather combined with an anticyclone and windless conditions, collected airborne pollutants mostly from the use of coal to form a thick layer of smog over the city. It lasted from Friday 5th to Tuesday 9 December 1952, then quickly dispersed after a change in the weather.

In the weeks that followed, statistics showed that the fog had killed about 4,000 people[9]. Most of the victims were very young, elderly, or had pre-existing respiratory problems. Deaths in most cases were due to respiratory tract infections from hypoxia, and due to mechanical obstruction of the air passages by pus arising from lung infections caused by the smog. The lung infections were mainly bronchopneumonia or acute purulent bronchitis superimposed upon chronic bronchitis. A total of 12,000 people are believed to have died in the weeks and months that followed. (4)

It is considered the worst air pollution event in the history of the United Kingdom, and the most significant in terms of its impact on environmental research, government regulation, and public awareness of the relationship between air quality and health. It led to several changes in practices and regulations and restriction of dirty fuels in industry and banning black smoke, In the years that followed, various legislation such as the Clean Air Acts of 1956 and 1968, and the City of London (Various Powers) Act 1954, greatly restricted air pollution. (5)

3.0 Types of Air Pollution, its sources and effects on human health

3.1 Nitrogen dioxide (NO2)

In urban areas the concentration of NO2 is primarily dependent on meteorological conditions and the supply of ozone, but also the amount of traffic in the city. On cold days, with little wind, the concentration is particularly high. In vulnerable groups inhalation of nitrogen dioxide (NO2) provides increased cough, bronchitis, lower resistance to infections, increased allergic response and increased morbidity. Asthmatics react with impaired lung function even after short-term exposure. Healthy people can tolerate relatively high NO2 pollution without giving any negative health effect.

3.2 Particulate Matter

PM (Particulate Matter) is dust that stays in the air over a certain period.

PM 10 and PM 2, 5

PM 10 is the particles lower than 10 μm. When inhaled, they can stay in the thoracal part of the respiratory tract. PM 2,5 which is the smaller particles will move to the alveoles. The particles may be even greater than 10 μm (coarse particles), but these are exhaled. The number behind set the size in micrometers (1 microns = 1 / 1000 mm = 1 / 10, 000 cm = 1 / 1 000 000m). PM10 comes mainly from minerals, which are teared off from the road by studded tires. PM 2.5 is a type of particulate matter which mostly contains particles from combustion processes - primarily wood-burning, but also exhaust. Diesel vehicles contribute especially with emissions that create dust of this type.

From road traffic and wood-burning

The highest levels of particulate matter (both PM10 and PM2, 5) occurs along the heavily trafficked streets. In some areas, wood-burning is a major source of pollution. Particulate matter is also found in indoor air, but the contribution of outdoor air will normally be lower than the level of particulate matter which has natural sources indoors. Nevertheless, particles originating from outdoor air may dominate the air in heavily trafficked areas.

Particularly vulnerable groups

Particulate matter can trigger and exacerbate disease in people with chronic respiratory disorders. Reactions requiring hospitalization can occur in people with respiratory disease or cardiovascular disease, the elderly and young children with respiratory diseases. In the worst case, exposure to particulate matter results in death.

Particle properties as chemical composition, size and surface area and the number of particles affect how they allocate, how long they remain in the body and how they affect your health. Larger particles lodge largely in the airways, while the smaller particles can penetrate into the blood and thus get transferred to other organs.

3.3 Sulphur dioxide

The most common sulfur oxides (SOx) are sulfur dioxide (SO2). SO2 is a colorless gas with a penetrating, sickening smell. It is forming sulphuric acid together with water, leading to acidification of waters. Sulfur oxides (SOx) are used for bleaching, disinfecting and as food preservatives. Sulphur dioxide (SO2) is formed by the combustion of substances containing sulfur - primarily oil and coal, and in a variety of industrial processes. Power stations, oil refineries and other large industrial plants are the main source of SO2 emissions today. Oil heating and natural sources such as volcanoes and forest fires also release sulfur dioxide. From 1970 to 1998, emission of sulfur dioxide has been reduced by 75 percent. The main reason for this reduction is less use of coal in energy production and conversion from coal to gas power plants.

Healthy individuals react first at the concentrations of gas that are far higher than current levels in levels of most cities in Norway. Asthmatics are more susceptible, and may react at levels that can be found close to the industry without proper cleaning in some parts of Europe.

3.4 Ozone (O3)

Ozone (O3) occurs at several levels in the atmosphere. In the stratosphere, 10-30 km above the ground, represents a naturally formed ozone protection for all life on Earth in that it reduces the ultraviolet radiation from the sun. In the troposphere, 0-10 km above ground level, ozone is formed as a result of emissions of pollutants from human activity. This is called ground-level ozone and cannot replace the reduction of the ozone layer in the stratosphere.

Problems related to tropospheric ozone

Ground level ozone is a major environmental problem in many parts of the world and leads to
damage to vegetation and reduced crop, negative effects on human health, decomposition of materials (rubber, etc.)

Ground level ozone is formed through chemical reactions between nitrogen oxides in the air and hydrocarbons at sufficient solar radiation. Episodes of high ozone levels occur in Norway, therefore, only in summer. Since the chemical reactions that form ozone in the air takes several hours or days, the ground-level ozone is usually not a local problem, but will cover large geographic areas when it first occurs.

The major sources of emissions of nitrogen oxides and hydrocarbons are traffic. Hydrocarbons in air stems from other emissions - including solvents, production and distribution of oil and gas, as well as from natural vegetation. Episodes with a lot of ground-level ozone in Norway are primarily related to transport of polluted air from the UK and from continental Europe. In Norway the problem is greatest in the southern part of the country.

High concentrations of ozone can cause health effects such as impaired lung function, more cases of bronchitis and asthma, headaches and eye and mucous membrane irritation.

For people with reduced lung function, such effects can occur at ozone concentrations of 160 µg/m3 (micrograms per. cubic meters), while the normally healthy people will first experience the discomfort and health effects at concentrations of 240 µg/m3.

At lower ozone concentrations over a long time, the connective tissue in the lungs changes. The concentrations we see in Norway are fortunately much lower than for example in southern European countries. In Norway, it is therefore primarily the most vulnerable part of the population that will notice symptoms of high ozone concentrations. People with normal lung function will generally not notice symptoms in such situations, but should not engage in strenuous physical activity at high ozone concentrations.

3.5 Carbon monoxide (CO)

Carbon monoxide (CO) is an odourless gas and is formed by incomplete combustion of organic material, such as petrol and diesel. Road traffic is the largest source of carbon pollution, and therefore the greatest problem in cities and towns.

CO may be a good indicator of how much of the pollution in the air that comes directly from combustion.

The gas is absorbed into the blood and prevents transport of oxygen and thus the supply of oxygen to the tissues. People with cardiovascular disease are extremely sensitive to inhalation of CO gas.

3.6 Benzene

The main source of benzene in outdoor air is emissions from traffic. Benzene is a volatile organic compound found in oil products. The level is higher in refined products than crude oil. The main source for emission of benzene is different motor vehicles, but emissions from the petrochemical industry and various combustion processes also contribute something. The average level of benzene over a year is usually low in low populated areas (<1 µg/m3), while the level in major cities in

Europe is from 5 to 20μg/m3 air. In Norway, there have been relatively few measurements of benzene. In Drammen, however, an annual average equivalent to levels in European cities is measured. There are guidelines for the benzene content in gasoline in combination with other measures to reduce the levels of benzene.

Benzene may cause leukaemia and damage the genetic material. The carcinogenic effects of benzene are determined by the total exposure during a lifetime. It is believed that the negative health effects also could be due to correlation with other air pollution components, such as particulate matter and NO2. (6)

3.7 PAHs (polycyclic aromatic hydrocarbons)

PAHs (polycyclic aromatic hydrocarbons) are formed by incomplete combustion of organic material. Aluminium industry and wood burning are the major sources of PAHs. PAHs are spread both through the atmosphere and ocean currents over large distances. The compounds in air are deposited in the environment through precipitation. Studies have shown that there is a relationship between occupational exposure to PAHs through the skin and lungs, and cancer. PAH compounds can be converted into reactive molecules that can affect genetic material. The number of PAH compounds is great. Risk assessments of PAHs have often been related to a smaller number of compounds especially those who are regarded as carcinogens such as benzo (a) pyrene. (6)

3.8 Lead

Lead is a toxic heavy metal with both acute and chronic health and environmental effects. Air pollution from lead can be long transported as particles of Particulate Matter, or it can come from local sources. Emissions of lead have been greatly reduced since the 1980s. This is particularly due to the transition from leaded to unleaded gasoline. Norway introduced this gasoline in 1985, and in 1996, all sold gasoline was unleaded. Chronic lead poisoning may have neurotoxic and immunological effects and may affect the formation og haemoglobin. Lead compounds can also cause fetal damage and they have a possible risk of reducing the reproductive ability. There is done a lot of research on children's exposure to lead in low concentrations and it is suspected that exposure may affect children's intellectual development. (7)

4.0 Air pollution in Norway

Car traffic is the major source of air pollution in cities and towns in Norway. A substantial portion of NO2 - and carbon emissions come from cars, and cars generate about half of the tissue dust of the land base. In the four largest cities live about half of people in areas where the recommended air quality criteria are exceeded at times. In some areas of the cities exhaust and dust from roads could sometimes lead to health problems.

4.1 **Car traffic contributes the most**

Air pollution in cities and towns have changed the character and composition over the past 10-20 years. In the 1960s and 70s, the air pollution was dominated by emission from heating plants and industry. From the beginning of the 1980s, motor vehicle traffic gradually took over as the main source of local air pollution in the towns and cities, and today the contributions from motor vehicle traffic is completely dominant.

4.2 **NO2 and particulate matter, most importantly**

The main air pollutants in urban areas are nitrogen oxides (especially NO2), which comes from the combustion engine, and particulate matter that partly stems from the exhaust and partly from studded tire wear of roads.

4.3 **The biggest problem in cities**

Air quality in cities is sometimes so bad that the KLIF's (Climate and Pollution Agency in Norway) recommended air quality criteria are exceeded. The highest concentrations occur commonly in combination of emission close to the ground and special meteorological and topographical conditions. Pollution from motor vehicle traffic has been a great satisfaction and health problem for people who live in cities. (6)

Particulate matter and nitrogen dioxide are the most important components of local air pollution in Norway. The amount of health impacts and annoyance due to particulate matter and other air pollutants is substantial; hence further measures are required to reduce present concentration levels.

Air quality measurement data from Norwegian cities and other densely populated areas indicate that many people still are exposed to levels exceeding limit values and national targets. Modelling calculations for 2005, carried out by the Norwegian Institute for Air
Research, show that 230 000 people in Oslo and 21 000 people in Trondheim were exposed to levels of particulate matter that exceeded the national target for 2010.

Air pollution causes health effects at lower concentrations than the national targets, hence concentration levels in cities and other densely populated areas cause substantial negative health impacts. Norwegian and other European studies also indicate a correlation between air pollution and *annoyance*. Annoyance also increases with increased concentrations at levels below existing limit values and national targets. Research indicates that more than 800 000 people are annoyed on a daily basis due to traffic and air pollution in the cities. Research indicates that both short-term and long-term exposure to air pollution can enhance existing disease in the population. Furthermore long-term exposure can directly contribute to the development of disease. Short-term exposure to air pollution has been linked to increases in daily mortality and the number of hospitalizations due to respiratory and cardiovascular diseases.

Relatively few studies have documented the effects of long-term exposure to local air pollution. However, it has been demonstrated a higher relative risk associated with long-term exposure than short term-exposure. American studies indicate more severe implications for long term exposure to PM2,5 than coarser particle fractions. (6)

Annual average of air pollution levels in and outside of cities in Norway is usually relatively low compared to many other countries in Europe. Exceedances of European and national limit values and recommended air quality criteria occur anyway in several areas over a shorter time, especially in urban areas. Overruns mainly occur in concentrations of particulate matter, measured as fractions PM10 and

PM2,5, but also in the concentrations of NO2 and tropospheric ozone. It can also happen overrun of other types of pollutants, such as polycyclic aromatic hydrocarbons (PAHs) and metals in some industrial areas. Other components of air pollution include ultra-fine particles (PM0, 1), sulphur dioxide (SO2), carbon monoxide (CO), nitrogen oxides (NOx) and volatile organic compounds (VOCs, including benzene). The best scientific evidence for negative health effect exists mainly of particulate matter and ozone. Like previously mentioned in Norway, the effects of PM 2,5 are most documented. (3)

All particle sizes have a potential to cause adverse health effects. The coarse particle fractions may attract more biological material such as bacteria components than smaller particles and may contain pollen. The finer particles are composed mainly of elemental carbon, hydrocarbons and metals and may bind allergenic pollen protein. It seems that the health effects from particles cannot be attributed to single components, but rather a combination of various components.

It is difficult to estimate the population's exposure for particulate matter around the country. Many of the estimated concentrations are very rough and uncertain. The assessment of
population's exposure is in the report from Folkehelseinstituttet (The Norwegian Institute of Public Health) are made on the basis of measured, calculated and estimated values around country. Best data basis for the calculation of particulate matter are the largest city areas. Population exposure in the rest of Norway may only roughly be assumed on the basis of measured concentrations at nearby monitoring stations, knowledge of geographical and meteorological conditions, as well as knowledge of emission sources. Places that are strongly influenced by local industry require independent assessment and management. (8)

4.5 Preventive measures in Norway

In Norway we have 49 monitoring stations for different types air pollution that are distributed in 23 different areas in the country. Most of them are located in the southernmost parts of Norway and in Oslo. These measurement stations give us important knowledge including concentrations of PM10 and PM2,5 both in hours each day and over the years. Measuring stations are set up near major emission

sources such as road or industry, or to measure the background exposure from natural sources and transboundary pollution.
The measured concentrations will therefore rarely be suitable to describe the exposure levels in areas where much of the population living or staying, and they may not mirror people's varying exposure as they travel.

Because the data from monitoring stations alone cannot represent population's exposure, it has to some extent been adopted models. These model calculations aims to describe the geographical distribution of the different components of air pollution by combining information about the measured concentration levels, information on traffic density, knowledge about the spread of the different types of air pollution and information about meteorology and topography. However, there are many factors that can affect a
person's exposure, and it is limited what to take into account on these model calculations.

A number of preventive measures have been implemented to reduce the contribution to air pollution related to transport:

- Traffic reduction measures are most effective when multiple measures are used simultaneously, for example, to combine road pricing, parking restrictions and collective commitment. Other instruments can be actively used by the Planning and Building Act relating to the location of businesses and homes to reduce the total transportation needs and make a transition to environmentally friendly forms of transport. The policy guidelines for coordinated land use and transportation planning are a tool for this.

- By removing dust from the roads, one removes an important source of particulate matter. Speed reduction will reduce the formation of studded tire dust, because it reduces the turbulence created by the cars and power that the spikes wear on the pavement. Permanently reduced speed is more cost effective than reduced speed as a short-term measure.

- Technical measures can be used to reduce exhaust emissions from vehicles. Emission requirements for cars are renewed constantly and the quality of petrol and diesel is improved. From 1 January 2005 requirements for sulphur-free fuel was introduced for use in passenger cars and heavy vehicles.

- Local emissions from road traffic may also be reduced through increased use of alternative fuels such as gas, hydrogen or electricity.

- Some cities have measured a good effect of watering the road with Magnesium during street cleaning. Magnesium occurs naturally in seawater and binds the dust. In some tunnels, the experiments have given very good results. The salt is used systematically on main roads in Oslo and Trondheim, but there are restrictions to the use as it may cause material damage.

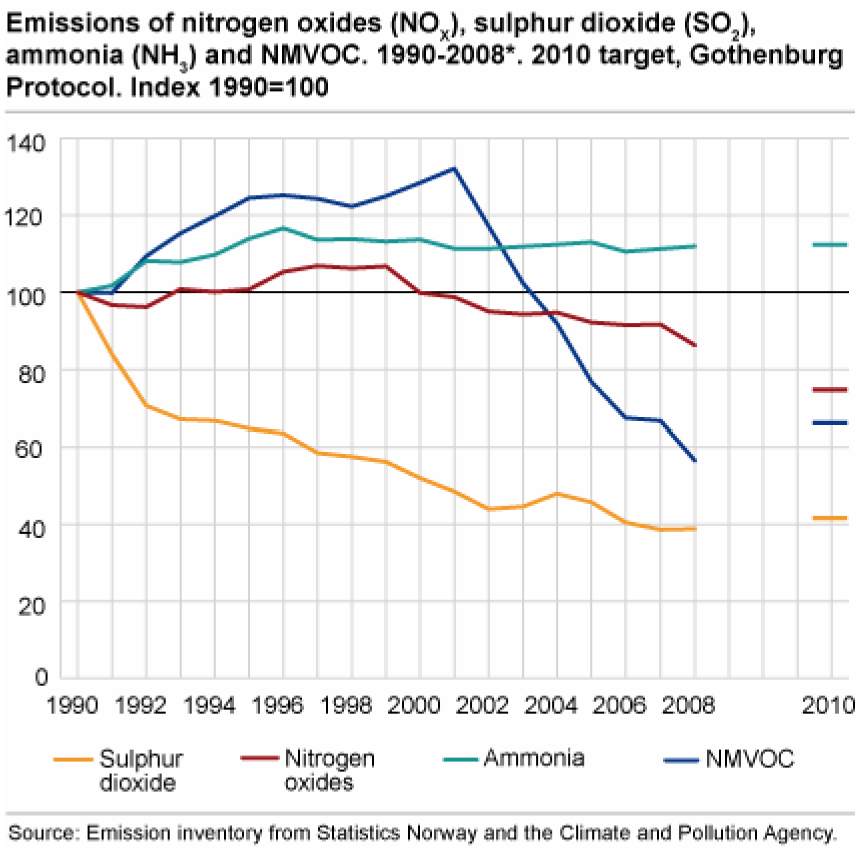
- The use of studded tires is reduced in all the biggest cities Oslo, Trondheim and Bergen through local regulations by special fees in the winter.

- On 1 July 1998 there were introduced requirements for emissions of particulate matter from all new wood-burning stoves sold. To reduce the proportion of older, polluting wood-burning stoves, some cities like Oslo and Bergen are attempting to impose deposit schemes to stimulate the old furnace to be replaced with new furnaces with low emissions. Other relevant measures are the installation of purification devices on the pipes or the installation of the burners in the older, polluting stoves.

- Transboundary pollution can be reduced through international agreements and EU directives. Examples are the Convention on Long-Range Transboundary Air Pollution and the EU directive, which will limit the emissions from large combustion plants. In addition, there is a new directive that provides an upper limit on emissions of various substances ("Takdirektivet").

4.7 Legislations

Norway has set national targets for emissions of harmful air pollutants, and the legislation lays down limit values for air pollution. To achieve these targets, action is being taken to reduce emissions from road traffic. But Norway will not be able to solve all its own problems without emission reductions in other countries, and is therefore taking part in international efforts to reduce long-range transport of pollutants. Norway has implemented the EU legislation. The Pollution Control Act and regulations set limits for the particular parameters.



(15)

5.0 Air Pollution in the Czech Republic

In the 1970s and 1980s, some of the most polluted industrial areas in Europe were situated in the Czech Republic. After 1989 there were introduced a set of measures to reduce the air pollution, particularly in energy with decreased use of brown coal (containing high content of sulphur dioxide) in large power plants which lead to a decrease in air pollution mainly of the substances SO_2, dust particles and oxides of nitrogen. After 2000 the trend was reversed and the concentration of many pollutants increased considerably. The process of EU Enlargement was an important stimulus for a new improvement of the air pollution.

At present the main air quality problems in the Czech Republic are similar to other countries of the European Union, in particular pollution dusty particles and ozone. Most of the country's population is exposed to concentrations of these pollutants that exceed the applicable limits. This applies in areas with intensive automobile transport and areas with high concentration of industry. (10)

5.1“The Black-Triangle”

The coal-fired boilers of public and industrial power generation, cogeneration, and district heating plants are the largest sources of pollution in Central Europe. Dramatic measures to reduce and control this problem on an international scale are illustrated by the joint efforts of Poland, the Czech Republic, and Germany in the highly polluted "Black Triangle." Ten power plants in this heavily industrialized region make the major contribution to the 3 million tons of SO_2 and 1 million tons of NO_2 emitted annually in the region. In 1991 environmental ministers of the three countries with a representative from the European Union initiated the "Black Triangle Regional Program" to bring the plants into compliance with European standards, focusing on SO_2 in particular. Significant progress has already been made using circulating fluidized-bed boilers, high-efficiency electrostatic precipitators, coal cleaning technology, low-NO_2 emission burners, exhaust gas recirculation equipment, improved control systems, and in-plant and regional monitoring systems. The success of the strategies employed provide models for application in other industrial regions of the world where investments in existing resources and facilities cannot be abandoned and simply replaced with alternate fuels and technologies. (11)

The Czech Republic's focus is on modernizing fossil fuel-burning plants. This strategy includes the six sizable power stations in the Black Triangle: Prunerow, Tusimice, Pocerady, Ledvice, Milnik and Porici. Out of a total 8,447 MW of fossil fuel burning capacity nationwide, 6,427 MW will be desulfurized. In addition, the Czech Republic is eliminating the oldest equipment in various power plants. (10)

The progress being made in the Black Triangle bears significance not only for that Central European Region, but also has important lessons for other industrial areas of the world. Despite the Czech Republic’s increasing use of nuclear power, the primary source of power in all three countries in the Black Triangle region remains locally produced lignite coal burned in existing, renovated facilities. The experience in this region demonstrates that major environmental improvements can be achieved through the application of a combination of modern technologies. The strategies adopted in the Black Triangle can be applied as beneficially by North American states, provinces, counties, and municipalities whose financial resources demand that they retain existing facilities and modify them incrementally to achieve improvements. The concentrated effort in this region of Central Europe simply makes the successful results more visible and more easily studied for application by others. (11)

5.2 Teplice Program – Impact of Air pollution on human health

The aim of the Teplice Program was to investigate and assess the impact of air pollution on the health of the population in the district of Teplice, a mining-district in Northern Bohemia with a high pollution level. The first signs of deteriorating human health were related to an increase in allergies, immunodeficiencies and respiratory illnesses in children. Simultaneously, an increase in birth defects and a rising prevalence of children with low birth weight was observed. Especially striking was the shortening of life expectancy for inhabitants of this region as compared to the rest of the country; this was observed mainly in males with an increase in mortality rates for cancer and cardiovascular diseases.

In November 1990 the Czech government accepted this program to improve the situation, and the district of Teplice was recommended as a model district. The less polluted region in Southern Bohemia, Prachatice, was chosen as a control district.

The original task of the Teplice Program was formulated in five points:

1. To determine if alarming results about the impact of polluted environment on human health in mining districts are valid and serious, and to evaluate the health status of the population using international accepted methods
2. To formulate and evaluate a system of hypotheses on health effects
3. To evaluate how the health status of the population is directly affected by environmental factors and indirectly by socioeconomic actors

4. To determine the individual risk factors and their complexes, and determine priorities for preventive measures
5. To evaluate the impact of accepted preventive measures

The Program was developed as a collaborative research program with the U.S. Environmental Protection Agency, which brought knowledge in modern methods to Czech scientists. Especially during the Teplice Program I (-91-96), the Czech- U.S. collaboration was very extensive.

Teplice Program II (-97-99) was carried out as a project supported by the Ministry of the Environment of the CR. Based on the experience and results obtained during the Teplice Program I, the scope of the second program was detailed studies of the most important findings, especially on the genotoxicity and mutagenicity, the effects of air pollution on reproductive outcomes, mortality and risk assessment. A systematic continuous air-monitoring program was carried out and sociological studies made.

- The study and its results:

Air monitoring: SO2, NO, NO2, NOx, CO, O3, PM2,5, PM10 and PAHs were monitored on daily basis. Improved technologies for desulfuring the burning process and decrease in particulate matter emissions in power plants as well as a decrease in the use of coal for house heating have been responsible for a substantial decrease in sulphur dioxide and PM2,5 and 10. The concentration of PAHs has decreased less significantly. The concentrations of NO2 and CO have remained more or less stable, while the concentration of NO2 is growing. This may be related to the increase in traffic.

- *Air genotoxicity and reproduction outcomes*: The extractable organic compounds from the air particles PM10 collected in polluted and control area were investigated using Salmonella typhimurium indicator strains (Ames test). Higher amount of organic matter, carcinogenic PAHs and increased mutagenicity of air particles were found in the polluted district. The impact of air pollution on reproduction quality was studied and a significantly increased risk of IUGR was established for mothers from Teplice who were exposed to PM10 levels >40 ug/m3 during the first month of gestation. Adverse effects were more common in infants conceived in the winter and whose mothers were smokers. Also a primary role of carcinogenic PAHs in slowing down the fetal growth was hypothesized. In addition, the sperm was found to impaired both in morphology and motility in young men who were exposed to elevated SO2 levels in Teplice, and it was suggested that exposure to periods of high levels of air pollution may be associated with an increased risk for sperm aneuploidy.

- *Immunity and childhood morbidity*: The study of births and children aged 0-3 years showed an increased susceptibility to infections with a higher rate of otitis media, gastrointestinal infections, upper respiratory tract infections and pneumonia. Characterization of the air pollutants demonstrated unusually high concentrations during winter of fine particles dominated by acidic sulphates, genotoxic organic compounds, and toxic trace elements.
- *The neurobehavioral studies* indicated significantly higher teacher referrals for clinical assessment in Teplice, but the majority of objective performance measures did not differ.
- *Mortality*: The life expectancy at birth in Teplice was analyzed to be shorter in both genders by 3-4 years compared with the entire CR. Factors influencing the higher mortality were socioeconomic status, low educational level, a relatively large gypsy minority, unhealthy lifestyle, a high prevalence of smoking, nutritional deficiencies and air pollution.

Conclusion of the Teplice Programs:

The results indicate that air pollution affects genetic material and reproductive functions. The knowledge obtained was new, and implicated new factors that were never used for the risk assessment of human population. The most important findings in Teplice Program II were:

- Air pollution may have impact on both genders with adverse reproductive outcomes
- DNA adducts and some genotypes are sensitive biomarkers of exposure
- Sperm morphology and aneuploidy by FISH are sensitive biomarkers of semen quality
- PAHs are an important source of genotoxic and embryotoxic activities of organic mixtures associated with urban air particles. (12)

5.3 The Czech Environmental Health Monitoring System

The Environmental Health Monitoring System is a comprehensive system of collection, processing and evaluation of data on environmental pollution and effects on population health in the Czech Republic. The results of the Environmental Health Monitoring are provided in the summary report, which is set out annually. The results provide important background information to the national and regional authorities to facilitate health risk control and prevention, and are also made available to other specialists and general public. Finally, they represent information for the other European countries on environment and health in the Czech Republic.

Long-term monitoring of direct pathways of population exposure to harmful substances reveals that particularly serious health burden is caused by air pollution in cities. Measurements confirm the continuing significance of traffic and local sources of elevated or over-limit burden by fractions of suspended PM10, fine PM2.5 fractions, nitrogen dioxide and PAHs. Levels of pollution in the surroundings of industrial sources remain significant; the highest long-term concentrations of PM10 and PM2.5 fractions, benzene and PAHs are recorded in the Ostrava-Karviná region. Concentrations of heavy metals in most localities are only slightly elevated above the rural background.

In terms of population health, suspended particulate matter and PAHs are the most significant. Based on mean concentrations of PM10 fractions in an urban environment it is estimated that the effects of this pollutant in outdoor air may play a role in the increase of premature mortality by 2 % on average. Other substances may be significant in certain localities: for instance, nitrogen dioxide in areas with heavy traffic burden (Prague in particular) or heavy metals in areas with heavy industry or old loads (Příbram, Ústí nad Labem, Ostrava). Monitored airborne substances with potentially carcinogenic properties may have contributed to an average 2 cases per 10,000 of the population with lifelong exposure. (13)

6.0 Common approach to preventive measures improving air pollution

For improving the air quality of big cities, a variety of measures are being taken by governments of respective countries. Like previously mentioned, a number of policy measures like switching to clean fuels without lead and not diesel, and changing to hybrid or electrical cars are implanted. The engines are improved and exhaust controls on new vehicles have been applied to reduce emission from vehicles, and also the governmental granting of more money to the improvement and construction of public transport facilities. Some of these measures are meant for reduction in traffic congestion, since congestion exacerbates air pollution emissions. Some large cities charge a fee when vehicles enter a designated part of the city, and other more effective strategies like “car free days” and others that restrict the circulation of vehicles especially during peak hours are being implemented. (14)

European countries are through the Convention on Long-Range Transboundary Air Pollution, obliged to protect the human environment against air pollution and to gradually reduce and prevent air pollution, including long-range transboundary air pollution. The 1999 Multi-effect ("Gothenburg") Protocol which is a part of this convention is a multi-pollutant protocol designed to reduce acidification, eutrophication and ground-level ozone by setting emissions ceilings for sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia to be met by 2010. Since 2007 the UN ECE Working Group on Strategies and Review has been working to revise the Protocol and this work is expected to be completed by late 2010.

The European IPPC (Integrated Pollution Prevention and Control) Bureau has been founded to organize the necessary exchange of information and produces Best Available Technology (BAT) reference documents which member states are required to take into account when determining best available techniques generally or in specific cases.

A reduction in air pollution can be achieved by a change in the collective awareness of the environmental problem. Even on the lowest level, each individual should be encouraged to do small changes in the everyday life. This means using less gasoline, natural gas, and electricity. Individuals may transform wasteful habits by implementing a few changes in their household activities. An important step is to reduce the waste by recycling as many products as possible, and not burn wastes in local heating facilities or in gardens. Other preventive behaviours like reducing the use of cars and choose the public transport facilities are important measures that easily can be taken into account.

CONCLUSION

The reports conclude that urban air pollution has worsened the health in the cities of both developed and developing countries. The health impacts in the developing world are driven by population growth, industrialization and increased vehicle use. These conditions together with the personal habits and living style and environment of the population have become the major interacting factors in influencing health morbidity.

Environmental pollution from various sources is also one of the most important socio-economic problems today. Pollution is closely related to economic growth and it is proportional to production activities. Economic growth is required for meeting consumer demands for goods, but it is inevitably accompanied by pollution.

In Europe, emissions of many air pollutants have fallen substantially since 1990, resulting in improved air quality. However, since 1997, measured concentrations of particulate matter and ozone in the air have not shown any significant improvement despite the decrease in emissions. A great proportion of Europe’s population still live in cities where certain EU air quality limits are exceeded. Several countries are also likely to miss one or more legally binding 2010 emission ceilings of four important air pollutants. The need to reduce exposure to air pollution remains an important issue.

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