

## PROPOSAL FOR REDUCING PROBLEMS OF THE AIR POLLUTION AND NOISE IN THE URBAN ENVIRONMENT

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**Abstract:** This paper analyzes the state of the environment in the City of Novi Sad, as the representative of a typical central European city by its architectural heritage. The impact of traffic on urban environment of Novi Sad has been examined and presented through a state of air quality, noise pollution and frequency of passenger and freight vehicles in the period from 2006 to 2008. The following indicators of air quality have been measured: total amount of sediments in air, sulphur dioxide, soot, NO<sub>2</sub>, CO, CO<sub>2</sub>, total quantity of suspended particles, benzo(a)pyrene (BaP), benzene, and ground-level ozone. The parameters whose maximum annual values are constantly exceeding the legally permitted limits are the following: total amount of sediments in the air, soot, total amount of suspended particles and BaP as a representative of polycyclic aromatic hydrocarbons. The tree-year monitoring of the noise levels indicates the exceeding of permitted daily and nightly noise levels as well as their annual growth. Moreover, the obtained results about the average 15-minute frequency of passenger and freight vehicles in traffic also indicate an obvious growth trend. In addition, this paper brings forth one of the possible solutions for solving mentioned problems proposing the cycling as a sustainable alternative for commuting. Furthermore, it presents the research conducted in the form of a survey on cycling as a way of transportation among the students of the University of Novi Sad. Finally, the last part of the paper presents the newly built bicycle parking which has proven to be a good investment and a template for other educational institutions and companies with a large number of employees as well as ideal solution applicable in solving the great part of problems of air pollution, noise, congestion, land consumption and time for reaching the destination.

**Keywords:** urban environment, air pollution, noise, cycling

### 1. INTRODUCTION

In the year of 2006, there were close to 491 million inhabitants in the EU-27 and 80% of Europeans live in an urban environment. Regardless of age, most people will use transport to go to work or to school, to do shopping and to travel in their leisure time. As the location of jobs, residences, and other facilities within the city affects transport demand, that also conditioning the number and length of trips as well as the modal split. Furthermore, over recent decades, many large

European cities have grown in a scattered way. Hence, the current trend towards a decentralization of population and employment has led to longer trips and an increasing dependence on cars, exerting great pressure on the environment. In the same year, an average of 34km was travelled daily by EU-27 passengers, 26km of which by passenger car. In fact, in 2006, there was nearly one car for two inhabitants. (European Commission, 2006; European Commission, 2009b; Muniz & Galindo, 2005).

We are all witnesses that cities are growing inexorably, causing many to think that inevitably

their environmental impact will worsen. Thereby continued rapid growth of cities raises a number of persistent questions. Are they becoming so big that their negative impacts outweigh the opportunities that they provide (Newman, 2006).

Accordingly, each community – in particular the urban ones – has a task to face its existential space and act continuously to develop the ecological framework of the settlements and to change in a sustainable manner, with an important awareness of the need to respect the environment, social objectives, economic needs, cultural achievements, urbanity and tolerance (Ianos et al., 2009).

Problems that used to emerge, but which still appear at attempting to improve the traffic are complex and could be divided in 3 groups:

- Problems related to land, due to the need of providing areas for different purposes in transport (roads, parking lots, bicycle and pedestrian areas, etc.);
- Problems related to energy consumption (consumption of fossil fuels);
- Problems related to environmental degradation (air pollution, soil pollution, noise, land consumption, etc.).

## **2. SOME FACTS ABOUT ENVIRONMENT AND URBAN TRANSPORT**

### **2.1. Situation in EU**

As highlighted by the mid-term review of the 2001 White Paper, "Keep Europe moving", the goal of the EU's sustainable transport policy is to ensure that our transport systems meet the citizen's economic, social and environmental needs (European Commission, 2009b).

One of the main problems faced by the many EU cities are the negative impacts on urban environment caused by increasing number of citizens and change in their mobility patterns (Dodman, 2009) - illustrated best by the fact that the emissions from the transport sector in EU increased continuously between 1990 and 2006 (27.3%) (European Commission, 2008). The motorization rate of passenger cars for the EU-27 in 2006 was 466 passenger cars/1000 inhabitants (Luxembourg have the highest motorization rate 671 passenger cars/1000 inhabitants), which corresponded to a 5% increase since 2002. Almost the halves of the countries were above the EU-27 average rate. (European Commission, 2008).

Analysing the period from 1995 to 2003 in EU, it is obvious that passenger transport demand and the gross domestic product (GDP) both have

increasing and nearly linear trend (European Environment Agency, 2005). Considering the transport policy, this fact is very important for the newly joined EU and the EU pre-accession countries due to expectation of their GDP growth and higher pressure on the environment.

Many Europeans still remain exposed to dangerously high levels of air and noise pollution (Picu, 2009). Namely, the concentration of particulate matters (PM<sub>10</sub>), of which transport is the second most important source, exceeds the 2005 limit value in many air quality zones. Moreover, almost 67 millions EU-27 inhabitants are exposed to daily noise levels exceeding 55dB while almost 48 million people exposed to night-time noise levels exceeding 50dB (European Environment Agency, European Commission, 2009a).

In addition to a series of studies indicating industry as polluter of the soil by heavy metals (Secu et al., 2008; Damian et al., 2008), the soils located along the street areas suffer from substantial amount of pollution by traffic, also (Lacatusu et al., 2008).

### **2.2. Situation in The City of Novi Sad**

Novi Sad is the capital of Vojvodina, the northern province of Serbia. The City of Novi Sad itself (without suburbs) covers an area of 106 km<sup>2</sup>. According to the 1991 census, the city had about 170.000 inhabitants, in 2002 about 290.000 inhabitants, while the latest research estimates over 350.000 inhabitants in 2008.

In recent years, the City of Novi Sad has experienced the "construction boom", righteously claiming an epithet of the "biggest building site in the Balkans". The single-storey houses that once dominated the city are now replaced by an average of four to five-storey buildings.

The growing number of citizens led to construction of new residential buildings and increased need for the transportation of commuters. As a result, the number of cars has noticeably increased in Novi Sad in the last few years. The average year increase of passenger cars is 10% in three last three years. Direct consequence of such a surge of people and passenger vehicles is the air pollution, higher level of noise, congestion, lack of parking space, increased daily commuting time (to work, school, recreation, shopping, etc).

### **2.3. Cycling as a solution**

This paper aims to highlight cycling as a solution which fits perfectly into any general policy which seeks to re-enhance the urban environment

and improve the quality of a town and it mobilises (European Commission, 1999).

More and more official EU reports and actual researches put an emphasis on cycling as significant urban transport options. Furthermore, frequent statements are made about cycling as one of the most sustainable modes of transport (Kenworthy, 2006).

A safer and more secure urban environment can be conducive to greater use of public transport, of cycling and of walking, which would not only ease congestion and reduce emissions, but also have positive effects on peoples' health and well-being (European Commission, 2009a).

The 1999 Handbook of European Commission shows that more than 30% of trips made in cars in Europe cover distances of less than 3km and 50% are less than 5km. Considering those journeys alone, bicycles could easily replace cars, thus satisfying a large proportion of the demand and contributing directly to cutting down traffic jams, air pollution and noise. We cannot afford to ignore the potential of cycling, whether for daily trips to school or to the workplace (which account for 40% of all journeys made) or for other reasons (60% of journeys made are to do with shopping, services, leisure pursuits, social activities, etc.) (European Commission, 1999).

Comparing situation in Europe and other regions of the world some researches indicate that the proportion of people walking or cycling to work varies from 32% in Copenhagen to 0.3% in Atlanta, from 30% in Santiago to 2% in Brasilia. The range of urban trips by motorized private transport ranges from 89% in the USA to 50% in Western Europe, 42% in high-income Asia to 16% in China (Newman & Kenworthy, 1999).

According to appreciation of Kjellstrom and Mercado (2008), investment in improved public transport (three to five times more energy efficient than private transport) as well as encourage cycling can create great improvements in air pollution exposure, as well as traffic crash injury prevention and improved daily physical activity (Pikora et al., 2003).

The EU can promote the study and exchange of best practice across the EU in areas such as transport infrastructure, norm-setting, congestion and traffic management, public transport services, infrastructure charging, urban planning, safety, security and cooperation with the surrounding regions (European Commission, 2006).

Among the numerous examples, there is a good example of the British city Leicester which has developed the cycling strategy with the target of

doubling levels of cycling, which has resulted in a significant increase in the numbers of cyclists. (Roberts, 2000).

### 3. RESULTS AND DISCUSSION

Due to the fact that meteorological factors (such as wind speed, relative humidity ratio and temperature) have a close relationship with concentration of air pollutions (Cuhadaroglu & Demirci, 1997) below have been presented particular meteorological as well as climatologic parameters for Novi Sad which can have some influences on the concentration of air pollution.

Novi Sad lies in the southern part of the Pannonian Plain, at the altitude of 77 to 80m. Its landscape is divided into two parts; one side of the Novi Sad lies on one of the southern lowest parts of Pannonian Plain, while another side is a horst mountain. The river Danube is a natural border between them.

The city is located between 19°51' of the east longitude and 45°20' of the north latitude. In the last three years the average annual air temperature is 12.5°C. The average annual precipitation in the last three years is 656mm and there are 122 days with different forms of rainfall.

Novi Sad has a moderate continental climate, with four seasons. The southeast-east wind, called "Kosava", which blows from the Carpathians and brings clear and dry weather, is characteristic of the local climate. It mostly blows in autumn and winter, in 2-3 days intervals.

The table 1 shows meteorological factors, which have well known influence on concentration of air pollutions. Measurements are conducted by Republic Hydrometeorological Service of Serbia in the period from 2006 to 2008. Presented parameters are: air temperature, rainfall, relative humidity ratio and wind speed.

Table 1. Annual values of the meteorological factors which have influence on concentration of air pollution

Parameters	2006	2007	2008
Max. air temperature [°C]	34.5	41.6	37.8
Min. air temperature [°C]	-13.8	-7.4	-12.1
Rainfall [mm]	641	798	529
Avg. relative humidity ratio [%]	76	74	73
Min. wind speed [m/s]	1.8	1.9	1.8
Max. wind speed [m/s]	3.1	3.1	3.4

The following chapters of the report present the results of a three-year research that was

conducted by the Institute of Public Health of Vojvodina on the territory of the City of Novi Sad in the period from 2006 to 2008.

The following parameters have been measured:

- Parameters of air quality;
- Daily and nightly noise levels;
- Number of vehicles.

### 3.1. Air pollution - methodology and results

Determining the value of air quality indicators has been performed according to the prescribed methodology and valid regulatory basis of the Republic of Serbia (Law on Environmental Protection; Law on Air Protection; Rule book on limit values, methods of emissions measurement, criteria for determining the measuring sites and data recording; Regulation on Establishing the Air Quality Control Program in 2006 and 2007). Each parameter has been measured by using the prescribed methodology and equipment. However, this paper will not present the sampling methodology and measuring equipment, due to their extensiveness.

For all the parameters measured in this research, the main source of emission is traffic. All the parameters in high concentration have proven negative effects on the environment and human health, such as suspended particles, which are a complex mixture of organic and inorganic substances. Whereas benzo(a)pyrene (BaP), the main representative of polycyclic aromatic hydrocarbons (PAHs), is a cancerous substance that separates from the exhaust fumes.

In addition, many studies have proven that increased concentration of suspended particles and BaP often leads to hospitalization and mortality.

Table 2 presents annual maximum values of the measured air quality parameters. Further, Table 2 presents legally permissible mean limit values of emission for the given parameters as prescribed by the domestic law.

The air quality parameters whose maximum annual values constantly exceeded the legally permitted limits are the following: total amount of sediments in the air, soot, total amount of suspended particles and BaP as a representative of polycyclic aromatic hydrocarbons.

Table 2. Maximum values of air quality parameters

Air quality parameters	Limit values of emissions	2006	2007	2008
Total amount of sediments in air (air sediments)	200 [mg/m <sup>3</sup> ] (annually)	746.6	1649.1	2257.4
Sulphurdioxide	150 [µg/m <sup>3</sup> ] (annually)	140	129	150
Soot	50 [µg/m <sup>3</sup> ] (annually)	110	167	190
NO <sub>2</sub>	150 [µg/m <sup>3</sup> ] (monthly)	135	143	197
CO	10 [µg/m <sup>3</sup> ] (monthly)	9,21	11	13,81
CO <sub>2</sub>	* [µg/m <sup>3</sup> ] (monthly)	984	1231	1679
Total quantity of suspended particles	70 [µg/m <sup>3</sup> ] (annually)	785	1422	3081
BaP	1 [ng/m <sup>3</sup> ] (annually)	15.7	17.4	57,1
Benzene	4 [µg/m <sup>3</sup> ] (annually)	13.5	53.7	55,7
Ground-level ozone	85 [µg/m <sup>3</sup> ] (daily)	78	203.3	217.20

\* Not defined by the Serbian law

Taking into account the continuing trend of the growing traffic frequency in Novi Sad as well as the three years' results of the measured parameters, it is obvious that the air quality is seriously affected by the traffic. In order to improve the health and environment of the citizens of Novi Sad, it is necessary to pay more attention to the urban transport, especially the number of passenger cars.

### 3.2. Noise - methodology and results

Determining daily and nightly average noise levels in Novi Sad over a period of three years was done according to the prescribed methodology in

line with the applicable legislation of the Republic of Serbia (The Law on protection against noise in living environment; The Rule book on permitted noise level in the environment). This paper will not describe the measuring methodology and noise measurement equipment, due to their extensiveness.

The noise levels were measured at 18 locations within the inhabited area of the City of Novi Sad. According to the applicable legislation, the prescribed levels of communal noise are 65dB(A) by day and 55dB(A) by night.

Figure 1 and figure 2, respectively, present average values of the measured minimum and maximum daily and nightly noise levels.

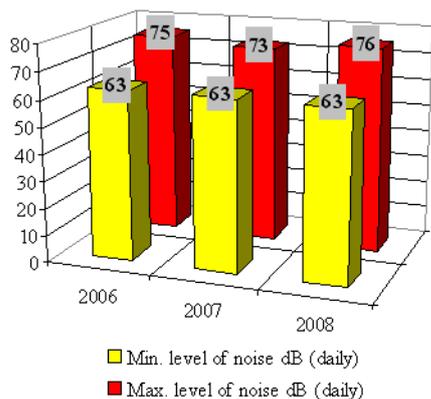


Figure 1. Minimum and maximum daily noise levels

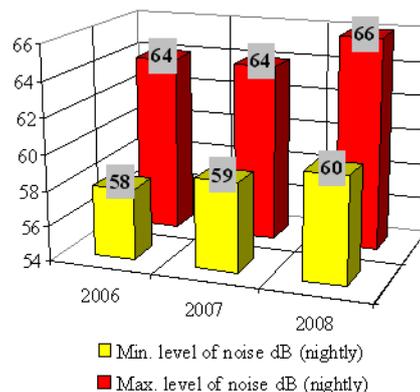


Figure 2. Minimum and maximum nightly noise levels

The three-year monitoring of the noise levels in the City of Novi Sad indicates the exceeding of permitted daily and nightly noise levels as well as their annual growth. Many studies confirm (Hodolic et al., 2009) that the effects of noise on people can vary from subjective effects of annoyance, nuisance and dissatisfaction; interference with activities such as speech, sleep, learning; and physiological effects such as startling and hearing loss.

Therefore, considering the trend of increasing number of motor vehicles (primarily cars) as the main cause of noise in Novi Sad, and taking into account the results of the noise level measurement, it is necessary to take all possible measures to reduce the traffic frequency in order to achieve the legally permissible noise level values.

### 3.3. Number of vehicles - methodology and results

Within this part of the research, the average 15-minute frequency of passenger cars and freight

vehicles in traffic was monitored at 18 locations in Novi Sad. Figure 3 and figure 4, respectively, present the results as maximum and minimum number of passenger and freight vehicles in the period of three years.

Comparing the year 2006 and 2008, there is an increase of the maximum annual 15-minute frequency of passenger cars in traffic of 267%, while the increase of the maximum frequency of 15-minute freight vehicles during the three years is 250%. The direct consequences of the traffic frequency increase in Novi Sad are mirrored, on a daily basis, in the increase of air pollutants, noise that surpasses the permitted levels, traffic congestion, increasing need for unoccupied parking space and in longer time required for commuting to work, school, shopping, recreation, etc.

All these facts indicate the necessity of taking all available measures to reduce the frequency of passenger and freight vehicles on the roads of Novi Sad.

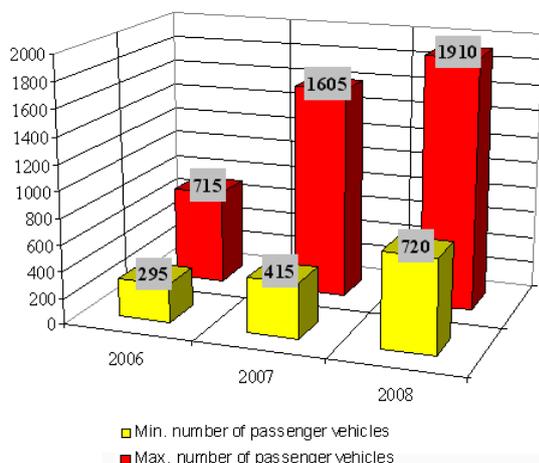


Figure 3. Minimum and maximum number of passenger vehicles (15-minute frequency)

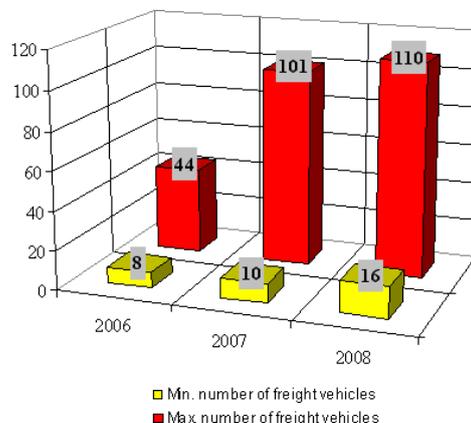


Figure 4. Minimum and maximum number of freight vehicles (15-minute frequency)

#### 4. ONE OF THE POSSIBLE WAYS FOR MITIGATION OF ENVIRONMENTAL PROBLEMS IN THE CITY OF NOVI SAD

In order to propose cycling as the best solution for the problems caused by increased number of cars, such as: air pollution, noise, congestion and increasing time to reach the destination, the second part of this paper attempts to present the research conducted in the form of a survey about cycling as a way of transportation among the students of the University of Novi Sad.

This research is focused on students only, due to the fact that each bicycle-user group (workers, pupils, students, etc) need a special approach for popularization of cycling as a way of transportation. Moreover, Novi Sad is the regional university centre with a significant number of students. Consequently, number of the inhabitants increases during the period from September to June as well as their demand for mobility. The city's annual number of students amounts to approximately 35.000. Furthermore, students represent a very important part of the overall population of the city, especially taking into account their present and future role in the modal split as well as in the transport policy (as a future decision makers).

After the survey, the next step was designing and construction of the first safe parking (from thief) for bicycles in Novi Sad and, along with an active promotion of cycling as environmentally friendly means of transportation.

After processing the results of the survey, the following data were obtained (from one to five), respectively:

- Outcome 1: 49.3% students own a bicycle, which clearly indicates the great capacity of developing this form of transport.

- Outcome 2: Only 0.6% students come to University by bicycle - this fact clearly points to insufficiently developed cycling and the need for greater share of cycling in modal split.

- Outcome 3: 49.9% of the students responded that the main reason for not using bicycles as means of transportation to university is non-existence of the safe parking space (from theft). This fact clearly indicates the direction in which to proceed in order to increase the use of bicycle.

- Outcome 4: The time required for students to arrive from their home to University is given in Fig. 5, according to the means of transportation they use. It is obvious that cycling is an utterly competitive form of transportation compared to the car or public transportation, with regard to time. Moreover, considering the time needed to get from a parking lot

or bus stop (public transport) to the faculty (door-to-door), bicycle wins an absolute advantage for the distances up to 4 to 5 km.

- Outcome 5: An average distance travelled by the students to university is 3 km. This fact indicates that the mentioned average distance is ideal to use bicycle as the means of transportation.

Upon conducting the survey and finding that 49.3% of students own a bicycle (Outcome 1), and on obtaining the data that reveals the main reason for not using bicycle as a form of transport (Outcome 3) - that is the lack of secure parking for bicycles, the next stage was to design and build the first secure parking for bicycles in the City of Novi Sad (Fig. 6).

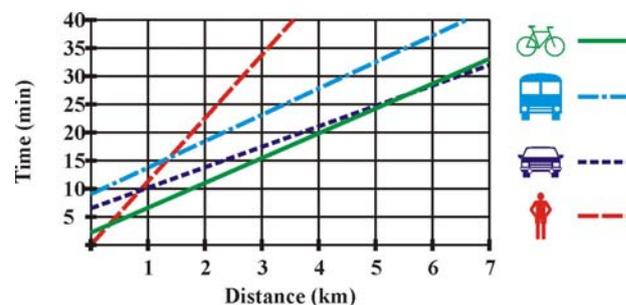


Figure 5. The time required for students to arrive from their home to the University



Figure 6. The new bicycle parking

One of the main ideas in this stage was to construct a parking which would serve as the basic model in terms of its ideal properties, such as utilization of its maximum capacity. Such a parking would serve as a template for other educational institutions and companies with a large number of employees. Also, the full range of activities from surveying the students, designing and building safe parking and promoting this form of transport represents a good example of successfully combating the use of cars, as one of the causes of the pressure on urban environment.

During the design and construction phase, attention was paid to create the future product (safe parking) that is acceptable from environmental and

economic aspects. This implied integration of environmental aspects into planning, design and development of the new product (parking for bicycles). The process of planning and development has until recently included only technical, aesthetic, economic and market demands. Besides these factors, a modern product must meet environmental requirements, thus introducing a new dimension to the process of planning and development, which is equally important and worth considering as the previously mentioned requirements. Unfortunately, environmental demands have been taken into account in the last 15 to 20 years and have only since recently been considered as equally important as the other requirements. Since this primarily applies to the highly developed countries, observing this request during the designing and construction of the new bicycle parking could be regarded as a pioneering step in this region.

During the designing phase, care was taken that the future solution has modular structure (easy to disassemble, simple maintenance, easy replacement of technical and outdated aesthetic parts) for whose realization would be spent as little material and energy as possible and that the structural parts are made of recyclable materials available on the local market.

The newly built bicycle parking (Fig. 6), which is covered and has 24-hours surveillance and lighting, has been constructed in the place of the old one, which previously only had bicycle racks. The new parking lot, compared to the old one, occupies the same surface and has better organization of racks that has doubled the number of parking places - from 17 to 34.

The average capacity occupancy of the old parking lot was 5 places (about 30%) of the 17 places, while the average capacity occupancy of the new one is 34 places (100%) of the 34 places, when the minimum weather conditions for cycling are satisfied. In planning the new bicycle parking, the main shortcoming was that there was not envisioned sufficient number of parking spaces.

In addition to these activities, an educational campaign was launched to raise students' awareness on using bicycle as environmentally friendly means of transportation. This was done through the web site of the Faculty of Technical Science, local TV stations, radio stations, newspapers, posters and by means of appropriate visual solutions (Fig. 7) in order to promote the new cycling facility, safe against theft. This also means that the students using bicycle for transport to university will no longer have to worry about the safety of their bikes or about weather conditions.



Figure 7. The promotion flyer for the new bicycle parking facilitate

## 5. CONCLUSIONS

Building a safe bicycle parking has proven to be a great investment and ideal solution applicable in solving the great part of problems of air pollution, noise, congestion, land consumption and time for reaching the destination. Also, it is important to note that the new attractive look of the covered parking, which was made of recyclable materials, has already significantly contributed to the popularization of this form of transportation as it leaves an extremely positive impression on students.

A specific value of this solution lies in the fact that in designing and construction phase a special care was taken to ensure that the future product (bicycle parking) is acceptable from environmental aspect as well as economic one. Additionally, since the solution was inexpensive in relation to its benefits for the community as a whole, soon after the new bicycle parking was built at the University of Novi Sad, the City Authority built three more bicycle parking lots in the central area of the city. The same principles were applied in the designing and construction phase (covered parking and surveillance).

This is an indicative example of how small investments in cycling facilities, such as secure parking and well-planned comprehensive public campaign (promotion) on cycling as a transport mode, can substantially contribute to the share of cycling as the most sustainable way of transport in the modal split of the City of Novi Sad.

Considering the pressure of traffic on urban environment and the fact that Novi Sad has the total length of approximately 65km of bicycle paths as well as acceptable weather conditions for cycling for the most part of the year, the solution presented in this paper seems logical and approved in the light of planning and building a bicycle parking according to the above described model, in order to mitigate the environmental problems of the city. Furthermore, this solution can be the most suitable one for the mentioned problems as well as for the cities which have a great student population.

Finally, the guidelines for future research could be focus on the most eligible materials for

building this kind of parking lots, as well as finding adequate mathematical and economical models that could clearly quantify the reduction of pollution in urban environment, which is achieved by increased use of bicycle as a mode of transport.

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Received at: 17. 11. 2009

Revised at: 28. 12. 2010

Accepted for publication at: 18. 01. 2010

Published online at: 22. 01. 2010