SOME ASPECTS ON THE EVALUATION OF THE NOISE CONTRIBUTION OF A FACTORY SITUATED IN A COMPLEX AREA

Toma ZAPLAIC[1], Nicolae ENESCU[2]

Measurement of the contribution of a factory to noise levels in the vicinity of sensitive receptors - dwellings - is a difficult activity, when at the measurement points there is a residual noise level comparable to the noise levels to be assessed.

This paper shows that using measurements in such situations has a limited utility, and that an assessment using calculation methods is more convenient.

The authors used the combination of zoning of the area analyzed by the difference map method, with the correlation of maps with the provisions for the correction of residual noise provided in the standardized measurement method.[1]

Keywords: industrial noise, road and rail traffic noise, specific noise, residual noise, noise map, difference map

1. Introduction

The purpose of this article was to highlight some difficulties that may arise in the process of measuring noise levels in an area where several sources act, considering that for the characterization by measurement of each source the others are sources of residual noise. The noise maps used as means of highlighting these difficulties were elaborated in a wider project involving the authors of this article.
Considering the need for a factory, as the one shown in Fig. 1, to operate in accordance with the limits imposed by environmental legislation on noise levels at neighboring sensitive receptors – residential buildings –, it is the question of assessing the contribution of the noise associated with the operation of this plant at the noise levels existing at the facades of the most exposed inhabited buildings in the vicinity.
The attempt to measure the noise levels in a point in the inhabited area highlights the existence of a residual noise L_r having comparable levels to the specific noise level L_s, generated by the factory's exclusive activity in many situations.

[1]Ph.D. student, University POLITEHNICA of Bucharest e-mail: toma.zaplaic@cepstra.ro
[2]Prof., Department of Mechanics University, POLITEHNICA of Bucharest,
e-mail:enescu.nae@cat.mec.pub.ro

The residual noise in the area has as sources the high road traffic existing on a national road, the road traffic on the access streets to the inhabited area and the factory, a railway artery (traffic and other noises), plus the noise generated by existing domestic sources in the area, including the presence of yard animals, conversations, etc.
A sonometer placed in a receptor point in this area over a given reference period will measure total L_t noise level as a result of the action of all sources in the area during that reference period. If the analyzed source, in this case the plant activity, is stopped, the sonometer will measure the residual noise level L_r.
In this phase, for the assessment of the specific noise level (generated exclusively by the factory), the corrections given in SR ISO 1996-2: 2008 Acoustics - Description, measurement and assessment of environmental noise - Part 2: determination of environmental noise levels, Chapter 9.6 Residual sound, page 17, are used. [1]
It is specified that, when the difference between the noise level measured having the factory in operation (total) L_t and the residual noise level Lr, measured with the factory stopped, fulfills the condition:

$$L_t - L_r > 10dB \tag{1}$$

no correction is made, the measured value being valid for the analyzed source with an acceptable approximation.
If

$$3dB \le L_t - L_r \le 10dB \tag{2}$$

to obtain the specific noise level (generated exclusively by the factory), the following correlation relation is applied:

$$L_s = 10 * \lg\left(10^{\frac{L_t}{10}} - 10^{\frac{L_r}{10}}\right) \tag{3}$$

If

$$3dB > L_t - L_r, \tag{4}$$

corrections are not allowed, the uncertainty of measurement being high in this case.
In the following, using the facilities offered by an appropriate mapping software, it will be shown why in a situation such as the one presented, the use of evaluation by measurement is not possible, in this case the calculation methods remaining an alternative for solving the requirement regarding the evaluation of the plant contribution.

Difference maps

One of the regulated obligations at European Union level regarding strategic noise mapping for noise sources in agglomerations and other objectives, is the

development of conflict maps, to illustrate the difference between the values of the noise levels in an area and the admissible limit set for that area. Difference maps are also used to estimate the results of applying a measures plan to reduce noise levels in an area, the maps presenting the difference between the noise levels existing before and after the application of the reduction measures, in the studied area.
In this paper, for the first time the difference maps are elaborated in relation to conditions (1), (2) and (4) above, in order to zoning the analyzed area according to the permissiveness of applying the residual noise correction, by using the flexibilities of the mapping software (SoundPlan 7.1).
Zonings will be carried out for two situations - the day period (interval between 7.00 - 23.00) and the night period (interval between 23.00 - 7.00), for the long-term average emission of the plant, and for the residual noise generated by road traffic and rail traffic, situations in which residual noise sources have completely different emissions and, in the end, the two situations obtained will be compared and the resulting conclusions will be drawn.

2. Current situation

The layout of a wood processing plant is illustrated in Fig.1.

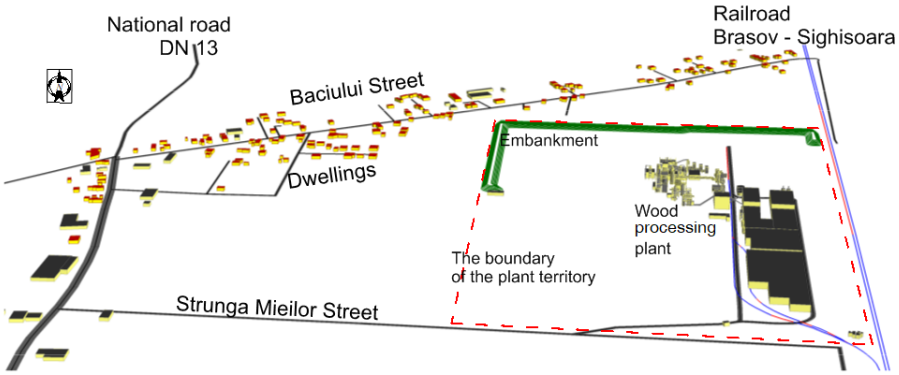

Fig. 1: Location of a wood processing plant in the territory

Inside the area there is an inhabited area with about 130 houses. This area can be accessed via Baciului Street, the street being characterized by a low road traffic. There is also an artery with moderate traffic, Strunga Mieilor St., mainly used for access to the factory of heavy vehicles, which ensures the supply of raw materials (logs) necessary for production.The factory is located in an area bordered to the east with an important railway, Brasov - Sighisoara, and to the west with a main traffic road, the national road DN 13.

The noise on the facades of buildings in the inhabited area has as its source the activity of the enterprise, road traffic, the railway traffic, as well as the existing domestic noise in the neighborhood of the dwellings.
The main industrial noise sources associated with the activity of a wood processing plant are illustrated in Fig.2.

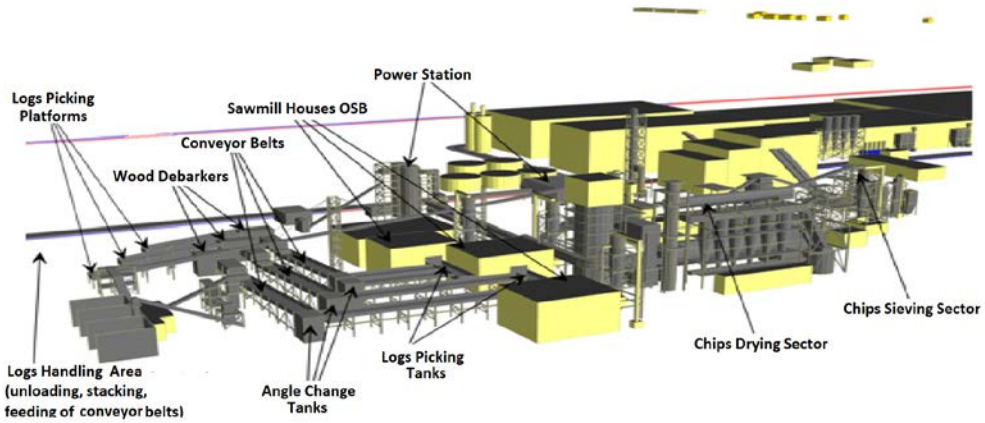

Fig. 2: The main industrial noise sources associated with the activity of the analyzed factory

In the followings are shown the difficulties of assessing the noise levels generated exclusively by the industrial activity.

3.Way of working

In order to highlight the problems encountered in the measurement activity, we used noise mapping carried out according to the calculation methods established on the basis of the existing Romanian legislation [2], [3], in connection with the Government Decision no. 321/2005 on Environmental Noise Assessment and Management, transposing EC Directive 2002/49 on the Assessment and Management of Environmental Noise. To produce these mappings, we used an appropriate software that meets the requirements of the Directive, in this case SoundPlan 7.1. As stated in Chapter 1, one of the possibilities offered by this type of softwares is the creation of differential maps for making comparisons between different situations, in particular to forecast the effects of applying measures in the case of noise reduction action plans.
In the innovative approach of this study, the software's feature is useful to highlight the difficulties that arise in assessing the factory's contribution to noise from a sensitive area.
Characterization of considered sources [3]

Table 1

Road traffic considered for national road DN13

Period of the day	Road traffic	
	Light vehicles / h	Heavy vehicles / h
7.00 - 23.00	780	190
23.00 - 7.00	208	50
	Speed = 70 km/h	Speed = 70 km/h

Table 2

Road traffic considered for Strunga Mieilor Street

Period of the day	Road traffic	
	Light vehicles / h	Heavy vehicles / h
7.00 - 23.00	20	6
23.00 - 7.00	8	4
	Speed = 50 km/h	Speed = 50 km/h

Table 3

Road traffic considered for Baciului Street

Period of the day	Road traffic	
	Light vehicles / h	Heavy vehicles / h
7.00 - 23.00	11	1
23.00 - 7.00	4	1
	Speed = 50 km/h	Speed = 50 km/h

In order to prepare the input data for the calculation, the characterization of the industrial sources was made by measurements in their vicinity, where the condition (4) is met, being evaluated the acoustic powers with their spectral distributions, the quotas at which the sources are located, the averaging of their acoustic powers based on the operating regimes of the equipments, and the duration of these regimes (5).

Since the activity of the plant is not dependent on the day - night cycle, the characterization of a long - term average function has the same representativeness in calculation over any reference period of a full day, namely 7.00 - 23.00 or 23.00 - 7.00.

The acoustic power level used for a particular source having several operating regimes over a time period T, each of duration t_i, is averaged using the relation:

$$L_W = 10 * \lg\left[\left(\frac{1}{T}\right) * \sum_{i=1}^{n}\left(t_i * 10^{\frac{L_{Wi}}{10}}\right)\right] \quad (5)$$

Where:

L_W is the level of acoustic power considered for calculation

n is the number of operating regimes of a source

L_{Wi} is the level of acoustic power corresponding to regime i, in dB(A)

t_i is the operating period in the regime i

By fulfilling the condition:

$$T = \sum_{i=1}^{n} t_i \quad (6)$$

In the calculation are included the acoustic power values of the noise sources associated with the factory activity, averaged according to the operating regimes and the durations corresponding to these regimes.
For example, in Tab. 4 are presented the acoustic power levels for a device (wood debarker), characterized by two operating modes.

Table 4

Acoustic power of the wood debarker

f [Hz]	63	125	250	500	1000	2000	4000	8000	L_{Wt}
L_{w1}	56.4	64.2	78.5	87.5	92.6	86.5	103.4	84,6	104.0
L_{w2}	53.5	61.6	72.2	82.4	84.0	83.2	78.8	70.3	88.7
$L_{w,av}$	55,5	63,3	76,9	86,1	90,8	85,3	101,2	82.5	101,6

In the second line are listed the acoustic powers in bands of one octave band in the regime 1.
In the third line are listed the acoustic powers in bands of one octave band in the regime 2
In the third line are listed the acoustic powers averaged for an operating period of 60% of the time in regime 1 and 40% of the time in regime 2, by applying the relation (5), and used in the calculation program. Relation (6) represents an example of calculation for the octave band of 63 Hz.

$$L_{W,av,63Hz} = 10*\lg\left[\left(\frac{1}{100}\right)*\left(60*10^{\frac{56.4}{10}} + 40*10^{\frac{53.5}{10}}\right)\right] = 55.5dB(A) \qquad (6)$$

In the last column is presented the total value of the acoustic power level, obtained by the logarithmic summation based on the relation:

$$L_{Wt} = 10*\lg\sum_{i=1}^{n}\left(10^{\frac{L_{Wi}}{10}}\right) \qquad (7)$$

Where:
L_{Wt} is the total level of acoustic power
L_{Wi} is the level of acoustic power corresponding to the octave *i*
$L_{W,av}$ is the total level of acoustic power averaged for a long time interval
$n = 8$ is the number of octave bands

4. Results and conclusions

Fig. 3 and Fig. 4 present the distributions of L_{eq}, total noise level generated in the area of calculation for the activity of the analyzed plant, as well as for the road traffic and the railway traffic, for the day period (7.00 - 23.00) and for the night period (23.00 - 7.00).

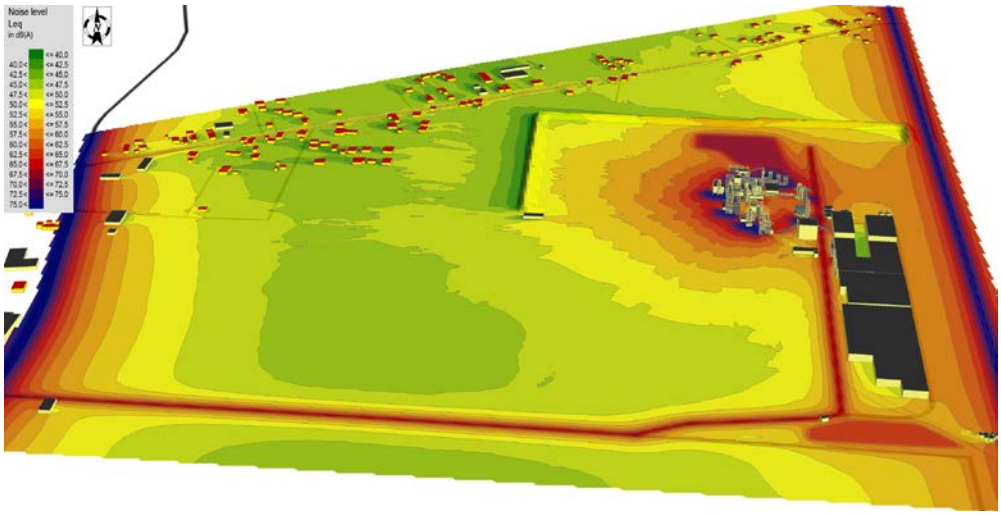

Fig. 3: Map of the combined action of noise generated by industrial activity, road traffic and rail traffic, for the L_{eq} parameter, with the significance of total noise, for the day period (7.00 - 23.00)

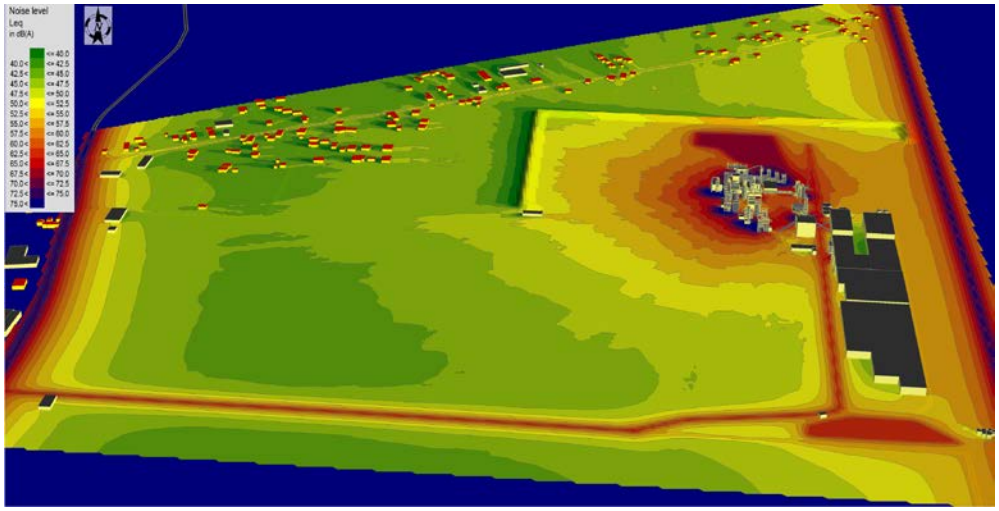

Fig. 4: Map of the combined action of noise generated by industrial activity, road traffic and rail traffic, for the L_{eq} parameter, with the significance of total noise, for the night period (23.00 - 7.00)

The purpose for which these mappings were presented is to show the distribution of the total noise level existing in the analyzed area as a result of compiling the specific noise level generated by the activity of the plant with the residual noise level generated by road and rail traffic.

Considering that there is no differentiation between the daytime and nighttime operations, its time-weighted contribution to total noise is the same.

Road traffic and rail traffic are subject to significant variations depending on the different periods of the day, and their intensity is diminished during the night, this aspect affecting noise emissions during the respective periods.

Fig. 5 and Fig. 6 present the distributions of the L_{eq} level, the noise generated in the computing area only by road and rail traffic, for the day period (7.00 - 23.00) and for the night period (23.00 - 7.00). The obtained results, ignoring the domestic noise, are the long-term mean values of the residual noise (L_r)

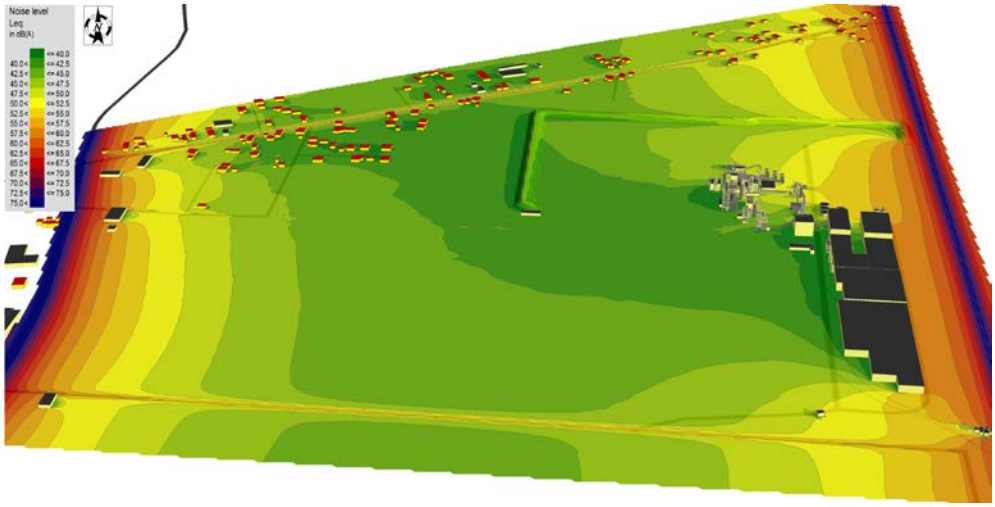

Fig. 5: Map of the combined action of noise generated by road traffic and rail traffic, for the L_{eq} parameter, with the significance of total noise, for the day period (7.00 - 23.00)

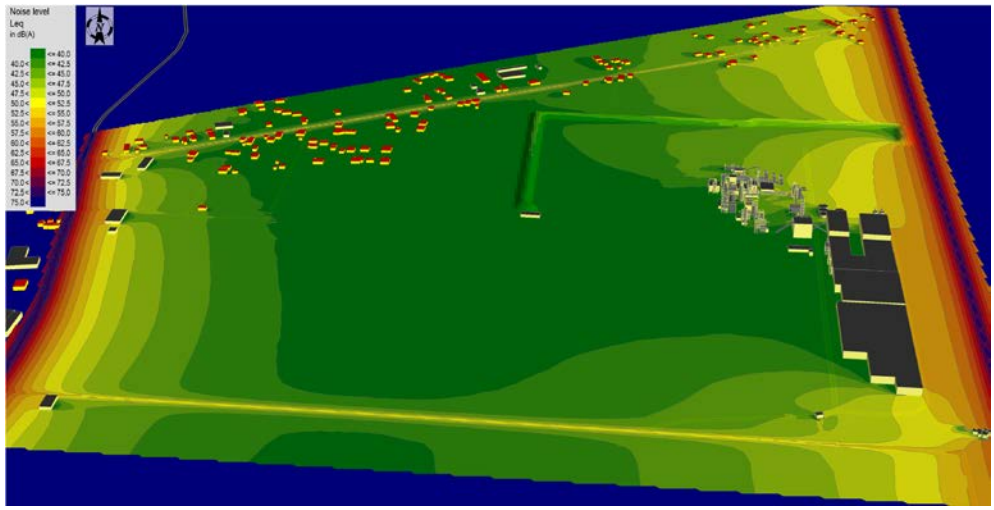

Fig. 6: Map of the combined action of noise generated by road traffic and rail traffic, for the L_{eq} parameter, with the significance of total noise, for the night period (23.00 - 7.00)

The specific noise level (L_s) corresponding to the factory's contribution to total noise would be obtained by using the relation (3).
Conditions (1), (2) and (4) set the restrictions applicable to the calculation of residual noise corrections.

Fig. 7 and Fig. 8 show the distribution of the difference between the total noise level and the residual noise level at each point, both for the daytime and night time.

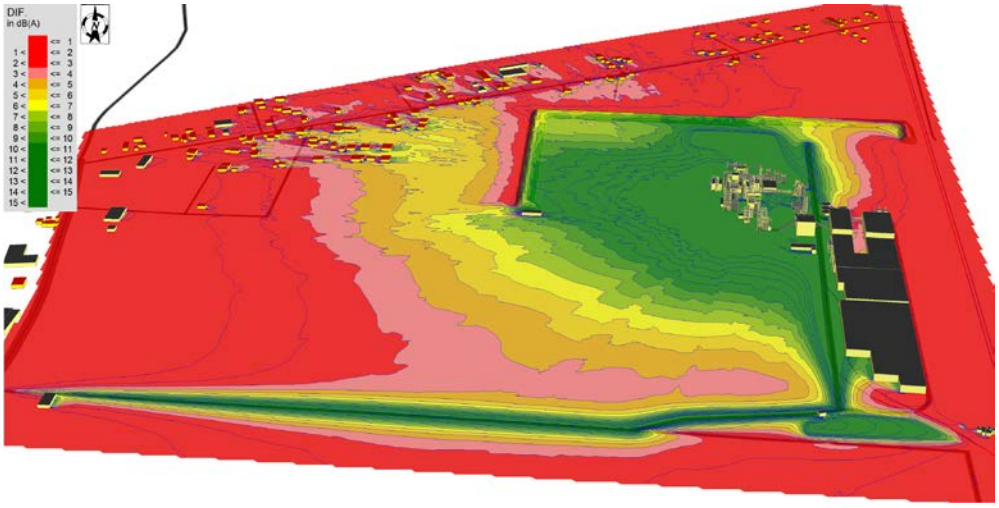

Fig. 7: Map of the differences between total noise and residual noise for the day period (interval 7.00 - 23.00)

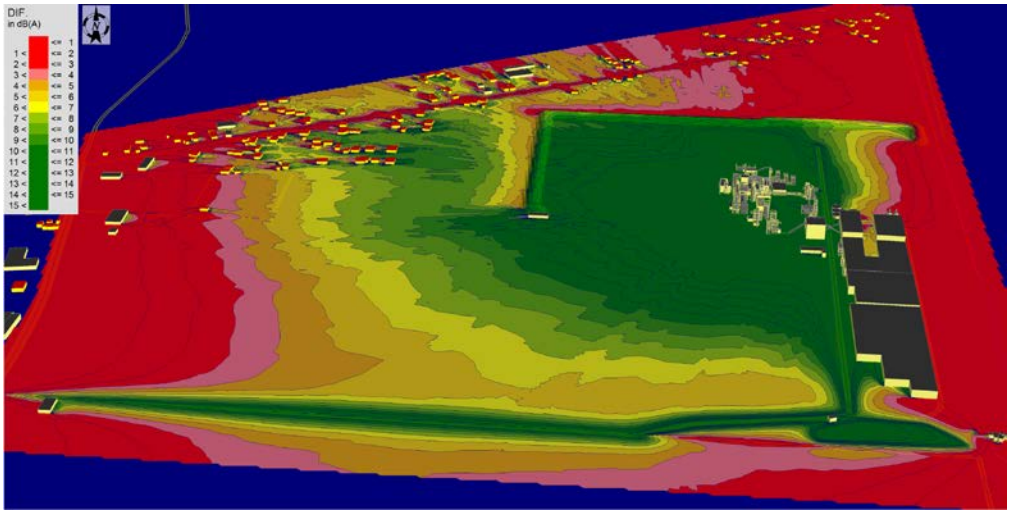

Fig. 8: Map of the differences between total noise and residual noise for the night period (interval b23.00 - 7.00)

Based on the conditions (1), (2) and (4) imposed by ISO 1996-2: 2008, the difference maps of Fig. 7 and Fig. 8 represent zonings of the analyzed area with the following interpretation:

a) the green color corresponding to the condition (1) in which no correction is needed, the measured value being valid for the analyzed source;
b) red color, corresponding to the condition (4) in which no corrections are allowed, the uncertainties being unacceptably high;
c) other colors, marks the area where corrections are allowed and necessary.

As can be seen, the area in which measurements can be made, with or without corrections, is relatively reduced. The disadvantage of this situation is all the more so as the residual noise did not include the domestic, random, higher levels of noise in the vicinity of the dwellings.

Another useful aspect of comparing the day-to-day difference maps is that areas where corrections are possible or unnecessary are normally larger at night when residual noise is lower, but even during this period, only a fraction of the sensitive receptors included.

Also, the plant activity is characterized by inevitable variations in noise emissions, which affect the representativeness of measurements over relatively short time intervals.
An important observation is the existence of the green color - the fulfillment of the condition (1), corresponding to the area where no corrections are needed, in the vicinity of the sources of the factory, which suggests that the determination of the descriptive parameters of the noise sources necessary for the evaluation by calculation (acoustic powers, spectral distributions etc.) is advantageous in the vicinity of sources. However, care should be taken to avoid situations in which, when analyzing a source belonging to the plant, other sources belonging to it could affect the fulfillment of the condition (1).

From the above, it results that an evaluation of the contribution of the activity of the factory by calculation (fig.9), has many advantages, among which we mention:

- eliminates the influence of residual noise, generated by road and rail traffic, and by domestic sources not included in the mappings;
- by appropriate analyzes of the technological processes, the emissions of the associated noise sources can be weighted over a long time, eliminating the inherent fluctuations in time of the plant emissions at limited intervals, with significant repercussions in the measurement activity ;
- eliminates the influence of weather conditions;

- through appropriate simulations, the contributions of each source to the noise in the sensitive area can be determined, so that an effective and predictable reduction strategy can be achieved;
- has the advantage that the effects on sensitive receptors of any change in the technological processes could be quantified and, if necessary, corrective measures can be taken.

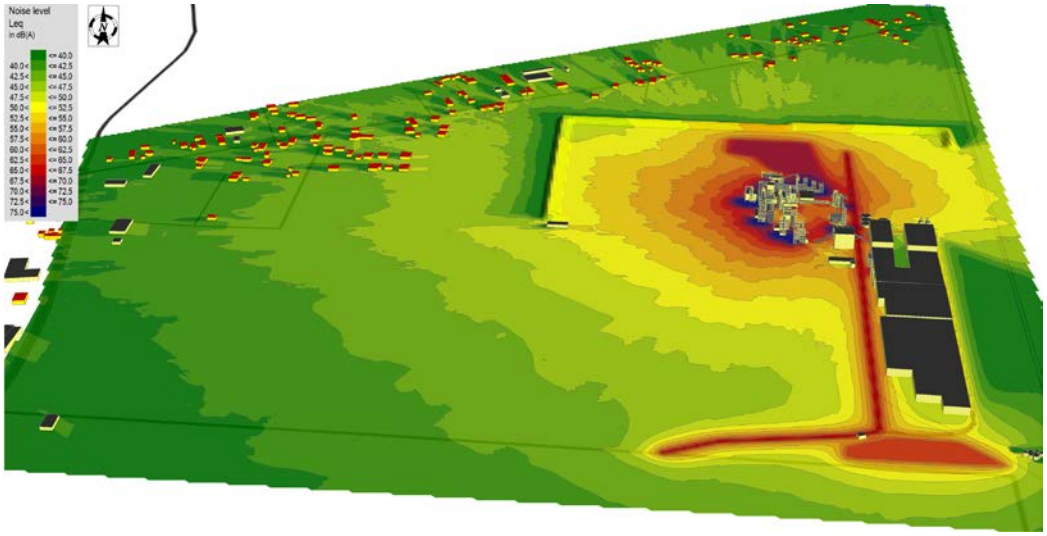

Fig. 9: Map of noise generated exclusively by industrial activity, for a long-term average situation

R E F E R E N C E S

[1] SR ISO 1996-2: 2018 Acoustics - Description, measurement and assessment of environmental noise – Part 2: Determination of environmental noise levels
[2] GD no. 321/2005 relating to the assessment and management of environmental noise;
[3] MO no. 678/2006 on the approval of the Guideline on Interim Methods for Calculation of Noise Indicators for the Noise Produced by Activities in Industrial Areas, Road, Rail and Air Traffic in the vicinity of Airports;
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