



INVESTIGATION ON THE IMPACT OF TRANSPORT EXHAUST EMISSIONS ON THE AIR

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Abstract. The investigation carried out has revealed that in Vievis settlement and near the highway Vilnius – Kaunas the highest concentrations of pollutants are emitted during morning and afternoon rush-hours when motor transport traffic is the heaviest. Extremely high amounts of emitted aerosol particles were recorded 1-2 m away from the driving part, and 4-6 m away the amounts of aerosol particles sharply go down. CO gas concentrations caused by passing motor transport were also analysed. It has been set that the concentrations of CO and aerosol particles depend directly on motor transport traffic intensity. CO concentration goes evenly down receding from the driving part. In most cases maximum permitted concentration of CO was recorded.

Keywords: air pollution, mobile pollution sources, motor transport.

1. Introduction

Currently increasing transport flows have a heavy impact on the environment. Transport emissions contain a lot of different chemical compounds that have a negative impact on the surrounding environment. Chemical compounds (also known as pollutants) have a harmful effect not only on the environment but also on human beings living in that environment [1-3].

Air pollution from motor transport causes ecological problems on a local, regional, and global scale. Although the total pollution (stationary pollution sources) has been reduced in Lithuania, the problems that are encountered by most European states are also characteristic of Lithuania. The air quality in Lithuanian towns depends mostly on emissions from mobile pollution sources and meteorological conditions [4]. In big and small towns the most favourable conditions for pollution concentration occur when the weather is conditioned by anticyclones, when prevailing weather is calm and without precipitation, when fogs are frequent and the temperature inversion prevents pollution dispersion at higher atmospheric layers. A lot of pollutants – in the form of aerosol particles and CO – are emitted into the environment from motor transport. Thus, it is particularly important to examine emissions into the environment from motor transport resulting from a heavy traf-

fic. This would enable a better examination of street pollution caused by transport emissions [5-7].

Pollutants get into the air from three main sources: exhaust pipes of vehicles through which combustion residues are emitted into the air (65 % of all the transport-caused pollutants); a crankcase (20 %); and during hydrocarbon volatilization from a carburettor (9 %) and fuel pump (6 %). The air is also polluted with the dust caused by tyre wear (annually up to 1,6 kg per vehicle), asbestos dust, cadmium that are diffused in the air during the wear of brake pads and friction clutch, also with the dust of other materials occurring during the friction at various junctions of a vehicle. More than two hundred of different chemical compounds are found in emissions from the internal-combustion engine of a vehicle; most of these compounds are harmful to human health and the development of all living organisms, they cause metal corrosion, destroy construction materials, etc. Carbon monoxide, nitric oxides, sulphur compounds, unburned hydrocarbons, soot, lead compounds account for the major part of such toxic compounds and materials [2].

The highest extent of air pollution is detected at the initial start-up, braking and slow motion of a vehicle. It has been found that at the initial start of a vehicle air pollution is 50 times higher than the grand average. Thus, street crossroads are the most harmful pollution centres. In segments between crossroads the air is

mostly polluted when vehicles move at a speed not exceeding 30 km/h; at a speed going up to 90 km/h, a lower amount of fuel is consumed and, thus, the amount of emitted pollutants is twice as low [8].

2. Characteristics of emissions from vehicle engines

Nowadays most vehicles have an internal-combustion engine. In a perfect case, the molecules of hydrocarbons completely burnt in a combustion chamber should turn into two non-toxic compounds: carbon dioxide and water. However, in reality the main non-toxic gas components found in air mixtures and toxins as well as the components of unburnt fuel and its incombustible impurities are emitted into the air (Table 1).

The amount of toxic substances emitted into the environment from an internal-combustion engine depends on the fuel and conditions of the formation of an air mixture, also on the air excess coefficient λ , expressing the ratio of the air amount actually used for fuel burning and that needed theoretically. Investigations have proved that an ideal mixture does not exist. At $\lambda = 0,9$ (fat mix), an engine may reach the highest number of revolutions; however, at a full load the fuel input increases. An optimal fuel input is reached when $\lambda = 1,1$ (fat-free mix). In this case CO and C_mH_n emission is minimal but the amounts of emitted nitric oxides (NO_X) are maximal [4].

The main part of a car fleet is comprised of cars with two types of internal-combustion engines – petrol engines and diesel engines. As it is seen in Table 1, the emission of toxic substances from these engines differs both in absolute amounts and proportions of emitted components. These differences are conditioned by different principles of the formation and ignition of a fuel mix.

3. Investigation methods

The investigation was aimed at measuring the emissions of fine dispersive aerosol particles from motor transport with the help of the AZ-5 meter in Vievis settlement and on Vilnius – Kaunas highway and finding out the alteration of pollution in the course of the day depending on motor transport flow and meteorological conditions, taking into consideration the chosen hours for measuring (morning and afternoon rush-hours; the time between rush-hours); also at finding out how many times pollution differs compared with a relatively clean air [9–11].

The operation principle of the meter. The meter AZ-5 [12] employing the optical (light dispersion) measuring method and setting not only the numeral concentration of pollutants but also their dispersion composition in the interval from 0,4 to 10,0 μm particle sizes was used (Fig 1). Through a laminarizing orifice, with the air flow a particle of aerosol gets into the formed beam of light. The light dispersed by the particle is

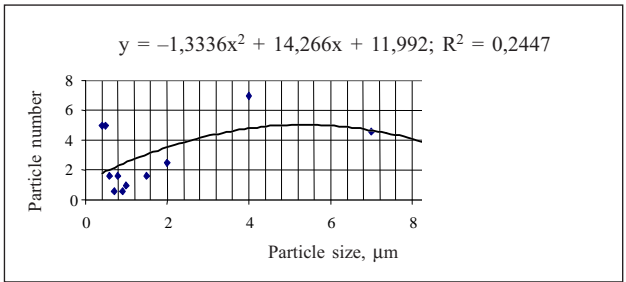


Fig 1. Graph of the measuring results of aerosol particle emissions from motor transport in a relatively clean environment, using the AZ-5 meter

Table 1. Basic chemical elements and their compounds in motor car exhaust gases

The highest concentrations		
	Petrol	Diesel
NON-TOXIC SUBSTANCES		
Nitrogen, vol %	74–77	76–78
Oxygen, vol %	0,2–0,8	0,4–18,0
Water vapour, vol %	3,0–13,5	0,5–10,0
Carbon Dioxide, vol %	5,0–12,0	1,0–12,0
TOXIC SUBSTANCES		
Hydrocarbons, vol %	0,2–3,0	0,01–0,50
Nitric oxides, vol %	0,1–10,0	0,01–0,30
Aldehydes, vol %	0,0–0,2	0,00–0,05
Sulphur oxides, vol %	0,000–0,003	0,000–0,015
CANCEROGENIC SUBSTANCES		
Soot, $\mu g/m^3$	0–100	0–2000
Benz(a)pyrene, $\mu g/m^3$	0–25	0–10
Lead compounds, $\mu g/m^3$	0–60	–

recorded with an optical sensor-photomultiplier. The main parts of the device are the following: an optical sensor, an electric block and a pneumatic mechanism [13, 14]. In the optical sensor an electric impulse with an amplitude proportional to the square of particle sizes is formed for each particle of the aerosol under study. In the electric block these impulses are intensified and totalled up according to the values of individual amplitude. The pneumatic mechanism sucks the needed volume of air (1,2 l/min) through the measuring area of the optical sensor. The device measures the numeric concentration of particles from 0 to 300 000 particles per litre within the following ranges: >0,4; >0,5; >0,6; >0,7; >0,8; >0,9; >1,0; >1,5; >2,0; >4,0; >7,0; >10,0 µm. The measurement error: –20 %, +20 % [2, 12].

4. Results

4.1. Measurements of the number of aerosol particles in a relatively clean environment of Ignalina district (Ignalina – Kaltinėnai)

Aerosols are liquid and solid particles suspended in a gaseous medium – the air in this case. The particles of a size 0,1–2,5 µm [5] have a negative impact on human health and take part in the formation of „acid rain“. To find out the nature of pollution, the measurements were carried out as far from mobile and stationary sources as possible. To this end a non-developed area with the following environmental conditions was chosen: temperature +(20,2) °C, dry weather, prevailing southwest wind, 0,5 m/s. The results of measurements are presented in Table 2.

Table 2. Number of passing cars during 35 minutes and their distribution according to mass

Distribution of cars by their capacity	Number of passing cars
Cars	12
Medium-size cars	3
Lorries	2

The measurements were carried out on April 23, 2002 from 3:5 p.m. to 3:40 p.m.

On the basis of the data given in Table 1, it could be stated that particles of a size of 4,0 µm accounted for the highest number of particles caught. The total number of such particles caught was 70.

4.2. Measurements of the number of aerosol particles in Vievis settlement and close to the highway Vilnius – Kaunas

During these measurements it was noted that they had to be carried out under the same environmental conditions as those carried out in a relatively clean environment.

At the beginning of the work the flow of motor transport was calculated using the meter AZ-5. Passing cars were counted for 2 hours: from 8 to 10 a.m. during morning rush-hours, Fig 2 and from 4 to 6 p.m. during afternoon rush-hours. Cars were also counted in the day-time from 12 to 2 p.m (Fig 3).

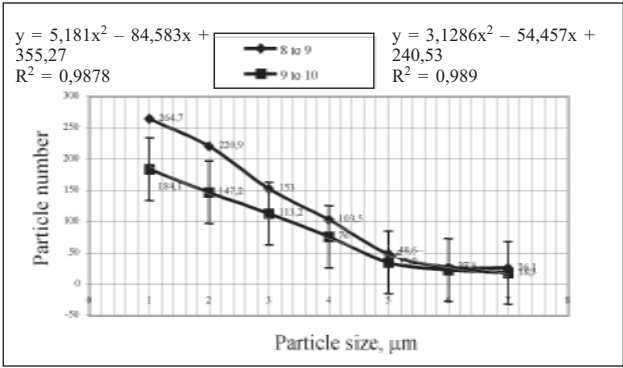


Fig 2. Distribution by size of aerosol particles emitted from cars passing during morning rush-hours, depending on the number of particles

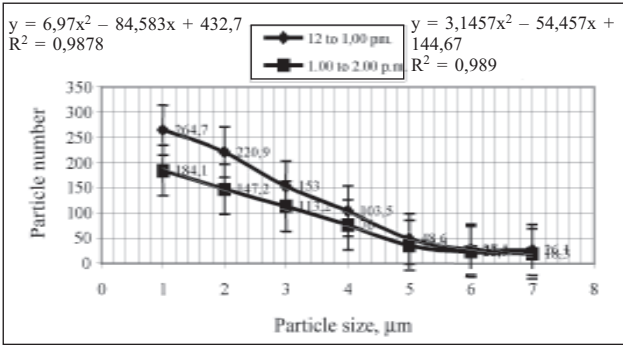


Fig 3. Distribution by size of aerosol particles emitted from passing cars between rush-hours, depending on the particle number

Three main categories of cars have been singled out: 1) cars, 2) lorries, 3) buses. It has also been found out that the highest traffic intensity is observed during rush-hours: from 8 to 10 a.m. and from 4 to 6 p.m.

Fig 2 shows that particles of a size of 0,4, 0,5 and 0,6 µm prevail. This can be explained by the fact that the number of aerosol particles in transport exhaust is the highest during morning rush-hours, as the intensity of the passing transport flow is the heaviest at that time of the day. Emitted aerosol particles are not able to get dispersed during such a short period and concentrate close to the road.

It could be concluded that the number of aerosol particles between rush-hours is lower than that during morning rush-hours, as the intensity of car traffic goes down, while that of heavy vehicles goes up. This could be explained by the fact that during working-hours most enterprises make use of goods transport for distant journeys and local routes (Fig 4).

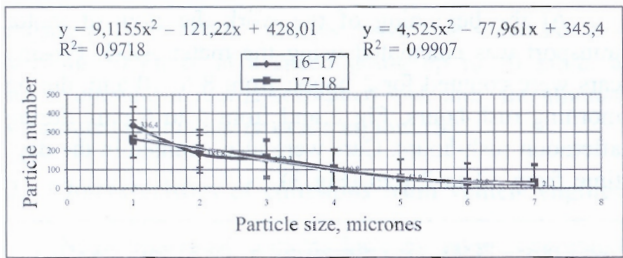


Fig 4. Distribution by size of aerosol particles emitted from passing cars during afternoon rush-hours, depending on the particle number

Analysing the amounts of emitted aerosol particles by their size during afternoon rush-hours it could be stated that at that time of the day the emissions of aerosols are at the highest intensity. Particles of a size from 0,4 to 0,6 μm prevail. Due to traffic jams, long flows of motor transport, slow moving, the emitted amounts of aerosols often start concentrating near the road.

4.3. Measuring Point 1

The following environmental conditions were set during measurements: temperature, prevailing wind, wind speed (m/s). The obtained results are presented in Table 3.

Table 3. Parameters of environmental conditions during measurements

Measuring point No	Environmental conditions			
	Temperature ($^{\circ}\text{C}$)	Prevailing wind	Average wind speed (m/s)	Time of reading taking (hour)
1	11	P-R	1-1,5	7,30-8,30
2	-1	P-V	1,0-2,0	8,30-9,20
3	-2	P-V	2,0-2,3	16,30-17,30
4	-2	P-V	2,0-2,3	8,30-9,30
5	-2	P	1,0-2,0	16,30-17,30

At Point 1 most of the territory is undeveloped with prevailing detached bushes. At this Point the intensity is rather high, especially during morning rush-hours.

Increase in the concentrations of aerosol particles emitted by motor transport flows was observed at Point 1 (Fig 5). Increase in the concentrations interchanges with their decrease. This is explained by unstable intensity of motor transport flows that day, although the study was carried out during morning rush-hours. Such an instability resulted from a traffic accident on the highway Vilnius – Kaunas and road repair. Such a situation was also influenced significantly by the distribution of transport categories: light vehicles accounted for 65 %; public transport (passenger buses) – for 23 %; heavy vehicles (long-distance transport) accounted for the remaining 12 %. Particles of a size of 0,4 and 0,5 μm were prevailing in the air. The concentrations of emitted aerosol particles of other size could be considered as even.

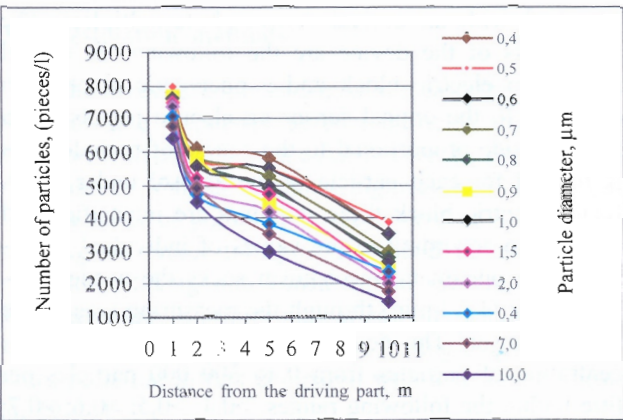


Fig 5. Distribution of aerosol particles at Point 1, depending on the distance from the highway Vilnius – Kaunas (7:30–8:30 a.m.)

Speaking of a distance, the maximum amount of aerosol emissions was detected 1 m away from the driving part, and 2 m away from the driving part the amount of emitted aerosols went down by 25 %. This means that pollution with aerosol particles keeps subsiding receding from the highway.

4.4. Measuring Point 2

The area chosen for measurements is of a relatively low development. A square and a children's playing ground are located at some distance from the driving part. Some detached bushes and trees are seen near the driving part.

On the basis of measuring results at Point 2 (Fig 6) it could be concluded that the emission of aerosol particles was rather stable. This is related with increase and decrease in transport flows during morning rush-hours. 1 or 2 m away from the road a gradual even decrease in the emissions of aerosol particles was detected; and 1,3–1,5 m away from the road the amounts of any size particles started going down (eg, from 9000 to 7400). This is directly related with decrease in the amount of transport. This place was chosen for measurements

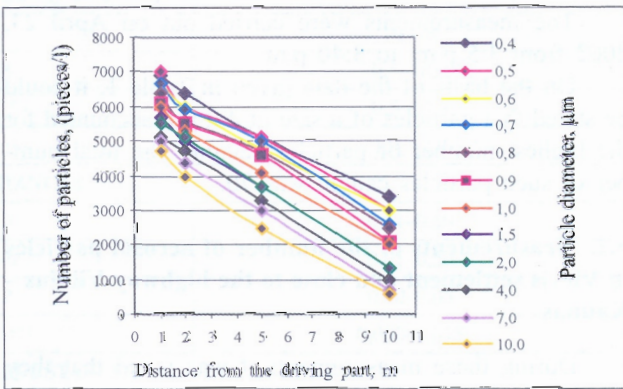


Fig 6. Distribution of aerosol particles at Point 2, depending on the distance from the highway Vilnius – Kaunas (7:30–8:30 a.m.)

because a rather high number of people was seen there, and, as it has already been mentioned, aerosol particles have a negative impact on human health (causing respiratory diseases).

4.5. Measuring Point 3

The environmental diversity is not very rich here, with detached bushes and trees prevailing, there are many dwelling houses, a school and a kindergarten around the measuring points.

At Point 3 an even decrease in the concentrations of aerosol particles was observed receding from the road (Fig 7). Analysing the results of measuring, it could be concluded that the numbers of any size particles gradually decrease receding from the highway.

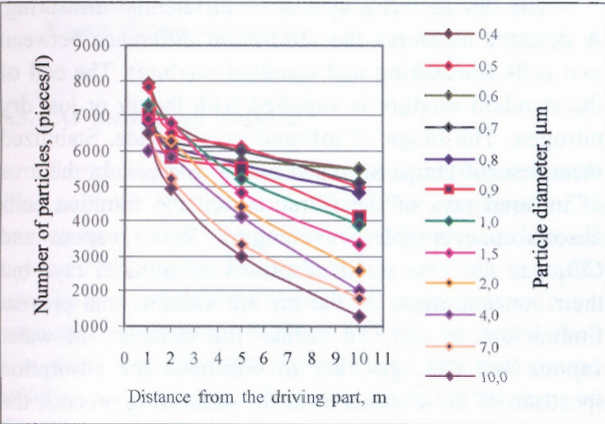


Fig 7. Distribution of aerosol particles at Point 3, depending on the distance from the highway Vilnius – Kaunas (4:30–5:30 a.m.)

Two meters away from the driving part the difference reached 1200 (from 8000 to 6800).

However, in the case of some amounts of particles, an even proportional decrease was observed (eg 0,9 μm: at a distance of 1 m the number of the measured aerosol particles was 7000/l; at a distance of 2 m it was 5600/l; at a distance of 4 m it was 5800/l). This could be explained by instantaneous increase in heavy vehicle flows.

4.6. Measuring Point 4

The environmental diversity is not very rich here, with detached bushes and trees prevailing. There are many dwelling houses and public buildings around the measuring points.

At Point 4 an even but insignificant decrease in the concentrations of 1,0 μm and bigger particles was observed receding from the highway (Fig 8).

This could be explained by the fact that receding from the driving part, the emitted aerosol particles are dispersed by air masses and, thus, lower concentrations of aerosols are recorded. Analysing the obtained results of the study, the following alteration in the numbers of 0,7 μm aerosol particles was observed, depending on

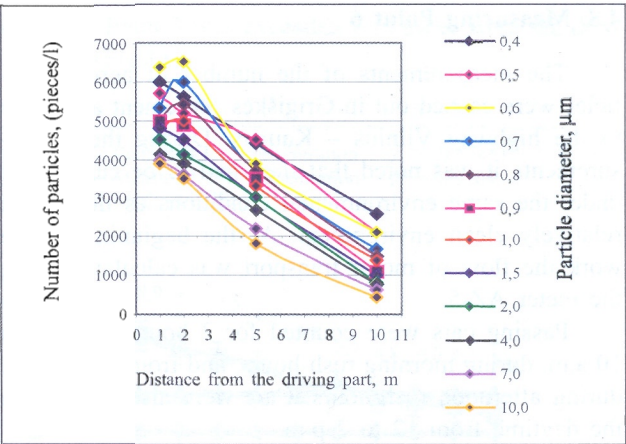


Fig 8. Distribution of aerosol particles at Point 4, depending on the distance from the highway Vilnius – Kaunas (8:30–9:30 a.m.)

the distance: at a distance of 1 m their number did not exceed 5400; at a distance of 2 m it went up to 6000; at a distance of 3 m from the driving part the number of aerosol particles went down to 5500. During the measurements motor transport was categorized as follows: I – light vehicles (73 %); II – public transport (buses, minibuses (17 %)); III – heavy vehicles (10 %).

4.7. Measuring Point 5

At point 5 detached bushes and trees prevail; besides, a meadow is located not far from the place of measuring. A parking lot for different types of cars is located behind the meadow.

During the measurements, receding from the driving part of the road, decrease in the aerosol concentration was observed, which is directly related with decrease in traffic intensity; besides, that is also influenced by the wind direction. The place of measuring was chosen so as to be able to analyse the dependence of the dispersion of aerosol particles on meteorological conditions. On the basis of the results of the study, it could be concluded that in non-developed areas the dispersion of aerosols is more intensive because no obstacles (buildings, parks, dwelling houses) are encountered (Fig 9).

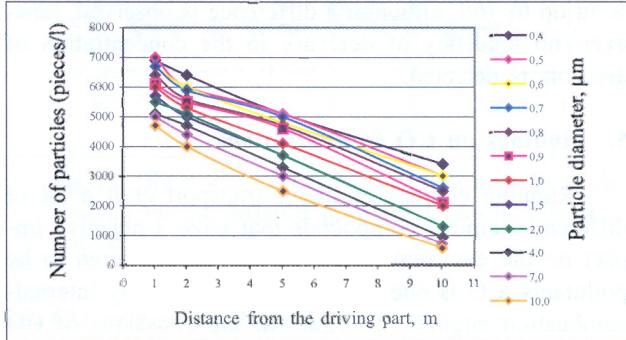


Fig 9. Distribution of aerosol particles at Point 5, depending on the distance from the highway Vilnius – Kaunas (8:30–9:30 a.m.)

4.8. Measuring Point 6

The measurements of the number of aerosol particles were carried out in Grigiškės settlement and close to the highway Vilnius – Kaunas. During these measurements it was noted that they had to be carried out under the same environmental conditions as those in a relatively clean environment. At the beginning of the work the flow of motor transport was calculated using the meter AZ-5.

Passing cars were counted for 2 hours: from 8 to 10 a.m. during morning rush-hours, and from 4 to 6 p.m. during afternoon rush-hours. Cars were also counted in the daytime from 12 to 2 p.m.

During the measurements the air temperature was 16 °C; the weather was dry; the south wind prevailed; an average wind speed was 2–3 m/s.

At this Point particles of a size of 0,4; 0,5; 0,6; 0,7; 0,8 μm prevail. This can be explained by the fact that the passing transport flow is heavy during afternoon rush-hours. The measurements were carried out 1–10 m away from the driving part, and a distance between the measuring points was 1 m (Fig 10).

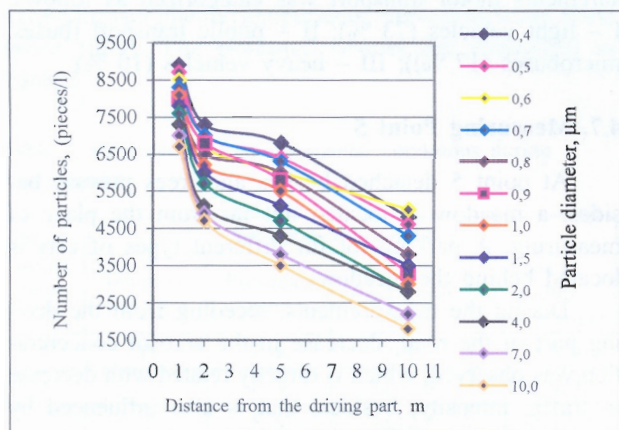


Fig 10. Distribution of aerosol particles at Point 6, depending on the distance from the highway Vilnius – Kaunas (Grigiškės settlement) (4:30–5:30 p.m.)

One meter away from the driving part the concentration of 0,9 μm particles was 72/l, and 2 m away it went up to 76/l; although a difference is observed, however, no tendency of decrease in the concentration of aerosols is detected.

5. Findings on CO concentrations

Running engines of motor transport emit a lot of different chemical compounds that have a negative impact on the environment and thus are considered to be pollutants. CO is one of them. It is emitted by internal-combustion engines. To find out the emissions of CO from motor transport, the measurements of CO concentrations were carried out. On the basis of data of the

measurements, the obtained concentrations were compared with the permitted (background) concentration of CO which is 2,2–2,4 mg/m^3 , the results were also compared with the maximum permitted concentration (MPC) (5 mg/m^3). To get a general view of emissions, the same measuring points were chosen as those for aerosol particle concentrations.

5.1. Operation principle of a CO meter

For continuous measuring of carbon monoxide in the air, devices able to absorb infrared rays are widely used. CO has absorption lines in the area of infrared rays.

Like in an osonometer, the absorption of infrared rays depends on the concentrations of the gas measured.

The device has a system of differential measuring. A detector measures the absorption difference between two cells (measuring and standard mixture). The cell of the standard mixture is supplied with the air or just dry nitrogen. The range of infrared rays is wide. Stabilized incandescent lamps are used as ray sources. In the area of infrared rays of the filtration cell the filtration cells absorb unacceptable wavelengths. Water vapour and CO_2 gas are also good absorbers of infrared rays but their concentrations in the air are variable and prevent finding out of CO. To reduce the influence of water vapour and CO_2 gas, i.e. to eliminate the absorption spectrum of these gases from the measuring process, the filtration cells are filled with their sufficient amount. A modulator lets the rays in turn into the cells of measuring and of the standard mixture (at the frequency of some 10 Hz). The detector cell is filled with CO gas and separated with a thin membrane. Thus, both sides of the detector cells get portions of ultrared rays which get warmed because of CO gas absorption. Because of gas expansion, the membrane periodically moves to one side, then to another side. If the measuring cell contains a certain amount of CO gas, the gas absorbs part of the rays and the gas gets less warm in that part of the detector cell. Thus, the move of the membrane is lower. The detector, turning the membrane oscillatory amplitude into an electric signal, transfers the altered signal. The sensibility of such devices is about 2,5 $\mu\text{g}/\text{m}^3$.

5.2. CO measuring Point 1

After analysis of 5 air samples taken at Point 1 it could be concluded that the highest CO concentration was observed 1 m away from the driving part and was 7,5 mg/m^3 . Receding from the driving part, decrease in CO concentration was detected in all the five samples. The MPC of CO was exceeded 6 m away from the driving part. The background pollution was exceeded even more than 10 m away from the driving part (Fig 11).

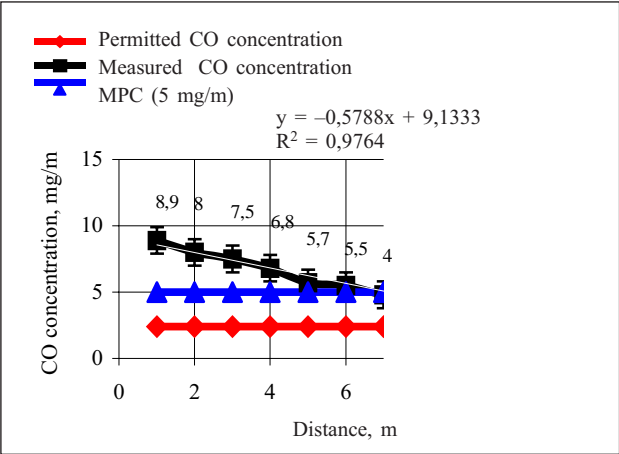


Fig 11. Distribution of CO concentration at Point 1, depending on the distance from the highway Vilnius – Kaunas (Vievis township)

5.3. CO measuring Point 2

Comparing the measuring results at Point 1 with those at Point 2, it could be stated that increase in CO concentration from 7,7 mg/m³ to 8,6 mg/m³ was detected at point 2. This could be explained by increase in traffic intensity and decrease in dispersion, depending on environmental parameters. MPC of CO was exceeded even 5 m away from the driving part, and the background pollution was exceeded 10 m away from the driving part (Fig 12).

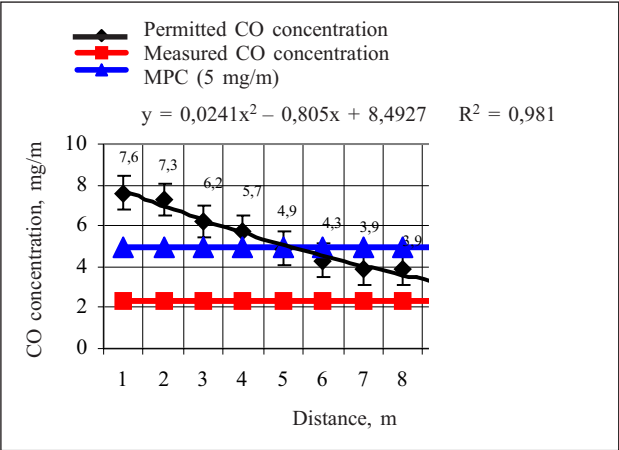


Fig 12. Distribution of CO concentration at Point 2, depending on the distance from the highway Vilnius – Kaunas (Vievis township)

5.4. CO measuring Point 3

At this Point CO concentration did not exceed 8 mg/m³. Receding from the driving part of the highway, an even decrease in CO concentration to 1,6 mg/m³ was detected. MPC was exceeded 3 m away from the driving part, and receding from it the concentration reached the permitted limits. The permitted background concentration

of CO at Point 3 was exceeded 8 m away from the driving part (Fig 13).

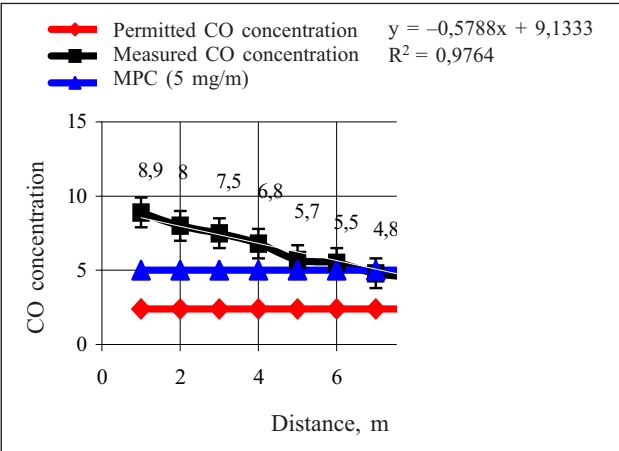


Fig 13. Distribution of CO concentration at Point 3, depending on the distance from the highway Vilnius – Kaunas (Vievis township)

5.5. CO measuring Point 4

At Point 4 the highest CO concentration was 6,7 mg/m³. Comparison of the obtained results with those at Point 3 shows that lower CO concentrations were obtained. This is conditioned by the flow of motor transport and environmental-climatic conditions. Comparing the obtained results with those obtained at Point 1, at which CO concentration was 7,5 mg/m³, it could be stated that the concentration was lower. MPC was exceeded even 5 m away from the driving part. The permitted background concentration of CO was exceeded even 9 m away from the driving part (Fig 14).

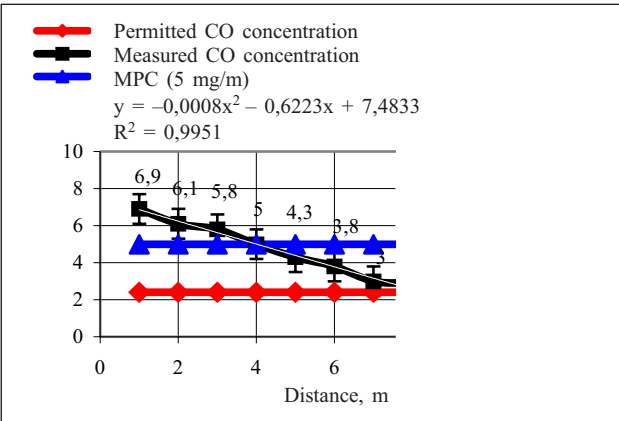


Fig 14. Distribution of CO concentration at Point 4, depending on the distance from the highway Vilnius – Kaunas (Vievis township)

5.6. CO measuring Point 5

The measurements of CO concentration at Point 5 have showed that the highest CO concentration was 6,6 mg/m³, and the lowest concentration was 1,3 mg/m³.

On the basis of the obtained results, it could be stated that decrease in CO concentration was even and proportional to the distance from the driving part. MPC of CO was exceeded even 5 m away from the driving part, and the permitted background concentration of CO was exceeded even 8 m away from the driving part (Fig 15).

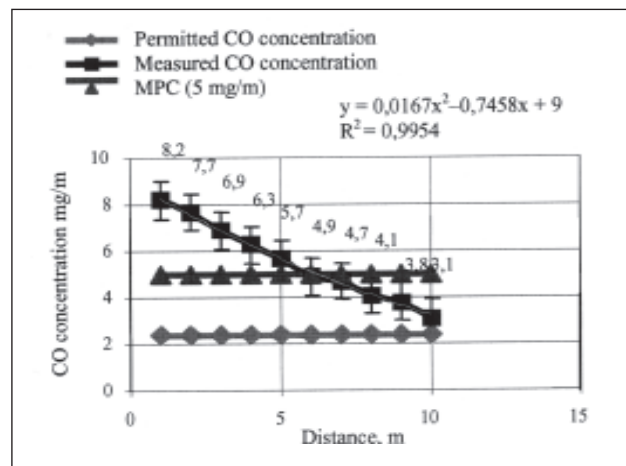


Fig 15. Distribution of CO concentration at Point 5, depending on the distance from the highway Vilnius – Kaunas (Vievis township)

At Point 5 the highest CO concentration was 8,1 mg/m³, and the lowest one was detected 10 m away from the driving part (1,5 mg/m³). It could be stated that decrease in CO concentration was proportional to the distance from the driving part and depended on the measuring time. MPC was exceeded 6 m away from the driving part, and the permitted background concentration was exceeded even 9 m away from the driving part.

6. Conclusions

1. On the basis of the measuring results obtained on aerosol particle concentrations, it could be stated that pollution with aerosol particles depends on the intensity of passing transport flow and measuring time (the highest pollution was recorded during rush-hours: 8–10 a. m. and 4–6 p. m.).

2. During the investigation it has been found out that the aerosol particles of a size of 0,4 µm prevail. This is influenced by the prevailing flow of cars.

3. It has been found out that the concentration of aerosol particles near the driving part is several times higher than that in a relatively clean environment. The concentrations of aerosol particles in the air depends on environmental conditions.

4. On the basis of the results of CO concentration measuring, it could be stated that the concentrations of

CO and aerosols directly depend on traffic intensity. CO concentration goes evenly down with increase in the distance from the driving part. In most cases MPC and the permitted background concentrations were exceeded.

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AUTOMOBILIŲ IŠMETAMŲ DUJŲ POVEIKIO ATMOSFERAI TYRIMAS

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Santrauka

Atlikus tyrimus Vievyje ir šalia esančioje automagistralėje Vilnius – Kaunas, nustatyta, kad daugiausia autotransporto teršalų išmetama rytinio ir vakarinio piko valandomis, kai eismo intensyvumas didžiausias. Ypač dideli išmetamų aerolių dalelių kiekiai 1–2 m atstumu nuo važiuojamosios kelio dalies, o už 4–6 m staigiai sumažėja. Iširta dėl pravažiuojančio autotransporto srautų susikaupusių CO dujų koncentracijos. Nustatyta, kad CO ir aerolių dalelių koncentracijos tiesiogiai priklauso nuo autotransporto eismo intensyvumo. CO koncentracija tolygiai mažėja didėjant atstumui nuo kelio važiuojamosios dalies. Daugeliu atvejų CO (DLK) koncentracijos viršija didžiausias leistinas.

Raktažodžiai: aplinka, atmosferos oro tarša, mobilieji teršimo šaltiniai, autotransportas.

ИССЛЕДОВАНИЕ ЗАГРЯЗНЕНИЯ АТМОСФЕРЫ ВЫХЛОПНЫМИ ГАЗАМИ АВТОТРАНСПОРТА

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Резюме

Измерения проводились на определённом участке автомагистрали Вильнюс–Каунас. Было установлено, что наибольшее количество вредных веществ из выхлопных труб автомобилей было зарегистрировано в утренние и вечерние часы „пик“. Наибольшее количество выбрасываемых частиц наблюдалось на расстоянии 1–2 м от проезжей части, а на расстоянии от 4 до 6 м количество выбрасываемых автотранспортом частиц резко сокращалось. Также была измерена концентрация выбрасываемых газов CO. Доказано, что количество выбросов пропорционально совокупности и величине транспортного потока. Во время исследований наблюдалось, что выбросы CO превышают предельно допустимую концентрацию.

Ключевые слова: природа, загрязнение атмосферного воздуха, мобильные источники вредных веществ, автотранспорт.