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# INVESTIGATION OF PARTICULATE MATTER CONCENTRATION IN THE AIR OF ŽVĖRYNAS DISTRICT IN VILNIUS

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**Abstract.** Reduction of pollution is among priority environmental problems in our country. Real-time information about the air pollution in the biggest Lithuanian cities and industrical centers is received from the air quality stations every day. It is the main method for the air quality assessment. On the basis of this information it is possible to conclude that concentration of particles in some areas exceeds allowable limits. The concentration of particles in Žirmūnai and Žvėrynas districts of Vilnius exceeds the limits too. Assessment of changes in this air quality indicator and forecasting their development is rather complicated as regular measurement of particulate matter concentration (with the particle diameter up to 10 μm) was started at Lithuanian air quality stations only in 2003. The paper describes the methodology of recording particle concentrations in Žvėrynas district of Vilnius. The results of particle measurements are compared with a maximum allowable concentration (MAC) of the analyzed pollutant, the results of analysis are given in two- and three-dimensional graphics.

**Keywords**: particulate matter (PM), ambient air pollution, concentration of particulate matter, points of measuring, cross-sections, Žvėrynas district.

## 1. Introduction

Vilnius, the major and heavily populated city, has lots of industrial and power enterprises, and high flows of transport. Thus, it encounters pollution problems that are also topical in other European cities [1].

In the biggest cities of Lithuania 75 % of pollutants are emitted into the air from road transport. Its exhaust gas getting into the ambient air contains carbon monoxide (CO), nitric oxide ($NO_x$), volatile organic compounds (VOC), heavy metals, and fine particulate matter (PM) [2]. The road transport also conditions secondary pollution resulting from dust on roads. Moreover, the data of Lithuanian air quality monitoring shows that in the places of intensive transport traffic concentration of particulate matter exceeds the limits.

Short-term but marked increase in pollutant concentration can cause acute damage to human health. Long-term increase in pollutant concentration can cause chronic diseases. To avoid or minimize damaging impact on human health, guidelines for limiting values of main pollutants (including particulate matter) in recommendations of the World Health Organization (WHO) were established, that must be achieved in certain time and not exceeded later.

Analysis of the data of the years 2003 and 2004 (air quality in Vilnius city was analysed regularly this long) revealed that in Žvėrynas district, at a low-intensity crossing of Kęstučio and Sėlių streets, maximum values of average means of a day and a year were over the valid norms. The valid norm of 2003 was exceeded in Žvėrynas on the 41st day [3]. Respectively, the valid norm of 2004 was exceeded in 53 days in Žvėrynas [4]. Assessing concentration of particulate matter according to a higher limit value that came into force in 2005, the number of cases when the norm was exceeded was even greater: in 2004 in Žvėrynas air quality station the norms were exceeded 74 days.

Thereby, according to this information, it is a very relevant problem; moreover, that under the requirements of the EU directives and national legislation, limit values with margins of tolerance (norms) were going down due to lower margin of tolerance, and in 2005 the margin of tolerance stopped to be applied. Therefore, only real time and objective finding and assessment of particulate matter concentrations can help to see the reasons for growing pollution.

The aim of this investigation is to assess the concentration of particulate matter in Žvėrynas district of Vilnius, using a real time monitor "Microdust pro" from the company Casella Ltd, and to assess pollution with PM at the most impure crossroads of Vilnius.

## 2. Methodology of investigation

Precise measuring of dust (particulate matter) concentration using the monitor "Microdust pro" is possible with the help of an optical method [5].

The monitor "Microdust pro" has the highest level of sensibility for measuring measure inspirable fractions (with the help of „Microdust pro" it is possible to measure particulate matter with a diameter from 0,1 μm to 10 μm) [6].

Places of measuring points were chosen in Žvėrynas which is one of the most impure districts of Vilnius. To form a network of measuring places, points near crossroads as well as near carriageways were chosen for measuring.

40 points for measuring PM concentration were chosen in Žvėrynas district (Fig 1).

As shown in Fig 1, the whole Žvėrynas district under investigation was divided into eleven cross-sections each of which consisted of three to five measuring points.

Measuring at each point was carried out until a stable value of PM concentration was achieved. Depending on the stability of pollutant concentration, it could be measured with a monitor within a few minutes or an hour. An important requirement was to measure in the wind direction [7]. The concentration of pollutants was measured 1,50 meter above the ground level.

Different hours of road transport intensity in the city were chosen for the investigation. In the same way concentrations of particulate matter were measured in the year 2005: on April 26, during increase in the road transport intensity from 16.45 to 19.00 in the afternoon, and on July 11 from 11.00 to 13.30 in the morning. In this part of the day the intensity of road transport was lower.

## 3. Results of investigation

The results of measuring PM concentrations at individual points during investigation are given in Figs 2–12. in the form of the above-mentioned cross-sections the number of which in Žvėrynas district was 11.

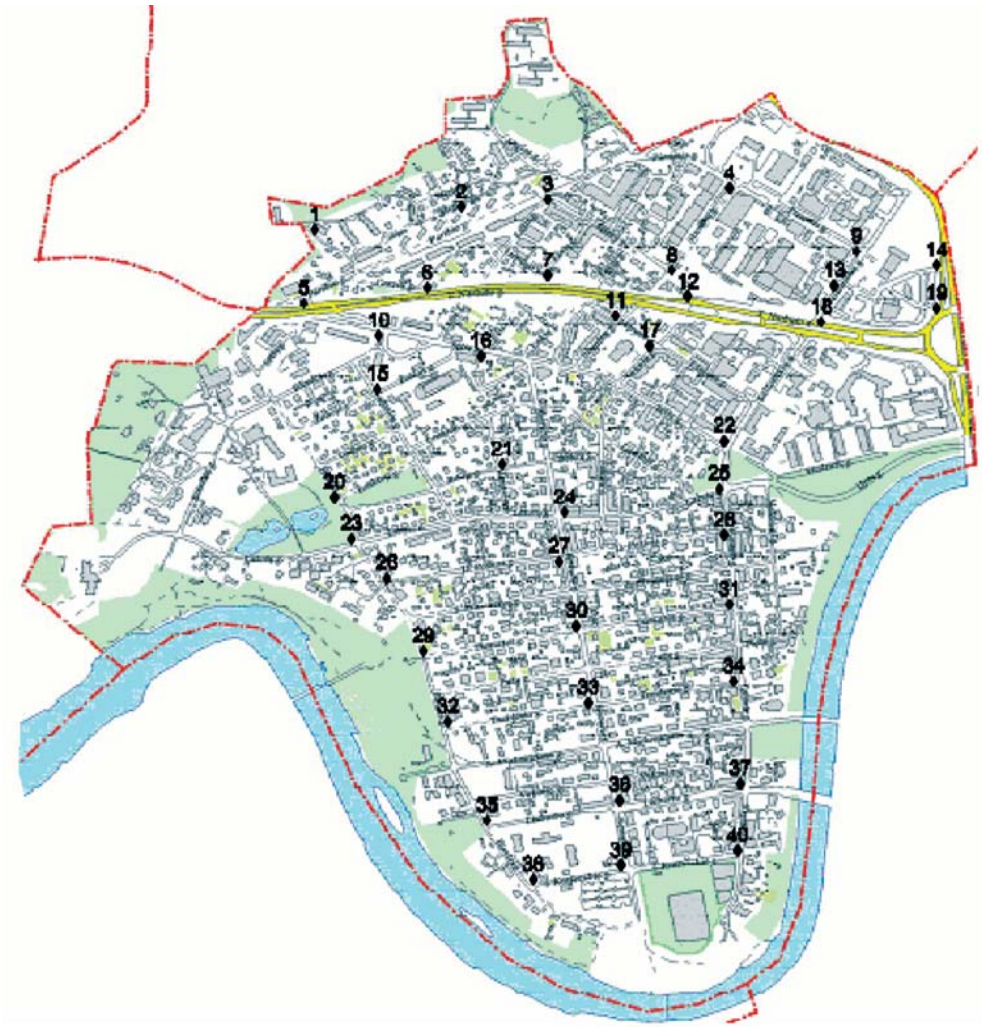


**Fig 1.** Network of measuring points for investigation of PM concentration in Žvėrynas district of Vilnius

As shown in Fig 2, concentrations of PM recorded on April 26 in Žvėrynas district at points 1 (0,540 mg/m$^3$), 2 (0,555 mg/m$^3$) and 3 (0,560 mg/m$^3$), that were located in a residential area of housing, were lower than those at point 4 (0,590 mg/m$^3$) which was located close to industrial objects.

Besides, concentrations of PM recorded in Žvėrynas in July were lower than those recorded in April; however, the same tendency was observed when concentration of pollutants under consideration in the residential area (points 1, 2 and 3) was lower (respectively, 0,380 mg/m$^3$, 0,390 mg/m$^3$, 0,410 mg/m$^3$) than that at point 4 near industrial objects (0,430 mg/m$^3$).

The highest concentration of PM recorded on April 26 within the second cross-section (Fig 3) was observed at point 7 (on the crossing of Elnių and Liepyno streets). We consider that increase in PM concentration up to 0,650 mg/m$^3$ at this point was caused by onset of wind that stirred dust on a gravel road. The lowest concentration of PM within the second cross-section recorded on April 26 was 0,560 mg/m$^3$. This pollution was measured at point 5 (on the crossing of Narbuto – Paribio streets), though at this point a high intensity of motor transport was usual. Concentration of PM at the other points of the second cross-section was very similar: at point 6 – 0,600 mg/m$^3$, at point 8 – 0,588 mg/m$^3$, at point 9 – 0,600 mg/m$^3$.

Meanwhile, on July 11 concentration of PM at point 7 (0,420 mg/m$^3$) was very similar to that at the other points of this section: at point 5 – 0,396 mg/m$^3$, at point 6 – 0,420 mg/m$^3$, at point 8 – 0,410 mg/m$^3$, at point 9 – 0,422 mg/m$^3$. The same as in the first cross-section, concentration of PM within the second cross-section was lower in July than in April. It was presumably caused by stove heating inside houses, as the air temperature at the time of measurements was only 11 °C above zero, and Žvėrynas district has a great number of private houses. Meanwhile, the air temperature during measurements was 25 °C above zero in July.

Another reason for increase in PM concentration could be dust particles and salts that were used at wintertime.

The highest concentration on April 26 between 16.45 and 19.00 in the afternoon within the third cross-section (Fig 4) was observed at point 14 (0,660 mg/m$^3$) that was near the exit from the business centre Hanner. When measuring at that point, a traffic jam was observed which could cause an increase in PM concentration. At the other points PM concentration was very similar.

As shown in Fig 4, PM concentration on July 11 between 11.00 and 13.30 in the morning at all the points within the third cross-section was similar and varied from 0,410 mg/m$^3$ (at point 11) to 0,423 mg/m$^3$ (at point 13).

As shown in Fig 5, a maximum measured concentration of PM within the fourth cross-section both in April and July was observed at point 19 (respectively, 0,608 mg/m$^3$ and 0,425 mg/m$^3$) near the transport hub. Slightly lower concentration was recorded at point 18 (0,602 mg/m$^3$ in April, 0,424 mg/m$^3$ in July), where works of destruction and

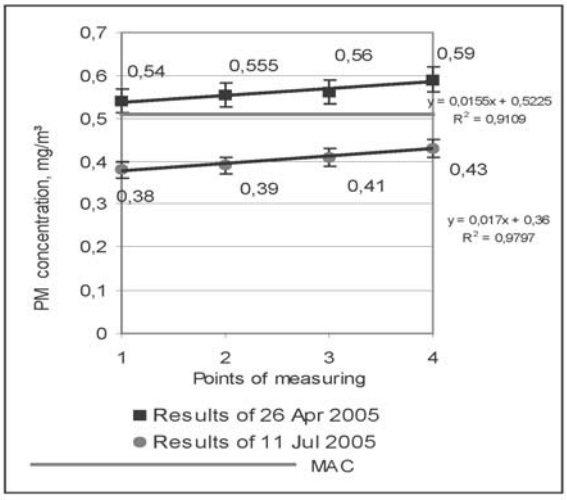


**Fig 2.** Results of PM concentration measurement within the first cross-section in Žvėrynas district, mg/m$^3$

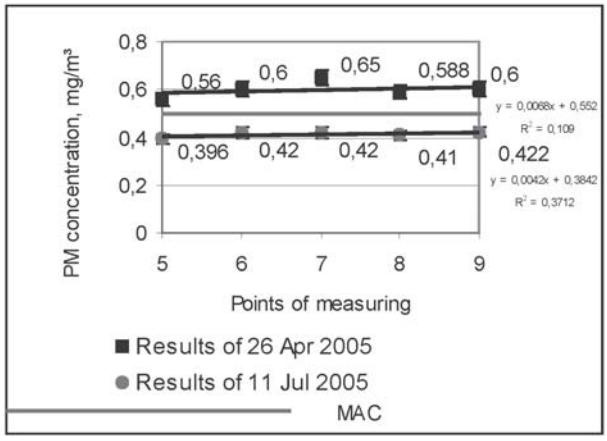


**Fig 3.** Results of PM concentration measurement within the second cross-section in Žvėrynas district, mg/m$^3$

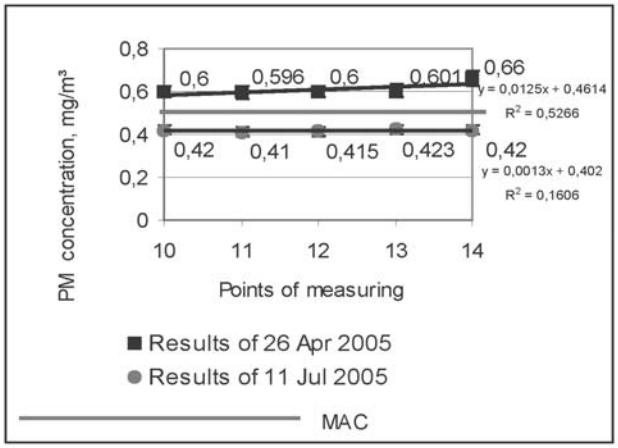


**Fig 4.** Results of PM concentration measurement within the third cross-section in Žvėrynas district, mg/m$^3$

building (near the former Milk Processing Company) were being carried out in the days of measurements. Point 16 within this cross-section was special due to the vicinity of an air quality station of Žvėrynas (on the crossroad Kęstučio and Sėlių streets).

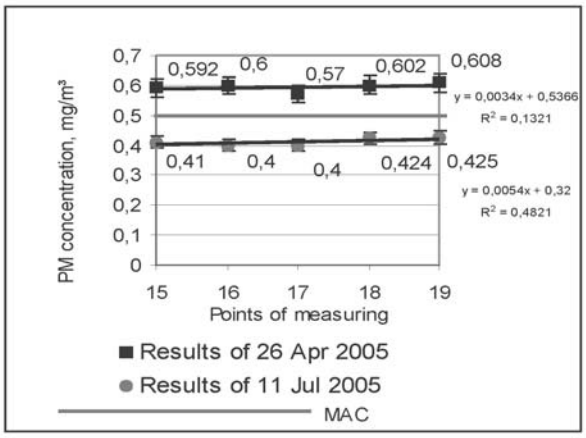


**Fig 5.** Results of PM concentration measurement within the fourth cross-section in Žvėrynas district, mg/m$^3$

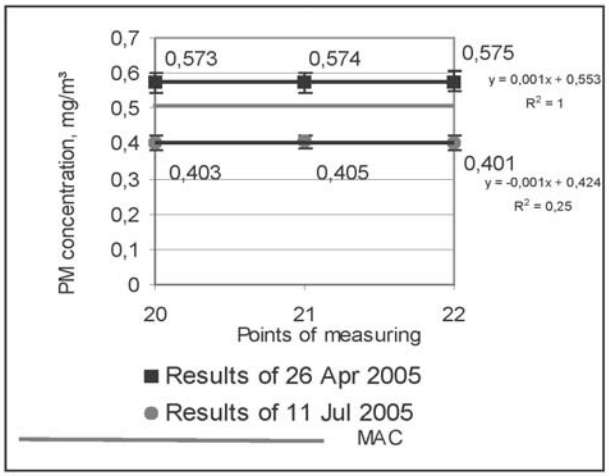


**Fig 6.** Results of PM concentration measurement within the fifth cross-section in Žvėrynas district, mg/m$^3$

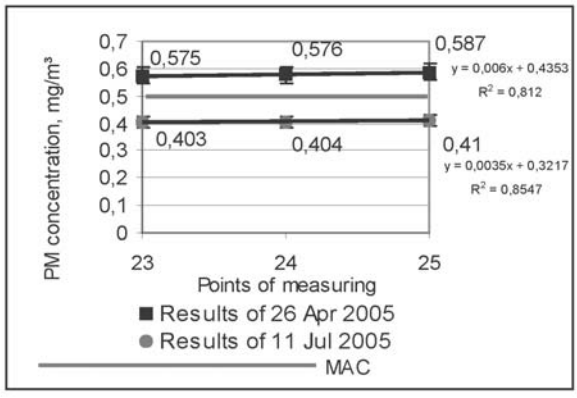


**Fig 7.** Results of PM concentration measurement within the sixth cross-section in Žvėrynas district, mg/m$^3$

As within all the above-mentioned cross-sections, PM concentrations within the fourth section measured in July were lower than those measured in April. The main reasons for increase in the concentration of the main pollutant were described above.

The results of PM concentration measurement within the fifth cross-section were almost the same. A slightly higher concentration at point 22 was recorded in April, as a big traffic jam was observed there during measurements, which could have influenced increase in concentration up to 0,575 mg/m$^3$.

Similar results were achieved within the sixth cross-section (Fig 7). The highest concentration was recorded on the crossing of Latvių and Vytauto streets at point 25 (concentration on April 26 was 0,587 mg/m$^3$ and on July 11 it was 0,410 mg/m$^3$). We consider that increase in concentration was conditioned by the same reasons that were described above at point 22, as at the moment of measurements transport traffic there was very intensive.

In Fig 8, that shows PM concentrations within the seventh cross-section in Žvėrynas district, increase of the pollutant in question was recorded on the crossing of Poškos and Vytauto streets, i e at point 28 (0,595 mg/m$^3$ in April, and 0,412 mg/m$^3$ in July). On the crossing of Poškos and Kęstučio streets (point 27), that was characterized as a street with a more intensive transport traffic, concentration of the pollutant in question was slightly lower (respectively, 0,570 mg/m$^3$ and 0,400 mg/m$^3$). Again, we can note that PM concentration is higher at springtime.

From Fig 9 we can conclude that PM concentrations measured within the eighth cross-section were very similar to those within the seventh cross-section that are shown in Fig 8. Increase in pollution within the eighth cross-section was recorded on the crossing of Treniotos and Vytauto streets (at point 31). A slightly lower concentration of PM was recorded on the crossing of Treniotos and Kęstučio streets (point 30).

Within the ninth cross-section (Fig 10) the highest PM concentration was recorded on the crossing of Kęstučio – Traidenio streets at point 33 (0,613 mg/m$^3$ in

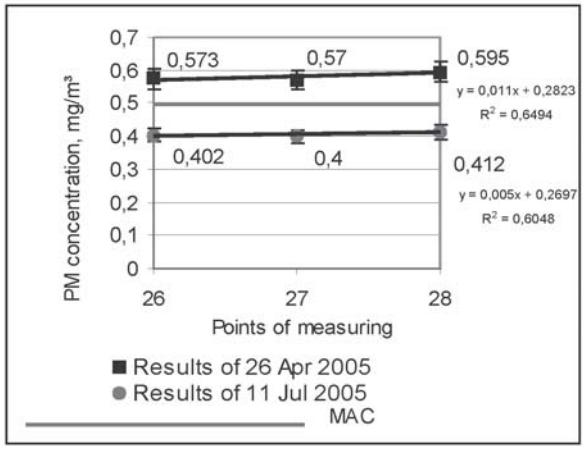


**Fig 8.** Results of PM concentration measurement within the seventh cross-section in Žvėrynas district, mg/m$^3$

April, 0,421 mg/m$^3$ in July). We consider that concentration of the pollutant in question was higher at this point as the intensity of motor transport was higher on Kęstučio street due to public transport.

The lowest PM concentration was recorded on the crossing of Traidenio and Birutės streets (point 32). The latter point was within a good distance from streets with a higher intensity of transport, but pollution was measured along the wind direction that stirred dust on a non-asphalted road.

Fig 11 shows PM concentrations within the tenth cross-section. The highest and lowest values of concentrations on both April 26 and July 11 were determined on analogous crossroads as those within the ninth cross-section (Fig 10), i e the highest concentration recorded on the crossing of Liubarto and Kęstučio streets (point 36) and the lowest concentration recorded on the crossing of Birutės and Liubarto streets (point 35). On the crossing of Kęstučio street increase in PM concentration was observed, as mentioned, due to an intensive transport traffic along Kęstučio street.

The lowest concentration of the pollutant in question both in spring and summer was recorded on the crossing of Birutės and Liubarto streets (point 35) which is a bit further from the streets of an intensive motor transport traffic.

The results of PM concentration measurement within the last cross-section of the network of measuring points in Žvėrynas are given in Fig 12. The highest concentration within this cross-section was recorded at the last point (point 40), i e on the crossing of Kraševskio and Kęstučio streets, and reached 0,572 mg/m$^3$ in April, and 0,402 mg/m$^3$ in July.

The lowest concentration of the pollutant in question was recorded at point 38 (the crossing of Birutės and Kraševskio streets). As it was mentioned before, Birutės street was further from the main streets that were characterized as streets with a high intensity of motor transport, so the concentrations of PM on crossings with this street were usually lower.

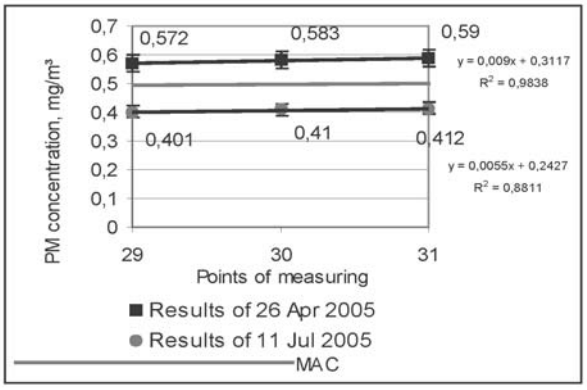


**Fig 9.** Results of PM concentration measurement within the eighth cross-section in Žvėrynas district, mg/m$^3$

Just like all the above results (Figs 2–11) achieved when measuring PM concentration in Žvėrynas district, the results given in Fig 12 show that PM concentration was lower in July.

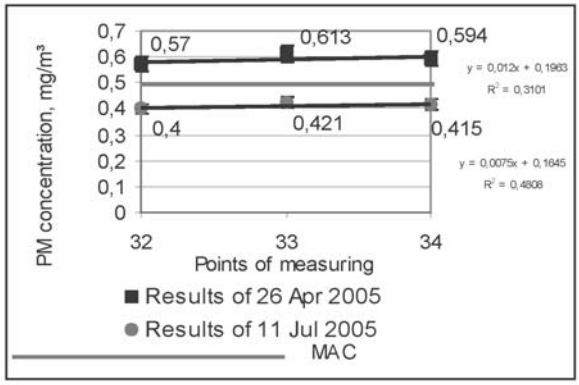


**Fig 10.** Results of PM concentration measurement within the ninth cross-section in Žvėrynas district, mg/m$^3$

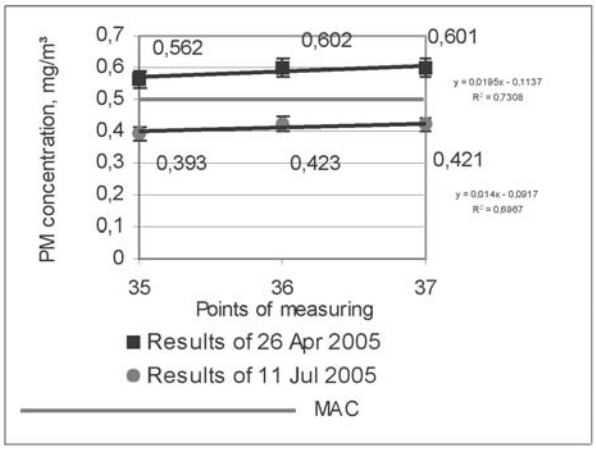


**Fig 11.** Results of PM concentration measurement within the tenth cross-section in Žvėrynas district, mg/m$^3$

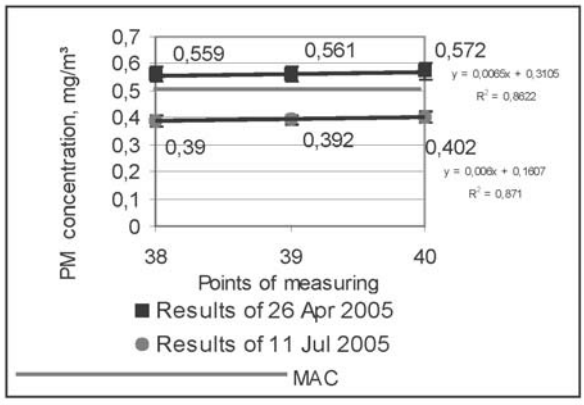


**Fig 12.** Results of PM concentration measurement within the eleventh cross-section in Žvėrynas district, mg/m$^3$

The results of investigation in Žvėrynas district are presented in three-dimensional graphics below. It was done with the help of SURFER software. SURFER software is designed to create all types of maps. It is a program that is designed to compose plans of surfaces and contours using a mesh of coordinates. All the maps of surfaces and contours can be composed of lots of values. With the help of this program, it is possible to create a map of the ground surface, at the same time presenting values of a certain pollutant (in this case – particulate matter) [8].

PM concentrations measured in Žvėrynas district on April 26 are given in Fig 13, while those measured in July are given in Fig 14.

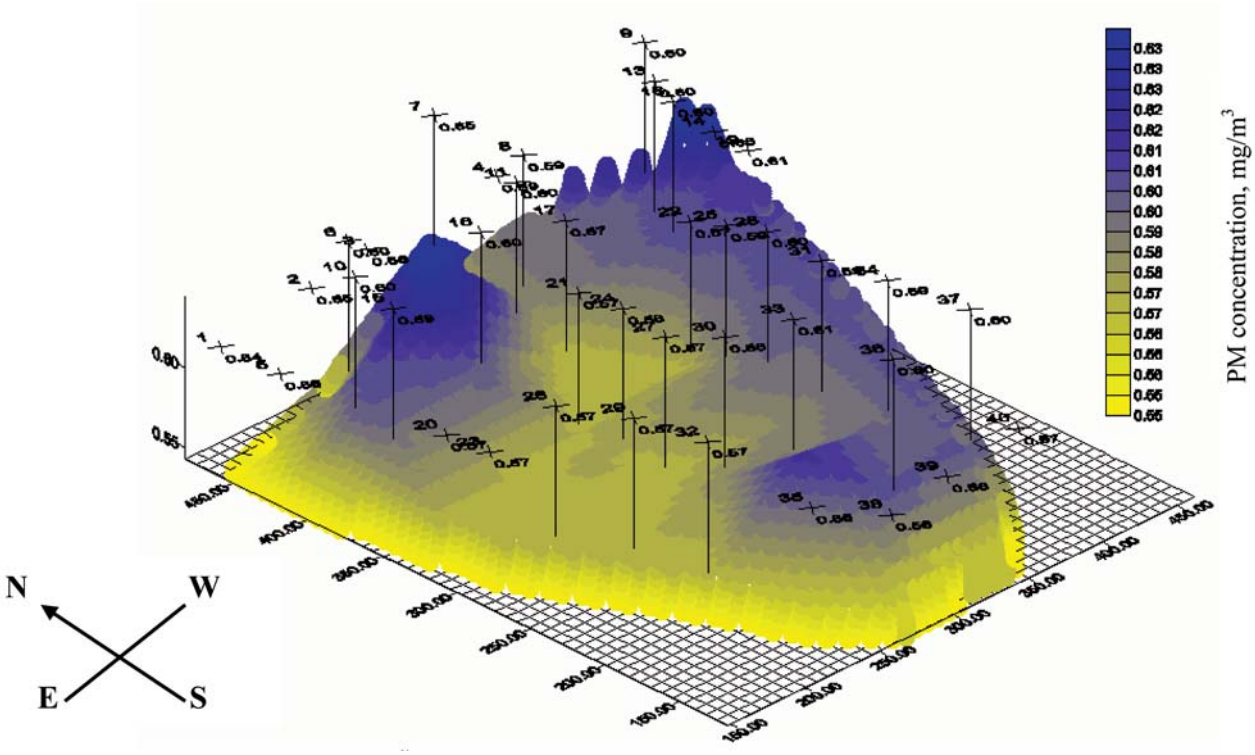


**Fig 13.** Concentrations of PM in Žvėrynas district on April 26, 2005

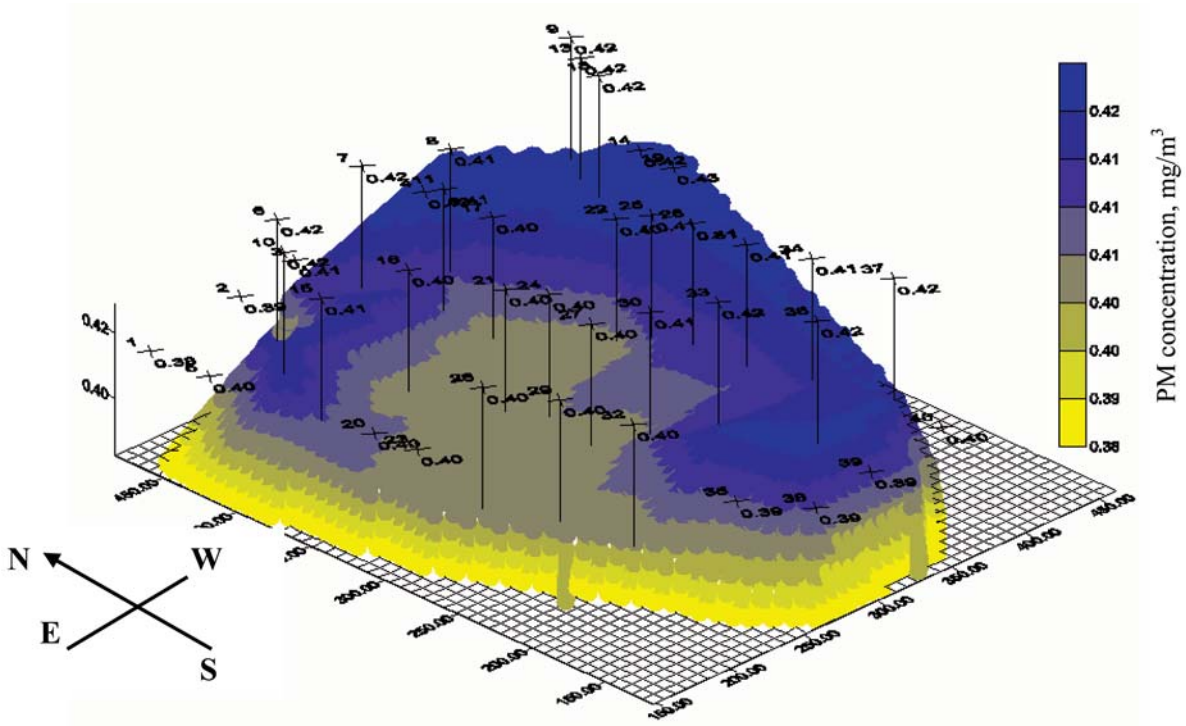


**Fig 14.** Concentrations of PM in Žvėrynas district on July 11, 2005

Some peaks in the three-dimensional graphics, that are shown above, could be seen. Peaks represent higher concentrations of PM in Žvėrynas district. It is possible to segregate zones that are near industrial objects (JS Company Vilniaus Pergalė), zones that are near objects of destruction and building (the former Milk Processing Company) and near streets with a high intensity of motor transport (Narbuto, Kęstučio, Vytauto streets).

## 4. Conclusions

1. The measurements of PM in Žvėrynas district reveal that the concentration of the pollutant in question exceeds the concentration of PM measured at Žvėrynas air quality station during investigation hours. The reason for this is the fact that the concentration of PM was measured 1,50 meter above the ground level during investigation, while the concentration of PM was measured 4 meters [9] above the ground level at Žvėrynas air quality station.

2. In summer, on July 11, the concentration of the polutant in question did not exceed a single maximum allowable concentration [10], while on April 26 this level was exceeded.

3. Comparing each value of PM concentration measured on April 26 and the lowest value (0,540 mg/m$^3$) recorded on that day, it could be seen that the ratio of values differed from 1,02 to 1,22 times. Respectively, the ratio of each value of PM concentration recorded on July 11 and of the lowest value (0,380 mg/m$^3$) recorded on that day differed from 1,03 to 1,12 times. Thus, the ratio of each value of PM concentration and of the lowest PM concentration was very similar both at springtime and summertime.

4. Comparing each value of PM concentration recorded on April 26 and of the highest value (0,660 mg/m$^3$) that was fixed on that day, it could be seen that the ratio of values differed from 0,82 to 0,93 times. Respectively, the ratio of each value of PM concentration recorded on July 11 and of the highest value (0,425 mg/m$^3$) recorded on that day differed from 0,89 to 0,99 times. Thus, the ratio of each value of PM concentration and of the highest PM concentration was very similar both at springtime and summertime.

5. The ratio with a maximum allowable concentration (MAC) of PM (0,5 mg/m$^3$) in April differed from 1,08 to 1,32 times, i e MAC was exceeded.

6. The ratio with MAC of PM (0,5 mg/m$^3$) differed from 0,76 to 0,85 times, i e MAC was not exceeded.

7. Higher PM concentrations were recorded on crossings in comparison with the results that were received when measuring PM concentrations near carriageways. Moreover, higher concentrations of the pollutant in question were measured on crossroads with a higher intensity of motor transport. Increase in PM concentration was observed close to destruction and building works too.

8. Increase in PM concentration was caused by the wind that stirred up dust on a non-asphalted road in places with a lower intensity of motor transport.

9. Lower PM concentrations were recorded within sections of block dwelling houses, further from industrical objects and main streets.

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## KIETŲJŲ DALELIŲ KONCENTRACIJOS ORE ŽVĖRYNO MIKRORAJONE VILNIUJE TYRIMAI

**P. Baltrėnas, J. Morkūnienė**


S a n t r a u k a

Mažinti taršą yra vienas prioritetinių aplinkosaugos uždavinių mūsų šalyje. Kiekvieną dieną iš aplinkos oro kokybės kontrolės stočių, įrengtų didžiausiuose Lietuvos miestuose ir pramonės centruose, gaunama operatyvi informacija apie taršą Vilniaus ir Kauno aglomeracijų bei likusios zonos teritorijose. Tai yra pagrindinis oro kokybės vertinimo metodas. Remiantis aplinkos oro kokybės tyrimo stočių informacija, galima daryti išvadą, kad kietųjų dalelių koncentracija tam tikruose rajonuose

dažnai viršija leistinąsias normas. Vieni iš tokių yra ir Vilniaus Žirmūnų bei Žvėryno mikrorajonai. Vertinti šio aplinkos oro kokybės indikatoriaus kaitą ir prognozuoti jo raidą gana sunku, nes tik 2003 m. Lietuvos aplinkos oro kokybės tyrimų stotyse kietųjų dalelių, kurių skersmuo ne didesnis kaip 10 μm, koncentracija pradėta matuoti reguliariai.

Straipsnyje pateikta kietųjų dalelių koncentracijos nustatymo Žvėryno mikrorajono aplinkos ore metodika, aprašytos vietos, kuriose matuota kietųjų dalelių koncentracija. Kietųjų dalelių kiekių matavimo duomenys palyginti su nagrinėjamojo teršalo vienkartine didžiausia leistinąja koncentracija (DLK), tyrimo rezultatai pateikti grafiškai dvimatėje ir trimatėje erdvėje.

**Prasminiai žodžiai:** kietosios dalelės, aplinkos oro tarša, kietųjų dalelių koncentracija, matavimo taškai, pjūviai, Žvėryno mikrorajonas.

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