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NOISE IMPACT ASSESSMENT USING NOISE MAPS AND NOISE CONFLICT MAPS IN BRAILA – A CITY SITUATED BETWEEN THE LARGEST RAMSAR ROMANIAN AREAS: DANUBE DELTA AND BRAILA SMALL ISLAND

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Abstract: This paper presents 1 year of working on creating the acoustical and conflict maps for Braila – the 11th city in size in Romania. These maps show the noise and the conflict made by the road traffic, railway traffic (trams included) and industry. In order to complete these maps all the factors were taken into account: the GIS system, the statistical data which refer to the demographic structure of the city (areas, neighbourhoods, streets) given by the City Hall, data obtained from the public transport company and from the railway company, data obtained from the industrial companies, weather conditions (dry roadway, T=10-22°C, gentle wind), etc. both noise maps as well as conflict maps were created for a 4m height, according to the standards. The experimental measurements were made using the Blue Solo - 01DB Metravib sound level meter. The software used was CadnaA (Computer Aided Noise Abatement)-DataKustic (software for calculation, presentation, assessment and prediction of environmental noise).

The obtained results were alarming, especially those referring to the historical city centre (50-60dB), to the main city streets (60-75dB) and to some of the neighbourhoods (> 75dB). Similar results were obtained in the night time measurements (the same main city streets have noise problems). The conflict maps were drawn in order to solve these problems and in order to identify the conflict areas and the on these maps were identified the areas for which the legal limits are exceeded, including L_{den}>70dB(A) and L_n>60dB(A), according to the standards. The preliminary data obtained after each conflict map was completed show that:

- During the night there is a conflict of: 0-5 dB for the buildings situated at a distance of 32-55 m from the road; 5-10 dB for the buildings situated at a distance of 15-32 m from the road; higher than 10 dB for the buildings situated at a distance under 15 m from the road.
- During the day there is a conflict of: 5-10 dB for the buildings situated at a distance of 32-55 m from the road; 10-15 dB for the buildings situated at a distance of 15-32 m from the road; higher than 15 dB for the buildings situated at a distance under 15 m from the road.

Keywords: Noise pollution, Strategic noise maps, Conflict noise maps, Directive 2002/49/EU

1. INTRODUCTION

Strategic noise map shall mean a map designed for the global assessment of noise exposure in a given area due to different noise sources or for overall predictions for such an area.

All the countries of the European Community and all the developed countries have implemented many years ago laws against surrounding noise, which presumes drawing up city noise maps.

The Noise Directive 2002/49/EU includes obligations for noise mapping for agglomerations above 250 thousand citizens in the first step and later - above 100 thousand people. The noise map of the city consists of, at least, 4 layers of information. Each layer, in graphical form, represents different kinds of noise distribution, for traffic, railway, air and industrial noise (Murphy & King, 2011).

The surrounding noise is the sum of all unwanted noises, including the harmful ones, resulting from human activities, including the ones from road, railway and air traffic and the ones from the areas with industrial activities statutory by the Directive 2002/49/EC of the European Parliament and of the council, of 25 June 2002 relating to the assessment and management of environmental noise.

This Directive applies to the surrounding noise which people are exposed to, especially in some constructions areas, public parks or other peaceful places in the middle crowded areas or open spaces, near schools, hospitals or other buildings sensitive to noise and do not apply to the noise made by the exposed person alone, to the noise resulted from household activities, to the noise made by neighbours, workplace noise, noise inside public transportation or noises which came from military activities inside military areas (Mrkajic et al, 2005), (Popescu et al., 2010).

Noise maps' purpose is to highlight the populated areas where the noise level is above the limits stated by the law and thus the maps are used to develop action plans to protect citizens against exposure and to reduce noise levels.

In this paper were drawn noise maps (road, railroad and industrial) and also conflict maps for the city of Braila. In order to achieve these noise maps, we considered the documents provided by the City Hall of Braila:

- Data regarding the population and its distribution on inhabited areas;
- Information regarding the street network set and its main characteristics;
- Date regarding the economic societies and their distribution on areas;
- Date regarding the internal traffic flows (vehicles and trams) inside the main crossroads (18 crossroads);
- Information regarding the external traffic flows and transit for people and goods, according to the traffic census CNADNR-CESTRIN and to the Origin-Destination Survey from 2013.

This is a process that is usually associated with high operative costs. Some statistical techniques have been employed that have allowed the extrapolation of some measured values to assess noise at different times of the year. The day-evening-night level L_{den} is used as the rating method to describe long-term annoyance (Zannin & de Sant'Ana, 2011).

2. MATERIALS AND METHODS

In order to draw up noise maps one must gather, put together and report data regarding the noise levels in the environment, according to comparable criteria. This implies the use of some consolidated markers and computing methods as well as some criteria to range the noise mapping.

The selected common noise markers are L_{den} to determine the discomfort and L_{night} to determine the sleep disturbance.

1. „L_{den}" (noise marker for day-evening-night) represents the noise marker associated to the general discomfort,
2. „L_{day}" (noise marker for day) represents the noise marker associated to the daytime discomfort,
3. „$L_{evening}$" (noise marker for evening) represents the noise marker associated to the evening discomfort,
4. „L_{night}" (noise marker for night) represents the noise marker associated to the night discomfort,

The day-evening-night level L_{den} (dB) is defined by:

$$L_{den} = 10\lg \frac{12 \cdot 10^{\frac{L_{day}}{10}} + 4 \cdot 10^{\frac{L_{evening}+5}{10}} + 8 \cdot 10^{\frac{L_{night}+10}{10}}}{24}$$

where: L_{day} / $L_{evening}$ / L_{night} are the average sound pressure levels, A weighted, during long time periods, according to the ISO 1996-2:1987 definition, determined for the total day/evening/night periods during a year, where the day has 12 hours, the evening has 4 hours and the night has 8 hours; a year is a relevant year in terms of sound emission and an average year in terms of weather conditions. The incident sound taken into consideration which means that the noise reflected by the establishment in question is not taken into account (as a general rule this means a 3dB correction of the measurements) (Ko et al., 2011).

The height of the determination point for L_{den} depends on the application:

► In the case of the determinations for strategic acoustic mapping in terms of noise exposure inside or near buildings, the determination points must be at 4.0 ± 0.2 m above ground and on the most exposed frontage; for this, the most exposed frontage will be the front exterior wall nearest to the specific noise source; for other purposes, other configuration can be choose;

► In the case of the measurements for strategic acoustic mapping in terms of noise exposure inside or near buildings, other heights can be chosen but never smaller than 1.5 m above ground and the results are corrected for an equivalent height of 4 m.

It is also useful to use extra markers to monitor or control special noise cases, for example:

- the analysed noise source is on only a short period of time (for example less than 2% of the time, referring to the total daytime, evening time or night time in a year);
- when the number of noise events, during one or more time periods, is very small (for example less than one event an hour); a noise event can be

defined as a noise that lasts less than 5 minutes (for example the noise made by a passing train or an airplane;

- the low frequency component of the noise is strong;
- L_{Amax} or SEL (sound exposure level) is the night time noise screening for noise peaks;
- extra protection at the end of the week or during certain year seasons;
- extra protection during the day;
- extra protection during the evening;
- blending of multiple noise sources;
- peaceful areas in open spaces;
- the noise involves important tonal components;
- an impulse kind of noise.

The experimental measurements were made using the Blue Solo - 01DB Metravib sound level meter.

2.1. Working methodology with the CadnaA software

The noise maps for the city of Braila were drawn up using the CadnaA software. It offers many instruments to set up the determination pattern, to present the results and to send forward the data to interfacing applications like tabular computing software, CAD software or GIS systems through mport and export interface. The noise level determination is always accurate and keeps to the most recent standards and international references (Foraster et al., 2011).

The system consists of a sound level meter, a GPS receiver, a database program to manage the measured data, and a program to produce the noise map including a computer model of the target area. The GPS receiver interfaced to the sound level meter allows simultaneous measurement and storage of the noise level and the global position at a location. The database program directly imports one or more measured data stored in the sound level meter. Then, selected measurement results are exported to the noise mapping program for producing colour-coded or noise contour line maps using measured data at user-defined locations (Ausejo et al., 2010).

The input data are entered by the digitizer, using one of the CadnaA interfaces. The heights and all the other data are entered by keyboard. The proposed model is virtual represented, can be rotated around each axis, objects can be added or data can be modified from the editing window. Through the interfaces one can import data from CAD-GIS files, data base systems and other applications. This makes possible the data update which are transmitted by the environmental agencies, by importing them from time to time.

CadnaA determines the noise levels in any areas, on the points positioned on the horizontal or vertical grids or on the rollers from the buildings' frontages. In the case of some special sources, like roads, railways or airports, the levels of acoustic emissions are determined using the technical parameters values. CadnaA helps importing the geometry of all objects, like buildings, roads, railways, etc.

Noise data were collected at varying intervals: morning, afternoon, and evening in both summer and winter. The spatial distributions of the noise levels during each time interval were evaluated and visualized by geographic information systems (Seong et al., 2011).

The experimental results obtained for the interest areas can be simulated using CadnaA; therefore the obtained map is overlaid on the actual thematic layers (barrier-buildings, street network, parks, etc.).

2.2. An overview of Braila

Braila is a city in eastern Romania, a port on the Danube and the capital of Braila County. According to the 2011 Romanian census there were 180,302 people living within the city of Braila, making it the 11th most populous city in Romania.

Streets radiating from near the port towards Braila's centre are crossed at symmetrical intervals by concentric streets following the geometric design of the old Ottoman fortifications.

Braila features one of the oldest electrical tram lines in Romania, inaugurated at the end of the 19th century and still in use. Braila's bus system is operated by the town hall in cooperation with Braicar Company, with four primary bus configurations available servicing most of the city.

3. RESULTS AND DISCUSSIONS

3.1. Road traffic noise analysis

The measurements of the noise due to road traffic were made in 21 crossroads according to the Feasibility Study regarding the acoustic mapping of Braila. Hereinafter is a description of some of these results (Fig. 1, Table 1). The traffic flows were estimated by bearing on the network of the total Origin-Destination matrix, which was calibrated for the year 2013 using the traffic flows measured for the main crossroads in Braila.

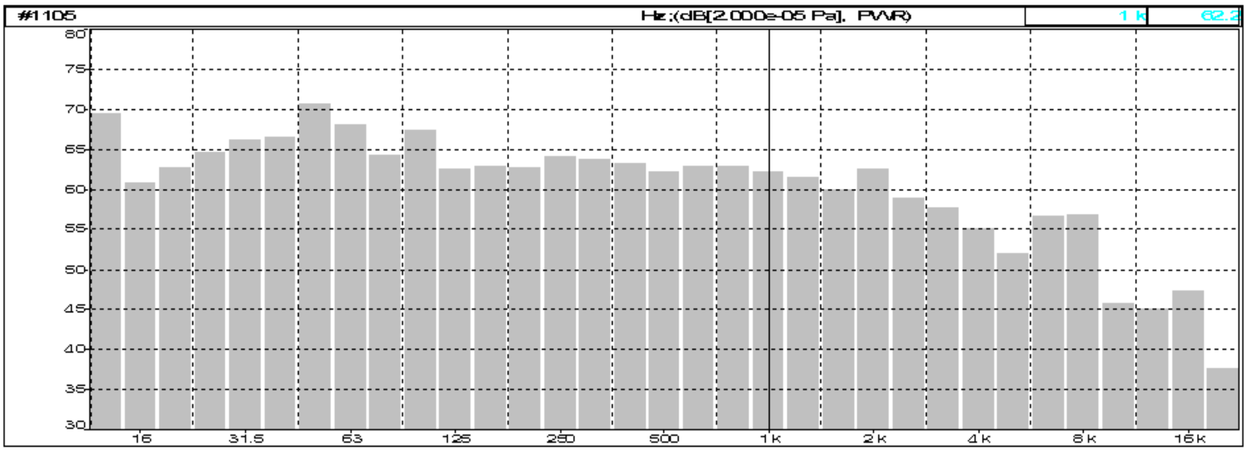

Figure 1. Spectral analysis in 1/3-octave of noise level recorded near Calarasilor Av. / Rubinelor St. area

Table 1. Measurements results in different areas of Braila

Parameter	**Leq**	Lmin	Lmax	L10
Calarasilor Av. / Rubinelor St.	**72.0dB**	54.4dB	90.6dB	71.8 dB
Place Traian / M. Eminescu St.	**62.4**	52.7	75.5	65.1
Galati Av. / Place Traian	**69.7**	55.8	81.2	72.6
Galati Av. /Al. I. Cuza Av.	**67.5**	54.1	76.4	70.6
Calarasilor Av./Independentei Av.	**69.7**	57.5	79.2	72.9
Galati Av. /Garofitei St.	**71.8**	52.3	87.6	73.5
Rm. Sarat Av. / Transilvaniei St.	**67.8**	56.8	76.8	70.5
1918, December 1 St./Dorabanti Av.	**66.4**	56.1	76.1	69.1
Calarasi Av. / across the street from City Hall	**69.0**	54.9	75.7	72.5
Buzau Av. /Milcov St.	**63.0**	55.0	69.4	65.5
1918, December 1 St./Independentei Av.	**68.5**	51.9	78.9	73.8
Near rail station	**70.8**	59.6	82.2	73.8

The results of these types of measurements are influenced by many factors: temperature, humidity, wind speed, if the measurements are made during working days or during holidays, etc. The measurements were made on dry roadway, at a temperature T=12-25°C with a moderate wind, during a year.

3.2. Rail traffic noise analysis

To obtain the data necessary for drawing up railway noise maps all rail operators were asked for information:

a) The noise limits for stationary goods wagons

The stationary noise is described in level $L_p(A_{eq})$ terms of A, continuous equivalent weighted acoustic pressure, according to the ISO 3095:2013 standard.

b) The noise limits for passing good wagons

The marker for the passing noise is the level $L_p(A_{eq})$ of continuous equivalent weighted acoustic pressure A, measured during a train passing, at a distance of 7.5 m from the railroad axis and 1.2 m above the track rail. The measurements are made in conformity with the ISO 3095:2013 standard.

c) The noise made by railway engines, motorailers and coaches

The stationary noise limits are determined at 7.5 m from the railroad axis and 1.2 m above the track rail. The measurement requirements are provided by the ISO 3095:2013 standard.

From a total of 28 de trains that pass through Braila station, 12 are express trains, 12 are InterRegio and 4 are optional (those at 07:44, 10:03, 12:03 and 13:40).

Between 22:08 and 05:00 there are no passenger trains that stop in Braila station. S.C. Transferoviar Călători S.R.L is among the private rail operators on the route Bucureşti N. – Urziceni – Făurei – Galaţi.

Measurements were made near apartaments buildings in front of the station.

3.3. Tram traffic noise analysis

The old tram spectrum is richer in high frequency components than newer tram and the speed does not change the relative frequency distribution of the old tram spectrum.

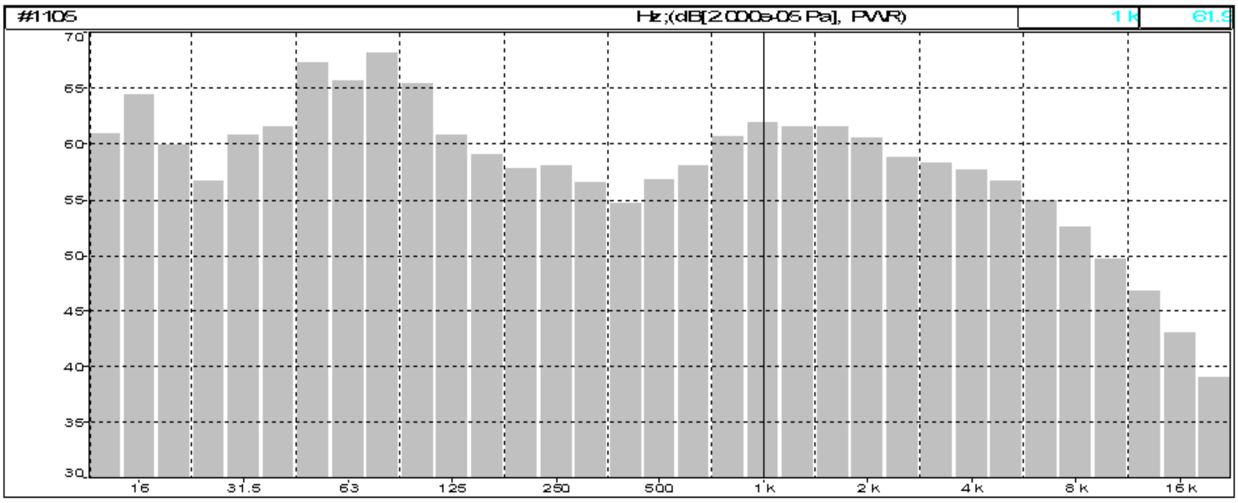

Figure 2. Spectral analysis in 1/3-octave of noise level recorded near Calarasi Av. /Dorabanti Av. area

Period start	**Leq**	Lmin	Lmax	L10
Overall	**70.9**	51.7	85.8	72.8

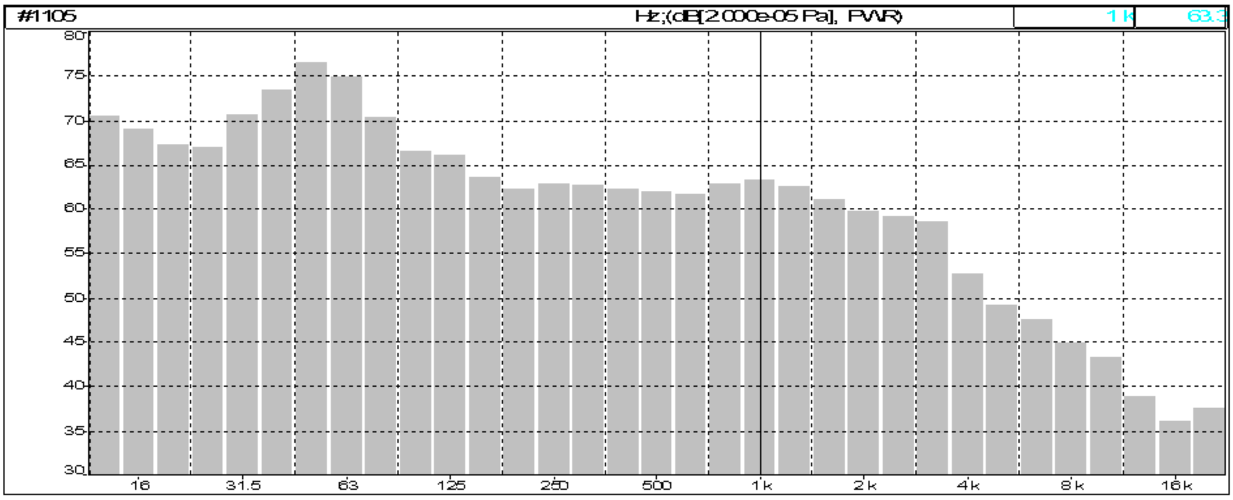

Figure 3. Spectral analysis in 1/3-octave of noise level recorded near "Laminorul" factory area

Period start	**Leq**	Lmin	Lmax	L10
Overall	**71.7**	58.4	83.0	75.5

As for the type of path, the terrain with asphalt gives higher noise levels, with a greater contribution of middle-range frequencies, than the ground with soil.

Measurements were made along the two tram lines that cross the city (Fig. 2).

3.4. Industrial activity noise analysis

The relevant economic fields in Braila are represented by metal constructions, metallurgical manufacture, machinery and equipment (Fig. 3), ship construction and repair, electricity generation and distribution, food and beverage production, furnishings and furniture items, agriculture, tourism.

To obtain the necessary data for the industrial noise maps Braila Environmental Protection Agency was asked for the list of all the industrial units which are subject of OUG 152/2005 regarding the prevention and integrated control of pollution, data regarding their activity, employed noise sources and their acoustic emission, industrial units location map.

The determination method is based on default data of acoustic emission conveyed as acoustic power per square meter of the industrial area, which can be found at Chapter 3.2. pt. 10 Instrument 5, from the Guide book regarding the interim determination methods of the noise markers for the noise generated by the industrial activities, by the rail and road traffic, approved by the Ministry of Environment and Climate Change, the Ministry of Transportation, Construction and Tourism, the Ministry of Public Health and the Ministry of Internal Affairs, nr. 678/1344/915/1397/2006. Thus, the implicit values for the entire industrial area were considered (Picu, 2009), (Picu & Nastac, 2010).

After analyzing the current situation, we can say that the Braila has a relatively high traffic, the level of mobility estimated at about 98,000 vehicle trips per day standard, including internal displacements, external and transit. Also, it is high values of traffic flows into the city on DN2B, both from Galati and from Buzau, and on Route 22B, from Galati.

The Service Level is satisfactory in the central area, except on the Galati avenue, towards Galati, after the crossroads with Al. I. Cuza Blvd, where on some road segments are recorded traffic capacity exceedances. This also happens on the Eremia Grigorescu Str. Where, on some road segments, the capacity backup falls under 10%.

The whole vehicle flow generates a sound level ranges as follows:

- 50-60dB is the average sound level for the central area (historic center);
- 60-75dB is the average sound level Regiment streets, Galati, Apollo - Baldovineşti, Rm. Sarat and neighborhoods Viziru II and Radu Negru (only in some areas),
- greater than 75dB is the average sound level roads Buzau Viziru and Ring Road.

4. CONFLICT MAPS

Perhaps more important than the noise map, from the point of view of an inhabitant of an urban

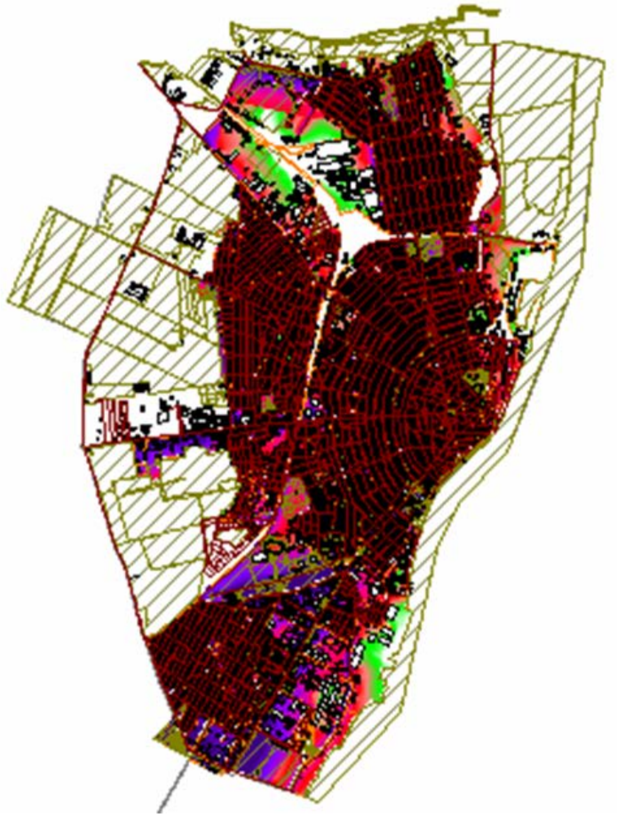

Figure 4. Conflict map – traffic noise

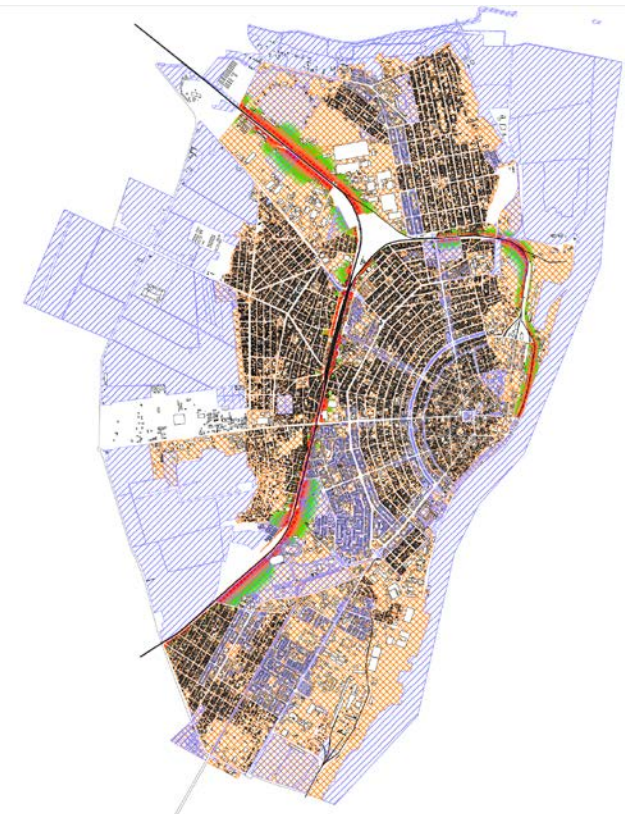

Figure 5. Conflict map – rail noise

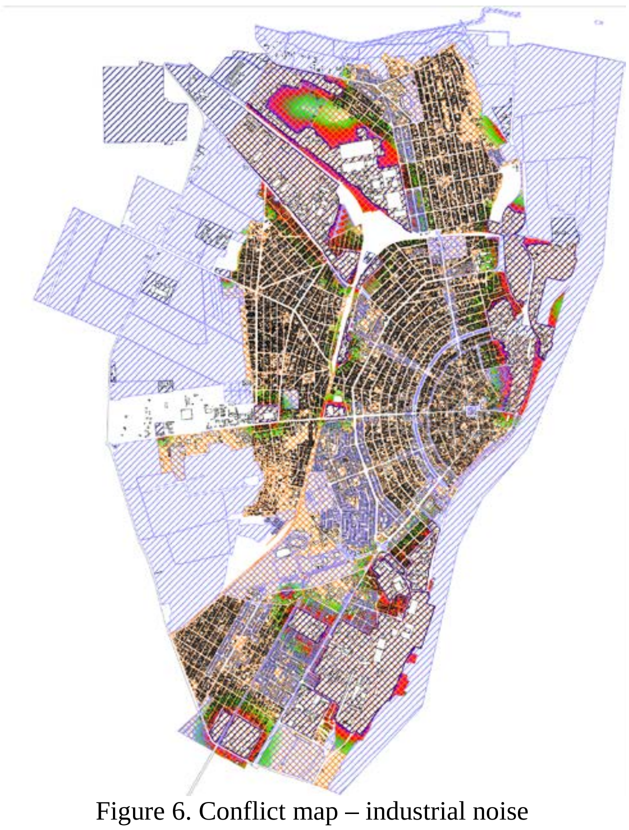

Figure 6. Conflict map – industrial noise

agglomeration, is the conflict acoustic map which shows the occurrences of the exceeding of the sound level limit value.

The conflict maps (Fig. 4, 5, 6) were drawn up after mapping the noise and were discovered the areas where the noise levels were exceeded for each noise source. Therefore it was found that the noise source which has the most effect on Braila residents is the road traffic.

The conflict maps were drawn up to identify the conflict areas, where the legal limits are exceeded, including L_{den}>70dB(A) and L_{night}>60dB(A) (OM MMDD / MT / MSP / MIRA nr.152/558/1119/532/2008). These maps are drawn for daytime as well as for night time.

The preliminary data obtained after the drawing up of each conflict map

Estimating the number of people exposed to noise

Estimating the number of people	**L_{den}**	**L_{night}**
Road traffic	102106	81418
Rail traffic (tram included)	19123	11756
Industry	2263	317

Estimating the number of buildings exposed to noise

Estimating the number of buildings	**L_{den}**	**L_{night}**
Road traffic	7024	5389
Rail traffic (tram included)	437	325
Industry	267	155

Estimating the number of weak buildings exposed to noise

Estimating the number of weak buildings	**L_{den}**	**L_{night}**
Road traffic	98	10
Rail traffic (tram included)	21	2
Industry	22	1

During the night there is a conflict of:

- 0-5 dB at the buildings situated at a distance of 32-55 m away from the road.
- 5-10 dB at the buildings situated at a distance of 15-32 m away from the road.
- Higher than 10 dB at the buildings situated at a distance smaller than 15 m away from the road.

During the day there is a conflict of:

- 5-10 dB at the buildings situated at a distance of 32-55 m away from the road.
- 10-15 dB at the buildings situated at a distance of 15-32 m away from the road.
- Higher than 15 dB at the buildings situated at a distance smaller than 15 m away from the road.

The noise maps as well as the conflict maps were drawn up for a 4m height from the ground, according to the standards. This is the correct height to draw the proper conclusions.

5. CONCLUSIONS

Looking at these maps, we find that the average values of the sound levels in the main areas of Braila are 50-60dB for the Historic Centre, 60-75dB for Dorobanţi Av., Galaţi St., Apollo-Baldovineşti, Rm. Sărat, Viziru II and Radu Negru and higher than 75dB for Buzăului Av. and Viziru Av.

Noise data were collected at varying intervals: morning, afternoon and evening in both summer and winter. The spatial distributions of the noise levels during each time interval were evaluated and visualized by Geographic Information Systems. The analytical results indicated that the highest and lowest average noise levels were 59.5 dB(A) and 51.4 dB(A) during summer mornings and winter evenings, respectively.

Similar results were obtained during the night time measurements (the same roads have noise problems).

The most common noise consequence is the impact on the neurovegetative balance which can occur at 60dB. The noise can lead to caloric volume remission, circulatory impairment, heart rate and blood pressure changes, gastric neuroses, insomnia. Also, noise can cause fear and discomfort, attention deficit and uneasiness.

Urban agglomeration inhabitants are directly exposed to the background noise of the city they live in. These noises, even at low intensities and without waking-up people from their sleep, can lead to reactions of the neurovegetative system, such as insomnia or disturbed sleep.

Many inhabitants of the cities with busy and noisy streets think that they have accommodated with those noises. Actually, the researches have shown that these people are more stressed and tense, psychically speaking, than the inhabitants of smaller cities. Under these circumstances it can be said that the risk of damaging their mental health is increased. Cities need to monitor their ambient noise.

It is normal that these maps are dynamic (they can be modified at any time the circumstances at the site ask for it– construction sites, public roads repairs, etc.); also, they can be revised if permanent noise sources appear: construction of new noise generating businesses, extinction of natural barriers (trees) or even artificial barriers (other buildings).

Basic is the way the damaging effects of noise pollution can be attenuated and in this regard, the market of this industry provides us with many solutions to reduce the urban noise: the panel which absorbs over 10 dB and which can be fixed on fences, the noise reduction envelope used to diminish the noise inside tunnels or under bridges.

The effectiveness estimation of the noise-reducing measures will be made by drawing up difference maps inside the conflict areas. Acoustic measures will be made at a later deployment of the noise-reducing measures in order to establish their effectiveness.

After analysing the obtained results one can conclude that the problems that generate the traffic noise can be eliminated by optimizing the traffic flow and by improving the road safety, by extending to the most the geometric possibilities of the roads and of the traffic light timing.

However, the inability to obtain a continuous flow, at least on the highways, leads to a major decline in the traffic capacity. By an exponential increase in volumes, the mentioned alternatives are no longer satisfactory, thus other answers are needed such as: developing bypass roads, redirecting traffic to obtain a uniform distribution from the point of view of noise immission, establishing one way roads, synchronising traffic lights, seed limits, etc.

Other imposed measures could be: denying passing through for some types of vehicles during the hours when the noise level is over the established limits, totally ban of some types of vehicles on some specific roads, discharging the traffic in some areas by building overpassing and under passing passages, placing noise absorbing panels and/or green areas.

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