An investigation on time-interval optimisation of traffic noise measurement

Madjid Abbaspour[1], Rostam Golmohammadi[2], Parvin Nassiri[3] and Hossien Mahjub[4]

[1]Dept. of mechanical engineering, Sarif University of technology

[2]Occupational Safety and Health Dept. Health School, Hadadan University of Medical Sciences, PO Box 4171, Hamadan, Iran, Fax: +98 811 8255301, Website: /www.umsha.ac.ir/

[3]Tehran University of Medical Sciences

[4]Hamadan University of Medical Sciences

Noise is one of the most important sources of pollution in metropolitan areas, it causes discomfort for urban residents and hampers the efficiency of work force. Currently, there is an urgent need to conduct basic studies on this issue in order to attain a mathematical model for prediction of traffic noise levels in the major cities of Iran. This article is the result of research conducted in the city of Hamadan in 2005 with the ultimate objective of setting up a traffic noise model based on the traffic conditions of Iranian cities. For this study, main access roads of Hamadan city were divided in 64 segments and after careful considerations, 94 measuring stations were assigned to them. For the optimisation of noise measurement intervals in each station and the determination of background noise impact on the main traffic noise, 30 stations with the specifications of the target stations were randomly selected at the pilot stage. In all the pilot stations, the background sound pressure level (SPL_b), L_{eq}, SPL_{max}, L_{10} were measured simultaneously in 10, 30 and 60 minute intervals (in random non-holiday days at random hours). The measurements were made 3 meters away form the road side. Pilot results indicated that the mean equivalent sound pressure levels at the measuring stations in 10, 30 and 60 minute intervals were 70.76±2.11 dBA, 30 minutes 70.88±2.19 dBA, and 60 minutes 70.93±2.13dBA respectively. The mean background sound pressure level at the stations was 60.77±5.04 dBA. The results of the traffic noise measurements at the research stations through the comparison of mean values (Variance Analysis) indicated that there is no meaningful deviation between the L_{eq} in the above-mentioned time intervals (10, 30 and 60 minutes) in the hourly measurements (P= 0.998). In the pilot phase, it was determined that the background noise level did not impose a considerable impact on the main traffic noise and it was possible to make 10-minute interval measurements to forecast the 30-minute and 60-minute interval equivalent levels. Therefore in the main phase of study with the utilisation of the 10-minute interval results collected from each of the 94 stations, a total of 282 measurements including 2 daily-hour and one nightly-hour measurements were conducted. The final results revealed that the average Leq in all stations was 69.04±4.25 dBA, the average speed of vehicles was 44.57±11.46 km/hr and average traffic load was 1231.9 ± 910.2 V/hr. Moreover, the results indicated that the Leq in the studied roads were exceeding the allowable levels of urban noise pollution and there was a meaningful deviation between equivalent levels during a 24-hour period, traffic load and various vehicle speeds (P=0.003).

1. INTRODUCTION

Noise pollution is one of the most important environmental problems, it not only is an urban management predicament in the developing countries, but also, it is a lingering concern of the developed countries (1). Moreover, traffic noise is the main source of noise pollution in urban areas [2]. Studies on this phenomenon offer a quantitative description of noise distribution as a foundation for effective environmental impact assessments that are in line with sustainable urban development and ultimately could provide models for production and distribution of noise in metropolitan areas. Noise assessment could result in the design of mathematical models for prediction of noise pollution in order to forecast pollution levels for various urban traffic conditions.

Systematic urban management in relation to the protection of the environment requires the utilisation of various disciplines for the establishment of a coherent and balanced infrastructure. One of the factors to be considered in the infrastructure of urban design is noise pollution. Traffic noise could adversely affect the relative advantages of urban areas and thus, it has to be considered as an urban management criterion. The purpose of this study is to determine the most suitable time-interval for optimisation of noise measurements and the estimation of hourly equivalent sound pressure levels.

2. METHOD

This report is the result of research conducted in the city of Hamadan (West of Iran) in 2005 with the ultimate objective of setting up a traffic noise model based on the traffic conditions of Iranian cities. The collected data consists of field measurements and digital maps. In this study, Hamadan's main roads are divided into 54 segments and after careful consideration of various criteria based on the research strategy, 94 measuring stations were assigned randomly. For the optimisation of noise measurement intervals and determination of background noise impact on the main traffic noise, 30 stations with the specifications of the target stations were randomly selected at the pilot stage. In all of the pilot stations, the background sound pressure level (SPL_b), L_{eq}, SPL_{min}, SPLmax, L_{10} were measured simultaneously over 10, 30 and 60-minute intervals. On random non-holiday days at random hours, the measurements were made 3 meters away from the roadside. Measurements were based on the frequency weighting of (dBA) and the Slow mode condition by B&K type 2260 Sound Level Meter.

In the main phase of study with the optimisation of the 10-minute measurement duration, results were collected from each of the 94 stations, a total 282 measurements including 2 daily-hour and one nightly-hour measurements were conducted. The L_{eq}, SPL_{min}, SPL_{max}, L_{10}, load of traffic, vehicle speed in the four vehicle groups {(cars), (Light trucks and mini-buses), (heavy trucks and buses) and (Motorcycles)} as well as air temperature and humidity were measured. The research data was transferred to Excel and SPSS data sheets for statistical analysis.

3. RESULTS

Distribution of the main parameters of the research data in the pilot phase are shown in Table I, where the equivalent sound levels in the aforesaid time intervals in a 60-minute period are provided.

Pilot results revealed that the mean equivalent sound pressure level at the measuring stations in 10, 30 and 60 minute intervals were 70.76±2.11 dBA, 70.88±2.19 dBA, and 70.93±2.13 dBA, respectively. The mean background sound pressure level at the stations was 60.77±5.04 dBA. The results of the traffic noise measurements at the research stations through the comparison of mean values (Variance Analysis) showed that there are no meaningful differences between the Leq in the above-mentioned time intervals (10, 30 and 60 minutes) in the hourly measurements ($P=0.998$). Results of L_{eq}, SPL_{min}, SPL_{max} and L_{10} in time intervals of the study are shown in Figure 1.

Results of Pearson Correlation between L_{eq} in hourly time interval measurements are shown in Table II which indicates a high Pearson's correlation between them. Table III represents the analysis of research data for 10-minute and hourly intervals based on the pilot data and the estimation of L_{eq} for the entire target study field with the estimation of values with 95% Confidence. The comparison of the mean equivalent sound levels for a 24-hour period of the traffic load and vehicle speeds, points to a meaningful deviation (P=0.003).

In the main phase of this study with the optimisation of the 10-minute duration, results collected from each of the 94 stations, a total of 282 measurements including 2 daily-hour and one nightly-hour measurements were conducted. The final results revealed that the average L_{eq} in all stations was 69.04 ± 4.25 dBA, which is compatible with the pilot estimation results shown in Table III. The distribution of the central parameters for traffic load and average speed of the above-mentioned four vehicle groups namely are indicated in Table IV.

Figure 2 illustrates the distribution of equivalent sound pressure levels results. Figure 3 shows a typical 1/3 octave band frequency analysis of traffic noise. The highest level in the noise level analysis shown in Fig 3 is at 63 Hz. Figure 4 shows the distribution of equivalent sound pressure levels results with the total hourly traffic load of the vehicles.

Table I Distribution of central parameters of L_{eq} in the studied stations in the pilot phase

	Min	max	mean	sd
$L_{eq(10min)}$*	66.60	78.20	70.76	2.11
$L_{eq(30min)}$	67.30	78.00	70.89	2.19
$L_{eq(60min)}$	67.20	78.00	70.93	2.13
$L_{background}$	51.50	70.70	60.77	5.04

*All the level measurements are based on (dBA) for slow mode condition

Table II Results of Pearson Correlation amongst hourly L_{eq} measurements

	$L_{eq(10min)}$	$L_{eq(20min)}$	$L_{eq(30min)}$	$L_{eq(45min)}$	$L_{eq(60min)}$
$L_{eq(10min)}$	1	.962	.951	.945	.949
$L_{eq(20min)}$	.962	1	.983	.974	.970
$L_{eq(30min)}$	.951	.983	1	.993	.991
$L_{eq(45min)}$	.945	.974	.993	1	.996
$L_{eq(60min)}$	.949	.970	.991	.996	1

Table III Analysis of research data for L_{eq} in 10-minute and hourly measurements and estimation of values with 95% Confidence

		95% Confidence Interval of the Difference	
L_{eq}	Mean (dBA)	Lower	Upper
L_{eq}(10min)	70.76	69.97	71.55
L_{eq} (60min)	70.33	68.78	71.87

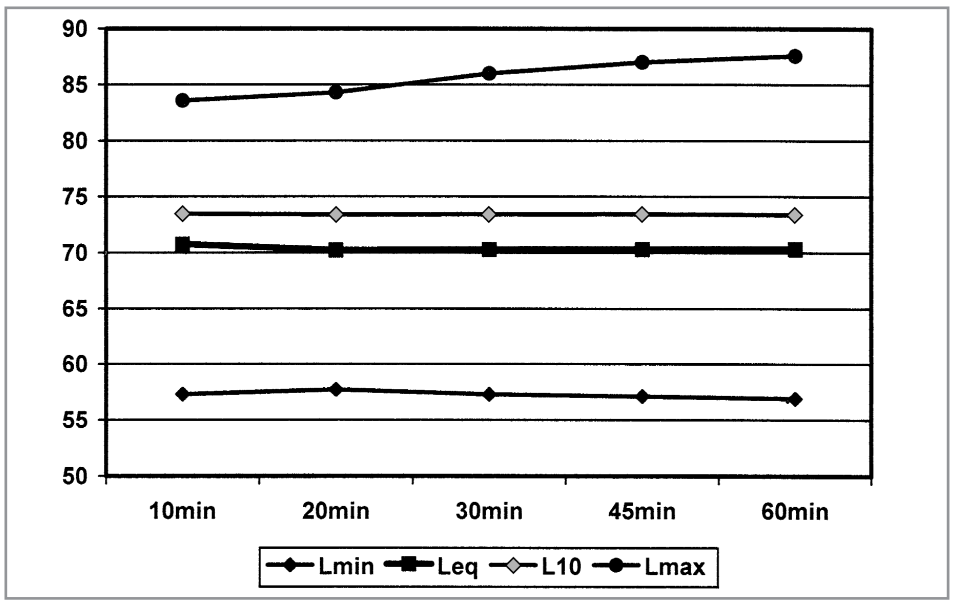

Figure 1. Comparison results of L_{eq}, SPL_{min}, SPL_{max}, L_{10} (dBA) in time steps of study

Table IV Distribution of main statistical Parameters for traffic load and average speed of vehicles at the study stations

Traffic Parameters	Min	Max	Mean	S.D.
Car load (v/h)	6	3630	1006.60	777.68
Light truck load (v/h)	0	516	33.21	54.28
Heavy truck and bus load (v/h)	0	306	44.28	61.83
Motorcycle load (v/h)	0	558	147.82	114.14
Total load (v/h)	12	4116	1231.90	910.24
Heavy truck percent (%)	0	36.36	4.50	6.3
Car speed (km/hr)	16.34	105.99	53.23	14.87
Light truck speed (km/hr)	13.01	84.19	41.52	12.18
Heavy Truck and bus speed (km/hr)	13.77	99.20	40.99	13.39
Motorcycle speed (km/hr)	16.58	111.72	48.08	14.77
Total mean speed (km/hr)	18.24	82.15	44.57	11.46

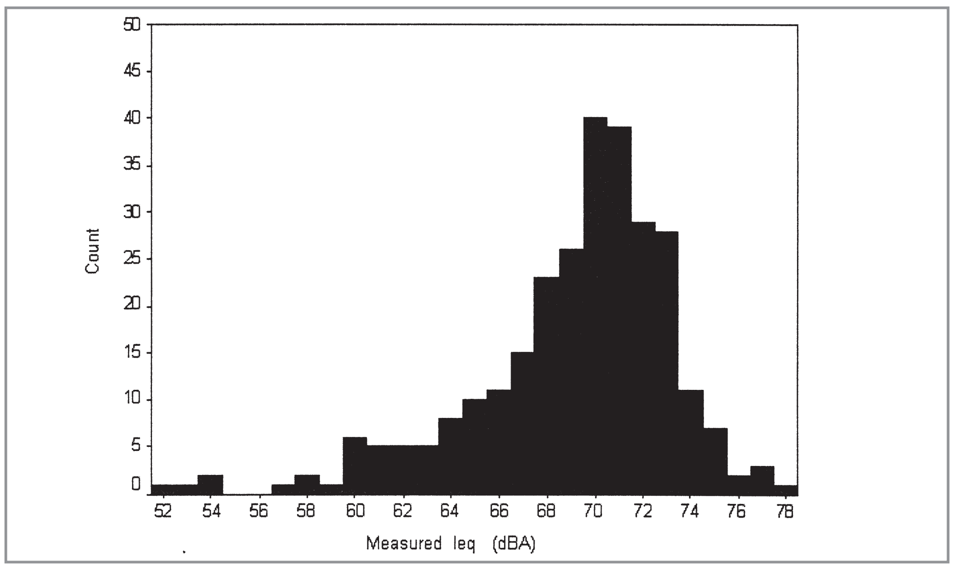

Figure 2. Distribution of equivalent noise levels in main phase of the study

Noise Notes 6-3 27/09/07 10:30 am Page 13

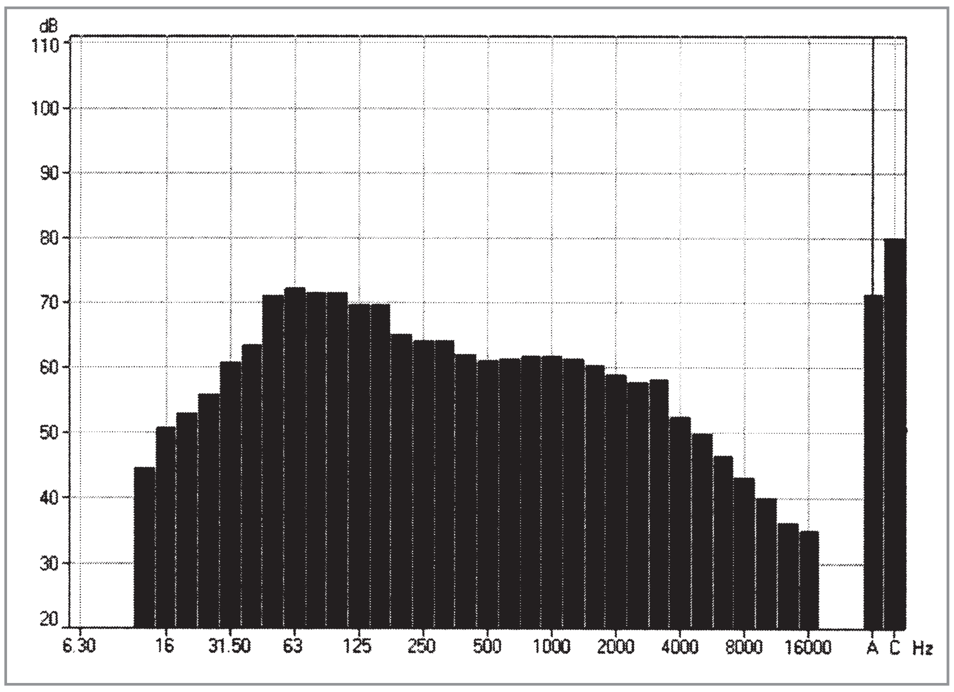

Figure 3. Typical 1/3 octave band frequency analysis of traffic noise results

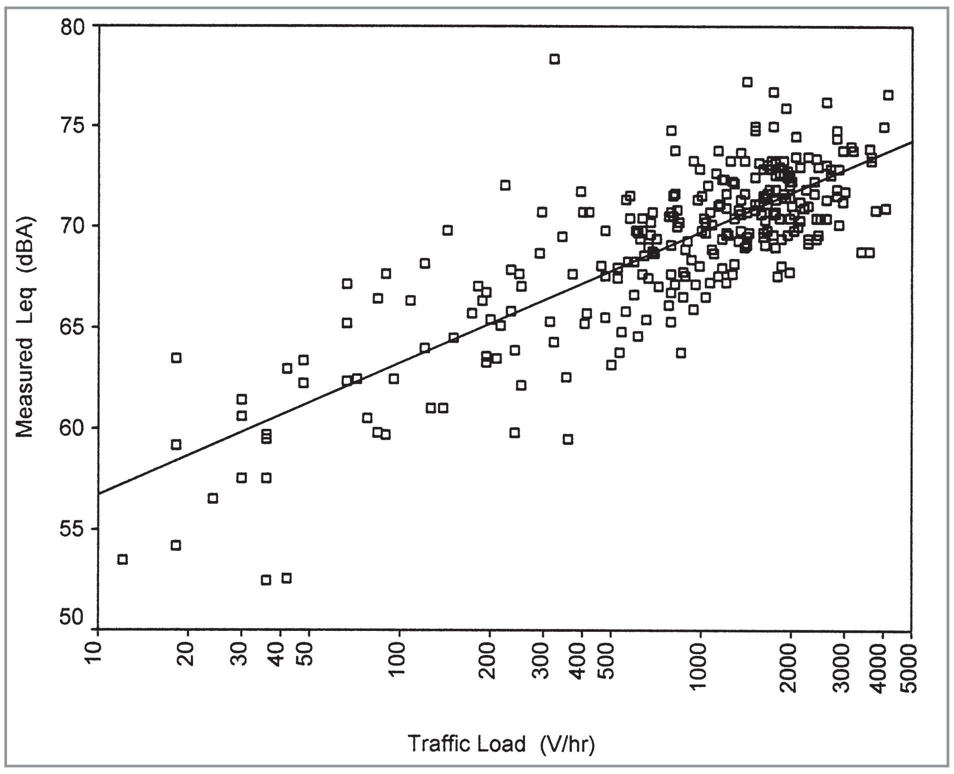

Figure 4. Distribution of Leq with total traffic load

4. CONCLUSIONS

Noise pollution is still one of the most important environmental problems in metropolitan areas in both developed and developing countries. Although widespread control measures are being implemented for mitigation of this predicament. Noise pollution already is a worldwide policy problem [1]. Urban traffic noise is the main source of noise pollution in the cities [2], where new regulations for its control have appeared in recent years. This report is the result of research conducted in Iran in 2005, whose two-phase plan was implemented based on field data obtained from 282 measurements.

As it is shown in Table I, the

difference in mean equivalent sound pressure levels in 10-minute and hourly intervals is just 0.17 dBA, which is quite modest for an hourly period. The mean background sound pressure level in measuring stations were 60.77±5.04 dBA and the difference between equivalent level and background level were 9.99 to 10.16 dBA in the measured time intervals. The aforesaid deviation indicates that the background noise level (consist of noise emitted from commercial activities and pedestrian conversations) does not affect the pressure level of L_{eq} and therefore is negligible.

In pilot phase of the study, a mean level of $L_{10(60min)}$ was 73.65±2.08, which the mean difference of the above-mentioned indicator for an hourly period was 0.06 dBA and thus negligible. In the same manner, the mean SPL_{max} was 88.02±2.94 dBA with the deviation of 4 dBA. It is noteworthy that only the SPL_{max} during a 60-minute interval has an increasing trend. The logical explanation for this phenomenon is that various noise sources like vehicle horns could introduce peak levels even in measurements conducted over a time span of several hours. Any other index of traffic noise has little fluctuation in a one-hour period.

As it is shown in Table II, the Pearson Correlation Coefficient between L_{eq} in the specified time intervals is very high and the Variance Analysis of traffic noise measurements at the research stations did not reveal a meaningful deviation for a one-hour period (P – 0.998). Therefore, a 10-minute measurement in each station could predict the hourly equivalent levels. Also, the reliability of model FHWA TNM 2.5 based on 15-minute measurement has been verified [3]. These experiences point out that the changes in sound pressure levels in a time interval of 10 to 15 minutes could forecast the hourly changes.

As the final results indicate, the mean equivalent sound pressure level at all stations was 69.04 ± 4.25 dBA, which is equal to the estimates of the pilot phase shown in Table III. Some studies have reported similar results for L_{eq} limits [4]. The distribution of the main parameters for traffic load and average speed of the above-mentioned vehicle groups namely, {(cars), (Light trucks and mini-buses), (heavy trucks and buses) and (Motorcycles)} are indicated in Table IV.

The distribution figure for traffic load data for various types of vehicles in comparison to the equivalent sound level illustrates that the variables of traffic load (v/h) have a logarithmic distribution plot data L_{eq} values and the total traffic load has linear regression line. Most of the pertinent studies have reported similar results [5, 6, 7, 8, 9, 10, 11 and 12]. Figure 3 displays the logarithmic distribution as an important factor in the establishment of a model for prediction of noise levels. In this study, the automobiles are divided into three groups and motorcycles due to their importance are categorised as a separate group. Similar studies have also allocated a separate group for motorcycles [12]. Motorcycles, in developing countries like Iran have a multifaceted usage in urban transportation and thus are highly significant in any traffic noise model.

The final conclusion of this study based on the obtained results is that 10-minute interval measurement of equivalent sound pressure level could effectively forecast the hourly values of L_{eq} in each station.

REFERENCES

1. Brain Ross M., and Tjeert ten wolde, Noise from traffic as a worldwide policy problem, *Noise Control Engineering Journal*, Vol.49, No. 4. (2001) July-Aug.

2. Stefano R, de Danato and Barbara Morri, Technical Note: A Statistical Model for Predicting Road Traffic Noise on Poisson Type Traffic Flow, *Noise Control Engineering Journal*, Vol. 49, No. 3, (2001) pp. 137-143.

3. FHWA, FHWA-EP-02-031, TNM Ver 2.5. *Addendum to validation FHWA's traffic noise model*, July 2004.

4. Morillas J M B et al, An environmental noise study in the city of Cacers-Spine, *Applied Acoustics*, Vol.63 (2002) pp. 1061-1070.

5. Steele Campbell, A Critical Review of Some Traffic Noise Prediction Models, *Applied Acoustics*, Vol.62 (2001) pp. 271-287.

6. Tang S K and K K Tong, Estimating Traffic Noise for Inclined Roads with Freely Flowing Traffic, *Applied Acoustics*, Vol.65 (2004) pp. 171-181.

7. Calixto Alferdo et. al., The Statistical Modeling of Road Traffic Noise in an Urban Setting, *Cities*, Vol. 20 (2003) p.23-29.

8. Pamanikabud Pichai, Prakob Vivitjinda, Noise Prediction for Highways in Thailand, *Transportation Research Part D*, Vol.7 (2002) pp. 441-449.

9. Li Bengang, Shu Ta, R W, Dawson, Evaluation and Analysis of Traffic Noise From the Main Urban Road in Beijing, *Applied Acoustics*, Vol.63 (2002) pp. 1137-1142.

10. Pardina M, Jain S S, Mittal N, Modelling of Metropolitan Traffic Noise in Dehli, *ITPI Journal*, Vol.21:1 (2003) pp. 5-12.

11. Gundogdu O, M Gokdag, F Yuksel. A Traffic Noise Predication Method based on Vehicle composition using Genetic algorithms, *Applied Acoustics*, Vol.66 (2005) pp. 799-809.

12. Tansatcha M, P Pamamikabud, A L Brown, J K. Affum. Motorway noise modelling based on perpendicular propagation analysis of traffic noise, *Applied Acoustics*, Vol.66 (2005) pp. 1135-1150.

WAIKATO AGAIN TOPS LIST FOR FARM-BIKE CRASHES

Figures recently released show the number of farm bike accidents in the Waikato area New Zealand, resulting in a claim, has doubled in the last five years. There were 79 new all-terrain vehicle (ATV) claims in the region in the year ending July 1, 2006, compared to 40 in the year ending July 1, 2002. The cost of the claims in that time rocketed from $193,528 to $464,980. Farmer Kevin Richards, who was paralysed below the waist 17 years ago when he rolled a farm bike on his parents' Morrinsville farm, said ATV safety was something that farmers needed to work on. "It's disappointing for someone like me, as I have been spreading the message for an awfully long time," said Mr Richards, 40. And not only are ATVs sources of accidents, they are bad for your health! Otago University School of Physiotherapy study, published by Dr Stephan Milosavljevic, found farmers using ATVs for an hour a day were exposed to maximum levels of low-frequency whole-body vibration that could change the physical capacity of the spine to handle load.

GOLD PLATING THE REGULATIONS

A council has ordered a man to move a tiny wind chime form his back garden following an investigation that cost more than £1,000. David Bavington was stunned to receive an official letter claiming that the 1 inch diameter chime was a 'statutory nuisance' following a complaint. And he was warned he had to take it down - or be served with a noise abatement order and face legal action. Ironically Mr Bavington, 57, and his wife Sheila bought the chime to create a feeling of calm while they were sitting in the garden of their £300,000 detached home in Ryton-on-Dunsmore, Warwickshire, with noisy airliners flying overhead on final approach to Coventry airport just over a mile away. But, instead, it has landed them in a two-month legal row with officials at Rugby Borough Council, which has spent £1,000 writing letters, phoning the couple and sending two officers out to listen to the chime because of a complaint that it tinkled too loudly in windy weather. Now the couple have agreed to move it 15ft from their garden fence on to an apple tree as a compromise solution to settle the dispute and end the legal action. Retired sales executive Mr Bavington said: "You can't even hear the chime if you go inside the house. But the council said there had been a complaint from someone who was annoyed by the tinkling. I told them it was ridiculous. Sending around officers to listen to a tiny wind chime is a complete waste of taxpayers' money." But Sean Lawson, head of environment for the council, said officers had a duty to investigate every complaint. "It does cost a lot of money - about £1,000 for something like this - but it is our job. People become very concerned about noises or anything else that intrudes into their lives from their neighbours' gardens."

OULTON PARK MOTORCYCLING

Motor Sport Vision, the UK based race circuit owner and operator, is considering replacing a number of car racing events with motorcycling racing events at its Oulton Park Circuit in Cheshire following a noise assessment. A series of detailed noise studies conducted on behalf of the circuit's liaison group, by environmental consultants engaged by the Vale Royal Borough Council has prompted MSV to agree to noise restrictions being put in place. Councillor Dennis Ford, lead councillor for Community Safeguards, said, 'This work has enabled us to assess the difference between the noise levels created in the local villages by car and bike events. Whilst this has established that bikes are slightly louder than cars, we have agreed additional restrictions on the bikes themselves that will ensure there is no audible difference beyond the circuit.' MSV will also introduce new controls aimed at limiting the impact of the public address system at Oulton Park and will install trackside noise monitoring equipment that will help identify and control individual vehicles that are particularly noisy. MSV CEO Jonathan Palmer said, 'We have been eager to have increased flexibility of operations at Oulton Park in order to maintain the economic viability of the circuit. However, we recognise this should not result in any increase of noise locally. We have been happy to accept the conclusions of the council's noise monitoring and are appreciative of a constructive approach that has resulted in an optimised solution for both the community and Oulton Park."