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تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

Socio-acoustic surveys and Soundscape
The case of Al-Doll neighborhood, Tripoli- Libya

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Abstract

In the last decade, electricity became a critical problem in the city of Tripoli as well as other cities in Libya. This shortage in power led to the increasing use of power generators at homes, which generated negative impacts such as air contamination and noise pollution, particularly in residential areas. Since Libya have no standards or policy to protect public health and wellbeing of the public form noise pollution the study adopt the World Health Organization (W.H.O) regulation and the Egyptian standard of the maximum permissible limit for noise intensity in different land use area.

This paper addresses the environmental noise pollution and investigates the impact of the private power generators use in a residential district in Tripoli - Libya. The study focuses on monitoring the sound level in a neighborhood to assess the soundscape quality. The study adopted two methodologies for data collection, sound walks, and interviews. In the sound walk, participants were asked to answer questionnaire while monitoring the sound level in (dB-A) in six locations along the street during the day. A second group of participants were asked in their homes to tune into the surrounding to indicate their level of annoyance using the five level of Likert scale. The measurement of noise level was taken during day and night for three normal days and three days during the power outage.

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

The study concludes that social survey analysis indicates the awareness level of such noise pollution and its impact on the built environment requires broader attention. Moreover, the monitoring results show the noise level externally is much intolerable. In addition, the study determines that the relevant authorities need to establish regulation and policy to protect public health and wellbeing of the public from noise pollution and set a recommended noise limit according to Land use.

Key words: electricity, power generators, noise pollution, Tripoli – Libya.

المسح الصوتي \ الاجتماعي والمشهد السمعي

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ملخص

نتيجة لازمة الكهرباء نلاحظ تزايد في السنوات الأخيرة استخدام مولدات الكهرباء في ليبيا، مما أدى لخلق ما يسمى (بالتلوث السمعي). ووفقا لتقرير منظمة الصحة العالمي (W.H.O– 2018)تم اعتماد خطه لتحديد مستويات للتلوث السمعي تنص إلي أن التلوث المستحدث في القرن الواحد و العشرين أدى إلى أضرار على صحة الإنسان لا يمكن إغفالها و يجب التنبيه إلي تبعياتها و كيفية التقليل منها .هذه الورقة تبحث بدراسة مستويات التلوث السمعي في البيئة السكنية وتأثير الضجيج الصادر من مولدات الطاقة على المناطق السكنية في طرابلس – ليبيا. الدراسة تتضمن المسح السمعي بالمنطقة السكنية لتحديد الوضع المشهد السمعي(soundscape) .الورقة تتبنى نظريتان لجمع المعلومات للبحث :المشي السمعي(sound walk)و المقابلة (interviews). تتمثل النظرية الأولى

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

في تحديد ست نقاط على امتداد شارع الظل، و طلب من المشاركين الإجابة على استبيان المسح السمعي مع قراءة لمستوى الصوت بمقياس ديسبيل ((dB–A) و في النظرية الثانية قام الباحثين بإجراء مقابلات مع السكان في بيوتهم و تحديد مدى إدراكهم للبيئة السمعية المحيطة بهم. حيث أجريت المقابلات خلال فترتي النهار و الليل لمدة ست أيام ، ثلاثة منها حين انقطاع التيار الكهربائي و استخدام المولدات الكهربائية و ثلاثة أيام بدون مولدات .الدراسة استنتجت من تحليل المسح السمعي للمجتمع مدى تأثير التلوث السمعي على الصحة الجسدية والنفسية للإنسان و أهمية وضع قوانين وأنظمة لاستنباط المستوى المثالي لمستوى الصوت وفقا لاستخدامات الأراضي.

الكلمات الدالة: كهرباء، مولدات كهرباء، تلوث ضوضاء، طرابلس–ليبيا.

Introduction

The negative effect of noise pollution on human wellbeing and its epidemiology aspect is extensively studied during the last 20 years by researcher, international organizations and governments (WHO (2018), (World Health Organization, 1999, European Parliament and Council, 2002, World Health Organization, 2011), the International Organization for Standardization (ISO). The effect of noise on human wellbeing can be categorized as physiological and psychological effects. (Anees, M., et al., 2013).

Although the effect of noise pollution related studies are increasing in Europe and the developed countries, (Kang, et al., 2016; Kang &Aletta, 2018) However, in Libya there is only few paper researching the effect of traffic noises on urban areas (Amer, T., 2013), (Omar, I., 2019).

The study adopts the soundscape method, it considered to be the most effective method to understand more deeply the impact of sound on humans in specific contexts. (Adams, Mags, 2008). The International Organization for Standardization (ISO) published Part 1 of a new International Standard, ISO 12913, on soundscape, which defines the term as "[the] *acoustic environment as perceived or*

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

experienced and/or understood by a person or people, in context" (International Organization for Standardization, 2014). In order to evaluate the soundscape quality, methodologies for data collection, such as sound walks, listening tests, interviews, and focus groups, were developed. (Brown, Kang, & Gjestland, 2011; Brown, 2012, International Organization for Standardization2014).

1. Field Study

Two data collection methods of sound walk and interviews used to evaluate the human perception of acoustic environment. Firstly, the sound walk procedure considered by many researchers as most reliable evaluation method that allows qualitative and quantitative data collection as multimodal experience (Adams & Bruce, 2008; Yong Jeon et al., 2013). A group of student were asked to follow a predefined walking route and use a structured protocol which enables the sonic evaluation as well as to collect context-sensitive data. The questionnaire was based on data collection protocol proposed in ISO 12913-2 Method A (Section C.3.1 of the ISO/TS 12913-2:2018). Method A is a qualitative data collection protocol that allows all responses to be expressed as numeric data. Through asking the level annoyance using the scales of assessment a five point Likert scale.

The duration of sound walks nearly 30 min, furthermore, in order to include the effect of the variation of the acoustic environment with time, the sound walk were conducted during the day and evenings for three days during the power outage days and normal days. (Semidor, 2006; Maffei, 2008). Furthermore, as quantitate data the study monitors the noise level in a neighborhood using (day -night noise indicator) in decibels dB(A).

The Sound walks were combined with monitoring the level of noise using sound meter to record the equivalent noise level at different selected locations. The sound measurements were taken while the participants were listening to the acoustic environment, at each of the six locations of the sound walk.

Secondly, the study interviewed a sample group of resident to study their perception of acoustic environment and level of annoyance.

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

Most of the resident lives in houses and flats with two to three story buildings.

1.1. Site

For the purpose of this study, Al-Doll street (Figure1) and area neighboring the street was selected to present as a sample of residential area in the city of Tripoli, the study area characterizes as mixed-used urban planning with houses, apartment buildings, schools, hospitals and commercial use (Figure2). However, the study focuses on the effect of noise pollution on the residential area located along the main street. The neighborhood considered a resident for middle to high-income community. Furthermore, the street is one of the most crowded streets in Tripoli, where the acoustic environment considered to be characterized by a relatively wide variety of sound source types, (human voices, traffic, natural sounds and industrial sound).

Figure (1): The site.

International Science and Technology Journal
المجلة الدولية للعلوم والتقنية
Volume32 العدد
Part 2 المجلد
July 2023 يوليو
المجلة الدولية للعلوم والتقنية
International Science and Technology Journal
ISTJ
تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

Figure (2): Land use.

1.2. Participants

The participants were divided into two groups, the first group conducted the sound walk, the group included architecture students 10 females and 10 males, aged between 20-23, accompanied by 3 architects aged between 30 to 55. Participants were carefully selected from the architecture department studying acoustic course, who had a knowledge in acoustics and soundscapes this make their respond to the questionnaire more efficient.

The second group includes 25 residents' 14 females and 11 males, aged between (18 to 75) were interviewed in their homes and asked about their level annoyance, during the power outage days and usual days.

1.3. Source of sound

According the ISO, the sources of sound can be categorized into four sources; nature (birds and wind), traffic mainly cars, people (student and shoppers) and finally industrial (power engine, water Pump and air-condition units), for the purpose of the study the survey focuses on the industrial sound mainly from power generators and water pumps. According to the General Electrical Company of Libya (GECOL), there is a power deficiency of approximately 25%, accordingly power outages in Tripoli typically last five hours per day during spring and autumn and for up to

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

fourteen hours at a time in the peak summer and winter months (Y.Abdulkherb, 2020). (Figure 3). Private power generators used by the resident comes in different sizes and types. As It depends on the electric power demand. Accordingly, small portable ones used in small shops and houses, medium stationary generator used in big shops and apartment buildings, finally the central power generator mainly in shopping center and apartment buildings. The noise level of the generators is associated with the type, size and age of generator, which ranges between 65-100 dB-A. Portable generators have nearly 100 dB-A while stationary generators have lower level of noise ranges between 60 to 75dBA. Additionally, the effect of the power generators depends on the location of the power generator, number of generators and the availability of sound isolation to reduce the noise level. (Azodo & Adejuyigbe;2013).

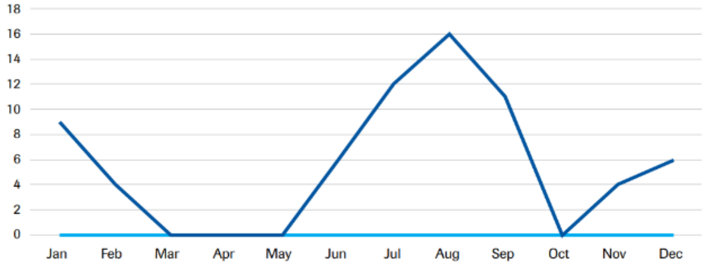

Figure (3): Average power load shedding hours. (Y.Abdulkherb, 2020)

In addition, the study showed that more than 65% of the houses in the neighborhood uses power generators (Figure 4), while it rises up to 80% in the commercial building. That shows sound pollution from commercial buildings are responsible for that most of the noise pollution in the main streets.

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

Figure (4): Power generators within the neighborhood (Based on the interview by the researcher)

2. Data Collection

First, Sound walk, six sample location were assigned on the walking route, along the main street, the locations were carefully selected and the planned at particular locations, near focal building such as schools, hospitals and shops. The duration of the walk nearly 30 minute The locations were plotted in (Figure 5). The sound walk took place during the hottest season when power outage occurred, the participant walk in small groups of two or three. Furthermore, they were asked to follow the predefined walking route and answer a questionnaire during their walk.

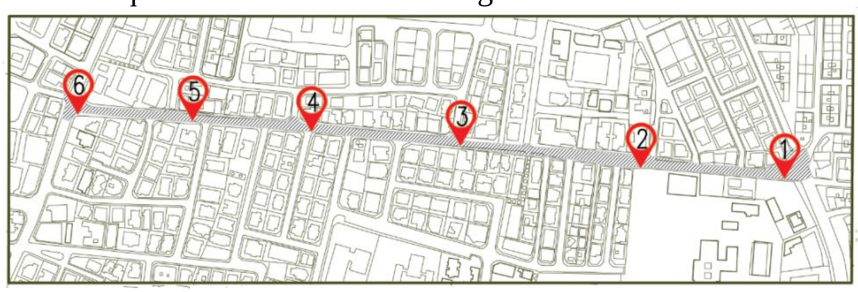

Figure (5): The selected locations along the four streets.

The questionnaire, consists of three main sections, in the first section, participants were asked to tune into the caustic environment, mainly focus on the four sources of noises in the environment; nature (birds and wind), traffic mainly cars, people (student and shoppers) and industrial (power generator, water Pump

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

and air-condition units), evaluating their perception toward the sound, and answer to what extend they hear the four sourced of sound. The responses based the five-point scale (1- not at all 2- A little 3- moderate 4- A lot 5- Dominates completely).

The second section of the questionnaire divided the sound environment into 8 scales starting from pleasant to monotonous and questioned the extent in the range (agree or disagree). And thirdly, participants were asked about the overall quality of sound environment, and evaluate their level of annoyance on five-point scale .

2.1. Analysing sound measurement

Measuring of the sound level during the walk by using sound meter to record the equivalent sound level at different selected locations. The devices have a measurement range of 30–130 (dBA) with an error of <1.5 (dB A). The sound measurement was recorded for the 6 locations along the sound walk route. The recording duration 5 minutes for each location, during usual day when electricity is operating. and during the outage when power generators are in use. The results of both conditions were shown in the tables below (table-1and 2).

Table (1): Sound level reading during the usual day (Operating time).

	Day				Night			
Locations	min (dBA)	Avg/Leq (dBA)	max (dBA)	SD	min (dBA)	Avg/Leq (dBA)	max (dBA)	SD
1	68	71	77	3.5	50	57	63	4.4
2	60	65	70	3.3	45	52	60	5.1
3	60	66	73	4.3	50	55	59	2.8
4	65	69	75	3.5	45	51	56	3.7
5	55	64	70	5.1	45	54	61	5.1
6	65	70	77	4.6	45	53	57	4

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

Table (2): Sound level readings during the outage days.

	Day				Night			
Locations	min (dBA)	Avg/Leq (dBA)	max (dBA)	SD	min (dBA)	Avg/Leq(dBA)	max (dBA)	SD
1	70	82.3	97	9	40	53	60	6.9
2	77	80.2	85	3	45	51	60	6.7
3	76	85.2	96	7	45	53	65	7.4
4	65	72.3	77	4	45	52	60	5.9
5	70	75.6	80	3	55	59	65	3.4
6	70	85.8	104	11	45	58	74	6.5

The results compared with several permissible noise limits law. During the usual day (power operating time) (Table1), the results showed that the mean sound levels at the six locations were higher than permissible limits (table3), the mean sound levels during the day were ranged from minimum 64dBA to maximum 71dBA, with nearly 76 % of the reading exceeded the permissible limits according to W.H.O for commercial area and 100% for residential area. However, at night the readings show that 76% of the mean sound levels were within the permissible limits for commercial area, with only 24% it is still higher than the permissible limits by small margin 5dBA. Moreover, when compared the result with the residential areas limit the sound level was higher by 7dBA, with nearly 70% above than the permissible limits.

The readings indicate an increase to dangerous level during the outage when power generators are in use. The highest noise 104dBA during the day and 74dBA at night. In general, nearly all readings during the day exceeded the permissible limits recommended for both residential and commercial area.

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تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

Table (3): Comparison of L level (dBA) of the present study with permissible noise limits law for different countries.

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
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

2.2. Questionnaire data analysis

The questionnaire purpose is to realise the human perception of the acoustic environment. Questions were answered during the walk at the 6 preselected locations, 20 participants responded the questionnaire in each 6 locations, the data in total 120, Two sets of data were collected one during the power outage days and the second during usual days (operating time), Thus nearly 240 sample were collected and analyses.

Participants were able to tune with their caustic surrounding and measured their level of annoyance toward the four sources of sound the result plotted on the charts (figure 6) for both conditions during the outage and during the operating time. In both situations, the noise from traffic flow remains the most common noise pollution in the area in all six locations.

The study shows that during the operating time the traffic noise considered to be the dominant sound as nearly 55% of the participants were completely annoyed mainly on the intersection at location (6), The level of annoyance reduced at other locations. In general, the participants' perceptions toward sound from traffic ranges between (10% moderate) to (55% dominate completely) in one location. This is relative to each individual's behavior and personality, as the data depends on personal expectation and experience. The participants could not perceive any sound of nature in the walk other than the sound of birds heard nearby location (2).

International Science and Technology Journal
المجلة الدولية للعلوم والتقنية

Volume32 العدد
Part 2 المجلد
July 2023 يوليو

المجلة الدولية للعلوم والتقنية
International Science and Technology Journal
ISTJ

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

Figure (6): Sources of sound vs level of annoyance During opratinge timeat Six Location at Al Doul street.

On the other hand, Human impact on the street acoustic environment vary according the activities and land use, consequently people sound was considered dominant by 50% of the participants on location (5) near the school during the daytime, and in the evening near the mosque and cafe. Finally, the industrial sound was dominant near the hospital at location area and commercial buildings (4), the source of the sound mainly from air-condition units and water pomp.

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

During the outage, the participants experienced the impact of power generators on the acoustic environment, which dominate the level of other sound sources. this reduce the effect of other sound sources. Traffic sound was lower than the power days with nearly 20% in most location except at the intersection location (6) (Figure 7).
As mentioned earlier the nature sound was nearly nothing compared to the other sound, nearly 90% to 100% of the participant voted Not at all in most locations.

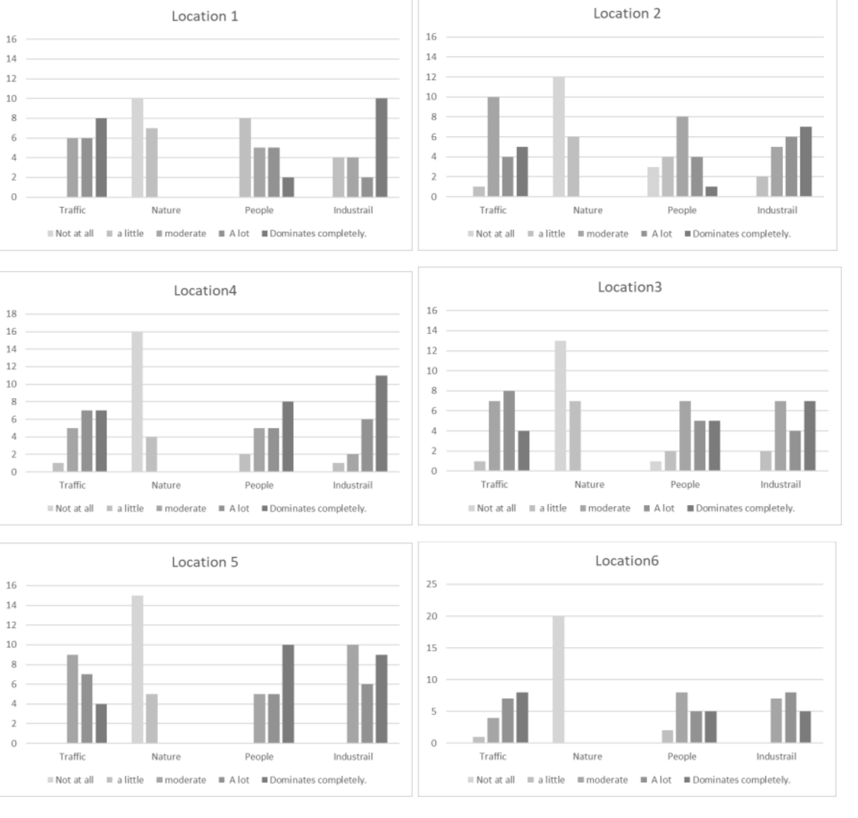

Figure (7): Sources of sound vs level of annoyance During outageat Six Location at Al Doul street.

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

The study shows that the sound of people varies according to the level of activity or according to building use (land use), thus human sound can be heard near the school, hospitals and commercial buildings, in different time of the day. Sounds are perceptible near the school in the morning and afternoon, and near mosques at the praying time.

Finally, the participants perceived the impact of the industrial sound from power generators that dominate the acoustical environment as the sound concentrated and echo through the narrow street cross – section.

The second part of the questionnaire concerned with the questions how participants perceived the quality of sound environment and plot their response on 5 points scale ranges from Strongly agree (1), Agree (2), neither agree, nor disagree (3), Disagree (4) to Strongly disagree (5). The results are plotted on a radar graph (Figure 8) the graph shows the perceived affective quality data of the six locations. The participants' responses vary according to the location and the activity that contains.

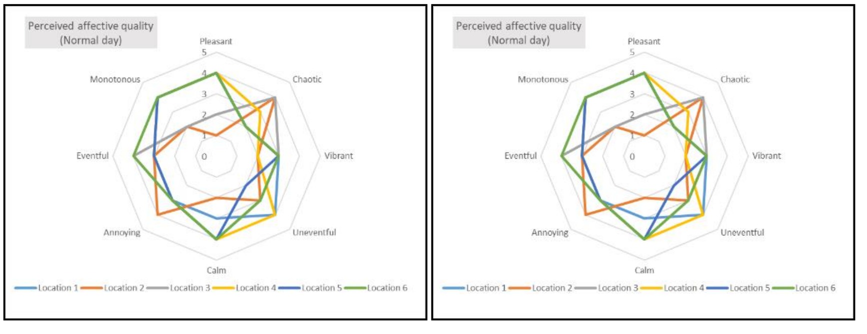

Figure (8): Mean scores of Perceived effective quality items at the six location-the higher scores imply higher level of disagreement with the specific attribute .for both condition (power and outage times).

The graph shows the louder and unpleasant location sound scape was reported at location 1 and 6, at the intersections. Locations 5, 4 and 3 perceived as chaotic and unpleasant during few hours in the day mainly morning and afternoon during the school time.

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

Moreover, it is clear that location 2 is the most pleasant and calm part of the street as most of the neighboring buildings are houses.

Finally, in the third part of the questionnaire, participants were asked about the overall quality of sound environment, and Appropriateness on five-point scale at six sound walk locations. The result plotted on chart shows the mean scores selected by the participants with only 4% percentage error.
The first question concludes the Overall description of their present surrounding sound environment, their responses selected from Very good (1); Good (2); Neither good, nor bad (3); Bad (4); and Very bad (5).
The second is to what extent is the present surrounding sound environment appropriate to the present place? Participants selected their preferences from the following scale: Not at all (1); Slightly (2); Moderately (3); Very (4); Perfectly (5). The results were shown in bar chart (figure 9).

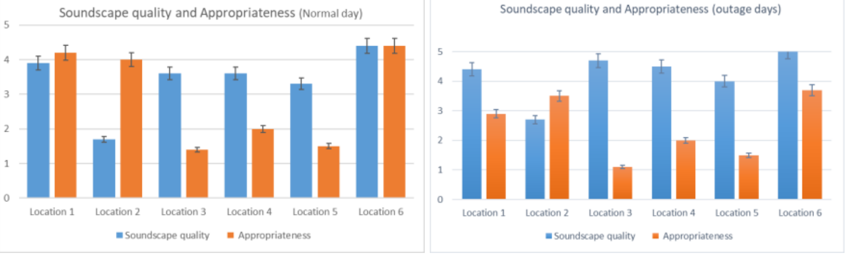

Figure (9): The mean scores for the data of the overall quality category of the questionnaire on both situations (normal and Outage).

During normal days Location 2 is the only area the most of participants consider it as a good sonic environment and an appropriate sound environment, this also selected as pleasant area. Moreover, 80% of participant consider the overall quality of sound in locations 1 and 6 (very bad) at both ends of the street at intersections. However, for the same locations the participant found it very appropriate to the present place, this can be related to the activity and expectation of noise level near the intersections.

International Science and Technology Journal
المجلة الدولية للعلوم والتقنية
Volume32 العدد
Part 2 المجلد
July 2023 يوليو
المجلة الدولية للعلوم والتقنية
International Science and Technology Journal
ISTJ
تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

Moreover, at locations 3, 4, and 5 nearly 50% of participants describe the sound environment in these locations as (Bad), which is reflecting that they were annoyed by power generators, air conditioning and ventilation unit noise, they also consider these locations as inappropriate for their land use as residential area.
On the other hand during the outage, the result shows that in all area nearly 85% of participant describe all area as either bad or very bad and inappropriate for land use. Although the Location (2) considered pleasant at the normal day, on the outage day sound form nearby location mainly lacation1 disturbed the sound environment and affect the quite location.

2.3. Interviews

An interview was conducted with the second group (25 residents) in their homes. Participants were asked to tune into the surrounding and answer three set of question. First, what is the dominant type of the four sound sources; nature, traffic, people and industrial is noted? And the level of hearing annoyance the experience using the five scale, 1-Not at all 2- a little 3-moderate 4 – A lot 5 –completely annoyed. Second, the participants were asked to if they use any type of noise insulation in their house. Finally. they were asked if they owned power generator and its location and its distance from their house, and accordingly, to what extend they were annoyed by its sound?

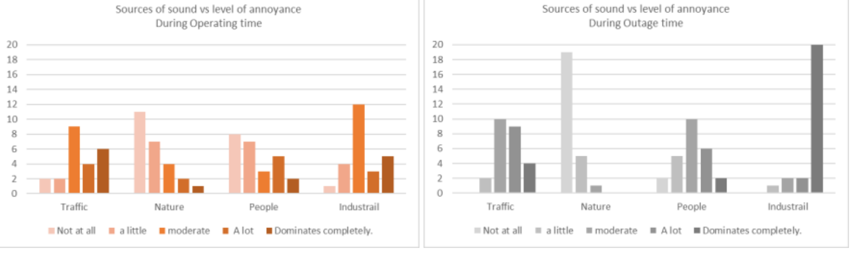

Figure (10): Sources of sound vs level of annoyance During Operating and Outage time

From the interview the participants were able to distinguish noise sources from traffic, nature, people and industrial, and asked about

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

their level of annoyance toward the four sources of sound the result plotted on the charts (figure 10) for both conditions during the outage and during the operating time. In both situations, the noises from industrial (generators and air conditioners) remain the most common noise pollution in the area. Nevertheless, Traffic noise considered the dominant sound during the operating time as nearly 20% of the participant were a lot annoyed and 24% were completely annoyed by the sound of traffic. The level of annoyance reduced during the outage, this can be related to the impact of other sound source. The duration of traffic noise occurred at early morning and afternoon, nevertheless the level of noise decreases at night as shops closed.

During the outage the sound of generators dominated the environment, as 80% of the participants were completely annoyed by industrial noises mainly from power generators and water pump. The effect of the industrial noise reduces with respect to the house layout and orientation toward the noise source. Thus, houses with appropriate noise parries (double glazed or surrounded by trees), 8% of the participant were a little annoyed. However, during the power operating time the effect of industrial sound decreased to 20% of the participant were completely annoyed, the sound mainly from water pump used to enhance the water supply into the houses. The variation in respond toward the effect of human sound mainly related to the location of the dwelling, houses near shops and school were completely annoyed by people noises, while houses in a distance have little affect or no affect at all.

In the interview, nature sound such as birds, wind rain is hardly noticed. However, houses with big trees respond with 12% A lot annoyed, mainly the sound of birds. The interviews were conducted during hot season; therefore, the effect of rain or wind sound were deficient.

According to Locher, the differences between indoor and outdoor levels are usually estimated at around 10 dB for open, 15 dB for tilted or half-open and about 25 dB for closed windows. When considering more accurate estimation of indoor levels, using a range

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

of different predictors, the relevant scientific literature can be consulted (Locher et al., 2018). Consequently, sound level inside the houses are relatively lower than the external level it ranges between 65 dBA to 75 during the outage time, it differ accordingly to the location of the power generator and the level of sound insulation of the houses.

Since participants were asked at their homes, there are many non-acoustic factors such as human behavior and thermal comfort. Additionally, participant who owned power generator seems to accept the loudness of their power generator, as way to achieve their thermal comfort in their houses (air conditions).

3. Conclusion and recommendations

Appraising the results of noise measurements against World Health Organization guidelines and Egyptian permissible noise limits law for Commercial and residential areas, the overall outcomes on noise hazard in all locations were higher and in a dangerous level.

During the outage time, the study shows that all places were affected by the power generators and level of noises surpassed the permissible limits recommended for both; residential and commercial areas. Therefore, to maintain the recommended standards, low noise power generators installation needed for commercial use.

Guidelines and regulations to standardize the noise level are fundamental for the built environment and it is necessary to protect the human wellbeing.

The study found that noise levels varied significantly within the mixed-use neighbourhoods. Levels near commercial buildings were higher than in the residential area. These findings support the assumption of variation in noise levels correlated to the land use in the built environment.(King, 2013).

It is essential for urban designer to consider such implication in the futuristic land use and planning development strategies.

Participants' perceived positive and negative features in their responses. It varies according to their personalities and behaviors during time of walk. The results show time is a vital variable in the

تم استلام الورقة بتاريخ: 15 /2023/6م وتم نشرها على الموقع بتاريخ: 24 / 7 /2023م

acoustic environment research. Votes indicate that (unpleasant and Chaotic) only during the school's hours however, the voting however, changes to passive (neither agree, nor disagree) during the evening.

The interviews' results show that during the outage in all area nearly 85% of participants described all areas as either (bad or very bad and inappropriate) for land use. The percentage dropped to 20 % during the power operating time. The variation in responds toward the effect of noise mainly related to the location of the dwelling and the level of sound insulation.

Sound insulation in houses located in mix land use is vital to achieve residents' acoustic comfort.

In conclusion, the results suggest a permissible noise limits law to protect the environment form noise pollution and its effect on the human health and wellbeing is highly required.

Since 1958, there have been a series of Laws and Decrees in Libya concerning environmental protection. It dealt with the impacts and risks of environmental pollution with penalties imposition on violation of the provisions of such laws.(Otman& Karlberg, 2012). Subsequently, Law No. 15 - 2003, became a primary law for protecting and improving the built environment (Faraj.O, 2010).

The law specifies public duties and the other related parts towards preserving the environment in many fields; air, water, soil and food. Protection of the built environment from noise is mandatory issue that requires attention. In addition, forming Legislations, laws and Guidelines to control the permissible noise limits for different land use in the built environment is necessary. Further studies and researches needed in this area of study due its growing negative impacts.

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