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Traffic Noise in Arterial Streets: Case of Kirkuk City

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ABSTRACT

Loud noise can be extremely harmful to the auditory system as well as to human health. Noise pollution is primarily caused by traffic noise. The study's goal was to determine how various vehicle types and speeds affected the amount of noise generated by traffic. The two factors were investigated at seven different arterial streets throughout Kirkuk city to measure the noise levels. The measurements were performed during peak hours to compare the result with WHO standards for noise specification. Traffic volume and vehicle speed are shown to be the key elements that determine an increase in noise level.

Keywords: traffic noise; traffic volume; speed; Arterial Street

ضوضاء حركة المرور في شوارع الشرياني: حالة دراسة مدينة كركوك

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الخلاصة

يمكن أن تكون الضوضاء الصاخبة ضارة للغاية بالجهاز السمعي وكذلك بصحة الإنسان. ينتج التلوث الضوضائي في المقام الأول عن ضوضاء المرور. كان هدف الدراسة هو تحديد كيفية تأثير أنواع المركبات المختلفة والسرعات على مقدار الضوضاء الناتجة عن حركة المرور. تم فحص هذين العاملين في 7 شوارع مختلفة في جميع أنحاء مدينة كركوك لقياس مستويات الضوضاء. يظهر حجم حركة المرور وسرعة السيارة على أنهما العنصران الأساسيان اللذان يحددان زيادة مستوى الضوضاء. تم إجراء القياسات خلال ساعات الذروة لمقارنة النتيجة مع معايير منظمة الصحة العالمية لمواصفات الضوضاء.

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الكلمات الرئيسية: ضجيج حركة المرور؛ حجم حركة المرور؛ سرعة؛ شارع الشرياني

1. INTRODUCTION

Kirkuk, an urban city, situated in the North of Iraq, has seen a significant increase in vehicle numbers in the last decade. As a result, noise pollution is out of control in the city, as already reported in previous studies **(S. M. Ali et al., 2017)**. The cause-and-effect cycle is a result of noise pollution caused predominantly by vehicles. This is responsible for heavy and medium truck mobility across the major roadway and excessive noise levels during the day. Recently, the city has seen a lot of expansion and progress, but the development was unplanned. However, the city is becoming increasingly crowded, with open spaces disappearing as a result of many sorts of infrastructure. The road system has remained unchanged, and the road network has not been developed to keep up with the growing number of cars on the road. **Table 1** shows different countries and WHO-defined permissible noise levels **(Kogan et al., 2018)**.

The significant noise sources are industries, vehicles, airplanes, construction, and demolition works. Among the sources, vehicular noise is most common for all classes of cities. Traffic flow, traffic speed, the proportion of heavy vehicles, the road gradient, and the road surface characteristics are the key elements influencing the emission of road traffic noise **(Williams and McCrae, 1995)**. Furthermore, urbanization and population growth contribute to increasing traffic noise levels (**Björk et al., 2006)**. Thus, research has many significant advantages as it raises awareness for architects, experts, and policymakers about the issues of indoor environmental quality **(Hamad and Ibrahim, 2020).** Moving vehicles and the roads are the most common sources of traffic noise and the main source of annoyance and discomfort **(Li et al., 2002)**.

Table 1 Noise Standard

Country	Leq day (dBA)	Leq night (dBA)
WHO	55	45
Germany	55	40
Austria	48-51	36-43
Switzerland	60	50

Numerous factors influence traffic noise levels, which include traffic volume, vehicle speed, driver behavior, vehicle type, and the speed-reducing method **(Kalansuriya et al., 2015)**. The various traffic conditions, including the mix of different vehicle kinds, traffic jams, poor driving conditions, loud honking, poor traffic sense, and other behaviors such as braking and acceleration, are reasons for traffic noise **(Kalaiselvi and Ramachandraiah, 2010)**. Road traffic, by far the

most prevalent of these, is responsible for around 78% of all annoyance-causing noise. Traffic volume contributes significantly to noise levels in an urban area **(Sazegar Niya et al., 2005)**. About 55% of all urban noise is caused by vehicular activity **(Jamrah et al., 2006), (Martin et al., 2006), and (Omidvari and Nouri, 2009)**. Various types of vehicles produce different amounts of noise. Studies have found that fluctuations in the ratio of cars cause changes in traffic noise levels **(Kamineni et al., 2019) and (Agarwal and Swami, 2011)**. An increase in traffic volume makes the noise level higher. A study carried out in Spain's Valdivia showed that city noise is primarily caused by traffic **(Sommerhoff et al., 2004)**. According to the research, there is too much traffic on the city's major roads, and the city noise levels are about 10 dBA louder than the Italian noise standards **(Piccolo et al., 2005)**. Research conducted in Cairo showed that placing restrictions on buses and other commercial vehicles could reduce noise by 10 dB(A) **(S. A. Ali and Tamura, 2003)**. The study has demonstrated that estimating typical noise level descriptors like Leq is de Vehicle speed and noise level have a positive correlation, regardless of the types of vehicles **(Alves Filho et al., 2004)**. Higher vehicle speeds result in more traffic noise more specifically from tire-road interactions **(Sandberg and Ejsmont, 2002).**

One of the main factors affecting traffic noise is honking **(Ramasamy and Alur, 2011) and (Wani & Jaiswal, 2010)**. Horns cause noise levels to rise by 0.5 to 13 dB **(Konbattulwar et al., 2016)**. Regardless of the type of road, honking occurs frequently. Events involving horn noise raise the equivalent noise level (Leq) by 2 to 13 dBA **(Kalaiselvi and Ramachandraiah, 2016)**. These pavements are used as a noise-reducing measure throughout much of Europe. With porous asphalt, noise levels can be reduced by up to 7 dB in comparison to regular asphalt, and an even greater reduction of the noise could be achieved with poroelastic and rubberized pavements **(Ohiduzzaman et al., 2016), (Sirin, 2016) and (Vázquez and Paje, 2016)**.

The research evaluated how much noise from vehicles affected the environment. The investigation's findings show that the observed noise levels exceed the maximum allowable limit (55 dBA) **(Mavrin et al., 2018)**. Noise levels were monitored in Chattogram City in Bangladesh. In 41 sites, 123 data monitoring points were chosen. It was observed that the population experienced excessive levels of noise exceeding DOE-set standards, in Bangladesh, for various land-use patterns **(Masum et al., 2021).** Measurements of street-level noise at 99 locations in New York City showed a range of 55.8 to 95 dBA **(McAlexander et al., 2015)**. A study investigated the spatial and temporal variations in noise levels in Toronto (2014) and found that 80% of locations had noise levels over the allowed threshold of 55 dBA **(Zuo et al., 2014).** Research conducted a study of traffic noise levels at four major roadways in Monastir, Tunisia, and found that the measured noise levels exceed both the WHO and Tunisian environmental regulations' maximum limit **(Chebil et al., 2019)**. The study employed a novel technique to measure noise levels: a cycle-mounted sound level meter in Nagpur, India. A total of 700 monitoring sites were used, and it was discovered that the noise level at every station exceeded the WHO recommendations for ambient sound **(Laxmi et al., 2019)**. The study investigated road traffic noise intrusion level in shops along an arterial road in Nigeria as a function of adherence to the recommended building structure setback. Analysis of the noise descriptors apparently gave a high traffic noise intrusion level in the assessed shops **(Azodo et al., 2019).**

2. SITE SELECTION

For the study on traffic noise, the northern Iraqi city of Kirkuk was chosen as an example of a modern city. Over the past few decades, Kirkuk saw significant urban development, becoming a hub for economic activity with magnificent and contemporary structures and settings. At seven

places along Kirkuk City's major arteries, traffic noise was measured, as shown in **Fig**. **1**. The data were collected at three separate times throughout the day to adequately capture and portray the city's traffic noise when there is a high volume of traffic. The time frame was from 8:00 am to 9:00 am (it is considered to be the time of day with the most traffic.), 1:00 pm to 2:00 pm (The end of the government workers' shift is scheduled at this time), and 6:00 pm to 7:00 pm (evening marketing period).

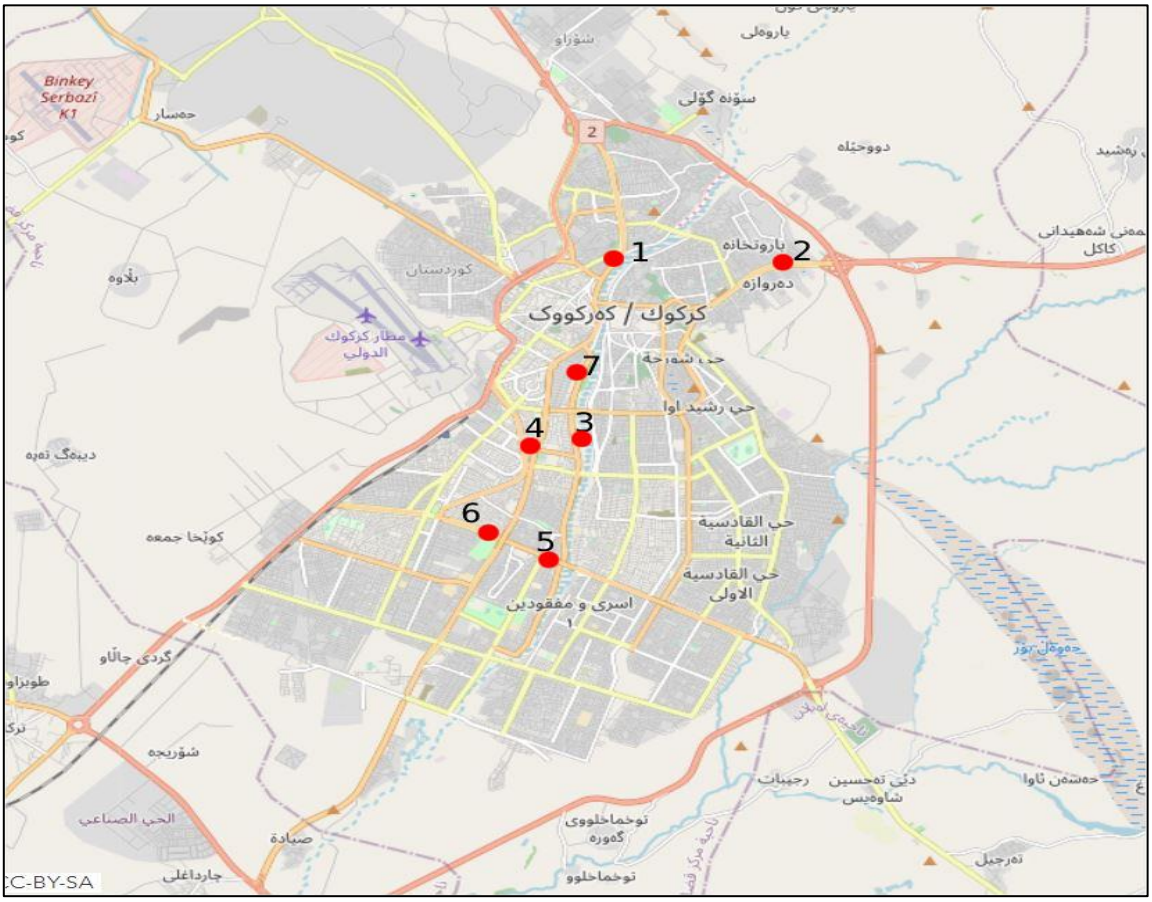

Figure 1. Sites of data collection in Kirkuk city

3. METHODOLOGY AND EQUIPMENT

The device is automatic backlighting, maximum value holding, low battery alert, automatic power off, and power distribution battery operation. China is the manufacturer of the device. This is a portable sound intensity measuring tool that is simple to use and manage. This device was developed to suit the measuring requirements of protection engineers, healthcare, personal protective, offices, and sound quality control in varied situations, which include factory, workplace, traffic, family, and audio system. **Fig**. **2** represents the digital sound level meter used in this study. The average of the maximum and minimum noise levels was plotted on the standard graph. A tripod supported the device, as depicted in **Fig**. **3**.

Figure 2. Sound level meter

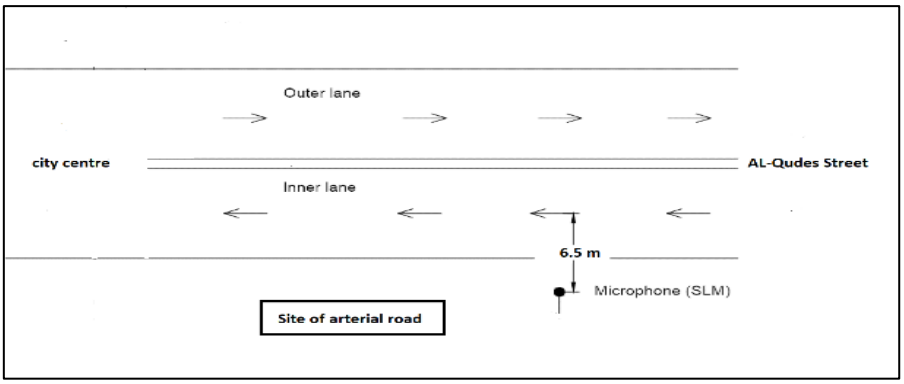

Figure 3. A schematic diagram of the monitored site

Traffic noise measurements were conducted at the seven locations on the main streets of Kirkuk city. A traffic volume study was carried out on seven arterial roads in the city. The following conditions were observed during the monitoring periods at the different locations. Certain streets showed traffic volume exceeding 2000 cars per hour and the speed limit at the low-speed lane of 30 km/h and high-speed lane of 80 km/h. At each location, a traffic volume survey was conducted manually by using camera video, and the speed of vehicles was recorded by using a velocity speed gun, as in **Fig**.**4**. The noise levels have a higher value on weekdays since the traffic volume is larger and has a greater influence as compared to the weekend. Measurements were also taken at different day times on different weekdays during the working day, nonworking day, and peak and non-peak hours. But sound levels may vary depending on the time and location of measurement. Nonetheless, the focus is on-peak hours in this study. The spot speed was measured simultaneously with the measurement of noise. Apart from speed and traffic volume, each region has its degree of Leq, which is determined by the amount of exposure and continuous everyday activities in the area. For example, residential areas, commercial establishments, free space, public utility areas, and playgrounds are all part of the zone pattern. Each location generates its completely uncontrollable noise. This scenario demonstrates that the background noise level is intimately associated with certain people's actions, such as vehicles honking, speeding, producing extreme noise emissions from big engines, and other vehicle modifications which significantly impact the background noise level during monitoring in the field. Moreover, parameters include vehicles that are no longer in service, extreme engine vibration and noise caused by freight vehicles, driver's

actions including strong horn honking and loud music, ineffective law enforcement, and congested flow caused by traffic management during rush hour. **Fig**. **(5) to (11)** show noise levels in sampling locations during rush hours.

Figure 4. Velocity speed gun

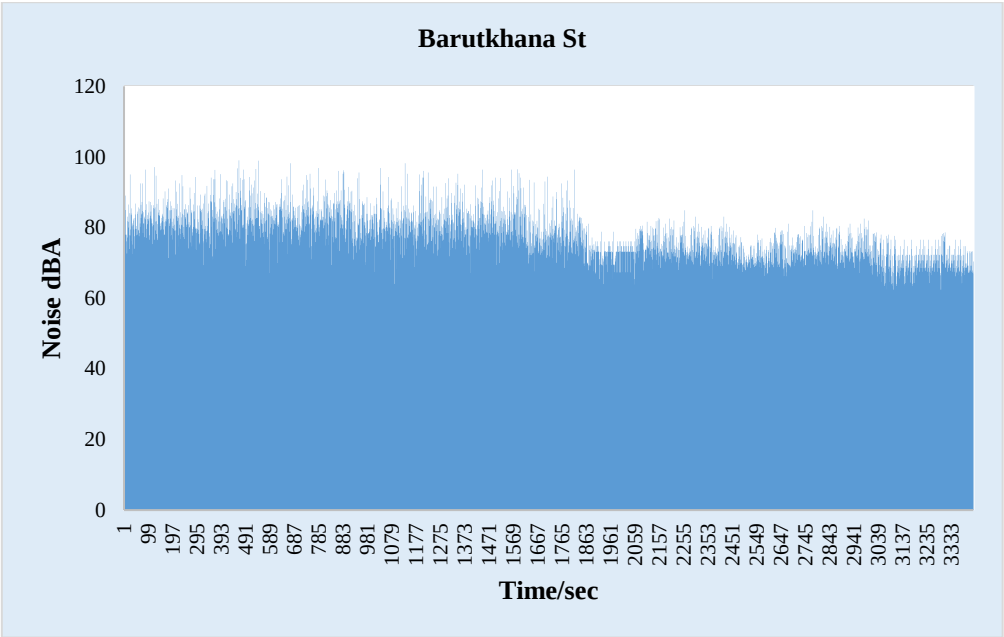

Figure 5. Noise level of Barutkhana St

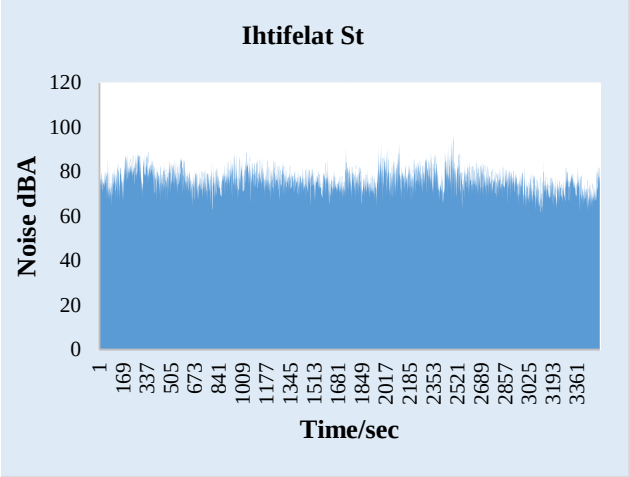

Figure 6. Noise level of Ihtifelat St

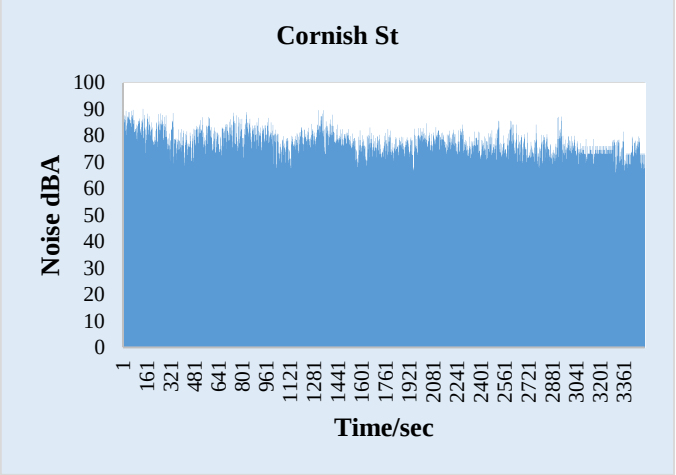

Figure 7. Noise level of Cornish St

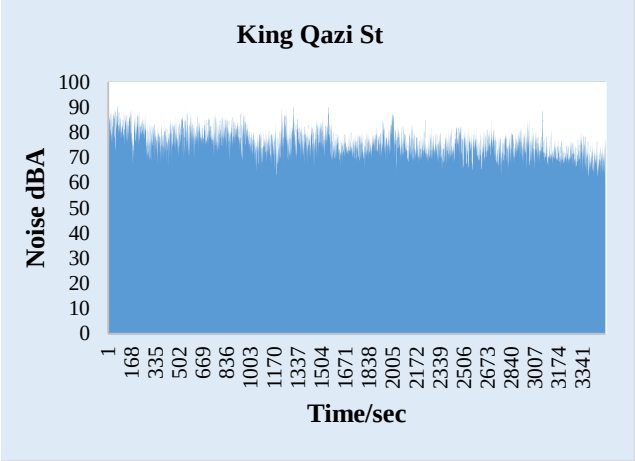

Figure 8. Noise level of King Qazi St

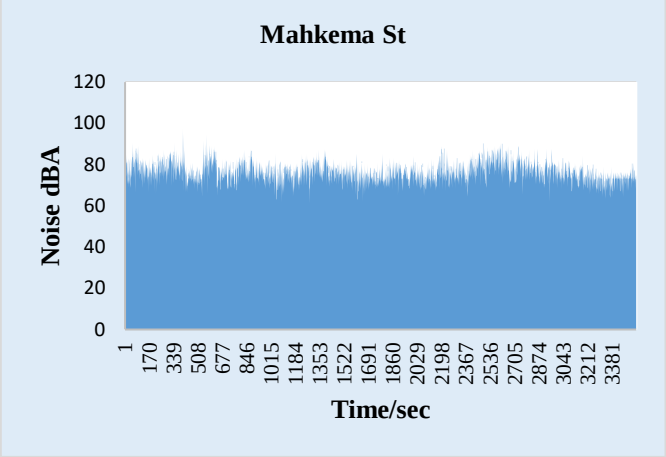

Figure 9. Noise level of Mahkema St

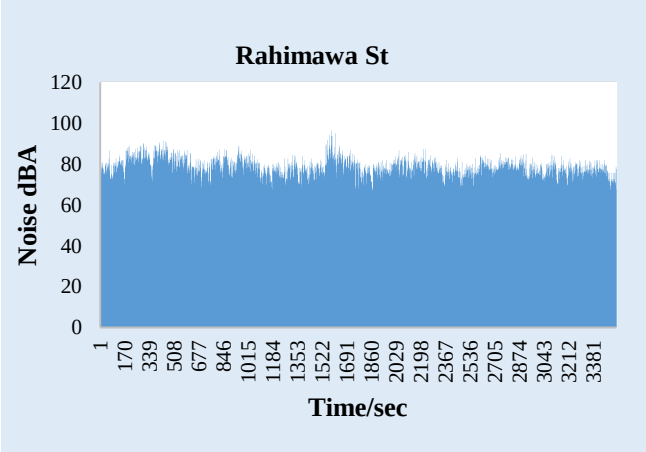

Figure 10 . Noise level of Rahimawa St

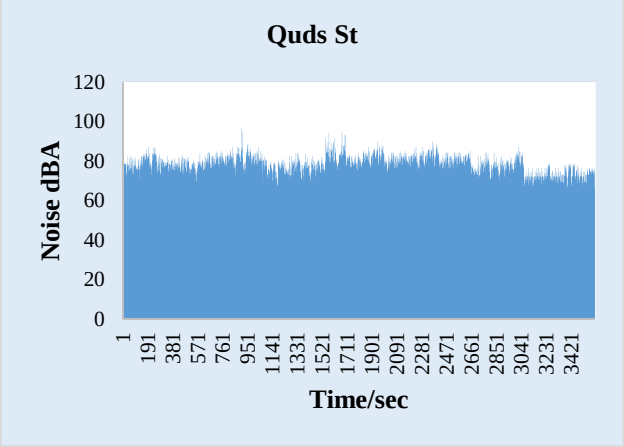

Figure 11. Noise level of Quds St

4. RESULTS

Arterial roads represent the mobility of traffic. The arterial roadways are designed to accommodate high speeds and are utilized in large-scale movements. Therefore, they are rather large and wide. They include Mahkema Street, Cornish Street, King Qazi Street, AL-Quds Street, Rahimawa Street, Ihtifelat Street, and Barutkhana.

Table 2 The dataset sample values

Site	Coordination		Traffic volume Vehicles/hr	Average speed (km/hr)	Noise dBA
	North	East			
Mahkema St	35°25'20.1"N	44°22'46.6"E	1409	67	78.8
Cornish St	35°26'51.2"N	44°23'10.2"E	1297	61	75.07
King Qazi St	35°27'56.2"N	44°23'24.1"E	1309	63	77.9
AL-Quds St	35°26'47.4"N	44°22'33.1"E	1542	65	76.6
Rahimawa St	35°29'36.7"N	44°23'43.5"E	1342	62	79
Ihtifelat St	35°25'39.5"N	44°21'56.9"E	1562	68	80
Barutkhana St	35°28'50.8"N	44°26'01.5"E	1287	63	83

4.1 Mahkma Street

The major function of the arterial road is to connect small urban places to the major trip generators. It is generally provided in the fastest type of travel and usually has low accessibility on the neighboring roads. Other locations in the study area might be classified as sensitive zones because Educational institutions (schools, universities, and institutes), courthouses, religious, and health facilities are all located in this neighborhood (clinics, hospitals, nursing homes, etc.), as in **Fig**. **12**.

Figure 12 Aerial view of Mahema Street

The Leq value in this zone is (78.8) dBA. The former Leq value in this area crossed the safety limit. The figure shows that the noise level is the maximum when the traffic volume is the

maximum. However, the traffic volume rate is (1409 per/hr.) vehicle, as in **Fig. 13.** The traffic volume was reported to be high in the vicinity of Kirkuk's courthouse. The area's educational and health facilities are close to the arterial road. Equations are linear regressions. These equations predict noise value (dBA) without using the sound level meter. R2 refers to positive relations between dependent noise (dBA) and independent variables (traffic volume and speed).

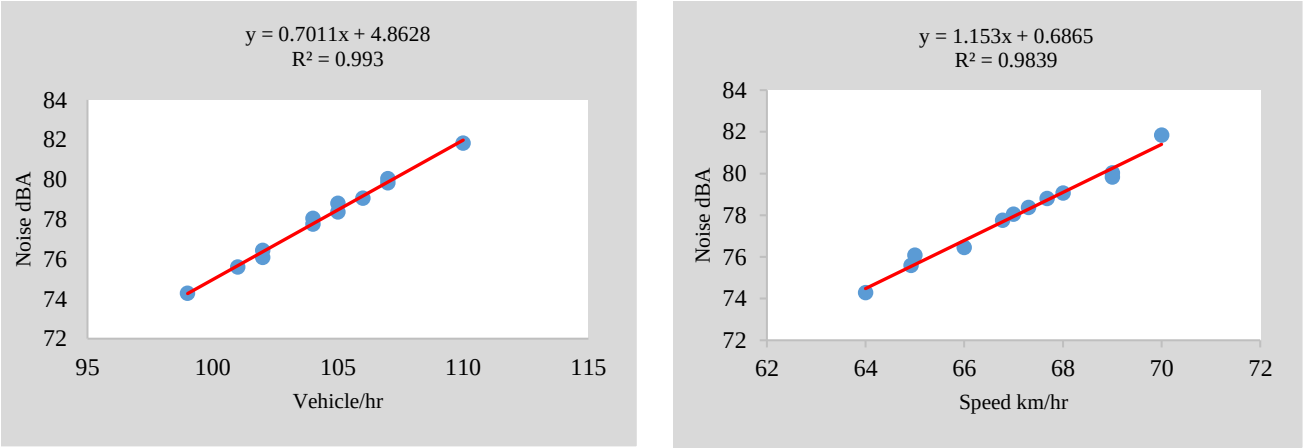

Figure 13 Noise of Mehkama street

4.2 Cornish Street

To determine the impact of noise levels along the arterial road, traffic noise is the main reason for creating extreme noise levels on Cornish street, as in **Fig**. **14**.

Figure 14. Aerial view of Cornish street

The noise level is (75.07 dBA) since traffic changes depending on various factors such as the rate and vehicle composition. Particularly, when the rate of the automobile is enormous (over 100 vehicles per 5 minutes), Leq went beyond (71dBA). The analysis of the composition of vehicles on the road revealed that trucks, buses, and containers generally impact the total noise levels on

Cornish arterial road. Therefore, the highest Leq was recorded at Cornish street owing to the sound of heavy vehicles' engines which were observed during monitoring. Additionally, it is observed that a steady stream of poorly maintained cars, the horns blaring, roadside encroachment, and bad road conditions were confirmed to be the source of the excessive noise level. Moreover, the ratio of heavy vehicles, the characteristics of the road surface, the velocity of the vehicles, and the composition of the type of vehicle may considerably contribute in this case to an increase in the noise level, as in **Fig**. **15**

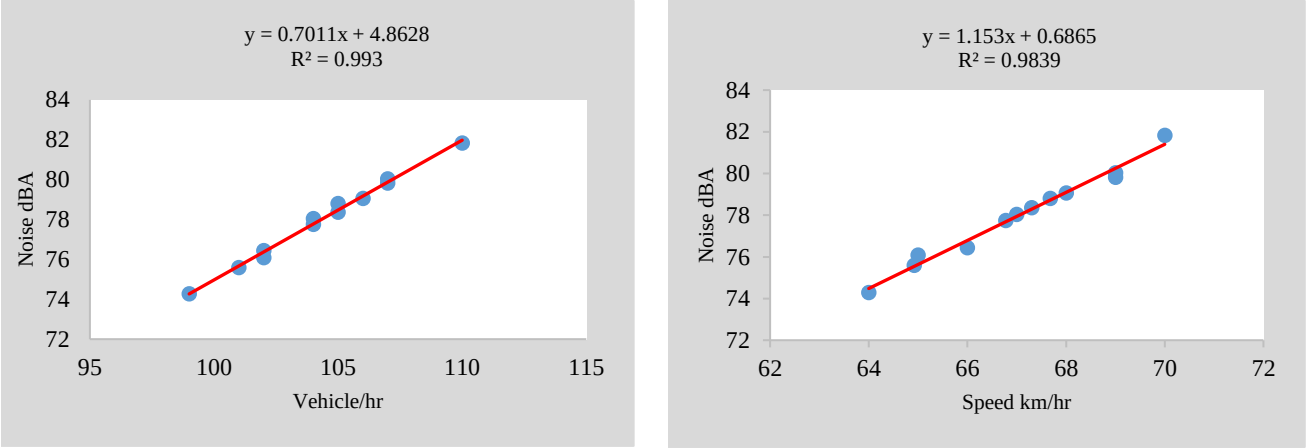

Figure 15. The noise of Cornish street

4.3 King Qazi Street

It is functioned to accommodate large traffic demands at greater speeds, especially through traffic. It also prioritizes traffic flow over access to nearby properties since the road functional class is arterial, as in **Fig**. **16**.

Figure 16. Aerial view of King Gazi street

The reason behind higher noise levels at this point because high traffic flow rate (1309) from five directions. The loudest place near the silent zones was Jumhouriya hospital (77.9 dBA). This noise was attributable to the fact that the hospital was situated in the city's center. Concerning average speed variation during the peak hour under analysis, it was found that it follows the same trends

with roads that have the same geometric characteristics. It was also observed that the mean speed during off-peak periods was slightly increased compared to that of the peak period due to lower traffic volumes. The noise levels of light, medium, and heavy vehicles are proportional to their speed, ranging from 59 to 67 kilometers per hour for all kinds of vehicles. The impact of larger vehicles on traffic noise is greater than that of cars. It should be pointed out, however, that there are many factors along traffic volume and speed that affect noise levels, such as driver behavior, parking availability, type of traffic control, and the type of adjacent land uses. Apart from that, the high value of Leq was further enhanced by the wailing sirens of police warning engines and ambulances. As a result, the noise level was increased significantly, and the increased noise level was largely caused by airborne noise, as in **Fig**. **17.**

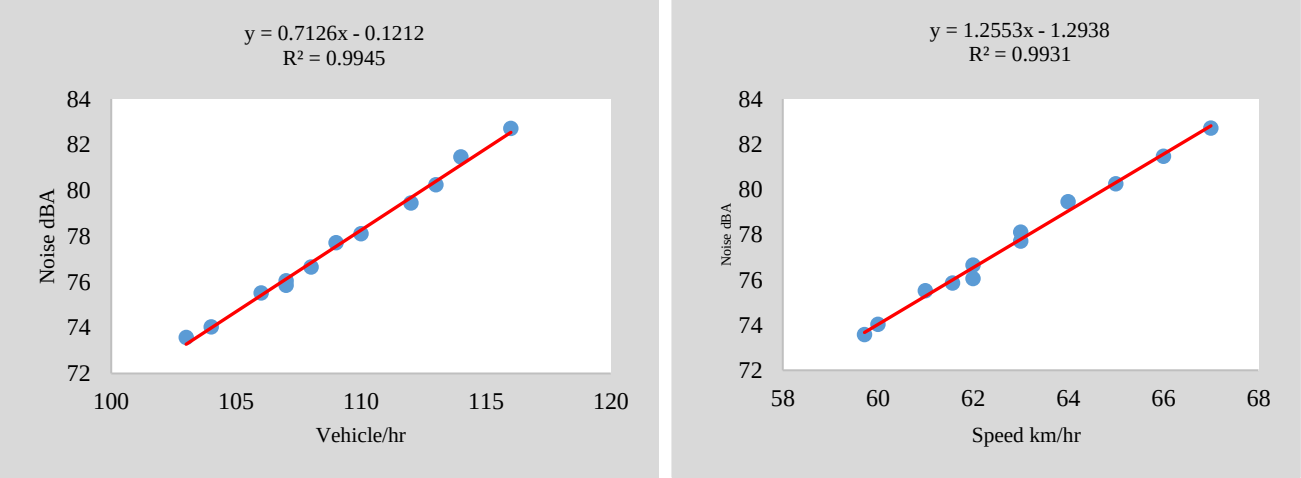

Figure 17. The noise of King Qazi street

4.4 Al Qudes Street

Al Quds Street is considered to be a commercial area, and the sound levels must not exceed 65 decibels World Health Organization in the commercial area. The noise level at the location was 76.6 dB (A) at 6:00 pm during peak hours. The number of cars was (1542), and the average speed is (65 Km/hr). The noise level was shown to have a positive correlation with vehicle speed and traffic volume. However, in the case of the arterial road, which is expected to carry large volumes of traffic, the noise level during the rush hour was higher. Little variation is due to variation in the number of vehicles, as in **Fig**. **18.**

Figure 18. Aerial view of Al Qudes street

The same trend was also seen on other roads of the same characteristic. Vehicle speed and traffic volume are considered the main noise sources, which are predominantly attributable to vehicular motor traffic and the gathering of the public for marketing and visiting malls because many markets, restaurants, and supermarkets line Al Quds Street, resulting in noise levels that exceed the guidelines that are recommended by WHO standard. The analysis has shown that the noise is very dependent on vehicle speed and traffic volume. Cars, in particular, and buses in general, are the main contributors to increased noise levels in this area.

Fig. **19** shows that in the site's study area can be seen the value increases, so noise levels were quite high during the peak hour. This increase is just because peak hours will have more traffic movement. Due to heavy movement of vehicles to reach workplaces people may face some unexpected situation this leads the traffic jams, which leads to the horn for clearing the way. So, this nuisance also increases the noise level during peak hours. So, the source of noise is mostly due to motor vehicle traffic. The noise levels are sufficiently increased in the location due to traffic noise.

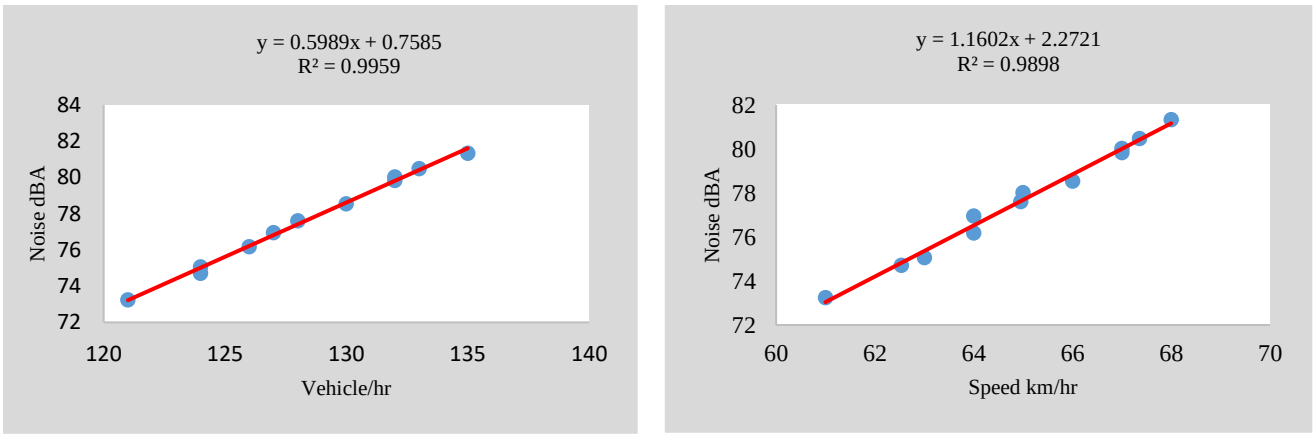

Figure 19. Noise of Al Qudes street

4.5 Rahimawa Street

This road provides mobility so traffic can quickly move from one place to another, as in **Fig**. **20.**

Figure 20. Aerial view of Rahimawa street

In the Rahimawa intersection, the noise level (79 dBA) went beyond the acceptable limit by WHO. The noise level depends not only on the traffic volume but also the horning of vehicles. From the figure, it is observed that the fluctuation of noise level follows the fluctuation trend of traffic volume. However, the average sound level fluctuates due to the variation of various activities at the intersection. Most of the noise at the signalized intersection is due to the deceleration of vehicles when they approach an intersection and acceleration when leaving the intersection after getting the green light. The increase in noise levels is due to the tendency of drivers to blow their horns by the end of the amber period and the start of the green period, as in **Fig**. **21.** Nonetheless, the mean volume of traffic ((1342) is from high to the highest range, but heavy vehicles create the majority of the instant noise. The movement of heavy vehicles such as trucks, trailers, and buses significantly impacts the noise level. During the classified traffic volume survey, it was found that the percentage of heavy vehicles is significant, which contributes more to the noise level. They do not just make a lot of noise but also restrict the free movement of vehicles and cause constant traffic congestion on the major arterial road during peak hours. Since traffic noise concerns people's health, strict rules and regulations must be enforced.

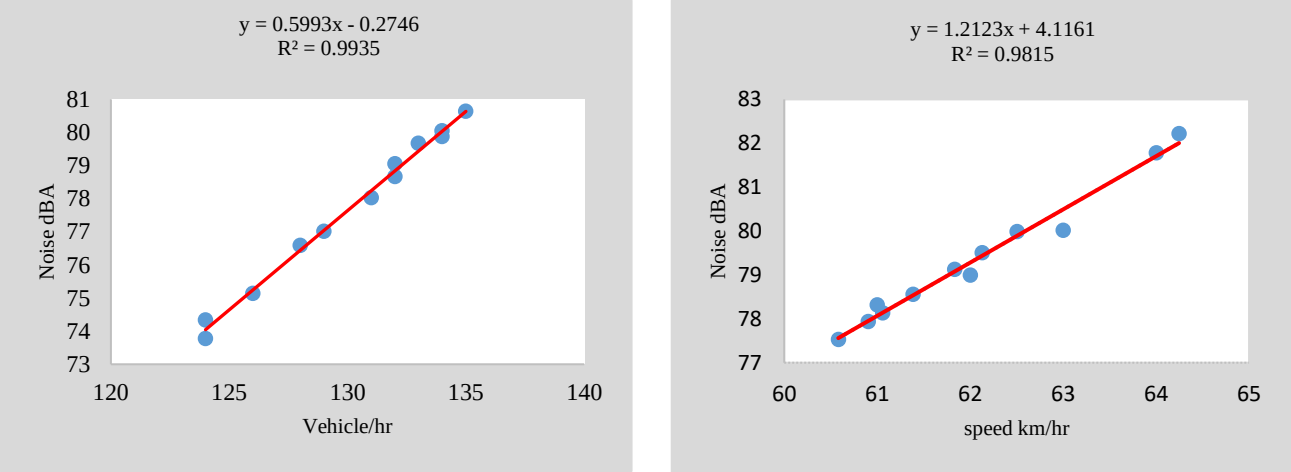

Figure 21. The noise of Rahimawa street

4.6 Ihtifelat Street

It is laid inside the city, which links Qudes street and Baghdad street and enables high-volume traffic transportation, as in **Fig**. **22.**

Figure 22 Aerial view of Ihtifelat street

During the peak hour, there are more severe levels of noise during the time of systematic travel (home-school/work) since this happens all of the time. **Fig**. **23** shows the average noise levels in peak hours, it observed that variation of noise levels for the traffic volume and speed, and the present study results clearly show that the peak hours were very high values that crossed the limit of WHO. On weekdays generally, peak hour's movement vehicles are more due to rushing towards office work as Kirkuk city is famous for oil city, so many of them depend on their private transport mode.

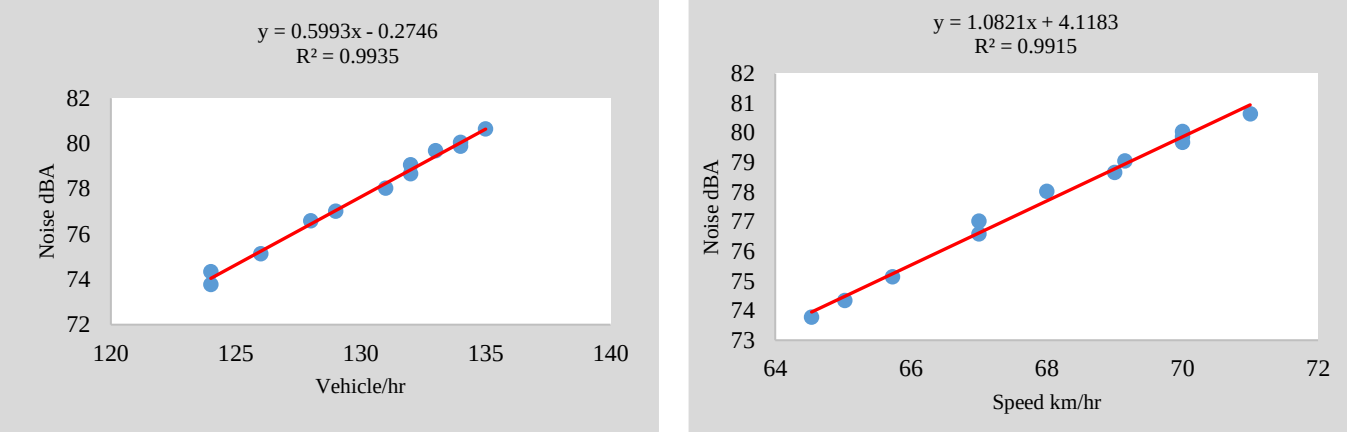

Figure 23. The noise of Ihtifelat street

4.7 Barutkhana Street

The amount of traffic significantly affects the level of noise that is evident, as more automobiles imply greater noise. Barutkhana is the noisiest area of the region (83 dBA), and the main reason is traffic noise from the state highway that runs alongside it, as in **Fig**. **24.**

Figure 24. Aerial view of Barutkhana street

The values of Leq measurements in the Barutkhana region, which is regarded as the major artery in Kirkuk city, showed a maximum value of noise was (83.9) dBA, which was extremely high in comparison to the permissible limits for the main road benchmarked as 60-70, while minimum value was (76.28) dBA during peak hour. It is worth mentioning that noise levels are substantially more severe in both peaks and off hours than the allowable levels. **Fig**. **25** shows that as speed increased, so did the level of noise, and vice versa. In comparison to the other sites, this value is higher and might be due to the site's increased traffic volume and wider lane width, enabling drivers to accelerate their vehicles. Nonetheless, the examination of traffic speeds revealed that vehicles at this site exceeded the speed limits of 78 km/h.

Also, the noise level was determined primarily by the site layout and the number of traffic vehicle services. Near the intersection, especially Barutkhana arterial road, has very elevated traffic volumes (2059 vehicles) and is responsible for unusually high levels of noise. In addition, the rate of honking is very extreme when traffic gets crowded on the highway. Therefore, many drivers tend to honk their horns excessively to alert other cars to their objectives. This area is considered a high noise risk zone and is important in the perspective that within a 100-meter radius are residential and medical facilities.

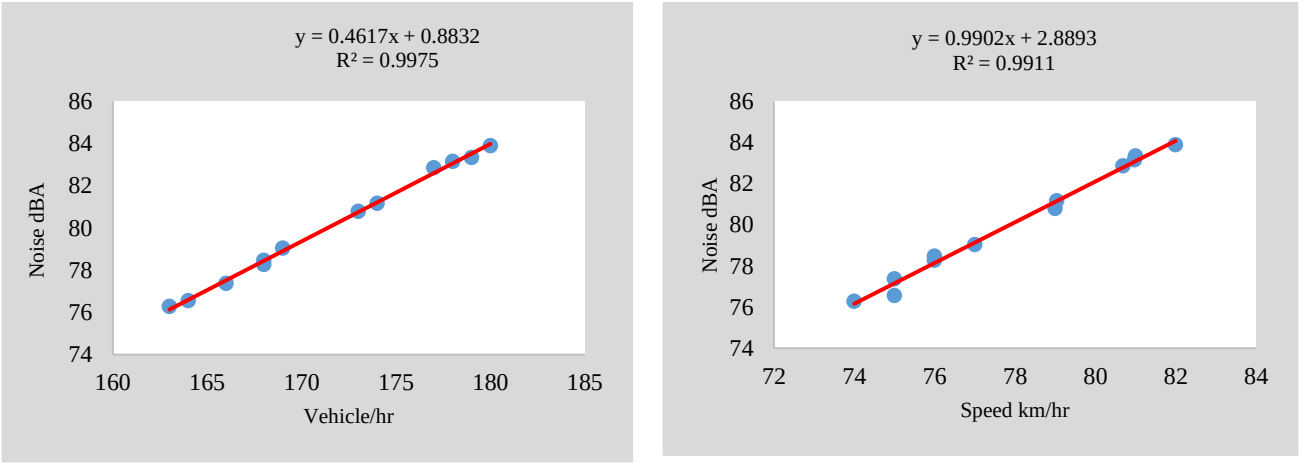

Figure 25. Noise of Barutkhana street

5. CONCLUSIONS

This study investigated traffic noise seven different locations. The author extensively measured road traffic noise levels at 7 sites covering various road types, counting the number of vehicles per hour and speed. Data on traffic characteristics and noise indices were recorded and analyzed to meet the study objective. It is found that the main factors that determine the increase in noise level are traffic volume, vehicle speed, and road functional class. The vehicle composition revealed that heavy vehicles like trucks, buses, and lorries significantly contribute to the average noise level. Additionally, the noise levels were affected by human activities and the environment. The study was conducted on different weekdays and weekends for different day periods and compared with ambient noise standards.

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