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Environmental noise with solutions: A case study

S. Saber

Department of Civil Engineering, College of Engineering, University of Salahaddin –Erbil, Iraq

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ABSTRACT

In this paper to examine the noise pollution level in the environment, the generated noises from outdoor, indoor, and road traffic sound sources (such as aircraft, road traffic, inside residential buildings, library, restaurant, classroom, administration office, construction equipment, and electrical generator) were monitored. Totally, sound pressure level (SPL) at 177 sites was measured. For instance, maximum recorded SPL values for indoor and outdoor were 87 dB and 105 dB, respectively. Usually, SPL value close to 110 dB causes hearing impediments. The obtained data were arranged and compared with the standards. To show the impact of distance on noise pollution, SPL values were measured at different distances from outdoor and road traffic sound sources. A mathematical model was derived to explain the influence of distance on SPL value. As a result, the increase of the distance between sound source and receiver was caused noticeable decreasing of noise pollution. Finally, several solutions were outlined to reduce noise pollution from the sound sources, transmission path, and receiver.

1. Introduction

Noise is any sound–independent of loudness–that can produce an undesired physiological or physiological effect in an individual, and that may interfere with the social ends of an individual or group. These social ends include all of our activities–communication, work, rest, recreation, and sleep (Davis and Cornwell, 2008). Furthermore, noise pollution commonly defined as an impurity of unpleasant sounds (Carera and Lee, 2000), is an environmental phenomenon to which human are exposed before birth and throughout life. Commonly, urbanization, the increase of population and number of vehicles, and construction huge number of projects in various fields cause increasing of the environmental noise pollution. In Erbil City (the capital city of Iraqi Kurdistan Region) and like other capital cities, rapid development and investment, the increase of population and number of vehicles, upgrading of Erbil International Airport, and wide extension of the residential, commercial and industrial areas, different projects etc. led to attention of the noise pollution problems in this city, Fig. 1.

In literature, quite a number of noise pollution studies were published, for instance, traffic noise pollution (Mehdi et al., 2011; Barros and Dieke, 2008); noise from speech interference (Zaheeruddin and Jain, 2008); noise emission evolution on construction sites (Ballesteros et al., 2010); determination of safe distance between roadway and school buildings (Avsar and Gonullu, 2005). But generally in Iraq and specifically in Erbil City, a gap of knowledge and a lack can be noticed in the field of noise pollution studies. So far, recognized information on noise pollution is very limited in the extant literature. Thus, the aims of the current study were to: 1) examine the generated noise from outdoor, indoor, and road traffic sound sources, 2) find the influences of distance between sound source and the receiver and barriers on sound pressure level (SPL), and 3) outline a number of solutions to minimize the produced noise from different sound sources.

2. Materials and methods

2.1 Sound sources

Based on Kiely (1997), noise can be emitted from a point source (electric fan) an aerial source (discotheque) or a line source (moving train). Noise diffuses rapidly from its source and at an adequate

* Corresponding author.
E-mail address: S-saber@yahoo.com (S. Saber)

distance from the source the noise is not felt. Noise pollution comes from a wide variety of sources, including: road traffic, rail traffic, air traffic, industrial equipment, construction activities, sporting and crowd activities, neighborhood and domestic noise. In the present study, all types of the sound sources (point, areal, and line sources) were monitored in Erbil City. The collected data are shown in Tables 1 to 2 and Figs. 2 to 6.

Fig.1. Erbil City (Travel Iraqi Kurdistan, 2012)

2.2. Data gathering

In Erbil City, generated noise pollution were measured from a number of outdoor and indoor sound sources such as air craft, under pass, residential houses (bed and living rooms), electrical generators, libraries, restaurants, road traffic, playing yard, classroom, office, inside and outside building, construction equipment (excavator, steel roller, rear-dump truck, and tractor shovel), and domestic electrical devices (refrigerator, exhaust fan, laser printer, computer, ceiling fan, electrical boiler, washing machine, juice machine, vacuum cleaner, hair dryer, and electrical shaver), Tables 1 and 2. SPL values were reported for the aforementioned sound sources. Regarding road traffic noise pollution during day time, SPL values were measured at Erbil-Kirkuk, Erbil-Shaqlawa, Qazi Muhammad, Erbil-Koya, Kurdistan, and Barzani Namr Roads, Figs. 2 to 5.

Table 1
SPL (dB) values from different outdoor sound sources

No.	Location (Sound source)	Description	SPL (dB)
1	Zanco Q.	Aircraft flying over City (8:40*)	73
2	Under pass	Erbil stadium-Akram Mantk overpass (18:92)	92
3	Under pass	Erbil stadium-Franso H. overpass (18:05)	83
4	Wall drill machine	At 7m distance- Zanco Q. (10:24)	71
5	Small electrical generator	At 7m distance-Zanco Q. (10:20)	65
6	Zanco Q.	Aircraft flying over City (9:23)	80
7	Traffic noise	Erbil-Kirkuk Road-College of Engineering	70
8	Under pass	Erbil stadium-Franso H. overpass (18:25)	85
9	Playing yard	Zanco Q. (23:35)	69
10	Playing yard	Zanco Q. (0:20)	72
11	Large electric generator	At 15m distance-Zanco Q. (12:35)	69
12	Playing yard	Zanco Q. (20:55)	79
13	In front of building	Kildan Culture Society –Ainkawa (17:38)	81
14	Excavation machine	Family fun Project (9:40)	89
15	Bending plate (air duct)	Family fun Project (9:40)	105
16	Small roller machine	Family fun Project (9:40)	105
17	Rear-dump truck	Family fun Project (9:40)	88
18	Tractor shovel	Family fun Project (9:40)	93
19	Electrical boiler	Zanco Q. (1:01)	48
20	Large electrical generator	Zanco Q., At 1m distance (22:45)	103
21	Traffic noise	Erbil-Kirkuk Road-Central library (9:00)	80
22	Traffic noise	Qazi Muhammad R.-Ahmadi-Khani School (9:20)	76
23	Traffic noise	Kurdistan R.-Nazhdar Haidari Hospital (9:10)	70
24	Traffic noise	Barzani Namr R.-Kurdistan Prep. School (8:00)	75
25	Traffic noise	Erbil-Koya R., at 10m distance (8:15)	67
26	Traffic noise	Erbil-Shaqlawa R., Shorsh School (9:00)	73

* Hour

To show the effect of distance on the generated noise from an electrical generator, SPL values were recorded at distances of 1m, 10m, 20, 30m, 40m, 50m , 60m, 70m, 80m, 90m, 100m, and 110m (Fig. 6). To examine the influence of distance on the produced noise from road traffic, SPL values at Kurdistan Road were measured at distances 0m, 10 m, and 20 m; while SPL values were recorded at 1m, 10m, and 20m at Barzani Namr Road. Additionally, the effect of barrier on reducing noise pollution was studied. The SPL values were measured using Sound Level Meter, NA-90, RION CO. LTD.

3. Results and discussion

3.1 Outdoor noise pollution

SPLs (dB) values for outdoor sound sources are given in Table 1. The SPL values measured from flying of aircraft over Erbil at Zanco Quarter were ranged between 73 to 80 dB. The recorded values were remained within the standards (120 dB) stated by Shaheen (1974). In underpasses located near to Erbil stadium, the minimum and maximum SPL values were 83 and 92, respectively. In literature; Shaheen (1974) reported that the SPL of heavy truck at 16 m is between 80 dB and 100 dB.

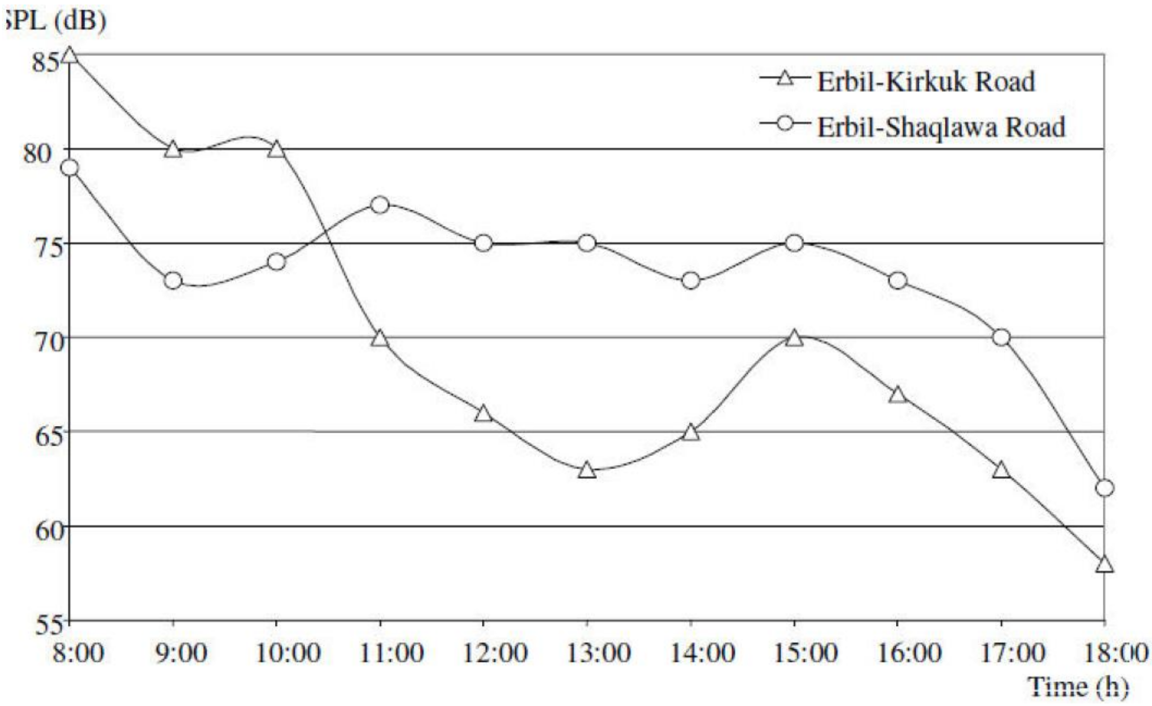

Fig. 2. Variation of SPL (dB) values at Kirkuk and Shaqlawa Roads versus time

The obtained results agree with the data published by Phan et al. (2010). The SPL figures for both wall drill machine and small electrical generator at 7 m distance were 71 and 65 dB, respectively. The produced SPL from both wall drill machine and small electrical generator were similar to SPL produced by sewing machine, 60 dB to 80 dB (Shaheen, 1974). Minimum and maximum SPL values for large electrical generator at 15m and 1m distances were 69 and 103 dB, respectively.

Obtained SPL value of 103 dB showed that the produced noise value was exceeded 100 dB at the selected location, which is very close to the level of 110 dB at which hearing impediments may take place (Mehdi et al., 2011). To reduce the SPL produced by these types of generators it is advised to put inside room (at acceptable distance from residential area). Activities from playing yards at night were produced SPL values from 69 to 79 dB; it can be regarded as crowded area. The crowded area (particularly at night) affects on humans' rest time and public service buildings. According to the World Health Organization (WHO) outdoor environmental noise exposure guidelines, SPL values of > 66 dB could make people feel seriously annoyed (Mehdi et al., 2011).

On the other hand, SPL values generated from excavation machine, small steel compactor, rear-dump truck, tractor shovel, and bending plate were ranged between 88 dB to 105 dB. As mentioned by Davis and Cornwell (2008), conversation is difficult for such type of SPL values and ear protection is essential for sustained exposure. Furthermore, SPL value close to 110 dB affects on human hearing (Mehdi et al., 2011).Noise emission from electrical boiler was 48 dB. Based on Waly (1990), the increase of fluid flow and number of valves were caused increasing in SPL value. The range of SPL for traffic noise was 67 to 80 dB; the recorded data agree with Rahmani et al. (2010).

According to (Carera and Lee, 2000), the present work remains within the normal traffic. Abo-Qudais and Alhiary (2007) concluded that the minimum noise level is significantly affected by pavement surface texture and lane width. Based on WHO outdoor environmental noise exposure guidelines, SPL values of > 66 dB could make people feel seriously annoyed (Mehdi et al., 2011).

3.2 Indoor noise pollution

Indoor SPL (dB) values from different sound sources are shown in Table 2. SPL figures in residential house (especially bed and living rooms) were varied from 35 dB to 59 dB. The obtained results in the current study were surpassed the standard limits issued by Davis and Cornwell (2008). Other SPL values of 55 dB (from 7:00 am to 7:00 pm), 50 dB (from 7:00 pm to 10:00 pm), and 45 dB (from 10:00 pm to 7:00 am) were reported by Zannin et al. (2002) at residential areas. High SPL values inside buildings were due to finishing and insulation materials. Inside libraries, the minimum SPL was 43 dB while the maximum was 58 dB, the smaller limit (less than 43 dB) mentioned by Davis and Cornwell (2008); Kiely (1997); Waly (1990). Finishing and insulation materials were caused generating high SPL values. Inside restaurants, SPL values of 72 dB and 75 dB were recorded.

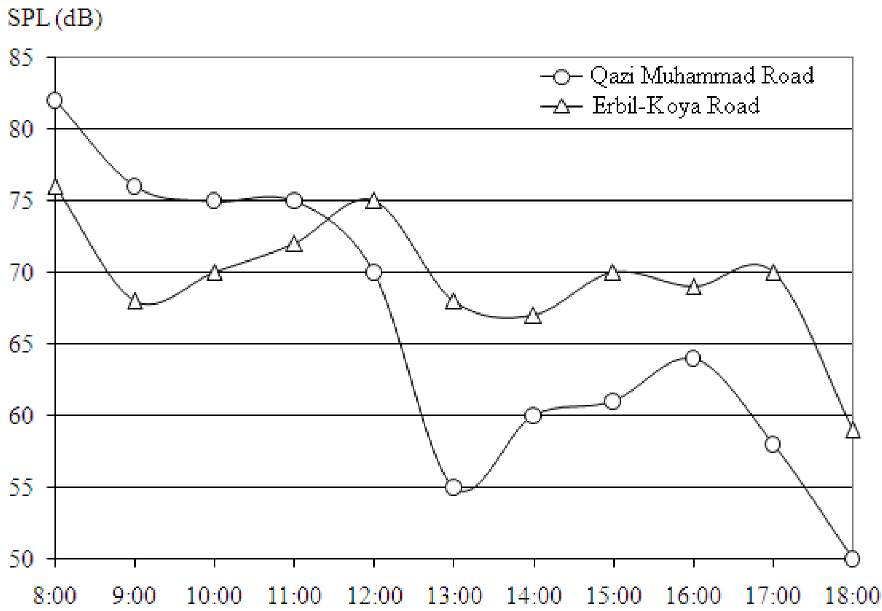

Fig. 3. Variation of SPL (dB) values at Qazi Muhammad and Erbil-Koya Roads versus time

The recorded values were greater than 65 dB (business office), it can be regard as crowd area. According to Zaherudeen and Jain (2008), the present data remain within high noise level (65 dB to75 dB). In classroom, the reported SPL value was 61 dB. Based on Zaherudeen and Jain (2008), it regards as medium noise level. In addition, according to Davis and Cornwell (2008); Kiely (1997), this type of SPL it can be regarded as conversational speech. In business office, a SPL figure of 53 dB was recorded; the present result was remained within low to medium low noise levels (Zaheeruddin and Jain, 2008). Furthermore, it was agreed with the reported limits for business offices (Davis and Cornwell, 2008). Inside and outside SPL values for Kildan Culture Centre in Ainkawa were 59 dB and 81dB, respectively.

It can be noticed that the finishing and insulation materials, wall, PVC doors and windows, and double glasses were caused to reduce of noise pollution. Information reported by Davis and Cornwell (2008) confirmed the present results. Regarding domestic electrical devices such as refrigerator, exhaust fan, laser printer, computer, ceiling fan, electrical boiler, washing machine, electrical juice machine, vacuum cleaner, hair dryer, and electrical shaver; the minimum SPL value was 48 dB while the maximum was 87 dB. Similar ranges were recorded for refrigerator, air conditioning, and sewing machine by Shaheen (1974).

3.3 Road traffic noise pollution

Figs. 2 to 5 showed the variation of SPL values during day hours from different roads: Erbil-Kikuk Road, Erbil-Shaqlawa Road, Qazi Muhammad Road, Erbil-Koya Road, Kurdistan Road, and Barzani Namr Road. Fig. 2 showed the SPL measurement for Erbil-Kirkuk and Erbil-Shaqlawa Roads. The SPL values were higher during the peak hours particularly during the mornings, and then decreased gradually until 11 am. This decrease continued until 1 pm for Erbil-Kirkuk Road and 2 pm for Erbil-Shaqlawa Road. From 2 to 3 pm, the SPL increased and then decreased gradually for both roads (Fig. 2). Reported data by Mehdi et al. (2011) confirmed the present results.

An almost similar trend for Qazi Muhammad and Erbil- Koya Roads is illustrated in Fig. 3, where the highest SPL was recorded during the morning followed by a decrease in the middle hours. A sudden decrease in SPL was observed for Qazi Muhammad Road after 12 pm. From 1 pm onwards, the increasing SPL trend was similar to that observed for Erbil- Koya Road. At the edge of the roads, SPL values of 50 to 85 dB were recorded. This result agrees with the average value 85 dB mentioned by Davis and Cornwell (2008); Kiely (1997). To observe the changes in SPL level with distance, the noise level was measured at 1, 10, and 20 m distances for two nearby roads, Kurdistan and Barzani Namr Roads. Figs. 4 and 5 showed the effect of distance on SPL for these roads. The increase in distance between the sound source and receiver led to a decrease in SPL values; the present results agree with the published data by Avsar and Gonullu (2005).

3.4 Effect of distance on SPL

The variation of SPL (dB) versus distance for large electrical generator is illustrated in Fig. 6. It can be seen from the aforementioned figure that the SPL values were decreased as the distance between the sound source and listener was increased. The SPL value for large electrical generator at 1m distance was 103 dB, while at distance 110 m was 56 dB.

Table 2
SPL (dB) values from different indoor sound sources

No.	Location (Sound source)	Description	SPL (dB)
1	Living room	Residential house-Mamostayan Q. (20:05*)	59
2	Bed room	Residential house-Mamostayan Q. (20:10)	48
3	Bed room	Residential house-Zanco Q. (10:24)	36
4	Library	College of Engineering	43
5	Central Library	Univ.of Saladdin-Erbil	47
6	Iskan Restaurant	Iskan Road	72
7	Chrakhan restaurant	Sharawane Road (17:23)	75
8	Classroom	College of Engineering (9:55)	61
9	Corridor	College of Engineering (11:15)	72
10	Library	College of Engineering (11:20)	58
11	Living room	Residential house-Zanco Q. (9:05)	39
12	Bed room	Residential house-Zanco Q. (9:08)	35
13	Office room	Kildan Culture Society –Ainkawa (17:35)	53
14	Inside building	Kildan Culture society –Ainkawa (17:47)	59
15	Refrigerator	Zanco Q. (0:45)	49
16	Exhaust fan	Zanco Q. (0:50)	62
17	Laser printer	Zanco Q. (0:54)	68
18	Computer (Lap top)	Zanco Q. (0:56)	52
19	Ceiling fan	Zanco Q. (0:58)	64
20	Washing machine	Zanco Q. (21:45)	71
21	Electrical juice machine	Zanco Q. (21:47)	87
22	Vacuum cleaner	ZancoQ. (21:50)	77
23	Hair dryer	Zanco Q. (21:56)	61
24	Electrical shaver	Zanco Q. (21:59)	72

* Hour

Kiely (1997) stated that the distance adversely affects the sound intensity; the obtained findings were agreed with Kiely (1997). Correlation models can be used to describe the variations in SPL values with distance. A mathematical model was derived to represent the relationship of SPL and the distance between the sound source and receiver (m).

$$SPL\ (dB) = 106.87\ D^{-0.1328} \quad (1)$$

Where, D is the distance between the sound source and receiver (m). The coefficient of determination (R2) for the mathematical model was 0.9846, indicating good relationship. In literature, exponential mathematical models were reported by Ballesteros et al. (2010).

3.5 Proposed solutions

Barriers decrease the noise pollution (Avsar and Gonullu, 2005); therefore it is recommended to: 1) construction of fence (bearing wall) for all buildings; especially for public service buildings (kindergarten, schools, institutes, universities, hospitals…etc.) and avoiding perforated fences (Jadan et al., 1997), 2) using high quality materials for doors and windows in residential houses, libraries, offices, and restaurants. As mentioned by Jadan et al. (1997), a closed single glazed window with 3 mm glass will give only 20 dB, scaling improves the effect up to about 25 dB and the use of heavy glass can improve things slightly more.

To gain a significant further increase it is necessary to use double glazing. In addition, large electrical generator must be put inside room and at a distance not less than 150 m from residential area and public buildings. To avoid humans' disturb (especially at night), it is recommended to construction playing yard at a suitable distance from residential area and public service buildings.

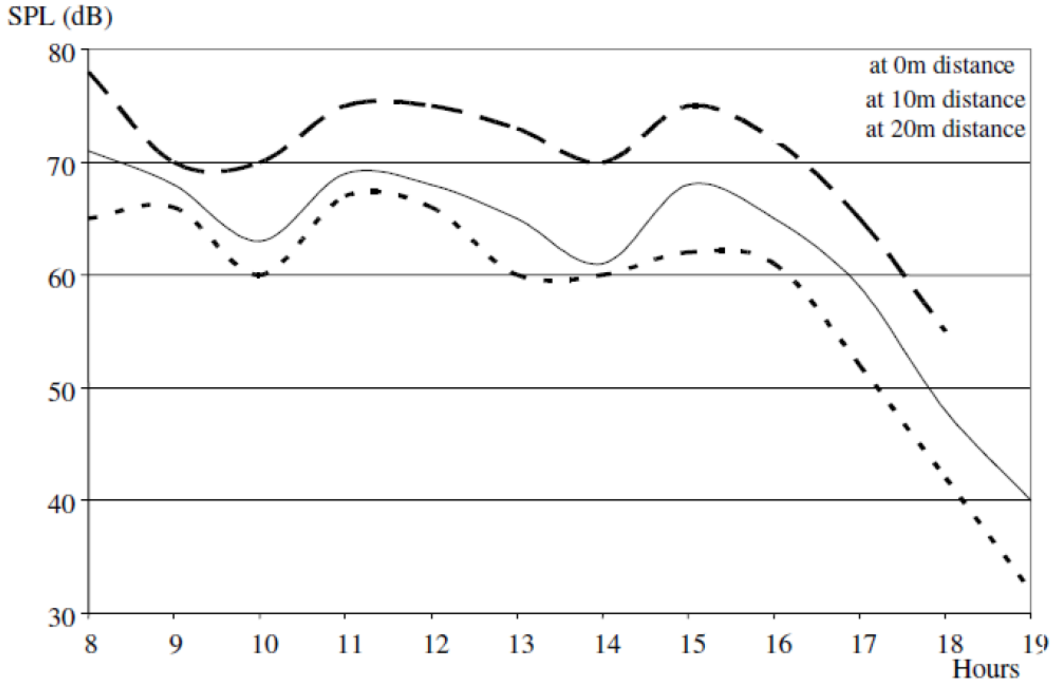

Fig. 4. Variation of SPL (dB) values from Kurdistan Road at different distances

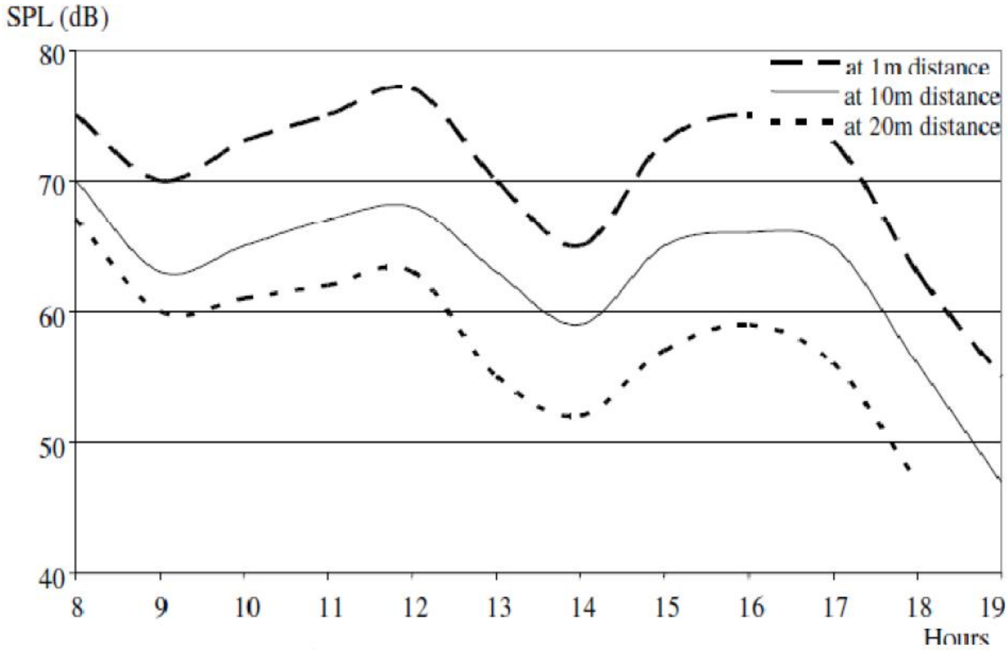

Fig. 4. Variation of SPL (dB) values from Kurdistan Road at different distances

Furthermore, it is recommended to construct public buildings (kindergarten, school, institute, colleges, hospitals…etc.) at distance > 50m from main roads. Finally, the road traffic noise can be reduced by applying: proper planning and zoning of land use, new roads, bridges, or freeways, new road use or upgrading of an existing road, bridge or free way; or new development near an existing road.

4. Conclusion

SPL values were monitored from different outdoor and indoor sound sources in Erbil City, Iraq. Additionally, generated noises from road traffic were studied from different roads. Variation of SPL values during day time from various roads were illustrated graphically. Barriers and distance had a great effect on decreasing SPL values inside and outside buildings. A mathematical model was derived to explain the relation between SPL and distance from sound sources. Based on the obtained mathematical model, SPL value was decreased noticeably with the increase of distance between sound source and the receiver.

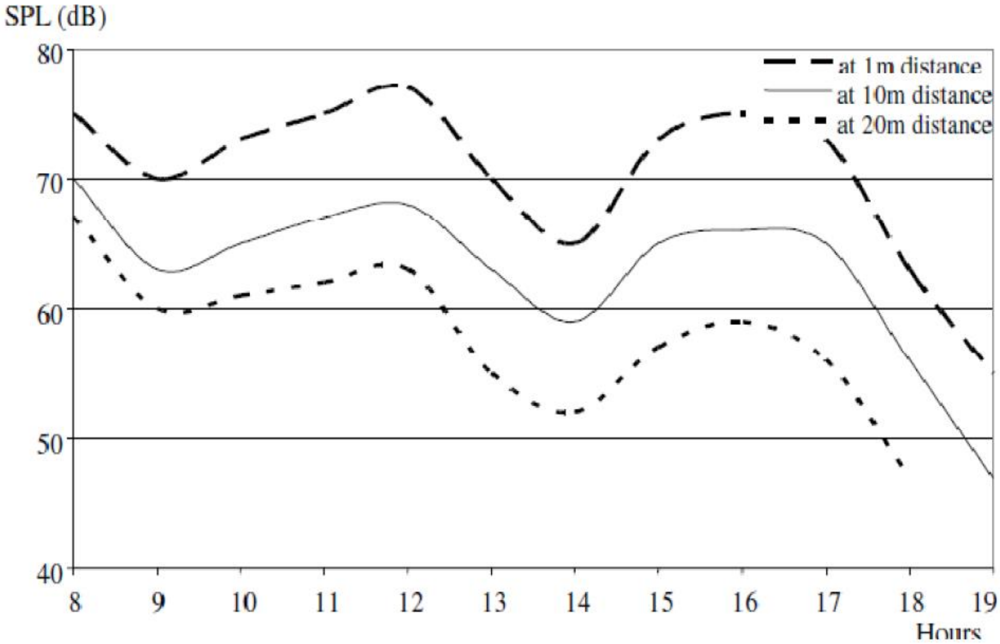

Fig. 5. Variation of SPL (dB) values from Barzani Namr Road at different distances

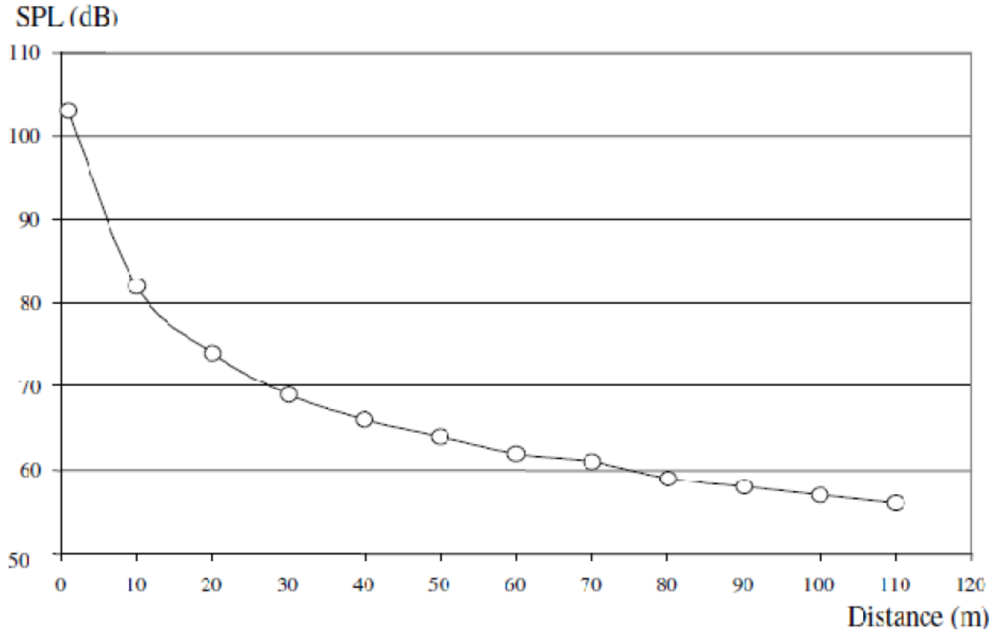

Fig. 6. Variation of SPL (dB) values versus distance for large electrical generator

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