Air pollution in Reykjvik the capital of Iceland

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Abstract

Reykjavik, with its 110,000 inhabitants, is the capital of Iceland, a volcanic island in the middle of the North Atlantic Ocean, located far away from the continents of Europe and America. Icelanders enjoy non-polluting central heating from natural geothermal heat and electricity from hydroelectric station which is relatively inexpensive. In Iceland there are only three relatively large scale aluminium and ferrosilicon factories as the major air-contaminating industry. The only pollution from the combustion of fuel in Iceland is from the fishing fleet, fishmeal factories and car traffic. The concentrations of main polluting gases has been measured systematically in Reykjavik since 1990. It is apparent that the main source of pollution in Reykjavik is from car traffic. However, pollution originating from continental Europe and America has been observed. High background ozone concentration in the air, especially in late winter months has a profound effect on the concentration of nitrogen oxides from car traffic. The nitrogen monoxide in car exhaust react with the high background ozon and is converted to nitrogen dioxide. In calm winterdays when the background ozon is high the exhausted nitrogen monoxide concentration tends to escalate causing the nitrogen dioxide to exceed the air quality limits. The high background ozon thus seem to play important role in the effect of emissions from car traffic on the air quality in Reykjavik.

1 Introduction

Iceland is an island high up in the middle of the North Atlantic Ocean (65°N, 20°W), in the path of the southerly low pressure weather systems running across the ocean from southwest to northeast. Despite of its northerly location the climate is described as a rather mild but windy and rainy ioceanic climate. Reykjavik, the capital of Iceland, is located on the southwest shore where the Gulf Stream plays an important role in the rather mild winter climate. The average/mean temperature in Reykjavik is 4,3°C. The warmest month is July 10,6°C and the coldest January -0,5°C. Calm weather is more often observed during the wintertime but there are only measured 3,4% calm days as an average of the year. The prevailing wind direction is from south but during the highest winter seasoning in January to Marz northerly wind can be frequent.

Iceland was settled from Scandinavia 1200 years ago. After rather difficult times in the darkness of Middle Ages the living standard in Iceland is high with good public education and a good state of health. The main income is from fishing industry which for the most part is using electricity as an energy source. There are no trains in Iceland and the main transport is by trucks. The car density is the second highest in the world after U.S. (1,8) and has increased the last years. Personal cars are very common, in the town of Reykjavik there are 66,000 vehicles and over 100,000 in the great Reykjavik area. Proportion of diesel vehicles are just within 10%.

Reykjavik is the center of government, finance, commerce and communications in Iceland and 160,000 inhabitants live in Reykjavik and neighbouring communities. There are no large scale air-polluting industry in Reykjavik itself and use of geothermal heat for central heating in all the houses is pollution free. There is rather large scale aluminium factorie 15 km to the west of Reykjavik and another 30 km to north together with a ferrosilicon factory. No evidence of air-pollution has been measured from that industry in Reykjavik. The great number of personal cars causes the main emissions of air pollutants in the city.

2 Previous measurements

The first air quality survey in Reykjavik began with a few measurements of carbon monoxide and nitrogen dioxide in the 1970s. These measurements showed that traffic-induced air pollution was not a problem at that time (Thormar&Johannesson 1977a,b). Some single measurements outside of Reykjavik in the years 1982-1987 alluded high background concentration of

ozone (Johannesson&Thormar 1989) which were confirmed some years later (Benjaminsson&Hauksson 1996). In the year 1985 continuous measurements with dust collecting monitor was started in Reykjavik by Environmental and Food Agency of Iceland. The year 1990 Reykjavik City Department of Hygiene and Environmental Control began monitoring of ambient air with a mobile station.

3 Data collection and results

Since the year 1993 the monitoring station has been situated mostly at 3 locations within Reykjavik with few exceptions. In January every year the mobile station has been downtown in Austurstraeti, a narrow shoppingstreet with 2,800 cars pr. day dropping from 3,700 cars pr. day in 1993. In every May (except '97) it is located at one of the most trafficated squares in Reykjavik, Hlemmtorg with 20,000 cars pr. day. Almost all other times of the year the mobile station is situated at the street Grensasvegur (24,000 cars pr. day) close to the corner of Miklabraut (39,000 cars pr. day) and the traffic at this site is believed to have increased 15-20% since 1993. Element measured: CO, SO2, O3, NOx, PM10 and since 1997 NMHC.

Table 1: Average concentration of the main pollutants (in μg/m3 but CO in mg/m3)

	1993	1994	1995	1996	1997	1998	1993-98
NO2		57,7	41,8	35,2	30,2	29,8	35,9
CO	0,85	1,02	1,21	1,20	0,88	0,95	1,02
O3		33,7	35,3	44,1	45,1	45,5	40,7
SO2	3,6	4,9	4,6	4,2	3,9	2,6	3,9
PM10	21,9	25,8	30,8	21,0	25,1	31,0	25,9
NMHC					181	192	

The main source of nitrogen dioxide in the air is mainly caused by the traffic either as direct emission from cars or through the transformation of nitrogen monoxide reacting with ozone to form nitrogen dioxide. Due to the reaction with high background ozone level nitrogen dioxide can exceed limit value at calm winterdays. Fig. 1 represent a typical cold and calm winterday. When the traffic increases in the morning, nitrogen dioxide concentration increase rapidly and the high background concentration of ozone decrease in the same proportion. At night when the traffic slows down nitrogen dioxide reduces and ozone concentration increases again.

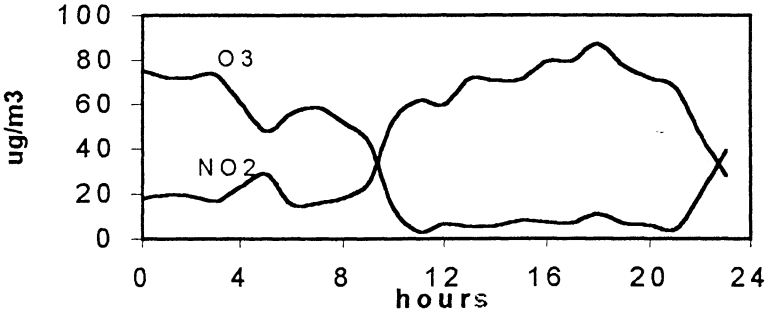

Figure 1: Concentration of ozone and nitrogen dioxide the 12th January 1997 in Austurstraeti, Reykjvik.

The evidence of high background concentration of ozone over the North Atlantic Ocean increasing to north has partly been explained as long-range transport of ozone from photochemically active regions over the continents (Winkler 1988, Oltmans&Levy 1994). Fig. 2 shows monthly average concentration of nitrogen dioxide indicating a slight reduction with time.

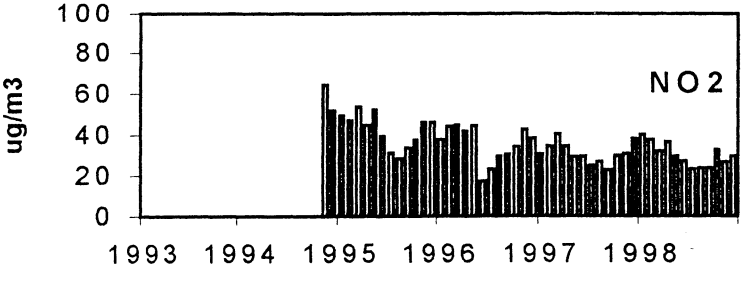

Figure 2: Monthly average concentration of nitrogen dioxide in Reykjavik.

Fig. 3 shows the monthly concentration of ozone indicating a vague increase. The maximun occurs in late spring. Our data response no photochemical episodes in Reykjavik indicating increasing activity of ozone. An unexplained anomaly in the spring of 1994 is adverted (fig. 3).

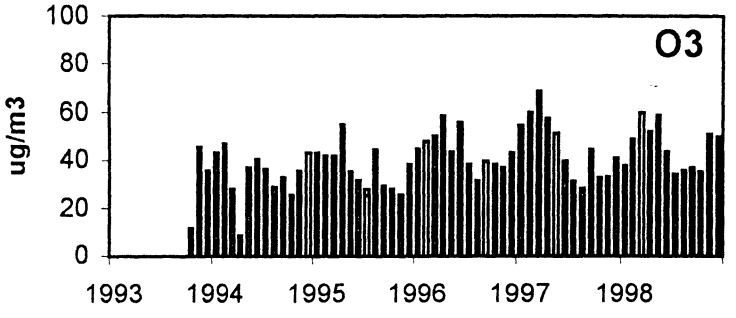

Figure 3: Monthly average concentration of ozone in Reykjavik.

The only source for sulpur dioxide emission is from vehicles apart from Austurstraeti where occasionally some of the sulphur dioxide concentration can be attributed from the fishing fleet as this location is close to the harbour. Comparing concentration to industrial towns abroad, where fossil fuel is used, the sulpur dioxide concentration is very low in Reykjavik (see fig. 4). The highest 24 hour value measured reached 58% of the limit value (50 μm/m3) when a polluted airmass hit Iceland in May '94.

In spite of great release of hydrogen sulphide into the atmosphere from high-temperature geothermal area 25 km east of Reykjavik no evidence of increase in sulpur dioxide concentration has been confirmed in Reykjavik from airmasses that have passed over the gethermal area. It is believed that sulpur oxides from geothermal areas will mostly return into elemental sulpur and sulphate.

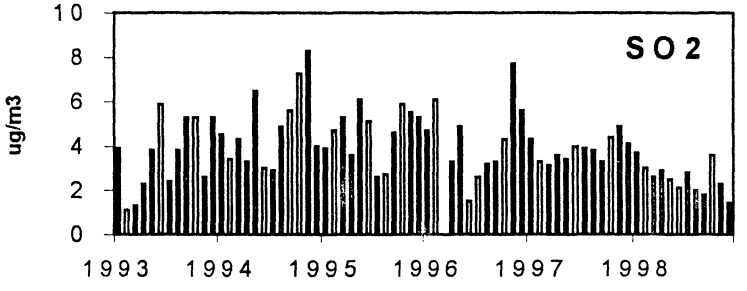

Figure 4: Monthly average concentration of sulphur dioxide in Reykjavik.

Although average value for the concentration of carbon monoxide (fig. 5) is low, occasionally carbon monoxide has exceeded 8 hours limit value (6 mg/m3) 28 times in the last 6 years. This happens at calm winter days early in the morning when the traffic is increasing.

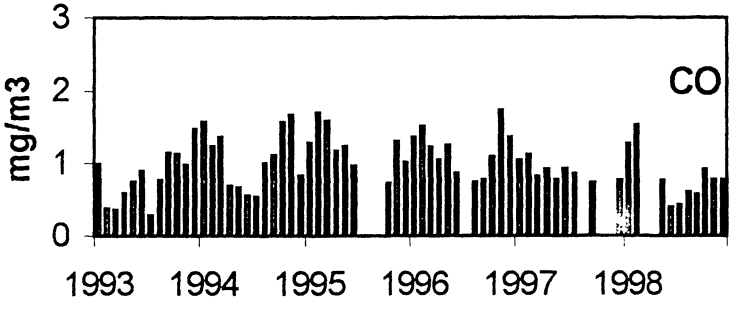

Figure 5: Monthly average concentration of carbon monoxide in Reykjavik.

While the amount of carbon monoxide is correlated to vehicle traffic the suspended dust PM10 (fig. 6) is not clearly related to traffic. It has been suggested that under dry conditions in summertime topsoil patricles are carried from central and southern Iceland to the Reykjavik region by strong easterly and southeasterly winds (Gustafsson 1992, Gustafsson&Steinecke 1995). The increase of PM10 in the springtime is attributed to increased road

wear due to extensive use of studded tyres during the winter season and is whirled up in the atmosphere from dry roads when ground frost melts. Also in wintertime, westerly and northwesterly winds blowing from the sea carrying salt drops that crystalises in the PM10-meter in addition to the dust from the traffic.

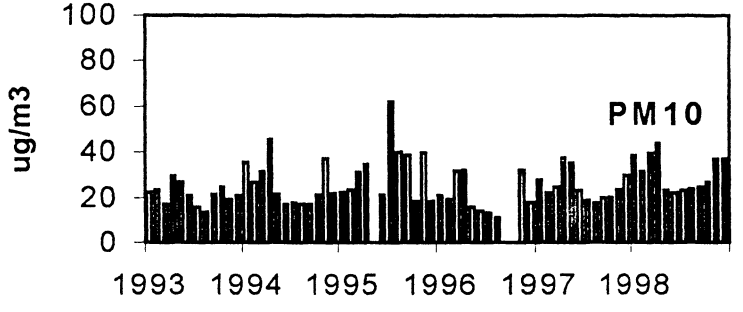

Figure 6: Monthly average concentration of PM10 in Reykjavik.

4 Conclusion

- The high ozone background concentration reacts with the nitrogen monoxide in the exhaust from vehicle to form nitrogen dioxide which is the main pollutant in the ambient atmosphere in Reykjavik.
- In spite of increasing car density in Reykjavik there is an evidence for decrease in nitrogen dioxide concentration attended with increase in ozone concentration. This is belived to represent less emmission from cars due to newer car models with better converters and more economic engines.

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