ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Influence Of Road Transport Load On The Phytotoxicity Of Snow Cover Of Roadside Areas.

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ABSTRACT

The article presents the results of studies of the ecological status of the roadside areas of the city of Stavropol based on an assessment of the phytotoxicity of snow cover. The dependence between the motor load and the phytotoxicity of snow collected from roadside areas was revealed.
Keywords: road transport load, phytotoxicity, biotesting, snow, roadside areas, environmental assessment, pollution.

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INTRODUCTION

At the present stage, the level of anthropogenic environmental impact is constantly growing. Road transport is a powerful source of environmental pollution. It accounts for at least 55% of the total mass of gaseous air pollutants. In recent decades, due to the rapid development of road transport, the problems of its environmental impact have intensified significantly (Mirzoyeva, Shekikhacheva, 2014; Maximova, 2017).

It should be noted that in the practice of modern environmental studies there are practically no cases of influence on the components of the environment by only one active factor - motor transport. Most of the roadside areas are subject to the simultaneous effects of several factors (physical, chemical, socio-economic, climatic, etc.). Under these conditions, to obtain an objective conclusion about the state of the environment, the degree of its transformation, an integral characteristic of its state is required (Okrut et al., 2018). In other words, it is necessary to evaluate the whole complex of factors in their interaction, mutual influence and total influence on natural objects.

The possibility of integral characteristics of the environment under the influence of the whole variety of physical, chemical, social and other factors is provided by biological methods of monitoring, in particular, the method of biotesting. The scientific literature notes that a biologically significant assessment of the state of the environment is carried out using organisms or their communities, as well as biologically active metabolites. The most commonly used bio-diagnostic methods in practice take into account the morphological changes of phytoindicators and test plants (Pospelova et al., 2015; Mandra et al., 2016).

In cities, technogenic biogeochemical anomalies are formed, which are characterized by polyenzyme composition and accumulation of heavy metals in the upper soil layer and snow cover (Kiriyenko, Cherepanova, 2012; Khokhryakova, Kulidzhanov, 2017). Snow is a good battery of pollutants, as it will make up from the main solvent - water. This circumstance necessitates an assessment of the contamination and phytotoxicity of snow cover in roadside areas, as the basis for the development of soil restoration measures.

MATERIALS AND METHODS

The object of the research is roadside plant communities located along 15 streets (highways) of the city of Stavropol, and grouped according to three criteria:

- city-wide roads with 4–6 lanes, with a one-lane width of 3.5 m, with an average design speed of a traffic flow of 60–80 km / h (Kulakova avenue, Lermontova str., Dovatortsev str., Staromaryevskoye highway, avenue Karla Marxa);
- roads of district value, having 2 - 4 lanes, with a width of one lane of 3.5 m, with an average design speed of a traffic flow of 50–70 km / hour (Mira str., Serova str., Oktyabrskaya str., Pirogova str. , Chapaevskiy passage;
- local roads with two lanes, with a width of one lane of 3 m, with an average design speed of the traffic flow 40 - 60 km / hour (Zelenaya Roshcha blvd., Repina str., Dostoevskogo str., Tukhachevskogo str., Dzerzhinskogo str.).

Studies were conducted in 1 stage:

1) determination of motor load;
2) assessment of phytotoxicity of snow cover.

Accounting for the traffic load was carried out at stationary posts within all selected road landscapes. The traffic flow was divided according to the types of vehicles operating on a particular fuel: gasoline, diesel fuel, liquefied gas. The intensity of traffic flows was taken into account during the day (normal time, "peak hours").

To assess the phytotoxicity of snow cover, cress "Azhur" was used as a test plant. This choice is due to the fact that it is a small herbaceous annual plant of the cruciferous family. This phytotest is characterized by rapid germination of seeds and almost one hundred percent germination, which decreases markedly in the presence of pollutants. In addition, the shoots and roots of this plant under the action of pollutants undergo noticeable morphological changes (growth retardation and curvature of the shoots, reduction of the length and weight of the roots, as well as the number and weight of seeds).

Selected snow in containers was transferred to the environmental monitoring laboratory of Stavropol State Agrarian University. Then, 20 seeds of watercress were placed in the previously sterilized Petri dishes, and thawed water was added to the bottom of each cup. A Petri dish with seeds moistened with distilled water was taken as a control. Observations were conducted for 7 days. In order not to allow the seeds and seedlings to dry, as needed, they added to the cups melt water obtained from the snow of the same areas.

The records of germinated seeds, the total length of the roots, which was determined by adding the length of each seedling, and the biomass of the seedlings were recorded. Length measurements were performed using a ruler with an accuracy of 1 mm; weighing the test-plants under investigation was carried out on an analytical pharmaceutical scale.

The percentage inhibition of the test response of plants was calculated by the formula:

$$I = 100\% - (К1 * \frac{100\%}{К2})$$

where:
I –percentage of inhibition of the test response of plants (%);
K1 – average value of the test response of plants in the experience,
K2 – average value of the test response of plants in the control.

The length of the roots of seedlings, germination of seeds, biomass of seedlings of test plants were used as a test response.

To obtain comparable results, a phytotoxic effect was calculated according to the test results using the formula:

$$PE = \frac{Мк - Мх}{Мк} * 100\%$$

where:
Мк – plant biomass in control.
Мх – plant biomass in the test sample.
The phytotoxic effect (phytotoxicity) was determined according to the scale presented in table 1.

Table 1: Scale of phytotoxicity of snow cover

The value of the phytotoxic effect (PE)	Phytotoxicity level
0 – 10	Non toxic
10 – 30	Weak phytotoxic effect
30 – 50	Average phytotoxic effect
>50	Unacceptable phytotoxicity

The obtained data of phytosteries were processed using statistical methods of analysis.

RESULTS AND DISCUSSION

The study of motor traffic showed a general pattern (Table 2): a gradual decrease in motor traffic from city-wide roads to regional-level roads (by 55.6%) and from districts to local roads (by 33.7%).

ISSN: 0975-8585

Table 2: Road transport load in Stavropol

Road category	Road name	Road transport load, cars / hour
Citywide value	1c. Kulakov Avenue	3024
	2c. Lermontova street	2952
	3c. Dovatortsev street	2064
	4c. Staromaryevskoe highway	2111
	5c. Karla Marxa Avenue	1958
	Average	2422
District value	1d. Mira street	1544
	2d. Serova street	1055
	3d. Oktyabrskaya street	1244
	4d. Pirogova street	1345
	5d. Chapaevsky passage	1548
	Average	1347
Local value	1l. Boulevard Zelenaya Roshcha	156
	2l. Repina street	248
	3l. Dostoevskogo street	252
	4l. Tukhachevskogo street	605
	5l. Dzerzhinskogo street	1007
	Average	454

The sanitary standard (200 cars / hour) is observed only for the Zelenaya roshcha Boulevard. For the rest of the survey sites, this indicator is exceeded on average by 2.6 times for local roads, by 6.7 times for regional roads and by 12.1 times for city roads. Such indicators of motor load are of particular concern, given that in recent years the flow of cars in the city has increased by an average of 2-2.5 times, and the ecological capacity of the territory does not increase, which can lead to a change not only in the socio-technogenic component of the urban ecosystem, but and degradation of natural phytocenoses.

The dynamics of traffic flows over time are relatively clearly visible only when the data is averaged. Maximum loads are noted in the morning and evening "peak hours" (respectively, from 8:00 to 10:00 and from 17:00 to 19:00). In the middle of the day (14:00 - 16:00 hours) there is a general decrease in the number of vehicles in the traffic flow. This is most noticeable for local roads, where it can be 40 - 60%. For city-wide roads, the difference between peak hours and normal periods is only 10–18%, and for individual observation posts rarely exceeds 20%.

The study of the structure of traffic flows of the city showed that, regardless of the intensity of flows and their dynamics over time, they are dominated by cars with petrol engines, which is 75–81% of the traffic flow depending on the category of roads. Taking into account the fact that 70% of the city’s road network is located in residential mixed and 14% in residential multi-storey areas of the city, such a large number of cars with gasoline engines creates the danger of intensive pollution of roadside landscapes and can have a negative impact on public health.

The next stage of research was the testing of snow cover, samples of which were collected along the roads.

Germination and seed germination energy were determined according to generally accepted methods. The research results (Table 3) show that in the conditions of the roadside areas of the city of Stavropol there is observed average pollution of the soil (snow) cover: germination rate of 20–60%, seedlings compared with the control are shorter and thinner. Strong contamination (seed germination of less than 20%) was not detected in any of the sites. We associate this fact with the short-term period of the existence of a stable snow cover along the roads.

In addition, it should be noted that in samples taken on roads with a higher intensity of traffic flow, a delay in germination of seeds (percent inhibition) was detected on average by 86% compared to the control on day 3 and 75% on the 5th day. This circumstance indicates the presence of adverse factors in the development of the test system in potentially contaminated samples.

Table 3: Cress seed germination in the snow samples tested

Sampling site	The number of germinated seeds			Germination, %	Number of non-germinated seeds, pcs. /%
	3rd day	5th day	7th day		
Control	**14**	**20**	**20**	**100**	**0**
1c. Kulakov Avenue	–	4	10	50	10
2c. Lermontova street	–	3	11	55	9
3c. Dovatortsev street	–	4	11	55	9
4c. Staromaryevskoe highway	2	5	14	70	6
5c. Karla Marxa Avenue	–	7	12	60	8
Group average	**2**	**5**	**12**	**58**	**8**
1d. Mira street	–	7	14	70	6
2d. Serova street	–	9	14	70	6
3d. Oktyabrskaya street	–	8	17	85	3
4d. Pirogova street	–	4	13	65	7
5d. Chapaevsky passage	–	8	16	80	4
Group average	**0**	**7**	**15**	**74**	**5**
1l. Boulevard Zelenaya Roshcha	8	12	20	100	0
2l. Repina street	6	13	19	95	1
3l. Dostoevskogo street	4	12	17	85	3
4l. Tukhachevskogo street	4	10	18	90	2
5l. Dzerzhinskogo street	3	11	16	80	4
Group average	**6**	**12**	**18**	**90**	**2**

A morphometric analysis of watercress sprouts, the results of which are presented in Figure 1, confirmed the data on seed germination estimates.

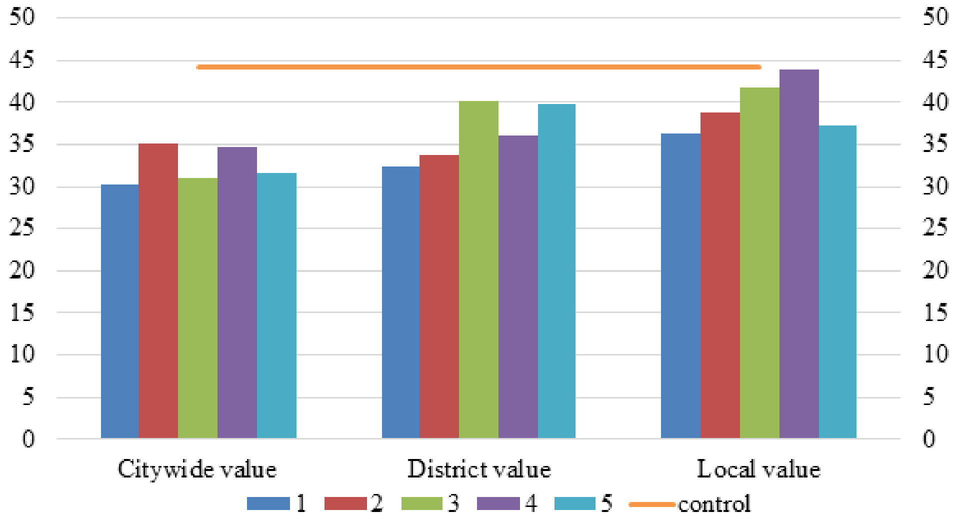

Figure 1: Average length of seedlings of cress (mm) on the 7th day of research

The growth rate of watercress sprouts is varied. The longest and thinnest shoots were in the sample number 5m. This is due to the relative purity of the collected on Blvd. Green Grove of snow, due to low traffic load. However, the total length of these seedlings is higher compared to the control, which allows to judge the presence of a growth catalyst in the snow.

The shortest and thickest seedlings were observed in samples No. 1m (Kulakova Avenue) and No. 3m (Dovatortsev Street). We associate this with a high traffic load. Automobile traffic jams are also often observed in these areas, idle in which transport emit a large number of toxicants into the atmospheric air.

In addition to taking into account the length of watercress sprouts, we determined the raw plant biomass as a test response, calculated per one seedling, and calculated the phytotoxic effect (PE). The results are presented in Figure 2.

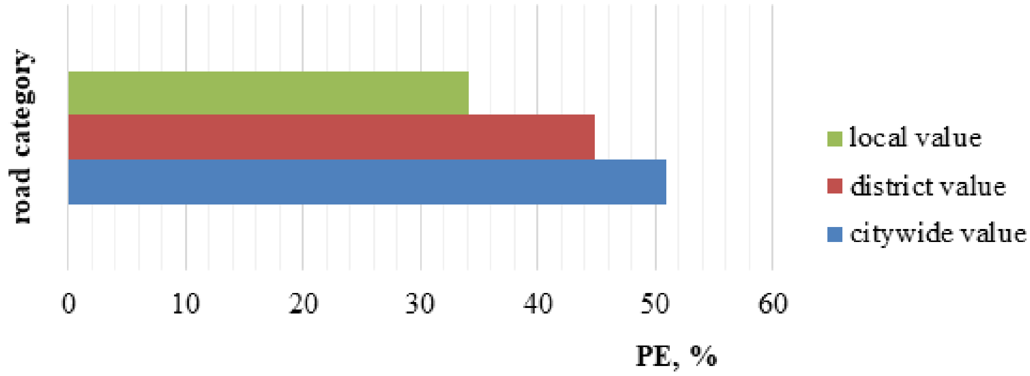

Figure 2: Phytotoxic effect (PE) of snow cover of roadside areas of various road categories

Analyzing the data, we concluded that the highest toxicity (PE = 50.9%) of snow along with the maximum motor load. Samples of snow collected along local roads (PE = 34.2%) are less toxic. Despite the difference in PE parameters between samples collected from different categories of roads, they all have an average phytotoxicity. (PE > 30%), except for Kulakova Avenue (PE = 52.3%), and Lermontova Street (FE = 52.1%), samples from which, according to the scale (Table 1), have a high degree of phytotoxicity.

CONCLUSION

The obtained results prove that snow is an informative indicator of the state of the roadside areas, since it is a battery of harmful substances emitted by motor vehicles. The degree of contamination of snow cover also depends on the traffic load: on roads with a traffic flow of more than 2,400 cars per hour, germination of watercress seeds was 58%, unlike local roads, for which seed germination was 90%. A similar pattern was found in terms of phytotoxicity of snow cover.

Conducted studies of the roadside areas of the city of Stavropol allow to determine priority areas for improving the quality of the urban environment by optimizing road traffic flows, especially in the central part of the city; improvement of the system of street parking, design and construction of multi-storey car parks, applications in landscaping of roadside areas that are resistant to gas pollution and soil pollution of plants.

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