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Evaluation of the Noise Protection Properties of the Zeravshan Juniper

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Abstract The article is dedicated to the study of the noise-protective properties of Zeravshan juniper (Juniperus seravschanica) in urban environments as an element of sustainable landscaping. The relevance of the work is determined by the problem of noise pollution in cities and the need to search for evergreen plants with year-round noise protection effectiveness, unlike seasonably effective leafy species. The goal is to evaluate the acoustic effectiveness of juniper in reducing transport noise and to establish the dependence of this effect on crown thickness and sound frequency. The method of simultaneous on-site measurements of the sound pressure level of traffic noise using two noise meters (control and measurement) behind plantations of varying thickness (1.0 m, 2.0 m, 3.0 m) along highways in the cities of Tashkent and Chirchik was used. Spectral analysis of noise was conducted. A direct proportional relationship between the decrease in sound pressure level and the crown thickness has been established. The noise absorption efficiency of a 3.0 meter juniper strip reaches 17 dB, with a maximum decrease at a frequency of 1000 Hz. This indicates a high ability of the dense coniferous crown to absorb medium and high-frequency noise (engines, tires). Additionally, it was found that the noise-protective properties increase by 1-3 dB as the crown grows and becomes denser. Zeravshan juniper (archa) is a highly effective, year-round noise-absorbing barrier, surpassing leafy species in its noise-protective properties and eliminating the problem of seasonality and "acoustic clearance" under the crown. The obtained data substantiate the recommendations for using dense juniper plantations (especially 2-3 m wide) to enhance acoustic comfort in urban development.

Keywords Noise protection, Noise pollution, Zeravshan juniper, Juniperus seravschanica, Juniper, Urban greening, Acoustic efficiency, Crown thickness, Transport noise

1. Introduction

The environmental situation in cities, related to the increase in the number of vehicles and the development of infrastructure, makes noise pollution a pressing issue. According to numerous literature sources, one of the means of combating urban noise is green spaces, which play a significant role in reducing noise levels in residential areas and also have several important ecological and microclimatic functions: they extinguish wind currents, improve air quality by releasing oxygen and utilizing dust, increase relative air humidity and lower its temperature during the summer period, and possess antibacterial and aesthetic properties [1,11,12,13].

According to Russian researchers Azarova O.V. and Bechina D.N. (2016, 2017), when using pyramidal-crowned poplar in optimal planting schemes (together with shrubs, to close the crown space), the average noise reduction reaches 10 dB [2,3]. A comparative assessment of air pollution levels, including road noise, conducted by Swedish scientists in the city landscape of Gothenburg, before and after the appearance of leaves on roadside trees, showed that the presence of leaves significantly reduced noise levels, allowing the authors to conclude that urban green zones are beneficial for the quality of the urban environment and this is important to consider when urban planning [9]. Belgian scientists Renterghem T. V. and Botteldcoren O. (2016) based on research results concluded that even if the physical level of sound pressure decreases insignificantly, viewing green spaces can reduce perceived noise irritation, and according to some estimates, the effect can reach 10 dBA, especially under high noise load conditions [10].

However, the main disadvantage of leafy species when used for noise protection purposes is their seasonal effectiveness [2,3]. In the autumn-winter period, due to leaf falling, the noise-protective effect sharply decreases or is completely absent. Additionally, to achieve maximum effect, it is necessary to close the crown space with dense shrubs, which increases plant maintenance costs. This criterion in acoustics is often described by the term "unobservability" of the plantation strip, which directly depends on the crown

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density [4,5,6]. In the context of the listed disadvantages of deciduous species, the Zeravshan juniper (archa) is of particular interest. Unlike leafy species, juniper has a dense, thick, evergreen crown, which ensures year-round noise absorption. This plant is also characterized by its low demand for urban conditions (noise, dustiness, gas contamination), high growth potential (15-20 m), and durability. The presence of a dense crown from the root itself eliminates the need for additional filling of the crown space with shrubs. It is assumed that with proper care and the formation of dense, continuous plantings, the arch can provide the necessary thickness of the noise barrier. Creating scientifically based optimal placement schemes and selecting resistant plant species for noise protection purposes is a key direction in urban planning ecology.

2. Aim

Assess the noise protection characteristics of Zeravshan juniper (Juniperus seravschanica) in urban conditions and determine the dependence of noise reduction efficiency on crown thickness and sound frequency.

3. Materials Methods

The object of the research work was the strips of Zeravshan juniper (Juniperus seravschanica) with varying crown thickness (width), located along highways in Tashkent and Chirchik cities, as well as in a farm in the Tashkent region. Noise and vibration measurements were carried out by a set of "Assistant Combi Total+" No. 229116 (Russia) and "SVAN-943B" No. 11026 soundmeters, which comply with the requirements of GOST 17187-2010 "Summeters. Part 1. General requirements. Measurement conditions and methodology: Measurements were carried out in dry eather with no precipitation and high humidity. The wind speed did not exceed 15m/s. A windbreak device was used to protect the microphone from the wind. Measurements of traffic noise were conducted during peak hours in accordance with the requirements of GOST 20444-2014 "Noise. Traffic flows. Methods for measuring noise characteristics" [8]. Measurements were taken simultaneously by two noise meters: Noise meter 1 (control) was located at a predetermined distance from the noise source (highway) outside the arch screen zone. Noise meter 2 (measuring) was located at the same distance from the source, but directly behind the juniper planting strip. The height of measurement is at the level of the average height of the human ear (1.2 m). Simultaneous measurement made it possible to correctly assess the noise reduction during the maximum load on the main line. Spectral analysis of noise was conducted to determine the effectiveness based on frequency characteristics. At each point, 9-10 measurements of the spectral characteristic of noise were taken.

4. Results and Discussion

For research, juniper plantations with dense, invisible crowns of varying thickness, height, and age were selected.

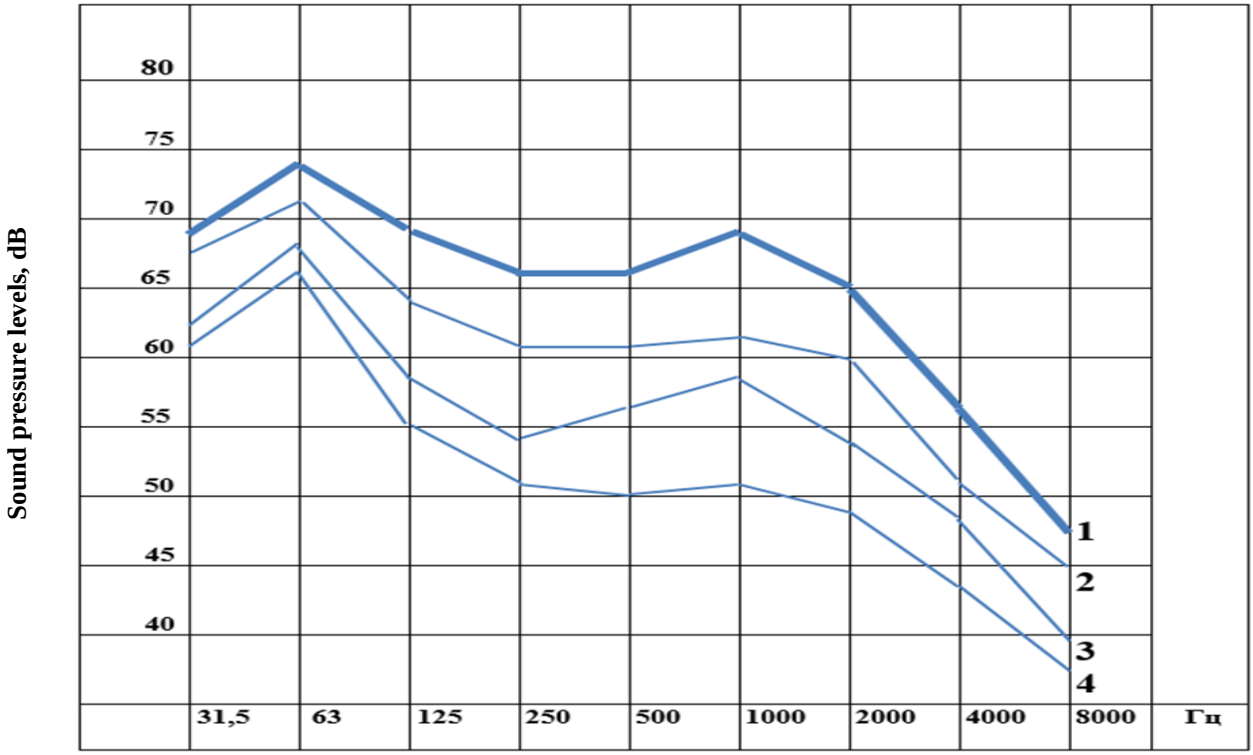
According to the obtained research data, a direct proportional relationship between the noise absorption efficiency and the crown thickness was established. Even at a minimum thickness of 1.0 m, a decrease in the sound pressure level is recorded in all octave bands, reaching 6 dB at medium and high frequencies.

With an increase in crown thickness to 3.0 meters, the decrease increases to 17 dB with a pronounced maximum at 1000 Hz. This indicates the high effectiveness of the dense coniferous crown in absorbing medium-frequency and high-frequency noise characteristic of urban transport (motor noise, tire noise).

A clearer reduction in noise behind the juniper strip is illustrated by **Figure 1.**

Table 1. Reduction of the sound pressure level depending on the crown thickness of the Zeravshan juniper in octave bands

2025	Point measurements	Crown thickness, m	Sound pressure levels, dB, in octave bands of average geometric frequencies, Hz.									General sound level, dBA
			31,5	63	125	250	500	1000	2000	4000	8000	
May	7.5 m from the first lane of the highway	-	68	74	68	66	66	68	65	56	47	72
	beyond the wall from juniper	1.0 m	67	72	64	61	61	62	60	51	45	66
	decrease		***1***	***2***	***4***	***5***	***5***	***6***	***5***	***5***	***2***	***6***
	beyond the wall from juniper	2.0 m	63	68	58	54	56	58	54	48	39	62
	decrease		***5***	***6***	***10***	***12***	***12***	***11***	***11***	***8***	***8***	***10***
	behind the wall from juniper	3.0 m	62	67	55	51	50	51	49	43	37	56
	decrease		***6***	***7***	***13***	***15***	***16***	***17***	***16***	***13***	***10***	***16***
September	beyond the wall from juniper	3.0 m	60	66	54	53	48	47	48	42	36	55
	decrease		***6***	***8***	***14***	***15***	***18***	***20***	***17***	***14***	***11***	***17***



1. 7.5 meters from the first lane of traffic flow.
2. The thickness of the arch crown is 1.0 meters.
3. The thickness of the arch crown is 2.0 meters.
4. The thickness of the arch crown is 3.0 meters.

Figure 1. Reduction of sound pressure levels in octave bands of average geometric frequencies behind the juniper planting strip, depending on the thickness of its crown

May 2025 September 2025

Figure 2. Processes of measuring the level of sound pressure in octave bands of average geometric frequencies after a strip planted with juniper

Repeated studies of trees with a crown diameter of 3 meters, conducted at intervals of 5 months (May-September), revealed statistically significant changes in the noise-protective properties of juniper. During this period, the plant's growth in height was up to 8-10 cm, and in diameter up to 5-7 cm. The noise-protective properties of juniper increased significantly, showing an additional decrease within 1-3 dB in the high-frequency region of the spectrum. This effect is likely related to the densification of crown structure as the tree grows, which increases the efficiency of sound wave reflection and scattering. This aspect requires further detailed study in laboratory (acoustic/reverberation

chamber) and field conditions.

The results obtained during the study convincingly demonstrate the high acoustic efficiency of Zeravshan juniper (Juniperus seravschanica) in reducing transport noise, especially at medium and high frequencies. The decrease in sound pressure level, reaching 17 dB at a crown thickness of 3 m, is significant and exceeds the indicators of most deciduous species described in the literature (average decrease of 3-10 dB) [2,9,10].

The maximum decrease in the sound pressure level recorded in the 1000 Hz octave band is of key importance. Sound waves in this range, along with frequencies of 2000 Hz and 4000 Hz, are the most characteristic for the noise created by urban vehicles (tire noise, engine operation) and the most critical for human hearing. The acoustic effect of the dense arch crown is due to two main mechanisms:

- scattering (diffraction): small, scale-like needles and complex, multi-layered structure of branches cause multiple refraction and scattering of the sound wave. The denser and thicker the crown, the more acoustic energy is dissipated in space, reducing its direct passage;
- absorption (absorption): needles and branches, having a porous structure and a high surface area, absorb a portion of the sound energy, converting it into heat energy. The direct dependence of efficiency on crown thickness confirms that the increase in the acoustic resistance of the arch layer is directly proportional to the number of scattering and absorbing elements in the sound path.

Compared to other breeds, Juniperus seravschanica's year-round effectiveness as a noise barrier is determined by its evergreen color and morphology. Firstly, unlike leafy species, whose noise-protective effectiveness is seasonal (down to 50% during leafless periods), juniper maintains a constant, year-round crown density. This makes it strategically indispensable for creating continuous acoustic comfort in conditions where traffic noise is active 365 days a year. Secondly, forming a dense crown from the very base of the trunk eliminates the problem of "acoustic clearance" under the crown of deciduous trees, which is a "weak link" in standard landscaping schemes. The arch thus provides a continuous, invisible acoustic barrier, which is a critical condition for achieving maximum noise protection [4,5,7].

The detected effect of increased noise-protective properties as the crown grows and becomes denser (by 1-3 dB in the high-frequency spectrum over 5 months) emphasizes the long-term investment value of this type of green plantation. Since the arch has the ability to live long, its noise immunity not only does not decrease over time, but also increases naturally. The obtained data provide a scientifically based basis for developing new dendrological schemes for landscaping in the conditions of Uzbekistan and other regions with similar climates. They allow for optimizing the width of noise barriers: it has been experimentally proven that increasing the band thickness from 2 m to 3 m significantly increases noise protection efficiency (up to 5 dB), which allows for the preferential use of Juniperus seravschanica in areas requiring constant acoustic monitoring (near hospitals, schools, residential areas). Further research should focus on assessing the synergistic effect of using juniper in combination with artificial noise barriers, as well as on a detailed study of its other functions (wind protection, bioindication, phytoncidal properties), which will allow us to fully reveal its potential as a unique element of a sustainable urban environment.

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