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ANALYSIS OF THE PRESENT STATE OF TRAFFIC NOISE IMPACT ON HUMAN

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Abstract

Traffic noise cause adverse effects on health and quality of life of population exposed to it, including annoyance, sleep disturbance, decreased performance at school/work, stress, hypertension, and ischemic heart disease. This paper reviews existing literature, evidence and policies related to traffic noise impact on human and combine them to different studies of mapping noise and population exposure levels.

1. INTRODUCTION

In the EU countries, the issue of harmful effects of noise in recent decades has become a worrying topic at both professional and political levels. It is currently one of the most widespread harmful factors in the living and working environment. A major problem has happened especially in recent years, particularly in the context of the advanced development of transport and industry. The noise burden of the population is generated in 40% of work and in 60% of the environment. In residential agglomerations, transport noise is dominated. According to the data published by the World Health Organization, an equivalent noise level exceeding 50 dB has an easily interfering and exceeding 55 dB, a very disturbing effect on humans. 40% of the EU population is exposed to traffic noise, which exceeds this level and 20% to traffic noise, which is above 65 dB (A) over the day. During nighttime, more than 30% of the population is exposed to an equivalent level of noise that exceeds 55 dB (A), resulting in disturbing and negative effects on healthy sleep. [1]

2. PROJECTS RELATING TO TRAFFIC NOISE

Over the past decades, road transport noise has been tackled by European research projects co-funded by the European Commission, each of which has focused its attention on the so-silent road surfaces. It belongs to them: [2]

- **SILVIA (2002-2005)** - the project focused on three areas: designing procedures for classification and conformity of low-noise roads for production, study and improvement of the functional and structural life of low-noise roads, compilation of cost-benefit analysis in the low-noise road life cycle. The final result of the project is the "European guide to the use of low-noise roads", which integrates low-noise roads with other noise control measures.
- **INQUEST (2006-2008)** - the aim of the project was to support the use of low-noise roads in Europe by disseminating the tools proposed in the SILVIA project. This was done through seminars for decision-makers, road administration authorities, road construction suppliers, road engineers and policy-makers.

- **ROSANNE (2013-2016)** - the main objective of this project was to improve the harmonization of standards for common European methods of measuring road resistance against slipping, rolling resistance, noise emissions and preparing for world standardization in this area.
- **HEALROAD (2015-2020)** - the project deals with the development of mixtures that can be inductive heated, which increases the life of asphalt roads by 30%. A few days normally needed to repair microcracks lasts for a few seconds with this method.

The purpose of Directive 2002/49 / EC of the European Parliament and Council is to establish a unified approach to prevent, control or eliminate the adverse effects of environmental noise. It recommended to member states to proceed according to action plans based on noise map results. These countries must compulsorily develop strategic noise maps for all agglomerations with more than 250,000 inhabitants, for airports, wider roads and railways. Consequently, strategic noise maps and APs are made available to the general public in accordance with the relevant legislative. [1]

Issues of noise exposure in the environment, risk assessment and health effects have been devoted to the LFUK Hygiene Institute (Bratislava) for decades. In their study of objective and subjective noise perception, they studied and compared college students from selected student homes in Bratislava (noisy area) and students living in quieter areas. The time range of the noise levels during the day and night was observed both inside the house and around. In the noisy area, equivalent levels of noise over the day occurred in the health-damaging risk zone, of absolute noise >65 dB (A), maximum levels climb to 84 dB (A). Measurement results indicated an increase in the average of 2 dB (A) with each additional floor. Equivalent level values significantly exceeded the statutory limits set for indoor areas. Subjective interference was evaluated by a questionnaire. In addition to the basic questions, it included items aimed at obtaining information about the characteristics of the living environment and the health status of the respondents. Trafficking, industry, neighboring flats, airports, railways and noise from entertainment companies were assessed.

Part of the questionnaire looked at the physiological and psychological impact of traffic noise and its interferences with different activities. As the assessment method was used the risk calculation for different types and consequences of environmental noise annoyance with special regard to traffic noise. The analysis showed that respondents from student homes, from noisy sites are much more disturbed by environmental noise. In addition to traffic noise, there was a significant disturbance in noise coming from nearby entertaining businesses, neighboring flats and industrial activities. Since respondents were juveniles, they could not be considered for health consequences, but only for a higher risk of neurovegetative deviations. [3]

3. HARMFUL EFFECTS OF NOISE

Harmful, disturbing and damaging effects of noise are dependent on many acoustic and non-acoustic factors listed in table 1. [4]

Table 1: Acoustic and non-acoustic factors of noise

Acoustic factors	Non-acoustic factors
• noise intensity	• the subjective attitude of a person towards the source of noise
• uniformity of noise	• time of perceiving noise by man (day, evening, night)
• the frequency of exposed noise	• immediate disposition of man
• tone components of the noise spectrum	• the need for noise associated with activities
• frequency spectrum	• social status
• exposure time	• past experience with noise

• sound pressure level	• economic dependence on the noise source
• frequency of noise interruption	• the overall health of a person

Acoustic waves effecting on humans have physical effects on their acoustic organs, physiological effects on the whole organism that depending of the intensity of acoustic energy and the psychological effects that stand on the qualitative characteristics of acoustic waves. The effects of noise exposure on a human organism can be divided into the effects of infrasound, the effects of audible sound and the effects of ultrasound (Figure 1). [5]

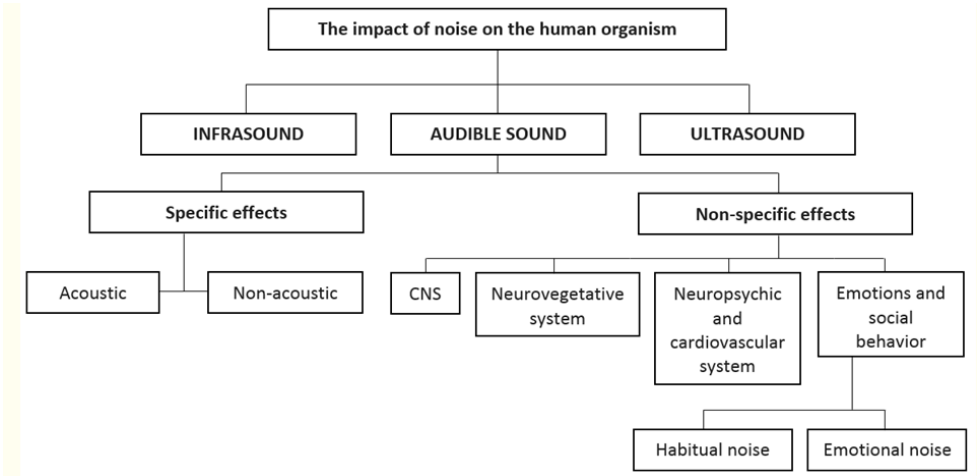

Figure 2 The impact of noise on the human organism [5]

From the point of view of the noise effects on the human organism, we divide the noise into: [6]

- **Habitual noise** - is perceived as common, familiar and normal. It is, for example, about noise on workplace, car, ordinary street traffic, sound background of home day, etc. It can cause blood pressure to rise to a sound pressure level of LA = 65 dB.
- **Emotional noise** - unexpected extraordinary noise causing reactions of the "what's happened" type, warning of danger or causing unpleasant experiences from the past. It works from the audience threshold.

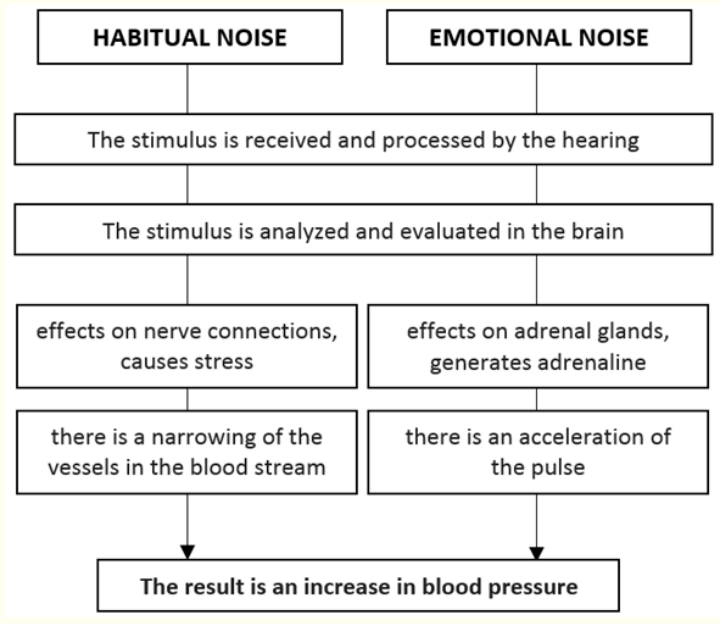

Figure 2 The impact of habitual and emotional noise [6]

4. STUDIES DEALING WITH THE HARMFUL EFFECTS OF NOISE ON HUMAN

Remarkable results have led to studies addressing the effect of traffic noise on the cardiovascular system, obesity, learning ability or the relationship of subjective noise assessment. Some of these are listed in the following table.

Table 2 Studies dealing with the harmful effects of noise on human

Author of study	Type of study	Country	Age range	No. of participants
Argalášová, Ľ. et al., 2017 [7]	Case study	Slovakia (Bratislava)	19-25	484 (2015-2016)
Study results: The study looked at the relationship between traffic noise and obesity markers in university students (average age 22.9 ± 2). 188 (38.8%) of students were resident in the road showroom (exposed area: LAeq, 24h = 67 ± 2dB) and 296 (61.2%) inhabited a non-noise board (control area: LAeq, 24h = 58.7 ± 6 dB). Students in the exposed area were more distraught: Odds Ratio (OR) = 4.1 (95% Confidence Interval (CI): 3.2-5.2), neighbors and entertainment facilities. The noise disturbed their sleep and caused wake-up: OR = 2.3 (95% CI: 1.48-3.58). The study showed a higher level of obesity markers in the exposed sample than in the treated. The percentage of body fat determined by Near Infrared Radiation (NIR) tends to be related to exposure to traffic noise in multiple linear and logistic regressions: beta = 1,320, p = 0,02, r2 = 0,14, Adjusted Odds Ratio (AOR) = 1, 76 (95% CI: 1.77-2.66) taking into account gender and other behavioral, psychosocial and nutritional factors affecting cardiovascular risks.				
Kahkashan, ***A. et al.,*** 2015 [7]	Case study	India (Bangalore)	6-15	160
Study results: The research sample was divided into 2 groups. The first group (80 children) learned 80.4 dB in the noisy environment and the second control group (80 children) learned at a noise level of 56.28 dB. Attention and memory were evaluated using performance tests. It has been shown that exposure to high levels of noise during learning has significantly reduced attention, working memory with auditory component and logical memory. For visual memory, this reduction did not occur. Overall results indicate that a high level of noise is a disadvantage of children's educational abilities and therefore the learning environment must not be neglected.				
Thiesse, ***L. et al.,*** 2017 [7]	Laboratory research	Switzerland (Basle)	19-33	23 (6 days)
Study results: The short-term effect of transport noise at a constant level of Leq 45 dB (A) during sleep on glucose metabolism was observed. On the first night, the sample was spent without noise (N1), 4 nights with noise (N2-N5) during which scenarios were changed: scenario1 - distant motorway, dense traffic and scenario2 - short distance, residential street or railroad. The study ended with a noisy night (N6). Metabolism of carbohydrates was evaluated by oral glucose tolerance test performed in the morning after N1, N5 and N6 nights. The glucose level increased overnight N2-N5 compared to night N1 (+12 ± 3%, p = 0.004 for scenario1N5 and +16 ± 3%, p = 0.0003 for scenario2_N5). After one regenerative night, the glucose level returned to the base line level for scenario1_N5, while for scenario2_N5 (A1-C6: p = 0.0004) it remained higher. The percentage increase in disease incidence was 31 ± 12% for the SC2_N5 group (p <0.036) and for scenario1 only 7 ± 8% compared to N1.				
Paunović, K. et al., 2018 [8]	Laboratory research	Serbia (Belgrade)	19-32	112 (30 min.)

Study results:
The experiment consisted of three 10 min. Phase: resting in silent conditions (Leq = 40 dBA), exposure to road traffic noise (Leq = 89 dBA) and noise rest (Leq = 40 dBA). The participants' blood pressure decreased during the quiet phase before the noise, increased in the first minute of exposure to noise, and then gradually decreased towards the end of exposure to noise. After exposure to noise, it continued to decrease to baseline. The heart index showed a gradual decrease during the experiment, while the total vascular pressure steadily increased during and after exposure to the noise.

5. FACTORS FOLLOWING THE LEVEL OF TRANSPORT NOISE

There are several factors involved in the creation and level of road traffic noise, which are a necessary part of a car or a result of natural physical patterns of the external environment. The spread of noise depends on the layout of the surrounding terrain as well as on climatic conditions. The resulting noise is further influenced by a range of vehicle technical parameters, road conditions and driving patterns. Although the noise levels have fallen sharply in recent years (mainly for passenger cars), road transport has continued to play a significant role in the complex increase of the noisy background of towns and villages. [9]

The sources of road noise are mainly: [10]

- **engine** - this type of noise is most favorable at speeds of 50 km/h, acceleration or deceleration,
- **tire rolling down the road - The noise generated thus dominates at speeds of 50 km/h (passenger cars)**
- **air flow around the vehicle - occurs at speeds of 200 km/h,**
- **to a lesser extent, the air movement of the vehicle's ventilation system.**

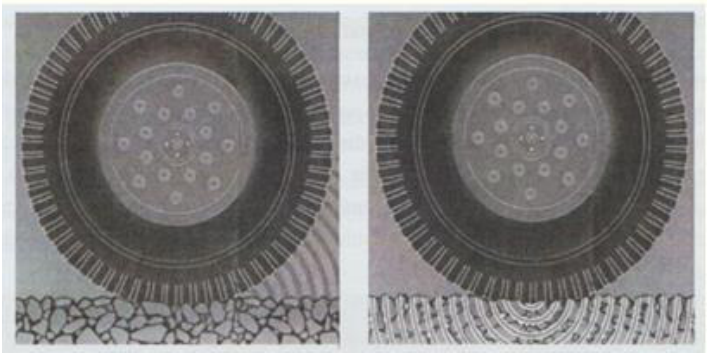

Figure 3 SMA LA blend - rolling noise and air-pumping effect. Right: mix PA - absorption of rolling noise and air-pumping effect [12]

Car noise recorded at a distance of 7.5 m from the source is: [10]

- passenger car - 79 dB (A),
- bus - 84 dB (A),
- truck - 91 dB (A),
- double driving speed increases noise by 8-10 dB (A).

The range of noise generated on the road is determined by its structure and pattern of tires, i. spacing on their surface. Research conducted not only in Europe but also in the US has confirmed that it is possible to create so- low-noise road surfaces that partially absorb the noise emission of vehicles: [10]

- drainage asphalt carpet (PA) - noise reduction of 5 to 8 dB,
- Mastic asphalt carpet (SMA LA) - noise reduction of 4 to 6 dB,
- thin asphalt carpet (VIAPHONE®) - noise reduction of 2 to 5 dB (thickness 1.5-2.5 cm),

- bituminous mixtures modified with rubber granulates - reducing the noise level by 4 to 6 dB.

For the purpose of designing ways to reduce noise on individual types of road surfaces, acoustic measurements should be made to provide reliable results. There are several methods for these measurements, but at the same time none is too universal to be used in different situations. That is why it is very important to choose it right. The individual guides and procedures for measuring all existing methods are detailed in the relevant standards and technical regulations. In Europe, we most encounter using the SPB, CPB and CPX methods. [11]

Conclusion

In the urban environment, exposure to harmful effects affects not only healthy adults within a certain time limit, as is the case with professional exposure (8-hour working time), but practically has no time limit on all parts of the population, including children, the sick and the elderly.

The most general response of the population to "perishable" noise levels is "annoyance". It is a psychic state that arises from an involuntary perception of influence, or when subjected to circumstances to which an individual has a negative attitude, because it breaks his privacy, interferes with the activity performed, or influences the quality of the rest.

The impact of noise on the human organism can be divided into 2 groups: [9]

1. Specific effects (> 90dB (A)), which manifests as a professional acute or chronic hearing impairment after repeated and long-term excessive noise.

2. Non-specific effects of noise (60-90 dB (A)) that affect the functions of various body systems as a result of the stress response. They often prevent specific damage to the hearing organ. (balance disorder, respiratory and digestive tract disorder, circulatory system, menstrual cycle disorders, high blood pressure, obesity, neurovegetative system, headache, malaise, sleep disturbances, behavioral changes, etc.).

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