A Proposal for a Normative to Regulate Noise Generated by the Operation of Motor Vehicles on Mexican Highways

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Synopsis

In Mexico, as in every country, noise generated by highway traffic has increased over the last number of years. This represents a serious health and environmental issue which up to now, has been poorly researched and poorly attended.

This paper presents a proposal for a federal normative, which would regulate and reduce noise generated by the operation of motor vehicles on Mexican highways. The proposal is based on research and analysis carried out by the Environmental Department of the Mexican Institute of Transportation (IMT), which included field measurement of noise generated by highway traffic in four Mexican States. These studies have been published by the IMT, and include all noise measurement data obtained at highways selected by means of their high traffic volume.

Taking both the analysis of obtained results and current international maximal noise values into account, this report proposes a standardised measuring method and a domestic maximal noise value for highways, incorporating a reduction of one dB (A) each year, which would align in the short term domestic maximal values with international regulations.

By undertaking these studies, the IMT seeks to improve knowledge and consciousness of the negative environmental impacts of highway construction, operation and maintenance. Furthermore, the exchange of information between countries with a similar problematic can contribute to finding improved methods to mitigate noise pollution on the highways.

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To reach a state which considers an integral development of the human being and all its activities, it's a growing concern of universal significance. However, this would only be possible if environmental issues are carefully observed during the process. Over the last decades, the environmental policies and the evolution of socio-economic interest consider a sustainable development model. This is reflected on the activity programs of international organizations, particularly the World Health Organization (WHO), the Organization for the Economic Cooperation and Development (OECD), and the European Economic Community (CEE).

Although the evaluation and control of the negative impacts generated by a highway on the environment is rather recent for planners, constructers and users, the world tendency aims to incorporate environmental analyses to identify and to value the potential negative effects on the environment of projected highways.

One of the most relevant issues to consider in environmental analysis in order to reach a sustainable transport, due to the effects and damages to the health, is the noise. Although noise can be defined as any unpleasant or disturbing sound, this depends not only of its characteristics, but also of our subjective attitude toward it; Noise has one or several of the following characteristics: lasting, high intensity, high frequency, and chaotic. Besides, a non acoustic component takes part of this appreciation, which involves physiologic, psychologic and sociologic factors, among others.

The noise is also a non desirable byproduct of modern life, an unpleasant auditory sensation that constitutes one of the most important environmental disturbances affecting directly the human being life quality, although mostly people are not conscious of its effects because the consequences usually do not manifest themselves immediately but over a long-term period. Hence, the relationship cause – effect is not clearly perceived.

Sound level values for different sources and typical acoustic environments are shown on table 1, measured in decibels with A ponderation (dBA). These values provide an objective sound measure related to deleterious effects for health and tranquillity, as well as its interference with diverse routine activities such as to sleep and to study. Furthermore, they don't depend on a subjective judgment and they have been obtained based upon studies of the WHO.

Table 1 Sound level values for different sources and typical acoustic environments [7]

Source	L_p (dBA)
Pain threshold	120
Nightclub	110
Pneumatic hammer at 2 m	105
Industrial environment	90
Piano at 1 m	80
Silent car at 2 m	70
Normal conversation	60
Urban noise at night	50
Indoors (day)	40
Indoors (night)	30
Recording studio	20
Soundproof room	10
Hearing Threshold at 1 kHz	0

Noise has diverse origins. According to the Noise Institute of London, motor vehicles with its mechanisms, engine and contact between tires and pavement surface, are the principal contributors to global noise. Noise contributors separated by sectors are shown in fig 1. Hence, noise generated by vehicles turns out to be one of the largest problems which affect the life quality, more evident in urban zones and residential areas near highways.

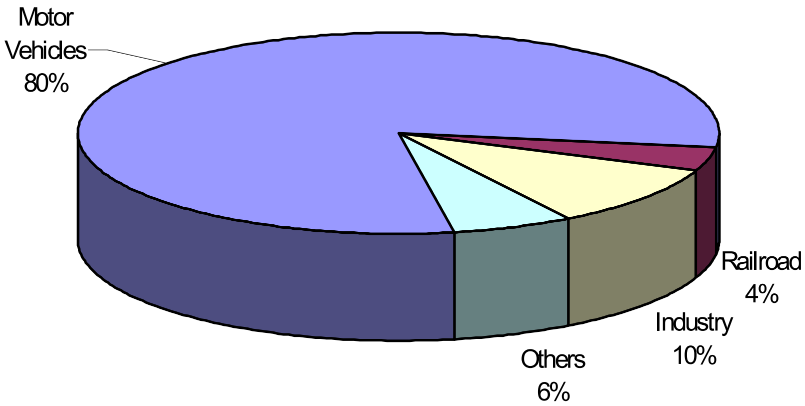

Fig 1 Noise Sources [10]

For our purposes, noise sources are divided into two main categories, the fixed and the mobile. The first includes equipment and facilities located in a specific area, such as machinery, motors, and sound systems. The second category includes self-propelled vehicles of any type. This classification stems from the need to clearly delimit the responsibilities of actors involved in conflicts generated by noise pollution.

It is relatively easy to identify and deal with high noise levels emanating from a fixed source. The identification of mobile sources of noise pollution however is a much more complex task. In the specific case of highways, it is extremely difficult to target a specific vehicle as one exceeding maximal noise values. This implies a co-responsibility for all vehicles using a specific highway.

The World Health Organization (WHO), in conjunction with the Program of the United Nations for the Environment (PNUMA), has recommended maximal noise values which take environment, time, and human activity into account. These values, as shown in table 2, are expressed in Leq dB(A), which is the equivalent continuous sonorous pressure level for a period of eight hours, in decibels with ponderation A. For the case of a labour environment, the time of maximum exposition should not exceed eight hours. If the noise level is higher that the recommended, the time of exposition will diminish in function of the increment.

Table 2 Recommended Maximum Noise Values, WHO [7]

Type of environment	Maximal Value Leq dB(A)
Labour	75
Classroms,	45
Dormitory	35
Outdoors diurnal	55
Outdoors nocturnal	45

For its recommendations, the Organization for the Economic Cooperation and Development (OECD) takes the economic implications of policies against traffic noise into account and hence, proposes maximum noise values to be achieved within a 5 to 10 year period. As is shown in table 2, the acceptable maximum value for the diurnal time in an existing highway is 70 dB(A), being desirable values up to 50 dB (A) in new highways during the night.

Table 3 Recommended Maximal Noise Values, OECD [8]

Acceptable levels proposed by OECD (Leq, limits on front residential zones)			
Leq (day)		Leq (night)	
New Highway	Existing Highway	New Highway	Existing Highway
60+/-5 dB(A)	65+/-5 dB(A)	50-55 dB(A	55-60 dB(A)

Considering both recommendations, an initial maximum permissible level of 70 dB (A) would be desirable and implies a minimal risk for human health, even when people is exposed for periods longer than eight hours [1].

Currently, there are only four federal norms for noise emission control in Mexico. These norms have established maximal noise values for new motor vehicles and motorcycles, fixed sources, and vehicles currently in circulation, which is taken at verification centres and results are obtained by measuring only the tailpipe noise emissions from static vehicles under controlled engine conditions. Hence, there is no regulation for the noise pollution on Mexican Highways.

Until now, Mexico didn't have studies or data to quantify the traffic noise levels on highways which would make possible to value the importance of its impact on the environment. Therefore, a main objective of the study was to determine whether noise traffic levels generated by vehicles on highways are of such magnitude that demands the analysis of measures to minimize it.

MEASUREMENT METODOLOGY

Measurements were carried out in four Mexican states which were selected due their economical relevance and traffic loads: Querétaro, Jalisco, Nuevo León and Veracruz. Highways were categorized according to their Average Daily Traffic (ADT), traffic loads, topographical location and the possible effects on users and adjacent residential areas. Taking both this information and a preliminary field survey into account, critical highway sections were identified.

At the critical sections noise levels were directly measured under the following considerations:

• Measurements were carried out during uninterrupted periods of 7 ½ h
• Noise measurement can be considered continuous over the period of measurement
• Measurements were not carried out under adverse climatic conditions like rain, excessive wind or snow because this variations could affect the results.

The measurement was carried out placing a precision sonometer on a standard tripod within a distance of 7,5 m of the highway shoulder and 1,5 m over the pavement surface. In order to avoid wind interference a windscreen on the microphone was used to absorb the wind whistle.

The measurement points were chosen within the critical sections. In order to take measurements in standard operation conditions, the selected point should not be near highway accesses or exits, neither on a step slope nor with obstacles around it which would damp the sound waves. Thus, a noise level increment caused by the vehicles velocity, the opening of the escapes in step slopes or a dampening caused by tree curtains or topographical place formations was avoided.

Readings of the equivalent sound pressure level (Leq) for 60 seconds were taken. This represents the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring. These readings were afterwards integrated to conform the Leq for 7,5 h or for this case, the Leq_{total} in decibels with ponderation A.

The results are shown in tables 4 to 7. To allow a comparison, some international regulative limits and recommended values by international organizations are also included. The 10th and 50th percentile values are included as well, representing the sound pressure level that is exceeded for 10% and 50% of the time for which the given sound is measured. Maps with the location of the measurement points in every State are also shown.

Table 4 Measurement results, Querétaro State [2]

QUERÉTARO	FINLAND 55 FRANCE 65 SPAIN 65 OECD 65+/- EU 65/70 WHO 75	USA 72	USA 75	JAPAN 65
SECTION				
México - Querétaro km 208+200 (M)	77,3	80,5	77,0	79,0
México - Querétaro km 208+000 (Q)	79,7	82,0	79,0	80,9
México - Querétaro km 193+050 (M)	81,1	83,2	80,5	81,8
México - Querétaro km 193+050 (Q)	80,6	83,0	80,5	81,5
Querétaro - San Luis Potosí km 26+200 (SLP)	76,2	79,0	76,0	77,0
Querétaro - San Luis Potosí km 26+100 (Q)	79,0	81,3	78,5	79,8
Querétaro - San Luis Potosí km 12+800 (SLP)	78,3	81,0	77,8	79,3
Querétaro - San Luis Potosí km 12+750 (Q)	78,6	80,6	78,5	79,6
Querétaro - Celaya km 10+000 (Q)	75,0	77,8	73,5	76,5
Querétaro - Celaya km 10+000 (C)	76,3	79,0	75,5	77,4

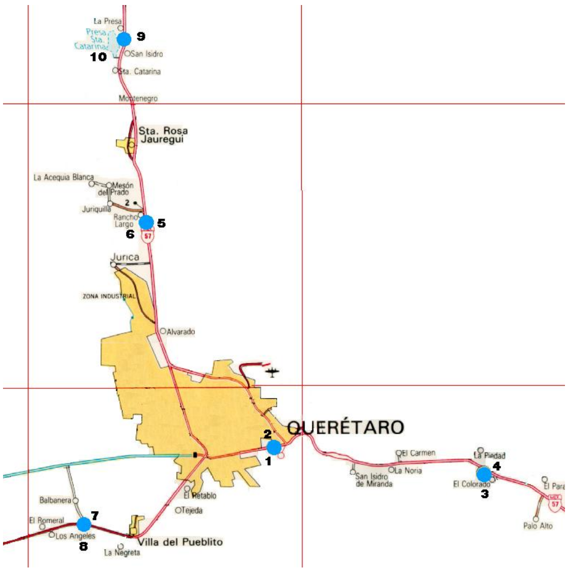

Fig 2 Measurement points in Querétaro State [2]

Table 5 Important characteristics of the sections in Querétaro [2]

SECTION	ADT	PAVEMENT TYPE	OPERATION SPEED (Km/h)
Mexico – Querétaro Km 208+200 (M)	37,488	Asphalt	110
Mexico – Querétaro Km 208+000 (Q)	37,948	Asphalt	110
Mexico – Querétaro Km 193+050 (M)	32,060	Concrete	110
Mexico – Querétaro Km 193+050 (Q)	32,590	Concrete	110
Querétaro – SLP Km 12+800 (SLP)	20,788	Asphalt	110
Querétaro – SLP Km 12+750 (Q)	20,898	Asphalt	110
Querétaro – Celaya Km 10+000 (C)	10,564	Asphalt	100
Querétaro – Celaya Km 10+000 (Q)	10,564	Asphalt	100
Querétaro – SLP Km 26+200 (SLP)	15,762	Asphalt	110
Querétaro – SLP Km 26+100 (Q)	15,670	Asphalt	110

Table 6 Measurement results, Jalisco State [3]

JALISCO	FINLAND 55 FRANCE 65 SPAIN 65 OECD 65+/-5 EU 65/70 WHO 75	USA 72	USA 75	JAPAN 65
SECTION				
Guadalajara-Zapotlanejo km 20+200 (G)	76,6	79,0	82,5	75,0
Guadalajara-Zacatecas km 15+000 (Z)	70,2	77,0	79,0	64,0
Lagos d Moreno-Guadalajara km 175+200 (L)	74,8	76,0	79,4	74,0
Jiquilpan-Guadalajara km 125+600 (G)	75,1	76,0	78,4	74,5
Guadalajara-Tepic km 22+000 (T)	75,5	78,0	82,2	73,5
Guadalajara-Chapala km 12+800 (Ch)	76,5	78,0	80,4	76,0
Guadalajara-Zapotlanejo km 20+200 (G)	69,5	75,0	80,5	71,0

Fig 3 Measurement points in Jalisco State [3]

Table 7 Important characteristics of the sections in Jalisco [3]

SECTION	ADT	PAVEMENT TYPE	OPERATION SPEED (Km/h)
Guadalajara – Zapotlanejo KM 20+200 (G)	21,382	Asphalt	110
Guadalajara – Zacatecas Km 15+000 (Z)	3,225	Asphalt	90
Lagos de Moreno – Guadalajara Km 175+200 (LM)	14,885	Asphalt	110
Jiquilpan – Guadalajara Km 125+600 (G)	23,102	Asphalt	110
Guadalajara – Tepic Km 22+000 (T)	20,798	Asphalt	110
Guadalajara – Chapala Km 12+800 (Ch)	22,066	Asphalt	110

Table 8 Measurement results, Nuevo León State [4]

NUEVO LEÓN	FINLAND 55 FRANCE 65 SPAIN 65 OECD 65+/- EU 65/70 WHO 75	USA 72	USA 75	JAPAN 65
SECTION				
Monterrey – Saltillo km 54+300 (sentido Monterrey)	78,1	79,0	80,5	77,0
Libre Saltillo – Monterrey km 26+000 (sentido Saltillo)	78,1	80,9	82,0	73,0
Libre Nuevo Laredo km 28+500 (sentido N. Laredo)	71,0	81,8	83,0	70,0
Monterrey – Ciudad Mier km 29+700 (sentido Monterrey	74,3	81,5	83,0	72,0
Ciudad Victoria – Monterrey km264+800 (sentido MTY)	71,9	79,3	81,0	73,5
Monterrey – Reynosa km 22+000 (sentido Reynosa)	75,1	79,6	80,6	75,0

Fig 4 Measurement points in Nuevo Leon State [4]

TABLE 9 7 Important characteristics of the sections in Nuevo León [4]

SECTION	ADT	PAVEMENT TYPE	OPERATION SPEED (Km/h)
Monterrey – Saltillo Km 54+300 (M)	41,728	Asphalt	110
Libre Saltillo – Monterrey Km 26+000 (S)	18,168	Asphalt	90
Libre Nuevo Laredo Km 28+500 (NL)	17,116	Asphalt	90
Monterrey – Cd Mier Km 29+700 (S)	11,328	Asphalt	90
Cd Victoria – Monterrey Km 264+800 (M)	41,884	Asphalt	110
Monterrey – Reynosa Km 22+000 ®	27,708	Asphalt	110

Table 10 Measurement results, Veracruz State [5]

VERACRUZ	FINLAND 55 FRANCE 65 SPAIN 65 OECD 65+/-5 EU 65/70 WHO 75	USA 72	USA 75	JAPAN 65
TRAMO				
Poza Rica – Tuxpan km 199+050 (P.R.)	74,9	80,9	82,0	73,5
México - Tuxpan km 164+500 (T)	73,7	79,0	80,5	72,5
Cardel - Veracruz km 238+900 (C)	74,3	81,8	83,2	73,0
Paso del Toro - Acayucan km 1+100 (A)	74,0	81,5	83,0	73,0
Xalapa .- Veracruz km 3+300 (V)	73,2	79,3	81,0	72,5
San Hipólito - Xalapa km 145+010 (X)	75,4	79,6	80,6	72,0

Fig 4 Measurement points in Poza Rica, Veracruz State [5]

Table 11 Important characteristics of the sections in Veracruz [5]

SECTION	ADT	PAVEMENT TYPE	OPERATION SPEED (Km/h)
Poza Rica – Tuxpan Km 199+050	11,580	Asphalt	100
Mexico – Tuxpan Km 164+500	9,020	Asphalt	100
Cardel – Veracruz Km 238+900	21,490	Asphalt	110
Paso del Toro – Acayucan Km 1+100	6,806	Asphalt	90
Xalapa – Veracruz Km 3+300	19,330	Asphalt	110
San Hipolito – Xalapa Km 145+000	9,840	Asphalt	100

CONCLUSION

Due to the lack of information regarding the noise levels generated by the Mexican highways, the primary objective of this study was to identify if there is or there is not a noise pollution problem. The finding of noise values in almost all the measured highways that exceed international regulations, lead us to the conclusion that the problem exists.

When a normative to regulate noise generated by the operation of motor vehicles is proposed, it should be recognized that such noise is a collective phenomenon, with responsibility being shared amongst all the actors. In order to achieve noise level reduction on highways, an integral focus is required, which must take legislative aspects as well as the planning and construction of the highways into account.

Considering both recommendations, an initial maximum permissible level of 70 dB (A) would be desirable and implies a minimal risk to human health, even if people are exposed for periods longer than eight hours [1].

Nevertheless, when results from 29 of the most important Mexican highways in Querétaro, Jalisco, Nuevo León and Veracruz states are analysed, it becomes apparent that almost all the measured noise levels exceeded current international norms and recommendations, with values in some cases greater than 80 dB (A).

Furthermore, taking a statistical analysis of all data obtained into account, the percentile for which the values are smaller or equal to 70 dB (A) is 3%. This implies that 97% of obtained results are above that value. The statistical analysis also shows that the media is approximately 75 dB (A), which means that half of results fall below this value whilst the other half exceed it. Hence, the IMT proposes to set Leq_{total} **75 dB (A)** as the initial maximum noise level permissible on Mexican highways, with a gradual reduction of 1 dB (A)/ year, in order to reach 65 dB (A)

In spite of the fact that the proposed value surpasses current maximum values in other countries, such as Finland (55), France (65) and Spain (65), the authors believe that the observance of this value would be more feasible considering the present conditions in Mexico, which include a lower level of environmental awareness and inadequate enforcement measures for existing federal norms. Hence, a gradual reduction of 1 decibel per year is recommended, leading to the establishment of maximal domestic noise levels in accordance with international standards within a ten year period.

Obviously, the obtained noise values result from the addition of different noise sources: engine, exhaust system, aerodynamic effect, brake system in some cases, pavement-tire contact, etc. and therefore the study takes into account pavement type, Average Daily Traffic, speed and weather conditions, which are included at the detailed research report.

Based on results of this noise pollution study, the IMT conclude that there is a noise problem on the Mexican highways and the obtained data identifies traffic transportation as the main producer of sonorous energy. As such, the responsibility to seek solutions to the problem falls on all actors involved. Mitigating measures should include: the design of highways which guarantee that inhabitants of adjoining zones will be exposed to acceptable noise levels, the consideration of sufficient protective measures (isolating barriers, tree screens, false tunnels, etc.), the use of specifically designed pavements that produce less noise and, most of all, the observance of existing noise control regulations.

With the former recommendations, reduction of noise pollution would be feasible not only on highways but also in Mexican cities. Nevertheless, the importance of a culture of respect toward our environment on the part of each individual user of land transportation cannot be underestimated. Control measures may prove to be fruitless if they are not accompanied by awareness campaigns which focus on the younger generations.

REFERENCES

1. BERGLUND, B, LINDVALL, T, (1995), *Community Noise*, Archives of the Center for Sensory Research, Vol 2, Issue 1, Stockholm University and Karolinska Institute.
2. INSTITUTO MEXICANO DEL TRANSPORTE, (2001), *Estudio del ruido generado por la operación del transporte carretero. Caso I, Querétaro*, Publicación Técnica No 154, México.
3. INSTITUTO MEXICANO DEL TRANSPORTE, (2001), *Estudio del ruido generado por la operación del transporte carretero. Caso II, Jalisco*, Publicación Técnica No 187, México.
4. INSTITUTO MEXICANO DEL TRANSPORTE, (2002), *Estudio del ruido generado por la operación del transporte carretero. Caso III, Nuevo León*, Publicación Técnica No 193, México.
5. INSTITUTO MEXICANO DEL TRANSPORTE, (2002), Estudio del ruido generado por la operación del transporte carretero. Caso IV, Veracruz, Publicación Técnica No 194, México.
6. INTERNATIONAL ORGANIZATION FOR STANDARIZATION; (1977), Acustics-Measurement of Noise Emitted by Stationary Road Vehicles- Survey Metod, Draft International Standard ISO/DIS 5130.
7. MINISTERIO DE OBRAS PÚBLICAS, TRANSPORTES Y MEDIO AMBIENTE, Dirección General de Carreteras, (1995), *Reducción del ruido en el entorno de las carreteras*, OCDE, Francia.
8. ORGANIZACIÓN PANAMERICANA DE LA SALUD, (1983), Criterios de salud ambiental 12: El Ruido, Organización Mundial de la Salud, México.
9. PETERSON, A, (2000), ContraFlow; *Journal World Highways*, Vol 9, pág 7, Reino Unido, ene/feb.
10. RUZA, F, (1988), El ruido del tráfico: Evaluación y corrección de su impacto, *Simposio sobre Impacto Ambiental de Carreteras*, PIARC, España.
11. SECRETARÍA DE DESARROLLO SOCIAL, (1994), Norma Oficial Mexicana NOM-080-ECOL-1994, México.