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NITROGEN DIOXIDE CONCENTRATION IN KAUNAS 2008–2009

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Abstract. The aim of the present study was to assess distribution of nitrogen dioxide concentration in Kaunas. A passive sampling method and triethanolamine as an absorbent was used. Sampling was carried out in 62 measurements points of Kaunas city during four different seasons in 2008–2009. According to measured concentration average seasonal and annual concentration of nitrogen dioxide was calculated.
The study results showed that mean nitrogen dioxide concentration in Kaunas was 18.1 μgm^{-3} (2008) and 25.0 μgm^{-3} (2009). The highest mean seasonal concentration was found during spring seasons (30.7 μgm^{-3}), the lowest – during summer (16.0 μgm^{-3}). The highest nitrogen dioxide concentration was in Centras district (2008 – 32.8 μgm^{-3} and 2009 – 34.0 μgm^{-3}), lowest in Panemunė (2008 – 9.7 μgm^{-3} and 2009 – 15.7 μgm^{-3}).
We found a negative correlation between nitrogen dioxide concentration and precipitation (r= -0.543, p= 0.000). Correlation between nitrogen dioxide concentration and wind speed and temperature was non significant.
Using Arc GIS program maps of nitrogen dioxide concentration distribution were plotted. Nitrogen dioxide concentration interpoliation results revealed, that the highest pollution was in Centras, Žaliakalnis, Dainava districts, the lowest was found in areas where lower traffic flows and more green places.

Keywords: nitrogen dioxide, annual and seasonal mean of nitrogen dioxide concentration, nitrogen dioxide concentration distribution maps.

1. Introduction

The attention directed at air quality in Europe is a result of not only the averse effects on humann health from high concentrations of air pollutants in the ambient air, but also of the EU regulations which aim to reduce emissions and to improve air quality (Velders and Matthijsen 2009b).

Nitrogen oxides (NOx = NO + NO_2) are an important group of air pollutants to study because they play an important role in the chemistry of the troposphere: they condition the concentration of the OH radical, the production of acids, and the regional formation of photochemical oxidants (Parra *et al*. 2009; Valuntaitė *et al*. 2009).

Large amounts of nitrogen oxides are emitted from mobile and stationary sources (Tsai *et al*. 2006). Motor vehicles can be the most important source of nitrogen oxides, especially in areas with few industrial sources (Tran *et al*. 2000).

Nitrogen dioxide (NO_2), a well-known traffic-related pollutant, is currently the biggest single cause of air quality problems in urban areas (Baltrėnas *et al*. 2008; Westmoreland *et al*. 2007). However, nitrogen dioxide is far more harmful with regard to toxicity than nitrogen oxide and it is a good predictor for traffic exposure (Schnitzhofer *et al*. 2008; Soltic and Weilenman 2003; Gilbert *et al*. 2003).

Nitrogen dioxide pollution is higher along busy roads compared to background locations. Air pollution in city centers and districts near highways is related to traffic density of the highway, distance of the measuring site to the highway (Bogo *et al*. 2001; Carslaw 2005; Beckerman *et al*. 2008).

Air quality is influenced not only by physical and chemical processes but also by synoptical situation and meteorological processes as well as geographical and social factors. Air quality also depends on whether the pollutants will accumulate in the emission place or they will be dispersed in a large area. Thereby poor air quality is influenced by a wide range of factors that include pollutant emission strengths, meteorology and landscape topography (Bimbaitė and Girgždienė 2007; Schnitzhofer *et al*. 2008).

The aim of the present study was to assess nitrogen dioxide concentration in Kaunas city 2008–2009.

2. Methods

For determination of nitrogen dioxide concentration a passive sampling method and triethanolamine as an absorbent was used. The passive sampler has an internal diameter of 25 mm and a depth of 10 mm (Fig 1). A disc of whatman 1chr filter paper impregnated with triethanolamine aqueous solution is used as the collecting element. The

inside of the passive sampler is protected against wind and dust deposition by a wind screen made of a polypropylene fibre material. After sampling, the content of nitrite ions is determined spectrophotometrically following reaction with Saltzman reagent (Krochmal and Kalina 1997; Gražulevičienė and Laurinavičienė 2001).

Nitrogen dioxide measurements were carried out in 62 points (Fig 2) of Kaunas city 4 times per year during 2008-2009 years period. We used mean of 1 week measurements of nitrogen dioxide concentration to characterize seasonal and annual mean of nitrogen dioxide in Kaunas districts and whole city. Using Arc GIS software annual maps of nitrogen dioxide concentration distribution in Kaunas were plotted. There were classified five areas, according the threshold value (TV=40 μgm^{-3}).

Statistica version 7 and Excel 2003 were used for data analysis. To assess relation with meteorological conditions correlation coefficients between nitrogen dioxide concentration and meteorological variables were calculated.

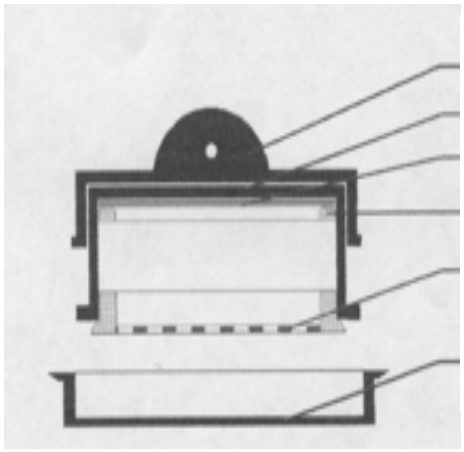

Fig 1. Passive sampler for determination of nitrogen dioxide concentration

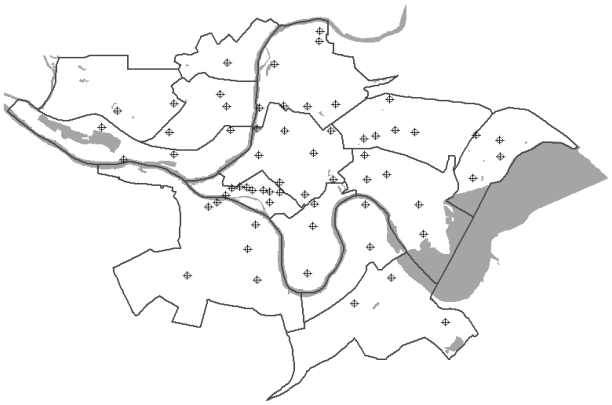

Fig 2. Nitrogen dioxide concentration measurements places

3. Results

3.1. Annual and seasonal distribution of nitrogen dioxide concentration

Average nitrogen dioxide concentration for the study period was 21.5 μgm^{-3}. In 2008 and 2009 nitrogen dioxide concentration was 18.0 μgm^{-3} and 25.0 μgm^{-3} respectively. The highest seasonal nitrogen dioxide concentration in spring was 30.7 μgm^{-3} and the lowest in summer and autumn -16.0 and 16.5 μgm^{-3} (Fig 3). In winter seasonss it was 22.8 μgm^{-3}. Figure 4 presents variation of nitrogen dioxide concentration in districts of Kaunas city in 2008. Nitrogen dioxide concentration ranged from 32.8 μgm^{-3} to 9.7 μgm^{-3}. Maximum concentration was in Centras district, minimum in – Panemunė and Rokai. Nitrogen dioxide concentration in Centras was on average 3 times higher than in Panemunė district. In districts which are in central part of the city concentration of nitrogen dioxide was higher than background areas (Velders *et al*. 2009a). In this districts there are more busy roads and more buildings. In other districts it ranged from 20.8 μgm^{-3} (Dainava) to 12.3 μgm^{-3} (Šančiai).

Distribution of nitrogen dioxide concentration in Kaunas city in 2009 is presented in figure 5. Maximum concentration was again in Centras district and was similar to concentration assessed in 2008 (34.0 μgm^{-3}), minimum in – Panemunė (15.7 μgm^{-3}). Nitrogen dioxide concentration in Centras was two times higher than in Panemunė district.

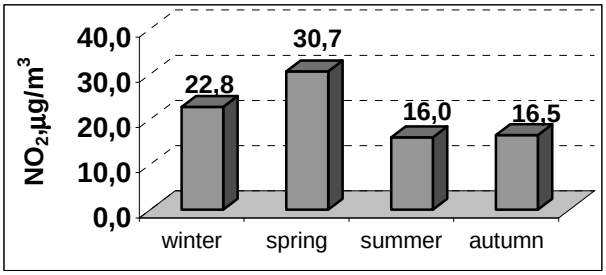

Fig 3. Seasonal nitrogen dioxide concentration in Kaunas 2008–2009

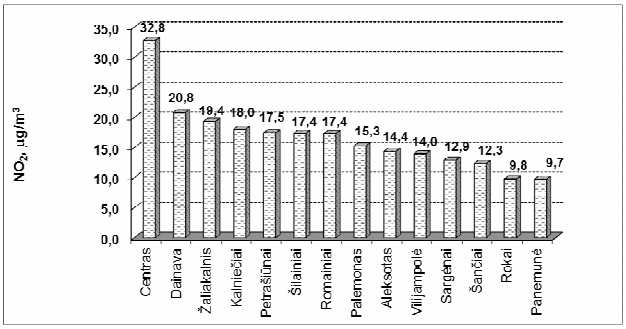

Fig 4. Nitrogen dioxide concentration in districts of Kaunas city in 2008

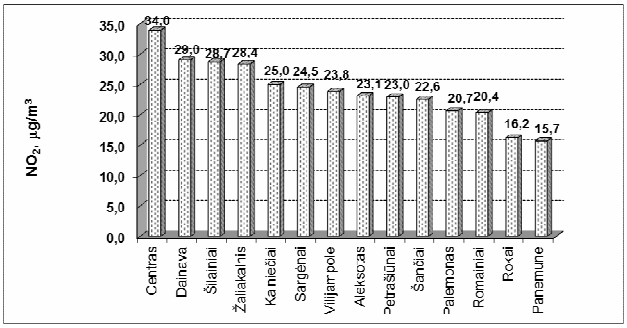

Fig 5. Nitrogen dioxide concentration in districts of Kaunas city in 2009

3.2. Distribution of nitrogen dioxide concentration

Using Arc GIS software maps of nitrogen dioxide distribution in Kaunas city were plotted (Fig 6-7). There were classified five areas of nitrogen dioxide pollution.

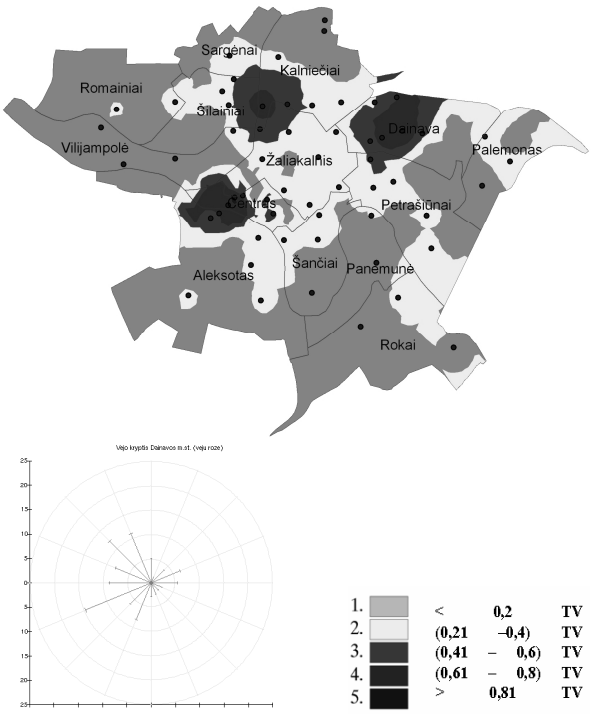

Fig 6. Distribution of nitrogen dioxide pollution in Kaunas 2008

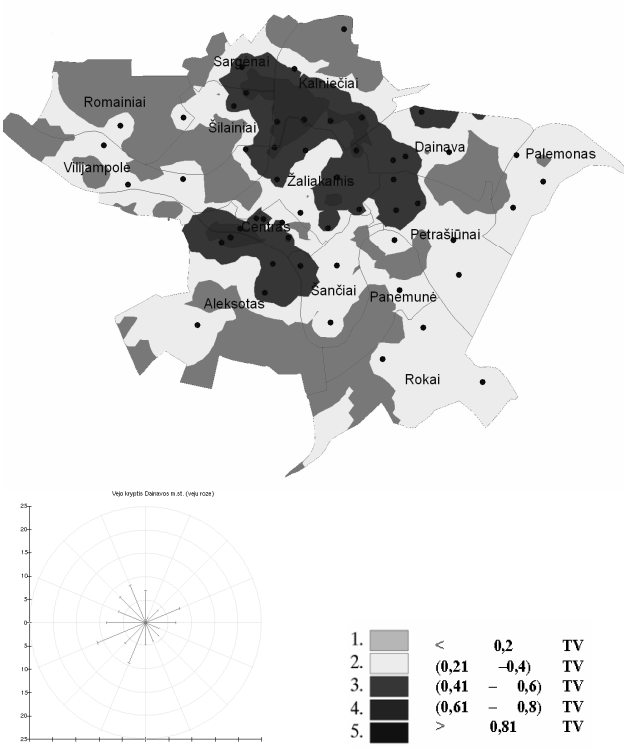

Fig 7. Distribution of nitrogen dioxide pollution in Kaunas 2009

Low area of nitrogen dioxide exposure have covered districts which are located in the periphery of the city (Fig 7). The high and very high areas of nitrogen dioxide exposure have covered central or near to centre districts of Kaunas (Centras, Aleksotas, Dainava, Kalniečiai, Šilainiai). It is caused by intensive traffic and unfavorable geographical position. Similar results were obtained from Costabile *et al*.(Costabile *et al*. 2006) and Jo and Park (Jo and Park 2005). The highest concnetration of nitrogen dioxide were measured at hihg-traffic streets, followed by industrial and downtown locations.

Distribution of nitrogen dioxide concentration in 2009 was similar to 2008 year. Low and medium areas of nitrogen dioxide exposure have covered districts which are located in city premises (Fig 7). The high and very high areas of nitrogen dioxide exposure have covered central districts of Kaunas (Centras, Aleksotas, Žaliakalnis, Kalniečiai, Šilainiai, Sargėnai, part of Dainava district).

To assess relation with meteorological conditions we calculated correlation coefficients between nitrogen dioxide concentration and wind speed, temperature and precipitation.

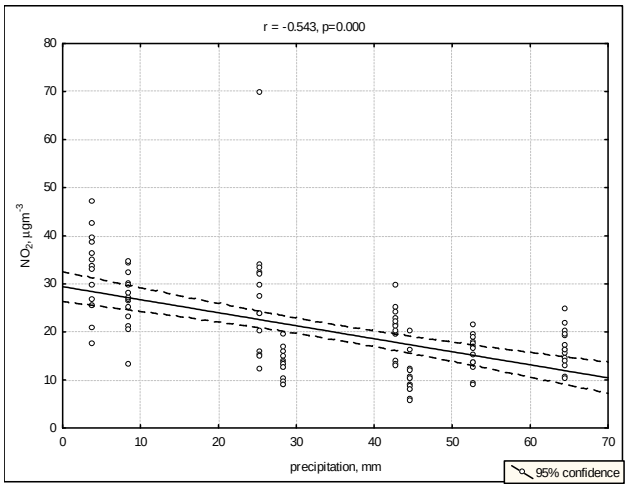

Fig 8. Correlation between nitrogen dioxide concentration and precipitation

We have found a negative correlation between nitrogen dioxide concentration and precipitation (r= -0.543, p= 0.000) (Fig 8). Negative correlation implies that lower nitrogen dioxide concentration coincide with higher precipitation. Correlation between nitrogen dioxide concentration wind speed and temperature was non significant. These results revealed that low nitrogen dioxide concentration is more associated with precipitation (Elminir 2005).

4. Conclusions

1. The average nitrogen dioxide concentration in Kaunas city in 2008–2009 was 21.5 μgm^{-3}. In 2008 – 18.0 μgm^{-3}, in 2009 – 25.0 μgm^{-3} .

2. The highest seasonal nitrogen dioxide concentration was in spring – 30.7 μgm^{-3} and the lowest in summer – 16.0 μgm^{-3}.
3. Nitrogen dioxide dispersion in Kaunas city area is uneven. Nitrogen dioxide pollution is higher along busy roads compared to the city premises. The highest annual nitrogen dioxide concentration was in Centras (2008 – 32.8 $\mu g/m^3$; 2009 – 34.0 $\mu g/m^3$), – the lowest in Panemunė (2008 – 9.7 $\mu g/m^3$; 2009 – mm 15.7 $\mu g/m^3$).
4. Nitrogen dioxide concentration interpolation results revealed, that low and medium areas of nitrogen dioxide exposure have covered districts which are located in the periphery of the city. The high and very high areas of nitrogen dioxide exposure have covered central districts of Kaunas (Centras, Aleksotas, Dainava, Žaliakalnis, Kalniečiai, Šilainiai).
5. We have found a negative correlation between nitrogen dioxide concentration and precipitation (r= -0.543, p= 0.000).

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