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The Impact of Vehicle Emissions on the Rate of Asymmetry of Urban Spaces on the Territory of Urban Districts

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The Impact of Vehicle Emissions on the Rate of Asymmetry of Urban Spaces on the Territory of Urban Districts

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Abstract. The article is devoted to the issue of assessing the impact of vehicle emissions on urban ecosystems by using such method of bioindication as the asymmetry coefficient. In general, the value of the asymmetry coefficient is mainly influenced by the amount of vehicle emissions. However, the value of the asymmetry coefficient within urban districts is influenced by a number of specific factors: traffic of adjacent highways, prevailing winds, the type of buildings on the territory of urban districts.

1. Introduction

Today, the problem of environmental protection is based on the concept of sustainable development, which is used throughout the world and serves as the basis for the development of environmental protection strategies for most countries in the world, including Russia [1, 2, 3]. At the same time, environmental problems are becoming increasingly important especially in urban areas.

City - a specific human creation, adaptation for which is linked to human health problems [4]. The human as a biological species is adapted to life in other conditions. But since man is also a social being, its development by is associated with social needs [5]. Satisfaction of social needs and transformation of a environment by human is leads to a violation of the balance. Than greater the transformation of the environment that stronger the negative impact on the biosphere. The human is also a part of the biosphere that is way unbalance of the environment is effect on his health [6]. There is a paradox - a human created urbanized areas for maximum comfort, but pays for it with his health. In the Orel region of the Russian Federation the incidence of cardiovascular diseases of the urban population is 15% higher than of the rural population [7]. This fact is due by the high concentration of industry and vehicles in a limited area. Besides, in large cities 60-80% of atmospheric air pollution falls on motor vehicles [7]. One of the most dangerous types of pollutants in emissions of motor vehicles is a heavy metals. The number of motor vehicles is growing so rapidly that the reduction of emissions that achieved by the cleaners and high-quality fuel is offset by an increase in the number of cars [8]. Vehicles is very mobile, so it easily penetrates into the residential areas, while large industrial enterprises are located outside the city and are separated by sanitary protection zones [9].

Cities are now becoming the main systems for life, so it is important to study and forecast their effects on humans, their environment and the biosphere processes. Due to the fact that in the city there are no full sanitary protection zones thach separating the roads from residential areas, it is important to understand how vehicle emissions are distributed within such zones and what factors influence this. One



of the methods for estimating emissions from motor vehicles is bioindication. They are fast, high quality and inexpensive.

2. Results and discussions

As an example, we have analyzed the land territory Orel city as a typical regional center of Central Federal District of Russia. We have chosen a part of residential area, bounded by two highwaya on Moskovskaya Street and Gruzovaya Street. At this area, linden (*Tilia cordata* Mill) prevails in the structure of urban greenery. All plants is a same age. Inside the area is dominated by five-floor houses. Thus, this area is characterized by the same urban characteristics (Figure 1).

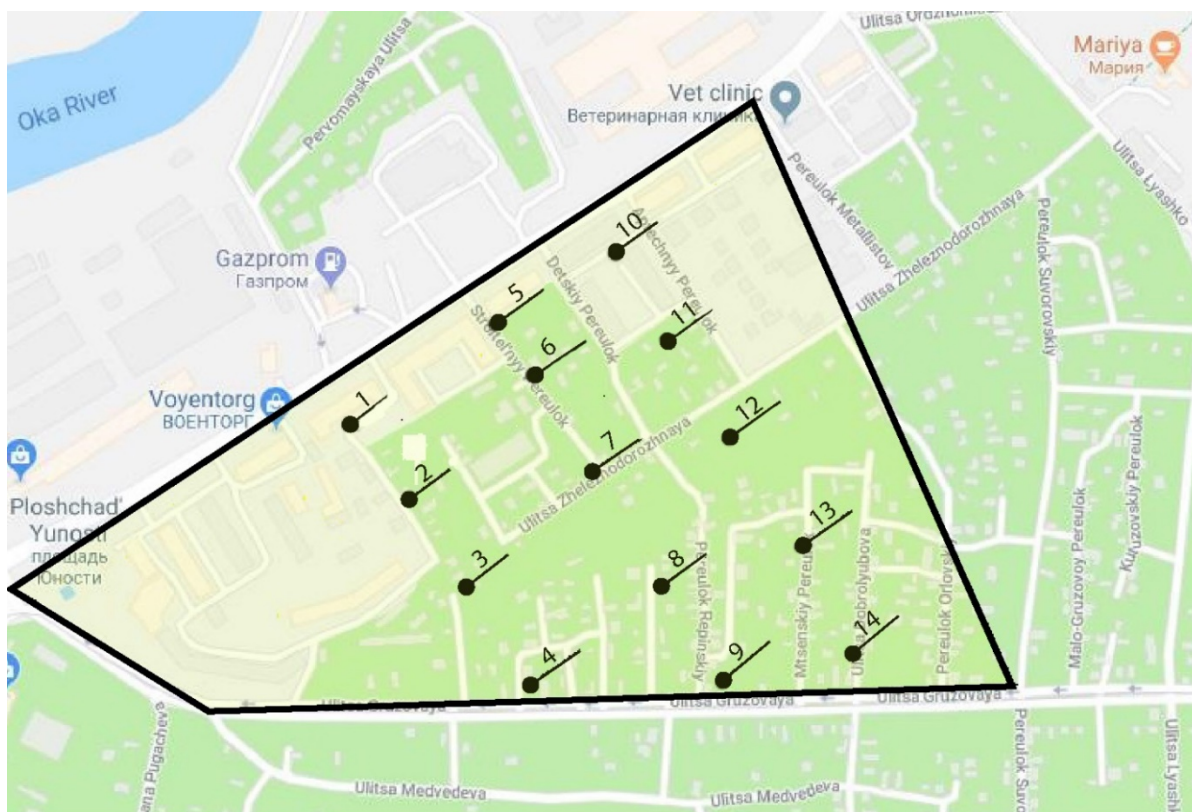


Figure 1. Investigated area

To determine the number of vehicles for the subsequent calculation of emissions, at study sites were counted in the rush hour, within a year. Noted the number of cars in 30 minutes, followed by recalculation of 1 hour. Car traffic was divided into categories: passenger road transport; cargo, with a diesel engine; truck, with a carbureted engine; bus, diesel engine; with carburetor engine bus; trolley bus; minibuses. Separation was made to more accurately assess the environmental burden, as each of these categories is characterized by a specific set of emissions. Traffic is amounted 1528 and 904 cars in hour, for areas 1 (Moskovskaya street) and 2 (Gruzovaya street) respectively.

Table 1. Number of vehicles in the investigated areas, pcs / hour.

Vehicle category	Number of vehicles, pcs / h.	
	Area 1	Area 2
Car	1100	802
Diesel truck	12	15
Gasoline truck	24	18
Diesel bus	2	4
Gasoline bus	95	45
Tolley bus	45	0
Minibuses	250	20
Total	1528	904

The main source of contamination at all study sites were selected vehicles, as it accounts for a significant portion of the emissions in the city of Orel. To determine the amount of pollutants from vehicle emissions has been used a technique developed by A. Voeikov [10].

We obtained the following results on the emissions of vehicles on the study areas (Table 2):

Table 2. Distribution of total and maximum single emission investigated areas

Investigated area	Indicator	
	Total emissio, t/year	Maximum single ejection, g/s
Area 1	13454	15.2789
Area 2	9265	0.8374

To clarify the mutual influence of vehicle emissions on the investigated areas in Orel, we have analyzed the meteorological data, summarized in Table 3. These data represent the average number of prevailing winds for 2017 year.

Table 3. Interference investigated areas in the context of wind direction

Contaminated areas	Polluting areas	
	Area 1	Area 2
Area 1	N, N-E, W, S-W, S, S-W	S-E
Area 2	N-W	N, N-E, E, S-W, S, S-W, W, N-W

Then calculations were made using the procedure described in [9,11]. Results are summarized in Table 4.

Table 4. Formation of pollutants at investigated areas in view of the air transport

Area	Emission, t/year
1	19619
2	11429

The analysis of the above table shows that, given the volume of the air transport of pollutants in the area 1 rose by 45%, on a area 2 increased by 23%/. This is due to the predominance of winds western and southern direction of the geographical location of the Orel.

The dependence of traffic and the amount of pollutants is confirmed by a high correlation coefficient $r = 0.96$.

To assess the quality of the environment, we used the method of calculating the index fluctuating asymmetry of leaves plants lenden (*Tilia cordata* Mill). This method is based on variance based on the difference between the sides are not zero, and from some differences between the parties taking place in the given sample and calculated as follows:

$$\sigma^2 = \frac{\sum(d_{i-r}M_d)}{n-1} \quad (1)$$

where d_{i-r} - the average difference between the parties;

M_d - difference of characteristic values.

These indices are calculated by the following formulas:

$$M_d = \frac{\sum d_{i-r}}{r} \quad (2)$$

$$d_{i-r} = \frac{2(d_i - d_r)}{d_i + d_r} \quad (3)$$

d_i – value of characteristic on the left side,

d_r – value of characteristic on the right side,

n – sample size.

Processing plant sample in determining the coefficient of fluctuating asymmetry is measuring the lengths of the veins on the leaf blade right and left.

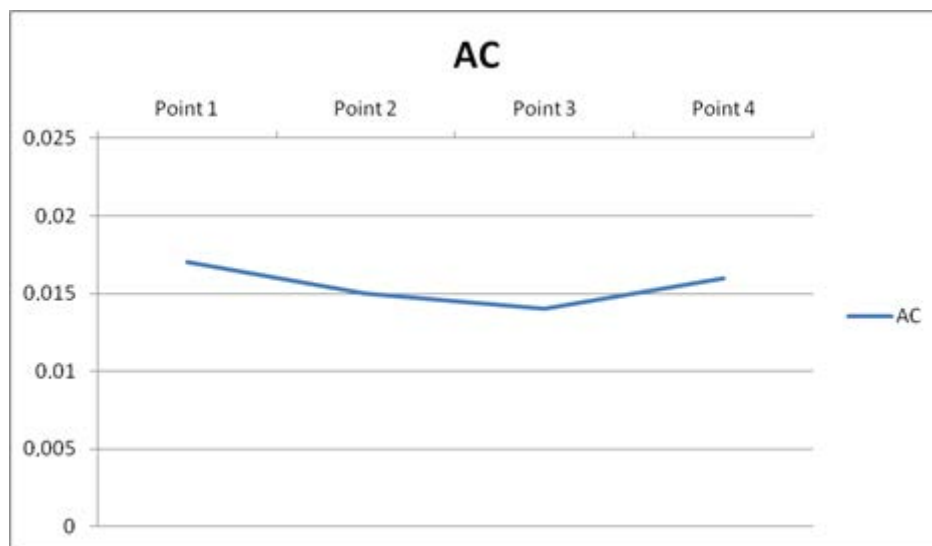
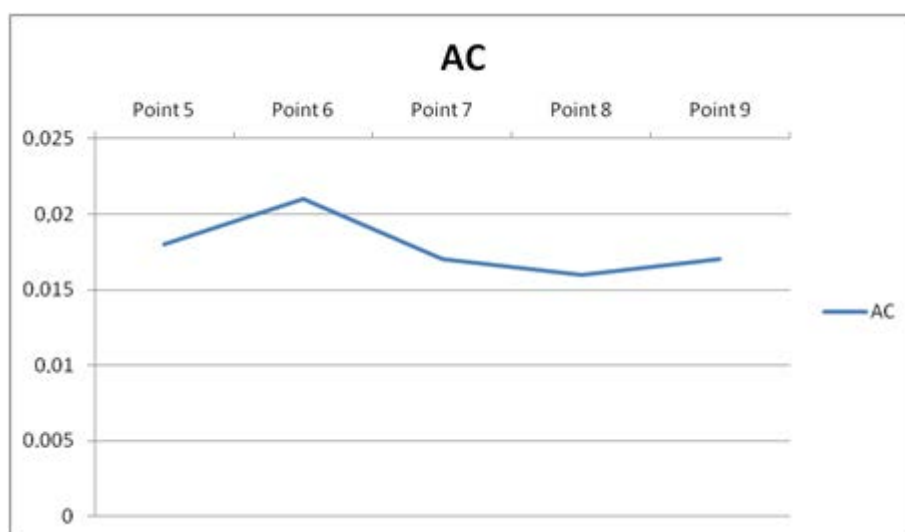
For sampling leave were selected plants of the same age. The leaves were selected from the bottom of the crown, with the side that facing to the highway.

The values of fluctuating asymmetry coefficient (AC) are given in Table 5.

Table 5. Values of the coefficient of fluctuating asymmetry

Points													
1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0	0	0	0	0
1	1	1	1	1	2	5	1	1	2	1	1	1	1
7	5	4	6	8	1		6	7	0	8	4	5	6

Analyzing the values of the coefficient of fluctuating asymmetry in a number of directions perpendicular to the highway (1-4, 5-9, 10-14) we obtained the following data (Figure 2-4).

**Figure 2.** Values of the coefficient of fluctuating asymmetry on line 1-4.**Figure 3.** Values of the coefficient of fluctuating asymmetry on line 5-9.

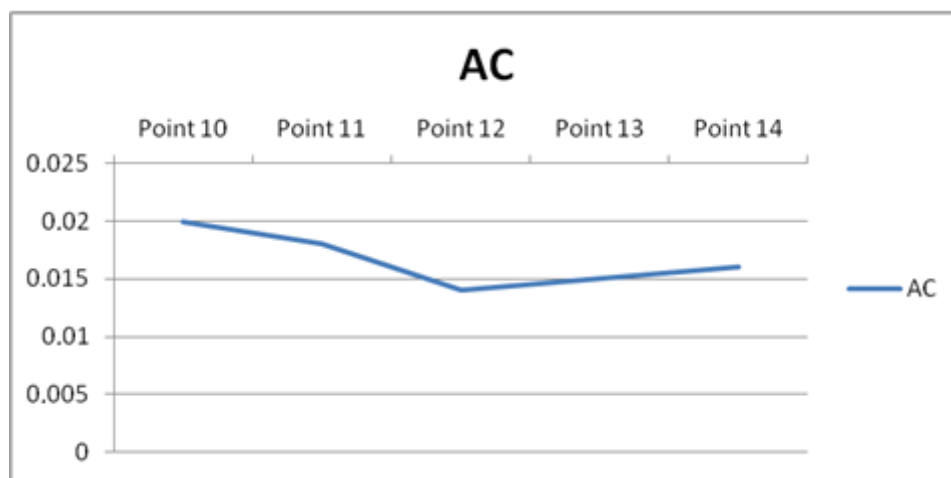


Figure 4. Values of the coefficient of fluctuating asymmetry on line 10-14.

The values of the fluctuating asymmetry are higher at those points that are located near the highway on Moskovskaya Street on all lines. On this street are maximum traffic and are maximum volumes of vehicle emissions, so the plants is experience maximum anthropogenic pressure, this is reflected in the values of the coefficient of asymmetry. This fact is confirmed by the high value of the correlation coefficient of these ($r=0.97$). Next is the decrease in the values of the coefficient of asymmetry to points located in the center of the district. After this, the values of the coefficient of asymmetry begin to increase again. This is due to the influence of the highway on Gruzovaya Street. The values of the asymmetry coefficient are less as well as the traffic on this highway.

In a detailed analysis of the values of the asymmetry coefficient on line 5-9, we see that the value at point 6 is the highest. This is due to the fact that this point is located in the yard, surrounded by blocked houses on all sides. There is no movement of air streams and concentrations of pollutants coming from a nearby highway are higher than at other points. This hypothesis requires further research by using special equipment.

When we analyzing the values of the coefficient of fluctuating asymmetry of points located near the highway (line 1-5-10 and line 4-9-14), the following data were obtained (Figure 5, 6).

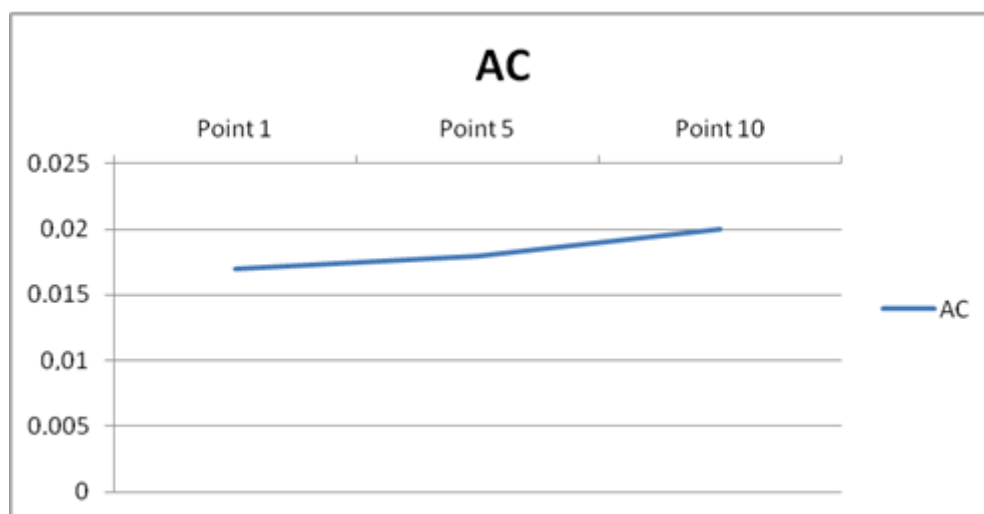


Figure 5. Values of the coefficient of fluctuating asymmetry on line 1-10.

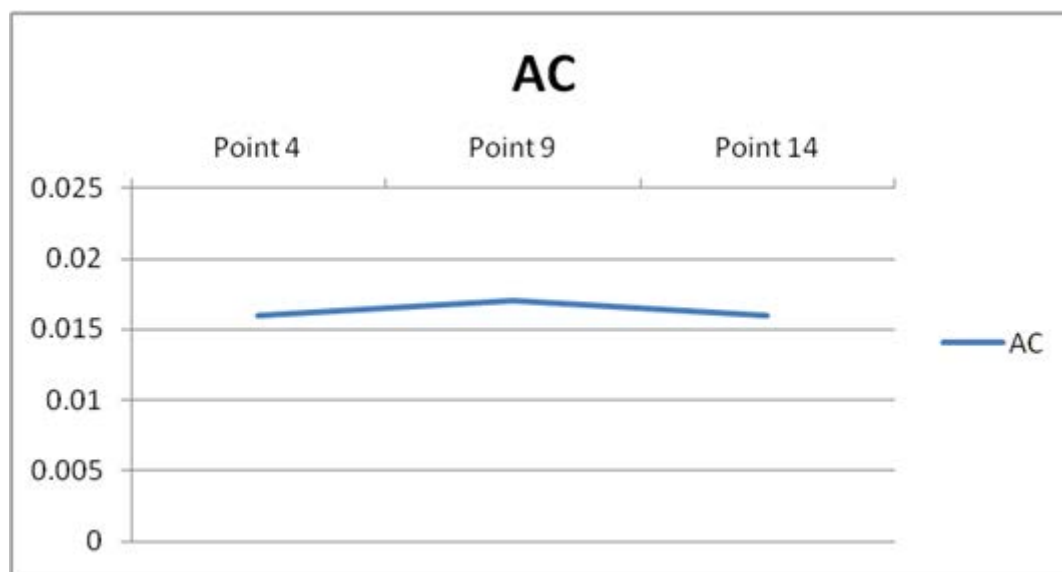


Figure 6. Values of the coefficient of fluctuating asymmetry on line 4-14.

The analysis of the values of the asymmetry coefficient shows that they increase in the direction to the point 10. This is due to the fact that there is a traffic light where cars are stop. During a stop, the car's motor emits more pollutants. This is confirmed by the high value of the correlation coefficient ($r = 0.97$).

The values of the asymmetry coefficient on line 4-14 differ from each other minimally. This is due to the lack of obstacles to traffic and the uniform nature of emissions throughout the highway.

3. Conclusions

The prevalence of winds of the western and southern directions in Orel city is determine the character of the distribution of vehicle emissions in the district. This fact is confirmed by the distribution of the coefficient of fluctuating amimmetry in the district. This bioindication method is quite effective and clear for analyzing the nature of the distribution of motor vehicle emissions and assessing the quality of the urban environment and is simple. The obtained data will be used to develop a mathematical model that describes the distribution of motor vehicle emissions within a district, taking into account blocked houses.

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