# Aspects of urban noise pollution in a large Brazilian city

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This paper presents the results obtained in a study on environmental noise pollution in the city of Curitiba, Brazil. The equivalent sound level values – $L_{A,eq,2hr}$ – were measured and tabulated for 1000 locations spread over the urban zones of the city of Curitiba. It was found that 93.3% out of the locations display, during the day, equivalent sound levels over 65 dB(A), and 40.3% out of the locations measured display during the day extremely high values of equivalent sound levels: over 75 dB(A). Measurement points were evaluated according to the assumptions established by two types of legislation: 1) local legislation: Law 8583 of 1995, which deals with urban noise and public comfort; 2) international legislation: the criteria of the US Department of Housing and Urban Development – HUD.

## 1. INTRODUCTION

This paper presents the results of measurements of noise emission levels carried out in the city of Curitiba, located in Southern Brazil. The city is one of the oldest and one of the most populated cities in Brazil (1,619,348 inhabitants) and is the capital of Paraná State. Curitiba underwent profound urban transformation along the last decade, characterized by intense industrialization, especially by the establishment of European automobile industries such as Renault and Mercedes-Audi. As a consequence of the industrialisation event, significant structural changes in the city have been observed, such as:

1) General improvement of the population life standards, placing Curitiba now among the 5 Brazilian cities with best average life standards,

2) Migratory movements of country people to urban areas in search of more lucrative jobs in automobile and other industries,

3) Increasing activities in civil construction in order to build new homes for the new inhabitants,

4) Increasing number of vehicles in urban streets,

5) Increasing in air traffic with the construction of a new international airport.

The population of Curitiba has been continuously increasing since 1970, as shown in Table 1 [1].

*Table 1. Populational growth in Curitiba*

| Year | Number of inhabitants |
|---|---|
| 1970 | 609,026 |
| 1980 | 1,024,975 |
| 1991 | 1,315,032 |
| 1996 | 1,476,253 |
| 2000 | 1,619,348 |

An increasing number of vehicles has naturally accompanied the increasing number of inhabitants. In 1995 the total number of registered vehicles was 536,641, of which 5,395 were buses and 391,461 were cars. In 1999, the last available information on vehicle number, the total of vehicles was 684,212, of which 6,983 were buses and 489,420 were cars. The increasing number of people and vehicles normally lead to increase in urban noise. However, in countries with severe economical and social problems such as Brazil, urban noise has not received much attention so far. Still, as a general rule in the whole world, the necessity for studies on noise pollution and its influences over the surrounding environment is increasing, especially by the increasing number of noise sources such as machines, markets, factories and the already cited motor vehicles. Many

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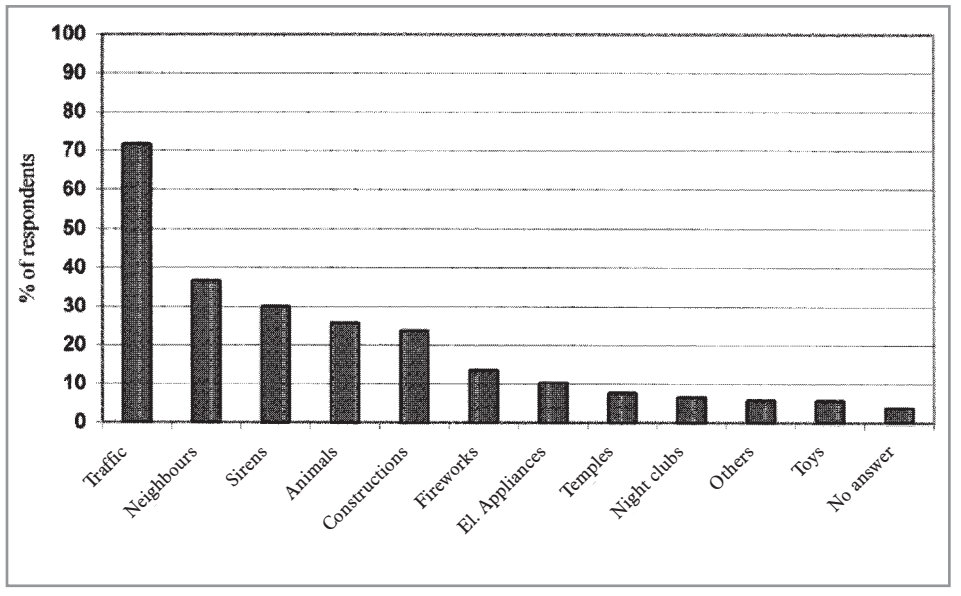


*Figure 1. Answers to: "What noise sources annoy you"?*

recent noise surveys have appeared, treating the problem of noise pollution [2, 3, 4, 5, 6, 7, 8, 9].

In some surveys such as in [7], noise impact was treated as a stress inductor, and in consequence the role of noise as a risk factor for human health was discussed. Maschke [7] says that the induced stress by noise has a psychosocial component.

A recent survey (see Figure 1) carried out by Zannin et al. [10] has presented the results obtained in a research conducted in the city of Curitiba, in which the answers collected from 860 questionnaires distributed among the population were analyzed, with the intention of verifying the impact of urban noise over the people. This study has shown that the noise generated by the traffic of vehicles is the most annoying noise, as indicated by 73% of the total of people who answered to the questionnaire. Noise generated by traffic of vehicles was then followed by noise generated by the neighbours, as indicated by 38% of the total of people. Noise generated by neighbours is a natural consequence of the increase in the number of inhabitants. Another consequence of the growth displayed by the city of Curitiba was the intense increase in occupancy of peripheral areas of the city, expanding the urban limits of the city. As a result, previously free areas along road margins have turned highly occupied, severely increasing the demographic density by the road margins. These areas are inhabited by the poorest population layer, with very modest housing, of course displaying no acoustic comfort at all.

The objective of the present research was to show the noise level measurements carried out in different urban zones of the city of Curitiba. Measured noise levels were classified according to the environmental legislation in effect in the city [11], and also according to HUD criteria [12].

## 2. MEASUREMENT OF ENVIRONMENTAL NOISE

Noise levels were measured by means of the following equipment: 1) Brüel & Kjaer Mediator 2238, and 2) Brüel & Kjaer Investigator 2260; both type 1 integrating and logging sound meters [13].

The city has been divided into urban zones, each of them with a particular noise emission limit according to the City Law number 8583 from 1995, which legislates about urban noise and public comfort [11]. The allowable limits for each zone in particular can be observed in Table 2.

In the present survey the measurements were carried out during the afternoon in 1000 locations spread through all zones listed in Table 3. This means that the city has been divided into one location for each 1,500 inhabitants. The distribution of measurement sites per zone can be seen in Table 3. A non-regular grid was used to distribute the measurement points throughout the city. The bias effect, the proximity to roads and to building facades were avoided. Figure 2 shows the distribution of the measurement

points through the city.

All measurements were carried out during working days and under ideal meteorological conditions: no wind and no rain. The duration of each measurement in each site was one hour, each site measured in duplicate. The first measurement was carried out while people were returning home from work to have lunch, or taking children to/ from school, between 12:00 and 01:00 pm. The second measurement was carried out when people were returning home after a working day, between 06:00 pm and 07:00 pm. The two $L_{Aeq}$ measurements were averaged for each site to find a single $L_{Aeq,2hr}$ value. The distribution of the measured equivalent sound level ($L_{Aeq,2hr}$) values across all measurement locations can be seen in Table 4. Table 5 shows the zone distribution of the measured equivalent sound levels.

Observing Tables 4 and 5 we can notice that in 37 locations, representing 3.7% out of the total number of locations considered in our survey, the equivalent sound levels ($L_{Aeq,2hr}$) have a maximum value of 55 dB(A), meaning that they are in accordance with the city urban legislation. Observing only Table 5 it is possible to see that the previously mentioned locations are all located in the residential zone. In our sample for this zone, formed by 350 locations, this represents 10.6% out of the measured points. Downtown and Industrial zones also have some measurement sites in accordance with the local legislation: 29 sites in the former (2.9% out of the measured locations) and 38 sites in the latter (3.8% out of the measured locations).

The U.S. Department of Housing and Urban Development (HUD) recommends the following noise levels for residential areas, measured outdoors:

$L_{Aeq} \leq 49$ dB(A) – clearly acceptable
$49 < L_{Aeq} \leq 62$ dB(A) – normally acceptable
$62 < L_{Aeq} \leq 76$ dB(A) – normally unacceptable
$L_{Aeq} > 76$ dB(A) – clearly unacceptable

By considering the above criteria, all the 37 locations mentioned above can be classified as normally acceptable. It is noticeable by looking at Table 4 that the measured $L_{Aeq}$, 2hr in 15 locations belonging to the residential zone ranged between 55 and 60 dB(A). These values do not satisfy the law number 8583

*Table 2. Limits for Urba Noise – dB(A) – according to the City Law number 8583 from 1995*

| Zone | Day – 07:00am Limit – 07:00pm | Evening – 07:00pm Limit – 10:00pm | Night – 10:00pm Limit – 07:00am |
|---|---|---|---|
| Residential | 55 | 50 | 45 |
| Mixed | 60 | 55 | 55 |
| Services | 65 | 60 | 55 |
| Downtown | 70 | 60 | 60 |
| Industrial | 70 | 60 | 60 |

*Table 3. Distribution of measurement sites along urban zones of the city of Curitiba*

| Zone | Number of locations | Percentage (%) |
|---|---|---|
| Residential | 350 | 3.5 |
| Mixed | 75 | 7.5 |
| Services | 239 | 23.9 |
| Downtown | 97 | 9.7 |
| Industrial | 239 | 23.9 |

*Table 4. Distribution of the measured $L_{Aeq,2hr}$ values in 1000 different sites in the city of Curitiba*

| $L_{Aeq,2hr}$ dB(A) | Number of sites | Percentage (%) |
|---|---|---|
| $L_{Aeq,2hr} \leq 50$ | 7 | 0.7 |
| $50 < L_{Aeq,2hr} \leq 55$ | 30 | 3.0 |
| $55 < L_{Aeq,2hr} \leq 60$ | 15 | 1.5 |
| $60 < L_{Aeq,2hr} \leq 65$ | 15 | 1.5 |
| $65 < L_{Aeq,2hr} \leq 70$ | 127 | 12.7 |
| $70 < L_{Aeq,2hr} \leq 75$ | 403 | 40.3 |
| $75 < L_{Aeq,2hr} \leq 80$ | 321 | 32.1 |
| $80 < L_{Aeq,2hr} \leq 85$ | 82 | 8.2 |
| $85 < L_{Aeq,2hr} \leq 90$ | 0 | 0 |
| $L_{Aeq,2hr} \geq 90$ | 0 | 0 |

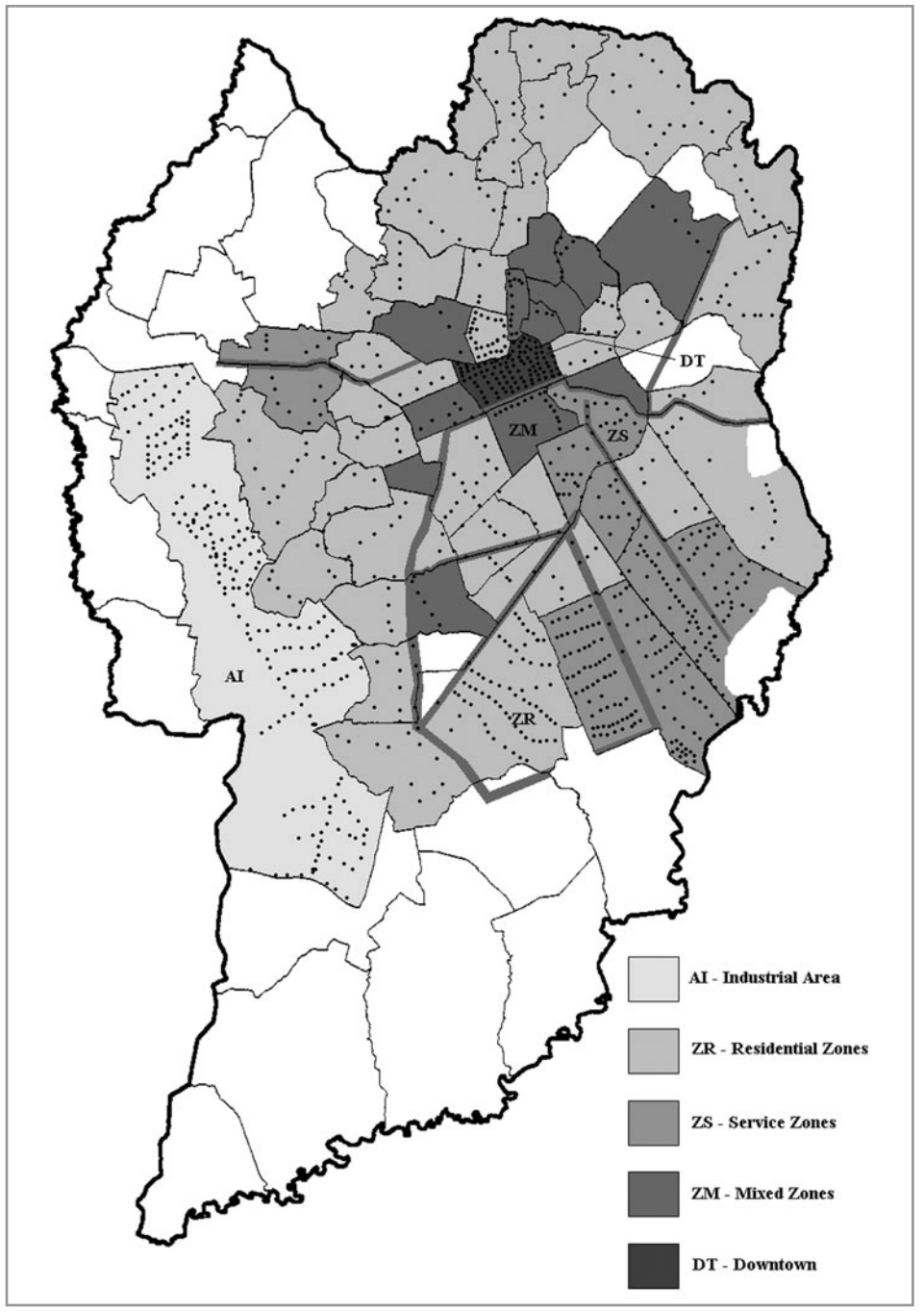


*Figure 2. Zone distribution of the measurement points throughout the city*

which states a 55 dB(A) limit for this zone, but according to the HUD criteria they are still classified as normally acceptable.

Table 5 shows that no location in the mixed zone satisfies the limits showed in Table 2 which states the maximum value of 60 dB(A) for sound emission during daytime. The mixed zone includes residential areas with strong commercial activity. Applying the HUD criteria to this case, it is noticeable that 90.7% out of the 75 locations in this zone range from 65 < $L_{Aeq,\ 2hr}$ (80 dB(A), being considered as normally unacceptable. In 7 locations the $L_{Aeq,2hr}$ exceeded 76 dB(A), being classified as clearly unacceptable. Table 5 also shows that in the service zone no location satisfies the criteria of Table 2. So, all 239 locations measured in this zone exceed the day limit of 65 dB(A), as the sound levels range from 65 < $L_{Aeq,\ 2hr}$ (80 dB(A).

At this point we can question whether the City legislation is not setting a limit for noise emission level that is difficult to be met – 55 dB(A) during the day for residential zones – facing the local conditions:

1) The bad conditions, in general, of the urban streets;
2) The poor maintenance of the vehicles: cars, buses, motorcycles. It is not rare to find vehicles with a damaged exhaust system or even without it.
3) Generally the vehicles are old. The average age of the vehicles circulating in Brazilian roads and streets is 14 years.
4) The bad habits, in general, of the Brazilian drivers:
   a) Using the horn for any purpose, with or without apparent reason to do so.
   b) Accelerating the vehicle during traffic jams or while waiting for green traffic light.
   c) High speed driving inside urban regions. It is not rare to find people driving over 70–80 km/h.

The present research does not have the objective of analyzing the applicability of the City legislation – Law 8583 of 1995. It is clearly noticeable that maybe before the setting of an environmental legislation establishing realistic limit sound emission levels, it would be desirable to conduct an awareness campaign for everybody in general and specifically for drivers to control their bad habits previously discussed, so that

*Table 5. Distribution of the measured $L_{Aeq,2hr}$ values per zone*

| $L_{Aeq,2hr}$ dB(A) / Local legislation dB(A) | Residential 55 | | Mixed 60 | | Services 65 | | Downtown 70 | | Industrial 70 | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Locations | % | Locations | % | Locations | % | Locations | % | Locations | % | |
| $L_{Aeq,2hr} \leq 50$ | 7 | 100 | – | – | – | – | – | – | – | – | 7 |
| $50 < L_{Aeq,2hr} \leq 55$ | 30 | 100 | – | – | – | – | – | – | – | – | 30 |
| $55 < L_{Aeq,2hr} \leq 60$ | 15 | 100 | – | – | – | – | – | – | – | – | 15 |
| $60 < L_{Aeq,2hr} \leq 65$ | – | 100 | – | – | – | – | 7 | 46.7 | 8 | 53.3 | 15 |
| $65 < L_{Aeq,2hr} \leq 70$ | 43 | 35.3 | 15 | 11.8 | 15 | 11.8 | 22 | 17.3 | 30 | 23.6 | 127 |
| $70 < L_{Aeq,2hr} \leq 75$ | 134 | 33.3 | 38 | 9.4 | 142 | 35.2 | 37 | 9.2 | 52 | 12.9 | 403 |
| $75 < L_{Aeq,2hr} \leq 80$ | 104 | 32.4 | 15 | 4.7 | 82 | 25.5 | 31 | 9.7 | 89 | 27.7 | 321 |
| $80 < L_{Aeq,2hr} \leq 85$ | 15 | 18.3 | 7 | 8.5 | – | – | – | – | 60 | 73.2 | 82 |
| Locations per zone | 350 | 75 | 239 | 97 | 239 | 1000 | | | | | |

maybe this 55 dB(A) limit could be met more often.

Figure 3 shows the average sound levels for all measurements per zone. It is clearly noticeable that all values exceed the limits specified by the environmental legislation for the city of Curitiba according to Table 2. It is also noticeable that the average value for all measurements made in residential zones is classified as normally unacceptable according to the HUD criteria.

During the conduction of this study it was observed that traffic noise was the major source of environmental noise pollution. These results agree with the results of a social survey carried out in the city of Curitiba, according to Figure 1 of reference [10], traffic noise being the major source of annoyance for the citizens.

In the paper by Maschke [7], he wrote that the sound level category of 66 – 70 dB(A) is to be regarded as the threshold of health impairments. According to this, from the point of view of preventive medicine, an equivalent sound pressure level of 65 dB(A) should be maintained as the limiting value of exposure to traffic noise during the day. From Table 5 we can notice that in 933 locations, representing 93.3% of the total locations considered in our 1,000-location sample, the values of the equivalent sound levels range from $65 < LAeq, 2hr \leq 85$ dB(A). So, it is noticeable that the major part of the population, i.e., 93.3%, is daily exposed to sound emission levels greater than 65 dB(A) everyday, considered by preventive medicine as the limit value one can be exposed to [7]. Table 4 also shows that 80.6% of the population is exposed to noise levels greater than 70 dB(A), considered as the threshold of health impairments.

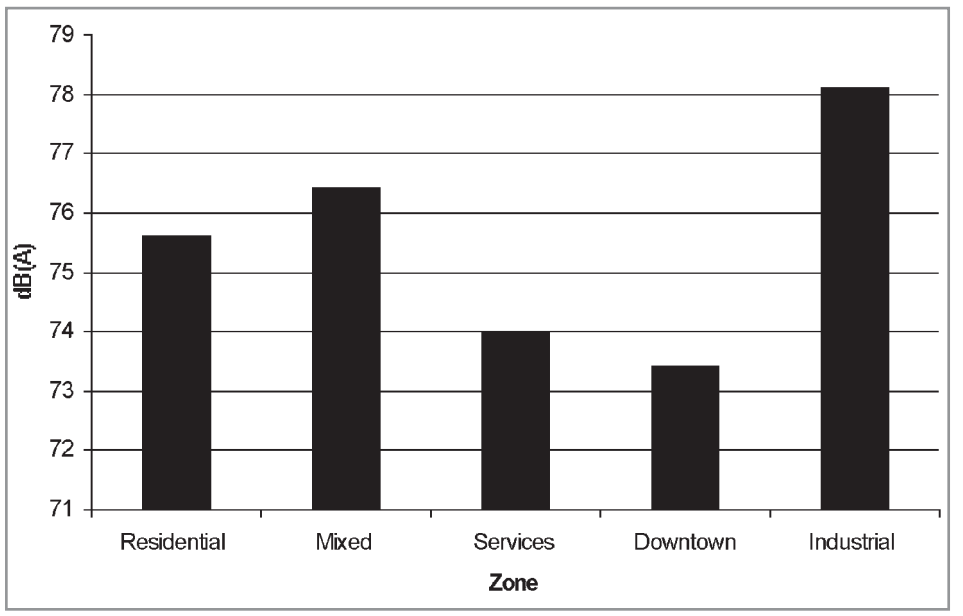


*Figure 3. Mean $L_{Aeq,2hr}$ values per urban zone. Residential: 75.6 dB(A); Mixed: 76.4 dB(A); Services: 74.0 (dB(A); Downtown: 73.4 dB(A); Industrial: 78.1 dB(A)*

## 3. CONCLUSIONS

At the end of this study we can conclude that the city of Curitiba one of the most populated cities in Brazil, and considered as a model of urban development in the third world, is environmentally noise polluted. About 93.3% of the locations measured in this study show during the day equivalent sound levels over 65 dB(A), the limit for preventive medicine. Over forty percent (40.3%) of the locations measured show during the day extremely high values of equivalent sound levels over, 75 dB(A). A widely accepted scientific fact is that living in "black acoustics zones" [7, 14], where the equivalent sound level is higher than 65 dB(A), put an urban population in a high risk category for numerous noise subjective effects, including psychological, sleep, and behavioural disorders.

Among all things that can be done to relieve the environmental noise pollution problem in the city of Curitiba, the most effective one is the:

1) Promote awareness of the population about the risks of daily exposure to high noise levels,
2) Promote awareness of the population about the existence of environmental legislation about noise emission,
3) Tighter police action toward punishing those who emit sound over the allowable limit or drive over set speed limits.

Noise abatement is less of a scientific problem but primarily a policy problem, and this is not yet understood in Curitiba as well as in Brazil.

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BUREAUCRAT VS. BUREAUCRAT

The US Navy wants to build a landing strip in Washington County, North Carolina. However, the US Fish & Wildlife Service (a division of the US Interior Department) is objecting to the proposals as they presently stand. The FWS wants noise impacts on waterfowl to be better evaluated; is concerned that flights and flight patterns are unpredictable; and that the presence of a landing strip would disturb the habits of migratory birds.

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# HELP!

*Sir – Can you assist on the following matters?*

*I live in a place that is surrounded by other houses which also has ex-fish cellars below (converted in the past few years to living accommodation). I have a hearing impairment plus an induction loop plugged directly into the tv.*

*None of the walls, floors or ceilings of this Housing Association property or other houses around are noise insulated, windows cannot be double glazed due to conservation area status. In any case, most of the latter are open throughout fine weather.*

*I have consistently complained that my floors vibrate regularly (even when I have no equipment in use) but it is ignored. Similarly, I frequently hear noises of various kinds during day and night which are termed by officials as "mysterious". As I'm a widow living on my own, few other people have heard them or felt the vibrations. I also have problems with exterior/background noise when trying to use loop/T switch which do not occur in other people's houses or in Church.*

*I suspect much of this is due to low frequency sounds which may come from electrical equipment below, machinery and/or vents elsewhere. The effect tends to produce sluggishness, headaches, very disturbed sleep patterns.*

*It has been suggested by a washing machine engineer that the buzz/hum he heard was coming from electrical equipment next door and/or from under floor/above ceiling below cables, pipes, etc.*

*Two days of DE equipment here apparently picked up nothing and does not pick up vibrations anyway. A similar case in an old house (surrounded by others) in town, where the resident still experiences vibrations, late night noise and has identified one or more vents as the cause, received the same negative response from DE.*

*What more, if anything can be done to identify the sources? As I write a buzz/hum is going through the house! The matter is now of some urgency.*

*Yours*
*(Mrs) P. Stevens*

Please email comments/suggestions to mscience@globalnet.co.uk

## FIRING RANGE

An Essex MP has said he will pursue the Government until a solution is found to reduce the noise and vibrations of explosions from a military range. Homeowners have long complained about the impact from Shoeburyness with some claiming their houses have cracks as a result of the continued testing of weapons at the site. A year long study is under way by science and technology company, QinetiQ, which does defence research for the Government, to try and find a suitable solution. But in a letter from the Ministry of Defence to John Whittingdale, MP for Maldon and East Chelmsford, it was revealed there had been a "lack of success" in finding a noise suppression method. It said various techniques to reduce the noise had been tried, including sound barriers and applying devices to the end of the barrels of weapons, but none had offered a complete solution. The letter from the Minister for Defence Procurement, Lord Bach, said sound deadening devices had interfered with the weapons and in some cases caused hazards to people testing them. He concluded: "Although successful in reducing the level of noise, the techniques resulted in problems that either made the trials ineffective or increased the risk of accident involving QinetiQ staff." Mr Whittingdale said the problems caused by Shoeburyness last month had sparked numerous complaints to Burnham Town Council. He said: "The noise and vibrations caused by the explosions at Shoeburyness ranges continue to cause distress to many of my constituents, particularly those living in the Dengie peninsula. "It is disappointing that it has, so far, not been possible to find a way of suppressing the noise without affecting the trials being undertaken. "This problem has gone on for far too long. I am pleased that at last action is being taken but I will continue to pursue the Government and QinetiQ until a permanent and effective solution is found."

## ENGLAND 'SUFFERING DRAMATIC POLLUTION LEVELS'

More than 90% of England is now affected by some form of pollution. According to a study expanding road networks and a sharp rise in flights have led to a dramatic jump in noise, air and light pollution in the past decade. London and the South East are the worst hit areas along with Birmingham, Liverpool, Manchester and Sheffield. Planned road developments are expected to increase the problem over the next few years. The number of people affected by unacceptable levels of noise from air traffic is also predicted to double by 2030 as passenger number soar. Only one tenth of the country now experiences a truly dark night after light pollution rose by a quarter between 1993 and 2000. Even on the clearest nights, less than half of homes in England can now see the Milky Way. The study by Country Life magazine is the first to assess the combined impact of noise, air and light pollution. It found Newcastle, Bristol and Norwich, also suffer from exceptionally high levels of pollution.

## NOISE IS POLITICS

The Belgian government has agreed to spread night flights to and from Zaventem airport across the surrounding area, banning flights from flying over central Brussels, to escape the accusation that Flemish speaking Belgians are being more heavily subjected to noise than French speaking ones. The issue of francophone communes being victim to less noise than their Flemish neighbours has dogged both this administration and the previous rainbow coalition. In future, more runways will be used both during landing and take off, and residents of northeast Brussels in particular will benefit from the changes. The plan is being introduced immediately and will remain in force until an inventory is made mapping out noise pollution levels around the city – the plan will be evaluated in a year's time. Under an earlier agreement, flights had been concentrated above the Flemish area northwest of Brussels, leading local residents to take the matter to court because of excessive noise levels. The court has now ordered that all flights should be spread fairly across the entire area and imposed a daily fine of EUR 50,000 if its decision was not implemented.

## STAGE 4 NOISE STANDARDS

In a Notice of Proposed Rulemaking published at the beginning of December, the FAA proposed that Stage 4 noise standards for all new designs for transport category aircraft and subsonic jets should take effect as of Jan. 1, 2006. "This noise standard would ensure that the latest available noise reduction technology is incorporated into new aircraft designs," the NPRM says. The Stage 4 standard is intended to provide uniform noise certification standards for Stage 4 airplanes certificated in the United States and those airplanes that meet the new International Civil Aviation Organization Annex 16 Chapter 4 noise standard, the FAA said. The FAA also offered reassurance that the adoption of a new noise standard for new aircraft designs is not intended to signal the start of any rulemaking or other proceeding aimed at phasing out the production or operation of current aircraft models. Currently, the FAA has no operational restrictions on Stage 3 airplanes, and the FAA has no plan to impose such restrictions.

## FIGHTING JAKE BRAKES

Tired of truckers roaring down Vail Pass and slamming on noisy "jake brakes", officials in Vail and other mountain communities are talking about some sort of crackdown. It is the latest development in an increasingly abrasive relationship between residents and Interstate 70, the main east-west route through Colorado and in many ways the lifeblood for tourist-dependent communities. Vail officials are calling for a regional meeting of local governments to talk about traffic problems. The town may even send its own police onto the federal highway to slow drivers down. The Vail City Council has already voted 4–3 to authorize fines of up to $999 for truckers who use their engine-compression brakes, known as jake brakes, as they pass through.

## DOGS

Dog noise has emerged as a public concern in the Minnesota township of Morse, following a recent community survey. Accordingly, the question of a noise ordinance is under consideration. Problems abound: not everyone objects to the noise – "whenever I hear dogs barking, I think, 'someone is living out their dreams'"; as many people complained about motor boat noise as dogs barking, but no-one has mooted restrictions on boats; the number of dogs – Morse being pack-country – is not necessarily an issue: one dog at 400 feet might make 52 decibels, but 30 dogs at 400 feet will only make 67 decibels; and, Morse has no police force to enforce any regulations!