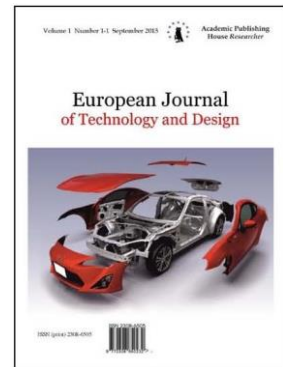


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## Articles and Statements

### Ecological Factors Regarding to the Site Selection and Architectural Design of Parking Garages

Bujar Bajcinovci <sup>a, \*</sup>

<sup>a</sup> University of Prishtina, Faculty of Civil Engineering and Architecture, Kosovo

#### Abstract

In the process of spatial planning there are the inevitable urban zones with the commercial public buildings, as one of the segments of the overall development of the city. They represent certain mandatory fulfilment for the functional urban design categories. However, actually, what happens to the environment? Urban actions should be preserved and limited in terms of the environmental impact. The aim and objective of this paper is to address dimensions that relate to the parking garages in relation to air quality, and health impact according to the actual site location and distance of open public parking garage to the communities. The research methods consist of empirical observation through urban zones of Prishtina, with an accent to the future structures of the parking garages in the city. Hence, the same architectural design strategy cannot respond to all specific problems faced by contemporary urban issues. The current degraded state of environment as a whole “Umwelt”, requires specific responsibilities and activities, exclusively when the environmental condition is directly linked to the quality of life and public health. Based on the conceptual results of air pollution and ecological concepts for parking garages presented in this paper, site locations for the parking garages of Prishtina must fundamentally accompany ecological patterns for the healthier communities in coming decades.

**Keywords:** architecture, ecology, design, parking garages, environment.

#### 1. Introduction

In the process of spatial planning there are the inevitable urban zones with the commercial public buildings, as one of the segments of the overall development of the city, they represent certain mandatory fulfilment for the functional urban design categories. However, what happens to the environment? Urban actions should be preserved and limited in terms of environmental impact. Decisions for actions of this nature in connection with the community and contemporary society needs are more complex and present a wide functional system, with full comprehensive nature. Hence, we must seriously respect the ecological procedures for obtaining the legal opinion of all stakeholders in the process. Moreover, the ‘green’ strategies regarding to the preservation of the environment often show greater activities in relation to financial boards or comities and decision-makers, therefore, we must encourage to actively participate on public debates for these

\* Corresponding author  
E-mail addresses: [bujar.bajcinovci@uni-pr.edu](mailto:bujar.bajcinovci@uni-pr.edu) (B. Bajcinovci)

vital final decisions. Furthermore, in relation to communities which are near those polluted zones or specific architectural structures which emanate or contribute to air pollution, surely we must undertake environment protection actions to all the specific tasks and requirements in terms of capacity, planning, development, traffic, volume of use, the risk of environmental pollution and noise pollution.

“Many structures cope with fundamental demand of functional, energy efficiency and sustainability objectives, with the immediate need to implement the energy of new renewable sources ... Hence, we aim environmentally and sustainable to introduce those actions into the practice, green actions, backed up with the legal premise for environmental protection and respect the biodiversity” (Bajčinovci, 2016).

Parking garages are major infrastructure facilities in the complex parking urban zones, which may be located above or below ground. Parking garages are also important contributing sources of air pollution, with environmental impact near or beyond of their site location. But at the same time, they are also functional auxiliary points accompanied to the cultural, social, economic and commercial architectural structures. Parking garages with a quality architectural design play a symbiosis with other buildings features, which in many cases shape the state of operating environment system as an urban entity in itself.

There is a huge traffic of potential urbanites in between urban zones, and urban regional communities, accompanied with different types of functional services such as hotels, airports, and mega terminal structures, a complex situation where essentially the architects and urbanists has a crucial role to address the conceptual models of urban planning (Bajčinovci, 2016).

Among the negative impacts on the surrounding environment, the dominant position of functional architectural complex is a source of environmental pollution causing noise and air pollution in their surroundings as well as the emission of significant quantities of harmful gases. Noise from vehicles is one of the most difficult problems to be addressed. These emissions reach peak operations during and about inadequate parking (operating, manoeuvring, igniting, obtaining and driving force behind), furthermore, the noisier actions are, the dominant long narrow parking manoeuvres. Moreover, the problem of noise is one of the problems which is constantly being addressed by the UN and WHO, to the date. Basically, there are five approaches to mitigate the noise problem as follows:

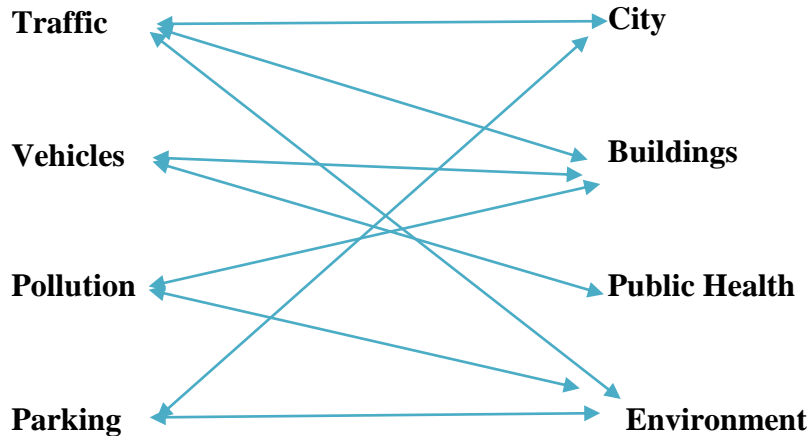
- Site selection, and optimal use of the location and environment for parking garages.
- Adequate urban planning, with communities near the parking garage facilities, with sound insulation barriers.
- The use of Nano materials and contemporary technology in architectural building structures in relation to preserve the environment
- Implementing the new contemporary technologies related to the gas emissions from vehicles and heavy traffic.
- The full environmental policy functionality of parking garages in the context of procedures for sustainable operation.

Hence, the determination of design strategy requires many factors to be considered in selecting the best access and management options with project delivery methods suitable for preserving the environment and public health. All motor combustion engine vehicles during their operation create noise pollution, especially in a heavy traffic urban zones and dense populated communities, a pollution, which present a permanent environmental issue. Problem arise, when vehicles are operating close to the residential areas and urban areas, in actions to make parking operations, goods handling, preparation and departure procedures. It can be conceptually concluded that all cities in the world are more or less affected by air pollution. Therefore, ecological factors regarding to the site selections and architectural design process of parking garages are crucial and fundamentally necessary, for healthier communities and requires the consent of local neighbourhood.

## 2. Material and Methods

There are an essential and vital questions: which are the biggest pollutants emitted in parking garage structures and their level of toxicity? To answer those questions, we must investigate the problem locally in a very complex research methods. Therefore, we must consider the risks

associated with any contaminants, risk includes emanation of pollutants but also we must consider in account their exposure in time, in relation to the toxicity. Regarding to the level of the toxicity that causes damage to health, special attention should be taken in a pollutant that can be emitted in small amounts, however, they represent significant risk. In contrast, focusing on pollutants with high overall emissions (across the garage) can be treated with a less attention on toxic pollutants relatively which may emanate, thus, in preliminary analysis of the emanations are minor quantities without having an impact on public health. However, the component of time dimension and route of exposure to them, should be taken into account, presented in [Figure 1](#).



**Fig. 1.** Ecological interdependence of urban design factors

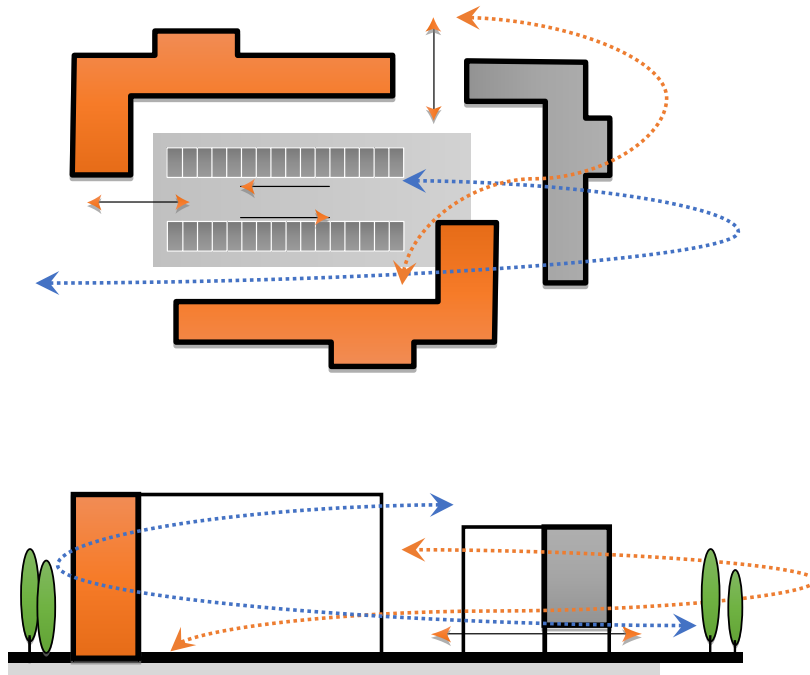
Many parking garages are islands of high level pollution, air quality is significantly poorer than in urban surroundings, poor quality of air adversely affects the health of humans and other species that exist or may be transported in the vicinity of the neighbourhood. Those ecological phenomena are especially visible and may lack the quantities of vegetation, trees and shrubs along the traffic roads to the parking garage. Poor air quality in open space conceptually means that the buildings suffer from poor quality of indoor air. Consequently, the closed types of parking garages are maintained with air conditioning, either in whole or in part zones, by adding at least indirectly health problems through the use of CFCs. Therefore, the right sustainable development necessarily affects the neighbourhood, site location, architectural design approach of parking garages, and land use planning.

“Outdoor concentrations of traffic-related air pollutants (nitrogen dioxide  $PM_{2.5}$ , particles with a 50 % cut-off aerodynamic diameter of 2.5  $\mu m$  and soot) were assigned to birthplace home addresses with a land-use regression model [...] Traffic-related pollution was associated with respiratory infections and some measures of asthma and allergy during the first 4 yrs. of life.” ([Brauer, 2007; Bajčinovci, 2016](#)).

Also, in Kosovo, there was study research in the field of air pollution and efficiency of energy, related in emissions of  $CO_2$  and Gross Domestic Product, “Kosovo as one of the richest countries with lignite in Europe with 95–97 % of the electric power production from lignite and with 90 % of vehicles over 10 years old, represents one of the regions with the greatest  $CO_2$  output per GDP per unit of economic activity, as well as one of the countries with the most polluted atmosphere in Europe. In this relation, we must consider the fact that Kosovo is a developing country ([Kabashi, 2011; Bajčinovci, 2016](#)). Besides the use of energy, commercial buildings and parking garages are big users of other resources and land resources. As a result of this consumption, buildings are significant producers of waste volumes, pollution (air, water, noise) and land pollution in the long-term cycle of heavy metals.

The contribution of parking garages on air pollution can be tricky, because of all those pollution factors can influence significantly to the pollution of the site. Also, many of them can contribute in different ways and react dramatically in interdependence with each other (one factor may interfere with the effectiveness of another). Therefore, parking garages can generate lower emissions of certain pollutants, such as nitrogen oxides ( $NO_x$ ), but because the surrounding environment it may be affected by weather conditions or a climate that is conducive to forming the

pollution, can contribute more to the detriment of air quality than a factory that produces higher emissions of NO<sub>x</sub>. The situation becomes more complicated when health hazard effects are being generated, as this depends on the location of the community. The research case is made, when the community surrounding is in vicinity of parking garage, and it is directly affected by prevailing dominant wind, then, this phenomenon causes the parking garage to be the biggest contributor which emanate environment pollution, and ecological hazard impact to the public health, presented in [Figure 2](#).



**Fig. 2.** Urban block zone, design of parking garages and effects of prevailing dominant wind in the neighbourhood

Primary and secondary pollutants refer to the pollutants that are emitted directly from a source (NO<sub>x</sub>, CO, VOCs, PM<sub>2.5</sub>) or formed in the atmosphere through chemical reactions or physical processes with secondary pollutants. The main pollutants in parking garages and similar buildings:

- Carbon monoxide (CO)
- Nitrogen dioxide (NO<sub>2</sub>)
- The particles are 10 µm in diameter (PM<sub>10</sub>)
- The particles are 2.5 µm in diameter (PM<sub>2.5</sub>)
- Sulphur dioxide (SO<sub>2</sub>)

Similarly, international standards set a dangerous pollutant emissions to the air, necessary to control the mass air toxics emissions by promoting technology-based standards for each type of buildings separately, also, objectives targeting the exposure of the population and air quality standards as presented in [Table 1](#) and [Table 2](#).

These standards apply to equipment used in buildings, such as: power generators, boilers. “Humans can be adversely affected by exposure to air pollutants in ambient air. In response, the European Union has developed an extensive body of legislation which establishes health based standards and objectives for a number of pollutants in air. These standards and objectives are summarised in the table below. These apply over differing periods of time because the observed health impacts associated with the various pollutants occur over different exposure times” ([European Commission...](#)).

**Table 1.** PM<sub>2.5</sub> objectives targeting the exposure of the population to fine particles, European Commission, (AEI). ([European Commission...](#))

TITLE	METRIC	AVERAGING PERIOD	LEGAL NATURE	PERMITTED EXCEEDENCES EACH YEAR
<b>PM<sub>2.5</sub> Exposure concentration obligation</b>	20 µg/m <sup>3</sup> (AEI)	Based on 3 year average	Legally binding in 2015 (years 2013,2014,2015)	n/a
<b>PM<sub>2.5</sub> Exposure reduction target</b>	Percentage reduction + all measures to reach 18 µg/m <sup>3</sup> (AEI)	Based on 3 year average	Reduction to be attained where possible in 2020, determined on the basis of the value of exposure indicator, in 2010	n/a

**Table 2.** Air quality standards and objectives. ([European Commission...](#))

POLLUTANT	CONCENTRATION	AVERAGING PERIOD	LEGAL NATURE	PERMITTED EXCEEDENCES EACH YEAR
<b>Fine particles (PM<sub>2.5</sub>)</b>	25 µg/m <sup>3</sup>	1 year	Target value entered into force 1.1.2010 Limit value enters into force 1.1.2015	n/a
<b>Sulphur dioxide (SO<sub>2</sub>)</b>	350 µg/m <sup>3</sup>	1 hour	Limit value entered into force 1.1.2005	24
	125 µg/m <sup>3</sup>	24 hours	Limit value entered into force 1.1.2005	3
<b>Nitrogen dioxide (NO<sub>2</sub>)</b>	200 µg/m <sup>3</sup>	1 hour	Limit value entered into force 1.1.2010	18
	40 µg/m <sup>3</sup>	1 year	Limit value entered into force 1.1.2010	n/a
<b>PM<sub>10</sub></b>	50 µg/m <sup>3</sup>	24 hours	Limit value entered into force 1.1.2005	35
	40 µg/m <sup>3</sup>	1 year	Limit value entered into force 1.1.2005	n/a
<b>Lead (Pb)</b>	0.5 µg/m <sup>3</sup>	1 year	Limit value entered into force 1.1.2005 (or 1.1.2010 in the immediate vicinity of specific, notified industrial sources; and a 1.0 µg/m <sup>3</sup> limit value applied from 1.1.2005 to 31.12.2009)	n/a
<b>Carbon monoxide (CO)</b>	10 mg/m <sup>3</sup>	Maximum daily 8 hour mean	Limit value entered into force 1.1.2005	n/a

<b>Benzene</b>	5 µg/m <sup>3</sup>	1 year	Limit value entered into force 1.1.2010	n/a
<b>Ozone</b>	120 µg/m <sup>3</sup>	Maximum daily 8 hour mean	Target value entered into force 1.1.2010	25 days averaged over 3 years
<b>Arsenic (As)</b>	6 ng/m <sup>3</sup>	1 year	Target value enters into force 31.12.2012	n/a
<b>Cadmium (Cd)</b>	5 ng/m <sup>3</sup>	1 year	Target value enters into force 31.12.2012	n/a
<b>Nickel (Ni)</b>	20 ng/m <sup>3</sup>	1 year	Target value enters into force 31.12.2012	n/a

Parking phenomenon represents and is a major urban problem, so therefore it is logical to conclude that certain types and forms of parking are extremely irrational. Regardless, all forms of traffic transport are in the inevitable need for areas designated for parking and parking garages. These urban areas are in a large scale of zones and usually provided in relation to the number of urbanites, workers, industry, and overall urban zone development. In most developed countries, the ratio between residential zones or parking garage, are in range from 1/3 to 1/2 of the residential area!



**Fig. 3.** Travel distance of vehicles, from point A to the B

To travel the distance from point A to point B, presented in [Figure 3](#), passenger usually has many options available, ranging from urban buses, taxis, metro, trams, train, private automobile. In urban design planning, we must constantly use several enabled alternatives, in this research case if the passenger has several possibilities to go from point A to point B, then we can conceptually conclude, that urban design has sense of duty of functionality and vitality of society.

Therefore, the concept of right planning can affect the user to make a choice of means for transport, so that traffic in the city has to work as planned environmentally. In any circumstances the quantity volumes of vehicles are fully equal ecological pattern in the process of planning and urban design. The parking 'break' or 'rest' of vehicle occurs at the two fundamental points of any journey, which reflect two different geographical points and different periods of time! What happens at the starting point and to the final destination point? The vehicles need to 'rest' before departure and requires 'space', never less the vehicle should be left somewhere, where and how are the most crucial ecological question?

### 3. Discussion

The aim and objective of this paper is to address two dimensions that relate to the parking garages in relation to air quality, and health impact according to the actual site location and distance of open public parking garage to the communities in vicinity:

- Improving the quality of the urban environment and land use.
- The need for parking spaces and public parking garages in Prishtina.

The research methods consist of empirical observation through urban zones of Prishtina, with an accent to the future structures of the parking garages at the future urban design planning. In order to receive a clearer information's, research is made within spatial regulation of urban blocks, architectural structures, focusing on the ecological features regarding to the morphology of the city of Prishtina, environmental pollution, and quality of public health. This research was investigated through literature review, and urban city documentations.

From the data provided by the relevant offices, in 2014, in Kosovo were a total of 286,505 vehicles registered. Of them, only 111,855 are produced from 2000 and onwards, the



others, or 61 % of vehicles are produced between 1942-1999. In general, it appears that the average age of the registered vehicles in 2014 was 18.1 years (GAP Institute, 2016).

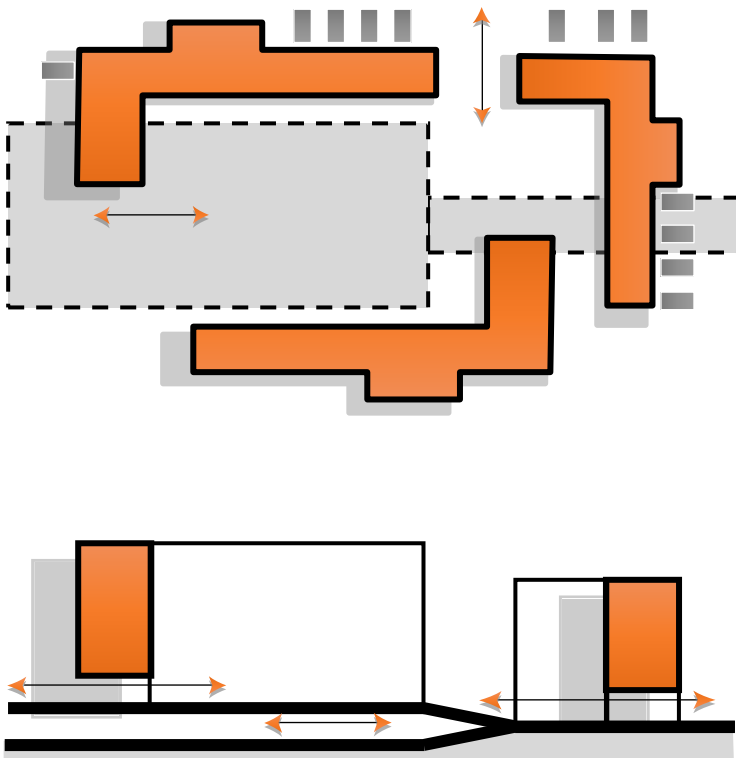
According to the researched results it can be concluded that Prishtina is heavy polluted in relation to the suspended fine particles  $PM_{10}$  and  $PM_{2.5}$ . Moreover, Prishtina is heavily polluted due to its urban spatial position regarding to the major polluters, power plants Kosovo-A and Kosovo-B. At the same time, pollution is substantial supported by heavy traffic, accompanied by the prevailing winds which increase and distribute more this pollution in certain directions at the winter season (Bajcinovci, 2016).

Regarding to the wind direction and near distance of parking garages it is expected that air pollution have to affect more communities in the vicinity of zone. According to the study “the number of high-traffic roads within a 250 m’ radius of a location, the presence of a major road within a distance of 50 m, the density of buildings within a 300-m radius and an indicator for the region of the country were used in the model [...] The finding of a positive association between air pollution and objectively measured sensitization to common allergens, supports the findings of subjectively reported symptoms” (Brauer, 2007; Bajcinovci, 2016).

Depending on the urban planning, architectural design, ecology, environment, technical and operating characteristics we can find four main groups of parking:

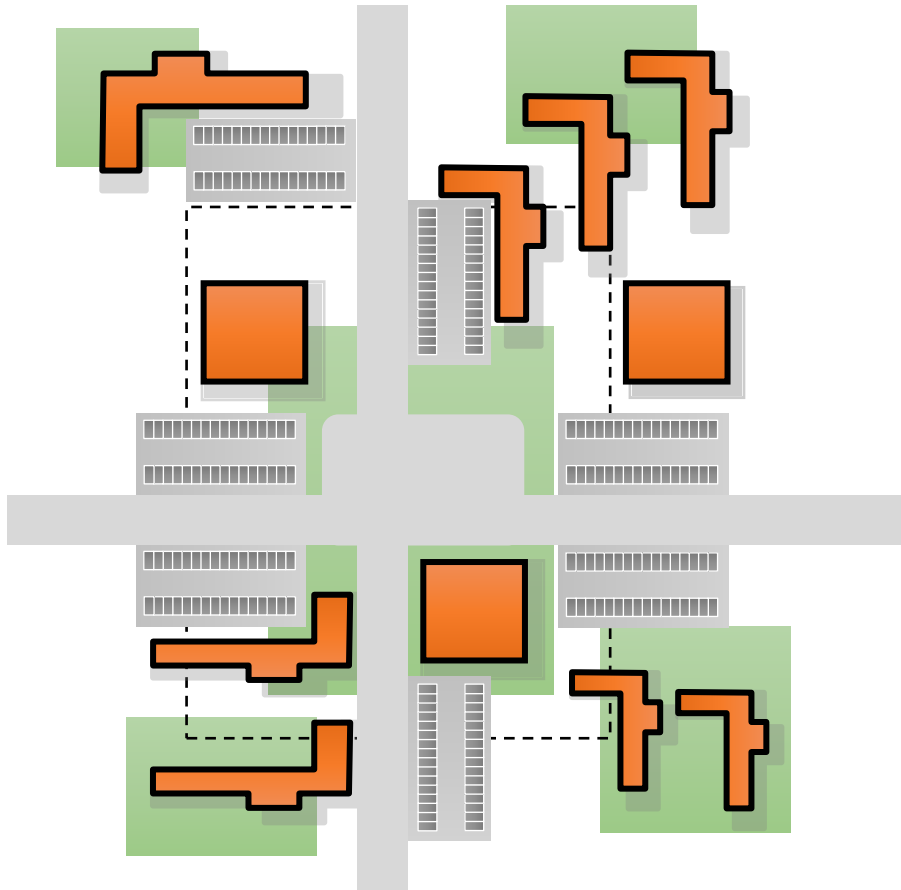
- Parking in residential area
- Parking at work
- Parking of vehicles for general purposes
- Parking areas and for special purposes

Parking in the residential area, an integral part of the residential zones, presented in Figure 4. Hence, construction of new residential areas, especially actually in Prishtina, the most vital problem would be to provide parking spaces. Also, the parking zones must legally identify itself, who is the owner and maintainer of public spaces in the residential areas. Furthermore, parking problem becomes very pronounced in areas with high population density, respectively in cases, where > 300-350 inhabitants/ha.



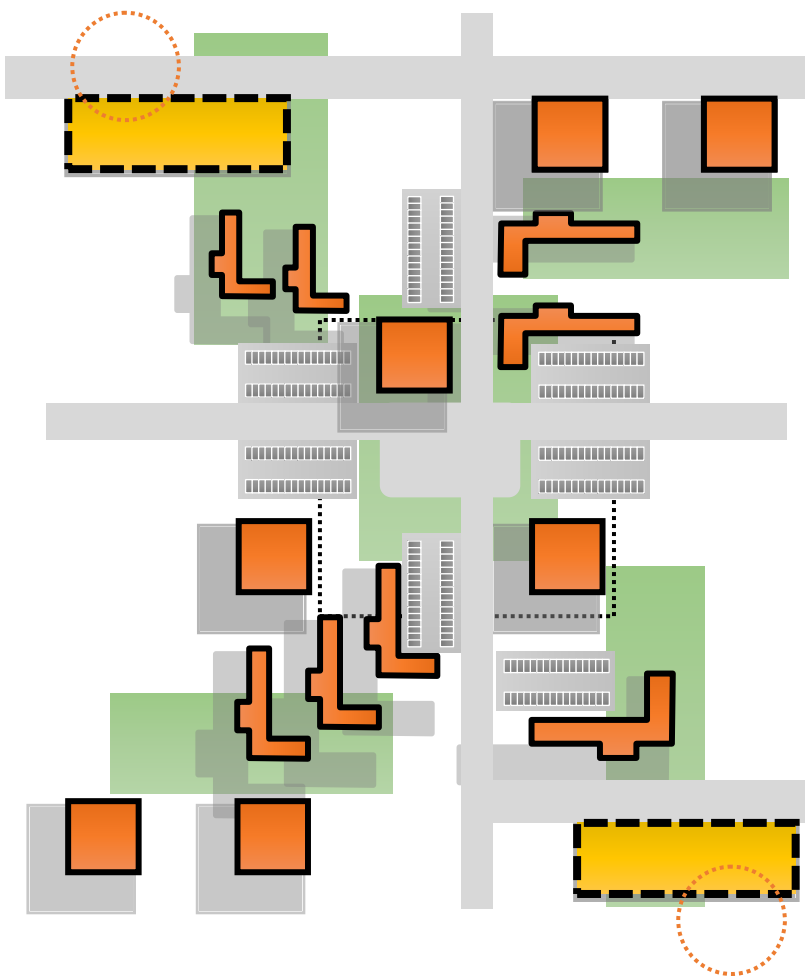
**Fig. 4.** Varieties of parking spaces in the residential areas

Parking in the workplace presented in Figure 5, this kind of typology are planned and will be constructed near commercial buildings with large concentration of workplaces, such as industrial complexes, administrative complexes, hospitals and similar buildings in Prishtina. Characteristic of this typology is that, those areas do not have a parking lot entrance and exit, parking zones as they are actually! It may happen that these parking areas are not near directly to the workplaces. Also, these parking areas may be at a distance with a greater travel destination, hence, it often happens that these areas for parking, are in the central area of the city and in different parts of the city that actually have good service of urban traffic. Moreover, these large areas of parking lots are often not rational as per urban design planning, and further complicate the situation by the high prices and the monthly costs reflecting to the family budget.



**Fig. 5.** Design of parking zones in the workplace areas





Parking zones as per general purpose, parking of vehicles for the purposes of general needs or public parking lots are planned near urban attractive general functions such as: shopping malls, architectural complexes of trade, business, entertainment, and sports activities, presented in [Figure 6](#). Due to the attractiveness of the buildings they serve, these parking lots mainly are planned as heavy concentration parking zones, which are carried in the multi-storey buildings, as underground or above ground architectural structures, moreover, as buildings around the perimeter of the core of the city centre. By lately ecological standards those types of buildings should be subject to payment of ecological pollution compensation and compensation for negative impacts on urban space and public health.

#### 4. Conclusion

Ecological specific problems of the time, we have to identify and to solve them in a more ecological and sustainable way, a heritage, which will not present a major problem for future generations. Global environmental challenges and air pollution is a global issue, hence, can't be addressed only locally. The same architectural design strategy cannot respond to all specific problems faced by contemporary urban issues. The current degraded state of environment and degraded ecology system as a whole "Umwelt", requires specific responsibilities and activities, exclusively when the environmental condition is directly linked to the quality of life and public health. Based on the conceptual results of air pollution, parking garages, and ecological concepts presented in this paper, site locations for the parking garages of Prishtina must fundamentally accompany ecological patterns for the healthier communities in coming decades. The potential future research will be more focused on the environmentally processes of the ecological patterns designs as an architecture sustainable strategy.

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