ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
MATHEMATICS, PHYSICS, THEORETICAL MECHANICS
FASCICLE II, YEAR XVII (XLVIII) 2025, No. 2
DOI: https://doi.org/10.35219/ann-ugal-math-phys-mec.2025.2.02

Urban noise pollution in a medium-sized city from Romania

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Abstract
This research examines urban noise pollution in Galati, Romania, focusing on sound intensity measurements across six strategic locations. The study investigates noise levels during weekends at different moments (morning and afternoon), to assess varying patterns of anthropogenic activities. Measurements revealed that the Harbor area maintained the lowest noise pollution levels, while the Ring Road consistently showed extremely high sound levels, often exceeding acceptable limits. The research identified road traffic as the primary contributor to noise pollution, with construction activities significantly impacting local areas, where heavy machinery was used. Quantitative analysis demonstrated that most studied locations exceeded the 55 dB threshold considered acceptable for residential areas, with particularly concerning levels during peak traffic hours. The study encompassed 15 days of measurements, strategically selecting Friday, Saturday, and Sunday to capture the gradual decrease in anthropogenic activities throughout the weekend. Results indicate a clear correlation between traffic patterns, urban planning, and noise pollution levels, with the highest readings recorded during Friday evening rush hours. The findings suggest an urgent need for traffic management solutions and stricter enforcement of construction noise regulations to mitigate the growing urban noise pollution problem, which affects approximately over a hundred million people worldwide.

Keywords: noise pollution, urban environment, road traffic, construction impact.

1. INTRODUCTION

Noise has become a major pollutant, along with the development of transportation means and corresponding traffic, both also because of industrial activities and construction sites, and even the use of air conditioning systems, lawn mowers, fireworks, outdoor concerts and street vendors [1-5].

The effect of noise on human and animal health has been already recognized, including by the World Health Organization (WHO). For people, the negative effects of noise exposure vary largely from annoyance to headaches, sleep disorders, temporary hearing disorders and even chronic illnesses [6-8].

As a consequence, laws limiting noise emissions were adopted in most civilized countries, as exposed in Table 1, which reunites a study concerning various countries and the Romanian Noise protection regulations [9-11].

Table 1. Average noise level limits ([10, 11]

Country	Industrial areas	Commercial areas	Residential areas	Quiet areas (parks etc.)
Australia (dB)	55	50	40	40
India (dB)	72.5	60	50	45
Japan (dB)	55	55	45	40
Romania (dB)	65	65	55	50
EPA, USA (dB)	65	55	50	40
WHO (dB)	65	55	50	40

A study published by EEA - European Environment Agency shows that in Europe, over 110 million people are exposed yearly to noise levels above 55 dB from road traffic, while 22 million Europeans are yearly exposed to noise from railway traffic, and 4 million from aircrafts. Thus, more than 20% of Europeans are exposed to high levels of noise because of road traffic (EEA, 2020). When considering urban areas, the noise impact from road traffic is highest, being bigger than even on highways, given the street density and multiple sound reflections on buildings [12].

Another study realized by the Department of City Planning from the city of Los Angeles and published in 2024, shows that various roads in one of the most famous cities in the world can present very high noise levels, such as 71.7 dB for Hollywood Boulevard, 71 dB for Sunset Boulevard, both values representing averages for daytime [13].

Another major impact within urban areas are the construction sites, both for repairing roads and buildings, and for raising new buildings and extending the road network, in order to cover the housing and transportation needs of increasing urban populations. But construction sites are the source of high sound levels, often above 80 dB, which is far above the supported and regulated noise levels within inhabited areas or those near schools or hospitals, where the activities require silence for many hours or even 24/24.

The impact of noise of human comfort and even on human health is proved even by the complaints made by many people because of it, but especially by the studies dating, in some countries, from a long enough time ago. Thus, in France, various equipment used in construction sites were inventoried as noise levels, such as in [14, 15], and in an extended study made by the Department of City planning of the city of Los Angeles [13]. Fig. 1 presents a graph of the noise levels corresponding to he most frequently used devices for construction works. Still, one must also consider the vibration induced by these devices, whose intensity and effects depend on the nature, density and porosity of the surface underneath and the buildings nearby.

As another example of regulations concerning construction sites, in the Czech Republic, the accepted limit for noise level depends on the time interval along 24 hours, varying from 45 dB between 10 PM and 6 AM up till 65 dB between 7-9 AM [16]. The main noise sources from building sites are divided into 5 classes: pile drivers, construction machines, earth-moving machines, pneumatically-driven devices, and also combustion engines [16]. Thus, when construction sites are involved, one also must consider the intensified road traffic given by the big and heavy trucks used for transporting many of the necessary machines, but also for building materials, soil removal etc., which amplifies the noise and general pollution all around.

Since the population worldwide is increasing fast and cities develop to host it, along with their roads and number of vehicles, with residential, commercial and industrial buildings to fulfill the needs of more and more people, ~~which~~ who are more and more interested in a high living standard and in using ultimate technology, the noise pollution problem is expanding also. Various studies have been published concerning noise pollution, dealing with both the causes, the status and methods for mitigating this problem, studies based on measurements and/or on population surveys.

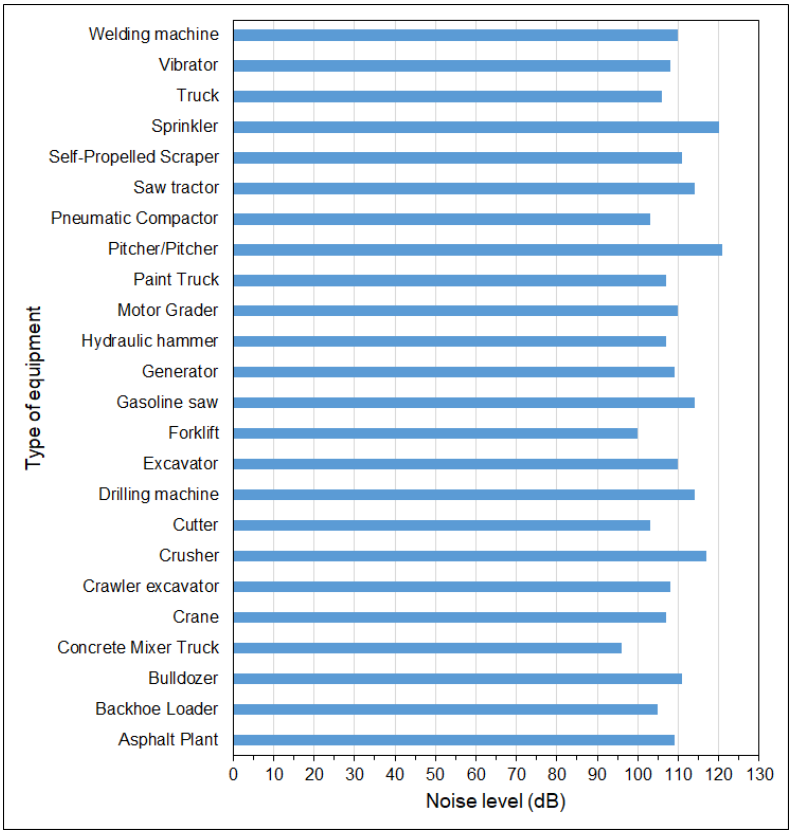

Fig.1. Average noise levels for various equipment (data from [13, 14])

Thus, in [17], a survey concerning the influence of noise caused by construction sites in the city of Jinan on the residents shows that this type of human activity affect people not only when they sleep or work, but even when wanting to talk to others or to listen to music, ~~such~~ so that several methods for reducing construction noise are proposed, from using low-noise mechanical equipment to installing silencers, implementing a stronger noise pollution regulation application and ~~to~~ solving promptly the complaints about noise pollution.

Another study [18] deals with noise monitoring in several cities in India, close to the border, including area mapping for noise levels and proposing solutions for decreasing noise pollution.

Urban morphology is also very relevant for noise pollution, ~~besides~~ in addition to the sources and the receivers (i.e. the population), since it strongly influences noise transmission, reflection, absorption and dissipation, depending on the density of buildings, open and green spaces, height of obstacles and nature of building materials and roads. Such a study is performed in [19], where building morphology is proved to strongly influence noise pollution in a city from Algeria, and the relevance of the study is proved by the fact that it is studied even within the architecture departments, like in case of the paper mentioned in this paragraph.

An even more complex study correlating noise pollution with urban morphology is that of Chen et al., 2024 [20], concerning New York city, where buildings height, shape and spacing are considered, street density and buildings along with them, green spaces presence within a certain area, tree size etc. and temporal distribution of noise pollution level land complaints about it. The study reveals that abundant vegetation, a low-density road network and open areas effectively decrease noise pollution.

This paper presents a study of noise pollution in some key locations in the city of Galati, Romania, chosen in order to assess the main causes of urban sound disturbance.

2. EXPERIMENTAL

The city of Galati is located in south-east of Romania, and it stands among the top 10 cities in the country both in terms of surface and population. The city has an alternation of narrow, older areas and larger, more recent areas, with less and less vegetation along the last 10 years, because of increasing number of buildings and the expansion of the road network. It has 2 universities, many schools, a commercial harbor and an ore harbor, a big steel plant, and some factories, along with ship transportation, railways and a rather poorly organized road network, giving rise to traffic congestion at peak hours, which leads to an increase of air and sound pollution.

Sound level measurements were performed at 6 key locations of the city, considered the most affected by human activities, as presented in Table 2.

Table 2. The locations used for the measurements in the city of Galati, Romania

Crt. No.	Location
1.	Ring Road
2.	`General` Area
3.	'Last Lion` Area
4.	`Dandelion` Crossroad
5.	Arts High School
6.	Harbor Area

The weekend days were chosen for measurements, comprising busy Fridays as workdays, which were compared to Saturdays and Sundays, non-working days, but sometimes as busy as the rest of the weekdays. Late morning, at 10:30 AM and afternoon, at 5 PM were the moments of choice for the study. The study comprises 15 days of measurements. March, 12-14; 19-21, 26-28 and April, 2-4; 9-11, 2021, ~~in~~ a total of 15 days of measurements.

The biggest machinery found on the spot ~~from~~ in the `General` Area, where heavy and long term construction works were in development before and after the months when measurements were performed are presented in Fig. 2, and only the first two of them had the noise level visibly written on the outside of the devices.

Fig. 2. Tools and equipment used on the construction site in the 'General' Area

3. RESULTS AND DISCUSSION

Figure 3 presents the average noise levels for each of the 6 locations for the entire set of 15 days of measurements, both during mornings and afternoons. It can be seen that the 'Ring Road' presented the highest noise levels, averaging above 60 dB, because of the high road traffic, but also given the rather narrow access area from the perpendicular road crossing it, where the measurements were performed. On the contrary, the `Harbor` Area was the quietest, since that is a residential part of the city, with a smaller density of inhabitants than other areas.

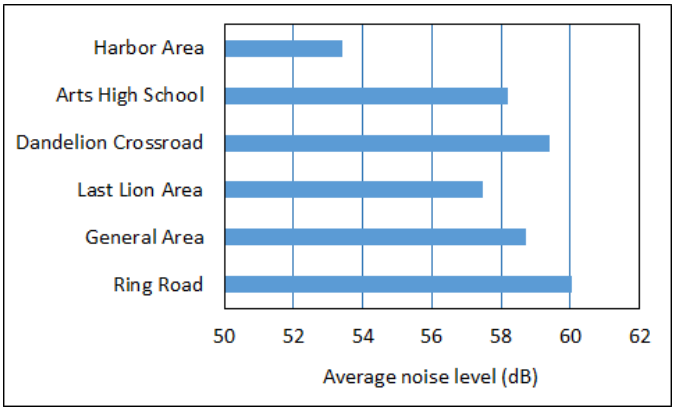

Fig. 3. Average noise levels for each of the 6 locations

Figs. 4 and 5 present, separately, the noise level in each of the 6 locations along all 15 days of measurements at 10:30 AM and at 5 PM, respectively. The late morning is, typically, a quiet hour, since the normal work and school schedule begin much earlier, before 9 AM. In contrast, 5:00 PM is typically, a rush hour, since most working population in Galati finishes work between 3:30 PM and 5:00 PM, and then shopping is done before returning at home. As it can be seen from Fig. 4 and 5, it was confirmed that the 5:00 PM measurements generally showed higher noise levels compared to 10:30 AM readings across all locations, indicating the impact of increased evening traffic and human activity.

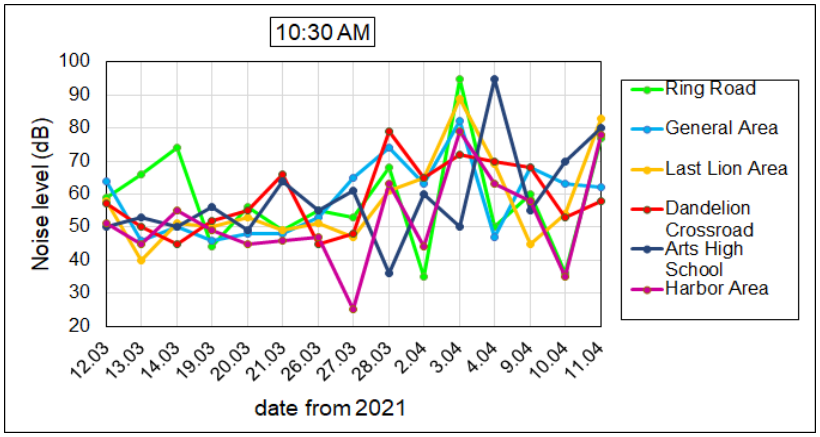

Fig. 4. Late morning noise level during each of the 15 days of measurements in the 6 locations

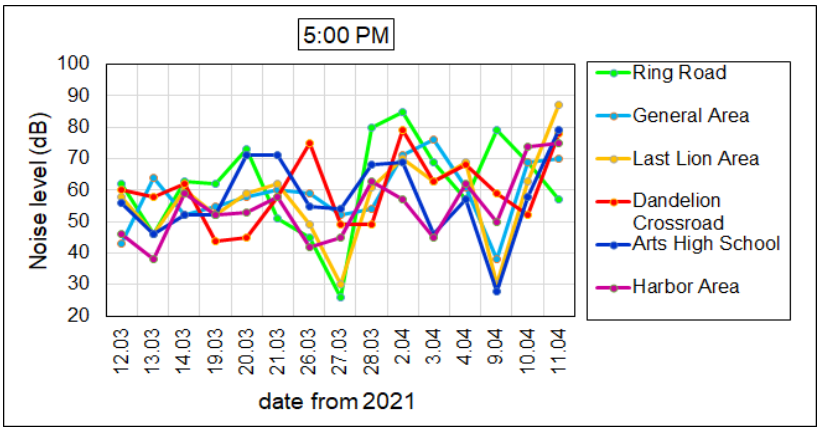

Fig. 5. Afternoon noise levels during each of the 15 days of measurements in the 6 locations

From Figs. 4 and 5, it can be seen that the 'Ring Road' prevails at the noise level, but the other crossroads follow it closely. The `Last Lion` Area has a lower noise level given its openness which leads to noise scattering.

The `Harbor` Area is less noisy all along the day, not only since there is less traffic there, but the proximity to water attenuates noises.

The `Arts High School` location shows moderate to high noise levels, accentuated by the buildings surrounding the area from nearby and also given the two bus stations on both sides of the roads, heavily frequented by students, not only from the high school but also from the faculties situated very close. Morning hours were much noisier than the afternoons in this area.

The `General` Area exhibited rather high noise levels, both in the morning and in the afternoon. The morning causes were given by the construction works, generally stopping Fridays before 4:30 PM, while the afternoon high-enough noise level is provoked by the high density of inhabited buildings and small stores where people shop frequently, especially ~~from~~ by those people living nearby.

The graphs from Fig. 6 present, for the entire period of 15 days of measurements, the average noise levels for each day of the weekend, for morning and for afternoon, separately.

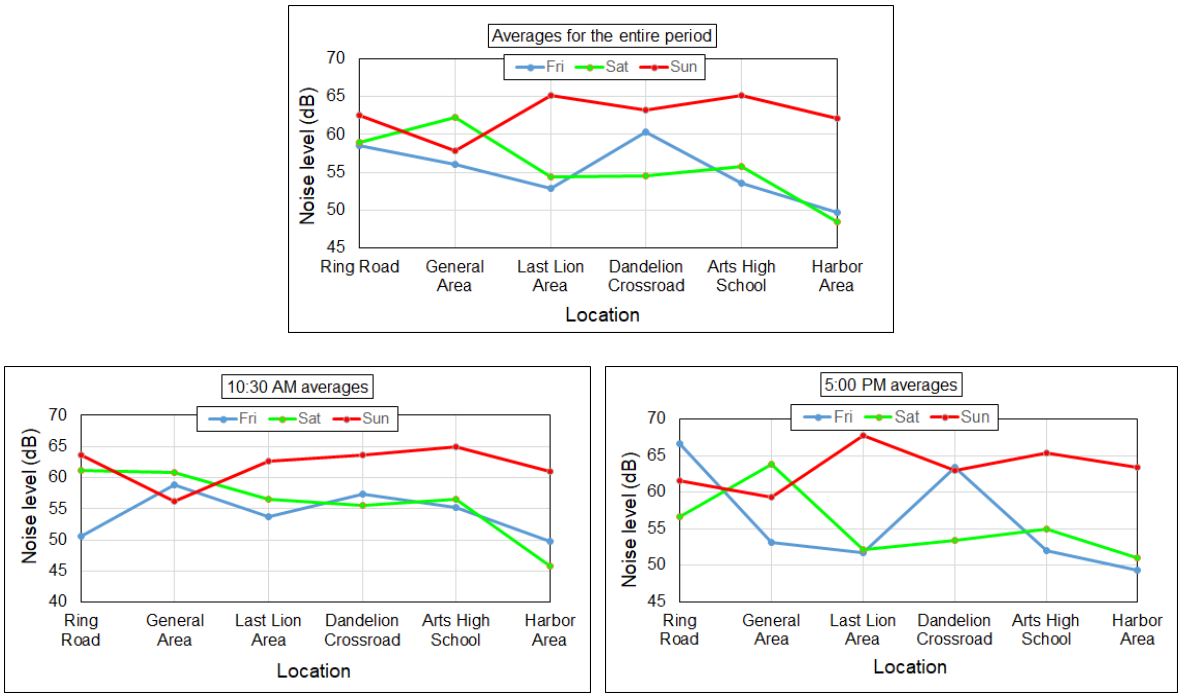

Fig. 6. Average noise levels for each day of the weekend, for morning and for afternoon

As concerning the averages for the entire period, presented as the top graph in Fig. 6, it can be noticed that Sunday's noise level is higher than ~~those for~~ Friday's and Saturday's, most likely because of shopping patterns in Galati and Romania, in general. Four of the six areas exhibited lower noise levels ~~during~~ on Fridays as compared to Saturdays and Sundays.

Passing to the late morning averages, as presented in the left graph from the second row in Fig. 6, also Fridays were, in general, less noisy, since most working people are at work and children at school. Sundays are still, at 10:30 AM, on top of noise level, except for the `General` Area. The `Arts High School` exhibits the highest morning noise level, given the bus traffic schedule which fits the students' schedule ~~both~~ attending the highschool and ~~those~~ ~~from~~ the faculties nearby.

The afternoon averages showed in the graph from the right, on the second row in Fig. 6, keep the prevalence of the high noise level for Sundays, but fluctuating noise levels for Fridays and Saturdays.

For each of the six locations and each day of measurements, we computed the noise level differences between afternoons and mornings, and the results are presented in Table 3, while the last two rows of this table present the numbers of noisier mornings and noisier afternoons, respectively.

Table 3. Noise level differences between afternoons and mornings for each of the 6 locations, while the last two lines depict nos. of noisier mornings and afternoons, respectively*

Date	Day	Ring Road	General Area	Last Lion Area	Dandelion Crossroad	Arts High School	Harbor Area
12.03	Fri.	3	-21	0	3	6	-5
13.03	Sat.	-20	18	6	8	-7	-7
14.03	Sun.	-11	2	9	17	2	4
19.03	Fri.	18	9	2	-8	-4	3
20.03	Sat.	17	10	6	-10	22	8
21.03	Sun.	2	12	13	-8	7	12
26.03	Fri.	-10	6	-2	30	0	-5
27.03	Sat.	-27	-13	-17	1	-7	20
28.03	Sun.	12	-20	0	-30	32	0
2.04	Fri.	50	8	5	14	9	13
3.04	Sat.	-26	-6	-26	-9	-4	-34
4.04	Sun.	7	14	0	-2	-38	-1
9.04	Fri.	19	-30	-15	-9	-27	-8
10.04	Sat.	33	6	9	-1	-12	39
11.04	Sun.	-20	8	4	20	-1	-3
averages		60.03	58.70	57.47	59.40	58.20	53.40
noisier mornings		6	5	4	8	7	7
noisier afternoons		9	10	11	7	8	8

*Negative numbers correspond to noisier mornings, while the positive numbers are associated to afternoons no noisier than mornings.

From Table 3 one can see that, except for the `Dandelion` Crossroad, the other five locations exhibited more noisier afternoons than mornings, especially for the `General` Area and the `Last Lion` Area. The `Dandelion` Crossroad, even though it is a major ~~intersection~~ crossroads as the `Last Lion` exhibited variable noise patterns, with no real difference between morning and afternoon. This was also the case for the `Arts High School` Area and the `Harbor` Area. The `Ring Road` presented more noisier afternoons than late mornings, likely because of the increased commuter traffic during evening rush hours.

The most extreme noise variation was recorded on 2.04 at the `Ring Road` (50 dB) and on 4.04 (-38 dB) for the `Arts High School`, indicating significant daily fluctuations.

4. CONCLUSIONS

The study revealed significant urban noise pollution in Galati, Romania, with measurements taken at six strategic locations showing varying levels of noise intensity throughout different times of day and weekend days.

Road traffic proved to be highly correlated with noise levels, particularly during peak hours, indicating the need for improved traffic management strategies to reduce noise pollution.

Construction activities are relevant, but the assessment of their contribution is hard to be done because of inconsistent use of different devices, the nature of the underlying and surrounding surfaces strongly influencing noise and vibration propagation.

A continuous noise monitoring and more obvious reduction solutions should be taken especially in sensible areas such as schools, residential buildings, hospitals etc., from the placement of noise-reducing panels to diverting traffic for certain periods during specific days or by setting-up more one-way roads.

Acknowledgements: The B. Sc. graduate student Romina I. Danaila is acknowledged for collaboration in performing the measurements.

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