MONITORING NOISE LEVELS ALONG THE GREATER CAIRO URBAN REGION RING ROAD IN EGYPT

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ABSTRACT

In this study, the noise levels were monitored at Cornish EL Maadi (A), Gezirat El Dahab (B) and Al-Marioteya (C). The data revealed that the noise levels at Corniche El Maadi Street (A) and Al-Marioteya (C) (all day) as well as at Gezirat El Dahab (B) (evening) exceeded the set noise regulations in Egypt. Overall, it was the buses, private cars + taxis, mini vans and mini truck that made the main bulk of traffic passing through the ring road on weekdays. However, the study revealed that the main category of vehicles contributing towards the recorded noise levels was the miscellaneous type. This means of transportation were slow and proceeded along the right lane of the road and thus had a more measurable impact upon the recorded noise levels at the 3 monitored locations. However, the contribution from vans and mini-trucks towards the noise levels recorded was significant at Gezirat El Dahab and Al-Marioteya during Monday and Friday, respectively. Nonetheless, such contribution was not witnessed for Corniche El Maadi Street, where the miscellaneous category was a predominant noise contributing factor during both Monday and Friday.

Keywords: noise pollution, urban transportation, traffic, Cairo Ring Road.

INTRODUCTION

Noise pollution has potential hazards on the human health (Recio *et al.*, 2016, Geravandi *et al*., 2016, Samra *et al*., 2016). Noise is a serious

environmental problem which has not been sufficiently investigated in Egypt (EEAA, 2007). Recent reports have ranked Cairo as the second noisiest city in the world in 2018 based upon the World Hearing Index report (Gray, 2019). Traffic has been identified as one of the main contributors towards urban noise. In their study, Ali and Tamura (2002) indicated that noise caused by traffic in Greater Cairo exceeded the set Egyptian standards (Ali and Tamura, 2002). This increase not only caused road congestion but also led to hearing impairment, lack of concentration, difficulty to communicate with each other and, finally, anger and rage (Habib *et al.* 2016).

In this study of elevated highways in Cairo, Dessouky (2016) stated that while elevated urban highways may increase traffic mobility in some areas within the city, they did have more negative impacts on the local population. Socially, these highways divided communities by installing physical barriers. As well, residents were constantly being subjected to vehicular related pollution, which ranged from environmental degradation of buildings, lung inflammation, vibration and heat island effect and, overall, the traffic related noise. In their report on traffic congestion in Cairo, the World Bank (2010) indicated that there was no significant variation in traffic volume throughout the city all day long. However, traffic volume in the morning and afternoon hours represented the highest traffic count during most locations within the city. On the other hand, being subjected to continuous high levels of noise not only contributed to material degradation of property and the physical health

of its dwellers, but also had significant psychological impacts on all members of the community (Dessouky, 2016).

The Ring Road is the most important freeway within the Greater Cairo Urban Region in Egypt that was constructed in the late 1980s (Wikipedia, 2018) (Figure 1). While it was originally intended to encircle the region in 3 of its 4 sides, the road remains unbuilt because its original plan took it very near the Giza pyramids (Wikipedia, 2018). However, the current road encircles large parts of the cities of Cairo and Giza, including Cairo International Airport. This 110 Km long ring road (Figure 1) has 22 legal exits and entrances in every direction plus another number of illegal exits and entries (Abdo, 2014). The daily traffic volume along this road was estimated to be 140,000 vehicles, 33% of which are heavy trucks. The highest volume was during the evening peak (9,605 vehicles/hour) along the Ring Road in the direction of Al Maadi (World Bank, 2010).

With this in mind, the aim of this paper is to explore the levels of noise along the Cairo Ring Road extending from the East (El-Maadi) to West (Al-Marioteya). The traffic noise levels and vehicle count will be assessed during weekdays and the traffic pattern and main contributors towards the measured noise levels will be accounted for. Statistical correlations will be undertaken to see the impact of the extent of vehicular activity by count and type along this portion of the ring road.

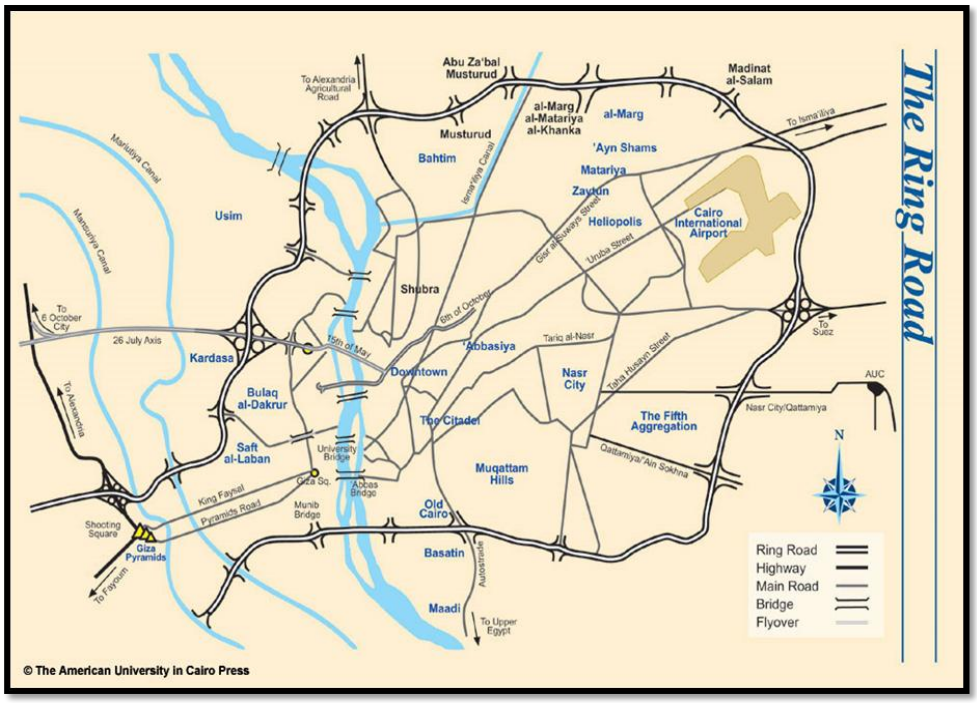


Figure (1): The Cairo Ring Road (AUC Press)

MATERIALS AND METHODS

Study area: Three locations were selected for the study along the Greater Cairo Ring Road after a survey during the year 2018. These locations typifies traffic peak activity, volume and frequency within the year as well as per week and day along this road portion. A brief description and coordinates of these 3 locations are provided herewith.

Location (A): Corniche El Maadi Street (29°59′27″N - 31°13′43″E): Location A is situated on the east bank of the Nile, North of Maadi district

nearby the Cairo Lawyers Riverside Club. It lies at a busy intersection with two flyovers, one connecting the Corniche El- Nile Street to the Ring Road at Maadi and another exiting the Ring Road to Maadi District. The area is residential / recreational with some houses. Noise measurement was made 50 meters away from the ring road, 100 meters away from the Cornich Nile road, 150 m away from the ring road entrance and 200 m away from any residential buildings.

Location (B): Gezirat El Dahab (29°59′16″N - 31°13′15″E): Location B is located on an island west of location A in the middle of the River Nile stream known as Gezirat El-Dahab. It is a sedimentary island formed in the Nile stream and is separated from the main- land east and west Nile banks and can only be reached by ferry or boat. The main activity on this island is agricultural with some houses scattered within. Sampling was done 50 m away from over flight of the ring road in the middle of the island.

Location (C): –Al-Marioteya Area (29°58′51″N - 31°10′39″E): Location C is located further to the west from both location A and B at Al-Marioteya area. The location is mainly residential with farms or agricultural lands at the outskirts of El-Giza City. This location is also the capital's gateway towards the busy Cairo-Alexandria desert highway and 6th October City and its industrial districts as well as is not far from the historical Giza pyramids plateau. Sampling at this point was located 50 m north of the ring road.

MATERIALS AND METHODS

Sampling protocol and measurements: Sampling period was conducted during 2018 starting from October till December, which represents the peak traffic activity along this ring road. From the initial survey, two days were selected to represent typical peak work day (Mondays) and non-peak weekend (Fridays). Noise was monitored continuously for 9-hrs per daytime till 5 pm. The sampling day was divided up into three segments: morning rush hour (7-11 am), midday traffic (11 am-3 pm) and evening rush hour (3-5 pm). The distance between the locations and any tree or building was maintained at 50 m in order to avoid interferences and for the sample to be representative of the ongoing activity. (ISO 1996 part I and II)

Noise Measurement instrument: Sound level meter (Sound Pro 3M SE) was used to monitor and record the equivalent continuous noise level (L Aeq). The instrument (2 dB accuracy, 0.1 dB resolution and measuring range 40 – 130 dB) was adjusted to record noise samples at 1-s intervals during the monitoring period. The microphone was located on the walkway next to the edge of the traffic path on the road and on a tripod stand at a height of 1.5 m from the ground level.

Traffic volume and car types: Traffic volume and cars passing through each location were counted by the hand-tally method (Al-Mutairi *et al*., 2011). Vehicles were classified as: buses, private vehicles, trucks and semi-trucks (all trucks), Minivans, and motorcycles or motorcycle transportation (tok-tok)

plus others were referred to as miscellaneous. The traffic flow and configuration was continuously calculated for each period of time.

Statistical Analysis of Data: Hierarchal Cluster analysis of data was carried out using 'StatistiXL 1.8' incorporated within the Microsoft Excel 2007 (Microsoft ® Windows 2007) software program using Ward's method for minimum variance and the similarity coefficient used was the Square Euclidean distance function.

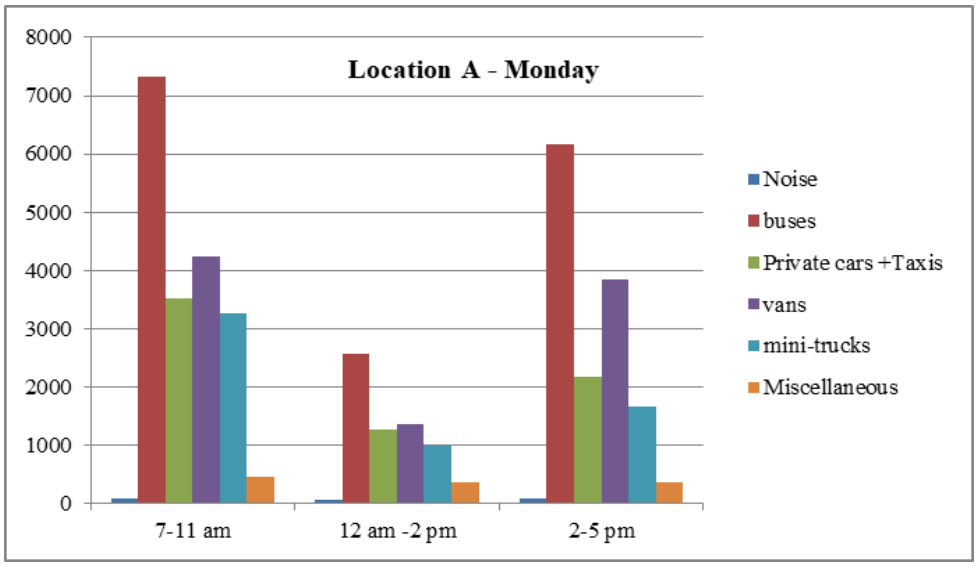
RESULTS

Location A – Corniche El Maadi Street: Table (1) shows the level of noise and car categories and count passing through location A during Monday and Friday, respectively. From the data, the noise level at this point ranged between 69 – 75 dB, however, it was generally slightly higher on Mondays than on Friday. Overall, it was observed that buses, private cars + taxis, mini vans and mini truck made the main bulk of traffic passing through A. However, in Figure 2, it was noted that the predominant vehicle category recorded at this location on Monday throughout the day was the public buses followed by the minivans. On the other hand, the predominant category on Friday was private cars + taxis and minivans. Another observation made was that the maximum car count was obtained during the morning and evening rush hours on Monday while it was in the afternoon and evening period on Friday. Nonetheless, the maximum noise level was maintained on both days during the afternoon period. However, from Figure 3, statistical correlation

between the recorded noise level and types of vehicles and its count revealed that the miscellaneous category and time of day was directly related to the noise level on both days.

Table (1): Noise levels, car types and count recorded at location A on Monday and Friday during the period from 7 am till 5 pm.

Parameter	Time and day					
	7-11 am		11-2 pm		2-5 pm	
	Monday	Friday	Monday	Friday	Monday	Friday
Noise (L Aeq)	74.3±3.5	69.2±1.94	71.5±1.94	70.2±2.63	74.5±1.798	73±1.43
Buses	7321	1054	2568	1369	6156	1189
Private cars +Taxis	3529	2158	1258	2487	2165	2285
Vans (microbuses)	4231	1598	1365	2685	3847	2385
Mini-trucks	3254	658	987	1964	1658	1189
Miscellaneous	465	458	368	435	358	126
Total vehicles	18800	5926	6546	8940	14184	7174



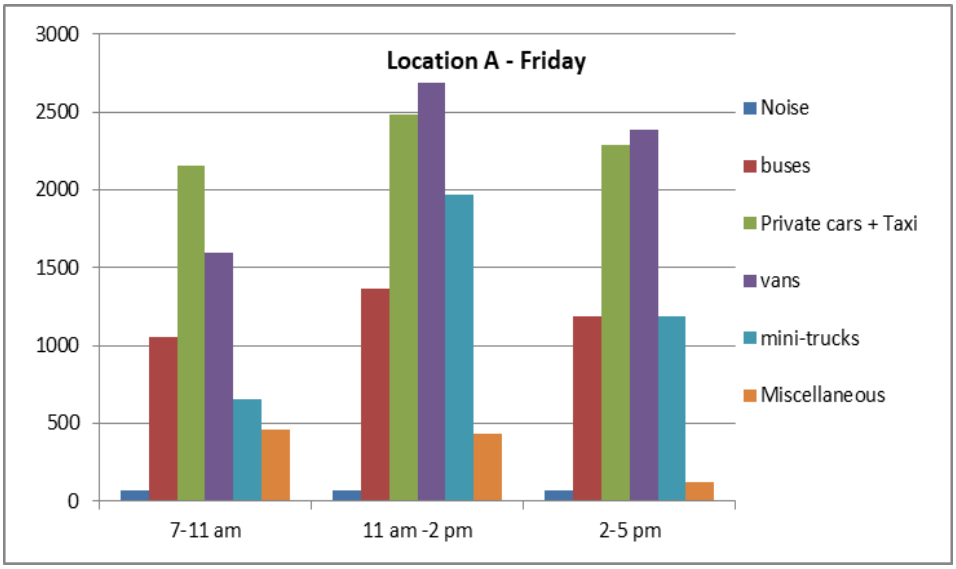


Figure (2): Variation in vehicle categories and count during Monday and Friday at Location A.

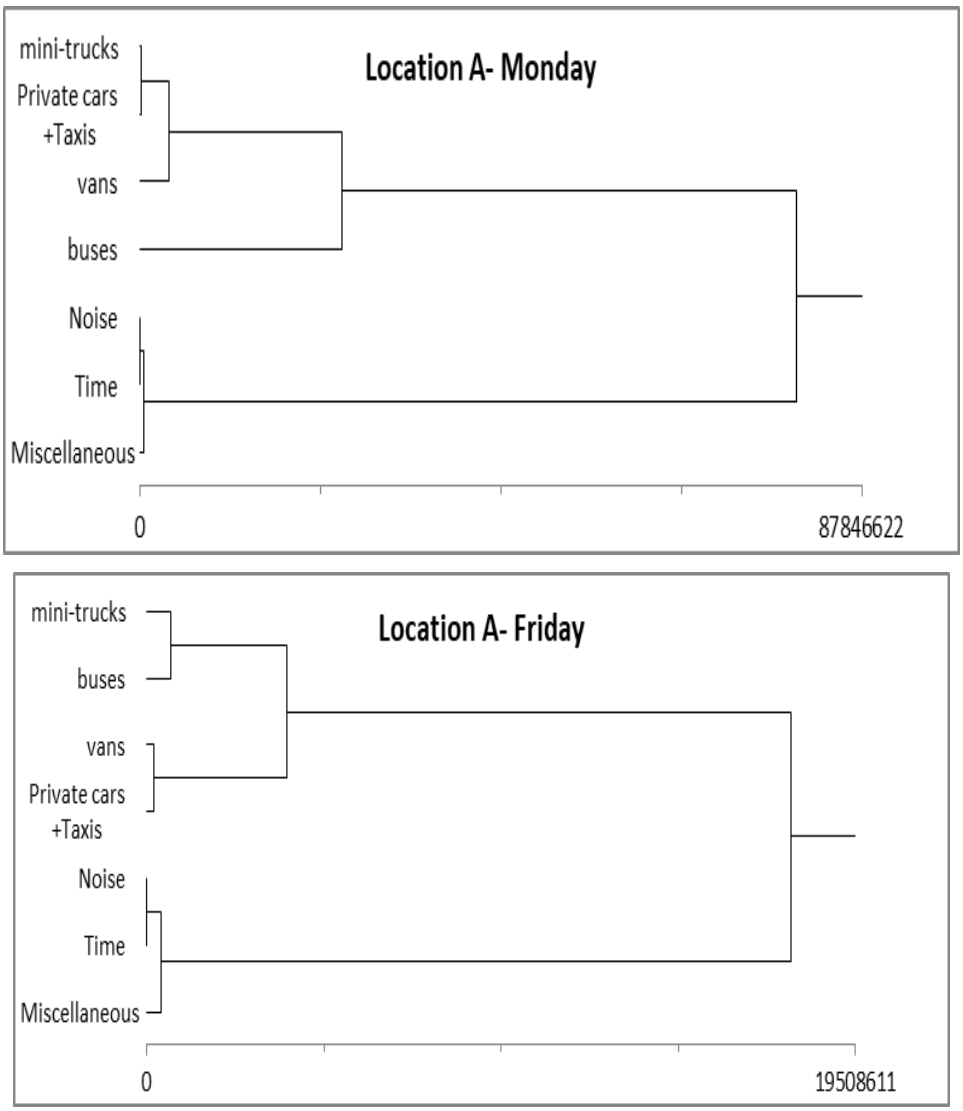


Figure (3): Dendrogram for Car categories count and Noise Levels recorded at location A during Monday and Friday

Location B – Gezirat El Dahab: Table (2) shows the level of noise and car categories and count passing through location B during Monday and Friday, respectively. From the data, the noise level at this point ranged between 50 – 63 dB, however, it was generally slightly higher on Mondays than on Friday. Overall, it was the buses, private cars + taxis, mini vans and mini truck that made the main bulk of traffic passing through B. However, it was noted that the predominant vehicle category recorded at this location on Monday throughout the day was the public buses followed by the minivans (Figure 4). On the other hand, the predominant category on Friday was private cars + taxis. Another observation made was the maximum car count was obtained during the morning and evening rush hours on Monday while it remained almost unchanged during Friday. Nonetheless, the maximum noise level was maintained on both days during the evening period. Statistical correlation (Figure 5) revealed that the miscellaneous category and vans were directly related to the noise level on Monday while it was the miscellaneous category and mini trucks on Friday.

Table (2): Noise levels, car types and count recorded at location B on Monday and Friday during the period from 7 am till 5 pm.

Parameter	Time and day					
	7-11 am		11-2 pm		2-5 pm	
	Monday	Friday	Monday	Friday	Monday	Friday
Noise (L Aeq)	60±1.81	50±1.874	55.3±1.87	53.2±1.41	62.4±1.27	58.3±0.96
Buses	3282	968	2136	1152	2987	1225
Private cars + Taxis	2153	1287	995	2035	2036	1863
Vans (microbuses)	984	532	423	1124	852	954
Mini-trucks	1987	197	658	281	1835	284
Miscellaneous	465	109	159	190	265	187
Total vehicles	8871	3093	4371	4782	7975	4513

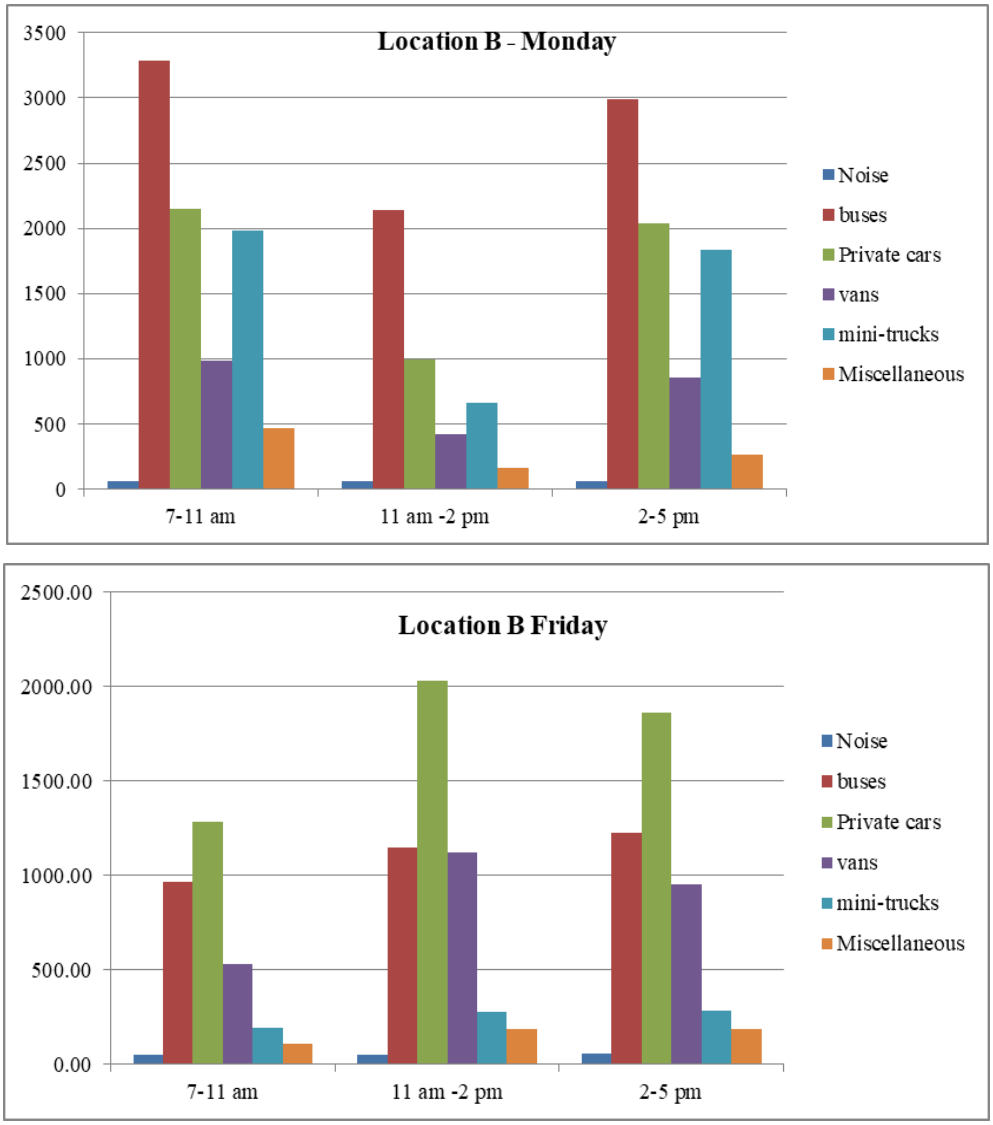


Figure (4): Variation in vehicle categories and count during Monday and Friday at Location B.

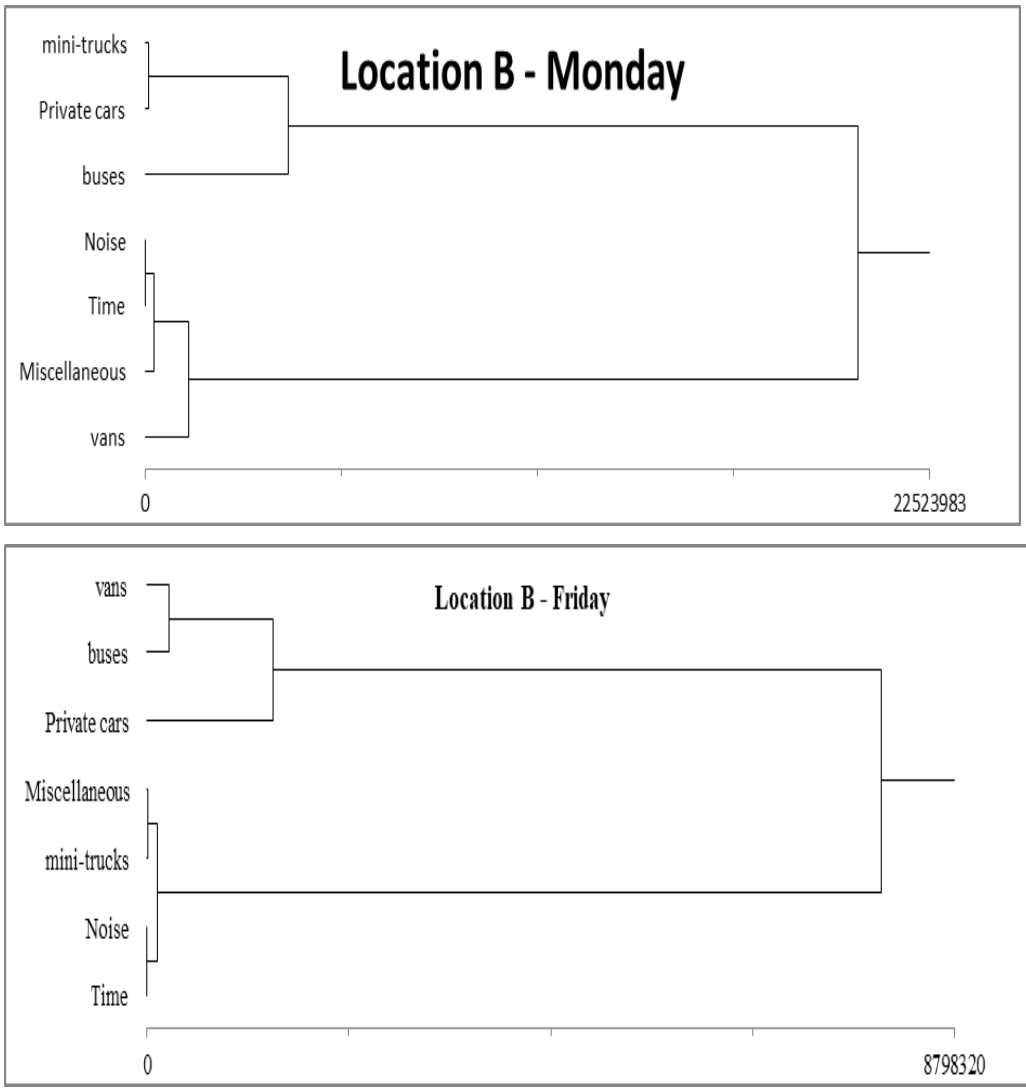


Figure (5): Dendrogram for Car categories count and Noise Levels recorded at location B during Monday and Friday.

Location C –Al-Marioteya Area: Table (3) shows the level of noise and car categories and count passing through location C during Monday and Friday, respectively. From the data, the noise level at this point ranged between 66 – 74 dB and it was generally maintained during both Monday and Friday. Overall, it was the buses, private cars + taxis, mini vans and mini truck that made the main bulk of traffic passing through C. However, it was noted that the predominant vehicle category recorded at this location on Monday throughout the day was the public buses followed by private cars + taxis (Figure 6). On the other hand, the predominant category on Friday was private cars + taxis. Another observation made was the maximum car count was obtained during the morning and evening rush hours on Monday while it was in the afternoon and evening during Friday. The maximum noise level was maintained on both days during the morning and evening periods. Statistical correlation (Figure 7) revealed that the miscellaneous category and mini-trucks were directly related to the noise level on Monday more than vans while it was the miscellaneous category and mini trucks on Friday.

Table (3): Noise levels, car types and count recorded at location C on Monday and Friday during the period from 7 am till 5 pm.

Parameter	Time and day					
	7-11 am		11-2 pm		2-5 pm	
	Monday	Friday	Monday	Friday	Monday	Friday
Noise (L Aeq)	73.6±2.14	68.5±1.48	70.5±1.78	66.3±1.63	73±1.414	69.2±1.74
Buses	6251	1136	4102	1095	6145	2257
Private cars + Taxis	4125	3214	2610	3474	3854	3852
Vans (microbuses)	2685	652	942	2295	1325	1195
Mini-trucks	1123	281	921	517	1185	384
Miscellaneous	789	195	286	159	682	324
Total vehicles	14973	5478	8861	7540	13191	7540

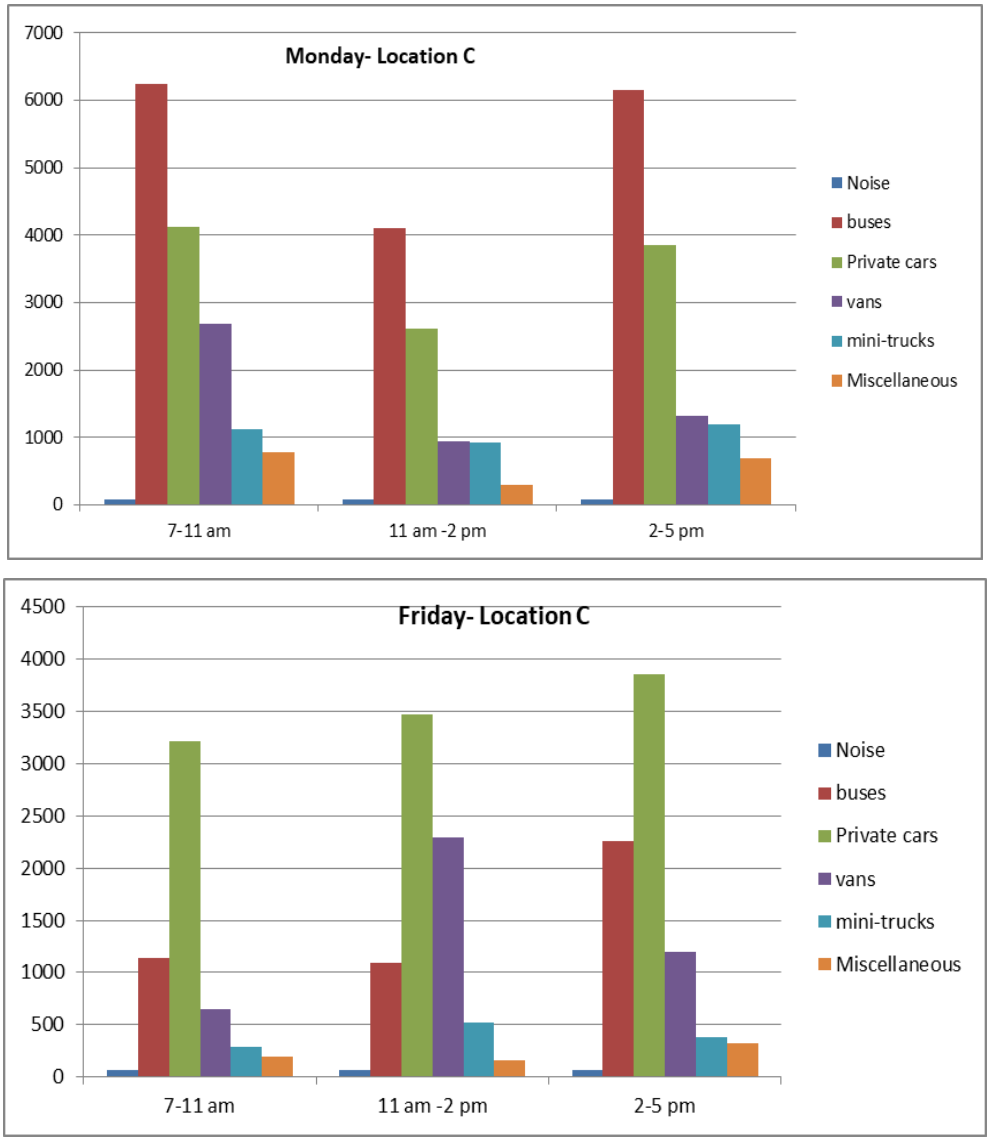


Figure (6): Variation in vehicle categories and count during Monday and Friday at Location C

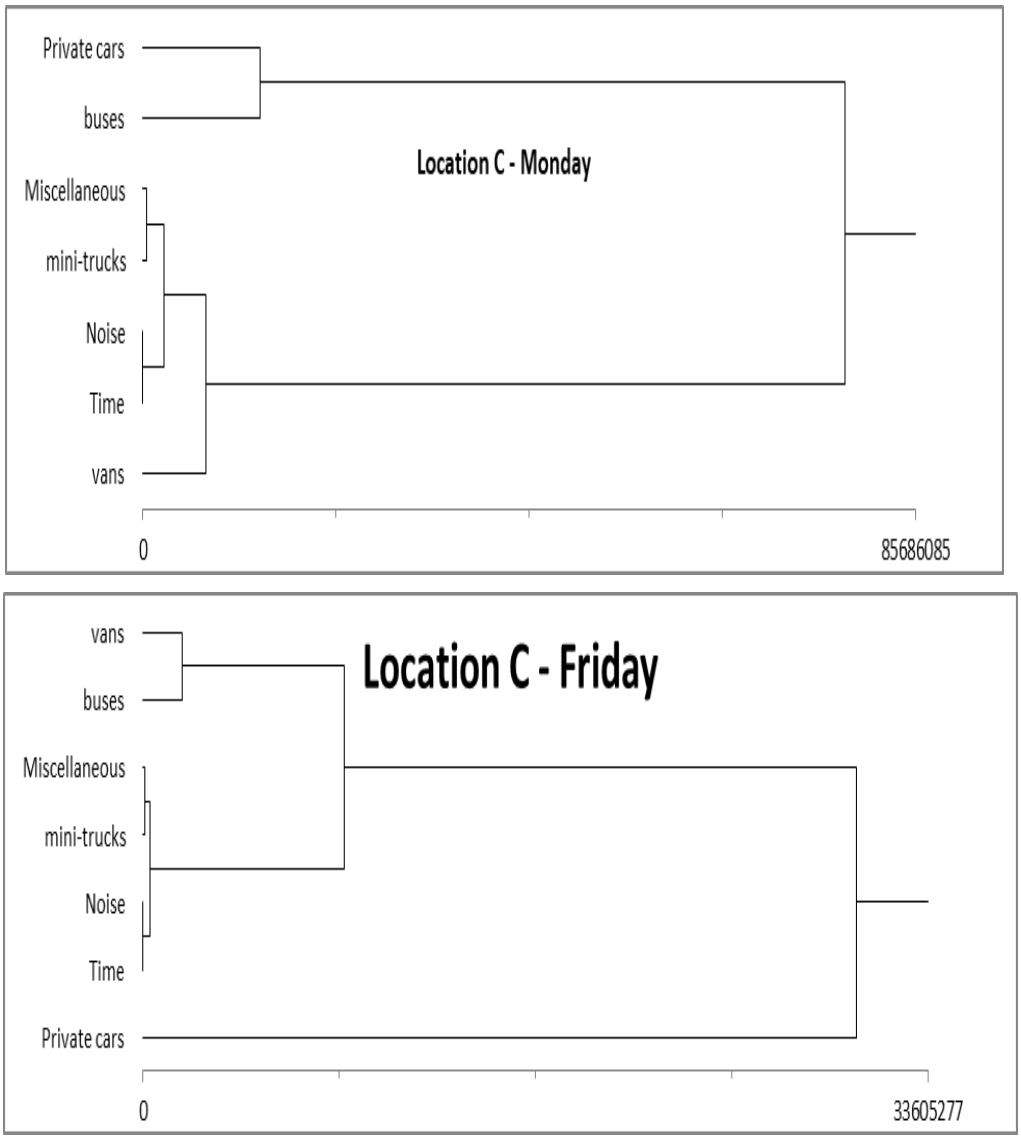


Figure (7): Dendrogram for Car categories count and Noise Levels recorded at location C during Monday and Friday.

DISCUSSION

Law 4/ 1994 has set regulations concerning the acceptable levels of noise per day and night within Egyptian cities (EEAA, 2007). These regulations have limited the noise levels within the city not to exceed 60 dB by day, 55 dB in the evening, and 50 dB by night. In this study, the data revealed that the noise levels at locations A and C (all day) as well as at Location B (evening) exceeded these set noise regulations.

Furthermore, both Location A and C showed similar traffic flow patterns than location B. However, the data revealed that there were definite peak hours observed along these points, namely: the morning and evening rush hours. This is in accordance with the World Bank, Cairo traffic report (2010). While the report indicated that the highest traffic count peak was observed at most locations during the morning period between 8 and 9 am, there were comparable traffic volumes during the different afternoon hours and no any specific peaking pattern at some locations (World Bank, 2010). This was confirmed by the traffic count for the 3 locations where A and C have a definite 2 peak periods while for B it was only in the evening. The latter may be because botanical soils were reported to absorb temperate noise relative to concrete or asphalt which reflected it (Ohiduzzaman *et al*., 2016, Baniya *et al.*, 2018).

On the other hand, the increase in the number of cars during the morning and evening was attributed to students and employees commuting to and from schools, universities and work (Fiedler and Zannin, 2015). As well it was

reported that vehicles tend to produce the most noise while ascending and descending steep slopes and around sharp corners which means that roads incorporating these features will tend to be noisier at those points (Gill *et al*., 2017). This is true for locations A and C which are located near entrances and exits of this Ring Road.

As well, these locations exhibited a high number of busses and heavy trucks during Mondays. Ali and Tamura (2002) studied the traffic related noise along Salah Salem Road during a similar period from September to October 2001. They indicated that the L Aeq along that road ranged between 78 – 86. As well, they revealed that the culprit for the recorded noise levels was the increase in heavy vehicle numbers passing through which comprised 20% buses and 10% heavy trucks. Road noise may also originate from main sources such as friction between vehicles and road surface, driver behavior and construction and maintenance activity (Nababan and Paresa, 2019, Abouel-Seoud, 2019). Moreover, it was the mechanical state of the engine and bad technical conditions of the tires of some of these large vehicles that contributed significantly towards the increase in traffic related noise levels as well as the exhaust emission (Ali and Tamura, 2002). This was true for all locations on Monday in this study. However, they also indicated that high volume of traffic moving along elevated highways, bridges added to this noise level as smooth traffic flow encouraged traffic speed, so the noise level increased due to the number of fast moving vehicles (Ali and Tamura, 2002; Kwatra et al., 2018; Tsunashima et al., 2014). This was more evident in the

case of Location C on Fridays. (Ohiduzzaman *et al.*, 2016)and (Lee *et al*., 2014) reported that high speed moving vehicles produce higher levels of noise upon sudden braking or acceleration. Other traffic related noise sources is blowing car horns and playing loud music (Kwatra *et al*., 2018, Tsunashima *et al*., 2014).

On the other hand, this study revealed that the main category of vehicles contributing towards the recorded noise levels was the miscellaneous type. This may be because these means of transportation are slow and that they proceeded to drive along the right slow lane of the road and thus had a more measurable impact upon the recorded noise levels for the 3 monitored locations. However, the contribution of vans and mini-trucks was significant towards the noise levels recorded at locations B and C during Monday and Friday, respectively. Nonetheless, such contribution was not witnessed for location A where the miscellaneous category was a predominant noise contributing factor during both Monday and Friday.

CONCLUSION

From the above results, it is clear that noise levels on working days were significantly higher than on weekends along the Greater Cairo Ring Road. As well, the locations along the ring road intersections, entrances and exits had higher levels of noise due to not only the number of cars passing through, but to its exhaust, acceleration, and fast travelling and sudden stoppage. While buses and heavy trucks were the predominant category going through these

locations on weekdays, noise levels was mainly related to the slow driving miscellaneous vehicles taking the right side of the road during both Monday and Friday.

RECOMMENDATION

For this study, a recommendation that can be set forth is to set noise barriers or fences along this busy Cairo Ring Road. These walls should be at least 5 meters high on the side of the road and be made of masonary as it is much more effective in reducing noise. This will reduce noise propagation into the nearby residential quarters.

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مراقبة مستويات الضوضاء على طول الطريق الدائرى بمنطقة القاهرة الكبرى الحضريه في مصر

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المستخلص

في هذه الدراسة، تم رصد مستويات الضوضاء في كورنيش المعادي (أ) وجزيرة الذهب (ب) والمريوطية(ج). كشفت البيانات أن مستويات الضوضاء في شارع كورنيش المعادي (أ) والمريوطية (ج) (طوال اليوم) وكذلك في جزيرة الدهب (ب) (مساءا) تجاوزت لوائح الضوضاء المحددة في مصر. بشكل عام، كانت الحافلات والسيارات الخاصة وسيارات الأجرة والميكروباصات والشاحنات الصغيرة تمثل الجزء الأكبر من حركة المرور التي تمر عبر الطريق الدائري في أيام الأسبوع. ومع ذلك، كشفت الدراسة أن الفئة الرئيسية للمركبات التي تسهم في مستويات الضوضاء المسجلة كانت من النوع المتنوع. ولما كانت وسيلة النقل هذه بطيئة وتسير على طول الممر الأيمن من الطريق، وبالتالي كان لها تأثير أكثر قابلية للقياس على مستويات الضوضاء المسجلة في المواقع الثلاثة المراقبة. ومع ذلك، فإن مساهمة الشاحنات والشاحنات الصغيرة في مستويات الضوضاء المسجلة كانت كبيرة في جزيرة الدهب والمريوطية خلال يومي الاثنين والجمعة، على التوالي. ومع ذلك، لم يتم مشاهدة هذه المساهمة لشارع كورنيش المعادي، حيث كانت الفئة المتنوعة عاملًا سائدًا للضوضاء خلال يومي الاثنين والجمعة.

الكلمات المفتاحية: الضوضاء؛ وسائل النقل ؛ المرور؛ جهاز مستوي الضوضاء؛ الطريق الدائري.