The impact of sound pollution on urban land use in Tripoli: a case study of Al-Jaraba neighbourhood, Libya

Nadya M. Gabril, Waseim B.Aburwin
Al Shomokh Higher Institute of Science and Technology
nadyagabril01@gmail.com, *waseim@gmail.com

ABSTRACT

This paper study the environmental noise pollution in mix use and residential district in Tripoli Libya, focusing on its impact on residents. The research involves monitoring the noise level using (day-evening-night (DEN) noise indicator) measured in decibels (dBA) to assess overall annoyance. Fourteen sampling point were assigned along the four main street bordering the neighbourhood. In addition, the site divided into twelve zone, monitoring the noise level in the in-centre node. Measurements were conducted during week days and weekends for week in Summer in 2024. The study's findings indicate that noise levels in the investigated area consistently exceed both WHO guidelines and the standards set by neighbouring countries like Algeria and Egypt for various land-use zones. Specifically, significantly high noise levels were recorded at intersections along Jama Assagga Road, The old-wall Road, and Aljaraba streets, particularly during. Day and evening hours. Moreover, the results show that noise levels in the district exceeded the limits for residential area, mainly near schools and government buildings during the weekday. However, the results dropped to permissible level during night time and on weekends. The survey results showed that social survey analysis highlights an insufficient level of public awareness regarding noise pollution and its effects on the built environment. This lack of awareness suggests the need for increased educational efforts and broader attention to the issue. In addition, the study conclude that the government need to establish regulation and policy to protect public health and wellbeing of the public form noise pollution and set a recommended noise limit according to Land use.

Keywords: Sound pollution, Soundscape, Sound walk, Land use , Environment Law, Noise legislation.

1. INTRODUCTION

Noise pollution has become one of the major challenges facing humanity and its negative effect on human wellbeing and its epidemiology aspect is well established in studies (WHO (2018), (World Health Organization, 1999, European Parliament and Council, 2002), the International Organization for Standardization (ISO). (Anees, M., et al., 2013). (Vijayalakshmi,2023). The effect of noise pollution related studies was increasing in Europe and the developed countries, (Kang, et al., 2016; Kang &Aletta, 2018), that led to established regulation and policy to protect public health and wellbeing from noise pollution and set a recommended noise limit according to Land

use. Moreover, in Arab countries, only nine Arab countries from 22 countries have developed legislation specific for noise: Algeria, Egypt, Jordan, Iraq, Morocco, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. (Bouzir. T. et al, 2023). However, Somaliland and the city of Tunis have also set a specific noise legislation. Although Libya has promulgated a national environmental law (Libyan Environmental Law and Issues (Otman, W.A., Karlberg, E. (2007). there is no legislation specific for noise pollution. However, in Libya there is only few paper researching the effect of traffic noises on urban areas (T.Amer,2013(Omar, I., 2019), (Gabril, et al.,2023). (Ahmida et al.,2024). However, except of (Gabril, et al.,2023) study, most of these studies were oriented to word the effect of traffic noise pollutions or noise pollution in industrial buildings. It recommended further study in the area to establish the Libyan noise standards and policy on the maximum permissible limit for noise intensity L (dB) in different land use areas.

2. METHODOLOGY

According to the International Organization for Standardization, the "soundscape approach" provides a deeper understanding of how people perceive the acoustic environment and how to design buildings accordingly. Soundscape research has developed a framework integrating psychological, psycho- acoustical, physiological and social factors to investigate how people perceive and experience the acoustic environment within a given context. Therefore, the research focuses on human perception to acoustic environment using the soundscape survey method, based on the International Organization for Standardization (ISO). published Part 1 of a new International Standard, (ISO 12913-1:2014 Acoustics – Soundscape).

In order to evaluate the soundscape quality, methodologies for data collection, such as sound walks, interviews, listening tests, and focus groups, were developed. (Brown, Kang, & Gjestland, 2011; Brown, 2012, International Organization for Standardization2014).

This research utilized two primary methods for data collection to assess human perception of the acoustic environment: sound walks and interviews. The sound walk method, widely recognized by researchers as an effective approach, facilitated both qualitative and quantitative data gathering through a multimodal experience. Participants, consisting of a group of students, followed a predetermined route while adhering to a structured protocol designed to support sonic evaluation and collect context-specific information.

During the sound walks, noise levels were measured using a sound meter at various locations along the route to record equivalent noise levels. These measurements were taken at 14 different points while participants actively listened to the surrounding sounds. Additionally, a questionnaire based on the ISO 12913-2 Method A (Section C.3.1 from ISO/TS 12913-2:2018) was administered during the sound walk. The questionnaire used a five-point Likert scale to assess participants' levels of annoyance.

In the second phase, the study included interviews with local residents to further explore their perceptions of the acoustic environment and their annoyance levels. For quantitative analysis, noise levels were systematically monitored across 12 zones in the neighbourhood, using the day-evening-night noise indicator (measured in decibels, dB).

3. STUDY SITE

For the purpose of this study an area of 465 km^2 were selected to present as a sample of residential area in the city of Tripoli, the study site surrounded by four main streets, Al-Jaraba, Gamma Assagga Road, Al-Doll and The Old Wall Road,(Figure 1) The study area characterizes as mixed-used urban planning with houses, apartment buildings, schools and commercial buildings, (Figure2). Thus, the study focuses on the effect of noise pollution on the residential area located between two main streets Al-Jaraba Street and Al-Doll Road. The neighbourhood considered a resident for meddle to high income community. The main streets Al-Jaraba, Gamma Assagga Road and Al-Doll are one of the most crowded streets in Tripoli. The acoustic environment of the site was considered to be characterized by a relatively wide variety of sound source types, (human voices, traffic, natural sounds and industrial sound).

Figure (1) Site location

Figure (2) site land use

4. DATA COLLECTION

4.1. Sound-walk

Fourteen sample locations were strategically chosen along the neighbourhood's four main streets. These included five spots on Al-Doll Road, one on Jamma Assagga Road, six on Al-Jaraba Street and two on Old Wall Road. The locations were carefully planned and the organized at particular locations, near focal building such as schools, hospitals and shops, the fourteen locations were plotted in Figure 3,

The study employed a structured questionnaire to measure participants' perception of a predefined walking route's sound environment. The questionnaire consists of three sections. Each designed to elicit specific insights into auditory experiences. The first section focused on participants' awareness and evaluation of four primary sound sources within the acoustic environment. Nature, Traffic, people and industrial sounds.

Participants were asked to actively attend to these sound sources and quantify the extent to which they perceived each. Responses were captured using a five-point Likert scale, with descriptors ranging from 1 "not at all" to 5" dominates completely". The second

section investigated participants' qualitative assessment of the overall sound environment.

Figure (3) sound walk predefined route.

This section presented eight distinct scales, ranging from "pleasant" to monotonous", "prompting participants to indicate their level of agreement or disagreement with each descriptor. Finally, the questionnaire's third section required participants to evaluate the overall quality of the sound environment and rate their level of annoyance. This assessment was also conducted using a five-point scale, providing a comprehensive measure of subjective discomfort related to the auditory landscape.

4.1.1. Acoustical measurement and data collection.

Measuring of the level of noise during the walk by using sound meter to record the equivalent noise level at different selected locations. The devices have a measurement range of 30–130 dB (A) with an error of <1.5 dB (A). The sound measurements were recorded for the14 locations along the sound walk route. The recording duration 3 minutes for each location. The result was presented in the table (1) below.

Table 1 The mean level of noise during the walk by using sound meter (*-intersections)

Locations	day			night		
	min (dBA)	Avg (dBA)	max (dBA)	min (dBA)	Avg dBA)	max (dBA)
1*	68	71	77	50	57	65
2	60	65	70	45	52	60
3	60	66	73	43	45	59
4	65	65	70	45	51	56
5	60	70	75	45	54	61
6*	66	75	85	50	57	66
7	65	74	80	43	56	66
8	65	68	71	40	45	54
9*	68	73	80	50	55	66
10	60	70	75	45	50	54
11	60	69	75	40	45	55
12	65	70	77	45	51	60
13*	65	74	80	43	50	57
14	60	73	77	45	48	55

The results compared with several permissible noise limits law, (Bouzir. T. et al, 2023), (WHO (2018), and results are encapsulated in the following key findings:

- During day time the results showed that the mean sound levels at most locations along the path were higher than permissible limits, as the mean noise levels at day were ranged from 65 dB to 75dB. with minimum reading nearly 60 dBA to maximum reading 85 dBA, with nearly 85 % of the reading exceeded the permissible limits according to W.H.O for commercial area and 100% for residential area.
- At night time readings, the mean sound level dropped to nearly 40 dBA as minimum level to maximum level nearly 66 dBA. with only 25 % of the reading exceeded the permissible limits according to W.H.O for commercial area and nearly 78 % for residential area. Table(2)
- However, comparing the results with Egyptian and Algerian permissible noise limits law the data shows that reading during the day exceeded the permissible noise limit with 85%, 40%, respectively, for commercial area, and 100%, 40% for residential area. The mean sound level at night time is within the permissible noise limits law for Algeria, however its nearly 66% above the Egyptian limits for residential area.
- In general, the results show that the Algerian low is more appropriate for the Libyan situation as almost all readings are within the permissible limit for Algeria Low.

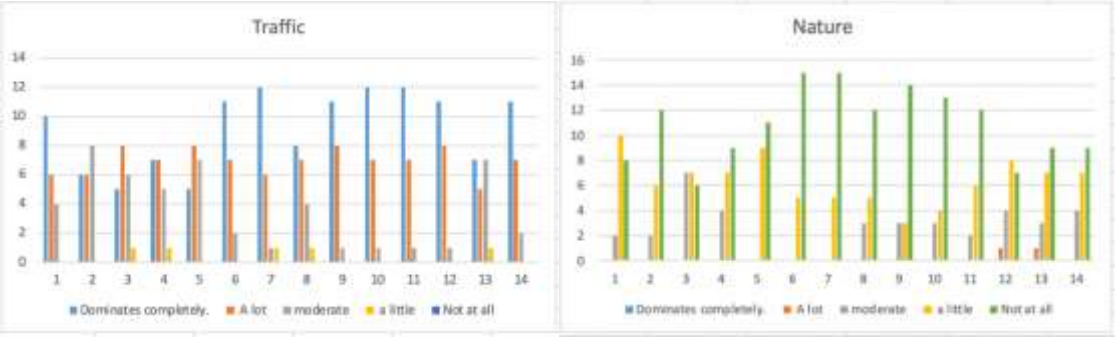
Notably, sound levels on Aldole Street surpassed those on Aljaraba Street although it is a main street. This phenomenon can be attributed to the acoustic reflection from surrounding structures, which amplifies sound in narrow streets.

Table (2) Comparison of L level (dB) of the present study with permissible noise limits law. All the reading were set to mean per period

Countries	Industrial		Commercial		Residential		Silent Zones	
	Day	Night	Day	Night	Day	Night	Day	Night
WHO/ EU	75	70	65	55	55	45	50	40
Egypt	70	65	65	60	55	50	45	40
Algeria	-	-	70	70	70	70	-	-
Saudi Arabia	70	70	65	60	55	55	-	-
US, EPA	70	60	60	50	55	45	45	35
Australia	55	55	55	45	45	35	45	35
India	75	70	65	55	55	45	50	40

4.1.2. Questionnaire data analysis

The purpose of the questionnaire is to realise the human perception of the acoustic environment. Therefore, questions were answered during the sound walk at the 14 preselected locations, 20 participants responded the questionnaire in each location, the data in total 280, Two sets of data were collected one during the day and the second during night. However, at night participant number dropped to only 12 person (10 male and 2 females). Participants were asked to quantify their level of annoyance towards four primary sources of sound: traffic flow, nature, people and industrial sounds. The results plotted on the charts (figure 4-a, b, c, d.) during the day and night time. In both situations, the noise from traffic flow remains the most common noise pollution in the area in all 14 locations.



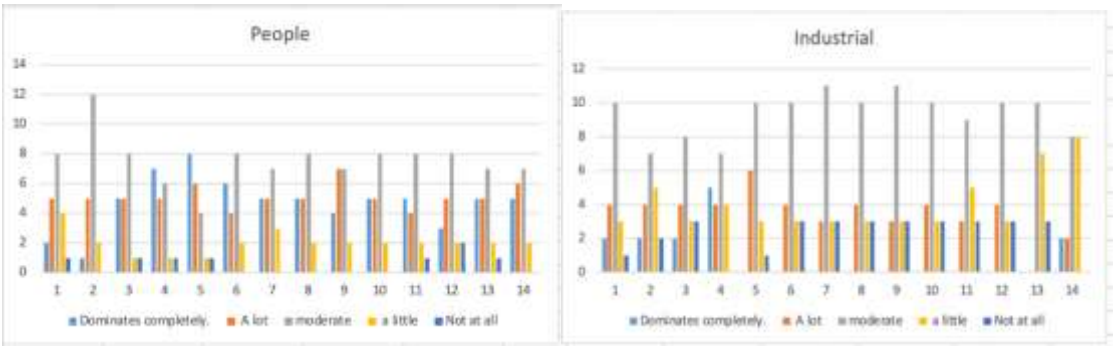


Figure (4) a,b,c,d, Participants' votes their level of annoyance towards four primary sources of sound: traffic , nature, people and industrial sound.

The study shows that during the day time the traffic noise considered to be the dominant sound as nearly 50% of the participants consider it "dominant completely" and 30% "A lot" mainly on the intersection at locations and 20% of the participants voted (moderate). However, at night time this rate drops to (moderate) to (not at all) on most location. Individual perception and prior experiences significantly influence the interpretation of natural soundscapes. In this study 40% of the participants reported an inability to perceive any natural sounds during the walk, apart from the sound of birds heard nearby locations (4,12,13). This could be attributed to the walk being conducted during the hot season, which would have minimized the impact of rain or wind sounds.

Diurnal variations in human sound are notable throughout the walk, particularly in proximity to educational institutions. Specifically, during the morning and afternoon periods, correlating with student arrival and dismissal times. Furthermore, human sound dominance is pronounced near mosques during designated prayer times, as noted on Al-Doll and Al-Jaraba streets. On Al-Jaraba street, a commercial thoroughfare operating from 11:00 PM to 11:00 AM, the prevalence of human sound is concentrated in the evening hours. Conversely, the level of human sound reduced around the intersections at locations.

The study investigated the impact of industrial sound on participants identifying air conditioners noise as the most dominant in this category. Its perceived dominance affected 25% of the participants, particularly around hospitals and commercial establishments. Conversely, water pump noise was found to significantly influence ambient sound level during night time hours.

In summary, the study effectively characterizes the vary perception of different sound sources across different times of day and locations, highlighting the impact of traffic noise, the limited perception of natural sounds, the context- dependent nature of human sound, and the specific influences of industrial noises such as air conditioners and water pumps.

The second section of the survey participants' perceptions of the quality of the sound environment are the subject of the second section of the questionnaire. They are asked

to plot their answers on a 5-point scale, which goes from strongly agree (1) to agree (2), neither agree nor disagree, (4) disagree, and strongly disagree. The results are plotted on two charts, the first chart plotted their responses for Al-Jraba street and Jamma-Assagga road and the sound chart is for their respond toward AL-Doll road and Old-wall road. (Figure 5) the two charts show the perceived affective quality data of the sound walk. The participants' responses vary according to the location and the activity that contains.

By comparing the participants responds it is clear that Al-Jaraba Street in notably perceived as more "eventful" than Al-Doll Road. A significant majority of participant (45%) "strongly agree" that Al-Jaraba Street's soundscape is eventful, with an addition 10% of the participant "Agree", this totals 55% expressing agreement. In contrast, Al-Doll Road is generally perceived as less eventful with only 20% of the participant expressing their agreement while 45% disagree.

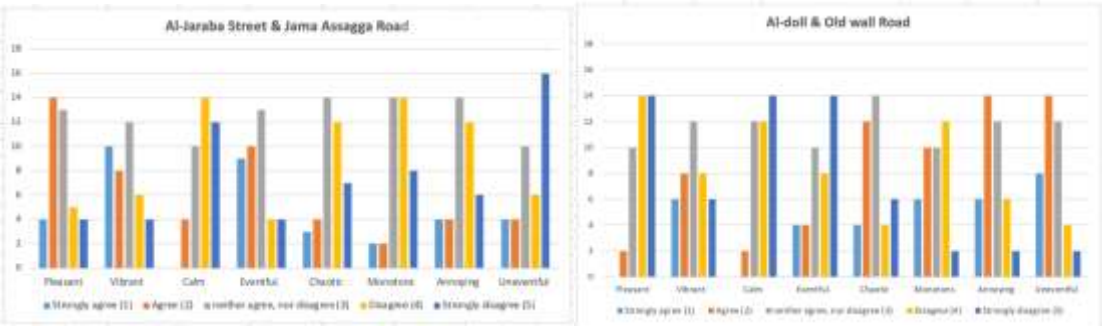


Figure (5) The Bar shows the participants' perceptions of the quality of the sound environment on (Charts show Al-Jaraba Street) and (AL-Doll Road and Old-wall Road).

However, Al-Jraba Street & Jama Assgga Road appears to be more positively perceived over all, particularly in its strong association with calmness and higher rating for "pleasant", "vibrant", and "eventful". However, it also registers a low level of "annoying" sounds.

On the other hand, Al-Doll & Old wall road are characterized by a more negative perception, with strong agreement on it being "chaotic", "monotonous", "annoying" and "uneventful" and notably lacking in "calmness" and "pleasantness".

The last part of the questionnaire focused on the participants' perception of the sound environment overall quality and its suitability for the specific location, these assessments were conducted at two part of the path Al-Jraba Street & Jama Assgga Road and Al-Doll & Old wall road.

The initial inquiry in this section prompted participants to describe the general quality of the ambient sound, selecting from Very good (1); Good (2); Neither good, nor bad (3); Bad (4); and very bad (5). Subsequently, participants were asked to rate the extent to which the observed sound environment was fitting for its context, using scale from Not at all (1); Slightly (2); Moderately (3); Very (4); Perfectly (5). The results were shown in bar charts figure (6)

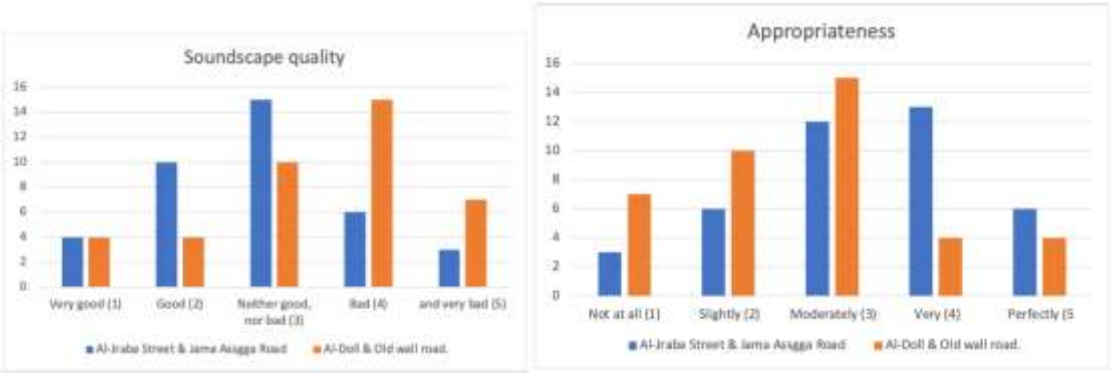


Figure (6) The overall quality of sound environment, and Appropriateness at the sound walk.

The results indicate that nearly 35% of the participants consider the sound environment on Al-Jaraba Street Suitable for its land use classification as commercial area rating it as "very" or "perfectly". Conversely, 55% of the Participants rated the sound environment on Al-Doll Road as "slightly" or "Not at all", attributing this to the street's activities being inappropriate for its residential Land use.

4.2. Interviews

The second part of the sound scape is interviews, 30 interviews were conducted with residents in twelve zone in the district shown in (figure 7), the participants were asked in their homes and shops to study their perception and responses toward the sound level in the area. At the same time, monitoring the sound levels in the area. during day, evening and night (Lden) for each zone. The map below summarized the average sound level in (dB-A).

According to Locher et al (2018), the estimated differences between indoor and outdoor sound levels are typically 10 dB for open windows, 15dB for titled or half open windows, and 25dB for closed windows. For more precise estimation of indoor sound levels, it is crucial to consider a broader range of predictors beyond simply window position. These predictors include, but not limited to, the acoustic insulation properties of the construction materials and the specific type on fenestration (e.g., windows and shutter designs) employed. Comprehensive scientific literature should be consulted for detailed methodologies and predictive model that integrate these variables for enhanced accuracy in indoor acoustic assessment.

Figure (7) The average sound *level during day, evening and night (Lden) in (dB) for the 12 zones*

In summary, the map shows that most border zones recorded slightly higher sound level than the inner zones, During, the daytime hours, recorded sound levels within the inner zones generally remain within the permissible noise limits for residential areas, as stipulated by Egyptian noise regulations. Zone 12 recorded high sound level with average 70dB (A), this can be attributed to the presence of multiple activities in the area, including schools, restaurants and a small shopping centre.

Participant were instructed to tune to their surrounding sound environment and respond to two set of questions. The initial inquiry focused on identifying the dominant sound source from four predefined categories: traffic, nature, people, and industrial sounds. Concurrently, participants assessed their level of hearing annoyance using a five-point Likert scale, rating from (1) "Not at all" to (5) "Completely annoyed". The subsequent set of questions addressed the perceived appropriateness of the current sound environment for the specific zones. residences indicated their preferences on a five-point scale, ranging from (1), Not at all appropriate" to (5) "Perfectly appropriate".

The interview results reveal that the majority of residents perceive traffic and industrial sound as the most dominant sound source. Notably,65% of the resident in Zones 1,2,3,4 and 5 consider their acoustic environment suitable for their mixed- use land classification (commercial/ residential). Conversely, residents in the inner zones exhibited greater acceptance of their acoustic environment, with approximately 70% rating the sound environment as "very" or "perfectly" appropriate. However, resident near zone 12 reported significant annoyance from commercial area noise, rating their acoustic environment as "Not al all" suitable. They attributed this dissatisfaction to the perceived incompatibility between the street's commercial activities and its residential land use.

This outcome diverges from the sound walk results, a discrepancy that may be attributed to the influence of indoor acoustic factors, such as the sound insulation properties of the construction materials and internal dwelling characteristics (e.g., number and age of occupants). These factors can significantly shape individual acoustic perceptions and thus influence interview responses. Consequently, further empirical

data collection is necessary to comprehensively monitor and evaluate the acoustic environment within the Libyan residential dwellings

5. CONCLUSION

This study shows the impact of environmental noise pollution on urban land use and the well -being of its residents. Through a combination of acoustical measurements and soundscape perception surveys, the research highlights that noise levels in the investigated mixed-use and residential areas consistently exceed both WHO guidelines and the permissible limits established by neighbouring countries like Algeria and Egypt.

Key findings reveals that significantly high noise levels are particularly prevalent at major intersections a long Jama Assagga Road, old wall Road, and Al-Jaraba Street, especially during day and evening- time hours. Even within residential zones, particularly those adjacent to schools and government buildings, noise levels frequently surpass acceptable threshold during weekdays, although a level dropped to acceptable level during the night time. The study identifies traffic flow and industrial sounds (e.g., air conditions and water pumps) as most dominant sources of annoyance, profoundly shaping the acoustic environment.

The sound scape analysis further underscores a critical disconnect: while some areas, like Al-Jaraba Street, are perceived as “eventful” and “vibrant” due to their commercial activity. On the other hand, locations on Al-Doll Road, are characterized by negative perceptions such as “chaotic”, “monotonous” and “annoying”, largely due to the incompatibility of street activities with their residential land use. The resident interview also reveal a divergence from sound walk results, suggesting that indoor acoustic factors (e.g., building material, widows types, dwelling characteristics) significantly influence individual perception of noise, necessitating further empirical data collection on indoor acoustic environments in Libyan dwellings.

Crucially, the social survey results indicate a pressing need for increased public awareness regarding the pervasive nature of noise pollution and its effect on public health and the environment. The lack of specific noise pollution legislation in Libya, despite existing national environmental laws, exacerbates the problem.

In light of these findings, this study strongly concludes that the Libyan government must prioritize the establishment of comprehensive regulations and policies to mitigate noise pollution. These measures should include setting recommended noise limits tailored to specific land use classifications, potentially drawing upon the more appropriate Algerian standard identified in this research. Implementing such policies, coupled with public education initiative and further research into indoor acoustic conditions, is vital to safeguarding public health, enhancing urban quality of life, and fostering a more sustainable and acoustically comfortable built environment in Tripoli.

REFERENCES

1. Adams, Mags D. et al. (2008): Sound walking as a methodology for understanding soundscapes. In: Proc. Institute of Acoustics at Reading, UK, Vol. 30.
2. Ahmida K. M. , Shnfier N. H, (2024) "Investigating Noise Pollution Levels in Tripoli City", International Science and Technology Journal http://www.doi.org/10.62341/kman0749
3. Alett,a F., Guattari, C., Evangelisti, L., Asdrubali, F., Oberman, T., and J. Kang. (2019): "Exploring the compatibility of "Method A" and "Method B" data collection protocols reported in the ISO/TS 12913-2: 2018 for urban soundscape via a soundwalk", Applied Acoustics, Vol. 155, pp. 190-203,.
4. Aletta, F., Kang, J. Axelsson, Ö. (2016),"Soundscape descriptors and a conceptual framework for developing predictive soundscape models", Landscape and Urban Planning, Volume 149, Pages 65-74, ISSN 0169-2046, https://doi.org/10.1016/j.landurbplan.2016.02.001.
5. Anees, M. M., Qasim, M., & Bashir, A. (2017). Physiological and physical impact of noise pollution on environment. Earth Science Pakistan, 1(1), 08-11.
6. Brown, L. A. (2012). A Review of Progress in Soundscapes and an Approach to Soundscape Planning. International Journal of Acoustics and Vibration, 17(2), 73-81.
7. Bouzir, T.A.K., Berkouk, D., Kafyah, W.Z.M., Aljadaani, A. (2025). The Arab Noise Pollution and Soundscape Project (ANSP): Preliminary Results and Future Directions. the 1st International Conference on Creativity, Technology, and Sustainability. CCTS 2024. Proceedings in Technology Transfer. Springer, Singapore. https://doi.org/10.1007/978-981-97-8588-9_51
8. Gabril.N., Aburwin.W Belkhir S.(2023) Socio-acoustic surveys and Soundscape The case of Al-Doll neighborhood, Tripoli- Libya International Science and Technology Journal Volume 32 part2 https://www.stcrs.com.ly/istj/docs/volumes/Socio-acoustic%20surveys.pdf
9. International Organization for Standardization: "ISO 12913-1: 2014 Acoustics—soundscape—part 1: definition and conceptual framework", ISO: Geneva, Switzerland, 2014.
10. J.YongJeon, J. Young Hong,a) and P. Jik Lee, (2012)." Soundwalk approach to identify urban soundscapes individually" , https:/ DOI: 10.1121/1.4807801 ·
11. King, G., Roland-Mieszkowski, M., Jason, T. et al. (2012). Noise Levels Associated with Urban Land Use. J Urban Health 89, 1017–1030. **HTTPS://DOI.ORG/10.1007/S11524-012-9721-7**
12. Locher B, Piquerez A, Habermarcher M, RagettliM, Broosli M. Brink M, et al. "Differences between Outdoor and Indoor Sound Levels for Open, Tilted, and Closed Windows" Int J Environ Res Public Health 2018;15;149 **HTTPS://DOI.ORG/ 10.3390/IJERPH15010149.**
13. Otman, W.A., Karlberg, E. (2007). Libyan Environmental Law and Issues. In: The Libyan Economy. Springer, Berlin, Heidelberg. https://doi.org/10.1007/3-540-46463-8_10
14. World Health Organization, (2019), "Environmental noise guidelines for the European Region", World Health Organization. Regional Office for Europe, ISBN: 9789289053563