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NOISE POLLUTION – INTRODUCTION TO THE STATE OF THE RESEARCH AND THE IMPLEMENTATION IN THE HORIZON 2020 PROJECT PIXEL

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Abstract

Noise pollution is a significant factor in the modern world. There are many researches dealing with the noise modelling, differing in their purpose, studied influence and the scope of the research, either in geographical terms or in the terms of studied noise sources. The objective of this paper is to give insight in the current state on the field of negative influence that noise has on the environment and/or human health. Special attention was given to the influence that ports' noise pollution has on the surroundings, both on the population and on the environment. Within the influence on the environment, underwater noise, which is often excluded when the main priority is the influence on general population, was also included. As it is one of the main tools for analysing the influence of noise, several examples of assessing the influence of the noise using noise maps are presented. Several objectives of the EU Horizon 2020 project (PIXEL), dealing with the reduction of ports' pollution, were covered. The segment of the project dealing with the noise is linked with the previous achievements, which forms the basis to give some guidelines for the further research of the noise influence on the environment.

1. Introduction

Noise pollution has a highly significant influence on human life and nature. There are as many noise pollution sources as there are human activities. Among those activities, special place is reserved for industry and traffic [1]. There are arguably no areas as affected by both industrial and traffic noise as the areas near the ports. In the assessment of the influence that ports have on their neighbourhood (and larger areas), there are many things to consider. Port environmental aspects include air emissions (including odour), emissions to water, waste generation, spills, resource use and noise pollution [3]. Those aspects are monitored in a fashion very different from each other and, apart from noise, won't be discussed in this article. However, it should give the reader a clear vision of the complexity of the port environmental management, as well as an importance of it.

On this poster, an introduction to the noise pollution and a description of the influence that ports have on noise levels, including underwater noise, is given. Also, insight to some of the researches dealing with the subject is provided. In order to show the more practical side of noise assessment, an example of the procedure is provided, done for the Port of Thessaloniki in the scope of a European Horizon 2020 project PIXEL. To conclude, results of the noise assessment procedure are analysed. There is a comparison of legislated noise levels with the ones resulting from the port activities, as well as a general overview of the noise dispersion in the port area and the influence of individual noise sources and individual groups of noise sources, together with noise barriers, like buildings, on the final noise levels.

2. Literature overview

2.1. Environmental noise

Before dealing with the practical application of noise assessment, it is useful to provide the current state of the literature, both those dealing with theoretical background and practical researches. Research on noise pollution is not a new subject. Importance of the noise impact was recognized in the late 1920's and by early 1970's, the research on noise pollution has grown significantly. However, most of the researches of the era cover the impact that noise has on human health. Despite that, some methods of dealing with the noise reduction were also mentioned, such as building barriers and using proper construction techniques.

Among the works dealing with the noise pollution as an environmental issue was [1]. It deals mainly with the traffic noise and recognizes it as the main source of noise pollution. Noise sources, monitoring of the noise and relevant predictions schemes are all covered in it. Recently, in works such as [4], traffic noise is still recognized as the most important noise pollutant, with road noise being the most significant. The article is important for this paper, as it also deals with calculation methods for traffic noise. Can and Aumond made a research about the influence that vehicle speed and acceleration have on noise emissions [5]. They compared various calculation methods based on its handling of speed and acceleration influence on the noise levels.

Noise pollution is widely recognized as a significant environmental aspect in ports. Most of the ports that have done environmental impact assessment reports mention noise among the most important aspects. Apart from 1996, noise was always in the Top-5 environmental priorities of European ports [6].

However, papers dealing with the noise resulting from port activities are not common. Most of the works deal with single issues, such as [7], which covers a topic of using electric rubber-tired gantries. Ship noise emissions and their propagation are analysed in [8], where the issue of ship noise was accentuated as an important factor in noise mapping. Among the papers that cover noise in the ports on a larger scale is [9], which covers a subject of noise pollution in the city of Piraeus, in form of noise mapping and developing action plans to fight noise pollution. Similarly, a case study for two ports (Patras and Tripoli, Lebanon) was conducted as part of another project, outlines of which were presented in [10]. In [11], straightforward noise mapping was done for the port in Livorno, with the conclusion that the road noise is the single most significant source, but that industrial sources (like cargo handling) have bigger influence when taken as a group. Ships were also found out to be significant noise pollutants.

2.2. Underwater noise

Although underwater noise is often overlooked by ports, it is nevertheless represented in scientific literature. In works like [12], it is considered as one of the main aspects of environmental pollution. Possible reason might be that it affects almost exclusively animal population and is insignificant when considering negative noise influence on people. Most of the papers deal with the influence of the underwater noise on marine species or with the sources of underwater noise and noise mapping. An example of the former was [13], which was conducted for the northern Adriatic Sea in Croatia and covers a topic of noise influence on the displacement of the bottlenose dolphins. The results have shown significant influence on the dolphin population, especially during summer months, when traffic flow is increased because of tourism.

Studies dealing with the underwater noise sources include sources such as drillships, submarines and marine propellers, as well as whole ports. Among the studies dealing both with sources of underwater noise and its abatement is [14].

3. Noise assessment in the PIXEL project

A practical example of the noise assessment in a port area would be shown in this section. Before continuing with the assessment, PIXEL project needs to be described in short. It is seen as a "smart, flexible and scalable solution for reducing environmental impacts" of the ports [15]. One of the main goals is the optimization of the port operations to have minimal negative impact on the environment.

For the noise mapping process described here, Predictor-LimA Software Suite, developed by Brüel & Kjær, was used, more specifically Predictor (v12.00, 64-bit). Required data is very similar to [2] and consists of geographical data and data about noise sources. Meteorological data is often cited among the requirements, but not all calculation standards support it. The process was done for the Port of Thessaloniki and was based on the data provided in their yearly reports, such as [16], based on historical average values. Main goal was to establish a valid model that would allow testing various scenarios, such as different meteorological conditions (primarily wind speed and direction) and various levels of traffic flows in the port.

The first step was to import building data and the data on noise sources, as well as the location of the receivers. It can be seen on the figure 1. Buildings are shown in grey and noise sources in red, while the receivers are small black symbols, such as the two in the upper left corner. Considering the sources, symbols similar to "*" represent point sources (ships and immobile cranes), dashed-dotted lines are railways and dashed lines represent roads. Areas inside dotted lines represent area sources, which consist of various port machinery that would be too complicated for modelling separately. Another data that could be used are terrain heights. However, they slow down the calculation and are also impractical for graphical representation. As the port has terrain height difference of less than couple of meters between the lowest and the highest points, this data was decided to be omitted.

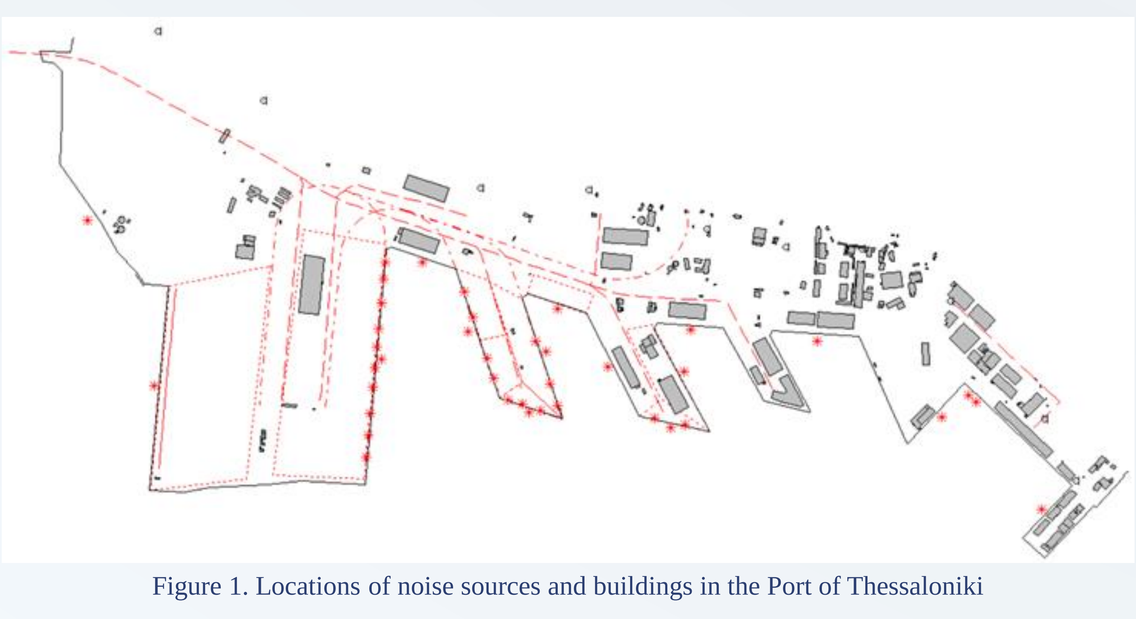

Figure 1. Locations of noise sources and buildings in the Port of Thessaloniki

Firstly, a relevant calculation method should be chosen. The software supports 20 methods, divided in four categories (industrial noise, road traffic, rail traffic and all of them). As all of the sources are present in the ports, one of the methods that support calculation with all of them had to be chosen. There are two such methods - CNOSSOS-EU and Harmonoise standards.

The first one tested was CNOSSOS-EU standard, because it is the most frequently used of the two. However, it doesn't support changing some of the important meteorological conditions (such as wind speed and direction). For that reason, the choice was on the newly implemented Harmonoise method. It is a calculation method developed during the course of the NoMEPorts project. Although it is still in the development, it showed accurate results for the calculation settings used in this example. The method uses the following calculation formula (*n* represents a source segment) [17]:

$$L_{eq1h,i,n} = L_{W,i} - A_{div} - A_{atm,j} - A_{excess,i} - A_{refl,i} - A_{scat,i} \quad , \qquad (1)$$

$L_{W,i}$ – sound power level of a unit length source segment (dB); A_{div} – attenuation due to geometrical spreading (dB); $A_{atm,j}$ – attenuation due to atmospheric absorption (dB); $A_{excess,i}$ – excess attenuation due to ground reflections and diffraction effects (dB); $A_{refl,i}$ – attenuation due to energy loss during reflection (dB); $A_{scat,i}$ – attenuation due to scattering zones (dB)

Results and Conclusion

Once the calculation is set-up, the model needs to be validated. The first choice was to do it by comparing it to on-site measurements provided by the port, which were taken on different days and in significantly different meteorological conditions and are affected by outside influence, like roads, social events, etc. As the data on some of those sources (especially social events) is not available, the choice was to compare the simulation results with the calculation results done by the port, described in [16]. Before comparing the results, several issues should be noted. The first is that there is no meteorological data provided in the port's report, so the conditions under which the calculation was made are unknown. The second one is that some of the buildings omitted in the report are used in the simulation done for this paper. The comparison of the results is provided in table 1. The meteorological parameters used in this calculation included: wind (1-3 m/s, south), temperature (25 °C), humidity (70%) and atmospheric pressure (101.33 kPa).

Table 1: Comparison of the results of the simulations conducted by the Thessaloniki Port Authority (ThPA) [16] and PIXEL

Receiver	L_{night} (dB(A))			L_{DEN} (dB(A))		
	ThPA	PIXEL	Difference	ThPA	PIXEL	Difference
1	51.2	50.3	-0.9	57.6	56.7	-0.9
2	39.1	38.7	-0.4	57.2	56.5	0.7
3	40.2	36.6	-3.6	55.9	51.1	-4.8
4	40.3	32.2	-8.1	50.2	46.4	-3.8
5	42.6	40.9	-1.7	52.9	56.2	3.3
6	44.1	42.0	-2.1	54.6	54.0	-0.6
7	45.3	46.6	1.3	56.9	59.4	2.5
8	46.7	47.5	0.8	58.3	61.0	2.7
9	43.7	46.4	2.7	59.4	57.1	-2.3
10	41.2	46.0	4.8	58.2	54.9	-3.3

As seen from the table 1, most of the results are within the range of 3 dB, which is very close, especially as meteorological conditions of the original simulation were unknown. The difference in receiver 3 can be attributed to the influence of the reflection factors of the nearby buildings. Using more reflections, the results come closer to the ones from the original report, but it slows down calculation significantly. The receiver 4 is the one receiver located near the buildings omitted in the original report and, as buildings function as noise barriers, it has lower values in this calculation. The last receiver is in the open space, with significant influence of the wind. If the wind direction is changed from south to north, Lnight would lower down to 42.7 dB. Similarly, some of the receivers located in lesser proximity to the buildings show slightly higher values of LDEN. The map is shown on figure 2.

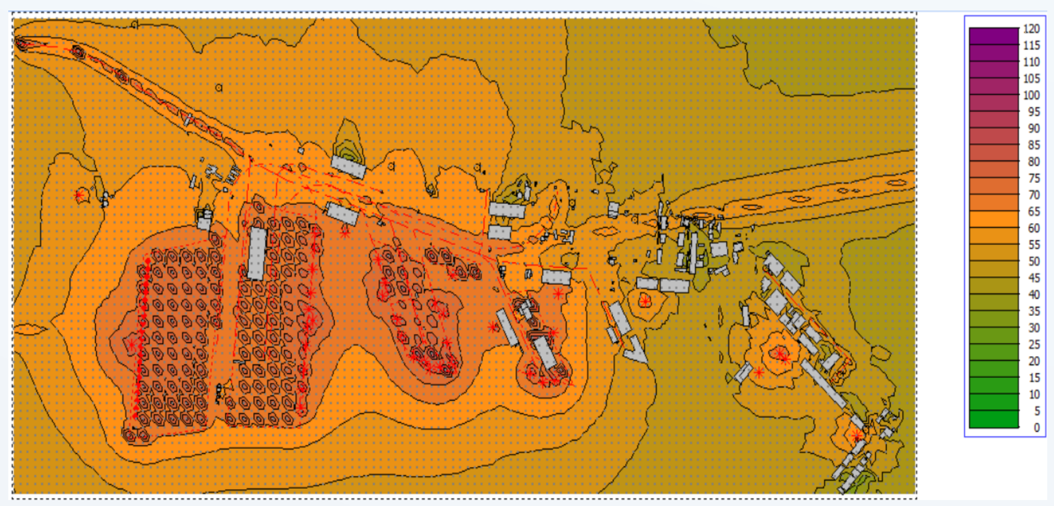

Figure 2. Noise map as done by PIXEL

Despite the similar results of the simulations, several things need to be discussed before bringing any final conclusions. Harmonoise method is still new to the software and some of the implemented code is still not optimized, so it takes significant amount of time to create a noise map, although the problem is less significant when calculating only values in the receivers. This can be an even more significant problem when using lower-capacity computers. Another subject for further research is to make simulations for different meteorological conditions, especially to test the influence of the unstable atmosphere and strong winds, which might represent a significant problem for areas near the port in unfavourable conditions. At the end, simulation results should be compared to the regulated values provided in [16]. The values stand at 70 dB(A) for LDEN and 60 dB(A) for Lnight and it is clear the simulation results are well under the limits. The last thing to note is the influence of various sources on the total noise levels. From the figure 2, it can be concluded that industrial noise sources have the largest influence on total noise levels and that traffic noise has a smaller role. Buildings, serving as noise barriers, have a significant influence in areas near them, but lower influence in areas farther away.

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