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AIR POLLUTION AS THE CAUSE OF URBAN STRESS. A CASE STUDY: NEMANJIĆA BOULEVARD, NIŠ, SERBIA

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Abstract. *Topic of this paper is air pollution as a cause of urban stress. This problem is analyzed within a case study in Bulevar Nemanjića in Niš. For the observed location, the measurements were conducted in a period of eight months (May 2007 – June 2007) by the Health Protection Institute in Nis. Motor traffic exhaust gases which were observed were: carbon-monoxide (CO), nitro-oxide (Nox) formaldehyde (HCHO). Measurements were taken at "Bulevar" green market, b standard methodology prescribed by the boundary values code book, immision measurement method, criteria for creation of measuring points and data records. Concentration of exhaust gases of motor vehicles did not exceed permissible limits, except carbon monoxide in May, while it continued to decrease and remained within the legal limits. If the Mediana – Bulevar Nemanjica location was enriched by green surface and pedestrian zones, this would lead to the decrease of exhaust gases concentration. That would prevent endangering environment and facilitate its healthy functioning.*

Key words: *urban stress, air pollution, environmental protection.*

1. INTRODUCTION

Notwithstanding the fact that man has managed to submit nature to serve human needs transforming it into a rather comfortable living space, man has also greatly impaired the natural balance thus creating large disturbances in the natural environment that will be inevitably felt in the future, as well (Trajković 2007, Blagojević et al. 2005).

Air pollution has become a growing problem in megacities and large urban areas through out the globe, and transportation is recognized as the major source of air pollution in many cities (Goyal et al. 2006). All advanced industrialized societies face the problem of air pollution produced by motor vehicles. In spite of striking improvements in internal combustion engine technology, air pollution in most urban areas is still measured at levels determined to be harmful to human health (Calef and Goble 2007). Investigation

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of influence of air pollution on urban stress is widely reported in the environmental literature. Ostachuk et al. (2008) investigate age-related lung cell response to urban Buenos Aires air particle soluble fraction. Bioavailability of soluble PM compounds like polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and transition metals has been shown to play a key role in lung injury. Leaves of the deciduous tree species, horse chestnut (Aesculus hippocastanum L.) and Turkish hazel (Corylus colurna L.) were used as accumulative biomonitors of trace metal pollution in the urban area of Belgrade in the Tomasevic et al. (2008). Using differential pulse anodic stripping voltametry, trace metal concentrations (Pb, Cu, Zn, Cd) were determined at the single leaf level (ten leaves per species, per month), during two successive years with markedly different atmospheric level of trace metals. Increased trace metal concentrations in the leaves of A. hippocastanum reflected elevated atmospheric trace metal pollution, whereas C. colurna L. did not respond accordingly. The contents of Pb and Zn in soil over the same period also followed this trend. Air pollution is one of the major environmental problems in India, affecting health of thousands of 'urban' residents residing in mega cities. The need of the day is to evolve an 'effective' and 'efficient' air quality management plan (AQMP) encompassing the essential 'key players' and 'stakeholders.' Jain and Khare (2008) describes the formulation of an AQMP for mega cities like Delhi in India taking into account the aforementioned key 'inputs.' Despite the progress made in controlling local air pollution, urban areas show increasing signs of environmental stress and air quality is one of the major concerns. The findings of several studies provide evidence that the shape of a city and the land use distribution determine the location of emission sources and the pattern of urban traffic, affecting urban air quality. (Borrego and al. 2006).

Various particles enter the atmosphere from either natural (volcanoes, plant and animal respiration, oxidation of organic matter, etc.) or anthropogenic sources (traffic, industry, plants for waste oxidation or energy production). The primary pollutants are gases, such as carbon monoxide, nitrogen and sulphur oxides, as well as both solid and tiny liquid particles. The solid particles - pollutants comprise livings organisms, such as bacteria, fungi, spores, organic matter or heavy metals particles. Those pollutants which enter the atmosphere directly from various anthropogenic sources (human activities) represent the so-called primary pollutants. They are: hydrocarbons, nitrogen and sulphur oxides and carbon dioxide. The secondary pollutants are formed in the reactions of the primary created pollutants: the radiation of the sun, and especially UV radiation which acts as a catalyst, start chain reactions and the creation of nitrogen-oxide and ozone. Different substances – air pollutants create ozone in mutual interactions triggered by the radiation of the sun, and that is the reason why ozone is considered to be the indicator of air pollution. The ozone present in the troposphere (8-17 km above the sea level), is known as bad ozone, because, unlike the good ozone of the stratosphere which forms protection against the negative sun radiation, it is harmful and affects human health, plants, animals and the whole surrounding – synthetic fibres, rubber, plastic, etc. Ozone attacks the respiratory organs and is particularly harmful for children and chronic patients. Being one of the strongest oxidants among the gases that are emitted in the oxidation process, ozone creates sulphur and nitrogen acid. This causes acid rains which have been known to be extremely harmful for both animate and inanimate world. Ozone is an extremely toxic gas whose effect can be compared to that of the poisonous (war) gases. Smog is rich with sulphur oxide in urban areas, especially during winter, which is, in the presence of the particles of metals, iron or vanadium, which function as oxidation catalysts, first transformed into sulphur-trioxide, and then in the presence of moisture into sulphur acid. This kind of pollution is extremely harmful for the health of the patients with lung, heart and nervous disorders. All these factors put together create the so-called urban stress. Thus the topic of this paper is air pollution as the cause of the urban stress in the area of Boulevard Nemanjica, Niš, Serbia.

2. Human environment and exhaust fumes

Human environment represents a group of natural and manmade values which are intricately connected comprising environment, space relation and living conditions. The quality of the human environment is in fact its condition represented by the physical, chemical, biological, aesthetic and other indicators.

Exhaust fumes exert a very pernicious effect on human environment. The air is directly polluted by the gases from internal combustion engines of motor vehicles by oxidation products. The emission of gases in motor vehicles is performed through three systems: exhaust fumes (around 60%), petrol evaporation from the reservoir and carburetor system (around 20%) and the oil system (around 20%). Exhaust fumes from cars represent the source of a great number of pollutants: unoxidated and partially oxidated hydrocarbons, carbon-monoxide, nitrogen oxides, lead, soot, etc. The process of oxidation is a chemical and physical process which transforms the chemical energy from fuel followed by an extreme release of heat. Chemically speaking the process of oxidation is binding of all fuel constituents with oxygen, which is in itself a turbulent and swift process. Hydrogen, carbon-monoxide, hydrocarbons are the oxidizable constituents of gas fuels. Those which are not oxidizable are carbon-dioxide, nitrogen and oxygen. Petrol engines burn the 'rich' mixture which often contains some extra fuel. Carbon-monoxide, unoxidated or partially oxidated fuel and 'cracked' hydrocarbons are emitted. Besides this, exhaust fumes contain inorganic lead compounds since there are still only a small number of motor vehicles using unleaded petrol in our country. Diesel engines (compression ignition) burn fuel with a great amount of extra air which usually does not create carbon-monoxide or unburned fuel. In case this engine is not properly fixed or is rather worn-out, then it works improperly and using up too much fuel which is the reason why the diesel engine emits black smoke and carbon-monoxide together with aldehids and other bad smelling compounds. Both engine types emit nitrogen oxides which originate both in fuel and in atmospheric air fixation at high temperatures and pressure which is formed in the combustion chamber. If worn-out they can eject oil. The concentration of pollutants from motor vehicles differs depending on season, traffic and the fuel quality. The way of measuring may be a problem arising from the study of the concentration of harmful materials in the atmosphere. Sometimes a rather great harmful concentration can appear in individual or momentary studies, whereas in occasional research to obtain average values there can arise small and harmless amounts. This may cause confusion since a great, lethal pollution may develop. Consequently, necessary protective measures should be undertaken to provide the normal living and working conditions in the observed environment, i.e., to provide the conditions under which humans can be exposed without any harmful consequences. The measuring for the observed location was done during the period of eight months (May 2007 - June 2007) by the Health Protection Centre in Niš. The following exhaust fumes from motor vehicles were studied: carbon monoxide (CO), nitrogen oxide (N_{ox}) formaldehyde (HCHO). The measuring were done in the vicinity of the 'Boulevard' green market using the standard methods prescribed by the regulations concerning the highest permitted values, emission measuring methods, criteria for determining the measuring spots and facts records (SLG RS number 54/92, 30/99, 19/06). It has been estimated that an average number of 10 000 motor vehicles drive along the Boulevard daily. The advantage is that the northeast moderate winds dominate the area thus blocking the higher concentration of exhaust fumes in the air. Nemanjića Boulevard is situated near to Nisava River (Brankovic and Trajkovic 2008), in the eastern part of Niš, in the vicinity of the centre of town and represents a very important traffic route which connects the central to the eastern part of the town. It passes through the town centre parallel with Dr Zorana Đinđića Boulevard and them together flow into Cara Konstantina Boulevard. All the way it passes through the residential area designed for high-rise apartment buildings. This boulevard is intended for passenger and goods traffic, as well as for quite frequent public transport. There is Sveti Sava Park very near with a great number of activities going on in it. The climate is humid (Trajkovic and Stojnic 2008). Manuel spectrophotometric method (West Gaeke) for sulphur dioxide estimation in the air, JUS ISO 6767, 1997, and Manuel spectrophotometric method for nitrogen oxide estimation in the air (Griess-Saltzman Reaction), APHA ISC 42602-03-73T.

Fig. 1 The position of the observed location in relation to the surrounding environment and the measuring spot within the observed location

The system consisting of eight-channel air sample **ProEkos** AT801x (with the digital display of start time, passed time, momentary flow and total flow) was used for exhaust fumes samples on the observed spots as well as two three-channel manifolds for the attached ablutions with the absorption solutions for nitrogen oxide and ammonia. The manifolds contain rotametres for the flow indication and needle-shaped valves for the flow regulation. The eight-channel sample turned on the manifolds one at a time, so that an everyday sampling in the period from 00:00 to 23:59 was provided. The sample was distributed to an absorbing funnel, so that it was recorded as one air sample in which two pollution parameters were estimated for the sample date. The four-channel air sample **ProEkos** AT401x was used for exhaust fumes samples on the measured spots. The spectrometer UV/VIS **PE** Lambda EZ 150 was used in the laboratory examination of samples.

Carbon monoxide (CO)

Carbon monoxide (CO) is an extremely toxic gas with no smell or taste which is lighter than air. It belongs to the group of chemical gases that cause suffocation and provokes general hypoxia due to the irreversible binding with hemoglobulin (Hb). Carbon monoxide has a very swift toxic effect even in small amounts. Carbon monoxide develops in the process of incomplete oxidation or the organic materials. One of the most important sources of air pollution is the exhaust fume from the internal combustion engine which contains 1 - 14 % of carbon monoxide, while the second big air pollutant is the metallurgic industry.

Fig. 2 The view of the Boulevard with the 'Boulevard' green market and Sveti Sava Park

It has been estimated in the USA that out of the total amount of CO emitted in the atmosphere 58 % are exhaust fumes from cars and other internal combustion engines. Over 50 % of all deaths by poisoning were caused by carbon monoxide. Carbon monoxide is taken and eliminated from the organism through lungs, whereas its final toxic result is hypoxia which develops due to the formation of carbon compounds which occupy the space for the oxygen binding (O_2) or for the oxygen transmission and its usage in the tissues and cells. Carbon monoxide binds with hemoglobulin a little bit more slowly than it does with oxygen, but the hemoglobulin affinity for carbon monoxide is 210 – 220 times higher than for oxygen, so that carbon monoxide has the advantage of binding with hemoglobulin even when it is present in disproportionately smaller amounts in relation to oxygen. The toxic effect of carbon monoxide on human body depends on the exposition time and some potential factors, that is on the breathing volume in a minute, muscle activity, individual immunity of every person, concentration of carbon monoxide and hypoxia intensity. The lethal doze for humans is 1000 - 2000 ppm (0.1 - 0.2 %) if exposed for 30 minutes. In the situations of high carbon monoxide concentrations death can come as soon as after 1 - 2 minutes. The maximum concentration allowed in industry is 50 ppm (0.005 %) if exposed for 8 hours, whereas the air that divers breathe in must contain the amount not higher than 10 ppm (0.001 %).

Nitrogen oxides (NOx)

Nitrogen oxides emitted in the atmosphere in the oxidation process are the pollutants which destroy the stratospheric ozone, increase the UV radiation intensity, affect the global climate changes, and produce acid rains and photochemical smog. The development of nitrogen oxides in the process of fossil fuels oxidation is a very complex process affected by chemise, fuel, heat exchange and some typical flows. Nitrogen oxides represent the main polluting materials. Solid fuels consumers emit great amounts of nitrogen oxides. It can be said that the filtration of smoke gases in order to eliminate solid particles has been done for quite a long time. The fuel combustion in engines creates nitrogen monoxide (NO), which develops in high temperatures. It is thermal nitrogen monoxide (NOx). Besides this thermal reaction (of nitrogen and oxygen from the air), there develops the thermal reaction with the chemically bound nitrogen in the very fuel they originate from – NOx from fuel. The nitrogen monoxide thus formed (thermally and from the fuel) is identified exclusively as NO in the heated smoke gas. Only after the cooling of the smoke gases and in contact with the atmosphere is it transformed into other oxides: nitrogen dioxide NO_2, nitrogen trioxide N_2O_3. It is the reason why certain data concerning NOx are unreliable if the study is not done under the determined conditions. The emitted NOx gases contain nitrogen monoxide NO the most and less the other nitrogen gases.

Nitrogen dioxide and nitrogen monoxide differ in the kind and level of harmful effect. The former is a dangerous irritable poison which provokes the respiratory tract mucous membrane inflammation, lung damage and swelling. Nitrogen monoxide causes the icorrigible hemoglobulin changes, that it it blocks the hemoglobulin in blood. Due to the ultraviolet radiation and in the presence of oxygen nitrogen oxides help create ozone which leads to the formation of smog in big cities. In small quantities it does harm to photosynthesis, plant respiration.

Formaldehyde (HCHO)

Formaldehyde is the simplest aldehyde. It is technically obtained from methanol (by hydrogenisation). 40% formalin solution of formaldehydes in water is used. In water formaldehyde is bound by the water molecule. It is the gas characterized by sharp smell, which boils at -21^{0}C. It is easily oxidated in the water solution

It is used for disinfection, the synthesis of medical drugs and artivicial resin, protein conservation. Its bad characteristic is that it is poisonous (it not only kills bacteria but also affects humans). The other name for formaldehyde is methanol. It belongs to the class of aldehydes. Its molecular formula is HCHO. Normally it is the gas of the particular smell. It has been determined to be cancerous (better to say it is the agent which provokes cancer) not just for animals but also for human beings. The most likely organs to be affected are respiratory organs, including the nose. The studies done on animals show that the expectancy for people exposed to formaldehyde is one in 10 000.

3. Results and discussion

The exhaust fumes estimation results are shown in tables and graphs. The estimation was done in the area of Medijana –Nemanjića Boulevard in Niš for: carbon monoxide (CO), nitrogen oxide (NOx) and formaldehyde (HCHO). The measuring was done by the Health Protection Centre in Niš. The estimation results led to the conclusion that carbon monoxide went beyond the allowed limit and amounted to 16.2 mg/m^3 in May, which is 6.2 mg/m^3 than the maximum allowed value. A rapid fall of carbon monoxide concentration was observed in the following months up to its minimal value in July and December of 0.9 mg/m^3. Nitrogen oxide did not surpass its maximum allowed value in the observed period of time. It showed a tendency of having some extremely high values as compared to the observed period in November when its concentration amounted to 62.40 mg/m^3. The rapid fall of nitrogen oxide is evident in December when it is 11.7 mg/m^3. The minimum nitrogen oxide concentration is in August when it is less than 5.2 mg/m^3. Formaldehyde does not go beyond the allowed limit of 100 mg/m^3. Its minimum concentration is evident in October and December which is 3.3 mg/m^3 in these two months, whereas it has its maximum values in between these two periods, in December, when its concentration amounts to 22.90 mg/m^3.

Table 1. Exhaust fumes from motor vehicles, location Medijana –Nemanjica Boulevard, Niš

Months	CO	NOx	HCHO
May	16.20	9.80	<6.60
June	2.50	13.10	<6.60
July	<0.90	28.30	<6.60
August	2.00	<5.20	7.20
September	2.00	23.50	<6.60
October	3.10	15.40	<3.30
November	0.90	62.40	22.90
December	<0.9	11.70	3.30
MIV	5/10 mg/m^3	85/150 mg/m^3	100 mg/m^3

MIV – maximum exhaust fumes imission values. The maximum emission values for carbon monoxide is 10 mg/m^3 in residential areas that is 5 mg/m^3 in nonresidential and recreation areas. MIV for nitrogen oxides is 150 mg/m^3 in residential areas and 85 mg/m^3 in nonresidential areas, while it is 100 mg/m^3 for fomaldehyde.

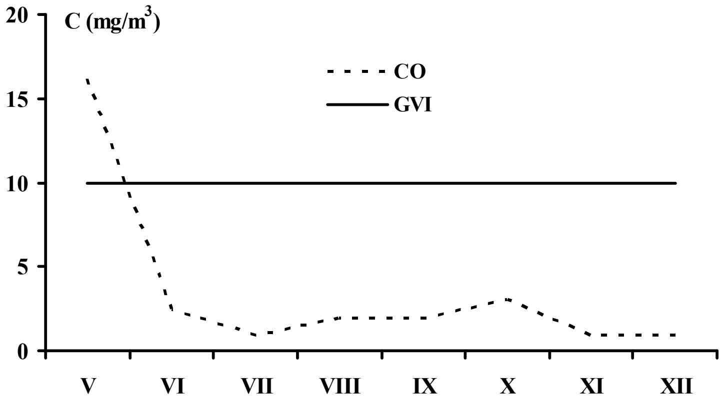

Fig. 3 CO air concentration (C)

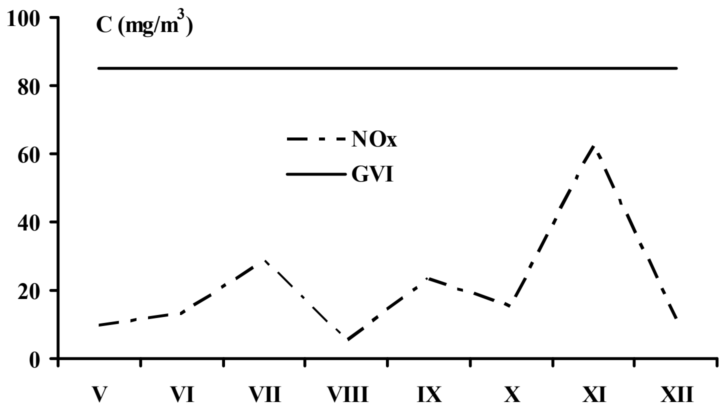

Fig. 4 NOx air concentration (C)

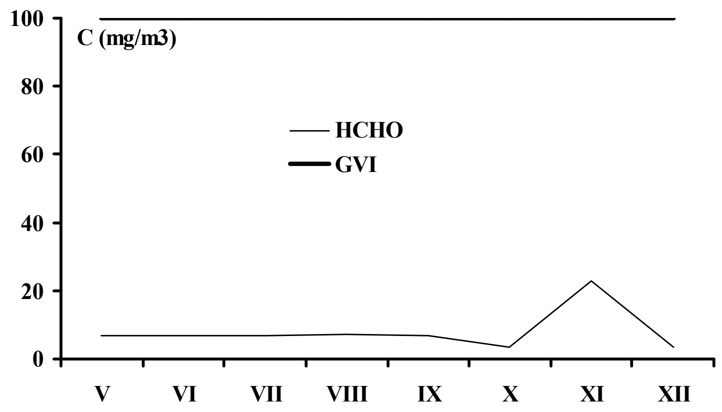

Fig. 5 HCHO air concentration (C)

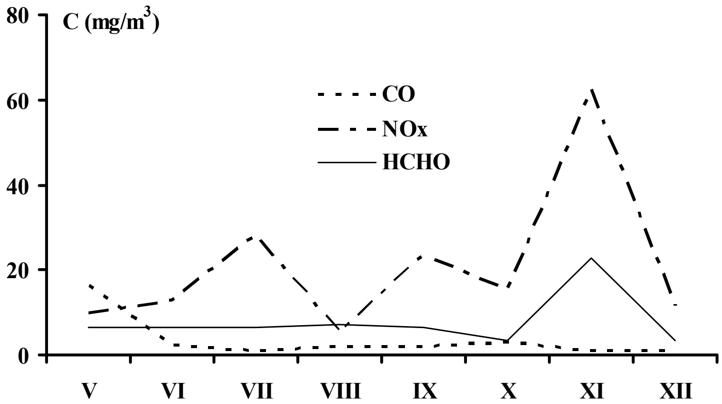

Fig. 6 The graphic presentation of the concentration of exhaust fumes in the air

4. Conclusions

The concentration of exhaust fumes from motor vehicles was never higher than allowed, except in the case of carbon monoxide in May after which it kept on decreasing and remaining within the allowed limits. The exhaust fumes concentration varied within the allowed values in the observed period. The data concerning the air quality in the observed area showed that the air pollution was of low intensity. No significant exceptions are expected in the forthcoming period. Regarding the data of the present air quality in the observed area showed that the level of air pollution was of a low intensity. There are not expected some significant exceptions concerning the increase of exhaust fumes concentration. The exhaust fumes concentration would significantly decrease if some green areas and multifunctional pedestrian zones would be build in the location of Medijana - Nemanjića Boulevard in Niš. This would prevent the further of the environment and its better functioning.

References

1. Blagojević, B., Trajković, S., Potić, O. i Prohaska, S., Hidrološke analize i proračuni za kompleks deponije "NIŠ '97" u svetlu EU Direktive o deponijama otpada, Nauka+Praksa 8, 117-124, 2005.
2. Borrego C, Martins H, Tchepel O, Salmim L, and Monteiro A, and Miranda AT, How urban structure can affect city sustainability from an air quality perspective, Environmental modelling & software, 21(4), 461-467, 2006.
3. Brankovic, S. and Trajkovic, S., The Nišava River water quality as the indicator of the sustainable development of the city of Niš, Spatium 15 – 16, 80 -84, 2008.
4. Calef D, and Goble R, The allure of technology: How France and California promoted electric and hybrid vehicles to reduce urban air pollution, Policy sciences, 40(1), 1-34, 2007.
5. Goyal SK, Ghatge SV, Nema E, and Tamhane SM, Understanding urban vehicular pollution problem vis-a-vis ambient air quality - Case study of a megacity (Delhi, India), Environmental monitoring and assessment, 119(1-3), 557-569, 2006.
6. Jain S, and Khare M, Urban air quality in mega cities: A case study of Delhi City using vulnerability analysis, Environmental monitoring and assessment, 136(1-3), 257-265, 2008.

7. Ostachuk A, Evelson P, Martin S, Dawidowski L, Yakisich JS, and Tasat DR, Age-related lung cell response to urban Buenos Aires air particle soluble fraction, Environmental research, 107(2), 170-177, 2008.
8. Tomasevic M, Vukmirovic Z, Rajsic S, Tasic M, and Stevanovic B, Contribution to biomonitoring of some trace metals by deciduous tree leaves in urban areas, Environmental monitoring and assessment, 137(1-3), 393-401, 2008.
9. Trajkovic, S., Održivo upravljanje gradjevinskim otpadom, Zbornik radova Gradjevinsko-arhitektonskog fakulteta 21, 115-122, 2007.
10. Trajkovic, S., and Stojnic, V., Effect of wind speed on accuracy of Turc method in a humid climate, Facta Universitatis, Series Architecture and Civil Engineering, 5(2), 107-113, 2008.

AEROZAGAĐENJE KAO UZROK URBANOG STRESA. STUDIJA SLUČAJA: BULEVAR NEMANJIĆA, NIŠ, SRBIJA

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Tema ovog rada jeste aerozagadjenje kao uzrok urbanog stresa. Ovaj problem se analizira kroz studiju slučaja, aerozagadjenja na Bulevaru Nemanjića u Nišu. Za posmatranu lokaciju merenja su izvršena u periodu od osam meseci (maj 2007. - jun 2007.) od strane Zavoda za zaštitu zdravlja u Nišu. Izduvni gasovi motornih vozila koji su obrađivani su: ugljen monoksid (CO), azotni oksid (Nox) formaldehid (HCHO). Merenja su vršena kod "Bulevarske" pijace, standardnim metodama propisanim pravilnikom o graničnim vrednostima, metodama merenja imisije, kriterijuma za uspostavljanje mernih mesta i evidencije podataka. Koncentracija izduvnih gasova motornih vozila nije prelazila dozvoljene granice, osim ugljen monoksida u maju mesecu gde se nakon toga nastavio trend opadanja i zadržavanja u okvirima dozvoljenog. Sa obogaćivanjem lokacije Medijana – Bulevar Nemanjića u Nišu zelenim površinama, pešačkim zonama oplemenjenog sadržaja dovelo bi do opadanja koncentracije izduvnih gasova motornih vozila. To bi sprečilo ugrožavanje životne sredine i njeno zdravije funkcionisanje.

Key words: *urbani stres, aerozagadjenje, zaštita životne sredine.*