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NOISE POLLUTION FROM TRANSPORTATION MEANS AND ITS CONTROLS

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ABSTRACT

This research is targeted to determine the noise levels emitted through regular transportation systems used in our society, to compare the transportation-related noise levels with the permissible limits according to the Egyptian law of environment and the world health organization limits, to quantify the noise annoyance cause to users by transportation modes and to highlight the main suggestions and recommendations for noise reduction and control. It was found that Mansoura city, (the case study of this research) has transportation-related noise levels more than the permissible limits according to the Egyptian law of environment. Also, the emitted noise levels through road traffic have peak values compatible with the traffic volumes peaks. Furthermore, the Current legislation for traffic noise not completed. For example, the use of vehicles alarm should be given more constraints in urban areas. Concerning railway systems, railway stations should provided with closed administrative building and elevated wall to work as a noise barrier. In addition, Railway stations should provided with waiting halls for passengers as airports in order to decrease the exposure time to rail noise. Railway lines should be sited outside the urban areas as they are significantly creating a noise problem. A questionnaire was designed for quantification of transportation-related noise annoyance and it is revealed that about 73% of people are significantly exposed to traffic noise, while near about 32% of people are significantly exposed to rail noise.

Key Words : *Noise pollution, traffic noise, and Railway noise.*

INTRODUCTION

Humans and many species of animals are able to hear sounds, which is of vital importance for the communication with other individuals of the same species, as well as for the orientation within the man-made and natural environment. Sounds may be considered by a human receptor as undesirable or even damaging; in this case, the term "noise" is used for the same physical phenomenon. Noise is derived from the Latin word "nausea" implying 'unwanted sound' or 'sound that is loud, unpleasant or unexpected'(Gundogdu O,20065). The noise originates from human activities, especially the urbanization and the development of transport and industry. Though, the urban population is much more affected by such pollution, however, small town/villages along side roads or industries are also victim of this problem. Noise is becoming an increasingly omnipresent, yet unnoticed form of pollution even in developed countries. On other words, noise is often used to refer to an unwanted sound; it is an undesirable compo-

nent that obscures a wanted signal. The sound waves most keenly detected by human ears are between 1000 and 4000 cycles per second or Hertz (Hz). The entire audible range extends from 20 to 20.000 Hz.

There is a large variety of sources of noise caused by humans, consisting of the following main groups (Ruedi Müller-Wenk, 1999, Pathak, et al., 2008): First, human individuals may directly be a source of noise, if they talk, sing, eat, snore, walk around, etc. A second group is equipment intended to produce or amplify sounds, like loudspeakers, music instruments, etc. Thirdly, noise is produced as a non-intentional by-product by many types of machinery and equipment, used indoors or outdoors, like motor cars, lawn mowers, aircraft, etc. The fourth group of noise sources caused by human activities are domesticated animals, like dogs, pigs, etc (Gregg, 2001).

All of these sources of noise are annoying for certain groups of the human population and each of these sources may be the main problem in specific situations. Transportation-related is a result of a lot of sources which have wide varieties in frequency and severity. Since noise is measured in (dB) unit, it is found that noise from the output of rapid motorcycles that have high frequency is equal with the noise resulting from goods transportation vehicles, when human is affected more by voices that have high frequency. For this issue, many studies have illustrated the maximum noise intensities resulting from the movements of different transportation modes [Thomas et al.,1999]. The effects of noise are seldom catastrophic, and are often only transitory, but adverse effects can be cumulative with prolonged or repeated exposure. In addition, noise can interfere with the teaching and learning process, disrupt the performance of certain tasks, and increase the incidence of antisocial behavior. There is also some evidence that noise can adversely affect general health and wellbeing in the same manner as chronic stress. (WHO, 1999; Passchier-Vermeer and Passchier, 2000). For this concern, a first look at the effects of noise on humans is therefore helpful, in order to select the most adequate way of describing noise and modelling its fate. The World Health Organisation (WHO) has given high attention to the problem of human health effects of environmental noise, the corresponding publications (WHO, 1995) offer a broad overview on the current knowledge and the relevant literature.

Noise resulting from transportation network on the urban cities is considered the main and continues source of noise that affects on people. This is due to the movement of vehicles produce many voices that come from alert device. In addition, tires friction with the road's surface, voice of gases emitted from the exhaust pipe, machine voice and air particles' friction with vehicles' specially vehicles that driven with high velocities are also considering a renewable sources of noise (Tang, 2004 S. Agarwal and B.L. Swami, 2009.).

The following list is summarizing the factors that increase the emission of noise from the road networks [Shoieb 1997].

Increasing of traffic volume., the frequent use of Alert devices, increasing of vehicles' speed, increasing of vehicles proportion that

causing noise, and the presence of roads' inclination.

Compared with aircraft and highway noise, more modest accomplishments have been achieved in the area of rail noise. The most substantial recent accomplishment has been the publication by the Federal Transit Administration of a guidance manual (Hanson, C. E., et al., 1995, Banerjee, et al., 2008).

Railway vehicles, for passenger as well as for goods transportation, generate both interior and exterior vibration and noise. The emitted external noise should not cause noise levels so high that the risk for impaired hearing among nearby residents is significantly increased. The noise from passing trains is rather a cause of irritation and sleep disturbances that affects the ability to perform well at home and at work. To reduce the noise disturbances the allowed maximum speed in residential areas has been reduced. Hence, a reduced noise emission making it possible to increase the allowed maximum speeds would improve the transportation efficiency. Another common measure taken to reduce the noise exposure in residential areas is to install noise barriers. Traditional noise barriers are expensive and considered unaesthetic and is therefore used only in lack of good alternatives. Yet another measure to reduce noise exposure is to improve the noise insulation of the buildings. This means for instance using high quality windows and doors with high noise reduction indices (Katalin, 2006).

The aim of this paper is determine the noise levels emitted through regular transportation systems used in our society, to compare the transportation-related noise levels with the permissible limits according to the Egyptian law of environment and the world health organization limits, to quantify the noise annoyance cause to users by transportation modes and to highlight the main suggestions and recommendations for noise reduction and control

Data Collection Program

The field experimentation was designed to collect data. Therefore, the following points were kept in mind while selecting the sites for data collection.

* Choice of different transportation systems in order to compare the noise level resulted through each system.
* Choice of different categories of noise sources in the same transportation system such as streets with heavily traffic volume and others with low traffic volume.
* Collecting data at different periods along the day and night hours to have a complete figure about variation noise levels along the whole day hours.
* Collecting data at different days along the week in order to compare between transportation-related noise levels in normal working days as well as off-days.
* Investigation of the feed-back knowledge from transportation systems users regarding the transportation-related noise annoyance in order to quantify the level of caused annoyance and disturbance.

For this issue, highway and railway transportation systems which are locally available in Mansoura city were selected in order to determine the transportation-related noise resulted through both systems.

Regarding highway transportation system, three different streets were selected for collecting data through the whole hours of the day (24 hours). The selected streets are shown in (Table 1)

It should be emphasized that the location of measurements was in the main stream of the street. This means vehicles; pedestrians and other noise sources were of variable distances from the recording device.

On the other hand, for railway transportation system, two different stations were selected for collecting data through the whole hours of the day (24 hours). The selected stations are shown in (Table 2)

Table 1 : Illustrate the selected streets location and characteristics .

Street	Location	Characteristics
El-Gomhoria	West district - Mansoura city	• Average width of 20 m • Two way traffic direction (Close to Talkha Bridge)
El-Gomhoria	West district - Mansoura city	• Average width of 15 m • One way traffic direction (Close to Al-Modeer Street)
El-Mokhtalat	East district - Mansoura city	• Average width of 20 m • Two way traffic direction (Close to Mansoura secondary school of girls)
Salah Salem	Talkha	• Average width of 25 m • Two way traffic direction (Close to Maxeem shop for sweets)

Table 2 : Illustrate the selected stations location and its characteristics.

Station	Location	Notes
Mansoura railway station	East district - Mansoura city	• Main station • Closed administrative building • Surrounding with an elevated wall of height near about 3.00 m
Talkha railway station	Talkha	• Sub-station • Open station with no borders, even though the administrative building is also in open area.

The measurements were recorded at different locations and timings in both selected stations such as inside/outside the administrative building, on the quay during train approach, during train departure and also during the time of no trains approaching or leaving the station.

It should be reported that measurements were taken in different week days i.e, Saturday up to Friday. Also, measurements were conducted through different hours in the same location. Readings were recorded every 15 minutes for road-noise and every minute for rail- noise.

- Measuring Device

Noise measurements were carried out in all selected sites using Digital Sound Level Meter. The device is of model Quest 215. The device was used after calibration by using a calibration unit of model CA-12B.

- Field Survey For Noise Annoyance

This research aimed to quantify the transportation-related noise annoyance. In addition, it is targeted to compare the results of the railway noise with the road noise. This was achieved through constructing a survey, to create a structure which would enable us to compare the results of investigated transportation-systems related noise.

For this concern, a questionnaire was designed to discover how many persons have been annoyed, bothered or disturbed by noise, and how much they would be willing to pay to reduce noise to a level where it would not annoy, bother, or disturb them anymore, given that the other factors (safety, air pollution, size of traffic) remain unchanged.

In the survey a sample of 300 people were interviewed, The interviewed persons (IPs) were divided in different groups depending on what source of transport noise they were bothered by (road, railway or none) and also into subgroups depending on the extent of exposure (significantly or not significantly exposed to noise).

The questionnaire was designed in multiple choice forms in order to have definite answers for the inquiries such as what is the main source of transportation-related noise your are suffering?. Also, what the severity of annoyance you are feeling?. The following form shows the designed questionnaire which was used for data collection in the field survey.

MANSOURA UNIVERSITY
FACULTY OF ENGINEERING

Application for Noise Exposure

Name : ……

Age : ……....

Date : ……

1- What are the main sources that you are suffering from along the day hours?

* Transpiration related noise. * Others.

2- What is the main source of transpiration related noise?

* Road noise. * Railway noise. * All of them.

3- What are the problems that u encounter because of the noise exposure?

* Do not open windows as often as I would if there were no noise.
* Find it hard to sleep.
* Disturbing when watching TV or listening to the radio/music.
* Hard to concentrate and disturbing when reading or working.

4- How much are you annoyed, bothered or disturbed by road and railway noise?

* Not at all. * Slightly. * Moderately.
* Very * Extremely.

5- How much percentage you loose in your working time due noise exposure?

* 10% * 20% * 30% * 40% * 50%

6- Do you think to change the transpiration system due to noise exposure?

* Yes * No

Give details ……

7- Do you suffered from health troubles due to noise exposure?

*Yes * no

RESULTS AND DISCUSSION

- Analysis Of Road-Noise

Based upon the measurements recorded in different investigated roads, it is revealed that noise levels at all investigated roads are varying through the whole hours of the day. This seems to be logical as the traffic volumes are variable and most of the road noise is resulting though movement of vehicles. Figures 1 to 4 are showing such trend in normal working days as well as off-days.

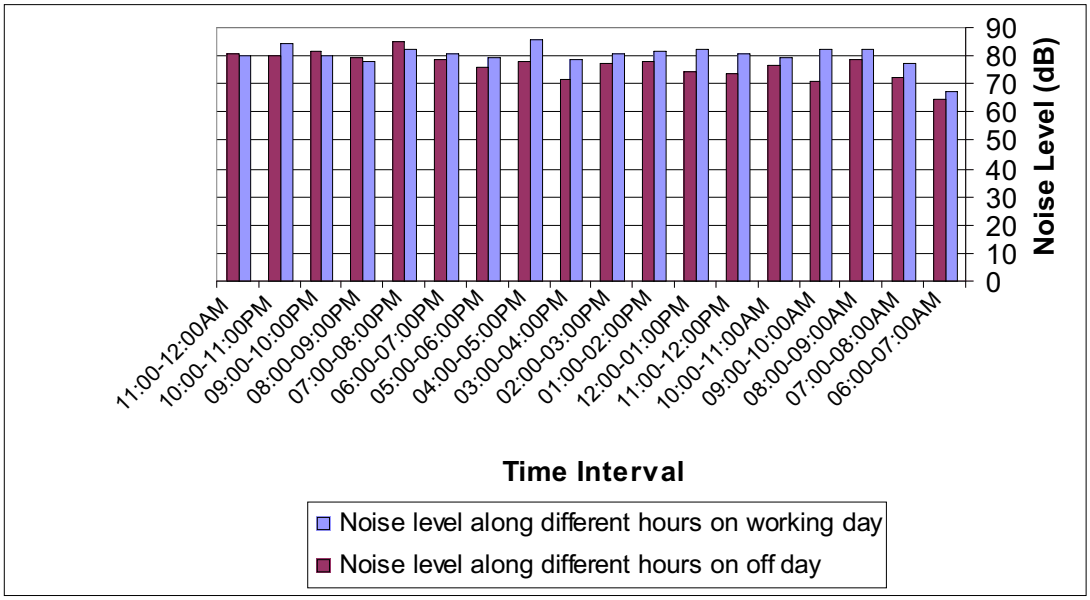

Figure (1) : Noise level along different hours in Site No.(1) on working and off day.

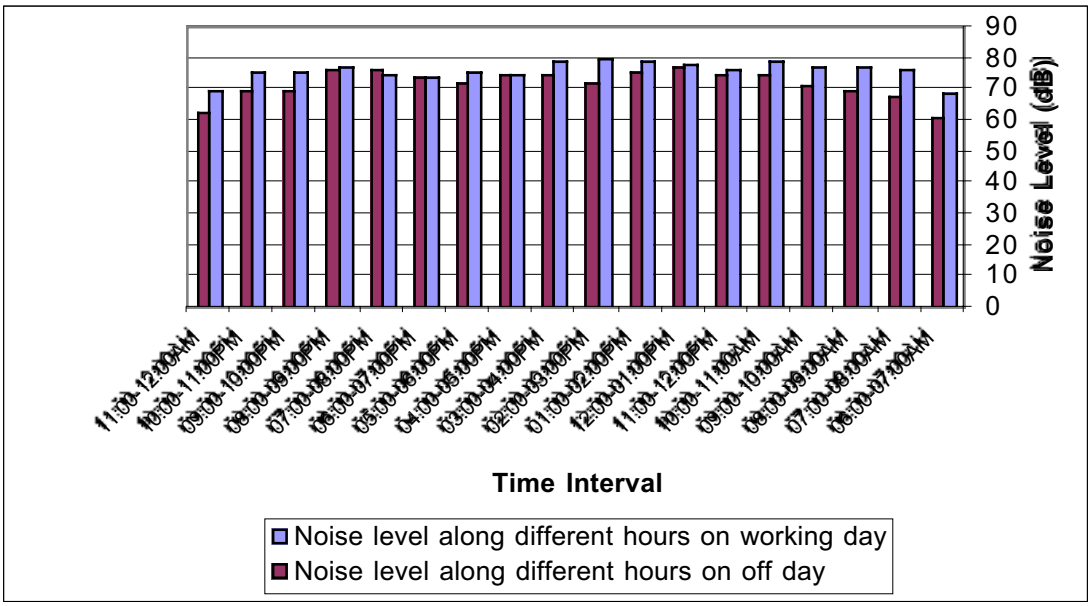

Figure (2) : Noise level along different hours in Site No.(2) on working and off day.

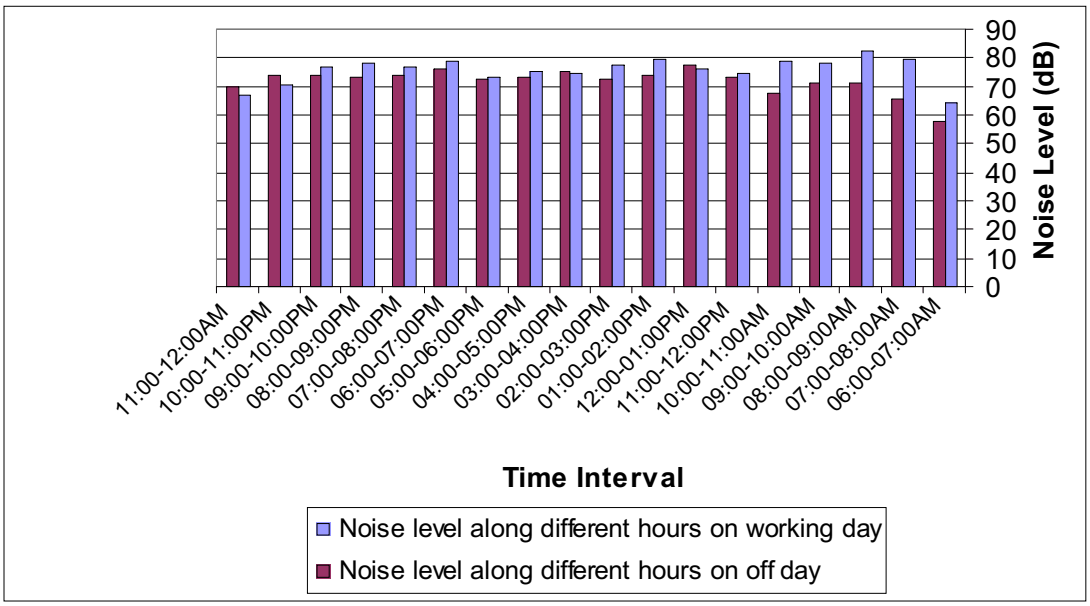

Figure (3) : Noise level along different hours in Site No.(3) on working and off day.

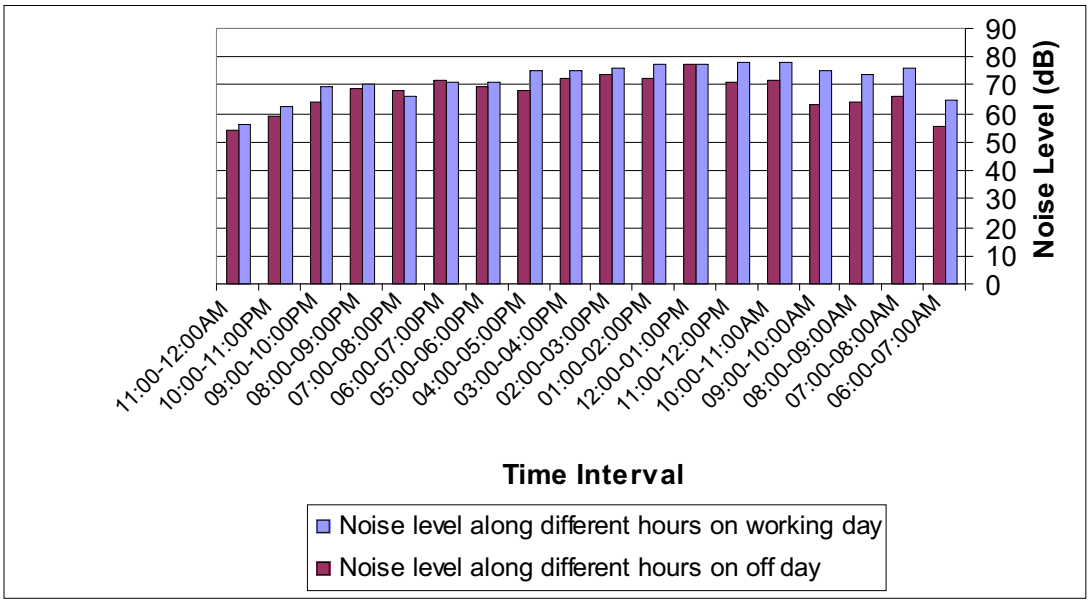

Figure (4) : Noise level along different hours in Site No.(4) on working and off day.

Through these figures many observations were noticed as follows.

1- So far as site No.1 (Al-gomhoria Street near talkha Railway Bridge) is concern, for noise levels in a normal working day, the maximum recorded noise level was around 80 dB during the peak times. The noise peak times are typically compatible with peak times of traffic volumes. For example, from 8 AM to 9 AM, noise was 81 dB which is matching with the morning traffic peak time when employers are going to their offices. It should be noted that most of the noise levels in all hours seems to be high. This is due to the existence of the railway bridge and the subsequently the moving trains are contributing in such readings of noise. This is illustrated through figure (1). On the other hand, from the same site during an off-day which illustrated through the same figure, noise levels are less than those for the working day but still high as compared with other sites. In addition, the peak noise level achieved during 11.00 AM to 13.00 PM which is the time of Friday prayers and slightly traffic movements were high.

2- It should be noted that, other investigated sites exhibits almost the same trend like site No.1 except that peak noise levels are less as there is no railway lines close to this site.

3- For sites 2 & 4, on off-days there is an average drop of 10 dB in noise values on the whole day compared with working days. However, site No. 1 and 3 has less difference or may be almost the same in working days as well as off-days. This is may referred to the existence of high traffic volumes in both sites and also the existence of the railway bridge close to site No. 2.

It should be reported that all the recorded noise levels in all sites during whole hours of the days are much more the permissible limits according to the Egyptian law of environmental and world health organization limits for noise levels. This is true as the permissible noise level for such types of areas is 60 dB.

For more comparison, the recorded measurements were categorized into three timings interval, morning, evening and night as presented earlier through figures 1 to 4. The average noise level during this period with the standard deviations of the recorded readings are shown through table 3.

The deep investigation through these tables showed that the morning interval recorded higher noise levels during normal working days however; during off-days the morning interval showed the lowest values of noise levels. For example, the average noise level in the morning interval of site No.4 during off-days was 65.25 dB. However, it was 74.17 dB. on working days. This is quite reasonable as the employers are not going to their work in off-days.

Another important observations can be revealed through these tables is that, the standard deviation of the recorded observations is varying through different intervals of the same day. In addition, it is also varying

Table 3 : Illustrate the average noise level and the standard deviations at selected locations.

Work index		Site (1)						Site (2)					
Work dates and times	Date	Working day			Off-day			Working day			Off-day		
	Time	M	E	N	M	E	N	M	E	N	M	E	N
Results of noise level measurement (Db)	Average of noise level	78.17	81.2	80.8	73.0	78.0	80.8	75.6	77.5	74.4	69.7	74.2	71.3
	Standard deviation	±6.2	±4.9	±3.5	±6.3	±3.6	±3.1	±3.7	±2.3	±3.0	±5.0	±2.4	±5.0
Work index		**Site (3)**						**Site (4)**					
Work dates and times	Date	Working day			Off-day			Working day			Off-day		
	Time	M	E	N	M	E	N	M	E	N	M	E	N
Results of noise level measurement (dB)	Average of noise level	76.30	76.0	75.1	67.7	74.1	73.5	74.1	75.4	65.9	65.2	72.3	64.4
	Standard deviation	±6.3	±2.9	±4.3	±5.4	±2.9	±3.0	±5.5	±2.7	±5.7	±5.8	±3.2	±6.4

Where : M means Morning, E means Evening, and N means night.

through different days even working or off-days. The variation is quiet random. This is quite reasonable as it simulates the actual trend in field. If a truck with very high alarm or an accidental brake of a car with high noise due to friction with road surface may cause a very high reading in random times. Also, the passage of trains also may cause the same. effect.

It is also obvious that Site No. 1 has the highest values of noise levels along different intervals as it is a two-way street with more traffic volumes compared with other sites. Site No. 3 also record high values as it are in Talkha which considered the western gate of Mansoura city to other districts. This means different transportation modes are there as well as very high volumes of traffic streams. Oppositely, site No. 2 is an one-way direction of traffic and also site No.4 is a low-traffic volume street so, recorded noise levels are less than those in sites 1 and 3.

- Analysis Of Rail-Noise

First of all, measurements were taken on the quay in both El-mansoura and Talkha railway stations. Measurements were conducted for an hour every minute. This was done to record all the variations in noise level due to entrance or departure of a train to the station. In addition, the periods of no trains in the station were also considered. It should be emphasized that a similar trend was observed

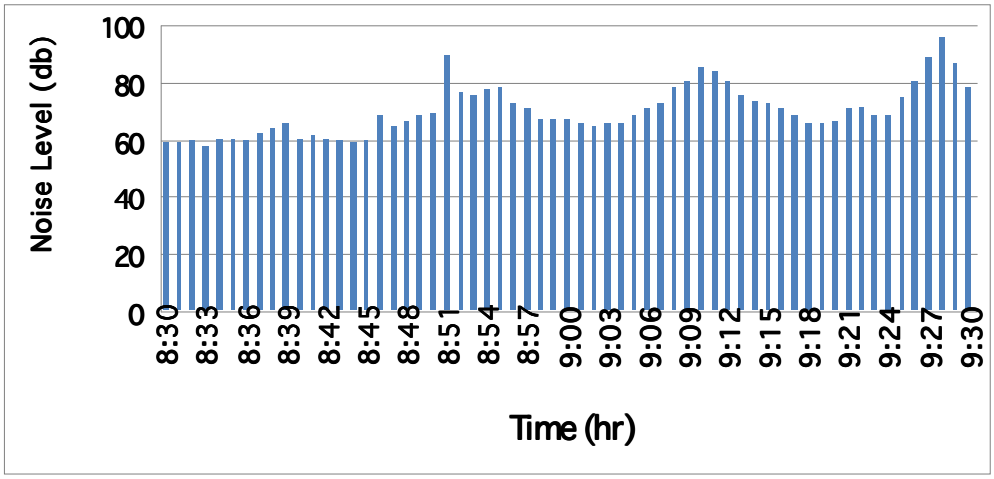

Figure (5) : Noise Levels at Different Times along one hour on The Quay of El-Mansoura Railway Station .

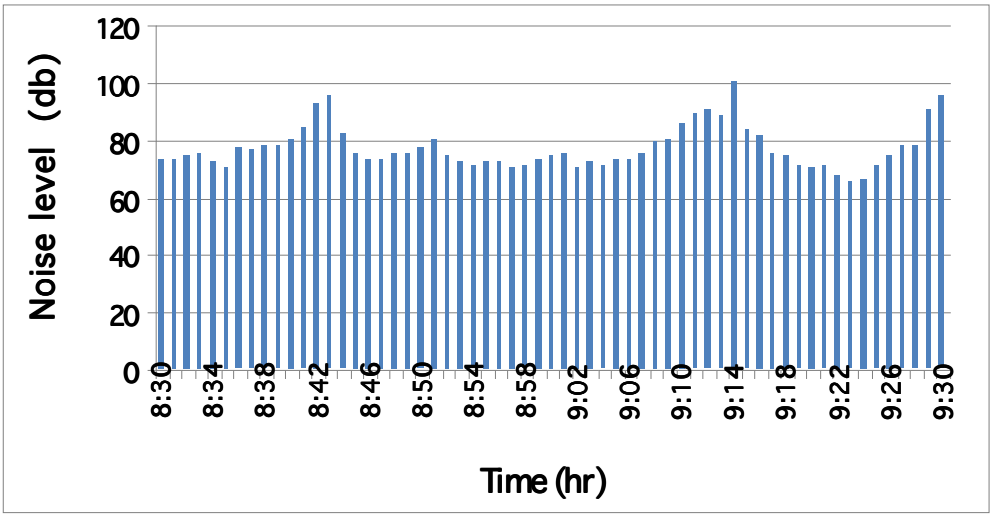

Figure (6) : Noise Levels at Different Times along one hour on The Quay of Talkha Railway Station.

during different time intervals of the day. This means there is no much difference between noise levels in morning, evening and night in railway stations. Figures 5 and 6 show such records for a complete one hour in El.Mansoura and Talkha railway stations respectively. It is important to highlight that Mansoura railway station has a closed building rather than talkha station which has an open building. In addition, Mansoura station is surrounded by an elevated wall of height 2.5 m and talkha station has no borders.

As shown in the previous figures, readings recorded in Talkha railway station are higher than El-Mansoura railway station. This is looking to be reasonable since Talkha railway station is an open station with no borders i.e,

noise are mixture of rail as well as adjacent streets and activities.

Moreover, other readings were recorded in the administrative building in both selected stations and compared, It was found that noise levels in the administrative building of El-mansoura railway station are less than those recorded in Talkha station as shown in Table (4). This is also referred to the nature of the close building which has benefits of reducing the noise levels than open buildings as in Talkha station.

- Quantification Of Noise Annoyance :

The data collected through questionnaire was analyzed in order to quantify the transportation-related noise annoyance. The interviewed persons (IPS) were categorized as percentages of different sub categories as shown in table (5).

Furthermore, the survey determines the severity level of exposure to noise annoyance. It has been have been put into 5 categories depending on how much they are annoyed, bothered or disturbed by road and railway noise. Table (6) shows such classification.

The main conclusion of such tables can be put into a quantification tool to how much transportation-related noise is costing people. So far as persons, who are extremely annoyed by transportation-related noise, are considered, they may feel that it is hard to sleep or feeling hard to concentrate and disturbing when reading or working. Furthermore, they may get headaches/migraine due to such types of noise. For this concern, a rating procedure was adopted based on table (7) which categorizes the severity level of exposure to noise annoyance. The extremely annoyed persons may suffer from all the pre-mentioned effects due to transportation-related noise so, they may loose 50% from their working hours. Subsequently, other persons may take a relative rating to such estimation. Table (7) highlights the estimated loss in working hours due to transportation-related noise annoyance.

Based upon table (7), if a person has an average income per month of 500 EGP, he may loss up to 50% of his income due to transportation-related noise annoyance. This may lead to future and further investigation regarding the cost evaluation of transportation-related noise.

Table 4 : Illustrate the average noise level and the standard deviations at Railway Stations administrative building.

Work index		**Railway Stations administrative building**					
Work site and times	**Site**	**Mansoura railway station**			**Talkha railway station**		
	Time	**Morning**	**Evening**	**night**	**Morning**	**Evening**	**night**
Results of noise level measurement (dB)	**Average of noise level**	68.40	68.80	67.80	72.70	71.10	72.10
	Standard deviation	±3.24	±3.12	±2.53	±2.26	±2.56	±2.02

Table 5 : Illustrate the percentage of IPS at each categories.

Categories	%	No. of IPS
Exposed to significant road traffic noise	73	219
Road traffic noise not significant	27	81
Exposed to significant railway noise	32	96
Railway noise not significant	68	204
Exposed to significant mixed noise due to road traffic and railway	84	252
Exposed to not significant mixed noise due to road traffic and railway	16	48

Table 6 : Illustrate the classification according to how much they are annoyed, bothered or disturbed by road and railway noise.

	Road	Railway
	%	%
Not at all	33	30
Slightly	17	18
Moderately	20	22
Very	22	25
Extremely	19	15
Number of answers (IPs)	100	100

Table 7 : Illustrate the estimated loss in working hours .

	Loss of working hours
	%
Not at all	0
Slightly	10
Moderately	20
Very	30
Extremely	50

CONCLUSIONS

1- The emitted noise levels through road traffic have peack values compatible with the traffic volumes peaks.

2- Mansoura city, (the case study has transportation-related noise levels) more than the permissible limits according to the Egyptian law of environment.

3- The Current legislation for traffic noise not completed. For example, the use of vehicles alarm should be given more constraints in urban areas.

4- Railway stations should provided with closed administrative building and elevated wall to work as a noise barrier.

5- Railway stations should provided with waiting halls for passengers as airports in order to decrease the exposure time to rail noise.

6- Railway lines should be sited outside the urban areas as they are significantly creating a noise problem.

7- About 73% of people are significantly exposed to traffic noise, while near about 32% of people are significantly exposed to rail noise.

8- The severity level of noise annoyance was categorized and near about 19% of people is extremely annoyed by traffic noise; however 15% are extremely annoyed by rail noise.

9- Transportation-related noise has created some problems such as; hard to concentrate and disturbing when reading or working, get headaches/migraine and disturbing when watching TV or talking in telephone.

10- Near about 10% of the interviewed persons may loss 50% of their working hours i.e, their income due to noise annoyance.

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الملخص العربى

التلـوث الضوضـائى النـاتـج من وسـائل النقــل المختلفــة وطـرق التحكـم فيــه

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أستاذ هندسة الطرق - قسم الأشغال العامة كلية الهندسة - جامعة المنصورة [٣]

تم عمل دراسة لتحليل مستويات الضوضاء المنبعثة من خلال الأنظمة المرورية الشائعة فى المجتمع وذلك لمقارنة الضوضاء الناتجة من الأنظمة المرورية مع مستويات الضوضاء المسموح بها حسب القانون المصرى لحماية البيئة ومنظمة الصحة العالمية، وذلك لتحديد مقدار الإزعاج الواقع على مستخدمى شبكات المواصلات ولإلقاء الضوء على أهم الاقتراحات والتوصيات التى من شأنها تقليل مستوى الضوضاء والتحكم فيه، وقد وجد أن مدينة المنصورة (حالة الدراسة لهذا البحث) بها مستويات ضوضاء ناتجة عن وسائل المواصلات أكبر من المستويات المسموح بها طبقاً للقانون المصرى لحماية البيئة، كذلك وجد أن أقصى إنبعاث للتلوث الضوضائى يتناسب مع أوقات الذروة المرورية لشبكات الطرق، لذلك يجب إكمال التشريعات المرورية الغير مكتملة (على سبيل المثال يجب وضع قوانين تقيد إستخدام اللات التنبيه فى المناطق الحضرية). وفيما يتعلق أنظمة السكك الحديدية بقاعات إنتظار للركاب كما هو الوضع فى المطارات وذلك لتقليل مدة التعرض للضوضاء.

تم تصميم إستمارة إستبيان وذلك لقياس مقدار الإزعاج الناتج من وسائل النقل، وقد وجد أن حوالى ٧٣٪ من الأشخاص يتعرضون بشكل ملحوظ للتلوث الضوضائى الناتج عن شبكات الطرق وحوالى ٣٢٪ يتعرضون للتلوث الضوضائى الناتج عن أنظمة السكك الحديدية وأيضاً وجد أن التلوث الضوضائى الناتج من شبكات النقل يخلق الكثير من المشاكل على الأشخاص مثل عدم التركيز فى القراءة أو العمل ويسبب فى بعض الحالات صداع وعدم التركيز عن مشاهدة التلفاز أو التحدث عبر الهاتف.

JOESE 5

NOISE POLLUTION FROM TRANSPORTATION MEANS AND ITS CONTROLS

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