ISSN 1648–6897
JOURNAL OF ENVIRONMENTAL ENGINEERING AND LANDSCAPE MANAGEMENT
http:/www.vtu.lt/english/editions

2005, Vol XIII, No 1, 17–22

INVESTIGATION OF ENVIRONMENTAL AIR POLLUTION AND ITS CHANGE ASSESSMENT IN ŠIAULIAI

Leonas Paulauskas[1], **Robertas Klimas**[2]

[1] Dept of Applied Art and Technologies, Šiauliai University,
Vytauto g. 84, LT-78360 Šiauliai, Lithuania. E-mail: albinas@cr.su.lt
[2] Šiauliai Municipal Environmental Research Laboratory,
Gegužių g. 94, LT-78365 Šiauliai, Lithuania. E-mail: matlsiauliai@takas.lt

Received 26 Oct 2004; accepted 12 Nov 2004

Abstract. Air pollution is one of the main reasons of pulmonary diseases, malignant tumours, allergic and other chronic deceases. In 2003, with the help of a mobile laboratory, investigation on air pollution and its distribution in Šiauliai city environment was accomplished. Measurements were performed once a month in exploratory positions deployed at 1 km intervals one from another. Average onetime annual pollutant concentration was measured, estimating one square kilometer. Concentration of CO in Šiauliai surroundings varied from 0,5 mg/m³ to 5,8 mg/m³ or by 51 % of Šiauliai area varied from 0,8 mg/m³ to 1,4 mg/m³. Concentration of NO_2 varied from 0,005 mg/m³ to 0,84 mg/m³ or by 57 % of the city area it varied from 0,010 mg/m³ to 0,020 mg/m³. Concentration of NO varied from 0,003 mg/m³ to 0,495 mg/m³. Concentration of SO_2 varied from 0,0015 mg/m³ to 0,012 mg/m³. Concentration of O_3 varied from 0,022 mg/m³ to 0,134 mg/m³. The total concentration of hydrocarbons varied from 1,5 ppm to 3,5 ppm. The highest level of pollution was observed in the central part of the city.

Keywords: environmental air pollution, maximum permissible pollutant concentration (MPPC), carbon monoxide (CO), nitric oxides (NO, NO_2), ozone (O_3), sulphur dioxide (SO_2), measurement interval, pollutant concentration.

1. Introduction

Human activities in harmony with nature have a great impact on person's health and on the quality of life [1]. The main requirements for a healthy environment were set in the United Nations Movement Programme (Agenda 21) in 1992. The first one among them is fresh air. This is a fundamental component of the environment sustaining life. We filtrate 12 m³ of it trough our lungs every day. Constantly respiring polluted air, noxious substances are gradually accumulating in our organisms, and that is one of the main reasons of pulmonary deceases, malignant tumours, allergic and other chronic diseases [1, 2].

According to the World Health Organization statistics, 1500 mln people live in cities with high air pollutant concentrations, hazardous to people [3, 4]. One of the main principles while developing cities in chime is ecological thinking [3, 5]. This is a complex system which consists of energy, natural resources and pollution. In 2003 in Šiauliai stationary polluters (44 reporting enterprises) discharged 1303 t of pollutants, 344 t of which were carbon monoxides, 160 t – nitric oxides, 5,4 t – sulphur dioxides [6]. One of the biggest stationary environment polluters is power industry. In Šiauliai they are boiler-houses. The dislocation of the biggest polluters in Šiauliai in 2003 is shown in Table 1, and their total amount of exhausted pollutants during one year are presented in the Table.

Table 1. Total amount of pollutants discharged by the biggest polluters in Šiauliai in 2003

Conditional polluter denotation in Fig 1	Total amount of pollutants discharged in 2003, tons
1	330,6
2	96,0
3	37,0
4	21,5
5	17,1
6	12,5
7	12,4
8	12,1
9	11,6
10	10,4

The biggest stationary polluters are situated in the southern and northern industrial districts of the city.

Discharge of pollutants into the atmosphere, because of economic depression and more efficient consumption of energetic resources, declined 3 times during the last ten years, and from stationary polluters – 5 times [7]. Though, production energy expenditures and air pollution quotas, while making one unit of gross national product, in comparison with other European countries, so far is 1,5–2 times bigger. It is quite often perceptible, that the increase of nitric dioxides in the air and dust concentration is influenced by old and inefficient traffic regulation systems and by increasing number of cars in tows, including Šiauliai [7–10].

Atmosphere pollution in Lithuania is also influenced by the transportation of distant masses of polluted air from other countries. Lithuania is on the motional way of polluted air concentrations.

The main act of law, regulating protection of air quality in Lithuania, is the Law of Environment on Air Protection (14 November 1999, No 7 – 1392). It determines the human right to fresh air, duty to prevent air pollution induced by human activities and to reduce their effects on human health and environment [11]. The Law conveys the essential principles of the EU Environmental Protection Plan and directives of the Air Sector. Moreover, it reflects air protection and its quality regulation requirements. The Environment Monitoring Law of the Republic of Lithuania (20 November 1997, No 8 – 529) regulates the environment monitoring control, data quality securing, environment monitoring informational data standardization, accumulation and saving. While performing the state air monitoring program, air quality investigation is performed at an air quality study station which is equipped with modern, according to EU requirements, installation. Air pollutant concentration is measured uninterruptedly for twenty-four hours a day.

The objectives of the investigation are to analyse pollution of Šiauliai with CO, NO, NO_2, SO_2, O_3 and with total amount of hydrocarbons, to evaluate pollutant dispersal and pollution alternation tendencies.

2. Investigation methodology

Environmental air quality measurements are performed at a fixed station, i e in one steady place. With the purpose of evaluating the discharge of pollutants in the city area, measurements must be performed periodically at gradually distributed places.

Environmental air pollution measurements were performed with the help of a mobile laboratory installed in a minibus “Daimler Benz 709D” which included:

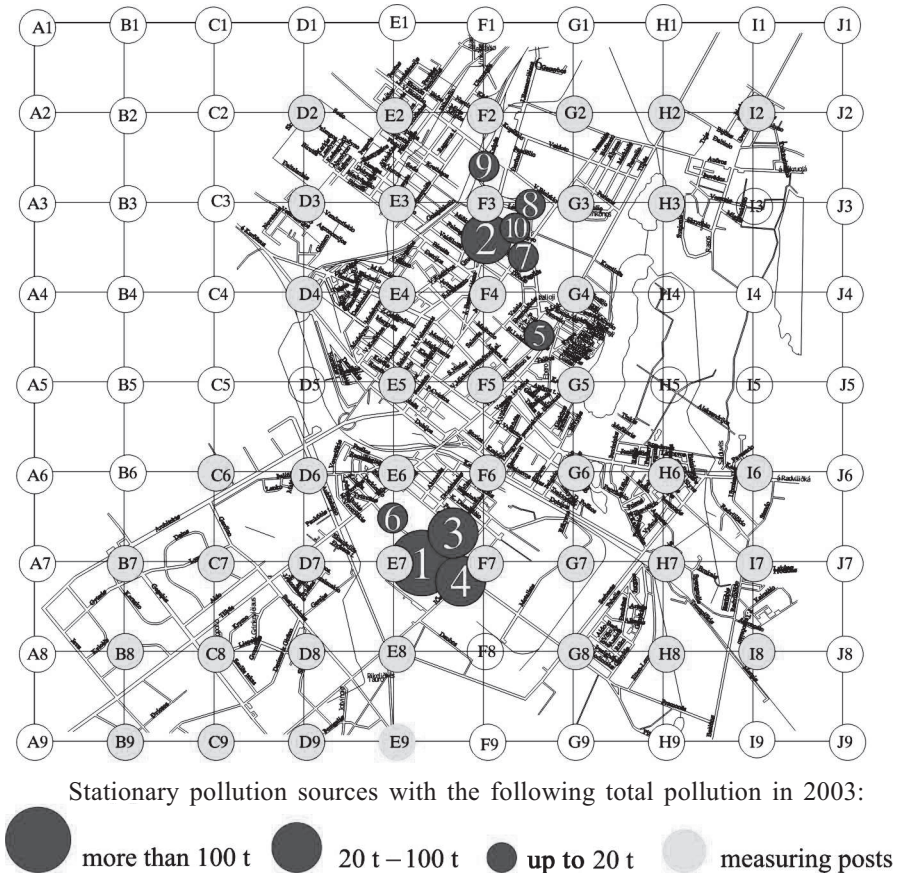

Fig 1. Location scheme of itinerary posts and stationary polluters during environmental investigation with mobile laboratory

1. "Therma electron Instruments" GFC carbon monoxide (CO) in the environment air analyzer MODEL 48, measuring interval 0–1000 ppm (parts per million).

2. "Environment SA" chemiliuminiscensic nitric oxides (NO, NO_2) analyzer AC 30M, measuring interval 0–10 ppm.

3. "Dasibi Environmental Corp" ozone (O_3) analyzer 1008, measuring interval 0,1 ppm.

4. "Monitor Labs" sulphur dioxide (SO_2) analyzer MODEL 8850, measuring interval 0,10 ppm.

5. "Heriba" environment hydrocarbons (methane, the total concentration of hydrocarbons) analyzer APHA – 300E, measurement interval 0,50 ppm.

During measurements at the dimensional places, in parallel the following meteorological conditions were fixed: temperature, wind speed, direction pressure and humidity.

The scheme of the investigation was arranged according to Nuremberg (Germany) chemical investigation practice in performing the assessment of environmental air quality with the help of a mobile laboratory. In accordance with that, the map of Šiauliai territory is overlaid with a 1 km interval grid (Fig 1), itinerary measuring posts were installed at the nodal points.

The work schedule at the itinerary posts was arranged so, that 12 measurements were performed in every nodal post during the year. The total number of such posts is 48. After the fulfillment of all the work schemes, using a computer programme "ANACOMP", an average air pollution was calculated in an area of one square kilometer.

The estimated air pollutant concentrations were compared with Lithuanian Hygiene Norms HN 35:2002 Living Environment Air Pollutant Concentration Marginal Values. They are one-time and measured for twenty-four hours MPV (MPV is the air pollution marginal value in the living environment, set from a sample taken during some period of time. One-time MPV is a marginal pollution value set from a sample taken in the living environment during 20–30 minutes). Measured marginal values are listed in Table 2.

Table 2. Marginal values of environmental air pollutants

No	Substance name	The highest permissible concentration, mg/m³	
		one-time	during 24 h a day
1.	Carbon monoxide (CO)	5	3
2.	Nitric oxide (NO)	0,4	0,06
3.	Nitric dioxide (NO_2)	0,085	0,040
4.	Sulphur dioxide (SO_2)	0,50	0,15
5.	Ozone (O_3)	0,16	0,03

3. Investigation results and analysis

The data of environmental air investigation with the help of a mobile laboratory in Šiauliai in 2003 are available on the site www.Siauliai.lt

Carbon monoxide (CO). An average distribution of CO concentration in Šiauliai environment in 2003 is presented in Fig 2.

One-time concentration of CO in the environment of the city varied from 0,5 mg/m³ to 5,8 mg/m³, i e from 0,1 MPV to 1,16 MPV. The highest one-time concentration of CO was registered on the 15th of October in the environment areas E2, E3, F2, F3 and E5, E6, F5, F6.

After dividing an average annual change interval of CO concentration into 8 parts (each of 0,2 mg/m³), the following territorial division of the city was obtained in percentage: CO concentration from 0,6 mg/m³ to 0,8 mg/m³ is 9 % of the city area; from 0,8 mg/m³ to 1,0 mg/m³ – 21 %; from 1,0 mg/m³ to 1,2 mg/m³ – 24; from 1,2 mg/m³ to 1,4 mg/m³ – 16 %; from 1,4 mg/m³ to 1,6 mg/m³ – 15 %; from 1,6 mg/m³ to 1,8 mg/m³ – 11 %; from 2,0 mg/m³ to 2,4 mg/m³ – 1%. In 51 % of the city area CO concentration varies from 0,8 mg/m³ to 1,4 mg/m³.

An average annual concentration of CO in the environmental air of Šiauliai in 2003 increased by 3 % in comparison with 2002.

Nitric Dioxide (NO_2). An average concentration distribution of NO_2 in the environment of Šiauliai in 2003 is listed in Fig 3. One-time concentration of NO_2 in the environment of the city varied from 0,005 mg/m³ to 0,084 mg/m³, i e from 0,06 MPV to 0,99 MPV. The highest one-time concentration of NO_2 was registered in June in the environment of areas E5, E6, F5, F6, i e in the central part of the city.

After dividing an average annual change interval of NO_2 concentration into 8 parts (each of 0,005 mg/m³), the following territorial division of the city was obtained in percentage: NO_2 concentration from 0,001 mg/m³ to 0,0015 mg/m³ is 17 % of the city area; from 0,015 mg/m³ to 0,020 mg/m³ – 18 %; from 0,20 mg/m³ to 0,025 mg/m³ – 24 %; from 0,025 mg/m³ to 0,030 mg/m³ – 8 %; from 0,030 mg/m³ to 0,035 mg/m³ – 18 %; from 0,035 mg/m³ t 0,040 mg/m³ – 13 %; from 0,040 mg/m³ to 0,045 mg/m³ – 2 %; 0,045 mg/m³ and a higher concentration is 2 % of the city area. In 57 % of the city area NO_2 concentration in the air varies from 0,010 mg/m³ to 0,020 mg/m³.

An average annual concentration of NO_2 in the environmental air of Šiauliai in 2003 increased by 2 % in comparison with 2002.

Nitric oxide (NO). One-time concentration of NO in the environment of the city varied from 0,003 mg/m³ to 0,495 mg/m³, i e from 0,07 MPV to 1,24 MPV. The highest concentration of NO was registered in August in the environment of areas E5, E6, F5, F6.

An average annual concentration of NO in the environmental air of Šiauliai in 2003 increased by 3 % in comparison with 2002.

Sulphur dioxide (SO_2). One-time concentration of SO_2 in the environment of the city area varied from 0,0015 mg/m³ to 0,012 mg/m³, i e from 0,003 MPV to

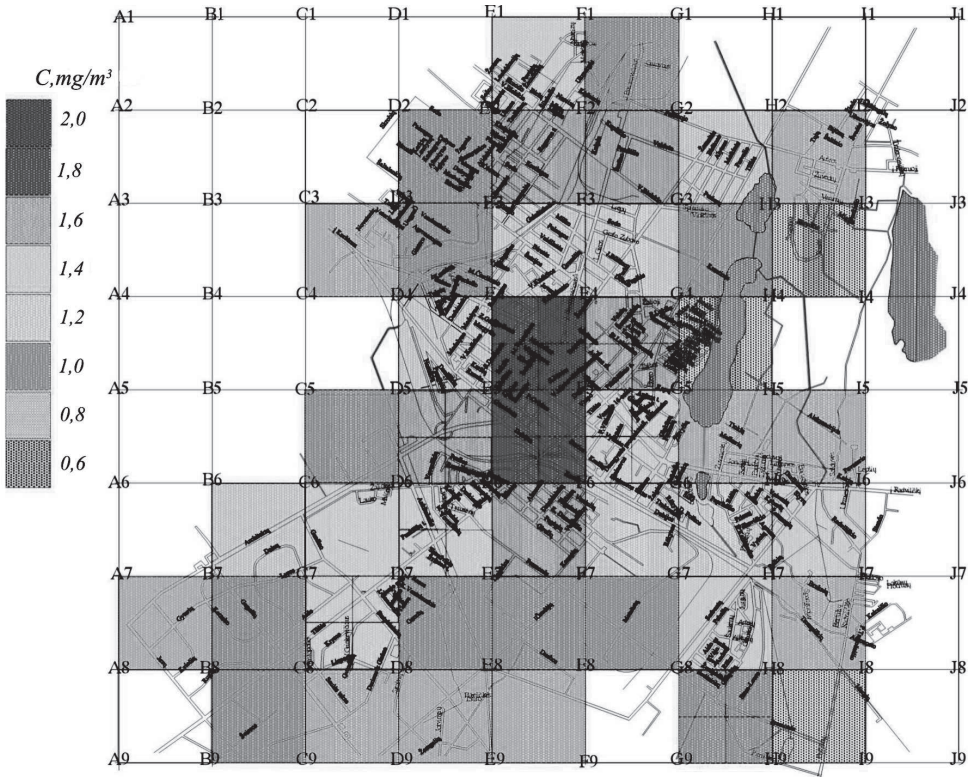

Fig 2. Average distribution of CO concentration in environmental air of Šiauliai in 2003

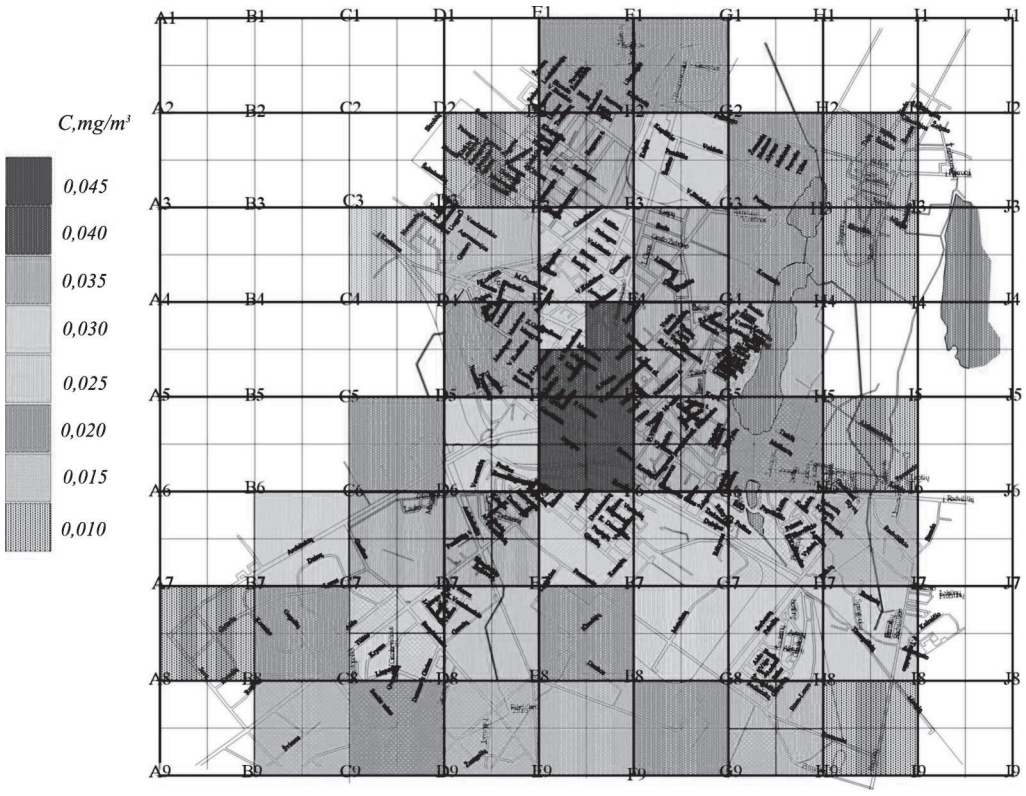

Fig 3. Average distribution of NO_2 in environmental air of Šiauliai in 2003

0,024 MPV. The highest one-time concentration of SO_2 was registered in December in the environment of areas D4, D5, E4, E5.

An average annual concentration of SO_2 in the environmental air of Šiauliai in 2003 decreased by 2 % in comparison with 2002.

Ozone (O_3). One-time concentration of O_3 in the environment of the city area varied from 0,022 mg/m³ to 0,134 mg/m³, i e from 0,14 MPV to 0,84 MPV. The highest one-time concentration of the O_3 was registered in March in the environment of areas F1, F2, G1, G2.

An average annual concentration of O_3 in the air of the city increased by 3 % in 2003 in comparison with 2002.

Total amount of hydrocarbons (THC). One-time concentration of THC in the air of Šiauliai environment varied from 1,5 ppm to 3,5 ppm, i e from 0,3 MPV to 0,7 MPV. The highest concentration was registered in November and December in the environment areas E2, E3, F2, F3 and G3, G4, H3, H4. One-time concentration of methane (CH4) varied from 1,4 ppm to 2,1 ppm. Concentration of non-methane hydrocarbons (NMHC) varied from 0,025 ppm to 1,7 ppm. An average annual concentration of the total of hydrocarbons increased by 4 % in 2003 in comparison with 2002. The highest concentration of pollutants was registered in the central part of the city in 2003 where there are no big stationary pollution sources. The main polluter here is motor-transport. Pollution increase from 2 % to 5 % in 2003 was caused by intensification of motor-transport which increased from 8 % to 10 %. The second most highly polluted environment of the city is the northern industrial district, the third one – the southern industrial district of the city. Here the main polluters are stationary pollution sources and motor-transport.

4. Conclusions

1. One-time concentration of CO in the environment of Šiauliai city varied from 0,5 mg/m³ to 5,8 mg/m³ in 2003. The highest concentration was registered in October in the areas E2, E3, F2, F3, and E5, E6, F5, F6. In 51 % of the city area the concentration of CO varied from 0,8 mg/m³ to 1,4 mg/m³. The concentration increased by 3 % in comparison with that in 2002.

2. One-time concentration of NO_2 in the environment of the city varied from 0,005 mg/m³ to 0,084 mg/m³ in 2003. The highest concentration was registered in June in the areas E5, E6, F5, F6 and in the central part of the city. In 57 % of the city area the concentration of NO_2 varied from 0,010 mg/m³ to 0,495 mg/m³. The concentration increased by 2 % in comparison with that in 2002.

3. One-time concentration of NO in the environment of Šiauliai varied from 0,003 mg/m³ to 0,495 mg/m³ in 2003. The highest concentration was registered in August in the areas E5, E6, F5, F6. The concentration increased by 3 % in comparison with that in 2002.

4. One-time concentration of SO_2 in the environment of Šiauliai varied from 0,0015 mg/m³ to 0,012 mg/m³ in 2003. The highest concentration was registered in November in areas D4, D5, E4, E5. The concentration decreased by 2 % in comparison with that in 2002.

5. One-time concentration of O_3 in the environment of the city varied from 0,022 mg/m³ to 0,134 mg/m³ in 2003. The highest concentration was registered in March in the areas F1, F2, G1, G2; the concentration increased by 3 % in comparison with that in 2002.

6. One-time concentration of THC in the environmental air of Šiauliai varied from 1,5 ppm to 3,5 ppm in 2003. The highest concentration was registered in November and December in the areas E2, E3, F2, F3 and G3, G4, H3, H4. The concentration of methane (CH4) varied from 1,4 ppm to 2,1 ppm. The concentration of THC increased by 4 %.

7. The highest pollution in the central part of the city in 2003 was caused by motor-transport. With increase of traffic intensity by 10 % air pollution increased by 5 % at that area.

8. Higher pollution in the southern and northern districts of the city is influenced by stationary polluters and motor-transport.

References

1. Gražulienė, R. Encyclopedia of a Man. Kaunas: VDU Press. 2002. 192 p.
2. Stretton, W. Density, Efficiency and Egnality in Austrian Cities. In: The compact city: A sustainable urban form? Oxford Brookes University, Oxford, UK 2000, p 45–52.
3. Burinskienė, M. Balanced City Expansion. Vilnius: Technika, 2003. 251 p.
4. Macaario, R. Upgrading Quality in Urban Mobility Systems. *Management Service Anality*, Vol 11, 2000, p 93–99.
5. Bukantis, A et al. The Effect of Climate Variation on Geographical Processes in Lithuania. Vilnius: Institute of Geography, VU, 2001. 280 p.
6. The Condition of the Environment in 2003. Ministry of Environment of the Republic of Lithuania. Vilnius, 2003. 213 p.
7. National Strategy for Sustainable Development. Approved by the Government of Lithuania on the 11th of September in 2003, by the decree No 1160. Vilnius, 2003. 29 p.
8. Baltrėnas, P.; Vasarevičius, S. Evaluation of Environmental Protection from Transport System. In: Transport: Technologies, Economics, Environment, Health. Vilnius, 2003. 29 p.
9. Oškinis, V.; Kinderytė, R.; Butkus, D. The Results of Transport Noise Investigation in the Highway Vilnius – Kaunas – Klaipėda. *Journal of Environmental Engineering and Landscape Management,* Vol XII, Suppl 1, Vilnius: Technika, 2004, p 10–18.
10. Von Maarseveen, M.; Zuidgesst, M. Sustainable urban transportation development: a modelling approach. In: Urban Transport and the Environment in the 21 st Century. Southhamp: Witpress, 2003, p 203–212.

11. Environmental Protection in Šiauliai. Šiauliai: Environmental Protection Sector in the Municipality of Šiauliai, 2003. 29 p.

12. Bubnienė, R. et al. European Environmental Protection Policy and its Establishment in Lithuania. Vilnius: Center of Environmental Protection Policy, 2002. 114 p.

APLINKOS ORO TARŠOS LYGIO ŠIAULIUOSE TYRIMAI IR JO KAITOS ĮVERTINIMAS

L. Paulauskas, R. Klimas

S a n t r a u k a

Aplinkos oro užterštumas yra viena iš pagrindinių plaučių ligų, piktybinių navikų, alerginių ir kitų lėtinių ligų priežasčių. Mobiliojoje laboratorijoje atlikti aplinkos oro užterštumo Šiauliuose 2003 metais tyrimai, analizuota teršalų pasiskirstymas miesto aplinkos ore. Matavimai buvo atliekami kartą per mėnesį tyrimo postuose, išdėstytuose 1 km atstumu vienas nuo kito. Nustatyta tokia vienkartinė vidutinė metinė teršalų koncentracija (viename kvadratiniame kilometre). CO koncentracija miesto aplinkos ore kito nuo 0,5 mg/m³ iki 5,8 mg/m³, o 51 % miesto teritorijos – nuo 0,8 mg/m³ iki 1,4 mg/m³. NO_2 koncentracija kito nuo 0,005 mg/m³ iki 0,084 mg/m³, o 57 % miesto teritorijos – nuo 0,010 mg/m³ iki 0,020 mg/m³. NO koncentracija kito nuo 0,003 mg/m³ iki 0,495 mg/m³. SO_2 – nuo 0,0015 mg/m³ iki 0,012 mg/m³. O_3 koncentracija kito nuo 0,022 mg/m³ iki 0,134 mg/m³. Suminių angliavandenilių koncentracija kito nuo 1,5 ppm iki 3,5 ppm. Didžiausia teršalų koncentracija nustatyta centrinėje miesto dalyje.

Raktažodžiai: aplinkos oro tarša, didžiausioji leistinoji teršalų koncentracija (DLK), mobilioji laboratorija, anglies monoksidas (CO), azoto oksidai (NO, NO_2), ozonas (O_3) sieros dioksidas (SO_2), matavimo intervalas, teršalų koncentracija.

ИССЛЕДОВАНИЯ УРОВНЯ ЗАГРЯЗНЕННОСТИ ВОЗДУХА ГОРОДА ШЯУЛЯЙ И ОЦЕНКА ЕГО ИЗМЕНЕНИЙ

Л. Паулаускас, Р. Климас

Р е з ю м е

Загрязнение воздуха является одной из основных причин болезней легких, рака, аллергических и других заболеваний. При помощи мобильной лаборатории исследовалось загрязнение воздуха города Шяуляй на протяжении 2003 года, его распределение. Исследования проводились ежемесячно в постах, расположенных на расстоянии 1 км друг от друга. Определена следующая средняя одноразовая годичная концентрация загрязняющих веществ в воздухе на расстоянии в один квадратный километр: концентрация CO в воздухе города изменялась от 0,5 мг/м^3 до 5,8 мг/м^3, а на территории города, составляющей 51 %, это изменение было от 0,8 мг/м^3 до 1,4 мг/м^3. Концентрация NO_2 изменялась от 0,005 мг/м^3 до 0,084 мг/м^3, а на территории города, составляющей 57 %, – от 0,010 мг/м^3 до 0,020 мг/м^3. Концентрация NO изменялась от 0,003 мг/м^3 до 0,495 мг/м^3. Концентрация SO_2 изменялась от 0,0015 мг/м^3 до 0,012 мг/м^3. Концентрация O_3 изменялась от 0,022 мг/м^3 до 0,134 мг/м^3. Концентрация суммарных углеводородов изменялась от 1,5 ppm до 3,5 ppm. Максимальное загрязнение воздуха установлено в центральной части города.

Ключевые слова: загрязнение воздуха, максимально допустимая концентрация загрязнений, мобильная лаборатория, моноксид угля (CO), оксиды азота (NO, NO_2), озон (O_3), диоксид серы (SO_2), интервал измерений, концентрация загрязнениий.

Leonas PAULAUSKAS. Doctor of Natural Sciences (since 1971), Assoc Prof, Šiauliai University (ŠU), Vilniaus g. 88, LT-78360 Šiauliai, Lithuania. E-mail: all@da.su.lt.

Publications: author (with co-authors) of 17 scientific publications. Research interests: problems of motor transport noise, environmental pollution by motor transport and industry.

Robertas KLIMAS. Master of Science (physics and mathematics), lecturer and head of Environmental Investigation Laboratory of Šiauliai Municipality. Šiauliai University (ŠU), Gegužių g. 94, LT-78365 Šiauliai, Lithuania. E-mail matlsiauliai@takas.lt.

Publications: co-author of 4 research papers. Research interests: pollution of air and soil, modeling of industrial and transport emissions.