J4.1 MOBILE MEASUREMENTS OF URBAN AIR POLLUTANTS

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1. INTRODUCTION

Inner city air quality is subject to considerable fluctuation over both space and time. Air quality is normally only monitored by a few widely spaced state measurement stations. The temporal resolution of the data available from these stations is very high, but not the spatial resolution. Data with high spatial resolution can be obtained by making air hygiene measurement trips. These measurement trips allow a high degree of differentiation in recording inner-city air pollutant concentration structure (KUTTLER, STRASSBURGER (1999), KUTTLER, WACKER (2001), LURIA et al. (1990) MAYER, HAUSTEIN (1994), SHORTER et al. (1998)).

2. EXPERIMENTAL ARRANGEMENT

Air hygiene measurement trips were made using the mobile laboratory of the Dept. of Applied Climatology, University of Essen. The air quality indicators CO, NO, NO_2 and O_3 were measured 1.5 m above ground level. The meteorological values recorded were air temperatures and relative humidity (2 m above ground level), global radiation, UV-radiation (3.5 m above ground level) and atmospheric pressure. The mobile lab travelled at an average of 30 km/h (8 m/s) on city streets and 60 km/h (16 m/s) on motorways. Using analysers with an analysis frequency of 1 Hz, one measured value was recorded every 8 m (or 16 m on motorways) on average. The measurement methods are summarized in table 1.

TABLE 1: Measurement methods for trace gases

Trace gases	Measurement methods
CO	IR absorption
NO, NO_X	chemoluminescence
O_3	UV absorption

The distribution from a vehicular exhaust plume is affected by the interaction between the vehicle-induced and atmospheric turbulence. At a downstream distance of 7 m, the NO_x concentration is approximately 7 % of the concentration at the exhaust (CHAN et al. (2001)).
The trace gas concentration can be expressed as a function of the variables included in table 2.
The investigation area included the cities of Essen, Mülheim, Bottrop and Gelsenkirchen (central Ruhr area, North Rhine-Westphalia, NRW) (location: 51° 27` N, 7° 47` E, inhabitants: 1.2 million). The measurements were made along a route with a length of 86 km covering typical land use types. The route passed various air quality stations of the North Rhine-Westphalian State Environmental Protection Agency. Air measurements trips were made in the period from 21 February 2000 to 12 January 2001 on various days of the week, mainly during anticyclonic weather situations (v_{max} < 4 m/s) between 9 a. m. and 3 p. m.

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TABLE 2: Variables of the function expressing the trace gas concentration

Constant parameters	Variables
road width	*roadside vegetation*
road-edge buildings	*road vehicle emission, traffic density*
road routing	*meteorological conditions*
	photochemical reaction conditions
	time of day, day of week, season

In view of the rapid fluctuation of the trace substance concentrations, average values for homogeneous road sections were calculated by equation 1.

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \quad \text{eq. 1}$$

$\bar{x}$ = average
n = number of measured values
Σ = total
x_i = measured value i

3. RESULTS

The concentration distribution of pollutants from road vehicle emissions in areas with various types of urban land use was statistically analysed by bivariate and multiple regression analysis of trace gas concentration with the variables average daily traffic density (DTV), land utilisation structure (FS), road design and surroundings (SG) and combinations of these variables (table 3).
With a correlation coefficient of r > 0.7, traffic density has a significant effect on trace substance concentration. The effects of land utilisation structure and road design/surroundings are less pronounced. Multiple correlation resulted in coefficients of 0.7< r < 0.9.

TABLE 3: Bivariate and multiple regression analysis of trace substance concentration with various factors

	CO	NO	NO_2	O_3
Average daily traffic density (DTV)	0.792	0.752	0.714	-0.792
Land utilisation structure[1)] (FS)	0.298	0.324	0.403	-0.408
Road design and surroundings[2)] (SG)	0.523	0.532	0.537	-0.548
DTV and FS	0.873	0.842	0.821	-0.894
DTV and SG	0.876	0.789	0.757	-0.845
DTV, FS and SG	0.945	0.935	0.910	-0.958

[1)] Calculated with green area, resid. area, sec. road, main road and motorway

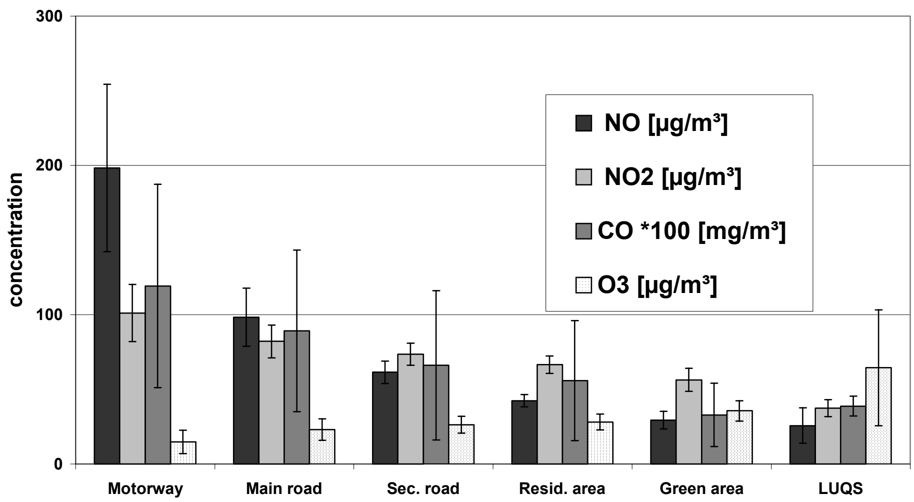
[2)] Calculated from open field around openly spaced buildings to street canyon

The data from the single field trips lay the foundation for calculated average values for different land use types which were classified as follows: motorway, main road, secondary road, residential area and green area (Fig. 1).

The standard deviation as a measure of the variation was relatively low, indicating that the measured values were representative. As expected, NO and NO_2 concentrations in motorway areas were significantly higher than for main roads and secondary roads. The concentrations fell off in green spaces, where the lowest concentrations were measured. The situation was reversed with ozone concentration, because of the higher ratio of NO2/NO.

A comparison with the pollutant concentration measured by the air quality monitoring stations of the state of North Rhine-Westphalia (LUQS) during the field trips indicates that the values of these stations were about the same as those recorded in residential areas and green spaces. This means that the data of the air quality network do not represent the different air hygiene situations in the conurbation investigated.

Fig. 1: Mean trace gas concentrations in areas with different land use types in the central Ruhr area (North Rhine-Westphalia) based on 20 measurement trips from 21.02.2000 to 12.01.2001 (LUQS = averages of concentrations of the air quality monitoring stations of the state of NRW)



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