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NOISE MONITORING IN EU

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Most noise levels are calculated by means of propagation models. Contours, grid points and single point calculations are often done in the acoustical domain. This it has many advantages. Noise levels can be determined regardless meteorological constraints, not disturbed by another type of noise and not time-consuming. Also, the reproducibility of noise calculations is an advantage as many other aspects more. However, disadvantages are also known. Reliable and up to date data is in many cases a problem. For traffic noise, the traffic data is hard to obtain in many Member States and cities. Regarding industrial noise, it is known that operating conditions are hard to establish because principals often have interests to manipulate these conditions for various reasons. Indicators have been used like L_{DEN}, L_{NIGHT}, $L_{Aeq(24\ hr)}$, et cetera which are hard to understand for politicians and residents. Even when understanding the decibel these and other indicators are incomprehensible for outsiders. When it comes to complainers, they do not understand or accept those indicators and if they do they do not accept that authorities use these units in legislation or regulations. This because annoyance or nuisance is felt at specific times of the day or night and not over the whole year or 24-hours. As residents have limited confidence in authorities the noise propagation software is perceived as a black box by outsiders. Residents and complainers have more confidence in noise levels measured, and that is why noise monitoring units appear. That is why Working Group Noise EUROCITIES initiated and installed the FONOMOC platform. FONOMOC is an acronym for Focusgroup On NOise MOnitoring Cities. However, FONOMOC has also knowledge institutes on board. The aim of this platform is to exchange and gain knowledge and experiences on noise monitoring in cities. In this paper, some observations regarding noise monitoring.

1. Introduction

Last decades noise calculations were and are more favourable than noise measurements. The added values of these calculations are mentioned above. It is less time consuming, not depending on meteorological conditions and reproducible. Also, specific contributions of noise sources can be identified which could be valuable when mitigating or reducing the noise. Also, the upswing of better hardware and software has accelerated the use of noise propagation instead of noise measurements. In this paper, noise measurements are defined as noise monitoring. As in previous times, noise monitoring was mainly done by traditional equipment such as sound level meters, sound analysers, etc. Nowadays the rise of sensors and even smartphones is observed conquering the traditional sound level equipment.

2. Why noise monitoring?

Living in the era of noise maps and strategic noise maps everyone can observe the noise in their city, district, street and sometimes, even the noise levels on the façade of the house. Often the noise levels derived from the noise maps, often L_{DEN} or L_{NIGHT} do not correspond with the perceptions of the observers. This because the indicators represent an annually averaged noise load. This annual noise load correlates rather well with the health effects that occur due to long-term noise exposure. However, people do not perceive the an-

nual noise load; they perceive the noise in the here and now. Together with a substantial degree of mistrust in the government public is not excited about noise maps. Most people desire real-time information. People want to know the noise levels at the time of annoyance or sleep disturbance or if noise is increasing or decreasing over time. These issues are often the reason that politicians promised to install noise monitoring systems. By means of the noise monitoring systems, it is possible to:

- observe the real-time noise levels
- link the noise levels to events (temporary)
- link the noise levels to complaints (real-time or in the past)
- validate the noise levels calculated (noise maps or single point calculations)
- observe trends in declining or inclining noise levels
- characterise the noise (continuous, tonal, pulse, intermitting, etc.)
- listen to recordings or actual noise

By installing noise monitoring systems, communication with stakeholders can be improved significantly. However, explanation about the noise levels measured and the static noise map is an extraordinary challenge for the government. Also, the comparison between the noise levels of the noise measuring systems and the legal limit values for noise is hard to understand. These limits often are based on a day-, evening- or night period or on a 24-hour average, expressed in an L_{Aeq} which means there is still some work te do. The development of the Harmonica-index by Bruitparif (www.noiseineu.eu) is the first pace towards a better understanding of the noise load.

3. Trends in noise monitoring

Besides the tendency to install more and more noise monitoring systems it is also observed that the traditional microphones are no longer the first choice. Smaller and cheaper sensors are capturing the market. Also, the use of smartphones with special applications like Noise Tube, Sound Meter, Decibel Meter, etc. is trending and are advancing. By installing or applying numerous sensors or smartphones on permanent, temporary or mobile noise monitoring systems, it is assumed to achieve an accurate and reliable view of the noise. By post-processing, the data obtained it is possible to draw conclusions. Especially when measurements are conducted long-term, the outcomes are more reliable. It is even possible by means of special techniques to locate the noise sources or to distinguish the sorts of noise. Different techniques are being used. Using smartphones and low-tech sensors mean a compromise between the costs and the quality of the noise data obtained [1] especially when it comes to single noise measurements. However, when obtaining numerous samples on numerous spots, this can be compensated. Besides the noise detection, sensors are also used to examine the meteorological conditions, air pollution and other pollutants. This is not a revolution because this can also be done when applying the more traditional noise monitoring systems with class 1 microphones. One of the advantages of the smartphones is that operators using noise measure applications also can log additional information [2] for instance perceptual items on noise and the surrounding. In The Netherlands, more than 80% of the population between 15 and 80 years owns a smartphone. That means that in The Netherlands there is a potential amount of 11 million sensors available! The problem is how to stimulate these 11 million to install a noise meter application on their smartphone and to join a nationwide noise monitoring campaign if there was such an initiative. From [3] it was found that to find volunteers who want to collaborate on noise measurement campaigns is crucial. In that pilot, the number of volunteers was rather limited. Other projects gained more success [2]. When using smartphones, it is very important to calibrate the smartphone because of the many brands on the telecom market and more importantly the numerous operating systems and versions of those operating systems. This means that calibrating a single exemplary of an Android telephone does not imply that all Androids work accordingly. Much depends on the microphone installed on the smartphone. Cheaper smartphones are expected to have moderate microphones. However, the smartphones used should be calibrated. In [4] this is done by means of comparisons with a sound level meter of class 1. Also, the pilot conducted in Rotterdam has shown that calibration of the smartphone is indispensable. The pilot showed that I-phones make better noise measurements than some Android phones when comparing the noise measured with a class 1 Sound Level Meter in dB(A). This contradicted with the view laid down in [5]. In that paper, it was suggested that Android-based smartphones could be the best platform, if ruggedized.

Using sensors seems to be very successful. Pilots and also projects have shown that results of low-tech and high-tech sensors can deliver reliable results. Especially when installing many sensors and conducting long-term measurements reliability increases. During the EURONOISE 2105 congress in Maastricht, a dedicated session was organised on noise monitoring. During this session, 9 papers were presented that gave a broad overview of Noise Monitoring Systems in use and used. From this session, it was clear that when conducting single measurements or measurements that are needed to start legal procedures traditional devices are preferable. In other cases, the use of sensors or smartphones can be considered. However, before starting with a sensor- or smartphones based noise monitoring network, it is recommended to provide a Cost Benefit Analysis. Such a Cost Benefit Analysis should take into account quantitative and qualitative aspects of the different options. The cost of installation, purchase and calibration should be considered as well energy, operational and maintenance costs. The costs of data transmission and communication should also be considered. Regarding the qualitative benefits accuracy, reliability, awareness and communication with the citizens, etc. should be included in the Cost-Benefit-Analysis. Lifetime benefits can make clear what option suits the best.

When it comes to verifying the noise emitted by industrial sites or noise emitted by equipment (noise labels) then use of sensors or smartphones is not recommended. This because when non-compliance with the noise limit values allowed of permitted is found, enforcement or even prosecution (court) can follow. In those cases, the government or inspectorate must be sure that the noise levels found are reliable and accurate. Even exceedances of 1 dB could have unpleasant consequences for the owner or manager. Fines or closing of the activity or company could follow or in the case of machines or equipment admission can be refused. Acousticians consider one decibel as no decibel (it within the accuracy of noise measurements) however for attorneys and judges maintaining the law 1 dB exceedance is an exceedance, so no consideration will be shown.

Noise Monitoring Systems, especially based on sensors are often applied in Smart Cities approach or Intelligent cities with all kind of sensors. For example, sensors in the so-called smart buildings, smart houses, smart roads and smart mobility means. It is expected that smart solutions to reduce the noise will increase as well which could mean that noise interventions only appear and work when the noise is there (e.g. a train passing by). The number of sensors and noise sensors will also increase using internet and energy. From [6] was learnt that the total energy used by the ICT sector amounted 9,4 TWh meaning 8% of the telecom total energy use in The Netherlands. Data centres are using 1,4 TWh and the telecom industry 1,0 TWh. The number and size of data centres are expected to grow which means more energy use. This should be realised when starting smart cities developments but also installing noise monitoring systems. By expanding the number of transducers (microphones, smartphones and sensors), the energy demand is also increasing. The use of sustainable energy (solar panels) should be seriously considered when planning a new noise monitoring system or expanding an existing noise monitoring system.

4. Conclusions

Noise Monitoring Systems can be used to support planning processes, to validate noise maps, to monitor execution of noise action plans, to support complaint management, to evolve public awareness, to enhance communication, to monitor noise abatement progress and also to examine whether industry is working in accordance with the noise limit values included in the environmental permit. Initiatives to start Noise Monitoring Systems should also include a Cost-Benefit-Analysis which should give insight in the quantitative and the qualitative merits of the systems that are under consideration. Quantitative merits are more about the costs of installing and running the system or removing the system - when temporary - or replacement. The qualitative merits are beside the societal and political benefits also stability, reliability and accuracy. Noise Monitoring Systems should be connected to sustainable power like solar panels.

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