Short-term Health Impact Assessment of Air Polution in Targoviste City (Dambovita County)

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Due to the increased number of diseases observed in the last decades, that can be associated with air pollution, the implementation of health impact assessments of urban pollution is necessary to transpose the results of this assessment in regional and national policies in order to reduce their impact on human health. The main objective of this paper was to assess the air pollution health impact in Targoviste city (Dambovita County) by creating an interactive interface based on virtual instrumentation and relational database management systems. The application allows the integration of information from different sources, data processing and validation, automatic evaluation of air pollution health impact assessment and the visualization of the interest parameters.

Keywords: air pollution, health impact assessment, virtual instrumentation, relational database management systems

From the outset the EU's policy on environmental protection took into account the health impact. Many environmental and health problems have been solved, but more needs to be done, especially regarding the health implications of chronic exposures, as pointed out by the European Environment Agency [1], the World Health Organization [2] and other national organizations [3]. They have shown that the interactions between environment and health are far more complex than it is generally understood. Thus, it was not given sufficient attention to the interaction that may occur between different pollutants inside the human body and in the environment. Even at relatively low levels of exposure, over long periods of time, there is a so-called *cocktail* effect of various pollutants from air, water, food, consumer products and construction that can dramatically affect the human health.

The assessment and management of varied and emerging risks that can influence human health, inherent in a modern society, is an extremely complex and crucial task that can improve the quality of life of all citizens and protect public health.

The issue of environment and health is characterized by multi-causality with different modes of association according to Directorate General for Health and Food Safety of European Commission [1,4]. This means that the links between exposures and their health consequences depend on environmental pollutants and the diseases considered, but are also influenced by factors such as: genetic constitution, age, nutrition, lifestyle and socioeconomic factors such as poverty and education.

Currently, the health risks related to air pollution are determined more precisely, especially for short-term effects. This is due to the large number of experimental and epidemiological studies that have been made public in last decades [5-11]. These allow establishing the role of atmospheric pollution in the development or exacerbation of a wide range of health symptoms ranging from early mortality to increased cardio-respiratory diseases.

These studies revealed that, in the absence of a threshold, adverse effects of pollution are observable for exposure levels well below the European guidance or the internationally regulated thresholds adopted so far.

The problem is not whether air pollution is responsible for the adverse effects on health, but to be able to better quantify the importance of its health impact.

Therefore, the health impact assessment (HIA) of air pollution is an operational risk management, to the extent that, the result of a measurement of impact based on the best knowledge currently available is more reproducible and more transparent than a judgment based on arbitrary assumptions.

In this context, in 1997 the French Institute of Health Surveillance (InVS) has implemented a model of epidemiological surveillance in nine French cities in order to quantify and monitor the relations between urban pollution and the short term health effects [12, 13]. This model was improved constantly, being expanded to 26 cities in 12 European countries [14, 15]. Based on this supervisory model we were able to use the methodology of evaluation for health impact of air pollution on a local scale, as shown in this paper.

Nowadays, the use of modern computer technology for environmental monitoring involves data acquisition, processing and validation, relational database management systems, virtual instrumentation and geographic information systems (GIS).

Due to the increased number of environmental related diseases observed in the last years in Targoviste city (Dambovia County), an interactive interface was created and used for air pollution health impact assessment using the above mentioned technologies. This application was used in order to promote efficient measures for environmental protection and public health.

Experimental part

According to the 2010 report of the Public Health Department of Dâmbovia County [16] the overall mortality has increased from 11.52‰ inhabitants in 2009 to 12.11‰ inhabitants in 2010, the leading causes of death being cardiovascular diseases and malignant tumors that preserved the growing trend towards the last five years.

Generally, higher pollution, stress, unhealthy and insufficient diet were important factors that affected human health, which led to a higher rate of malignancies.

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A health impact assessment (HIA) can be implemented in urban areas where human exposure to air pollution can be properly assessed and considered homogeneous. This involves in particular the existence of a surveillance network that reliable measures air quality for at least one year. The assessment assumes that no major sources of air pollution are included and also the population is present most of the time in the studied area.

The first step in health impact assessment is the delimitation of study area based on geographic position, population and the identification of pollution sources.

The area chosen for the assessment of air pollution health impact was Targoviste city (fig. 1), which fulfills the criteria mentioned above.

Fig.1. The selected area - Targoviste city

In order to meet the assumption of a homogenous quality of ambient air in the chosen clutter, only urban areas including city center were retained, excluding peripheral municipalities separated from the town by a green belt. For area selection, besides knowing *natural* land, GIS maps and aerial photographic images were used to assess the continuity of the urbanization.

According to the National Institute of Statistics [17], on 1 January 2010 resident population of Dambovita County has been estimated to 537994 people, of which 97151 being residents in Targoviste city. The population density within the county was 131 inhabitants / km^2, the highest being recorded in Targoviste (1416 persons / km^2).

Beside traffic, major sources of air pollution with significant impact are located within the city industrial platform (fig. 2), the main polluting activities being: metallurgy, chemical industry, machine and equipment building industry, food industry, oil industry etc.

In the selected area there is only one automatic measurement station belonging to the National Network for Monitoring Air Quality (DB-1). Its location can be seen in figure 2.

Within this network, air quality is represented by a general index based on specific indices for each measured pollutant. For its calculation, at least three specific indexes must be available. General and specific indexes are represented on a six unit scale, 1 being *excellent* and 6 *very bad* [18].

Fig.2. Representation of the principal sources of industrial pollution using GIS technology

Based on the following values of general parameter of daily air quality for DB-1 station [19] (fig. 3), air pollution impact on life quality can be assessed as significant in the chosen area.

The second step of air pollution health impact assessment was exposure estimation which consisted in determining the average of the collected data from the area where the population lives. Estimation of population exposure is based on the assumption that the daily averages are a good approximation of the daily individual exposure averages.

Thus, for each pollutant (sulfur dioxide, nitrogen dioxide ozone and particulate matter) it was necessary to create an average exposure indicator, which involved: selecting the stations, collecting data from surveillance network, determining the study period and calculating the exposure indicators.

Data collection on air quality was performed using an automatic data acquisition system based web crawling / web spidering technology [20].

For the selected measurement station (DB-1) and for each acquired pollutant, several information were acquired and stored in a relational database: name and location of the station, measuring period, station type, measuring technique and sensor's downtime.

In order to validate the values acquired from the station belonging to the National Surveillance Network on Air Quality, a graphical representation module was created for daily averages, which allows observing any abnormalities. Hourly averages (24 h) were collected and daily averages were calculated for all pollution indicators, excepting ozone which was calculated for the schedule 9:00 -17:00.

The daily averages were calculated by applying the rule of 75%: the daily average represents the arithmetic average of hourly values measured from 0 until 23 h when at least 18 (75%) of the hourly values are available. Otherwise, the daily value is considered invalid.

The selected period for health impact assessment depended on data availability. In this case, data acquisition began in September 2009. Although there have been short periods of time for which data have not been acquired, data acquisition period has been extended until reaching minimum one year or two tropical seasons (from 1st of April to September 30 for the summer season, from 1st of October to March 31 for winter). The same period of study has been used for all pollution indicators.

The availability period for nitrogen dioxide can be seen in the figure 4.

The gaps that can be seen in figure 4 (13.11.2009-24.11.2009, 26.12.2009-03.01.2010 etc.) are due to sensors malfunction, website or data acquisition server downtime. These short periods have been completed by extending the data acquisition so as to cover the time needed for health impact assessment.

For each pollutant an exposure indicator has been calculated as arithmetic mean of the daily measurements recorded by the selected station. The daily mean distribution of nitrogen dioxide indicator is presented as histogram using two classes of exposure: class 1 (step of 1$\mu g/m^3$ – fig. 5) and class 10 (step of 10$\mu g/m^3$).

It was also necessary to calculate the minimum, the average and the maximum values and percentiles of 5, 25, 50, 75 and 95 of the daily average for each pollutant

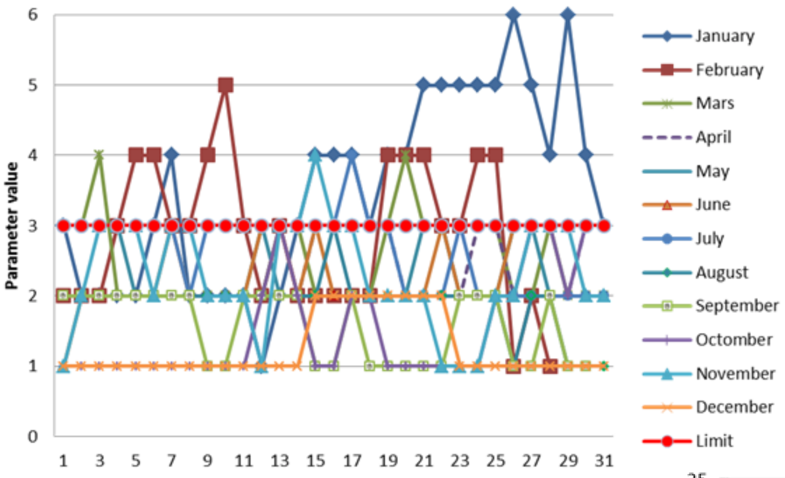

Fig.3. General parameter of daily air quality for DB-1 station

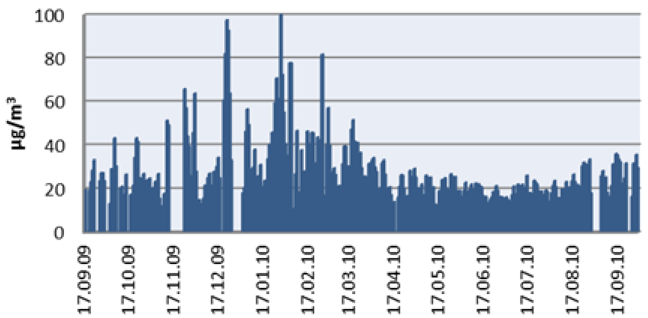

Fig. 4. The availability period for nitrogen dioxide

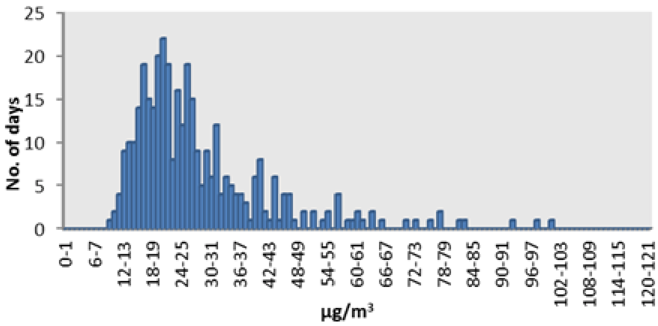

Fig.5. The daily mean distribution (class 1) of nitrogen dioxide indicator for all the period

Table 1
STATISTICAL DATA FOR SELECTED POLLUTANTS

Station ID	Pollutant	No. of days	Min.	Max.	Average	P5	P25	P50	P75	P95
DB-01	SO_2	360	1.02	113.78	18.60	3.72	13.06	18.07	22.86	34.19
	SO_2 summer	179	1.07	42.20	18.71	6.80	14.40	17.90	22.69	32.30
	SO_2 winter	181	1.02	113.78	18.50	2.64	11.49	18.42	22.90	36.25
	NO_2	359	9.64	100.03	27.78	13.17	18.45	23.71	31.90	57.10
	NO_2 summer	179	10.33	35.89	21.26	13.16	16.89	20.13	25.12	32.25
	NO_2 winter	180	9.64	100.03	34.25	13.18	21.67	29.43	42.36	70.76
	PM_{10}	290	1.11	144.36	20.30	2.61	9.61	17.38	24.41	44.26
	PM_{10} summer	148	1.11	36.06	13.55	1.93	5.77	14.10	20.55	24.10
	PM_{10} winter	142	1.70	144.36	27.34	6.27	13.60	23.38	32.68	74.03
	O_3 summer	179	12.42	97.94	54.08	32.55	44.02	54.32	63.76	76.35

considered, taking into account the distribution of values for the two seasons (table 1).

The third step consists in health data collection and establishing relative risk. At this stage, it is necessary to have health statistics which refer to mortality at all ages and in all cases (except accidentally) for the study area and for each season of the study period (table 2).

Table 2
TOTAL, RESPIRATORY, CARDIOVASCULAR AND CARDIAC MORTALITY

CLASS	CODE	Total no. of death:	0-14 years	15-64 years	>64 years	Total mortality ‰ inhabitants:	0-14 years	15-64 years	>64 years
RESPIRATORY SYSTEM	J00-J99	28	1	4	23	0.29	0.08	0.06	3.03
ARDIOVASCULARY SYSTEM	I00-I99	306	0	83	224	3.47	0.00	1.20	30.08
of which: CARDIAC MORTALITY	I00-I52	179	0	59	120	2.02	0.00	0.85	16.15
TOTAL		**606**	**8**	**222**	**377**	**6.87**	**0.67**	**3.22**	**50.66**
summer (March - August)		308	4	114	191	3.49	0.29	1.65	25.62
winter (September - February)		298	4	108	186	3.38	0.38	1.57	25.04

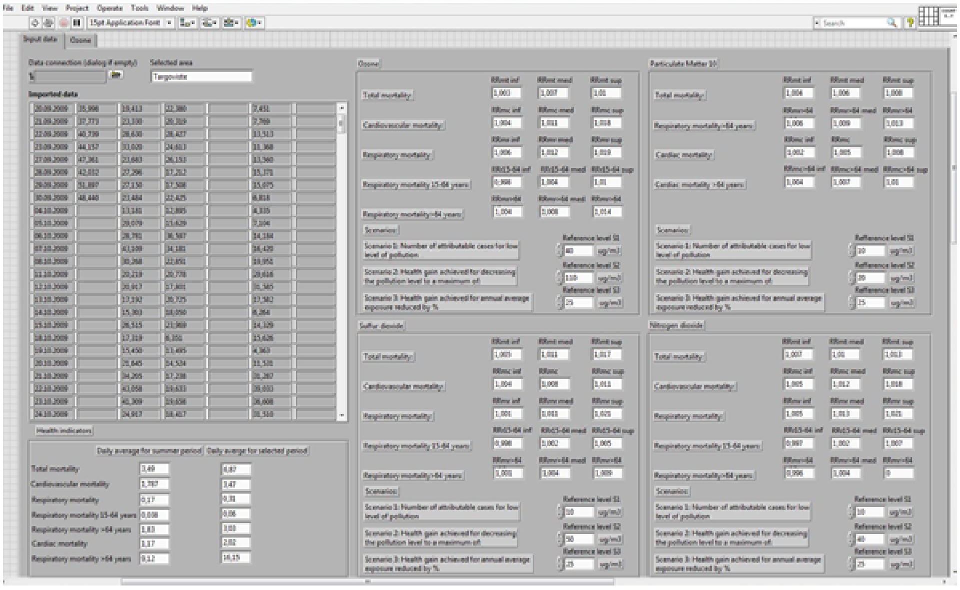

Fig. 6. Input data window of Labview health impact assessment application

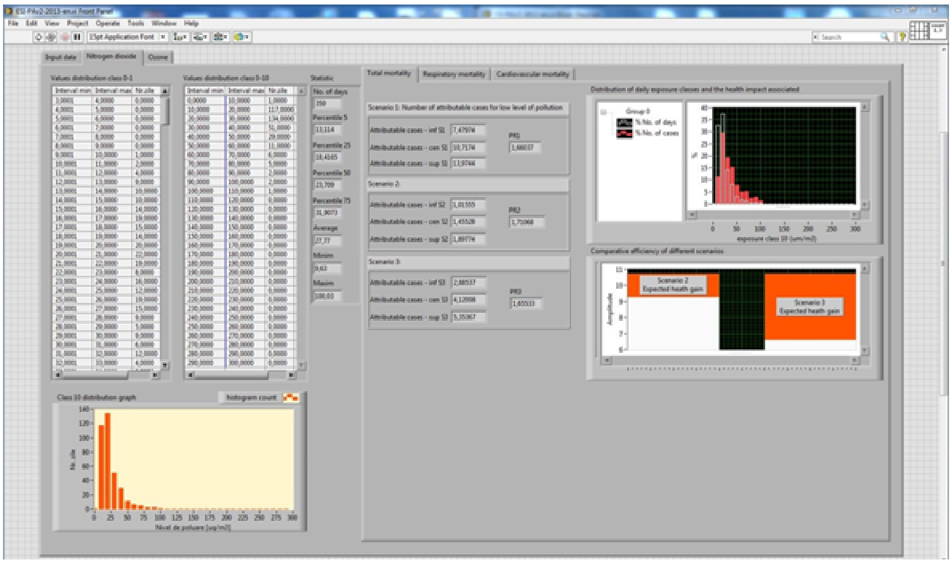

Fig. 7. Health impact assessment results for nitrogen dioxide

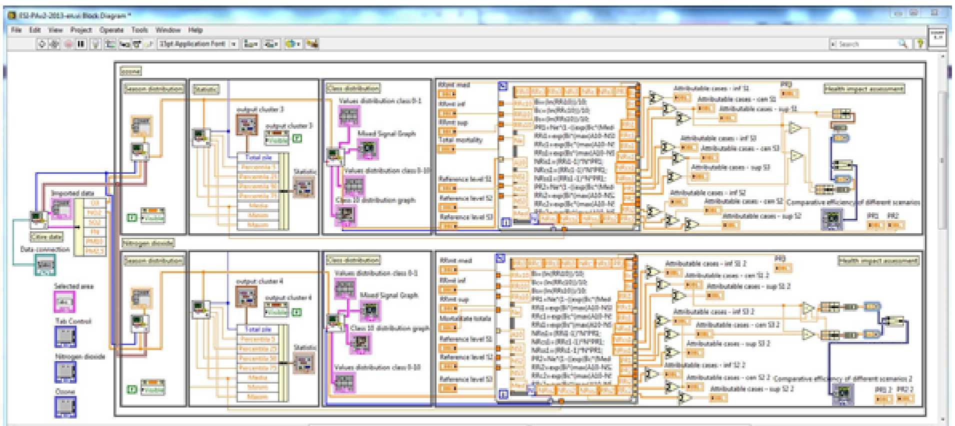

Fig.8. Programming window of Labview health impact assessment application

The main supplier of data on mortality is the National Institute of Public Health through its county departments. For the selected area, data on the medical causes of death according to the International Classification of Diseases (ICD) established by WHO were provided by the Public Health Department Dâmbovia. The name and the official geographic code of the studied area have been gathered along with the periods (corresponding to tropical seasons), mortality cause (code ICD 9 <800; CIM 10: S00-X59: all causes of death, without accidental ones) and the number of cases (table 2).

The last step was to implement the calculation model proposed by the French Institute of Health Surveillance (InVS) [11-15] in an interactive application built using visual instrumentation and database management systems. Thus, National Instruments LabVIEW graphical programming software was used for application development and Microsoft SQL Server Express for database management. The application interface consists in two different parts: one for health data input and air pollution database connection (fig. 6) and the other for health impact assessment results for each considered parameter (fig. 7). For each calculation step like daily mean distribution, season distribution, statistical calculation and the number of cases attributable to a level of pollution, it was necessary to create separate modules namely subVi's (fig. 8). By linking these modules the created application

Table 3
SHORT-TERM HEALTH IMPACT ASSESSMENT FOR NITROGEN DIOXIDE POLLUTION

RESULTS		Considered period	
		No. of cases	IC 95%
Scenario 1: Number of cases attributable compared to a low level of pollution:	10 µg/m³	**10.72**	**7.48 - 13.97**
Scenario 2: Health gain attributable to a suppression of pollution levels above:	40 µg/m³	**1.46**	**1.02 - 1.90**
Scenario 3: Health gain achieved for annual average exposure reduced by 25%	25 µg/m³	**4.12**	**2.89 - 5.35**

allows the health impact assessment for studied area and for each acquired pollution indicator.

Results and discussions

Health impact assessment was carried out for each exposure indicators (sulfur dioxide, nitrogen dioxide ozone and particulate matter) and for each scenario.

The results of the health impact assessment for nitrogen dioxide pollution are presented in table 3.

For the first scenario, it can be concluded that, if the mean value of pollution for each day of the studied period would have been 10 µg/m³ or less, about 11 deaths could have been avoided, confidence interval limits being around 7 and 14 deaths.

The distribution graphic of daily exposure classes and the health impact associated to each class is represented in figure 9.

Comparative efficiency of different scenarios has been illustrated by graphical form. Health gain and therefore acceptable risk is presented as chart bars (fig. 10).

According to the chart presented in figure 10, one can see that, the number of deaths avoided for scenarios 2 and 3 is much lower compared to scenario 1, being approximately one case for scenario 2 and 4 cases for the third one.

The results of the health impact assessment for ozone, sulfur dioxide and particulate matter less than 10µm pollution are presented in tables 4 to 6.

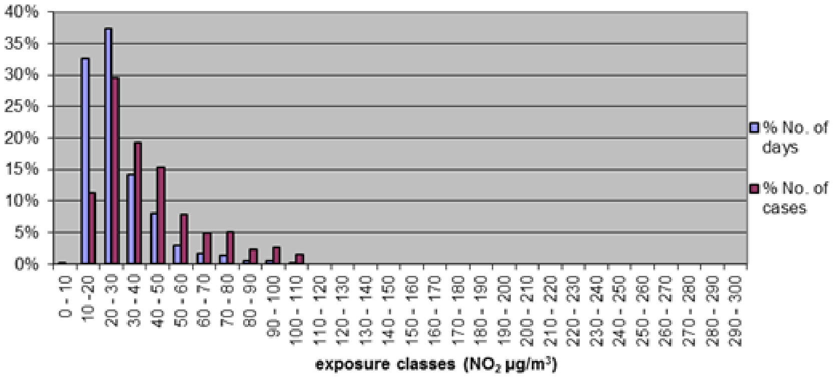

Fig. 9. The distribution graphic of daily exposure classes and the health impact associated to each class

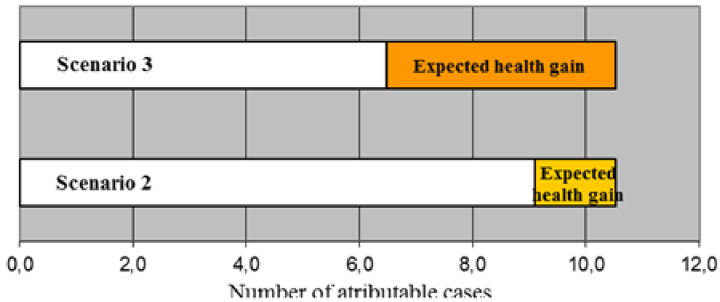

Fig.10. The number of cases avoided in scenarios 2 and 3 compared to scenario 1

Table 4
SHORT-TERM HEALTH IMPACT ASSESSMENT FOR OZONE POLLUTION

RESULTS		Considered period	
		No. of cases	IC 95%
Scenario 1: Number of cases attributable compared to a low level of pollution:	40 µg/m³	**1.75**	**0.75 - 2.51**
Scenario 2: Health gain attributable to a suppression of pollution levels above	110 µg/m³	**0**	**0**
Scenario 3: Health gain achieved for annual average exposure reduced by 25%	25 µg/m³	**1.52**	**0.65 - 2.17**

Table 5
SHORT-TERM HEALTH IMPACT ASSESSMENT FOR SULFUR DIOXIDE POLLUTION

RESULTS		Considered period	
		No. of cases	IC 95%
Scenario 1: Number of cases attributable compared to a low level of pollution:	10 µg/m³	**6.24**	**2.83 - 9.67**
Scenario 2: Health gain attributable to a suppression of pollution levels above	50 µg/m³	**0.15**	**0.07 - 0.23**
Scenario 3: Health gain achieved for annual average exposure reduced by 25%	25 µg/m³	**3.06**	**1.39 - 4.72**

Table 6
SHORT-TERM HEALTH IMPACT ASSESSMENT FOR PARTICULATE MATTER POLLUTION

RESULTS		Considered period	
		No. of cases	IC 95%
Scenario 1: Number of cases attributable compared to a low level of pollution:	10 μg/m³	**5.21**	**3.47 - 6.97**
Scenario 2: Health gain attributable to a suppression of pollution levels above	40 μg/m³	**1.72**	**1.14 - 2.30**
Scenario 3: Health gain achieved for annual average exposure reduced by 25%	25 μg/m³	**1.48**	**0.99 - 1.97**

Conclusions

The designed application enables that, based on pollution data, the daily number of events and the relative risk, one can calculate the health impact for each pollution indicator, for a season and for a given health effect, associated to the studied area.

The number of deaths calculated in this health impact assessement must be interpreted as an estimate of the number of people who, over a period, have not diminished life expectancy by the period corresponding to the expectations.

Health impact assessment enables comparison of health gain associated with different development scenarios or reduction of emissions. It is also possible to compare the impact of a reduction in daily levels of air pollution that of a suppression of pollution points. In practice, this allows to illustrate that a local management policy which will concern only to avoid regulatory exceedances, will have only a marginal impact in terms of public health benefits.

Presenting the results as the number of cases avoided under several options should allow a better consideration of health impacts in decision making and should contribute to fixing air quality objectives according to the public health objectives.

Acknowledgement: The work has been funded by the Sectoral Operational Programme Human Resources Development 2007-2013 of the Ministry of European Funds through the Financial Agreement POSDRU/159/1.5/S/132397

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Manuscript received: 24.09.2015