Reducing the Environmental Load on Urbanized Areas by Optimizing the Parking Lots Location

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Abstract. Currently, the problem of organizing permanent car storage places is relevant due to the high growth rate of motorization in the world. At the same time, excessively large Parking lots have a negative impact on the environment. The article considers various types of Parking lots and the main factors of their impact on the environment. A map of dispersion of emissions of harmful substances such as nitrogen oxides, carbon monoxide (II), total hydrocarbons for the city of Naberezhnye Chelny is constructed. To calculate the amount of emissions from one car in the Parking lot, a model is built in the AnyLogic simulation environment. The relationships between the number of Parking spaces and the amount of emissions from cars in the Parking lot were calculated and analyzed. It has been experimentally established that the more Parking spaces in a Parking lot, the longer cars search for Parking and, consequently, the more impact on the environment.

1. Introduction
Road transport is one of the main environmental pollutants, primarily atmospheric air.

More than 300 components were found in the exhaust gases of automobile engines, among which there are highly toxic substances, including carcinogens and mutagens. Currently, in Russia, there is a wide range of estimates of transport pollution of the atmosphere—from 25% to 80%. The lower limit is typical for its overall balance, while the upper limit is typical for the largest administrative centers or territories with virtually no industrial enterprises. According to expert estimates, in more than 150 cities in Russia, it is motor transport that has the predominant impact on air pollution.

One of the factors contributing to the deterioration of the transport situation in cities is the current disparity between the rate of development of the road network and the rate of growth in the number of vehicles, which leads to worsen traffic conditions, congestion, increased delays, and increased fuel consumption. This situation is becoming typical for many large and medium-sized cities. Rapid growth in the number of automobile fleets combined with insufficient development of the road network, optimized location of Parking spaces and poor quality of traffic management often leads to a critical environmental situation in cities. Along with the progressive deterioration of atmospheric air quality, environmental problems related to the noise impact of vehicles on the environment are also becoming more acute. In addition to environmental pollution, another serious problem associated with motor transport in the largest Russian cities is the search for and allocation of new sites for Parking lots and Parking lots [1-3].
2. Relevance

The shortage of Parking spaces was relevant in the 20-30s of the XX century in the United States. The reasons for the lack of Parking in large and medium-sized cities are obvious — this is a constant increase in the number of cars, which leads to a shortage of space for their storage. The city territory has its own borders, which simply cannot fit the required number of Parking spaces, trying to keep up with the growth in the number of personal transport not only for citizens, but also for visitors. We see the consequences of this deficit every day. The vast majority of cars in our cities are located in the courtyards of residential buildings, including on green lawns, recreation areas and playgrounds. First of all, this circumstance negatively affects the living conditions of the population [4-7].

Cars are also left on the roadway of streets, which makes it difficult for urban traffic and becomes one of the causes of road accidents [8]. Such "Parking lots" occupy huge areas of urban territory and spoil the appearance of cities. About 80% of all parked cars use the roadway as Parking; approximately 15% of drivers Park partially on the roadway and sidewalk; and 5% Park completely on the sidewalk. In addition, the share of cars parked in violation reaches 45%.

According to The International Parking Institute, about 38% of cars moving around the city are looking for free Parking spaces, which leads to increased pollution and subsequent health problems, as well as economic losses due to wasted man-hours.

In [9], the polynomial probit model is used to analyze driving behavior, and the results show that the closer car drivers are to their destination, the more likely they are to want to Park on the side of the road.

Drivers looking for Parking make a significant contribution to traffic congestion and, consequently, to the increase in emissions of harmful substances from the exhaust gases of cars. Safety is reduced both because drivers looking for a Parking space are more distracted than other road users, and because people getting out of parked cars pose a danger to cyclists. [10-15]

Therefore, almost every medium or large city needs special car parks. But on the other hand, Parking lots are stationary places where pollutants are concentrated. To solve this difficult environmental situation with Parking in Rome, for example, they are building underground Parking lots, above which there are gardens and playgrounds. And in Denmark, the best of the pilot projects to solve the Parking problem in a residential area has been implemented. In shape, the structure resembles the grandstand of a large stadium, where instead of benches there are stepped terraces, under which there is a Parking lot. The building is surrounded by greenery, which should compensate for the possible appearance of exhaust gases (in Europe, it is forbidden to Park near a residential area), provides powerful ventilation with the latest technology and excellent sound insulation.

There is such a type of Parking as eco Parking. Ecopark (ecological Parking) — an area for Parking vehicles, sown with lawn grass and reinforced with a lawn grid that prevents damage to the root system of plants by car tires, while maintaining the aesthetic appearance of the site.

Eco-Parking allows you to solve the problem with the placement of vehicles and, at the same time, keep the green lawn in excellent condition.

A special black or green lawn grid made of durable frost-resistant plastic or its equivalent made of concrete with wider module walls is used for eco-Parking. The grid is laid on the prepared ground, covered with earth and sown with lawn grass. After that, the lawn must be watered and mowed in a timely manner. Unlike Parking lots located along highways, which can significantly reduce the capacity of highways, eco-parks located in green areas do not interfere with traffic.

In addition, various systems of forced ventilation with partial cleaning of the main components of vehicle exhaust gases have been widely developed and put into practice [16-19]. They are mainly used in indoor and underground Parking lots. In addition, storing cars in insulated Parking lots allows you to spend less fuel on maneuvering and preparing the car for the trip. All this allows to reduce the distance of multi-storey car parks to residential buildings up to 15 m, the size of the sanitary protection zone for multi-story car parks can be significantly reduced through improved engineering garage equipment with forced ventilation with partial clearing remote from the interior air. [20]
However, it is not always possible to install this type of Parking, so you need to look for other options and ways to solve the environmental problem of Parking.

3. Results and discussion

Obviously, we need to look for a solution that is as efficient as possible and at the same time the least expensive. In our opinion, the most effective solution was to optimize the location of new Parking lots based on the data from the map of dispersion of harmful pollutants, for example, the city of Naberezhnye Chelny.

Automobile transport makes a big contribution to the environmental pollution of the city of Naberezhnye Chelny, since the main stationary sources of pollution are located outside the city or on its borders. This is also confirmed by state statistics. Therefore, for the ecological analysis of the city territory and determining the places of the highest concentration of pollutants, calculations of vehicle emissions were carried out on the basis of well-known methods. For this purpose, traffic intensity was calculated based on field surveys of the structure and intensity of the moving traffic flow on the main highways of the city of Naberezhnye Chelny.

Based on the intensity data obtained, vehicle emissions were calculated and a dispersion map was obtained for a pollutant such as CO (Fig. 1).

![Figure 1. Map of dispersion of pollutants in Naberezhnye Chelny.](image)

To identify the relationship between the size of car parks and the amount of harmful emissions from them, we built a simulation model and conducted several runs on the created model. The AnyLogic simulation environment was chosen to build the model.

AnyLogic is the latest generation simulation tool. It is based on results obtained in modeling theory and in information technology over the past decade. When developing the model, the traffic library was used (Fig. 2).
The developed model has a system for finding a Parking space that corresponds to the behavior of a driver who is looking for a Parking space in real life. The model also calculates the amount of time that the driver spends searching for a Parking space, and the amount of time spent by the driver to leave the Parking lot. In addition, emissions of pollutants from the car while driving in the Parking lot are calculated. The average data for pollutant emissions for the calculation were taken from GOST R 56162-2014 «Emissions of pollutants into the atmosphere. Method for calculating vehicle emissions in summary calculations for urban localities». By varying parameters such as the number of Parking spaces, you can see that the larger the Parking space, the longer the driver has to search for free space, respectively, such cars emit more harmful substances.

Based on the data obtained, it can be concluded that new Parking lots should be located based on the data from the dispersion map. Thus, in parts of the city where the environmental situation is difficult, you should not place Parking lots with a large number of Parking spaces, and in areas where the environmental situation is more favorable, you should build larger Parking lots in order to evenly distribute the load on the environment within the city.

4. Conclusion
Parking on the street is convenient, but has many disadvantages from using street Parking at the expense of other types of road use and to increased danger. Conventional land-based fenced Parking lots, which are the majority, solve this problem, but at the same time have a negative impact on the environment.

The idea proposed in the article allows you to more optimally distribute the load on the city's environment, but you need to work on improving it.

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**Acknowledgments**

The work was supported by the Russian Foundation for Basic Research, project No. 19-29-06008 \ 19.