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RESEARCH ARTICLE

Vibrational and Acoustic Noise as an Ecological Factor in an Industrial City

V.O. Kornienko[1,2]*, L.P. Antropova[1,2], M.S. Kryazhevskikh[1], S.G. Studennikova[1], A.I. Dudarev[1], K.S. Kuralimova[1]

[1]Don State Technical University, Rostov-on-Don, Russian Federation

[2]Donetsk State University, Donetsk, Donetsk People's Republic

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***Corresponding Author:**
kornienkovo@mail.ru

ABSTRACT

At the current stage of urban development in Donbas, vibrational-acoustic noise has become a significant factor transforming the urban environment. Assessing the responses of woody plants to technogenic noise is necessary for developing measures aimed at conserving and optimizing urban ecosystems. This study aimed to assess the condition of woody plants exposed to vibrational-acoustic noise in the central part of Donetsk, using Leninsky Avenue as a case study. Monitoring was conducted in Donetsk in 2024–2025. The study objects were woody plants growing along Leninsky Avenue, a major urban highway. Species composition, stand age structure, and morphological parameters were assessed. Tree vitality and general condition were assessed using the Alekseev scale. Noise pollution was assessed by measuring vibrational-acoustic noise levels in accordance with GOST 20444-85 "Noise. Traffic flows. Methods for measuring noise characteristics". The results indicate the need to revise approaches to roadside greening, taking into account traffic intensity, vibrational-acoustic load, and the biological stability of the species used. In particular, species that have lost adaptive potential due to critical age, such as P. bolleana and P. nigra, should be replaced with more resistant taxa demonstrating high vitality under comparable conditions. This would facilitate the formation of green plantings capable of performing protective and sanitary functions more effectively under conditions of continuous anthropogenic pressure.

INTRODUCTION

Urbanization is characterized by the intensification of technogenic pressure, resulting in profound transformations of natural conditions and ecosystems [6–8; 35–36; 42].

Anthropogenic pollution comprises a complex of adverse environmental changes caused by chemical and physical factors [1; 5; 9]. Its major sources include chemical, coke-chemical, mining, and metallurgical industries that generate emissions and solid waste [20; 39]. Intensive traffic flow also makes a substantial contribution to environmental pollution. Vehicle emissions are a major source of atmospheric contamination by a wide range of pollutants, including nitrogen and carbon oxides, aldehydes, sulfur dioxide, and other compounds [37]. Soil and surface water contamination resulting from atmospheric deposition and the input of petroleum products and heavy metals is likewise of considerable importance [2; 40; 43]. Traffic also generates vibrational-acoustic noise that exceeds maximum permissible levels. Elevated acoustic and vibrational exposure contributes to biodiversity loss in areas adjacent to transport infrastructure [26; 31].

This issue is particularly acute in regions exposed to multiple stressors, such as Donbas and the adjacent territories of Novorossiya, where long-term industrial pressure is compounded by the consequences of military activity. Infrastructure destruction, contamination of air and soils by hazardous substances, and mechanical disturbance of landscapes create a unique and extreme environment for urban flora [28; 34].

Climate change further aggravates the situation. Over recent decades, climate change in Donbas has manifested as an increase in mean annual air temperature and a reduction in the duration of cold periods [19]. These processes increase the sensitivity of urban green spaces to technogenic stressors, producing a synergistic effect of negative impacts [21].

Woody plants and dendrocenoses are among the most vulnerable components under these conditions. They perform essential ecosystem functions, including microclimate regulation, air filtration [18], soil stabilization [10], and biodiversity maintenance [3]. Their physiological condition serves as an indicator of urban ecosystem resilience [23]. The combined influence of these factors creates a complex of stressors capable of disrupting plant morphogenesis, altering metabolic activity and pigment composition, and reducing resistance to biotic and abiotic stressors. Ultimately, this may destabilize the ecosystems of Donbas and Novorossiya [4; 12; 32].

Assessment of tree vitality, morphological characteristics, and stress levels induced by vibrational-acoustic noise constitutes a priority task for the conservation and restoration of regional urban ecosystems and provides the basis for ecological rehabilitation strategies and the adaptation of urban stands to ongoing urbanization and climate change.

MATERIALS AND METHODS

Study objects. A total of 700 woody plants growing within the first and second rows adjacent to the highway were assessed during the study.

Populus bolleana Lauche naturally occurs in the foothills and plains of Central Asia. Trees may exceed 35 m in height. The species is characterized by high drought and frost resistance, as well as resistance to mechanical stress. It is widely used in street plantings, parks, gardens, and alley systems and is suitable for shelterbelts and soil stabilization [24]. This species contributes substantially to the formation of a comfortable urban microclimate. However, under the conditions of Donbas, especially in linear plantings, its vitality is comparatively short-lived and declines sharply after 50 years [27].

Populus nigra L. is widespread throughout the European part of Russia. It grows along riverbanks, lakeshores, and in valleys. Trees reach heights of up to 40 m and possess a broad crown and a well-developed root system that ensures wind resistance. The species tolerates both flooding and arid climatic conditions. Owing to its ornamental value, it may be effectively used in urban landscaping projects under appropriate maintenance conditions [24; 41].

Populus nigra var. *italica* Münchh. is distinguished by its narrowly pyramidal crown and may reach heights of up to 40 m. The taxon is distributed throughout the steppe and forest-steppe zones of Russia and Central Asia. It is drought-resistant, winter-hardy, and tolerates slight soil salinity. Due to its powerful root system, it is effective in establishing wind-protective and noise-attenuating green belts [14; 24].

Populus balsamifera L. is a North American species reaching 25–30 m in height and 4–5 m in diameter. It is characterized by high winter hardiness. The species is used in urban landscaping, shelterbelt forestry, and bank stabilization and is commonly found in gardens, parks, squares, and residential areas [24].

Acer platanoides L. is a widespread species native to the European part of Russia and Asia Minor, reaching heights of up to 30 m. The species is shade-tolerant, demanding with respect to soil fertility and moisture, and exhibits soil-improving properties. It is resistant to wind and low temperatures. Its tolerance to traffic-related impacts and ornamental qualities throughout the growing season account for its extensive use in urban landscaping [24; 41].

Acer saccharinum L. is a tree reaching 40 m in height and up to 1.5 m in trunk diameter. Its natural range encompasses eastern North America. The species is shade-tolerant and demanding with respect to soil fertility and moisture. It demonstrates moderate tolerance to soil salinity but is sensitive to impermeable surfaces, smoke, and dust. It is primarily used in park landscaping [24].

Sorbus intermedia (Ehrh.) Pers. is an ornamental tree 10–15 m high with a pyramidal crown. Its natural distribution includes southern Sweden, Bornholm, southwestern Finland, the Baltic states, and Poland. The species is drought-resistant and winter-hardy and is widely used for highway landscaping and alley plantings [25].

Ulmus pumila L. is a fast-growing, light-demanding tree reaching 3–27 m in height. Its natural range covers vast territories of East and Central Asia, while in cultivation it is distributed across southern Europe and North America. The species is drought-resistant, undemanding with respect to moisture supply, and tolerant to soil salinity, which determines its value in protective afforestation and landscaping under harsh environmental conditions [25; 29].

Fraxinus pennsylvanica Marshall is a tree 15–25 m in height naturally distributed in North America. The species is relatively drought-resistant and winter-hardy, readily propagates by seeds, exhibits high germination rates, and is capable of invading both disturbed and closed plant communities. In urban landscaping, it is mainly used in parks and alleys [41].

Robinia pseudoacacia L. originates from North America and may reach 25–30 m in height. It exhibits high drought and salt tolerance, while its dense and elastic wood provides resistance to mechanical stress. However, under adverse conditions, trees become severely weakened after 40–50 years and require sanitary felling [22].

Juglans regia L. is a woody species native to the Mediterranean region, including Italy, Greece, and Turkey. The species tolerates both high and low temperatures. J. regia is wind-resistant but demanding with respect to soil moisture and fertility. It is used in parks as a shade tree and occasionally occurs in alley plantings [30].

Quercus robur L. occurs throughout the European part of Russia and much of Western Europe. Trees reach heights of up to 40 m, are long-lived, and produce valuable high-strength timber. The species is drought- and salt-tolerant but demanding with respect to soil moisture and fertility. Its ornamental value makes the species suitable for landscaping confined urban spaces, including narrow streets and roadside areas [24].

Betula pendula Roth. possesses an extensive distribution range covering the European part of Russia from tundra to steppe zones. Trees reach 25–30 m in height. The species develops a powerful and widely spreading root system ensuring wind resistance. It is light-demanding, winter-hardy, drought-tolerant, and undemanding with respect to soil fertility and moisture. The species plays a key pioneer role in forest regeneration after fires and logging [41].

Prunus cerasifera var. *pissardii* (Ehrh.) Koehne is an ornamental tree 8–10 m high used in landscape design. The species is relatively undemanding but requires sunny, wind-protected sites and regular disease prevention measures. In urban landscaping, it is planted in parks, squares, and private gardens [15].

Picea pungens Engelm. originates from western North America and is widely cultivated across Russia, from Crimea to Arkhangelsk and Siberia, as well as in Central Asia. Trees reach heights of 20–45 m. The species is highly frost-resistant and smoke-tolerant and retains its ornamental qualities at maturity [24].

Study area. Monitoring was conducted in 2024–2025 in Donetsk along the city's main highway, Leninsky Avenue (Fig. 1). The total length of the surveyed route was 9.17 km in both directions, extending from Kommunarov Square in the Voroshilovsky District to the southern part of the city.

Figure 1 – Study area along the Leninsky Avenue highway in Donetsk (Shutova Street–Roslogo Street)

The study area along the central avenue of Donetsk (Fig. 1) was divided into seven sections: S1 – Shutova Street to Odesskaya Street; S2 – Odesskaya Street to Vani Drelya Street; S3 – Vani Drelya Street to Mechnikova Street; S4 – Mechnikova Street to Kuprina Street; S5 – Kuprina Street to Kirova Street; S6 – Kirova Street to Tyutcheva Street; S7 – Tyutcheva Street to Roslogo Street.

Figure 2 – Panoramic view of the study area along Leninsky Avenue, Donetsk

The highway has six traffic lanes separated by green plantings. The first row of trees is located at a distance of 0.5–2 m from the roadway (Figure 2).

Analysis of anthropogenic pressure. Noise pollution was assessed using the following approved regulatory documents:

– GOST 20444-85 "Noise. Traffic flows. Methods for measuring noise characteristics" [16];

– SanPiN 1.2.3685-21 "Hygienic standards and requirements for ensuring the safety and/or harmlessness of environmental factors to humans" [17];

– SP 51.13330.2011 "Noise protection. Updated edition of SNiP 23-03-2003" [33], according to which the equivalent daytime sound level in areas directly adjacent to residential buildings must not exceed 55 dBA, while the maximum sound level must not exceed 70 dBA. For equivalent noise levels measured 2 m from the highway, a correction of +10 dBA is permitted (correction factor = +10 dBA).

Noise measurements were carried out using a portable Benetech sound level meter with an accuracy of ±1 dBA at intervals of 20–30 m near the highway and within the first row of woody plants (Figure 3). Measurements were conducted during periods of peak weekday traffic intensity.

Traffic intensity in each study section was assessed as the number of vehicles of each type passing the measurement point per unit time [38].

Figure 3 – Interface of the "Sound Level Meter" application during operation

Morphological data. Tree vitality was assessed using the generally accepted integral scale proposed by V.A. Alekseev (1989), with subsequent modifications [11]. According to this scale, the following categories were distinguished: 1 point – healthy tree (absence of visible crown and trunk damage); 2 points – weakened tree (crown thinning and up to 30% dry or dying branches in the upper half of the crown); 3 points – severely weakened tree (substantial crown thinning and up to 60% dry or dying branches in the upper half of the crown); 4 points – dying tree (severe crown degradation, predominance of dead branches, and signs of stem pest infestation); 5 points – dead standing tree.

The results of visual inspection of the studied woody plants were recorded using a Nikon Coolpix S2600 camera. Subsequent laboratory processing and analysis of digital images, including assessment of trunk and crown morphological parameters, were performed using AxioVision Rel. 4.8 software with a reference scale. Trunk diameter was measured using a Haglof Mantax caliper.

Statistical data processing was performed using Microsoft Excel LTSC (version 2505, build 16.0.18827.20102) (Microsoft Corporation).

RESULTS AND DISCUSSION

Assessment of traffic intensity across all study sections demonstrated a high level of roadway congestion exceeding 1000 vehicles per hour. The average traffic volume along Leninsky Avenue amounted to 1451 ± 265 vehicles per hour (Table 1). The highest traffic load was recorded in Section 3 (Vani Drelya Street–Mechnikova Street) with 1740 vehicles per hour, Section 4 (Mechnikova Street–Kuprina Street) with 1608 vehicles per hour, and Section 6 (Kirova Street–Tyutcheva Street) with 1722 vehicles per hour. These indicators reflect substantial anthropogenic pressure on dendrocenoses. In contrast, Section 5 (Kuprina Street–Kirova Street) exhibited the lowest traffic intensity, with 1093 vehicles per hour.

The greatest contribution to vibrational-acoustic noise pollution was made by passenger vehicles, including foreign-made passenger cars (585 ± 138), domestic passenger cars (247 ± 25), and foreign-made SUVs (335 ± 48), whereas buses (72 ± 18) and light trucks (163 ± 37) contributed to a lesser extent (Table 1).

Measurements of vibrational-acoustic noise near the highway showed that in Section 1 the deviation from the maximum permissible level for mean values reached 45.5%; after applying the +10 dBA correction, the deviation amounted to 23%, while the maximum value exceeded the permissible level by 28.5%. In Section 2, the deviation from the permissible level for mean values also reached 45.5%; with correction, 23%; and for maximum values, 21.4%.

Table 1. Traffic intensity in Donetsk, vehicles h^{-1}

Study section	Vehicle type						Total
	Trucks		Passenger cars			Municipal transport — buses	
	Heavy	Light	1	2	3		
Section 1	48	120	540	240	360	72	1380
Section 2	24	132	420	216	288	48	1128
Section 3	60	204	720	264	396	96	1740
Section 4	60	180	684	288	324	72	1608
Section 5	32	123	400	218	270	50	1093
Section 6	58	200	734	253	389	88	1722
Section 7	62	179	600	251	320	75	1487
Mean value	49	163	585	247	335	72	1451
Standard deviation	15	37	138	25	48	18	265

Notes: 1 – foreign-made passenger cars; 2 – domestic passenger cars (VAZ, Lanos, etc.); 3 – foreign-made SUVs.

Abbreviations: Section 1 – Shutova Street–Odesskaya Street; Section 2 – Odesskaya Street–Vani Drelya Street; Section 3 – Vani Drelya Street–Mechnikova Street; Section 4 – Mechnikova Street–Kuprina Street; Section 5 – Kuprina Street–Kirova Street; Section 6 – Kirova Street–Tyutcheva Street; Section 7 – Tyutcheva Street–Roslogo Street.

In Section 3, the deviation from the permissible level for mean values reached 40%; with correction, 18.5%; and for maximum values, 15.7%. In Section 4, the corresponding values were 38.2%, 16.9%, and 14.3%, respectively. In Section 5, the deviations reached 47.3%, 24.6%, and 22.6%, respectively. In Section 6, the values were 38.2%, 16.9%, and 14.3%, respectively. In Section 7, the deviations amounted to 40%, 18.5%, and 15.7%, respectively (Table 2).

Table 2: Mean noise pollution levels along Leninsky Avenue, Donetsk, dBA

Study section	Distance from highway, m			
	0.5		2 (first row of trees)	
	Mean	Max	Mean	Max
Section 1	80 ± 2	90 ± 2	77 ± 2	81 ± 2
Section 2	80 ± 2	85 ± 1	77 ± 2	80 ± 2
Section 3	77 ± 2	81 ± 2	74 ± 1	79 ± 1
Section 4	76 ± 2	80 ± 2	75 ± 3	77 ± 2
Section 5	81 ± 2	86 ± 1	76 ± 2	79 ± 2
Section 6	76 ± 2	81 ± 2	73 ± 1	78 ± 1
Section 7	77 ± 2	81 ± 2	75 ± 3	77 ± 2
Mean value ± standard deviation	78.1 ± 2.1	83.3 ± 3.8	75.3 ± 1.5	78.7 ± 1.5

Abbreviations: Section 1 – Shutova Street–Odesskaya Street; Section 2 – Odesskaya Street–Vani Drelya Street; Section 3 – Vani Drelya Street–Mechnikova Street; Section 4 – Mechnikova Street–Kuprina Street; Section 5 – Kuprina Street–Kirova Street; Section 6 – Kirova Street–Tyutcheva Street; Section 7 – Tyutcheva Street–Roslogo Street.

Studies of vibration-acoustic noise within the first row of woody plants demonstrated that in Section 1 the deviation from the permissible level for mean values (55 dBA) reached 40%; accounting for the correction (65 dBA), 24.6%; and for maximum values (70 dBA), 15.7%. In Section 2, the corresponding deviations amounted to 40%, 23.1%, and 14.3%, respectively. In Section 3, the deviations were 34.5%, 21.5%, and 12.9%; in Section 4, 36.4%, 18.5%, and 10%; in Section 5, 38.2%, 21.5%, and 12.9%; in Section 6, 32.7%, 20%, and 11.3%; and in Section 7, 36.9%, 21.1%, and 12.4%, respectively.

The vibration-acoustic noise indicators demonstrated that maximum sound pressure levels near the highway reached 83.3 ± 3.8 dBA, corresponding to a 19% exceedance of the permissible limit, whereas within the first row of woody plants the maximum reached 78.7 ± 1.5 dBA, corresponding to a 12.5% exceedance (Table 2). Exceedance of the maximum permissible level for mean values amounted to approximately 37–42% regardless of the distance from the noise source. Consequently, such exposure may affect living systems. Variability in noise levels among sections indicates differences in traffic intensity and composition, as well as the presence of additional noise sources.

Figure 4 presents 30-second amplitude-frequency spectra of different vehicle types. In addition to elevated noise levels, the amplitude component of traffic flow is of critical importance. For organisms, extreme values of both anthropogenic and natural climatic factors, together with their periodicity, are of primary significance due to their influence on biological systems.

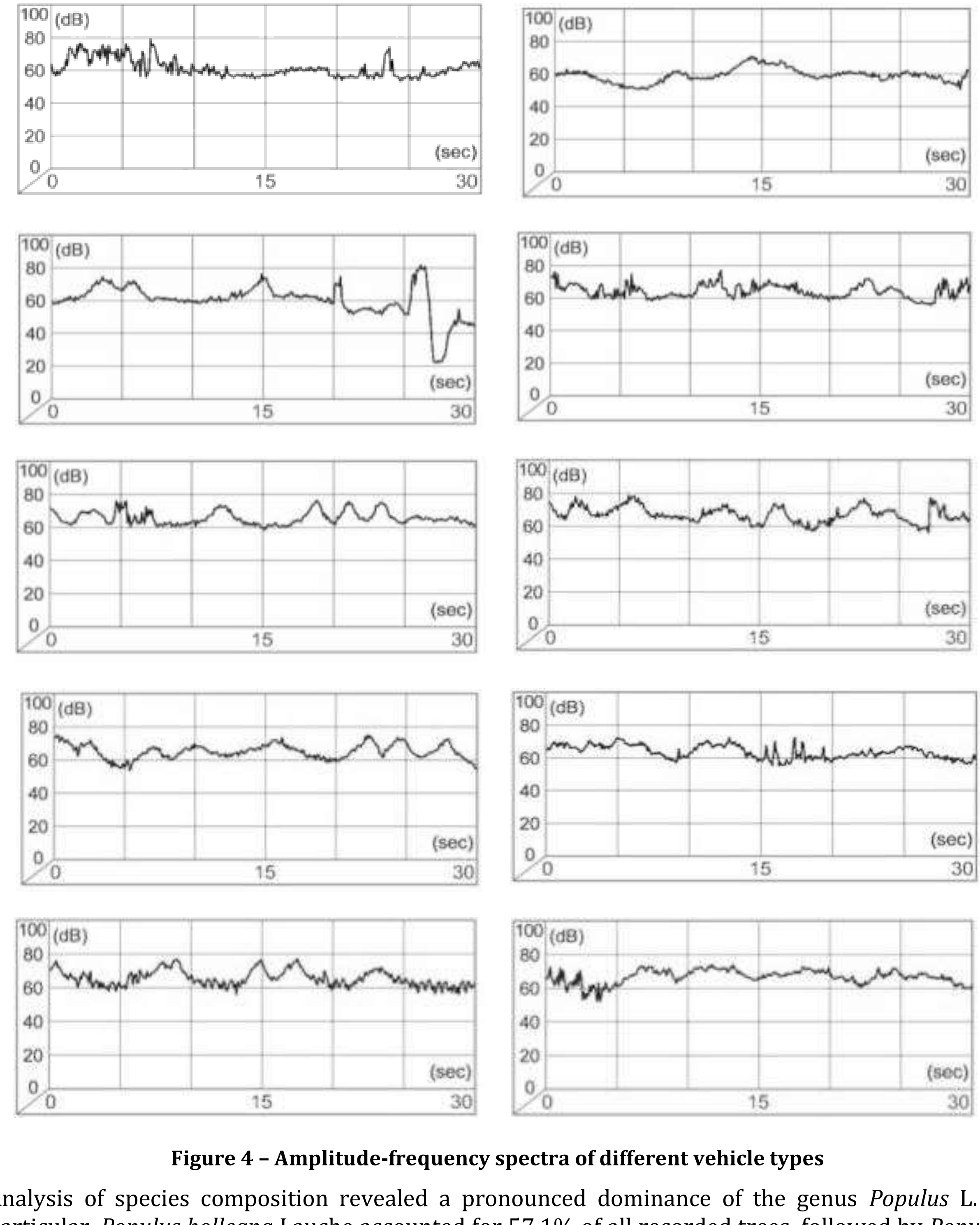

Figure 4 – Amplitude-frequency spectra of different vehicle types

Analysis of species composition revealed a pronounced dominance of the genus *Populus* L. In particular, *Populus bolleana* Lauche accounted for 57.1% of all recorded trees, followed by *Populus nigra* L. (21.4%) and *Populus balsamifera* L. (4.3%).

Species with moderate representation included *Sorbus intermedia* (Ehrh.) Pers. (2.9%), *Acer platanoides* L. (2.9%), *Acer saccharinum* L. (2.1%), *Fraxinus pennsylvanica* Marshall (1.6%), *Ulmus* *pumila* L. (1.4%), *Populus nigra* var. *italica* Münchh. (1.4%), *Robinia pseudoacacia* L. (1.4%), and *Quercus robur* L. (1.1%).

The least represented species within the study area were *Juglans regia* L. (0.7%), *Betula pendula* Roth. (0.6%), *Picea pungens* Engelm. (0.6%), and *Prunus cerasifera* var. *pissardii* (Ehrh.) Koehne (0.4%).

Overall, 15 species belonging to 11 genera were identified during the study. Species of European and North American origin predominated (Table 3).

Table 3: Species abundance and origin

Species	Number	%	Origin
Populus bolleana Lauche	400	57.1	Turkestan (Central Asia)
Populus nigra L.	150	21.4	Europe, Northwestern Africa
Populus balsamifera L.	30	4.3	North America
Sorbus intermedia (Ehrh.) Pers.	20	2.9	Europe
Acer platanoides L.	20	2.9	Europe, Southwestern Asia
Acer saccharinum L.	15	2.1	North America
Fraxinus pennsylvanica Marshall	11	1.6	North America
Ulmus pumila L.	10	1.4	Europe
Populus nigra var. *italica* Münchh.	10	1.4	Europe/Asia (hybrid)
Robinia pseudoacacia L.	10	1.4	North America
Quercus robur L.	8	1.1	Europe
Juglans regia L.	5	0.7	Asia (Persia)
Betula pendula Roth.	4	0.6	Europe
Picea pungens Engelm.	4	0.6	North America
Prunus cerasifera var. *pissardii* (Ehrh.) Koehne	3	0.4	Unknown (cultivar)

Analysis of the dendrourbanocenosis condition demonstrated that most trees in the principal age group (45–50 years) were classified as weakened or severely weakened (2–3 points) (Table 4).

Table 4: Species-specific dendrometric parameters of woody plants exposed to noise pollution along Leninsky Avenue, Donetsk

Species	Vitality, score	Diameter, cm		Height, m
		D_{base}	$D_{1.3}$ / DBH	
Populus bolleana Lauche	3.0 ± 0.5	84.9	83.3	22.2
Sorbus intermedia (Ehrh.) Pers.	2.0 ± 0.7	25.6	24.6	18.9
Populus nigra L.	3.0 ± 0.5	23.1	21.6	16.7
Ulmus pumila L.	3.0 ± 1.0	33.1	31.4	22.0
Populus nigra var. *italica* Münchh.	3.0 ± 0.5	39.2	37.2	20.7
Juglans regia L.	2.5 ± 1.0	24.0	23.0	18.9
Fraxinus pennsylvanica Marshall	1.5 ± 1.0	15.9	14.8	5.5
Robinia pseudoacacia L.	2.0 ± 1.0	12.7	12.1	3.0

The most vulnerable species were *Populus bolleana* Lauche, *Populus nigra* L., *Ulmus pumila* L., and *Populus nigra* var. italica Münchh., which exhibited low vitality scores (3.0 ± 0.5 points). These species had reached a critical age under regional conditions, which negatively affected their vitality. Exceptions to this general trend included species that had not yet reached the regional critical age, indicating either recent planting or active spread in the case of invasive taxa, and consequently better overall condition (age below 35 years). Such exceptions included *Sorbus intermedia* (Ehrh.) Pers. (2.0 ± 0.7 points), among which 67% of the examined individuals were healthy and had not reached the critical regional age; *Fraxinus pennsylvanica* Marshall (1.5 ± 1.0 points); and *Robinia pseudoacacia* L. (2.0 ± 1.0 points) (Fig. 5).

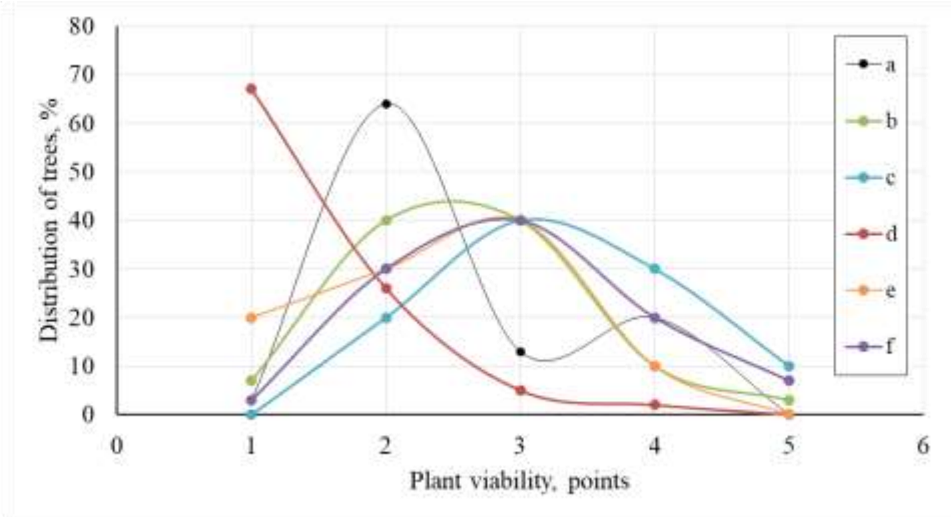

Figure 5 – Species-specific patterns of vitality in the principal tree species

However, data obtained under similar roadside conditions along Universitetskaya Street [13] indicate substantial suppression of photosynthetic processes in *Sorbus intermedia* (Ehrh.) Pers., accompanied by asymmetry of leaf blades (Fig. 6). Reduced chlorophyll a content and lower electron transport rate (ETR) values within the photosynthetic apparatus indicate weakening of the species' adaptive potential in zones exposed to intensive traffic pollution. *Sorbus intermedia* (Ehrh.) Pers. may therefore be recommended primarily for recreational and park areas characterized by lower levels of atmospheric pollution, where its physiological condition is less severely affected by environmental stressors.

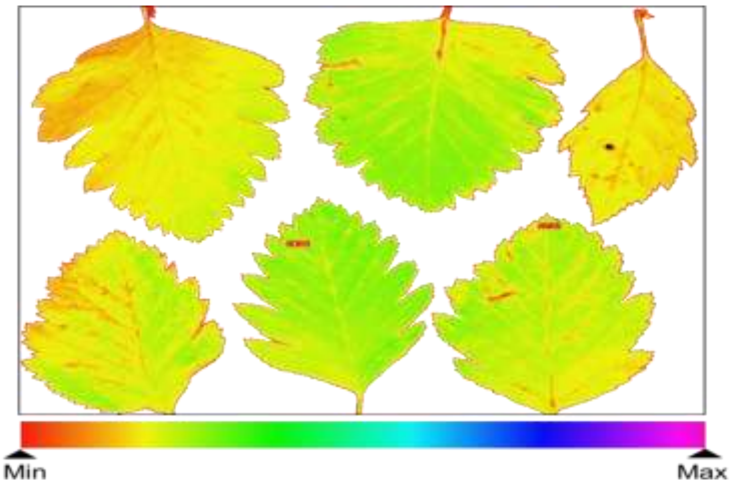

Figure 6 – Fluorescence of leaf blades in *Sorbus intermedia* (Ehrh.) Pers. [13]

Field investigations revealed morphological damage to trunks and crowns that adversely affected the general condition and vitality of woody plants. Trunk damage included mechanical defects (bark peeling and frost cracks) and biological injuries (canker formations and heart rot), resulting in tissue disruption, reduced mechanical strength of wood, and consequently diminished resistance of trees to external stress factors (Fig. 7).

Figure 7 – Typical trunk damage in woody plants: A – mechanical trunk damage and bark peeling; B – heart rot; C – canker formations; D – frost cracks

The age structure of green plantings is one of the key characteristics determining their condition and functionality (Fig. 8). Among the studied species, *Quercus robur* L. was the oldest representative. However, urban forest ecosystems currently lack so-called ecological cores, which should include old-growth trees characteristic of Donbas, such as pedunculate oak and common ash.

Most representatives of the genus *Populus* L. have reached a critical age, necessitating comprehensive renewal and landscaping measures. Existing sanitary pruning and severe crown reduction practices have failed to produce the expected effect. In many cases, such interventions result either in tree mortality or insufficient recovery of green biomass, preventing trees from fully performing their ecological functions. The youngest species represented within the study area were *Fraxinus pennsylvanica* Marshall and *Prunus cerasifera* var. *pissardii* (Ehrh.) Koehne.

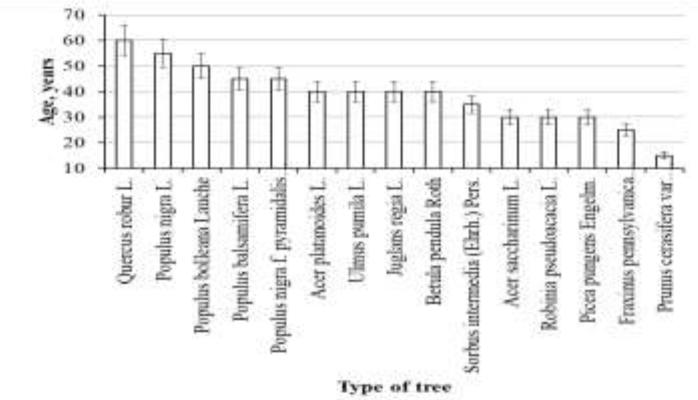

Figure 8 – Age structure of the dendrocenosis

CONCLUSIONS

1. The study showed that mean traffic intensity in the selected area reached 1451 ± 265 vehicles per hour across all sections, corresponding to a high level of anthropogenic pressure. The highest traffic intensity was recorded in Sections 3, 4, and 6, exceeding 1600 vehicles per hour.

2. Assessment of vibration-acoustic noise pollution revealed that maximum sound pressure levels near the highway reached 83.3 ± 3.8 dBA, while within the first row of woody plants they reached 78.7 ± 1.5 dBA. Exceedance of the maximum permissible level for mean values amounted to approximately 37–42% regardless of the distance from the noise source. Consequently, such exposure may have adverse ecological effects on urban forest ecosystems.

3. Species composition and tree condition were assessed. The dominant species were *Populus bolleana* Lauche (57.1%), *Populus nigra* L. (21.4%), *Populus balsamifera* L. (4.3%), *Sorbus intermedia* (Ehrh.) Pers. (2.9%), *Acer platanoides* L. (2.9%), and *Ulmus pumila* L. (1.4%). Most trees of the principal species were classified as weakened or severely weakened (2–3 points). Exceptions to this trend included species that had not reached the regional critical age, indicating recent planting or active spread in the case of invasive taxa and consequently better condition (age below 35 years). Such species included *Sorbus intermedia* (Ehrh.) Pers. (2.0 ± 0.7 points), among which 67% of the 20 examined individuals remained healthy and had not reached the critical age under regional conditions; *Fraxinus pennsylvanica* Marshall (1.5 ± 1.0 points); and *Robinia pseudoacacia* L. (2.0 ± 1.0 points).

4. Sanitary pruning and even severe crown reduction failed to produce the desired outcome. Trees either died after such interventions or failed to regenerate sufficient green biomass to fully perform their ecological functions.

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