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EVALUATION OF AIR POLLUTION IN OSLO
A SUMMARY

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LIST OF CONTENTS

		Page
1	BACKGROUND INFORMATION	3
2	REPORTS	3
3	PURPOSE OF THE INVESTIGATION	4
4	METHODS AND INPUT DATA	5
	4.1 Emissions	5
	4.2 Data on dispersion	8
	4.3 Dispersion calculations	8
5	RESULTS	10
	5.1 Pollution maps	10
	5.2 Population exposure	13
6	EFFECT OF REDUCED EMISSIONS FROM CARS IN OSLO ON THE MAXIMUM LEVEL OF EXPOSURE FOR PARTICULATE MATTER/SOOT, NO_x, CO, LEAD AND BENZENE	15
7	RELIABILITY OF CALCULATIONS	16

EVALUATION OF AIR POLLUTION IN OSLO
A SUMMARY

1 BACKGROUND INFORMATION

This project was undertaken in 1979 as a co-operative effort between the health authorities in Oslo and the State Pollution Control Authority in Norway (SFT).

The purpose was to quantify the population exposure to air pollution to provide data for an evaluation of health effects. The project was carried out by the Norwegian Institute for Air Research (NILU) with support from a project group with members from SFT, the Health Board of Oslo, and the Technological Institute of Norway (STI). Further, the Transport Economical Institute (TØI), Oslo Community, Institute of Geophysics, University of Oslo, and siv.ing. S.E. Riise have participated in the work.

The project was financed by SFT. Additional financial support was provided by NILU in resolving problems with calculation methods.

2 REPORTS

The results from the project have been previously published by NILU in the following reports (in Norwegian):

"Beregning av sprednings- og eksponeringsforhold for visse luftforurensningskomponenter i Oslo" ("Calculation of dispersion and exposure conditions for some air pollution components in Oslo", NILU OR 8/82). The results are given and discussed in the report. The input data and some results are given in appendix under separate cover.

The data on emissions are given in a separate report "Utslipp av luftforurensninger i Oslo-området 1979" ("Emission of air pollutants in Oslo 1979", NILU OR 10/82).

3 PURPOSE OF THE INVESTIGATION

- Map pollution distributions with different averaging times for concentration values that may be compared with air quality standards or guidelines.*
- Describe frequency distribution of air pollution concentrations in different parts of the area.
- Calculate the number of people exposed to doses higher than given values.
- Give the relative contribution to pollution concentration from vehicular traffic.
- Calculate the expected reduction in ambient concentrations as a result of 20%, 50% and 90% reduction in traffic emissions.

The investigation was carried out for the following air pollutants and averaging times:

SO_2	(1 hour, 24 hours and half year)
Particulate matter/soot	(1 hour, 24 hours and half year)
NO_2	(1 hour, 24 hours and half year)
CO	(1 hour, 8 hours)
Lead (inorganic)	(3 months)
Benzene	(1 year)
Ozone	(1 hour)

* The applied air quality guidelines (concentration values) are specified by SFT on basis of the SFT-report No. 38, "Air pollution. Effects on health and environment", and on the U.S. federal air quality standard for lead.

4 METHODS AND INPUT DATA

Emission data and data for dispersion conditions (meteorological data) were used for calculations of concentration distributions.

Figure 1 shows a map of the area for calculations. In calculating the population exposure, only the inhabitants of Oslo were considered and the population distribution is shown in Figure 2.

To calculate one-hour average doses, the distribution of people travelling, staying in their homes, or at work for each hour of the day was considered.

4.1 Emissions

The mass emissions of each pollutant for the Oslo area for 1979 were used. The following sources were included in the emission survey:

- vehicular traffic
- oil combustion
- industrial processes
- other sources, including incineration, aircraft at Fornebu airport, Oslo harbour, consumption of coke, wood, coal, distribution of gasoline, and use of solvents.

The emissions are given for each km^2, as shown in Figure 1, and for each of the major sources.

Calculations of emission were based on:

- number of km driven in each km^2 by vehicles using diesel oil and by vehicles using gasoline. The emission factors giving average amount of emission per km driven were provided by STI.

Figure 1: Grid system (km^2) for the area of calculations.

major roads

central area

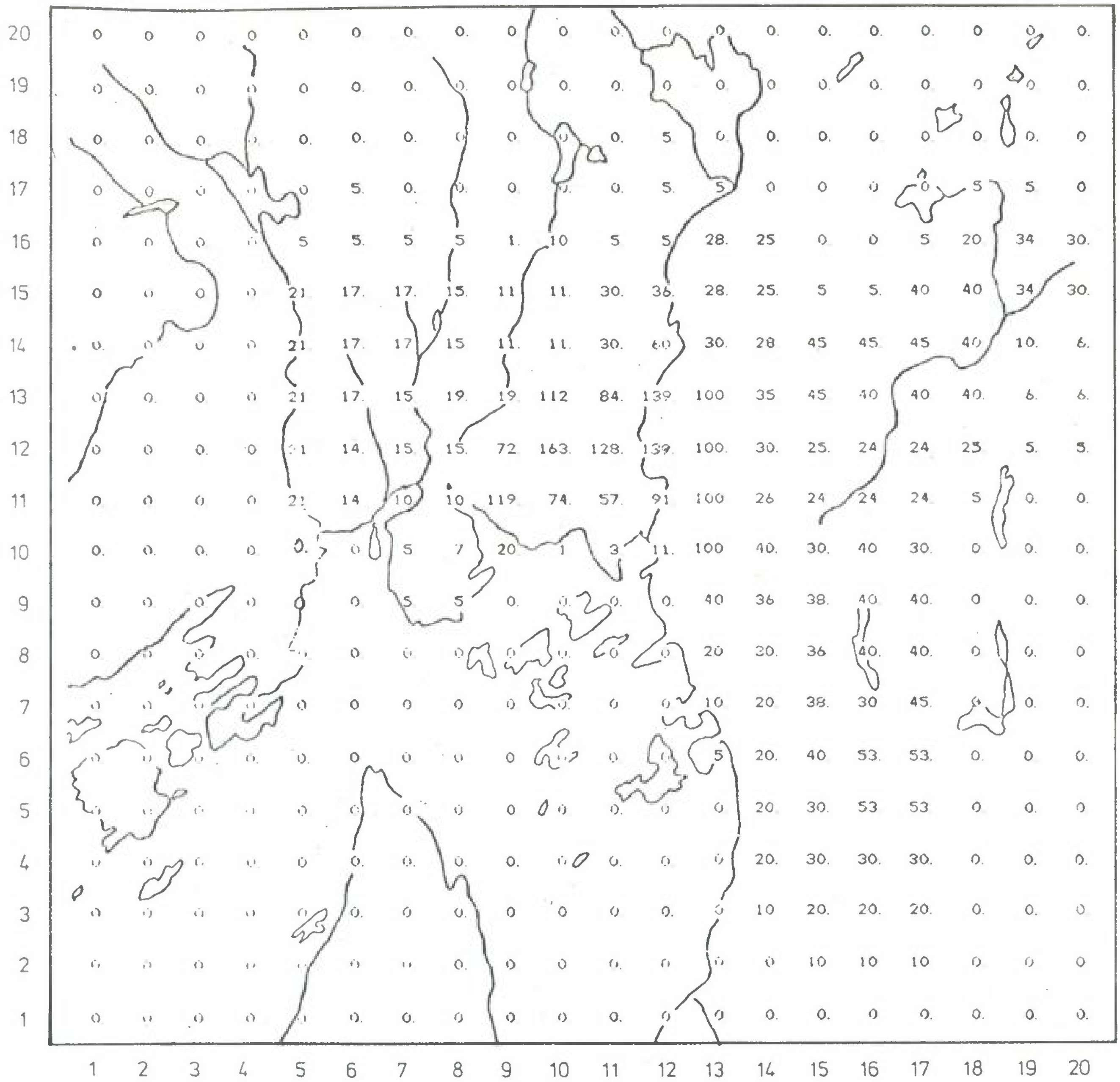

Figure 2: Population distribution in Oslo (31.12.76).
Unit: 100 persons/km^2.

- data on consumption of different kind of oils for each km^2. For large sources a resolution of 100 m x 100 m was used.
- data from SFT on emissions from industrial processes.
- data on traffic density at Fornebu airport and in Oslo harbour.

Emissions from thirteen large furnaces and boilers, and from about 120 streets were treated separately. Table 1 shows the average total emissions from the different sources in the Oslo area.

4.2 Data on dispersion

In 1970-71, NILU made an extensive survey of the dispersion conditions in Oslo, with emphasis on the conditions during pollution episodes. Data from this survey is used in the calculations of ambient concentrations. Ten episodes were used to estimate highest hourly and daily concentrations.

Dispersion conditions and frequency of episodes vary from year to year. Only a few episodes, and even no episodes with extremely bad dispersion conditions, were observed during the winter of 1970-1971. To account for this, stronger inversion than observed was assumed in calculation of maximum hourly and daily concentrations. Wind measurements from Valle Hovin were used in the calculation of long term average concentrations.

4.3 Dispersion calculations

Concentrations in streets with high traffic density were calculated using a method that has been previously validated in Oslo. To calculate concentrations downwind of single sources, a plume dispersion formula was used describing the growth of plumes under different dispersion conditions.

Long term average concentrations were calculated for the mid-point in each km^2, as shown in Figure 1. The contributions from point sources and area sources in each km^2 are additive.

Table 1: Average hourly emissions of air pollutants in Oslo, 1979. Unit: kg/h.

	SO_2	Part./soot	CO	HC	NO_x (as NO_2)	Local	Benzene
Winter							
Oil combustion	520	110	n*	20	290	-	n
Vehicle traffic	40	140	6400	440	390	7.6	34
Other sources	190	140	1200	540	100	0.8	12
Sum	750	390	7600	1000	780	8.4	46
Summer							
Oil combustion	320	60	n	10	170	-	n
Vehicle traffic	40	120	5500	400	380	6.9	31
Other sources	90	40	300	440	50	0.8	3
Sum	450	220	5800	850	600	7.7	34

*n: negligible.

Air pollution accumulation in the Oslo area during episodes have to be considered under conditions of stagnating wind to estimate the highest concentrations. The highest concentration values, as a result of data from 10 selected days, are referred to as maximum concentrations in Oslo. If the emission survey used is reasonably accurate, higher concentrations will be very seldom recorded.

5 RESULTS

5.1 Pollution maps

A number of maps have been drawn for Oslo, showing pollution concentrations for different averaging times extending from 1 hour to 6 months. Two figures are selected as examples. The SO_2 concentrations, shown in Figure 3, demonstrate the dispersion of pollutants mainly from area sources (e.g., domestic heating).

Dispersion of lead, originating mainly from vehicular traffic, is shown in Figure 4. The results are based on a content of lead in gasoline of 0.4 g/l. The allowable lead content in Norway will be reduced after 1 February 1983 to below 0.15 g/l. Thus, it can be expected that the concentration values will be reduced accordingly.

In order to use the results to improve the living environment in Oslo, the local authorities wanted to know the levels of pollution in individual streets. Concentrations in street canyons were calculated for about 120 blocks with high traffic density and buildings on both sides. Concentrations can also be high in streets with buildings on one side, or even lacking buildings, but then high traffic density is necessary (e.g., E6, E18, Ringveien). The highest concentrations occur in street canyons in the urban centre with buildings on both sides.

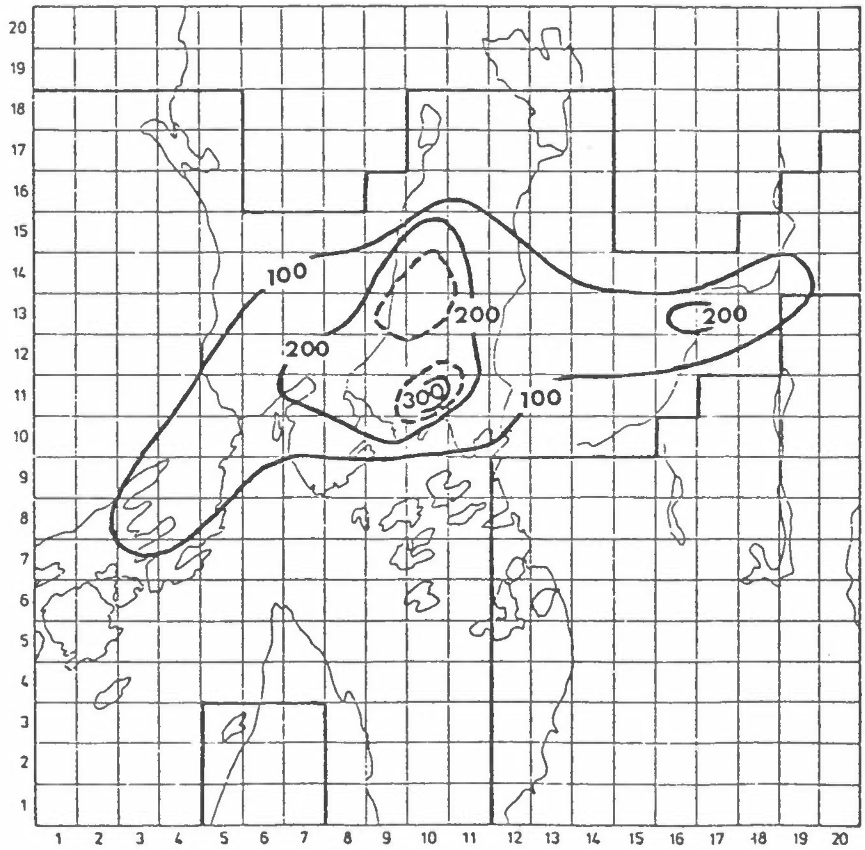

Figure 3: Maximum 24 h SO_2 concentration.
Unit: μg/m³.
NB: In some episodes the maximum values will also occur in other parts of the urban area.

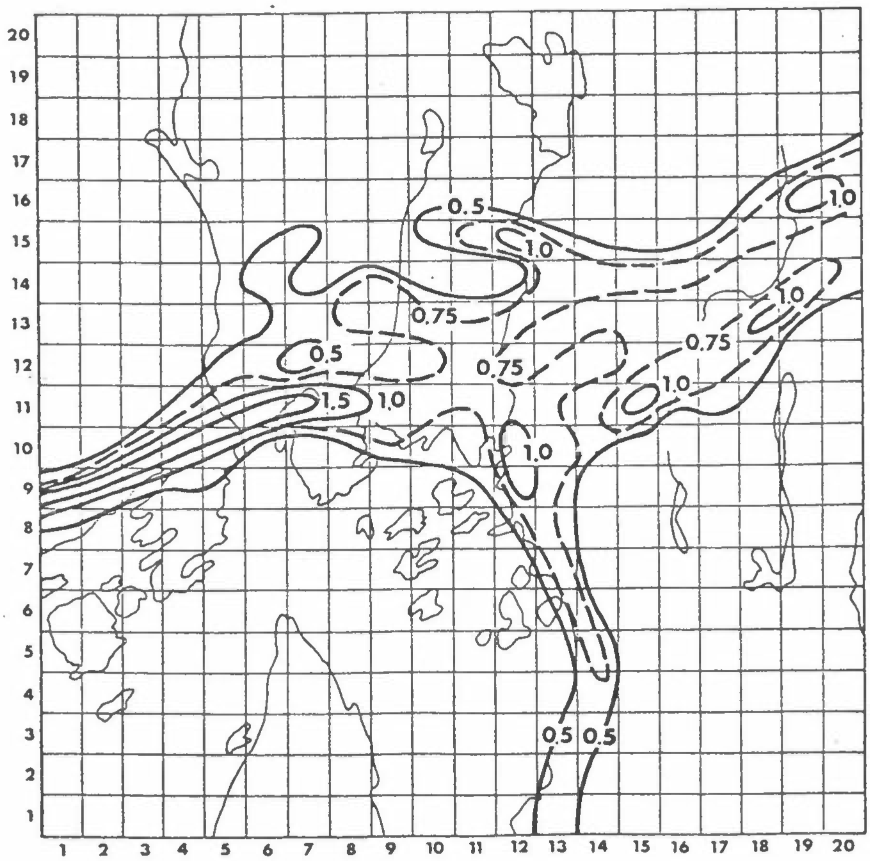

Figure 4: 3-month average for lead.
Unit: μg/m³.
The calculations are based on a lead content in gasoline of 0.4 g per liter gasoline.

For particulate matter/soot (24-h and 6-month averages), NO_2 (1-h and 6-month) and CO (1-h and 8-h values) it was found that one or several of the guidelines were exceeded by a factor of two in many street canyons. As an example, a map for 8-h average CO values is shown in Figure 5.

Tables 2 and 3 show a simplified view of the highest values occurring on the pollution maps presented in the main report. These values may be compared with the air quality guidelines.

Table 2: Calculated maximum long term concentrations.

Component, averaging time	Standard $\mu g/m^3$ x	Calc.max.value $\mu g/m^3$	Extension
SO_2, ½ year	40-60	70	Area
Part/soot, ½ year	40-60	40	Area
NO_2, ½ year	75	40	Area
Lead, 3 mo.	1.5	1.0	Area
		2.5	Local (industry and street canyons)

x: Air quality standards.

Table 3: Calculated maximum short term concentrations.

Component, averaging time	Standard $\mu g/m^3$	Calc.max.value $\mu g/m^3$	Extension
SO_2, 24h	100-150	300	Area
Part./soot 1 hour	100-150	150	Area
NO_2, 24h	100-150	90	Area
CO, 8h	10 000	7 000	Area
		25 000	Local (street canyon)
SO_2, 1h		300	Area
Part./soot 1 hour		400	Smaller area
NO_2, 1h	200-350	180	Area
		500	Local (street canyon)
CO, 1h	25 000	15 000	Area
		45-60 000	Local (street canyon)
O_3, 1h	100-200	200	Suburbs

Figure 5: CO:8-hour concentrations.

The figures show that for both SO_2 and soot higher concentrations than the air quality guidelines will occur simultaneously over large areas.

The highest concentrations were found in street canyons with busy traffic, where soot values are caused mainly by car traffic. The high SO_2 values are caused by combustion of oil. For NO_2 the calculations indicate that concentrations higher than the guideline value may be observed in streets with high traffic, but not over large areas. Lead concentrations exceed air quality guidelines along the main roads and in street canyons with high traffic density. Areas polluted by lead above the guideline value will be substantially reduced when the lead content in all gasoline is reduced to 0.15 g/l in 1983.

5.2 Population exposure

Quantification of population exposure may be an important parameter in evaluation of health effects. In order to present data on population exposure in a meaningful way, it is necessary to know the basis of air quality standards or guidelines. For standards based on epidemiological data, outdoor air pollution concentrations may be applicable (most epidemiological studies are based on measured outdoor concentration values). When the standards are based on experimental dose-response data, it seems reasonable to apply data on indoor as well as outdoor air quality depending on where people stay. It is estimated that as a daily average, about 70% of the population stay in their dwellings.

In this work, population exposure is based upon outdoor levels. For benzene, indoor measurements in selected appartments are used. For SO_2, particles/soot and NO_2, outdoor levels may be used since the standards are based on epidemiological data. For the other components (CO, lead, ozone), the indoor levels will also be of interest. A selection of the most interesting results is shown in Table 5.

Table 5: Summary of the exposure calculations: the number of people exposed to given concentrations (standard).

Component	Standard $\mu g/m^3$	Number of persons exposed to given values		
		Between given values	Above the values	50% above the values
SO_2 ½ year	40-60	175 000	59 000	-
Part./soot ½ year	40-60	85 000	ca. 100*	-
SO_2 24-h	100-150	82 000	133 000	ca 25 000
Part./soot 1-h	100-150	105 000	3 500	ca 50*
NO_2, 1-h	200-350	ca 4 000*	ca 1 000*	-
CO , 1-h	25 000	-	ca 3 700*	ca 1 400*
CO, 8-h	10 000	-		ca 3 200*
Lead, 3-mo	1.5		ca 4 000*	
O_3, 1-h	200		10 000 - 50 000**	

* Number of people living or working near street canyons with high traffic density.

** The method does not permit a more accurate estimate of the number of persons that are exposed to O_3 concentration higher than the standard.

Table 5 shows that far more people are exposed to high concentrations of SO_2 and particles/soot than to the other components considered in this investigation. For particles/soot, half-yearly average concentrations exceed the standard in the same areas as for SO_2. Concentrations considerably higher than the standards (more than 50%) may have an impact on that part of the population that live or work near the street canyons with high traffic density. The short term standards are often exceeded during the working hours. A few hundred people live near the street canyons with busy traffic and may be exposed to 50% higher concentration for SO_2 and particles/soot simultaneously. A large number of persons are exposed to high SO_2 values. A smaller part of these is exposed to high SO_2 and soot values simultaneously. The Norwegian guidelines for 6-month SO_2 and particulate values are specified as a range of concentration. It is estimated that 80.000-100.000 persons are exposed to concentrations within this range.

About 4000 persons living or working near street canyons may be exposed to maximum hourly NO_2 concentrations within the range given for NO_2.

High ozone concentrations over eastern Norway will be reduced over Oslo as a result of local emissions of NO. New formation of oxidants as a result of emissions from Oslo may in some episodes expose a few thousand people (10.000-50.000) to higher ozone levels than specified by the guidelines.

6 EFFECT OF REDUCED EMISSION FROM CARS IN OSLO ON THE MAXIMUM LEVEL OF EXPOSURE FOR PARTICULATE MATTER/SOOT, NO_x, CO, LEAD AND BENZENE

The following effects can be expected:

a) Reduction of emission from each vehicle will result in corresponding pollutant concentration reduction in the streets with high traffic density. A 50% reduction is necessary for CO concentrations to meet the guidelines in these streets.

b) Traffic regulations may be used to improve the pollution situations in single streets. Improved flow of the traffic will also reduce total emissions.

c) In episodes, 20-90% reduction in the emissions from motor vehicles should give the following average reduction in the pollution levels over the central area:

 2- 8% reduction in the SO_2 concentrations
10-44% reduction in the particle/soot values
18-82% reduction in the CO concentrations
12-53% reduction in the HC concentration
11-57% reduction in the NO_x concentration
19-85% reduction in the lead concentration
17-76% reduction in the benzene concentration.

7 RELIABILITY OF THE CALCULATIONS

Estimation of vertical exchange of pollution is probably the most important source of uncertainty in the calculations. The uncertainty in the vertical exchange is particularly important when the relative contributions from car traffic (emission close to the ground) and from home heating (emission above the roof level) are evaluated. The assumptions applied in this study should be tested by tracer experiments.

Data from the literature may be used for guidance on the expected uncertainty. Often the uncertainty in calculated average concentrations is estimated to be lower than 20% for long term average values, and to about 25% for daily mean values during shorter episodes.

The calculated exposure levels for the Oslo population will most probably occur. Type and frequency of different pollution episodes will vary from one year to another, and the maximum values are therefore difficult to quantify. Uncertainties may be reduced by improved data from further measurements.

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REFERAT (maks. 300 anslag, 5-10 linjer)

På grunnlag av utslippsdata og meteorologiske data er det utført spredningsberegninger for SO_2, svevestøv/sot, NO_x/NO_2, CO, Pb, O_3 og benzen. På grunnlag av befolkningsdata er videre befolkningseksponeringen estimert for korte og lange midlingstider. Virkning av reduksjon av avgassutslipp fra biler på eksponeringskurvene er vurdert.

TITLE Evaluation of air pollution in Oslo. A summary.

ABSTRACT (max. 300 characters, 5-10 lines.

Based on emission data and meteorological data from Oslo dispersion calculations are carried out for SO_2, particulates, NO_x, CO, Pb, O_3 and benzen. Population data are further used to evaluate population exposure for short and long exposure times. The effect of pollution reduction from car emission on exposure curves are considered.

**Kategorier: Åpen - kan bestilles fra NILU A
Må bestilles gjennom oppdragsgiver B
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