Evaluation of municipal waste incineration impact on environmental noise

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Abstract: The EU Directive 2002/49/EC or Environmental Noise Directive (END) aims to define a common approach intended to avoid, prevent or reduce the harmful effects, including annoyance, due to exposure to environmental noise. Under this Directive, member states are obliged to produce the noise maps of the major roads, railways airports, large agglomerations and industrial activity sites. The first maps had to be produced for the main agglomerations by July 2007 and the first action plans should be activated no lather than July 2008. In this work we consider the industrial noise produced by municipal waste incineration; the study was developed to provide data of the sound power level along the facades buildings and contours of this site that can be used to produce strategic noise maps. To characterize the impact of the waste incineration plant, measurements of the noise emissions were performed in situ. The distribution of sound power and sound input levels have been calculated by SoundPLAN® computer model. The results of this work can provide a re-applicable method for the production of noise levels due to industrial noise sources. The results are suitable to be included in noise maps for agglomerations, in line with the END expectation.

Keywords: Environmental noise, noise mapping, industrial activity, municipal waste incineration, IPPC.

Introduction

The Directive 2002/49/EC, or Environmental Noise Directive (END) [1], “relating to the assessment and management of environmental noise” aims to provide a common approach intended to avoid, prevent or reduce the harmful effects, including annoyance, due to exposure to environmental noise. The directive requires the following actions to be implemented progressively:

• Monitoring the environmental problem: the competent authorities in Member States are required to produce strategic noise maps for agglomerations, major roads, railways and airports, using harmonised noise indicators, namely L_{den} (day-evening-night level) and L_{night} (night-time level).

• Informing and consulting the public: the competent authorities are required to ensure that the public is kept informed and can participate in the assessment and management of noise.

• Producing local noise action plans: the competent authorities are required to draw up and publish noise action plans to reduce noise where it is necessary and maintain environmental noise quality where it is good. The actual content is left to the discretion of the competent authorities, as the Directive lays down only minimum requirements for the plans. As minimum requirements for strategic noise mapping for agglomerations the END sets to include the noise emitted by road traffic, rail traffic, airports and industrial activity sites, including ports.

Noise is one of the environmental issues that EU-27 Member States authorities must consider in issuing permits to operators of the large industrial and agricultural installations covered by the Integrated Pollution Prevention and Control (IPPC) Directive 96/61/EC[2]. The IPPC Directive is fully applicable to new installation, and to existing installation that are to undergo a substantial change. The main objective of the IPPC Directive is to ensure a high level of environmental protection with regard to the operation of the industrial activities covering the following main sectors: energy industries, metal production and processing, mineral industry, chemical industry, waste management, etc. The Directive is based on two key principles:

- Permits must include conditions to prevent and control all environmental impacts taking into account the whole environmental performance of the installations;
- Permits must include conditions based on the use of the best available techniques (BAT) [3].

Noise issues are dealt with in BAT reference documents, although in most cases no general conclusions are drawn as regards BAT for noise prevention and control. This is due to the fact

that industrial noise is a local environmental issue, and the measures to be taken at a specific installation depend on its location.
The END entered into force on 18 July 2002 and was transposed into Italian legislation on 23 September 2006 by legislative act No. 194/2005[4]. The key deadline for the full implementation of the IPPC Directive was on 30 October 2007 and it was transposed into Italian legislation on 18 February 2005 by legislative act No. 59/2005[5]. Over the last 30 years numerous countries have developed regulations concerning noise limits and determined how noise levels for existing and planned environments should be established. The Italian legislation states that noise levels should comply with the legislative act DPCM 14 November 1997. This act is applied by the Italian Authority in charge for the environmental inspections.
For existing infrastructure the noise levels can be measured, but if the noise levels exceed the criteria the damage is already done. It is much more economical to cope with noise problems before they arise. Noise assessments should be made after modelling the planned changes in the environment and checking if the resulting noise levels meet the noise criteria.
This work shows an example of the evaluation of the noise environmental impact due to a municipal waste incineration unit. The scope is to optimize the modelling system to obtain noise levels in the incineration plant area, according to the END principles and suitable to the IPPC purposes. Usually models are not a complete description of the reality as only the main aspects are described. For this reason the models need to be constructed as carefully as possible and calibrated with field measurements.

Methods

The case of study is related to the actual impact of an incineration plant in the north of Italy, at the interface between the Alps and the Padana plain. The plant is located within a plain industrial area, lasting about 200 m from a hill about 100 m higher. The plain area is crossed by a railway both for local and international transit and a road for local commercial transport (about 10,000 vehicles per day). A residential agglomerate is settled at the top of the hill. A building in this area is the main receiver for the noise impact evaluation, even used for measurements comparison. To the modelling purpose a total of four receivers, located about North, South, East and West to the plant, have been considered. Different scenarios have been evaluated: the full environmental noise, to be compared with measurements, the impact of the incineration plant and the influence of the orography in noise modelling.

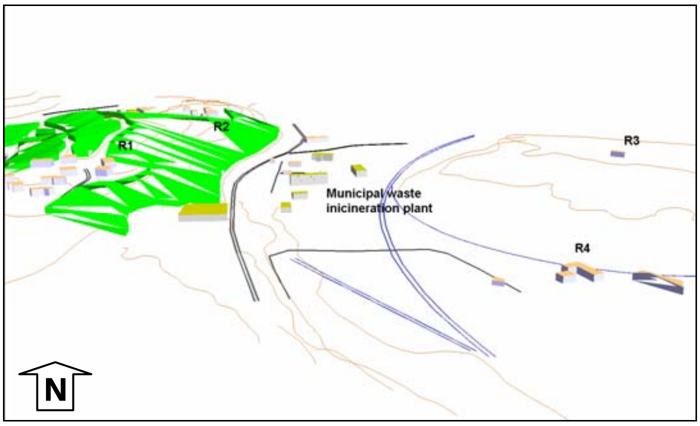

Figure 1 – Site view

The waste incineration plant has an area of about 13,000 m^2, a treatment capacity of 250 tons of waste per day for a total of 75,000 tons/year and operates 24 h/day, nearly 300 days/yr.
The basic structure of municipal waste incineration plant include the following operations: incoming waste reception, storage of waste and raw materials, pre-treatment of waste, loading of waste into the process, thermal treatment of the waste, energy recovery and conversion, flue-gas cleaning, flue-gas discharge, emission monitoring and control, waste water control and treatment, ash management and treatment, solid residue disposal.

In table 1 the most important sources of internal and external noise of an incineration plant are reported. According to the END, only outdoor sources have been considered, since indoor sources are shielded by the building structure.

Table 1 – Noise sources related to the incineration plant

Source	Description	Time to operate (on 24 hr/day)	Case of study
S1	Steam Generator Cooling Fan	Continuous	Yes
S2	Dust Redler Conveyor	Continuous	Yes
S3	Flue gas Recirculation	Continuous	Yes
S4	Burner Cooling Fan	Continuous	Yes
S5	Mill Cabin	Continuous	No
S6	Air Compressor Cabin	Continuous	No
S7	Exhaust Fan	Continuous	No
S8	Screw Conveyor	Continuous	No
S9	Ventilation and Air Exchanger	Continuous	No
S10	Steam Condenser	Continuous	Yes
S11	Cooling Groups Apparatus	Continuous	Yes
S12	Compressed Air (Silos)	Continuous	Yes
S13	Waste Vehicles Transit Area	Day-time period	Yes
S14	Unloading Waste Area	Day-time period	Yes

The SoundPLAN® computer model [6] was used to estimate sound propagation characteristics between each noise source and each prediction site. This model is a widely accepted tool for computing outdoor sound levels associated with ground-based noise sources. It provides an estimate of sound levels at a distance from a specific noise source or sources, taking into account:

- Specific characteristics of each noise source including its frequency spectrum and directivity characteristics.
- Terrain features including relative elevations of noise sources, receivers, and intervening objects.
- Ground effects due to areas of pavement, unpaved ground and water. Ground type affects sound propagation.
- Shielding and reflections due to intervening buildings or other structures and diffracted paths around and over structures.
- Atmospheric effects on sound propagation.

The SoundPLAN® model includes several different methods of accounting for atmospheric effects on sound propagation; for this evaluation, the model's implementation of ISO Standard 9613-2[7] has been used.

The terrain feature has been taken into account by the digital ground model elaborated by the "Regional Technical Map". Forest and green area effect, building position and volume, roads and railway characteristics have been also included in the model.

The END recommends some computation methods. Actually existing national noise indicators and related data may be used by Member States and should be converted into END indicators. In this work noise evaluation has been performed to cope with the Italian law indicators, thus applying the most suitable standards report to this scope. The noise evaluation includes the incineration plant according to ISO 9613-2 as primary source; roads according to RLS 90[8], railways according to Schall03 [9] as background sources.

The German RLS90 guideline establishes specific technical standards and measurement procedures for the prediction and reduction of road and parking lot noise. The RLS90 specifications rate the sound level at the receiver location for the day (6:00 to 22:00) and night (22:00 to 6:00) time. In order to calculate the sound level of the road the following data are required: vehicle data (number of vehicles per hour or days, % of heavy vehicles); speed for cars and trucks; road surface adjustments; road gradients; multiple reflection addition.

In order to take into account the railroad noise the SoundPLAN® implements different train noise models; all models attempt to calculate the L_{eq} from the train speed, length and number. In particular using the standard Schall03, developed by the German Federal Railroad, the

calculated sound levels are Leq for the day (6:00 to 22:00) and night (22:00 to 6:00). The required data are: number, length, speed and type of train per day and night, type of track.
The SoundPLAN® parameter menu offers six different choices for calculations of frequency dependent industrial noise, which have similar definitions for the physical parameters of the sound power and the spreading. As recommended by END, in the present work the ISO 9613-2 has been chosen as method, with the advantage of an improved calculation speed. The required input data are: source coordinates, working time, emitted frequency spectrum, noise directivity. The SoundPLAN® model provides source libraries with default parameters that can be optimized by the user.
The calculation has been performed to obtain noise level maps to be used for the aims of the END. The results are referred to the standard L_{den}, defined by the formula:

$$L_{den} = 10\lg\frac{1}{24}\left(12 * 10^{\frac{L_{day}}{10}} + 4 * 10^{\frac{L_{evening}+5}{10}} + 8 * 10^{\frac{L_{night}+10}{10}}\right)$$

in which:
- L_{day} is the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the day periods (07.00 – 19.00) of a year,
- $L_{evening}$ is the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the evening (19.00 – 23.00) periods of a year,
- L_{night} is the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the night (23.00 – 07.00) periods of a year.

The measured data have been obtained by the inspection Authority. To benchmark the simulated scenario with the measured values, the calculation was repeated referring to the Italian standard, i.e. the A-weighted sound level in the 06.00 – 22.00 period (L_d) and A-weighted sound level in the 22.00 - 06.00 period (L_n), determined over the periods of the measurement campaign, lasting 10 days.

Results and discussion

The incineration plant, the background sources and the orography effect have been considered in the real environmental noise scenario. The noise distribution levels maps represent the A-weighted sound level according to a colour scale. The area is crossed North-South by a grey band representing the road and slightly east the railways. The incinerator sets almost in the middle, while the residential agglomerate can be observed at the bottom west corner. The END standard L_{den}, is represented in Figure 2.

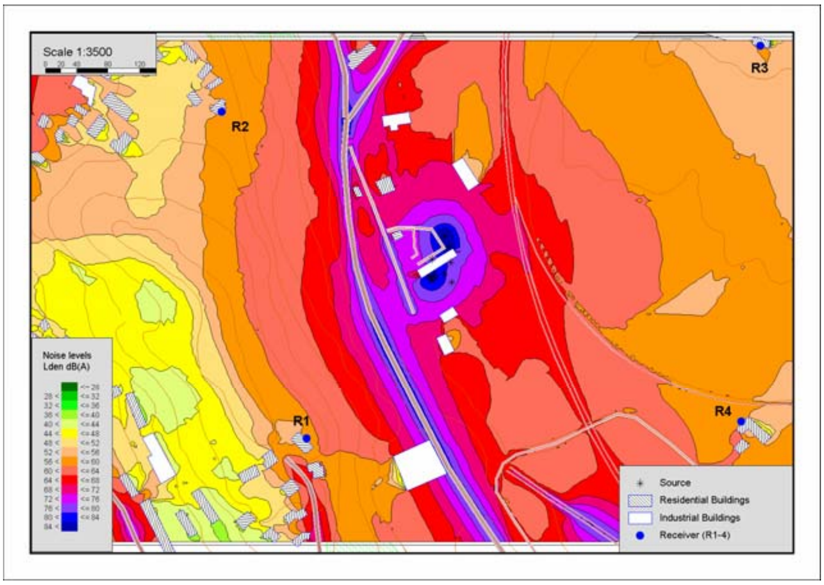

Figure 2 – Full environmental noise scenario, L_{den}

The Italian standards L_d and L_n have been both evaluated. The results are shown in Figure 3 and 4.

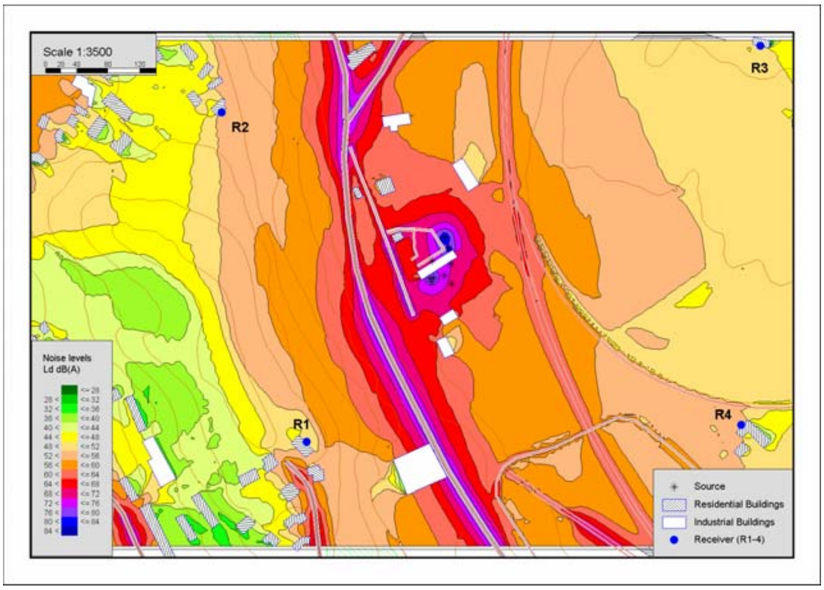

Figure 3 – Full environmental Noise scenario, L_d

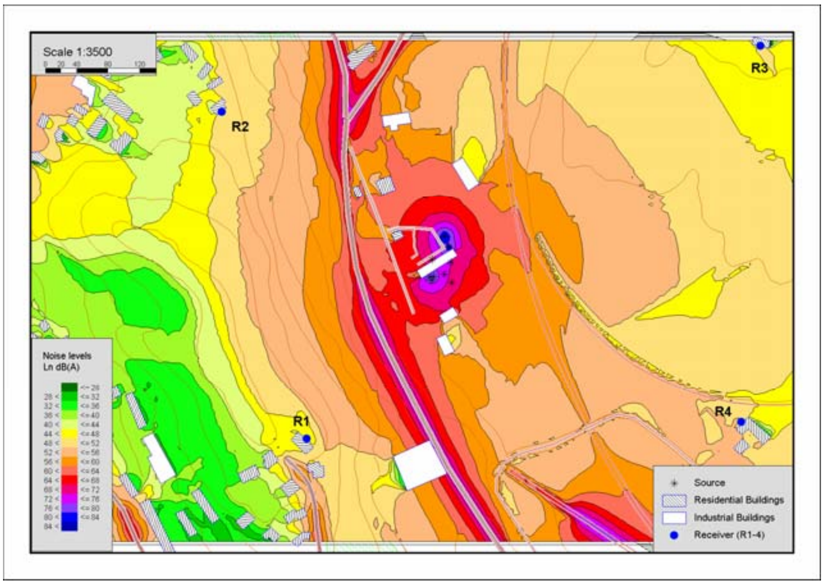

Figure 4 – Full environmental Noise scenario, L_n

The noise level spatial distribution is very similar in the three cases analyzed. The evaluation as L_{den} gives noise levels higher than italian indicators, because of its own physical definition. If we focus our attention on protection of the health of the population, the indicator L_{den} turns out to be more conservative than the other indicators, although the calculation carried out in the three different cases is based on similar theoretical hypotheses.

The figure 4 shows a noise level reduction during the night time (see also figure 3). As the incinerator operates 24 h/day, the reduction of the night noise level could be due to the decreasing of the traffic during the night. The calculation of the L_{night}, as defined by the END, shows the same behaviour of L_n.

In order to evaluate the incineration plant impact, the background sources and the incinerator have been simulated separately. The results referred to the END standard L_{den} are presented in Figure 5 and Figure 6.

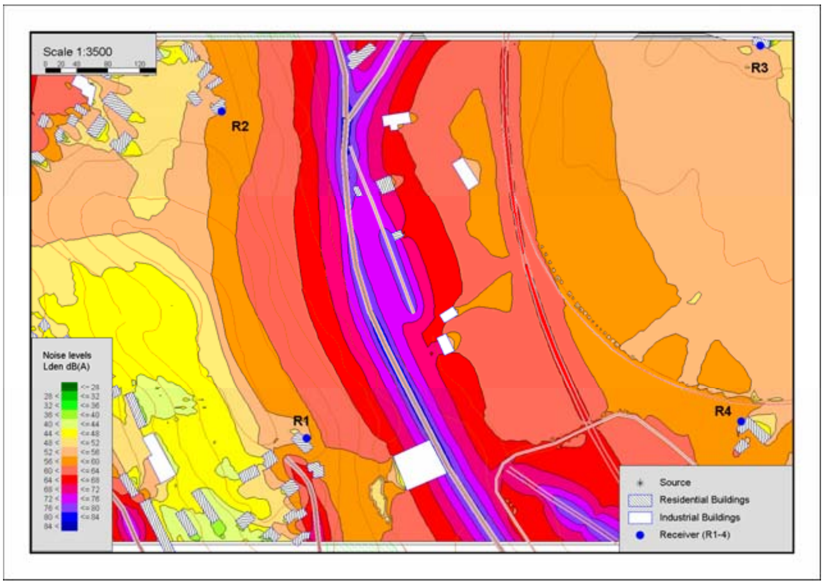

Figure 5 – Background, L_{den}

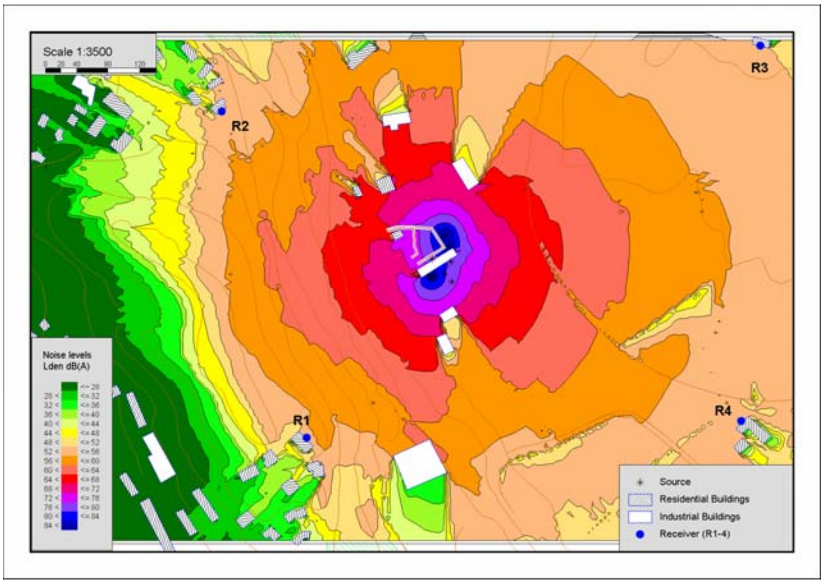

Figure 6 –Incinerator, L_{den}

The incinerator noise is locally higher than the roads and railways noise. The incinerator acts like a point source, with noise radiation in a half sphere affected by orography and human structures. Roads and railways are line sources and affect the receivers with contributions slightly higher than the incinerator contribution. The incineration plant units could not be stopped to measure the background noise. This study protocol allows evaluating the sound background that we can’t easily measure because of the continuous operation of the incineration plant.

Ground coverage is important effect of the terrain model. Mitigation effect of a forest located at north-west of the incineration plant is shown in Figure 6. As a first step, the default values for forest mitigation have been used in calculations. Better results have been obtained by choosing an appropriate mitigation factor because the measurements campaign took place during the winter and with deciduous local vegetation.

The ground model is fundamental describing noise propagation: as an exercise the noise power levels generated only by the incineration plant have been calculated over a plain ground. The noise map is shown in Figure 7, where the effect of the hill is clearly presented, when it is compared with the Figure 6 map. Another important terrain feature appears in analyzing the road noise level distribution: higher levels appear when the road gradient increases up to the hill and close to the cross (See figure 5).

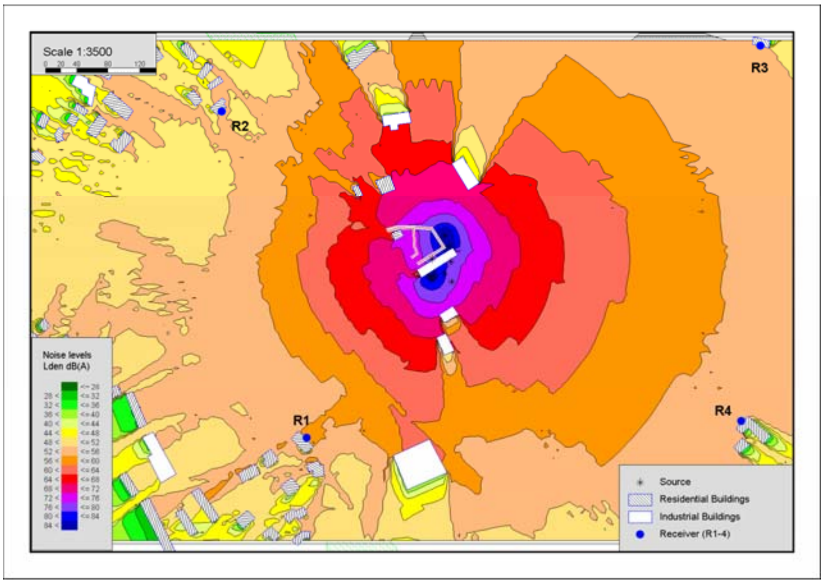

Figure 7 – Incinerator without orography, L_{den}

The noise model computations have been compared with measurements that took place at the main receiver point (see Figure 1) and lasted 10 days. A sound level meter of class I according to EN 60651/94 - EN 60804/94 has been placed at the first floor of the building at 1 m outside the facade. The measured L_d and L_n, obtained from the average over the measurements periods, are reported in table 2. It must be stressed that since the incineration plant units could not be stopped, the evaluation of the back ground noise can be obtained only by the model.
The modelling results at the receivers are also shown in table 2. A good agreement between measurements and simulation is obtained for the L_d value; the L_n measured value is slightly higher than the calculated one. It is possible to observe that during the day the main contribution arises from the background sources. During the night some sources of less impact can be measured by the sound level meter, while they are not included in the model.
It must be observed that the R3 receiver is located close to the study area border, where the simulation becomes less suitable, because in the real situation other external sources do exist.

Table 2 – Noise measurements and modelling at receivers

Receiver	Environmental noise dB(A)				Background noise dB(A)		Environmental L_{DEN} dB(A)	Background L_{DEN} dB(A)
	measured		calculated		calculated		calculated	
	Day	Night	Day	Night	Day	Night		
R1*	57.9	56.7	56.2	54.0	56.2	50.5	61.2	59.5
R2	-	-	55.7	53.1	56.2	50.4	60.4	59.5
R3	-	-	32.7	30.8	30.8	26.5	37.8	34.7
R4	-	-	53.6	52.7	53.5	50.9	59.4	58.2
*main receiver								

Conclusions

The acoustic impact of an incineration plant can be defined by a study similar to the one presented above. Since the noise levels of an incinerator are higher than the annoyance levels defined by the WHO[10], the study of its noise impact is very important. Following the IPPC principles this kind of study must come before plant construction. The essential points to take into account in order to evaluate the environmental impact of an incineration plant have been evidenced. The research outlines the importance of a correct characterization of the background noise, because during the day it can mask the incinerator effect. Orography,

ground coverage and natural mitigation elements, can be considered essential points in order to determine annoyance level due to the presence of an incineration plant. The ground gradient and the on site forest are mitigating factors that make the plant proximity to a urban settlement acceptable. This nearness must be a primary parameter in a good territorial management (END).
In our Country it is necessary a stronger effort to implement the END in the national law, that actually is not completely matching the E.U. Directive; in fact local authorities are obliged to apply those national rules that don't comply all END recommendations. We hope that the contents of this paper will be of some assistance, guide and support to the noise assessment for the incinerator plant within the EU-27.

References:

1. 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*.
2. Council Directive 96/61/EC of 24 September 1996 concerning *Integrated Pollution Prevention and Control*.
3. European Commission: *Integrated Pollution Prevention and Control*. Reference Document on the Best Available Techniques for Waste Incineration, BREF, August 2006.
4. Legislative Decree No.194 of 19 August 2005 on *Implementation of EC 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*.
5. Legislative Decree No. 59 of 18 February 2005, concerning *Integral implementation of Directive 96/61/EC on Integrated Pollution Prevention and Control*.
6. *SoundPLAN®* - Version 6.2, Braunstein + Berndt GmbH.
7. ISO 9613-2, *Acoustics- Attenuation of sound during propagation outdoors* – Part 2: General method of calculation, 1996.
8. RLS90 *Road Traffic Richtlinie für den Lärmschutz an Strassen* (Guideline/Standard for protection of road noise), 1990.
9. Schall03 *Richtlinie zur Berechnung der Schallimmission von Schienendwegen* (Guideline for the calculation of railway noise), 1990.
10. World Health Organization: *Guidelines for Community Noise*, 2002.