Science for Environment Policy
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THEMATIC ISSUE

# Environmental Noise

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## Editorial

## Steps to reduce noise pollution: for a healthier environment

Noise pollution is among the most common complaints regarding environmental issues in Europe, especially in densely populated and residential areas near major roads, railways and airports. But noise - unwanted sound - is more than a mere annoyance, even at levels below ear damaging volumes. It disturbs sleep, affects cognitive functions in children, causes physiological stress reactions and can lead to cardiovascular health problems, including artery disease (atherosclerosis), high blood pressure and heart disease, for those exposed to it on a repeated, long-term basis.

The EU's Environmental Noise Directive (END) has initiated action plans in Member States to reduce environmental noise exposure and its effects. This Thematic Issue reports on recent research to help guide effective noise action plans throughout Europe.

An important first step in noise management is to measure its effects on wellbeing and health. Medical tests suggest that noise affects the nervous and hormonal systems, which in turn disrupts the stability of the healthy human organism. Transferring these effects to the wider community, the article **'Traffic noise causes loss of over one million healthy life years in western Europe'** describes the World Health Organization's (WHO) quantitative tool for assessing noise-related health impacts which will help set priorities for local and global noise mitigation measures. This has estimated that the health impact of environmental noise in western Europe could be up to 1.6 million healthy life years lost annually through ill health, disability or early death.

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Adverse effects occur, in particular, when noise interferes with activities such as communication, concentration and sleep. Cognitive performance in children is reduced at even relatively low environmental noise levels around schools. Researchers have analysed European data on this, as described in **'Cognitive impairment caused by aircraft noise: school versus home'**, and concluded that exposure to aircraft noise during the day has a greater impact than sleep-disruption caused by exposure to aircraft noise during the night. Both are damaging, but protective policy could therefore be more effective if focused at the school level.

Noise maps drawn up according to the END can be used to assess public exposure to noise, an important step in developing appropriate action plans at a local scale. Researchers in Ireland have developed a method for this, explained in **'Noise maps suggest too many people exposed to damaging noise levels',** and estimated the reduction levels of exposure to high noise levels if measures such as reduced speed limits and noise barriers are introduced.

Annoyance is a major outcome of noise exposure. Public surveys provide some indication that aircraft noise is increasingly negatively judged by the population. However, it has been suggested that these survey results could be partly caused by changes in survey methods and participants. Recent research explores this possibility, but concludes that methodological issues are not the reason behind increased reported annoyance levels. See: **'Is the public really becoming more annoyed by aircraft noise?'.**

Noise from transportation is by far the most widespread source of noise exposure, causing most annoyance and public health concerns. A number of articles in this issue refer to noise mitigation measures. Quiet road surfaces should increasingly be used in areas of high traffic and have great potential to reduce noise emissions. Their durability can be improved when using dense surfaces instead of thin layer surfaces. **'Quiet road surfaces may have financial as well as acoustic benefits'** explores how to balance the impacts, both positive and negative, of quieter road surface materials.

Traffic management (reduction of heavy vehicles and speed reduction) is a cost-effective measure of reducing noise. New research in Spain has explored solutions to reducing traffic noise, and found that combining global measures, such as speed restrictions, and local measures, such as noise screens, provides a strong solution. See: **'Combined traffic management and physical measures reduce noise effectively'** for more details.

These articles provide just a glimpse into environmental noise research, and much further investigation is needed to help guide policy in the future. For example, the combined effects of noise exposure and other

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environmental stressors are as yet unexplored and there is a need to update annoyance responses to aircraft noise in view of recent trends. Furthermore, studies are needed to quantify the impact of emerging noise sources, such as high speed rail and wind turbine noise.

The effects of healthy sound environments should not be overlooked – quiet and restorative soundscapes can contribute to human wellbeing and deserve increased research and policy attention.

Existing techniques for measuring noise and assessing its impacts have some limitations, which means that current research cannot answer all policy questions. Research into noise and mental health in adults are compromised by poor study design and long-term studies using standardised clinical interviews to assess mental health diagnoses (affective and anxiety disorders), measuring exposure to other environmental and social stressors would be an advance in this area of research.

The use of Geographic Information Systems techniques has been an important technical advance in measuring environmental noise across large areas. However, their coverage of the road network is often incomplete, the grid size and the quality of the input data across countries may sometimes not be comparable, among other limitations. This situation may be improved after the second round of noise mapping according to the Environmental Noise Directive. The emphasis on energy averaged noise measures accounts for the number of events and the maximum noise level of a single event. However, although vehicles have become quieter according to EU regulations, the noise exposure of the population does not seem to have diminished due to an increase of the number of vehicles. Therefore more emphasis is needed to reduce the noise, including further reduction of noise emissions of cars, trucks and motorcycles.

While there may be gaps in our knowledge, existing evidence clearly points the way to increasing emphasis on reducing the exposure to environmental noise. An important document demonstrating that noise is not only a nuisance, but also an important factor affecting physical health is the World Health Organisation's (WHO) 'Burden of disease from environmental noise'[1]. The WHO's 'Night Noise Guidelines'[2] and the 'Good practice guide on noise exposure and potential health effects'[3] from the European Environment Agency (EEA) provide valuable guidance.

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1. www.euro.who.int/__data/assets/pdf_file/0008/136466/e94888.pdf
2. www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf
3. http://www.eea.europa.eu/publications/good-practice-guide-on-noise/at_download/file

# Traffic noise causes loss of over one million healthy life years

A new World Health Organisation (WHO) study has estimated that the health impact of environmental noise in western Europe could be up to 1.6 million healthy life years lost annually through ill health, disability or early death.

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"The results revealed that for cardiovascular diseases, which include hypertension and ischaemic heart disease (caused by reduced blood supply to the heart muscle), environmental noise is responsible for the loss of approximately 61,000 DALYs (disability-adjusted life years) in high-income countries."

The impact of environmental noise on health has been gaining policy attention, especially as exposure to noise appears to be increasing, alongside evidence of the negative health effects of environmental noise. In order to inform policy and develop management strategies, risk assessments are needed to evaluate the potential health effects of exposure.

The study brought together evidence on the relationship between environmental noise and health effects and provided estimates of the health impacts based on existing knowledge of the relationships between exposure and health. This was achieved using DALYs (disability-adjusted life years), which combine potential years lost from premature death with healthy years lost through disease and illness. It focused on the impacts of cardiovascular disease, cognitive impairment, sleep disturbance, tinnitus and annoyance. Annoyance was included because the WHO defines health as being a 'state of complete physical, mental and social well-being'. For some impacts, estimates could only be provided for certain parts of Europe and/or age groups owing to available data.

The results revealed that for cardiovascular diseases, which include hypertension and ischaemic heart disease (caused by reduced blood supply to the heart muscle), environmental noise is responsible for the loss of approximately 61,000 DALYs in high-income countries. By extrapolating data from Sweden to other western European countries, the study estimated that noise exposure accounted for the loss of 45,000 DALYs for children aged between 7 and 19 years, through cognitive impairment. Sleep disturbance caused an estimated loss of 903,000 DALYs, whilst annoyance accounted for a loss of 654,000 DALYs for the EU population living in towns of over 50,000 inhabitants. Noise-induced tinnitus produced an estimated loss of 22,000 DALYs in the adult population.

In total, this means that the health impact of environmental noise is between 1.0 and 1.6 million DALYs. The range takes into account the differing populations for which the estimations were made. The research highlights there may be other uncertainties, such as sub-clinical effects, complex influences, such as age, gender and occupation, and the health impacts of combined exposure to noise and other stressors, such as air pollutants and chemicals.

Nevertheless the practices of risk assessment reviewed in the study can be applied to national and local implementation of noise maps and action plans under the EU Environmental Noise Directive. For regions, such as south-eastern Europe, where required data are not as readily available, the study provides several options for calculating estimations.

**Source:** World Health Organisation Regional Office for Europe and JRC European Commission. (2011) Burden of disease from environmental noise. Quantification of healthy life years lost in Europe. *WHO European Centre for Environment Health, Bonn Office*. Downloadable from http://www.euro.who.int/en/what-we-publish/abstracts/burden-of-disease-from-environmental-noise.-quantification-of-healthy-life-years-lost-in-europe

[1] See: http://ec.europa.eu/environment/eussd/escp_en.htm

# Cognitive impairment caused by aircraft noise: school versus home

A recent study suggests that exposure to aircraft noise during the day has a greater impact on cognitive ability in children than sleep-disruption caused by exposure to aircraft noise during the night. Protective policy is therefore likely to be most effective if focused at the school level.

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"The scientists found no clear link between the new data on sleep quality and the original analysis of cognitive ability. This indicates that although aircraft noise and cognitive impairment are closely related, in this case the effect cannot be linked to sleep disturbance."

Two major pieces of research, the Munich[1] and RANCH[2] studies, have previously revealed a clear link between exposure to daytime aircraft noise and cognitive impairment in children, with comprehension and long-term memory skills most severely affected. However, these two studies did not address the impact of noise exposure at night.

Scientists have now revisited the data from both studies to determine whether the observed link between aircraft noise and impaired cognitive ability can be associated with quality of sleep.

In the original Munich study, 326 children were selected based on the proximity of their home to one of three major European airports: Schiphol (Amsterdam), Barajas (Madrid) and Heathrow (London). In the new study, the scientists analysed questionnaires given to the children at the time, in which they self-rated their quality of sleep.

The scientists found no clear link between the new data on sleep quality and the original analysis of cognitive ability. This indicates that although aircraft noise and cognitive impairment are closely related, in this case the effect cannot be linked to sleep disturbance.

A total of 857 children from a range of schools near London's Heathrow airport took part in the original RANCH study. The scientists used a statistical model to quantify the relationship between cognitive ability and the degree of noise exposure that the children experienced at school (daytime).

In the re-analysis, scientists compared the same cognitive performance data to information on night-time (23.00-07.00) noise exposure obtained more recently from the Civil Aviation Authority and matched to the children's home postcodes. Statistical analysis showed that the relationship between the extra variation among the children in terms of night-time noise and their cognitive performance was very weak (statistically non-significant).

These results suggest that disturbance of sleep caused by night-noise in addition to the noise level experienced at school alone does not affect the cognitive performance at school. The implication from this is that the contribution from day time noise is greater than the contribution from night time noise to the cognitive performance of children.

However, the scientists point out that this kind of secondary analysis does not allow separation into the independent effects of daytime and night-time noise, because they were highly correlated. Both showed a significant influence on child's cognitive performance; only the additional impact of night-time noise relative to daytime noise could be investigated. They therefore recommend dedicated research to quantitatively assess the effect of night-time noise on cognitive ability, plus research into the reasons for why excess noise causes cognitive impairment.

**Source:** Stansfield, S., Hygge, S., Clark, C. & Alfred, T. (2010). Night time Aircraft noise and children's cognitive performance. *Noise and Health*. 12 (49): 255-262.

[1] Available from: https://www.psychologicalscience.org/pdf/ps/children_airport_noise.pdf

[2] UK Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health (RANCH) study Available from: http://www.teamsofangels.org/publication/medical_journal_articles/Noise.pdf

# Noise maps suggest too many people exposed to damaging noise levels

Nearly 85% of residents in central Dublin, Ireland, could be exposed to damaging levels of night-time traffic noise, according to a recent study. The researchers explain how they assessed population exposure to noise and calculate the impacts of several noise reduction measures, providing information that could help EU Member States meet the Environmental Noise Directive's requirements.

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"The results indicated that a significant percentage of Dublin residents are exposed to noise levels that exceed the World Health Organisation's recommended limits."

The EU's Environmental Noise Directive (END)[1] was introduced in response to increasing scientific evidence that excessive noise can damage human health. It seeks to harmonise approaches to tackling noise pollution across Europe and to enable measures to reduce noise levels.

The researchers drew up two maps of Dublin's city centre: one illustrated average traffic noise levels in each street across a 24-hour period, and the other for the night-time (23.00-07.00), to correspond with the END's noise indicators: $L_{den}$ (day-evening-night-time) and $L_{night}$ (night-time).

To develop these maps, the researchers took traffic data from the City Council's traffic monitoring system and estimated noise levels using the UK's Calculation of Road Traffic Noise method[2], with some minor adjustments. Actual street side measurements of noise suggested that the model slightly underestimated noise levels (on average by 1.8 decibels), but it is still considered robust enough to use as an action planning tool.

They then estimated population exposure by referencing the maps against the number and location of dwellings in the city centre, using information from a national database maintained by the postal service.

The results indicated that a significant percentage of Dublin residents are exposed to noise levels that exceed the World Health Organisation's recommended limits. 27.2% of residents are exposed to noise levels exceeding an $L_{DEN}$ of 70 decibels. For $L_{Night}$, 84% were exposed to noise levels above the recommended night-noise guideline value of WHO of 40 decibels. These figures may be an overestimate, as the study only assumed noise levels at the front face of each dwelling. However, even when this is accounted for, the researchers suggest that there is little doubt that the scale of the problem is significant.

The study also investigated the impact of several noise mitigation measures. Modelled results suggested that a 10% reduction in traffic flow combined with a 10% reduction in travel speed would reduce the percentage of people exposed to noise levels above 70 decibels for $L_{den}$ by 1.8%. For $L_{night}$, 5% fewer people would be exposed to levels above 40 decibels.

Noise barriers were more effective. For example, a 2 metre barrier could reduce population exposure above 70 decibels by 5.9% and by 7.4% for a 3.5 metre barrier. These are unlikely to be suitable in most urban environments, but could be considered for noise hotspots where visual appearance is less important.

**Source:** Murphy, E. & King, E.A. (2011). Scenario analysis and noise action planning: Modelling the impact of mitigation measures on population exposure. *Applied Acoustics.* 72(8): 487-494.

[1] http://ec.europa.eu/environment/noise/directive.htm

[2] www.noiseni.co.uk/calculation_of_road_traffic_noise.pdf

# Is the public really becoming more annoyed by aircraft noise?

Surveys have suggested that the public have become more annoyed by aircraft noise over recent decades. A recent study has investigated whether these results are partly caused by changes in survey methods and participants. However, no methodological issues considered could satisfactorily explain the rise in reported levels of annoyance at a given noise exposure level.

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"These results suggest that disturbance of sleep caused by night-noise in addition to the noise level experienced at school alone does not affect the cognitive performance at school."

Annoyance caused by noise is recognised by policymakers as a harmful effect that should be reduced, under the Environmental Noise Directive[1]. There are several possible explanations for the increase in annoyance that has been found by recent surveys. One possible explanation is that many recent surveys were done in the context of airport expansions, to which the public may respond in a disproportional way, or it may be that residents have simply become more sensitive to noise.

However, some researchers have questioned whether the rising trend in results is caused by methodological issues, such as changes in the way that the questions are asked, or the age of participants who choose to complete surveys. To investigate whether annoyance levels really have changed over time, this study analysed annoyance data from 22 surveys of a total of 34 populations living near airports across Europe, North America and Australia, over the period 1967-2005 and involving 42,078 participants.

The survey results considered by this study suggest that reported annoyance levels have significantly increased, with a sharp rise around 1996. The researchers carefully analysed the methods of each survey, as well as the number and characteristics of participants, to determine the influence of these factors on the results.

At first glance, the annoyance scale used by surveys appeared to influence reported annoyance. Before 1996, surveys tended to use a 4 or 5 point scale for participants to describe their level of annoyance. A 0-10 scale was then introduced, which this study found corresponded to higher estimates of annoyance. However, on closer inspection, the researchers concluded that scale was not a satisfactory explanation as it did not result in different outcomes within those studies using more than one scale. Furthermore, other surveys investigating annoyance from road traffic noise have also changed scales in the same way, but annoyance levels have remained stable.

Among other findings, the increased use of postal surveys (over telephone or face-to-face surveys), the decreased response percentages and the rising age of survey participants, although influencing the annoyance response to some degree, were not found to explain the increase over time. These have all previously been suggested as possible factors in increased levels of reported annoyance. Surveys in which respondents reported their self-judged sensitivity to noise, did not provide evidence that sensitivity has increased over time.

Reasons for the changes in survey results therefore remain unclear, as this study could not identify any methodological issues as the cause. There is a possibility that rising levels of annoyance could be the result of changes in the way aircraft noise is assessed or of a higher rate of expansion of airports in recent years and the associated public interest, but these factors were not considered in this study's scope.

[1] See: http://ec.europa.eu/environment/noise/directive.htm

**Source:** Janssen, S.A., Vos, H., van Kempen, E.E., *et al* (2011). Trends in aircraft noise annoyance: the role of study and sample characteristics. *Journal of the Acoustical Society of America*. 129(4):1953-62.

# Quiet road surfaces may have financial as well as acoustic benefits

A recent report has reviewed research on the effectiveness of low-noise road surfaces, taking into account acoustic performance, safety, skidding resistance and cost. It concludes they could have substantial acoustic and financial benefits, but their durability and safety must be taken into account.

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"It has been speculated that low-noise surfaces may lead to increased risks because of driver behaviour. For example, the smooth ride may encourage motorists to drive faster."

The report was commissioned by the Scottish Government. An example of a low-noise road surface is thin stone mastic asphalt (TSMA). Using noise modelling, the report demonstrated that, compared to a surface of hot rolled asphalt (HRA), TSMA would achieve an initial reduction of between 1 and 4 decibels in the cities of Edinburgh and Glasgow. The acoustic benefits depend on the mean traffic speed and composition of the traffic. On major road routes similar reductions were estimated where mean traffic speeds are below 60 km/hour. For speeds of about 110 km/hour there would be reductions of up to 6 decibels.

A survey of Scottish local authorities on their current use and strategies for road surfaces indicated that the benefits of noise reduction are not, as yet, considered a priority when selecting road surface material. Most local authorities reported that HRA was considered to be the most cost-effective road surface as it has a longer life expectancy than TSMA, and structural durability is important. To help improve the durability of asphalt surfaces, it is important to produce dense, well-compacted layers with good bonding between layers and well-maintained drainage.

Where acoustic durability is a consideration for local authorities, research has found that the acoustic performance of all surface types worsens with age, with different surface types deteriorating at different rates. When initially open to traffic, significant reductions in overall traffic noise can be achieved using low-noise surfaces, such as TSMA, compared with dense surfaces, such as HRA. However, for TSMA-type surfaces, traffic noise levels on high-speed roads increase by approximately 0.5 decibels per year, compared to only 0.2 decibels per year for dense surfaces such as HRA.

Safety and skid resistance of surfaces is another important issue. Low-noise road surfaces tend to have less texture depth than conventional surfaces, which may increase the risk of skidding at high speed. Research has shown that low-noise surfaces can be made with adequate skid resistance, but they are sometimes less durable than traditional surfaces. One advantage of low-noise surfaces is that they can reduce the spray generated by tyres, although in heavy rain some types of low-noise surfaces can be prone to rapid flooding. It has been speculated that low-noise surfaces may lead to increased risks because of driver behaviour. For example, the smooth ride may encourage motorists to drive faster.

The report also considered the cost of using a low-noise surface over 60 years. Although no concrete figures were given, if the benefit of reduced noise is monetised alongside the cost of work, traffic management and user delays, then low noise surfaces appear to be more cost-effective.

**Source:** Abbott, P.G., Morgan, P.A. & McKell, B. (2010) *A review of current research on road surface noise reduction techniques.* Transport Research Laboratory report for the Rural and Environment Research Analysis Directorate of the Scottish Government. Downloadable from: http://www.trl.co.uk/online_store/reports_publications/trl_reports/cat_traffic_and_the_environment/report_a_review_of_current_research_on_road_surface_noise_reduction_techniques.htm

# Combined traffic management and physical measures reduce noise

New research in Spain has explored solutions to reducing traffic noise, and suggests that the best option is to combine global measures, such as speed restrictions, and local measures, such as noise screens.

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**Themes:** Noise, Sustainable mobility

"Excessive noise can be detrimental to health with effects on sleep, mental health and physical performance."

In 2000, it was estimated that more than 44% of European citizens (or about 210 million people) were exposed to road traffic noise levels that exceeded 55 decibels (dB). Excessive noise can be detrimental to health with effects on sleep, mental health and physical performance.

The study is based on a noise-mapping project for the entire city of Palma de Mallorca. The noise maps were created with a model (CadnaA)[1] that used geographic data on traffic, weather and populations. Using the maps, the study analysed possible noise mitigation solutions.

The noise maps revealed that the highest noise levels were near main roads and the highway. Nearly the whole population is exposed to noise levels of more than 55 decibels (weighted day-night noise level LDEN) and 50 decibels during the night ($L_{Night}$).

Based on traffic composition, the study divided the city into two parts: the city centre and the highway, and proposed four possible noise mitigation solutions:

1. A 50% reduction of heavy vehicles (HVs) at the city centre and a speed reduction from 90 to 70 km/hour on the highway.
2. A 50% reduction of all vehicles in the city centre and a speed reduction on the highway down to 60 km/hour for HVs and down to 70 km/hour for light vehicles.
3. A 75% reduction of HVs and 50% reduction of light vehicles in the city centre and on the highway a speed reduction of HVs down to 60 km/hour and down to 70 km/hour for light vehicles.
4. The use of local measures, i.e. tunnels and noise barriers, on the highway.

Using the noise maps and modelling techniques the study compared the impacts of the different scenarios. All solutions reduced the number of people exposed to the highest noise levels. Both global traffic management measures and local physical measures (e.g. barriers) reduce the number of inhabitants exposed to levels above 65 decibels, but it is a combination that yields the best results with a 31% reduction in the population exposed to levels exceeding 65 dB.

Scenario 2, which uses traffic management techniques, is the most cost-effective over one year, but after two years the solution that combines global and local measures (Scenario 3) is the most cost-effective, producing benefits worth €2,821,076 per year and total initial construction costs of €2,221,560. Scenario 3 also offered the highest noise level reduction, with levels reduced up to 5dB (as opposed to 3-4 dB in Scenario 2).

The study noted that some noise measures can interfere with other objectives, such as road safety, energy consumption and congestion. This must be considered when developing mitigation plans by involving stakeholders from other policy sectors, such as transport planning, road maintenance and air quality.

[1] See: http://www.datakustik.com/en/products/cadnaa

**Source:** Ausejo, M., Tabacchi, M., Recuero, M. *et al.* (2011) Design of a Noise Action Plan based on a Road Traffic Noise Map. *Acta and Acustica United with Acustica*. 97:492-502.

# A selection of articles on Environmental Noise from the *Science for Environment Policy* news alert.

## Sustainable natural materials can be used for noise insulation (5/5/11)

Researchers have found that natural materials, such as plant fibres or wool, can be used to construct sustainable sound absorbers that help prevent noise pollution, which are as effective as conventional absorbers made from combinations of minerals and plastics.

## Implementing the Noise Directive – lessons from Ireland (24/2/11)

New research has reviewed the Irish implementation of the first phase of the EU Noise Directive. So far 31 different organisations have been involved and this will increase throughout the second phase of the Directive's implementation. More standardisation is needed to harmonise activities, perhaps by establishing a national expert steering group.

## The economic impact of noise pollution on human health (4/3/10)

A recent report has assessed the latest research on the adverse affects of noise on health, focusing on approaches to estimating the economic cost of noise. This information could help policy makers tasked with designing cost-effective noise reduction and management policies.

## WHO recommends setting night noise limits at 40 decibels (1/7/10)

The World Health Organisation (WHO) has set the European target limit of outdoor night noise levels at annual average of 40 decibels (dB) in its new guidelines. This would protect the public, including the most vulnerable, such as children and the elderly.

## New method to accurately estimate levels of urban noise (25/3/10)

New research has identified 25 variables that influence noise in urban areas. By combining these into an equation, the study produced an accurate tool to describe urban sound environments that could be useful in urban planning.

## Noise pollution: separate regulations needed for construction 17/12/09)

In a new study, Spanish researchers describe a method specifically designed for measuring and characterising noise from building sites. They claim the method could help shape future policy related to noise pollution caused by the construction industry and provide important information to help reduce construction noise.

**To view any of these articles in full, please visit: http://ec.europa.eu/environment/integration/research/newsalert/index_en.htm, and search according to article publication date.**

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