



# **Distribution of Nitrogen Dioxide Concentration in Kaunas 2003-2007**

**Dovilė Laurinavičienė**

*Vytautas Magnus University*

*(received in July, 2010, accepted in December, 2010)*

The aim of the present study was to assess distribution of nitrogen dioxide concentration in Kaunas. A passive sampling method was used. Sampling was carried out in 62 measurements points of Kaunas city during four different seasons in 2003-2007. According to the measured concentration average seasonal and annual concentration of nitrogen dioxide was calculated.

The study results showed that mean nitrogen dioxide concentration in Kaunas was  $18.1 \mu\text{g m}^{-3}$ . The highest mean seasonal concentration was found during spring ( $20.1 \mu\text{g m}^{-3}$ ), the lowest - during winter ( $16.5 \mu\text{g m}^{-3}$ ). The highest nitrogen dioxide concentration was in Centras district ( $26.3 \mu\text{g m}^{-3}$ ), the lowest in Rokai –  $11.4 \mu\text{g m}^{-3}$ .

Using Arc GIS program, maps of nitrogen dioxide concentration distribution were plotted. Nitrogen dioxide concentration interpolation results revealed that the highest pollution was in Centras, Žaliakalnis, Dainava districts, the lowest was found in the areas with lower traffic flows and more green places.

Key words: *nitrogen dioxide, annual and seasonal mean of nitrogen dioxide concentration, nitrogen dioxide concentration distribution maps.*

## **1. Introduction**

Air quality receives considerable attention in Europe from the general public and also in the political arena. This is because of the adverse effects on human health of high concentrations of air pollutants in the ambient air (Velders et al., 2009).

Nitrogen oxides ( $\text{NO}_x = \text{NO} + \text{NO}_2$ ) 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; Filella and Peñuelas, 2006).

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 ( $\text{NO}_2$ ), a well-known traffic-related pollutant, is currently the biggest single cause of air quality problems in urban areas (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 (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).

The aim of the present study was to assess nitrogen dioxide concentration in Kaunas city 2003-2007.

## **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 the 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 2003-2007 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 the whole city.

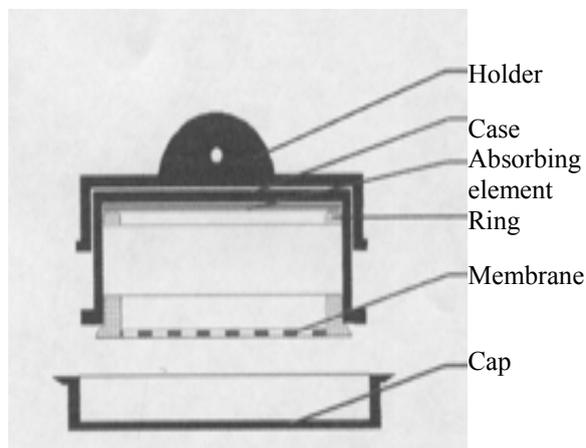


Fig. 1. Passive sampler for determination of nitrogen dioxide concentration

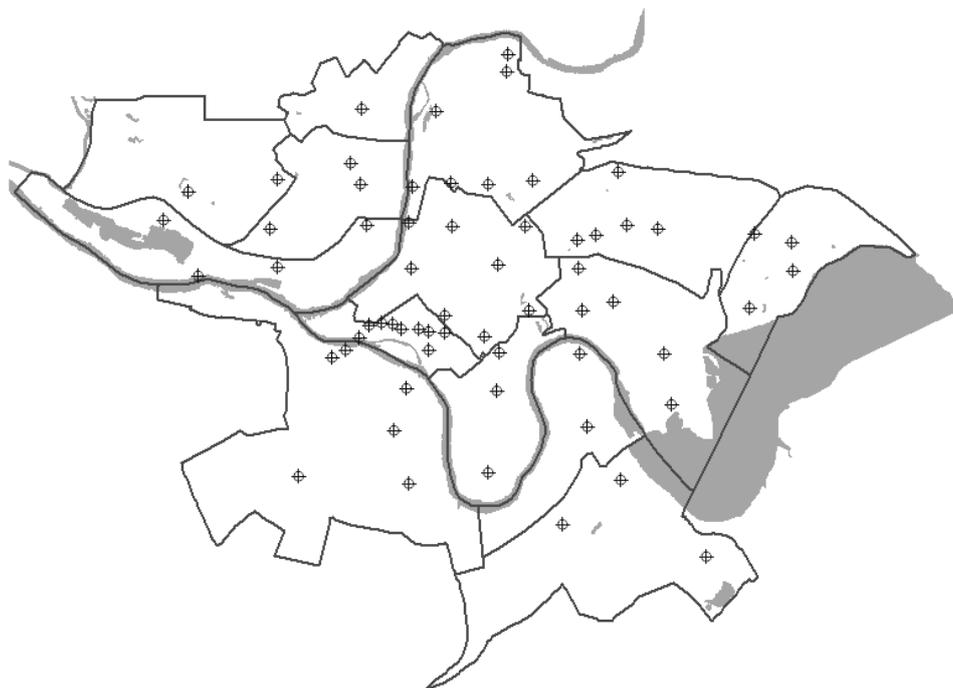


Fig. 2. Nitrogen dioxide concentration measurements places

Using Arc GIS software annual maps of nitrogen dioxide concentration distribution in Kaunas were plotted. There were classified five areas, according to the threshold value ( $TV=40 \mu\text{g m}^{-3}$ ).

Statistic version 6 and Excel 2003 were used for data analysis. SE was calculated. Average SE of the results obtained using three simultaneously exposed samplers was  $0.83 \mu\text{g m}^{-3}$ , using ten samplers –  $0.44 \mu\text{g m}^{-3}$ . Other authors reported that accuracy of passive sampling method ranged from 5-7 % (Krochmal, Kalina, 1997; Janssen et al., 2001).

### 3. Results

#### 3.1. Annual and seasonal distribution of nitrogen dioxide concentration

The average mean nitrogen dioxide concentration was  $18.1 \mu\text{g m}^{-3}$  during the study period. The highest nitrogen dioxide concentration was in 2007- $25.0 \mu\text{g m}^{-3}$  ( $SE=1.1$ ), lowest in 2004- $14.0 \mu\text{g m}^{-3}$  ( $SE=0.41$ ; Fig. 3).

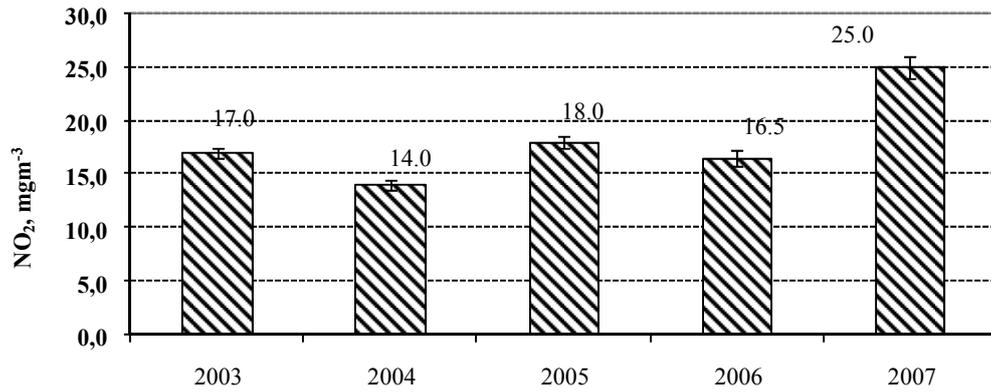


Fig. 3. Average nitrogen dioxide concentration in Kaunas 2003-2007

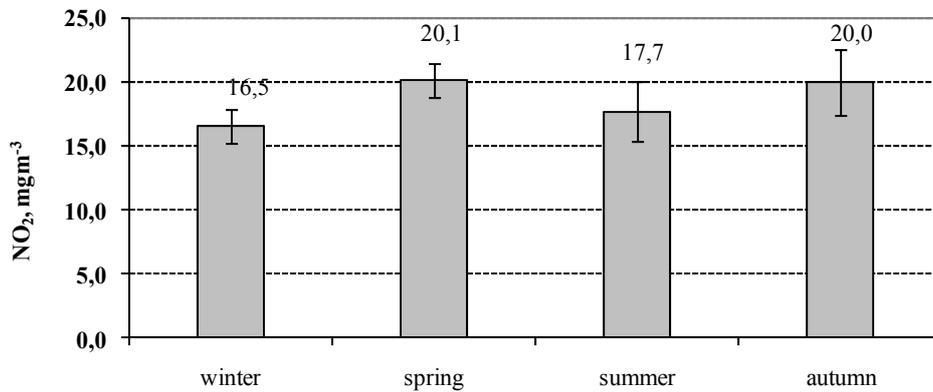


Fig. 4. Seasonal nitrogen dioxide concentration in Kaunas 2003-2007

The highest seasonal nitrogen dioxide concentration was in spring and autumn -20.1 (SE=1.28); 20.0 (SE=2.58)  $\mu\text{gm}^{-3}$ , respectively, the lowest in winter -16.5  $\mu\text{gm}^{-3}$  (SE=1.32; Fig. 4). In summer it was 17.7  $\mu\text{gm}^{-3}$  (SE=2.39).

Figure 5 presents variation of nitrogen dioxide concentration in districts of Kaunas city in 2003-2007. Nitrogen dioxide concentration ranged from 26.3  $\mu\text{gm}^{-3}$  to 11.4  $\mu\text{gm}^{-3}$ . Maximum concentration

was in Centras district, minimum in – Rokai. Nitrogen dioxide concentration in Centras was on average 2.3 times higher than in Rokai district. In the districts which are in the central part of the city concentration of nitrogen dioxide was higher than in background areas (Velders et al., 2009). In these districts there are more busy roads and more buildings. In other districts it ranged from 20.8  $\mu\text{gm}^{-3}$  (Žaliakalnis) to 11.7  $\mu\text{gm}^{-3}$  (Sargėnai).

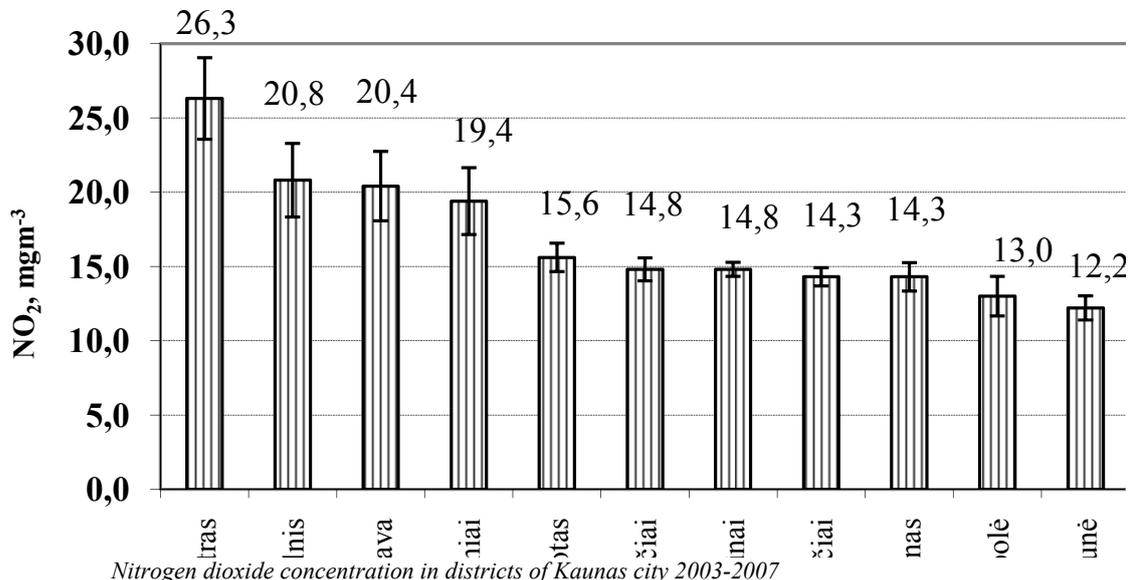


Fig. 5. Nitrogen dioxide concentration in districts of Kaunas city 2003-2007

Annual nitrogen dioxide concentration measured by a passive sampling method was compared to nitrogen dioxide concentration data from an automatic

station of Lithuanian environmental protection agency (this station is located in Kaunas, Petrašiūnai district, Fig. 6).

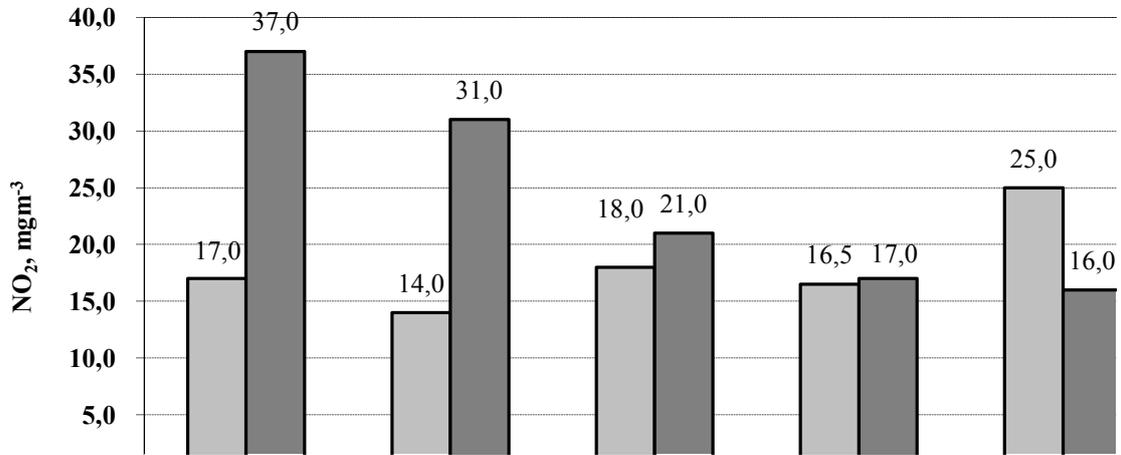


Fig. 6. Comparison between nitrogen dioxide concentration data

From the figure we can see that very big difference between nitrogen dioxide concentration data obtained by a passive sampling method and from an automatic station was observed in 2003 and 2004. This difference explains the information obtained from Lithuanian environmental protection agency. In 2003-2005 in the station there were technical problems with laboratory equipment. Nitrogen dioxide data collection was not sufficient for objective assessment of the pollution by this pollutant. In 2005-

2007 the difference between nitrogen dioxide concentration data was smaller.

### 3.2. Distribution of nitrogen dioxide concentration

Using Arc GIS software maps of nitrogen dioxide distribution in Kaunas city were plotted (Fig. 7-10). Five areas of nitrogen dioxide pollution were classified there.

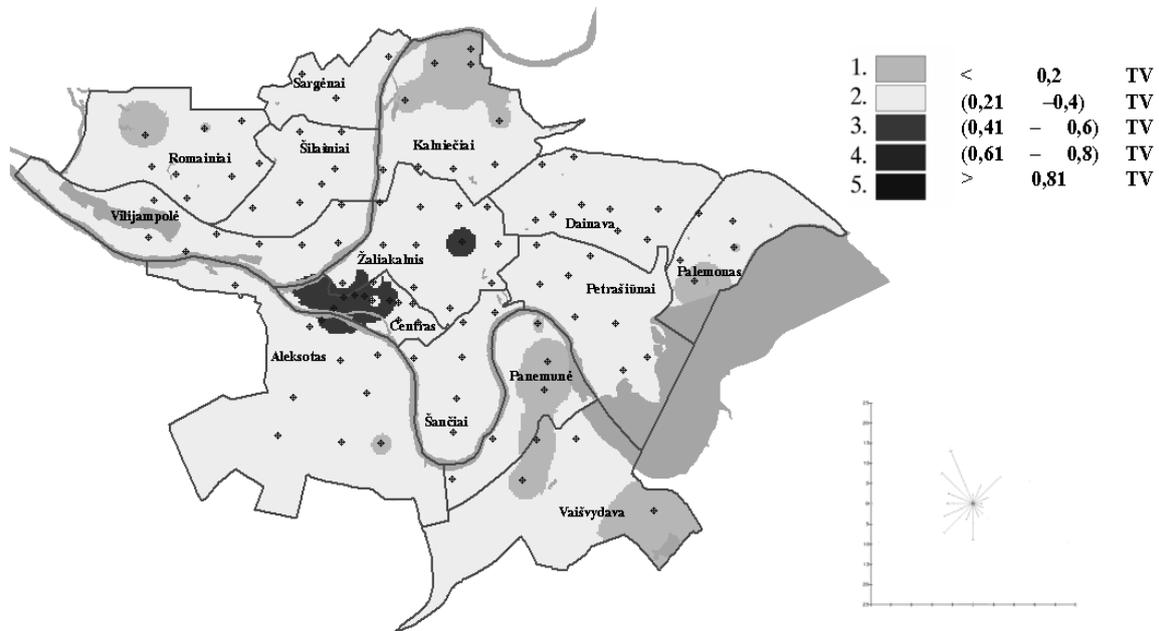


Fig. 7. Distribution of nitrogen dioxide pollution in Kaunas 2003

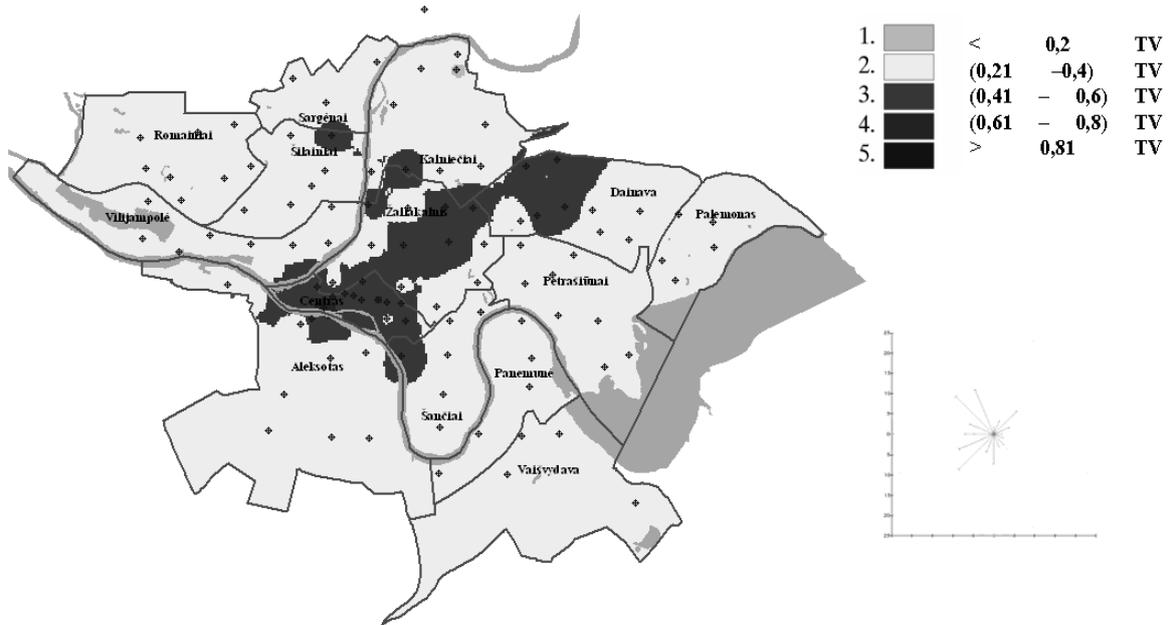


Fig. 8. Distribution of nitrogen dioxide pollution in Kaunas 2004

Medium area of nitrogen dioxide exposure covered the main part of the city in 2003 and 2004 (Figs 6-7). Big area of nitrogen dioxide exposure in 2003 was determined only in Centras and a small field

in Žaliakalnis districts (Fig. 7). In 2004 big area of nitrogen dioxide exposure covered Centras, Žaliakalnis districts, a part of Dainava and a small field of Kalniečiai and Šilainiai districts (Fig. 8).

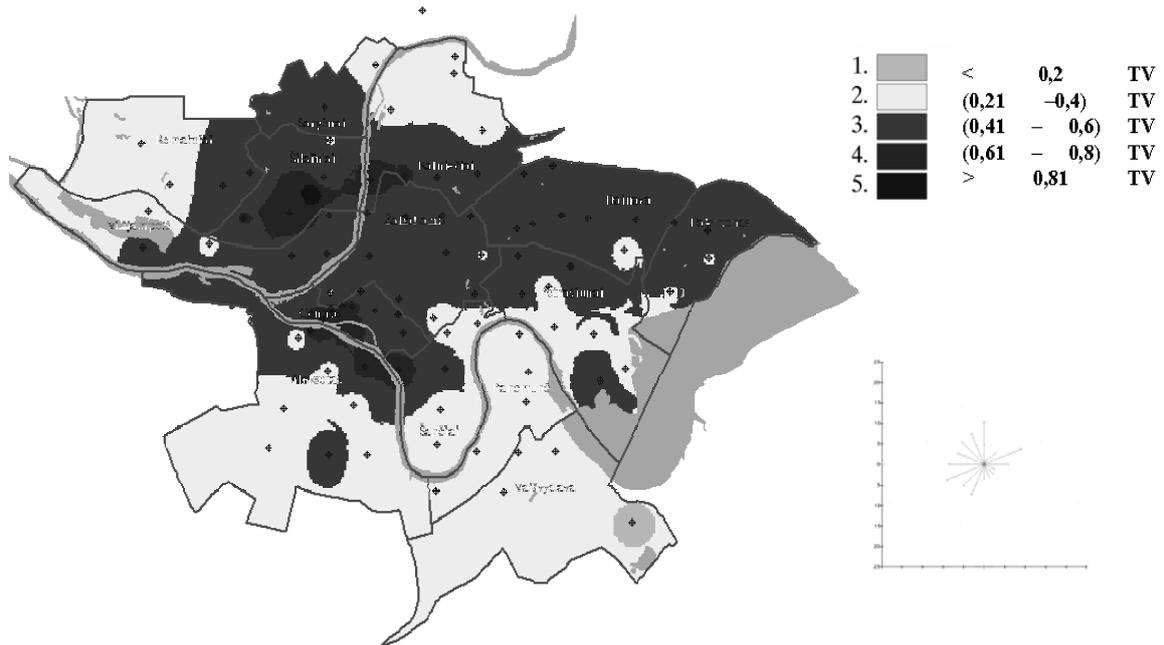


Fig. 9. Distribution of nitrogen dioxide pollution in Kaunas 2005

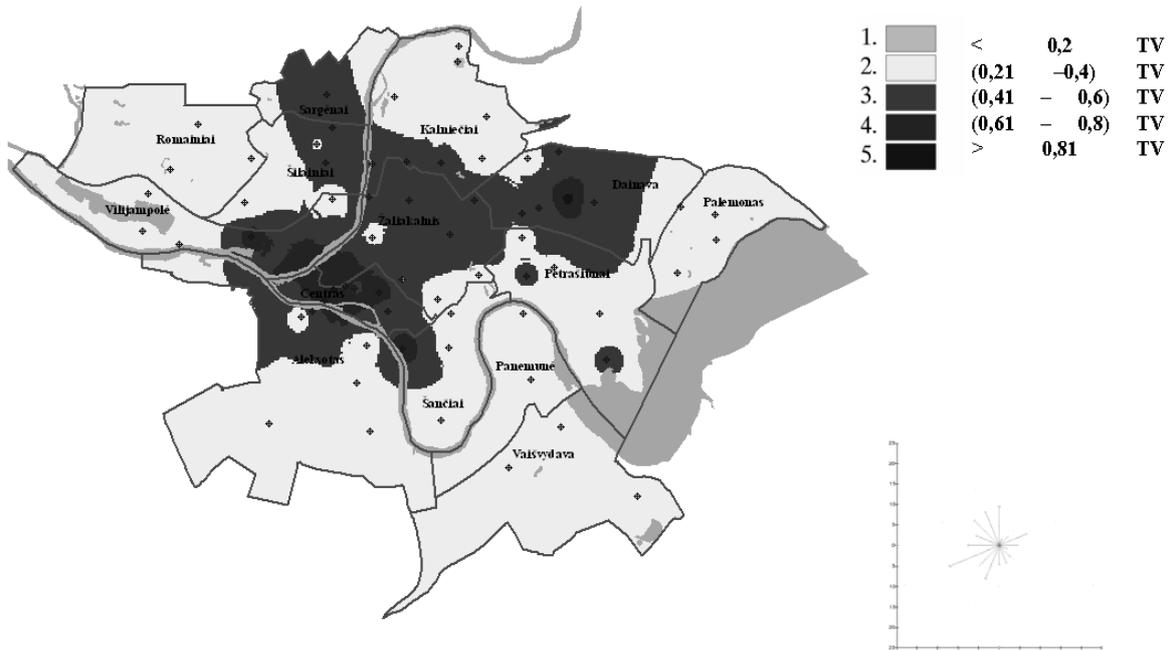


Fig. 10. Distribution of nitrogen dioxide pollution in Kaunas 2006

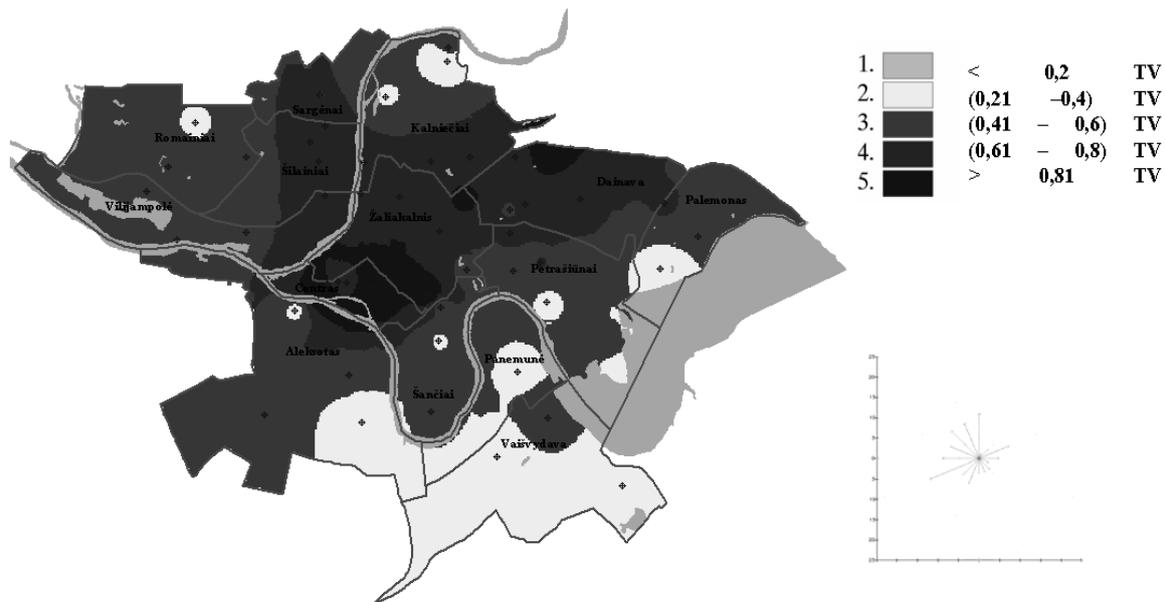


Fig. 11. Distribution of nitrogen dioxide pollution in Kaunas 2007

Big area of nitrogen dioxide exposure covered the main part of the city in 2005 (Fig. 9). Very big area of nitrogen dioxide exposure in 2005 was determined only in Centras Šilainiai and Kalniečiai districts. Medium area of nitrogen dioxide exposure covered the districts located in the periphery of the city. In 2006 medium area of nitrogen dioxide exposure covered the main part of the city. Big and very big areas of nitrogen dioxide exposure were determined in Centras, Žaliakalnis, Dainava, Sargėnai districts, a part of Aleksotas, Vilijampolė, Šilainiai and Kalniečiai districts (Fig. 10).

In 2007 there was determined the highest nitrogen dioxide pollution during the study period. The main part of the city was covered by big and very big areas of nitrogen dioxide exposure (Fig. 11). There was determined extra big area of nitrogen dioxide pollution in Centras, Žaliakalnis districts and a small field in Dainava district. It was caused by intensive traffic and unfavorable geographical position. Similar results were obtained by Costabile et al. (2006) and Jo and Park (2005). The highest concentration of nitrogen dioxide was measured in heavy-traffic streets, followed by industrial and downtown locations.

#### 4. Conclusions

The analyses presented in this article include the measurements of nitrogen dioxide concentration by a passive sampling method in Kaunas city in 2003-2007. The results have shown that average nitrogen dioxide concentration in Kaunas city in 2003-2007 was  $18.1 \mu\text{g m}^{-3}$ .

The highest seasonal nitrogen dioxide concentration was in spring  $-20.1 \mu\text{g m}^{-3}$ , the lowest - in winter  $-16.5 \mu\text{g m}^{-3}$ .

In the area of Kaunas city nitrogen dioxide dispersion is uneven. Nitrogen dioxide shows a wide range between different districts of the city. Nitrogen dioxide pollution is higher along busy roads compared to the city premises. The highest annual nitrogen dioxide concentration was in Centras ( $26.3 \mu\text{g m}^{-3}$ ), - the lowest - in Rokai ( $11.4 \mu\text{g m}^{-3}$ ).

Nitrogen dioxide concentration interpolation results have revealed, that the highest pollution was in Centras, Žaliakalnis, Dainava districts, the lowest was found in the areas lighter traffic flows and more green places. The observed nitrogen dioxide concentration is highly influenced by the traffic in the places close to the measurement site. Similar results are presented by other authors (Mazzeo et al., 2005).

Nitrogen dioxide concentration can serve as an indicator of air pollution.

#### Acknowledgments

The author would like to thank Gintautas Mozgeris who assisted in work with Arc GIS soft.

#### References

- Beckerman B., Jerrett M., Brook J. R., Verma D. K., Arain M. A., Finkelstein M. M. Correlation of nitrogen dioxide with other traffic pollutants near a major expressway. *Atmospheric Environment*, 2008, Vol. 42, p. 275-290.
- Bogo H., Gomez D.R., Reich S.L., Negri R.M., San Roman E. Traffic pollution in a down- town of Buenos Aires City. *Atmospheric Environment*, 2001, Vol. 35, p. 1717-1727.
- Carslaw D. Evidence of an increasing NO<sub>2</sub>/NO<sub>x</sub> emissions ratio from road traffic emissions. *Atmospheric Environment*, 2005, Vol. 39, p. 4793-4802.
- Costabile F., Bertoni G., Desantis F., Wang F., Weimin H., Fenglei L., Allegrini I. A preliminary assessment of major air pollutants in the city of Suzhou, China. *Atmospheric Environment*, 2006, Vol. 40, p. 6380-6395.
- Filella I, Peñuelas J. Daily, weekly, and seasonal time courses of VOC concentrations in a semi-urban area near

Barcelona. *Atmospheric Environment*, 2006, Vol. 40, p. 7752-69.

Gilbert N. L., Woodhouse S., Stieb D. M., Brook J. R. Ambient nitrogen dioxide and distance from a major highway. *The Science of the Total Environment*, 2003, Vol. 312, p. 43-46.

Gražulevičienė R., Laurinavičienė D. Ambient nitrogen dioxide dispersion in Kaunas and its relation to incidence of myocardial infarction. *Environmental research, engineering and management*, 2001, No.1 (15), p.1-6.

Janssen N.A.H., Vliet P.H.N., Aarts F., Harssema H., Brunekreef B. Assessment of exposure to traffic related air pollution of children attending schools near motorways. *Atmospheric Environment*, 2001, Vol. 35, p. 3875-3884.

Jo W. K., Park J. H. Characteristics of roadside air pollution in Korean metropolitan city (Daegu) over last 5 to 6 years: Temporal variations, standard exceedances, and dependence on meteorological conditions. *Chemosphere*, 2005, Vol. 59, p. 1557-1573.

Krochmal D, Kalina A. Measurements of nitrogen dioxide and sulphur dioxide concentrations in urban and rural areas of Poland using a passive sampling method. *Environmental Pollution*, 1997, 96:3, p. 401-407.

Parra M. A., Elustando D., Bermejo R., Santamaria J. M. *The Science of the Total Environment*, 2009, Vol. 407, p. 999-1009.

Mazzeo N. A., Venegas L. E., Choren H. Analysis of NO, NO<sub>2</sub>, O<sub>3</sub> and NO<sub>x</sub> concentrations measured at a green area of Buenos Aires City during wintertime. *Atmospheric Environment*, 2005, Vol. 39, p. 3055-3068.

Soltic P., Weilenmann M. NO<sub>2</sub>/NO emissions of gasoline passenger cars and light-duty trucks with Euro-2 emission standard. *Atmospheric Environment*, 2003, Vol. 37, p. 5207-5216.

Tran N. K., Steinberg S. M., Johnson B. J. Volatile aromatic hydrocarbons and dicarboxylic acid concentrations in air at an urban site in the Southwestern US. *Atmospheric Environment*, 2000, Vol. 34, p. 1845-52.

Tsai W.Y., Chan L. Y., Blake D. R., Chu K. W. Vehicular fuel composition and atmospheric emissions in South China: Hong Kong, Macau, Guangzhou, and Zuhai. *Atmos Chem Phys*, 2006, Vol. 6, p. 3281-8.

Velders G. J. M., Diederik H. S. M. A. Likelihood of meeting the EU limit values for NO<sub>2</sub> and PM<sub>10</sub> concentrations in the Netherlands. *Atmospheric Environment*, 2009, Vol. 43, p. 3060-3069.

Westmoreland E. J., Carslaw N., Carslaw D., Gillah A., Bates E. Analysis of air pollution within a street canyon using statistical and dispersion modeling techniques. *Atmospheric Environment*, 2007, Vol. 41, p. 9195-9205.

**Dr. Dovilė Laurinavičienė** – assoc. prof. at Vytautas Magnus University, Department of Environmental sciences.

Main research areas: assessment of environmental quality and air pollution.

Address: Vileikos str. 8  
LT-44404 Kaunas, Lithuania

Tel.: +370 37 327904

Fax: +370 37 327904

E-mail: dovile@gmf.vdu.lt

## Azoto dioksido koncentracijos pasiskirstymas Kaune 2003–2007

**Dovilė Laurinavičienė**

*Vytauto Didžiojo Universitetas*

*(gauta 2010 m. liepos mėn.; atiduota spaudai 2010 m. gruodžio mėn.)*

Šio straipsnio darbo tikslas – nustatyti oro taršą azoto dioksidu Kaune. Azoto dioksido tarša buvo nustatoma naudojant pasyvius kaupiklius. Miesto teritorijoje eksponuoti 62 bandiniai skirtingais 2003–2007 metų sezonais. Bandiniai buvo eksponuoti savaitę. Iš gautų koncentracijų matavimų apskaičiuotos vidutinė metinė ir sezoninė azoto dioksido koncentracija visame mieste ir atskiruose jo rajonuose.

Tyrimų rezultatai parodė, kad vidutinė 2003–2007 metų azoto dioksido koncentracija Kaune buvo 18,1  $\mu\text{gm}^{-3}$ . Didžiausia vidutinė sezoninė azoto dioksido koncentracija nustatyta pavasarį – 20,1  $\mu\text{gm}^{-3}$ , mažiausia nustatyta žiemą – 16,5  $\mu\text{gm}^{-3}$ . Oro taršos azoto dioksidu atžvilgiu miesto mikrorajonai buvo nehomogeniški. Didžiausia vidutinė 2003–2007 metų azoto dioksido koncentracija buvo Centre (26,3  $\mu\text{gm}^{-3}$ ).

Naudojant ArcGIS programinę įrangą, buvo sudaryti azoto dioksido koncentracijos pasiskirstymo žemėlapiai. Azoto dioksido taršos interpoliavimo rezultatai parodė, kad didesnė tarša buvo Centro, Žaliakalnio, Dainavos rajonuose, mažesnė – tuose rajonuose, kur mažesni transporto srautai ir daugiau žaliųjų plotų.

DOI: 10.5755/j01.erep.54.4.84