Long-term trends of NO_2 concentrations near a heavily congested road in Athens

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Introduction

NO_2 is the most prevalent form of NOx in the atmosphere that is generated by anthropogenic activities. Especially, road traffic is the main emission source of NOx in urban areas. NO_2 is not only an important air pollutant but also it is a precursor to ground-level O_3. In addition, NO_2 is a respiratory irritant and has a variety of adverse health effects on the human respiratory system. Thus, the EU has set air quality legislation and standards & the WHO has set strict Air Quality Guidelines (AQG) in 2021.

WHO 2021 AQG for NO_2	**annual**	**24-h**	**1-h**	**Directive 2008/50/EC**	**annual**	**1-h**
	10 (μg/m³)	25 (μg/m³)	200 (μg/m³)		40 (μg/m3)	200 (μg/m³)

Data and Methodology

The analysis of the NO_2 concentrations was performed in the computer software "R" by using the package "openair" (Carslaw and Ropkins, 2012). The 24-hour data on the NO_2 concentrations were derived by the air quality monitoring station (AQMS) in Patission from the 1st of January 1984 to the 31st of December 2021. The AQMS belongs the National Air Pollution Monitoring Network (NAPMN) which is operated by the Air Quality Department of the Ministry of Environment and Energy. The air pollution data is available online in the Ministry's official website (www.ypen.gov.gr).

Results and Discussion

The average annual mean concentration of NO_2 at the AQMS in Patission decreased over the 38-year period (1984–2021). From 1984 to 1990, the annual mean NO_2 concentrations were at high levels (100 μg/m³–120 μg/m³), while from 1995 to 2008, the annual mean NO_2 concentrations were approximately at 80 μg/m³–100 μg/m³. The decreasing trend since the beginning of the 1990's coincides with the introduction of catalyst-equipped cars in Greece (Mavroidis and Ilia, 2012). A great decline started in 2008 as a result of the Greek financial crisis and the implementation of Directive 2008/50/EC which further decreased the concentrations of NO_2.

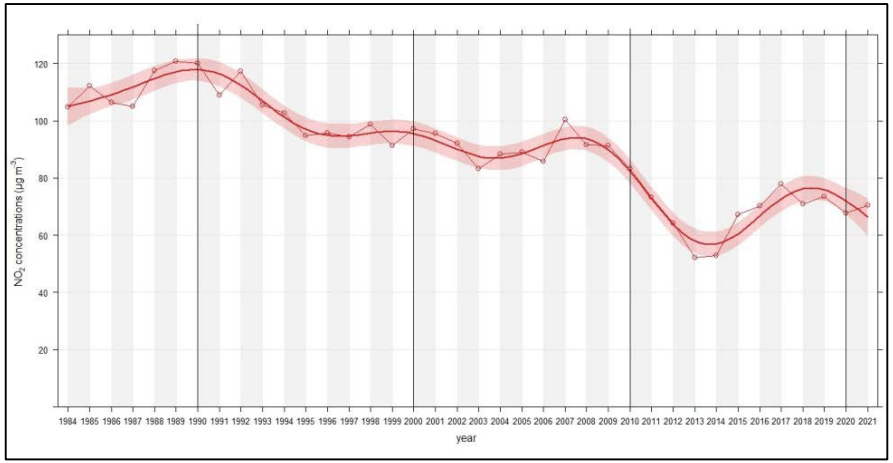

Figure 1. Interannual variations of mean NO_2 concentrations from 1984 to 2021

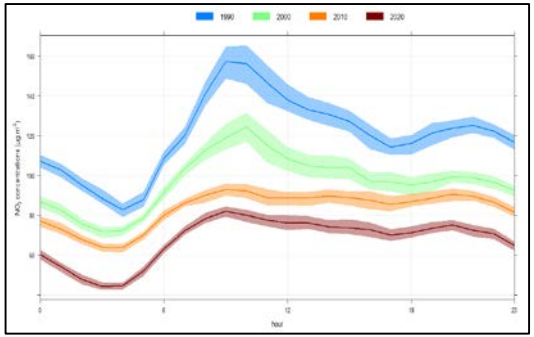

Figure 2. Diurnal variations of NO_2 concentrations

In 2013-2014 the annual NO_2 values dropped to their lowest levels (52 μg/m³–53 μg/m³). During the period 2017–2019 the annual mean NO_2 concentrations increased (71 μg/m³–78 μg/m³) until 2020 when the reduction in road traffic as a result of COVID-19 restrictions contributed to an abrupt decrease in air pollution levels. The annual mean NO_2 concentration in 2020 dropped to 68 μg/m³ (Figure 1). In general, the concentrations of NO_2 recorded at the air quality station in Patission are very high, since NO_2 is formed near the NOx emission sources from motor vehicles in a heavily congested road in Athens. The pollutants are also accumulated due to the limited dispersion within the street canyon (Mavroidis and Ilia, 2012). The decrease of NO_2 concentrations over the years is also evident in the diurnal patterns for the years 1990, 2000, 2010 and 2020. The diurnal variations of NO_2 concentrations rise rapidly after sunrise, reaching a maximum in the morning between 9.00 AM and 10.00 AM. The higher NO_2 concentration peak corresponds at the morning peak-traffic hour. A second, much smaller, maximum is observed after 9.00 PM. The peaks of the diurnal patterns are more distinct for the years 1999 and 2000 compared to the years 2010 and 2020 (Figure 2).

References

Mavroidis I. and Ilia M. (2012). Trends of NOx, NO_2 and O_3 concentrations at three different types of air quality monitoring stations in Athens, Greece. Atmospheric Environment, 63, 135-147.

Carslaw D. and Ropkins K. (2012). openair – An R package for air quality data analysis. Environmental Modelling & Software. Volumes 27–28, January–February 2012, Pages 52-61.