Environmental Noise Assessment in the Light of the Executive Decrees N°93-184 and N°03-410 – The Case of Annaba City

تقييم الضوضاء في ضوء المرسومين التنفيذيين رقم 184 -93 و410 -03 – حالة مدينة عنابة

Boulemaredj Ali
Department of architecture, Faculty of Earth Science
University of Badji Mokhtar, Annaba, Algeria

ali.boulemaredj@univ-annaba.dz

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Abstract:

Controlling noise in Algeria has seen various legal milestones, most notably the two executive decrees N°93-184 of 1993 and N°03-410 of 2003 relating to noise emission maximum limits, which assisted in the establishment of the regulatory framework to safeguard public tranquility. In this study, a quantitative assessment of the sound environment was carried out through a measurement campaign in five locations in Annaba's city center, in order to investigate the feasibility of applying the national noise regulation texts and their compatibility with the lived reality. The main findings revealed that noise levels ranged from 55 dB to 96 dB, primarily emitted by means of transportation as a result of drivers' social behavior, exceeding nearly 90% of the levels specified in the above-mentioned executive decrees.

Keywords: Noise; Noise Regulation; Executive decree n°93-184; Executive decree n°03-410; Annaba;

ملخص:

شهدت مكافحة الضوضاء في الجزائر مراحل قانونية مختلفة، أبرزها المرسومان التنفيذيان رقم 93-184 لسنة 1993 و رقم 03-410 لسنة 2003 المتعلقين بالحدود القصوى لانبعاث الضوضاء، اللذين ساعدا في وضع الإطار التنظيمي للحفاظ على السكينة العامة. في هذه الدراسة، تم إجراء تقييم كمي للبيئة الصوتية من خلال حملة قياس في خمسة مواقع بوسط مدينة عنابة، وذلك من أجل دراسة جدوى تطبيق النصوص الوطنية لتنظيم الضوضاء ومدى توافقها مع الواقع المعاش. وأظهرت النتائج الرئيسية أن مستويات الضوضاء تراوحت بين 55 ديسيبل إلى 96 ديسيبل، المنبعثة بشكل أساسي من وسائل النقل نتيجة السلوك الاجتماعي للسائقين، متجاوزة بذلك ما يقارب 90٪ من المستويات المحددة في المراسيم التنفيذية المذكورة أعلاه.

الكلمات المفتاحية: الضوضاء؛ قوانين الضوضاء؛ المرسوم التنفيذي رقم 93-184؛ المرسوم التنفيذي رقم 03-410؛ عنابة.

Auteur correspondent : Ali Boulemaredj

Introduction :

Noise has recently emerged as a new form of environmental pollution, mostly in industrial zones and densely populated residential urban areas. The enactment of numerous laws and regulations intended to reduce noise is becoming increasingly crucial. However, environmental noise is perpetually worsening due to the invasive sounds of technology, urban sprawl, overabundance of transportation, horns and loudspeakers, industrial machinery, and street vendors.

The environments in our cities are affected by unwanted sounds, i.e. noise, to an extent that is largely undesired, impacting the health and wellbeing of people. The United Nations (UN) and the World Health Organization (WHO) widely recognized noise as a significant environmental issue that poses a considerable threat to public health across various age demographics and societal strata, thereby contributing to the overall burden on sanitary system. They also have estimated the burden of disease from trasport-related noise within the western part of Europe, and concluded that we lose each year at least one million Disability-Adjusted Life Years (DALYs) and that only air pollution has a larger disease burden among environmental factors[1].

Environmental noise is therefore deemed to be considered among the primary causes for deterioration of life quality, forcing governments to adopt the required measures to regulate noise and maintain public tranquillity, within a consistent, up-to-date legislative framework, with the purpose of attenuating its harmful effects on the human health as addressed by WHO guidelines[2]. Researchers and environmental officials have spent the last two decades emphasizing on the monitoring and regulation of traffic and industrial noise since they are the most prevalent noisy sources that affect a large number of individuals worldwide[3].

As for the case of Algeria, in the first instance there is no published document or strong statistics related to the topic of noise health impact[4]. Hence, like any other country in the way of development, it suffers from the problem of environmental noise in large cities, due to high population density, rapid urbanization and the important volume of traffic flow and vehicles number, where it was found that one fifth (1/5) of the Algerian population suffer from auditive deficiency, mainly because of road traffic noise[5].

Limited studies and attempts were conducted to assess noise, particularly from transportation means, in several cities across the country, following the noise regulation in force, such as in Constantine[6,7], in Algiers[8,9], in Oran[10], in Biskra[11,12], in Souk Ahras[13], in Skikda[14] and in Guelma[15,16,17]. As well as other few studies that adressed the topic of noise from a legal point of view[18,19,20,21,22].

In this study, given the information concerning Algeria's noise abatement mechanisms are to be presented hereafter, the research problematic revolves around the following question:

To what extent noise levels from road traffic in Annaba's city-center are complied to the thresholds admitted in the national noise regulation, accentuated in the executive decrees n°93-184 of july 1993 and n°03-410 of november 2003?

The answer to this question is founded on a pragmatic method that consists of a field quantitative survey, which is based on noise measurements within the chosen areas, coded as indicated in the executive decrees.

The primary objective of this study is to gather more information about Annaba's noise status and add it to the list of other cities across the country that have been studied in this manner. It also aims to encourage the implementation of the Algerian noise regulation and assess how well the current soundscape complies with existing regulations for the purpose to propose action plans that will lower noise levels in urban areas and protect city dwellers' health within the framework of sustainable development.

In order to address this problem based on the state of the art found on this topic, this study adopted a methodology that consists of a descriptive analytical approach to present, firstly, the concept of noise and the regulatory context of fighting against it internationnally, and nationally

mainly in the light of the two abovementionned decrees, related to road noise emission thresholds. Secondly, to also indicate the negative effects of noise on human health and why it is necessary to reduce its levels. Thirdly, to compare the current state of noise levels at the city-center of Annaba, throughout a field survey to the national regulation texts on noise abattement.

Section I: Noise and Regulatory context of noise abatment

The Latin term "nausea," referring to sickness, is where the word "noise" originates. The level of sound that above the tolerable threshold and causes displeasure is referred to as noise. Any sound, regardless of volume, has the potential to negatively impact a group's physiology or mental state[23]. The maximum decibel that can be measured on the scale is 200 dB, which is equivalent to a rocket blasting launch. Although 0 dB is the definition of complete quiet, it is very hard to achieve in real life. As there is no air for sound to travel through, you would really need to be in space or a vacuum chamber to experience a sound level of 0 dB.

Long-term exposure to sound levels in excess of 85 dB, the level of a bruised canine, can be harmful to people. Some devices, such as aircraft, fireworks and cannons, have a sound power range of between 130 and 200 dB. Above 120 dB, the noise becomes distinctly unpleasant, and at 140 dB, a human being can lose his or her hearing irrevocably[24].

A) Worldwide noise abattement regulation

From the 1970s through the 1990s[25], many laws in Europe, for example, collaborated to attempt to decrease traffic noise, mostly by setting maximum sound levels L_{max} for certain vehicle classes, (eg: L_{max} 82 dB for vehicles intended to carry passengers with less than nine seats) as set in the first European council directive 70/157/EEC, which was applied for any type of motor vehicle intended to be used on the road, based on their categories regarding number of seats and power to mass ratio. After that, it was evident by the middle of the 1990s that noise control measures needed to focus on both the receiving side and the sound source, and the need to lower maximum noise levels emitted from vehicles, which was exactly applied in the European council directive 92/97/EEC amending the first directive and relative to the approximation of the laws of the Member States relating to the permissible sound level and the exhaust system of motor vehicles (eg: L_{max} 74 dB for vehicles intended to carry passengers with less than nine seats. Also, lowered to Lmax of 68 dB in phase 3 as introduced in the regulation 540-2014).

With technological advance in the use of computer simulation software and prediction models, the Environmental Noise Directive (END) 2002/49/EC[26] came along, which mandates that all European member States develop every five years strategic noise maps for all major agglomerations and major transportation infrastructures, as well as action plans, representing the culmination of a new approach to the development of a noise policy with the goal that no person should be exposed to noise levels above 55 dB that endanger health and quality of life[27,28], and a tool designed for the global assessment of noise exposure in a given area due to different noise sources or for overall predictions for a given area. It is for this reason, it was considered as a requirement of the Directive that these action plans are reviewed periodically once adopted and on an ongoing basis to account for major new developments in designated areas.

In addition, the implementation of Commission Directive (EU) 2020/367 gives a chance for relevant authorities to improve the management of environmental noise and marks a significant advancement in the effort to measure the extent of population exposure to environmental noise in Europe, in order to mitigate road traffic noise induced Ischemic Heart Disease (IHD), high annoyance (HA) and high sleep disturbance (HSD)[29].

Also according to Popescu[30], Romania transposed into its national legislation in 2005 the content of The Environmental Noise Directive, by the Government Decision HG 321 (2005) on the assessment and management of environmental noise. The document defined environmental noise as: “unwanted or harmful sound from the environment, created by human activities, which includes noise emitted by means of transport, road, rail, air traffic and from locations where industrial

activities are carried out" (HG 321, 2005). It introduced the noise indicators L_{den} (dayevening-night noise level) and L_{night} (night-time noise level), which could be evaluated by interim calculation methods or measurement during the noise mapping process.

Action plans had to be established in place for regions where high noise levels were present in order to avoid, minimize, and lessen the negative consequences that the public was exposed to, including discomfort. The government made the following decisions to complete and alter HG 321 (2005): HG 674 (2007), HG 1260 (2012), and HG 944 (2016). A number of Ministerial Orders have also been added to the law to provide clarification on how it is to be implemented. In 2007, Romania was required to submit noise exposure data for urban agglomerations with over 25,000 residents and main routes with over 6 million annual vehicle registries for the first noise mapping operation.

Several activities can be made to improve hearing comfort in order to battle this type of pollution, which is why many countries across the world have established required legislation and policies to address this issue. In Turkey, for example, the Environmental Noise Assessment and Management Regulation was first issued in 2005. It was issued with the number 27601 in the Turkish Official Gazette on June 4, 2010. It includes noise limitations (an average of 67 dB throughout 24 hours) and noise control zones, as well as the implementation of the Environmental Noise Directive into Turkish law[31].

Noise Pollution Rules in India were enacted in 2000 to address and prevent it in industrial, commercial, and residential areas, as well as to protect calm spaces like as hospitals, educational institutions, and libraries from noise pollution. Ambient noise levels in residential areas should be 55 dB during the day and 45 dB at night[32,33].

Also, the Environmental Protection Agency (EPA) of the United States has proposed a 24-hour exposure threshold of 55 dBA to protect the health and well-being of the general public in residential settings. Furthermore, the EPA in the United States also advocates for a secondary exposure threshold of 70 dBA, which represents an equivalent 24-hour continuous average sound pressure level [Leq(24)] designed to prevent hearing impairment. When compared to the L_{dn} threshold of 55 dBA, the 70 dBA threshold considers both daytime and nighttime exposures to have a similar detrimental effect on hearing[34].

As stated in the United Nations report[35], based on the critical analysis and evaluation of the Regional Office for Europe of the World Health Organization (WHO) reviews and guidelines, it puts specific recommendations pertaining to certain exposure thresholds aimed at mitigating adverse health effects. These thresholds are presented in a comprehensive manner, taking into consideration various time intervals such as during the day, evening, and night (L_{den}), and a night-time noise level (L_n), to underscore the importance of addressing noise pollution during nocturnal hours to preserve sleep quality. Mainly, the recommanded limits from road traffic noise are L_{den} of 53 dB and L_n of 45 dB. In addition, WHO recommands an equivalent continuous sound pressure level (LAeq) of 55 dB in the vicinity of residential areas and 70 dB in traffic and commercial areas.

Even when it comes to noise thresholds perceived inside buildings, many countries in south America[36] for example set regulations to help with sound comfort for building users, such as in Argentina, the apparent sound reduction index R'w, the weighted standardized sound insulation L'nw for impact noise, and the standardized sound insulation $D_{2m,nT,w}$ are the acoustic parameters used to assess building acoustics in the IRAM 4044 standard, which was approved in November 2015 and applied to residential buildings. Limits vary according to class, building type, and space type. distinct scenarios have distinct requirements, such as hospital rooms and hallways, schools and corridors, classrooms and noisy environments. For example, the minimum airborne sound insulation necessary between neighbouring houses in Class I is R'w 50 dB, while the minimum airborne sound insulation required between two hotel rooms is R'w 47 dB.

Regulations aiming at protecting individuals from noise have been in place in Colombia since 1983, thanks to the Ministry of Health. They do not govern sound insulation, but rather the maximum sound pressure level within a building. The maximum daily noise level for residential

areas has been reduced from 65 dBA to 55 dBA during the day and 45 dBA at night. There are no national building acoustics standards in Uruguay, although there are municipal noise emission limitations. Walls and floors must provide at least 45 dB of "sound insulation" in the municipality of Montevideo.

As for the case of noise control policies in the arab league, it was found in a recent study[4] that only three out of twenty-two of arab countries (Saudi Arabia, Oman and Qatar) have noise measurement guidelines, yet a weak and insufficient legislation which is hard to implement due to the absence of political will regarding the unstable political and economical situation in most countries, as well as the lack of public awareness on the negative effects of noise exposure on the human health.

Nonetheless, other arab countries initiated national action plans in order to attenuate noise for the benefit of the public, like Egypt who established a five-year program (from 2002 to 2007) that aims at mitigating environmental noise levels in egyptian cities under law 04/1994 and in accordance to international instructions. Likewise in Tunisia, a group of technicians were dispatched on patrols to monitor and assess noise levels using measuring devices and tools, throughout sensitive areas of the municipality.

In the same context, the rest of the arab countries, Algeria included, have only used laws, royal decrees, municipal or ministerial decisions in fighting against noise in a general way and preserving the environment, throughout fixing acceptable noise limits related to specific areas; for example, within residential areas a range of 40 dB, 65 dB to 70 dB at daytime in Iraq, Oman and Algeria, respectively. Also, in sensitive areas, noise limits varied in Kurdistan region and in Algeria from 35 dB to 45 dB at daytime. In opposition, most of the arab countries have not yet adopted the concept of noise mapping on a large urban scale, which can widely help in controlling noise emissions, except for non-detailled noise maps, produced in few cities, like Guelma (Algeria)[17], Sfax (Tunisia)[37], Doha (Qatar)[38], Jeddah and Riyadh (Saudi Arabia)[39,40].

B) Algerian noise regulation

Algerian acoustic and noise regulation has seen noise as a problem that has to be managed and controlled primarily to protect public health and peace of mind in both indoor and outdoor environments, ever since the country gained its independence. The decision on excessive noise abatement, made on February 25, 1964, came next. It stated in articles 1 and 2 that any type of noise nuisance that could jeopardize public peace and the welfare of the populace was prohibited, especially noise that came from vehicles that had exhaust systems and silencers modified. There were no guidelines or restrictions in place despite the fact that this decision made a clear statement about the nation's aim to reduce noise because of a number of issues, including a lack of information and experience, lack of measurement equipment and universal documentation on noise laws and regulations.

Likewise, another legal solution was later added by the decision of 4 April 1972 relative to the measurement of noise produced only by motor vehicles and the conditions imposed on silencing systems, throughout fixing thresholds for maximum noise levels L_{max} for a running engine, according to vehicle categorization (eg: L_{max} = 83 dB for specific vehicles), similarly to the content indicated at this decision, however, it was insufficient in terms of emphasizing various sorts of noise sources, noise indicators, and measurement time and duration.

Moreover, it was sought to take steps offered to limit the sources of noise and disturbance to inhabitants, as well as to impose a penalty for disrupting public quiet under Algerian legislation, in order to improve environmental preservation, public security, and tranquility. Algerian legislators began to broaden their understanding of noise abatement and control mechanisms, developing a regulatory arsenal to combat outdoor noise nuisance, nocturnal noise, and to establish technical specifications that maintain acoustic comfort inside residential buildings and even workplaces.

This valid arsenal is consisted of eight (08) laws, seven (07) executive decrees and seven (07) decisions[41].

Addionally, in a step to apply the protection of the environment law n°83-03 enacted in February 1983, in the purpose of having an optimized and adequate sound environment for the citizens, the publication of the first executive decree has seen the day, numbered as n°93-184 in July 1993[42], regulating noise emissions as defined in article 2 and 3, by introducing a different noise indicator (Leq_{max}) in function of time and type of area. It has fixed 70 dB as a maximum equivalent continuous sound level during day time from 6am to 22pm and 45 dB during night time from 22pm to 6am, in the vicinity of residential areas, in public squares and roads, near hospital facilities, educational institutions and recreational spaces and gardens, respectively.

Later on, and by the applicability of article 45 text from the law n° 01-14 of August 2001, on the organization, security and the police of road traffic, the Algerian legislator revealed another executive decrees n°03-410 in November 2003[43], which was supported by executive decree n°04-381 of November 2004[44] , laying down road traffic regulations. The executive decree n°03-410 of 2003 fixed limit values (L_{max}) for emissions of smoke, toxic gases and noise from motor vehicles, when stationary or in motion, on the basis of vehicles categories subjected to conformity and periodic check, yet relating to weight and speed (eg: L_{max} ranged between 74 dB and 80 dB, in the case of particular vehicles) as defined in article 5.

Despite the fact that some studies[45,46] have considered that the executive decree n°93-184 of July 1993 was repealed by the circumstance that it was not mentioned in the law n°03-10 of July 2003 relative to the protection of the environment in the framework of sustainable development, as far as the authors are aware, the legal status of this executive decree is still in force, and represent along with the executive decree n°03-410 the most notable legal stations in the Algerian noise regulation.

Thus, it was intended to chose another city to be added to the list of surveyed cities around the country, in order to add more data on the daily perceived soundscape, that is required to be assessed and compared with the national noise regulation set to tackle this issue. For this reason, Annaba was selected to be a case study.

Section 1I: Data on why noise should be mitigated

Currently, our lives are very much affected by noise, which seems to be an inevitable effect of modern technology. Recent noise monitoring research and social surveys have shown the need to reduce noise to acceptable levels. As a result, it is now publicly recognized that noise, mainly from road traffic, constitutes a serious risk to human health and quality of life[47].

Since the 1970s, the US Environmental Protection Agency (EPA) has classified road traffic noise as one of the main pollutants of the urban landscape, leading to a range of significant morbidities, making this type of noise, according to medical and epidemiological research, a major source of dissatisfaction. Thus, existing proofs indicating that noise pollution have negative impacts on human health have justified research in order to provide better understanding of noise pollution problems and control strategies[48,49].

The Regional Office for Europe of the World Health Organization (WHO)[2] embarked on a comprehensive endeavor consisting of systematic reviews aimed at evaluating the intricate connections between noise pollution and diverse health outcomes. This meticulous process was carried out with the overarching goal of formulating evidence-based guidelines and offering insightful recommendations designed to safeguard the well-being of individuals from the detrimental effects of exposure to environmental noise stemming from a multitude of sources. The health outcomes under scrutiny encompass a wide array of dimensions including but not limited to the following: annoyance; the impact on cardiovascular and metabolic functions; cognitive decline; disruptions in sleep patterns; auditory issues such as hearing impairment and tinnitus; adverse consequences on birth outcomes; as well as considerations related to quality of life, mental health, and overall sense of well-being[35].

According to studies carried out in England[50,51], exposure to traffic noise increases the proportion of people admitted to psychiatric wards. Also, as exposure to traffic noise increases, so does the number of psychiatric wards. Similar findings have been reported in Denmark, particularly in the vicinity of Copenhagen airport, where hospitalizations and psychiatric consultations are significantly higher in noise-exposed areas than in control areas.

Similarly, road noise can increase high blood pressure in adults living in areas where the L_{day} is over 65 dB. Where it was also observed that noise levels develop feelings of annoyance, irritation and invasion of privacy by noise[52].

Through another action-research[53] on environmental noise, which is more than just a nuisance but a first-class health, environmental and social pollutant, several medical researchers have contributed to demonstrating the harmful effects of noise pollution on human health. In addition, another research has shown that when the source of noise is removed, the persistence of symptoms due to noise impacts has been documented; uncomfortable sensations may persist for some time[54].

In the same context, it was also found that lon-term exposure to transport noise is linked directly to human health outcomes[55], as it can provoke annoyance[56], cognitive disruption[57,58], sleep problems[59,60], Noise-Induced Hearing Loss (NIHL)[61,62,63,64], and less directly as it is attributed to stress[65,66,67] wich in its trun leads to mental health[68,69], cardiovascular health[70], metabolic health[71] and health-related quality of life[72].

In Algeria, according to national press, professor Jamal El-Din Neboush, a cardiologist at Nafissa Hammoud hospital in Hussein Dey, Algiers, warned of the phenomenon of noise, which has reached its peak in recent years, and is not only a health problem, but also a moral issue that threatens children before adults. He declared that 70 % of diseases of hypoperfusion in the human heart and blood pressure, are caused by lack of sleep and auditory tension, due to outdoor noise in popular neighborhoods and major Algerian cities. He also said that the Hussein Dey clinic receives patients who always complain of lack of sleep and noise anxiety. Furthermore, professor Jamal El-Din Neboush claimed that transportation noise increases the chances of developing diabetes, as it provokes the increase of the stress hormone that affects the metabolism process.

In the same context, professor Mohamed Tagiza, head of the Mental Diseases Department at Duraid Hussein clinic, revealed that noise in Algerian cities is a dangerous hidden pollutant, that has recently contributed remarkably to psychological, neurological and mental illnesses, as it led to 15 cases per month. A state of nervous breakdown caused by loud sounds, including fireworks, noise of drilling machines, and raising dams at night, and a state of insomnia and lack of sleep, adding that 10 % of the mental illnesses that are treated in that clinic are caused by a disorder of the spiral system of the ear.

This is confirmed by a study carried out in 2006 in a textile company in Oran by Dr Resk-Kallah and his colleagues at the Centre Hospitalier Universitaire (CHU). "*They found a high level of hearing impairment among workers who, before retirement, were likely to reach the fateful threshold of 35 dB hearing loss, at which point they are recognized as hard of hearing*"[73].

The human auditory system, which is in constant contact with these decibels, finds noise annoying, and endorsed in all scientific, medical and social research studied, epidemiological estimates of the effects of noise have shown that the supreme cause of serious illness is perceived loudness.

In another study conducted in the city of Guelma, in the Chamsp de Manoeuvre neighborhood[15], the social survey revealed that four out of five (4/5) individuals declared that they are suffering from stress and anger in their dwellings, mainly because of road noise and neighbor's noise, and they were eager to either move out or find a suitable solution for their situation.

It is the reason why several reglementations, laws and methods have to be implemented to enhance sound comfort in urban environments, in order to mitigate this type of pollution, which is why many nations across the world have enacted regulations to tackle this issue.

Section III: Field study

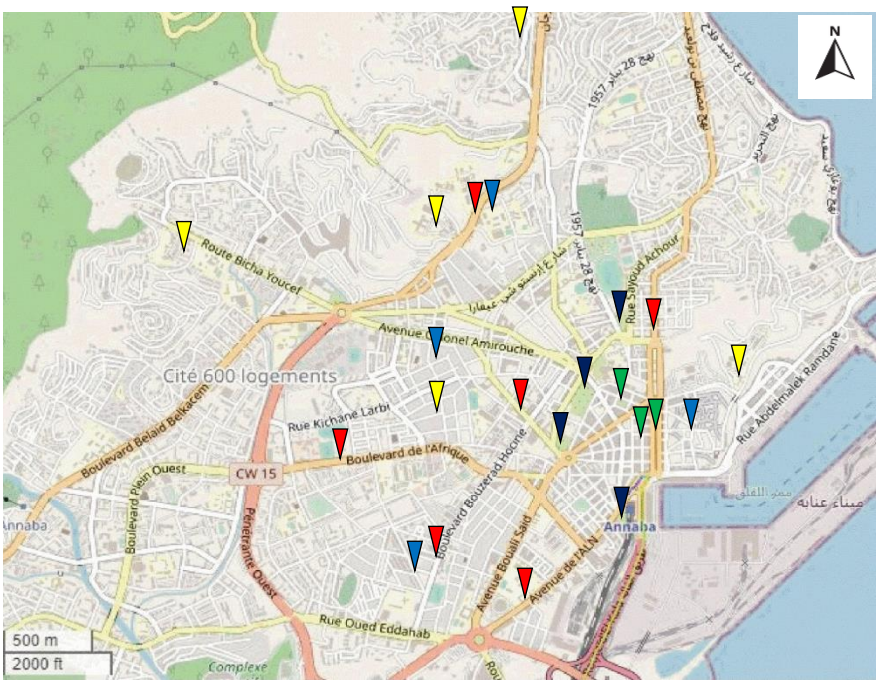
A) Studied area Presentation

Annaba is deemed to be one of the biggest and polar cities in Algeria, occupying a wide area of 1440 Km² on the north-east of the country. In the last decade, due to the rapid development in a matter of tourism, industry and commercial activities, Annaba experienced high population density and poor urban and architectural planning, the thing that led to be exposed to different forms of nuisance such as air and noise pollution. In this study, the focus will only be on Annaba's city-center, which is considered as a primary destination because of the existence of all public services (health care, education, recreational areas, commerce, housing, security, etc.).

Five representative areas from the city-center of Annaba (Figure N°1) were selected for quantitative investigation, based on the text of article 2 and 3 from the executive decree n°93-184 of July 1993:

- In the vicinity of residential areas: vieille ville, cité la Colone, cité Bouzerad, cité Police (area code A – blue colored triangle).
- On the main boulevards: bvd ALN, bvd Afrique, bvd Souidani, bvd Bouzerad Hocine, Bvd Seddik Benyahia, Bvd 1 November 1954 (area code B – red colored triangle).
- In public squares: Cour de la revolution, Alexis Lambert, Theater (area code C – green colored triangle).
- Near hospital facilities: Ibn Rochd, Ibn Sina, Pont Blanc, El Farabi clinic, Jasmin clinic (area code D – yellow colored triangle).
- In public gardens: El Edough, Liberté, Boukhtouta Hocine, la Gare (area code E – violet colored triangle).

Figure (N°1). Location of measuring stations in Annaba's city-center



Source: Google maps (modified by the author), 2023

B) Noise measurement design

For this study, it was required to follow a quantitative approach in order to assess noise levels in an urban environment, throughout a measurement campaign in the city-center of Annaba, for only twenty-two (22) working days in May 2023, to obtain an overall view on the noise situation. Because Annaba is a city that sleeps at night, and to have valuable noise data on the sound environment of the city-center, the measurements were conducted during daytime (8:00-10:00am),

(11:00-13:00pm), (14:00-16:00pm) and (17:00-19:00pm) according to an international standard[74], under good meteorological conditions.

Using a calibrated SoniCheck Pro sound level meter, with (A) weighted frequency, held comfortably in hand, with the microphone being pointed at the potential sound source, to record an interval of 15 minutes for a period of one hour, repeated one time.

In order to obtain noise data, two indicators were targeted in this measurement campaign; the equivalent continuous sound pressure level Leq_{max}, with maximum status, which represents the energy level produced by a given sound source over a period of time, and the maximum sound pressure level L_{max}. All of the information and noise data gathered were saved on a computer for further analysis and assessment.

Result analysis:

After taking the needed noise measurements within the studied areas in May 2023, in order to explore the sound environment of Annaba city-center where noise levels were observed during day time, within four-time intervals, the results obtained and developed in charts are shown as follows.

The average maximum equivalent continuous sound pressure level (Leq_{max}) measured in the vicinity of residential areas ranged from 63 dB to 86 dB, according to figure n°2 (area code A). Due to the low mobility and activity in these regions at that time of day, noise levels did not surpass the established threshold of 70 dB from 8:00 am to 10:00 am in la vieile ville and la cité bouzerred. Noise levels were recorded to be excessive and beyond the permitted threshold between 11:00 am to 13:00 pm and 17:00 pm to 19:00 pm, primarily from road traffic and commercial operations such as water and vegetable street vendors.

From 8:00 to 19:00, however, cité la colone and cité police suffered extremely high noise levels, reaching a maximum continuous equivalent average level of 86 dB. Given the availability of various services and amenities for the benefit of citizens in these two residential areas, the increase in noise levels was mostly due to the flow of traffic through these two housing estates.

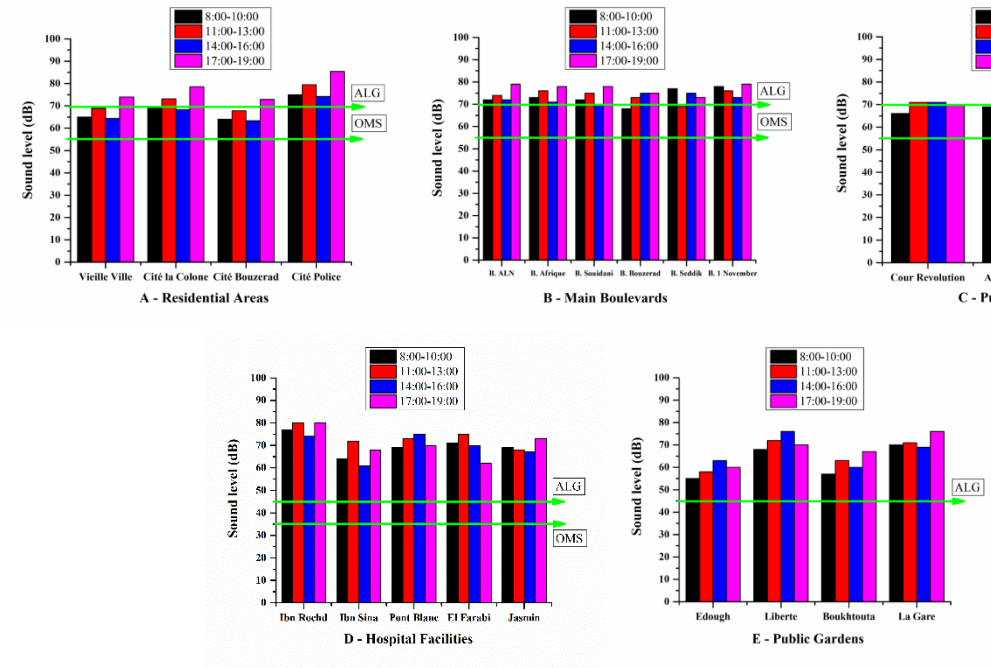
Also, from figure n°2 (area code B), it was observed that the average maximum equivalent continuous sound pressure level (Leq_{max}) measured on all six main boulevards of Annaba city-center, exceeded the national threshold fixed at 70 dB all day long, owing to the high importance of road traffic flow, which contains a significant percentage of heavy vehicles, and the altered behavior of most drivers (road rage), who tend to excessively accelerate, break a lane, and speed up. Similarly, vehicle motorization energy type, exhaust system effeciency connected to vehicle age and modifications were identified, with diesel-engined old vehicles producing more noise than other vehicles that run on gasoline energy. As well as the nature and condition of the road surface are also elements that are responsible for noise emission.

Furthermore, figure n°2 (area code C) shows that the average maximum equivalent continuous sound pressure level (Leq_{max}) measured on the Cour de la Révolution, the public square behind Azzedine Medjoubi's theater and Alexis Lamberd's square, can reach high levels of noise, ranging between 60 and 73 dB, from mid-day to afternoon. These noise levels are caused by the large number of vehicles passing through these areas, as well as the abnormal behavior of most drivers, who tend to excessively accelerate, break, and use car honking irrationally while parking their vehicles along the sidewalk, as well as people conversing and speaking loudly on the street.

Plus, figure n°2 (area code D), demonstrates high levels of the average maximum equivalent continuous sound pressure (Leq_{max}) measured in the vicinity of all hospital facilities, exceeding consequently the threshold of 45 dB as stipulated in the executive decree n°93-184, due to the high volume of traffic passing through these areas, particularly in the roundabout opposite Ibn Rochd hospital, as well as at both Jasmin and El Farabi clinics, where altered driving style of the majority of drivers, who constantly honk their horns inappropriately because of traffic jam and narrowness of the road.

Moreover, despite the fact that public gardens are built and designed to be a place that invites tranquillity and relaxation and to enjoy the sound of nature, however, all four public gardens located in the city-center of Annaba are exposed of an average maximum equivalent continuous sound pressure level (Leq_{max}) that surpassed 45 dB, which is a noise level set as a threshold in the national regulation, as it can be seen clearly in figure n°2 (area code E). The main sources of noise perceived in these spots were mainly from road traffic, sirens from police or emergency ambulance vehicles.

Figure (N°2). Averaged Leq_{max} at the five selected areas in Annaba city



Source: Boulemaredj, 2023

In terms of maximum sound level measurements (L_{max}), the stations chosen were primarily located on the city's main boulevards, as they are the main arteries in Annaba's road network, ensuring accessibility and links between the city's urban areas, and receive a high volume of traffic, which is diverse between cars, motorcycles, and trucks, as well as public transportation such as buses.

Table 1 demonstrates that the values collected from noise measurements on the six (06) boulevards are likely to surpass these thresholds and attain up to a L_{max} level of 96 dB, especially in the afternoon from 5:00 to 7:00 pm on the 1 November 1954 boulevard, leading to annoyance, discomfort, and stress for road users and pedestrians.

This is in relation to the content of Article 5 of Executive Decree n°03-410 of November 2003, which stipulates noise thresholds of 74 to 80 dB for running car and motorcycle engines.

These high levels usually resulted by traffic, with some vehicles' exhaust systems producing loud noises, or by some drivers' social behavior, especially at stop red lights or wedding occasions, where they tend to speed up, honk their horns, and play loud music on their radios.

Table N°1. Measured maximum sound level (L_{max}) in Annaba city main boulevards

	08 :00 – 10 :00	11 :00 – 13 :00	14 :00 – 16 :00	17 :00 – 19 :00
Bvd ALN	82	85	81	95
Bvd Afrique	83	86	82	91
Bvd Souidani. B	81	84	79	88
Bvd Bouzerad. H	76	84	87	86
Bvd Seddik. B	86	85	86	87
Bvd 1 November 1954	92	90	85	96

Source: Boulemaredj, 2023

In short, this study indicated clearly throughout the objective survey that the soundscape of Annaba's city-center seemed to be suffering from high noise levels, mainly due to road traffic. Similar results were reported by other studies, yet conducted in different regions around the world, such as in Corlu town in Turkey[75], where noise evaluation analysis revealed that road junctions had the highest noise pollution levels, followed by commercial centers, especially at evening period, exceeding therefore the limit value of 65 dB(A) according to Turkish Noise Control Regulation.

Equivalently, in another study[76] carried out in the city of Tirupur, India, the analysis of noise assessment showed that in accordance to the Environment Protection Act of 1986, the recommended noise regulations for commercial areas are 65 dB during the day and 55 dB at night, while those for residential structures' designated quiet zones are 50 dB during the day and 40 dB at night. Nearly every place studied had disturbing noise levels, between 6.30 a.m. and 9.30 a.m., where the mean noise levels in various locations ranged from 70 to 95 dB, surpassing as a consequence the Indian noise regulations.

In addition, noise surveys in residential areas in various districts of Thailand[77,78], shed lights on the fact that L_{eq} and Ldn noise levels exceeded the allowances made in Thai noise regulations and that residents' annoyance levels were high, indicating that they were not happy with the noise in their surroundings. Other noise surveys[23,79] were conducted in Africa to evaluate the vehicular noise in Onitsha and Benin in Nigeria. The acceptable level for noise (70 dB during the day) was found to be substantially exceeded with high levels at traffic intersections, then in business areas, passenger loading parks, high-density residential areas.

More recently, an extensive investigation of the soundscape in Al-Oqailat Park, Saudi Arabia[80], was given in a research that concentrated on the peak period between 1:30 and 5:20 pm. The soundscape was assessed using both objective metrics and ostensible judgments. According to it, noise pollution in metropolitan areas is substantially influenced by geography and transportation. Likewise, a study was carried out to assess noise levels from road traffic, based on the average equivalent continuous sound pressure levele (LA_{eq}), between residential and construction areas, in Seri Kembangan, Malaysia[81]. In compliance with Malaysian regulations, statistical analysis disclosed that both locations had excessive traffic noise levels that topped the maximum allowable limit of 60 dBA throughout the day.

At the end, the present study results revealed a negative compliance between the environmental noise levels percieved in the city of Annaba throughout measurement campaign, with the thresholds admitted in the executive decrees n°93-184 and n°03-410, which it is believed that this matter can be achieved positively if a restrictive strategy is applied.

Despite the fact that this study was inspired from numerous works around the world, it may be seen as a work complementary to the research in this domain, and as methodological guideline for national studies, encouraged to make similar assessment surveys in other cities across the country, this study faced few limitations such as the lack of state of the art and previous noise data, since that this study is primary in the city of Annaba. Human and material resources insufficiency may also represent a limitation for the implementation of this research.

Furthermore, since noise pollution is a very serious issue, that relates directly to the human health, the residents comfort and the urban soundscapes, this study identified a research gap (place gap) in order to add more insights on noise data and statistics. Consequently, the methodology and findings of this study have various implications for practice and future research, which can assist policy makers employ the necessary action plans against environmental noise.

Conclusion:

It is commonly acknowledged that noise, a byproduct of urbanization and industrialisation, is a significant environmental issue and major component in the decline of urban quality of life, especially if it is produced by non-domestic factors, such as transportation, public works, or urban living. In Algeria, noise pollution may not yet be seen as an important element in inhabitants' quality of life, which explains the lack of specific improvement initiatives. The present study

provided an evaluation of the noise levels in Annaba's city center based on the findings of a noise measurement survey, carried out in May 2023.

On the one hand, the findings of the analysis led to the following key conclusions:

- The soundscape of Annaba's city-center does not seem to comply with the content of the executive decrees n°93-184 of July 1993 and n°03-410 of November 2003.
- High noise levels were detected on the main boulevards of Annaba city, especially at roundabouts and road intersections, at the vicinity of hospital facilities, next to residential areas and at public gardens and squares, respectively.
- Road traffic noise has both an average equivalent continuous sound pressure level (Leq) that ranged between 63 dB and 85 dB on twenty-two (22) working days, and a maximum sound pressure level (L_{max}) that could reach up to 96 dB due to vehicle honking and acceleration.
- The Algerian social behavior while driving is a responsible factor for road noise, along with road surface and urban morphology.

On the other hand, to tackle the issue of environmental noise primarily in Annaba, the following points are recommanded:

- Encourage the enactment of the decisions n°2485 and n°2486 recently published in October 2023 by the state of Annaba authority (wilaya), that limited the circulation of noisy motor cycles and sport cars during the night, in order to improve the citizens' quality of life.
- Impose strict financial penalties on those causing noise on public road and disturbing public tranquility.
- Launch awareness-raising campaigns directed at citizens through the utilization of radio waves, or alternatively, by leveraging executive authorities to disseminate information regarding the hazards associated with exposure to noise, as well as highlighting the multitude of Algerian legal provisions that outline the acceptable thresholds for noise emissions.
- Renew road surface to enhance the contact between vehicle's tire and the asphalt, which can remarkably help in reducing noise.

Reference list :

[1] Forssén, J., Estévez Mauriz, L., Gustafson, A., & Kropp, W, How can we plan for a good urban sound environment, focusing on road traffic noise? IOP Conference Series: Earth and Environmental Science, 588, 052037, 2020.

[2] World Health Organization Regional Office, Environmental Noise Guidelines for the European Region, Denmark, 2018. https://www.euro.who.int/en/health-topics/environment-and-health/noise/publications/2018/environmental-noise-guidelines-for-the-european-region-2018

[3] Asensio, C., Gasco, L., De Arcas, G., López, J. M., & Alonso, J, Assessment of Residents' Exposure to Leisure Noise in Málaga (Spain). Environments, 5(12), 2018

[4] Bouzir, T. A. K., Berkouk, D., Schwela, D., & Lahlouh, M, A Review of Noise Pollution Policies in the Arab World, Acoustics Australia, 51, 2023.

[5] Rebah, M'hamed, Algérie: Gaspillage alimentaire et nuisances sonores : https://jne-asso.org/2022/04/29/algerie-gaspillage-alimentaire-et-nuisances-sonores/ (consulted on 05/09/2022)

[6] Benzagouta-debache, S., & Filali, S, La conception sonore des bâtiments d'habitation. problematique du confort sonore dans la maison traditionnelle -cas de Constantine, Sciences & technologie. B, Sciences de l'ingénieur, 20, 108–113, 2003.

[7] S. Chaour, K, L'optimisation Du Confort Sonore Dans L'architecture Traditionnelle-Cas D'étude: Vieille ville de Constantine. ,مجلة الثقافة الاسلامية، 12(1), 2016.

[8] Belayat, N. B, Entertainment noise control in Algeria, Ph.D. thesis, London Metropolitan University, 2009.

[9] Gramez Abdelghani, Introduction à la réglementation acoustique Algérienne et la réhabilitation acoustique des façades. 10ème Congrès Français d'Acoustique, Lyon, France, 2010.

[10] Hamou, A., Abderrahim, H., & Keciba, H, Etude des nuisances sonores dans la ville d'Oran. Communication science et technologie, 3(1), 2014.
[11] Bouzir, T. A. K, Morphologie urbaine et pollution sonore: Étude de cause à effet. Cas de la ville de Biskra, PhD thesis, University of Mohamed Khider Biskra, 2018.
[12] Bouzir, T. A. K., Berkouk, D., Boucherit, S., Khelil, S., Matallah, M. E., & Zemmouri, N, Evaluation of Soundscape Variations through the Open Public Spaces in Saharan Cities: A Case of Biskra, Algeria. Environmental Research, Engineering and Management, 78(4), 2022.
[13] دراسة تشخيصية للاضطرابات النفسية الاجتماعية الناتجة عن الضوضاء دراسة بمصنع ,.بن ناصر امال ,.كربوش رمضان الآجر بالزعرورية ولاية سوق أهراس. مجلة التكامل, 2(4), 164–188 ,.2018.
[14] Bourekba, O., Youcef, L., Amina, C., Secchi, S., & Amodeo, V, Assessment of acoustic comfort in Algerian hospitals with reference to national and international standards. The case study of the Urology Department in Abderrezak Bouharra Hospital, Skikda, Periodico Di Mineralogia, 92, 187–207, 2023.
[15] Boulemaredj, A., Haridi, F., & Bouttout, A, Assessment of Noise Pollution and Discomfort Levels of the Residents of the Champs De Manoeuvre Neighbourhood, Guelma, Algeria. International Journal of Innovative Studies in Sociology and Humanities, 7(6), 2022.
[16] Boulemaredj, A., & Haridi, F. Z, La pollution sonore en Algérie: Le décalage entre le cadre juridique et la réalité, Revue de Droit Public Algérien et Comparé, 8(2), 2022
[17] Boulemaredj, A., & Saifi, A, Road traffic noise mapping based on field measurements in location that do not have a standardized model in Algeria, Journal of architecture & environment, 22(2). 2023
[18] الحماية الجنائية من التلوث الضوضائي في التشريع الجزائري ,بوحزمة كوثر. مجلة القانون و العلوم الانسانية, 16(1), 2023.
[19] الضوضاء الصناعية و علاقتها بالتقدير الذاتي للفقدان السمعي المهني ,صليحة صليحة. مجلة دراسات في علم النفس و الصحة, 2(2), 2017.
[20] الضوضاء: المفهوم والمصادر ,بوبكر نسرين. المداد, 4(2), 2016
[21] الاليات القانونية الوطنية للحماية من التلوث الضوضائي ,لشهب صاش جازية، بوسبعة ريمة. مجلة الابحاث القانونية و السياسية, 2(1), 2020.
[22] التلوث الضوضائي في القانون الجزائري ,باقل علي. المجلة الجزائرية للحقوق و العلوم السياسية, 7(1), 2022.
[23] Madu, K., Uyaelumuo, A. E., & Orji, M. U, Evaluation of Vehicular Noise Pollution in Onitsha Metropolis, Nigeria. International Journal of Innovation and Sustainability, 2(15). 2018.
[24] Acoustix, Comparaison des niveaux de bruit en décibels : Acoustix Pan-Terre. https://www.acoustix.be/fr/isolation-acoustique/actualites/echelle-des-decibels-comparaison-des-niveaux-de-bruit-en-db (consulted on 24/06/2022).
[25] Ribeiro, J, Assessment of the CNOSSOS-EU model for road traffic noise prediction, 2016.
[26] Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise—Declaration by the Commission in the Conciliation Committee on the Directive relating to the assessment and management of environmental noise, OJ L (2002). http://data.europa.eu/eli/dir/2002/49/oj/eng
[27] Murphy, E., & King, E. A, Environmental Noise Pollution: Noise Mapping, Public Health, and Policy (Elsevier). Newnes, 2014
[28] King, E., & Murphy, E, Environmental noise – 'Forgotten' or 'Ignored' pollutant? Applied Acoustics, 112, 2016.
[29] Faulkner, J.-P., & Murphy, E, Estimating the harmful effects of environmental transport noise: An EU study. Science of The Total Environment, 811, 2022.
[30] Popescu, D, A study of the Romanian framework and the challenges in implementing the noise mapping legislation. Archives of Acoustics, 48(02), 2023.
[31] Benliay, A., Özyavuz, M., Çabuk, S., & Gunes, M, Use of noise mapping techniques in urban landscape design. Journal of Environmental Protection and Ecology, 20, 2019.
[32] Poddar, A, Noise pollution control and in re noise pollution case, International Journal of Advanced Research, 5, 2017.

[33] Goswami, S., & Swain, B, Environmental Noise in India: A Review. Current Pollution Reports, 3, 2017

[34] Monica S Hammer, Tracy K Swinburn, Richard L Neitzel, Environmental Noise Pollution in the United States: Developing an Effective Public Health Response, Environmental Health Perspectives Vol. 122/2, 2014.

[35] United Nations, Frontiers 2022 : Noise, blazes and mismatches, United Kingdom, 2022.

[36] Machimbarrena, M., Rasmussen, B., & Alves Monteiro, C. R, Regulatory sound insulation requirements in South America—Status for housing, schools, hospitals and office buildings. INTER-NOISE and NOISE-CON Congress and Conference Proceedings, 259(2), 2019.

[37] Mohamed Ali Abdmouleh, Salem Dahech, Cartographie de la pollution sonore dans l'agglomération de Sfax, XXIIIè^{me} Colloque de l'Association Internationale de Climatologie, France, 2020.

[38] Abdur-rouf, Khadija & Shaabane, Khalid, Measuring, Mapping, and Evaluating Daytime Traffic Noise Levels at Urban Road Intersections in Doha, Qatar, Future Transportation, 2(3), 2022.

[39] Zytoon Mohamed. A, Opportunities for Environmental Noise Mapping in Saudi Arabia: A Case of Traffic Noise Annoyance in an Urban Area in Jeddah City, International Journal of Environmental Research and Public Health,13(5), 2016.

[40] Alsaif, Khalid & Foda, Mossad, Development of Noise Maps of Great City of Riyadh by Using LimA, International Journal of Environmental Science and Development, 6(8), 2015.

[41] Boulemaredj, Ali, La rénovation acoustique des logements collectifs – Cas de la cité Champs de Manœuvre, Guelma, PhD thesis, University of 8 mai 1945 Guelma, 2023.

[42] JORA, Executive decree n°93-184 du 27-Juillet-1993 réglementant l'émission des bruits. https://www.joradp.dz/FTP/JO-FRANCAIS/1993/F1993050.pdf?znjo=50, 1993.

[43] JORA, Executive decree n°03-410 du 5 novembre 2003 fixant les seuils limites des émissions des fumées, des gaz toxiques et des bruits par les véhicules automobiles. https://fr.scribd.com/document/360323548/DE-03-410, 2003.

[44] JORA, Executive decree n°04-381 du 28 novembre 2004 fixant les règles de la circulation routière. https://www.interieur.gov.dz/index.php/fr/le-ministere/le-ministère/textes-legislatifs-et-reglementaires/58-la-circulation-des-biens/458-décret-exécutif-n°04-381-du-28-11-2004-fixant-les-règles-de-la-circulation-routière.html, 2004.

[45] مجاجي منصور., المعالجة التشريعية لمشكل التلوث السمعي في الجزائر. مجلة الاجتهاد للدراسات القانونية و الاقتصادية, 9(1), 2020.

[46] كوحيل حياة, الحماية القانونية للبيئة من التلوث الضجيجي. مجلة العلوم القانونية و السياسية, 12(2), 2021.

[47] Wang, L. K., Pereira, N. C., & Hung, Y.-T, Advanced Air and Noise Pollution Control: Volume 2 (Vol. 2). Springer Science & Business Media, 2007.

[48] Jamrah, A., Al-Omari, A., & Sharabi, R, Evaluation of Traffic Noise Pollution in Amman, Jordan. Environmental Monitoring and Assessment, 120(1), 2006.

[49] Georgiadou, E., Kourtidis, K., & Ziomas, I, Exploratory traffic noise measurements at five main streets of Thessaloniki, Greece. Global Nest I International Journal, 6, 2004.

[50] Tarnopolsky, A., Watkins, G., & Hand, D. J, Aircraft noise and mental health: I. Prevalence of individual symptoms. Psychological Medicine, 10(4), 1980.

[51] Jenkins, L., Tarnopolsky, A., & Hand, D, Psychiatric admissions and aircraft noise from London Airport: Four-year, three-hospitals' study. Psychological Medicine, 11(4), 1981.

[52] Bodin, T., Albin, M., Ardö, J., Stroh, E., Ostergren, P.-O., & Björk, J, Road Traffic Noise and Hypertension: Results from a Cross-Sectional Public Health Survey in Southern Sweden. Environmental Health : A Global Access Science Source, 8(1), 2009.

[53] Martin, R., & Gauthier, M, Meilleures pratiques d'aménagement pour prévenir les effets du bruit environnemental sur la santé et la qualité de vie: Guide. Institut national de santé publique du Québec.

[54] Jacques Chatillon. (2011). Perception des infrasons. Acoustique et Techniques, 67, 2018.

[55] Welch, D., Shepherd, D., Dirks, K., & Reddy, R, Health effects of transport noise. Transport Reviews, 1–21, 2023.
[56] Guski, R., Schreckenberg, D., & Schuemer, R, WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Annoyance. International Journal of Environmental Research and Public Health, 14(12), 2017.
[57] Thompson, R., Smith, R. B., Bou Karim, Y., Shen, C., Drummond, K., Teng, C., & Toledano, M. B, Noise pollution and human cognition: An updated systematic review and meta-analysis of recent evidence. Environment International, 158, 2022.
[58] Halin, N, Distracted While Reading? Changing to a Hard-to-Read Font Shields against the Effects of Environmental Noise and Speech on Text Memory. Frontiers in Psychology, 7, 2016.
[59] Weyde, K. V., Krog, N. H., Oftedal, B., Evandt, J., Magnus, P., Øverland, S., Clark, C., Stansfeld, S., & Aasvang, G. M, Nocturnal Road Traffic Noise Exposure and Children's Sleep Duration and Sleep Problems. International Journal of Environmental Research and Public Health, 14(5), 2017.
[60] Berglund, B., Lindvall, T., Schwela, D. H., & Team, W. H. O. O. and E. H, Guidelines for community noise. World Health Organization, 1999.
[61] Fink, D. J, What Is a Safe Noise Level for the Public? American Journal of Public Health, 107(1), 2017.
[62] Wang, T.-C., Chang, T.-Y., Tyler, R., Hwang, B.-F., Chen, Y.-H., Wu, C.-M., Liu, C.-S., Chen, K.-C., Lin, C.-D., & Tsai, M.-H, Association between exposure to road traffic noise and hearing impairment: A case-control study. Journal of Environmental Health Science and Engineering, 19, 2021.
[63] Bouccara, D., Ferrary, É., & Sterkers, O, Effets des nuisances sonores sur l'oreille interne, médecine/sciences, 22(11), 2006.
[64] Silva, V. A. R. da, Mitre, E. I., & Crespo, A. N, Is noise-induced hearing loss still a public health problem after decades of legislation? Brazilian Journal of Otorhinolaryngology, 86, 2020.
[65] Bluhm, G., Nordling, E., & Berglind, N, Road traffic noise and annoyance—An increasing environmental health problem. Noise & Health, 6(24), 2004.
[66] Bigert, C., Bluhm, G., & Theorell, T, Saliva cortisol – a new approach in noise research to study stress effects. International Journal of Hygiene and Environmental Health, 208(3), 2005.
[67] Wagner, J., Cik, M., Marth, E., Santner, B. I., Gallasch, E., Lackner, A., & Raggam, R. B, Feasibility of testing three salivary stress biomarkers in relation to naturalistic traffic noise exposure. International Journal of Hygiene and Environmental Health, 213(2), 2010.
[68] Stansfeld, S., Clark, C., Smuk, M., Gallacher, J., & Babisch, W, Road traffic noise, noise sensitivity, noise annoyance, psychological and physical health and mortality. Environmental Health, 20(1), 2021.
[69] Gilani, T., Mir, M. S., & Gilani, M, A study on the impact of road traffic noise exposure on work efficiency of housewives. Environmental Science and Pollution Research, 30, 2023.
[70] Bodin, T., Albin, M., Ardö, J., Stroh, E., Ostergren, P.-O., & Björk, J, Road Traffic Noise and Hypertension: Results from a Cross-Sectional Public Health Survey in Southern Sweden. Environmental Health : A Global Access Science Source, 8(1), 2009.
[71] Mette, S., Andersen, Z. J., Nordsborg, R. B., Becker, T., Tj, Onneland A., Overvad, K., & Raaschou, -Nielsen Ole, Long-Term Exposure to Road Traffic Noise and Incident Diabetes: A Cohort Study. Environmental Health Perspectives, 121(2), 2013.
[72] Welch, D., Shepherd, D., Dirks, K. N., McBride, D., & Marsh, S, Road traffic noise and health-related quality of life: A cross-sectional study. Noise and Health, 15(65), 2013.
[73] Boutaleb, D, Nuisances sonores dans les familles et écoles algériennes: Quelle culture du bruit ? CRASC, 2012.
[74] AFNOR, NF S31-010 Acoustique—Caractérisation et mesurage des bruits de l'environnement—Méthodes particulières de mesurage. Afnor editions. https://www.boutique.afnor.org/fr-fr/norme/nf-s31010/acoustique-caracterisation-et-mesurage-des-bruits-de-lenvironnement-methode/fa043150/296, 1996.

[75] Sisman, E. E., & Unver, E, Evaluation of traffic noise pollution in Corlu, Turkey. Sci. Res. Essays, 2011.
[76] Ravindran, G., Baskar, G., Keerthana, Singhvi, N., Chitravel, V., Saranya, S., & Kannan, T, Assessment and analysis of traffic noise in urban area—Tirupur City, Tamilnadu, India. Pollution Research, 33, 2014.
[77] Thareejit, M., Sihabut, T., & Patthanaissaranukool, W, The association between road traffic noise and annoyance levels in residential and sensitive areas of Ayutthaya, Thailand. Asia-Pacific Journal of Science and Technology, 25(3), 2020.
[78] Bunnakrid, K., Sihabut, T., & Patthanaissaranukool, W, The relationship between road traffic noise and annoyance levels in Phuket Province, Thailand. Asia-Pacific Journal of Science and Technology, 22(4), 2017.
[79] Collins, A. & Oviasogie, Noise Levels and Periods of Noise Experience within Residential Environment in Benin City, Nigeria. IOSR Journal of Environmental Science, Toxicology and Food Technology, 13(12), 2019.
[80] AlSaleem, S., Almhafdy, A., Berardi, U., Al-Shargabi, A., Ali, D. A., & Ali, M, Field Measurements and Human Perception to Remediate Noise Pollution in the Urban Public Parks in Saudi Arabia. Sustainability, 15, 2023.
[81] Faisal, F., Rahman, N., & Kamal, N, Assessment of road traffic noise in selected urban residential and construction areas. Jurnal Teknologi, 85, 2023.