Environmental Quality

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**Menno Keuken[1]*, Michiel Roemer[1] and Sef van Elshout[2]**

* menno.keuken@tno.nl

1 TNO Built Environment and Geosciences, Department of Environmental Quality, PO Box 342, 7300 AH Apeldoorn, The Netherlands

2 DCMR Environmental Agency for the Rijnmond Area, 's Gravenlandseweg 565, 3119 XT Schiedam, The Netherlands

# Trend of $NO_2$ urban background concentrations: direct $NO_2$ emissions or ozone/$NO_x$ equilibrium? Air4EU case study: Rotterdam

## Problem

$NO_2$ concentrations at the urban background in Rotterdam remain at the same level despite significantly decreasing $NO_x$ emissions in the period 1986-2005. This trend is analysed by two hypothesis:

## Hypothesis 1: Increasing direct $NO_2$ emissions by road traffic?

Hypothesis 1 is tested by using the oxidant concentration (Ox): the sum of the ozone and $NO_2$ concentrations. Under the $NO_x$/ozone equilibrium Ox should be constant. Due to direct $NO_2$ emissions in an urban area, urban background Ox is higher compared to regional background Ox. Thus, the delta Ox (from urban and a regional background stations) over the years is a method to identify the trend in direct $NO_2$ emissions. A positive trend of direct $NO_2$ emissions in 1986 of 9% to 13% in 2002 was estimated in Figure 2.

## Hypothesis 2: Ozone/$NO_x$ equilibrium?

The importance of the $NO_x$/ozone equilibrium to control $NO_2$ concentrations is demonstrated by using monitoring results of urban and regional background sites of $NO_x$ and $NO_2$.

- At *regional* sites (with higher ozone than $NO_x$ concentrations) $NO_2$ equals $NO_x$ concentrations: the straight line up to 25 ppb $NO_2$ in Figure 3;
- At *urban* background sites (with lower ozone than $NO_x$ concentrations because ozone has reacted with "fresh" NO emitted from combustion sources), $NO_2$ concentrations are controlled by the regional background $NO_2$ (25 ppb) plus addition of 5% direct $NO_2$ emissions: the second straight line in Figure 3: $NO_2 = 25 + 0.05 * (NO_x)$.

At urban background, *only* when $NO_x$ concentrations are below ozone concentrations will further reduction of $NO_x$ emissions result in lower $NO_2$ levels. Presently in Rotterdam, $NO_x$ concentrations at urban background are in the order of 40 ppb, while ozone is 20 ppb (see Figure 1) and thus local $NO_x$ emissions require almost 50% reduction.

## Conclusions

It is concluded that the $NO_x$/ozone equilibrium is the most likely reason for the trend of $NO_2$ in the Rijnmond area. Local $NO_x$ emissions in Rotterdam need to be reduced by 50% before lower $NO_2$ urban background levels can be achieved.

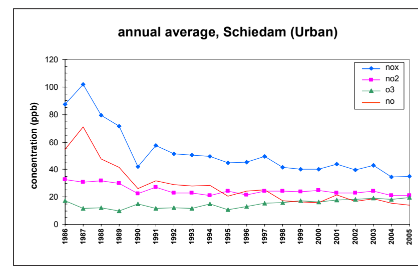


*Figure 1:*
*Trend of $NO_x$, $O_3$ and $NO_2$ at urban background station in Rotterdam: 1986-2005.*

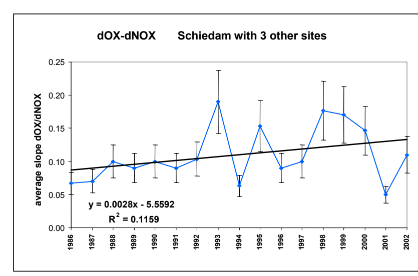


*Figure 2:*
*The trend in direct $NO_2$ emissions at the urban background in Rotterdam from 1986 to 2002 including the average standard deviation with in 95% confidence level.*

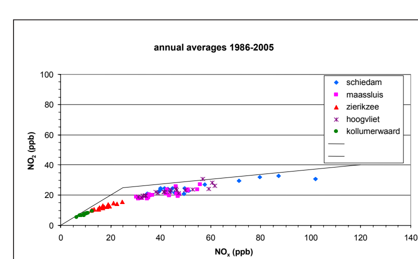


*Figure 3:*
*Annual average $NO_2$ as a function of $NO_x$ for a range of monitoring sites: Schiedam, Maassluis and Hoogvliet (urban background stations in Rijnmond) and Zierikzee and Kollumerwaard (regional background stations) over 1986-2005.*

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