Scientific report

Regarding the implementation of the project PN-II-ID-PCE-2011-3-0762, no. 175/25.10.2011

Reduction of nanoparticle emissions by the optimization of residual combustion gases filtering processes

during the period January – December 2015

Objectives:

1. ***Substantiation of a model of public environmental policy and strategies meant to reduce nanoparticles emissions in the city of Timisoara.***

Current air pollution levels in Europe have both short-term and long-term significant health effects (Kulbush et al., 2015). These effects are mortality increasing and corresponding decrease in life expectancy and respiratory and cardiovascular morbidity effects. Current research evaluation within the Clean Air for Europe (CAFE) process showed clearly that investment in air quality improvements will yield financial benefit, in terms of population health, environmental improvements and quality of life.

The current measurement of air quality changed in the last years reflecting the concurrent knowledge about the adverse effects of air pollution, as well as through technological developments. The oldest measurement methods have involved labor-intensive, requiring long analysis with a low time resolution. The second half of the 20th century enabled better quality data to be obtained with lower limits of detection using automated methods continue. In Timisoara already exists some stations which monitors air quality, and displays at regular intervals and put online data regarding air quality index. Evolutions in online air quality monitoring allowed the development of public warning systems and immediate notification if alert thresholds were exceeded. Such short-term measures can be taken to reduce emissions during pollution episodes. A such intervention model can include traffic reductions and closing industrial facilities, reactive measures that are now common place in new legislation (EC Directive, 2008; CFR 40, 2011; JAPC, 2011), along with public information to help vulnerable people to cope with pollution episodes (Kelly et al., 2012). In the EU, the current air quality monitoring strategy is mainly driven by the need to achieve and to comply with limit values. The monitoring sites are predominantly installed where exceedances of limits are likely to occur. However, within Europe, a new additional requirement to reduce average pollution exposure of the urban population marks an important change in policy direction. The concept is based on the measurement of PM2.5 (mass concentration of airborne particles smaller than 2.5 mm in diameter) at urban background stations. The average PM2.5 concentration of selected urban background sites in a given country over a period of 3 years forms the so-called Average Exposure Indicator (AEI, Brown and Woods, 2012). This AEI should not exceed a limit value of 20 mg m^{-3} by 2015, and should be reduced by a percentage (depending on the initial PM2.5 concentration) by 2020. This emphasis on large-scale pollution reduction should bring health benefits to a much larger number of people when a limited number of fixed-site monitors are available. For air quality metrics with higher spatial variability is indicated a suitable monitoring approach.

- Developments in air quality monitoring techniques, such as
  - small, low-cost, outdoor-installable or portable devices/sensors with low power consumption,
  - analysers for new particle metrics, as in the case of our study where we monitored the concentration of airborne particles in the PM0.3 range, nanoparticles that have been proven to be harmful for human health.

  Developments in data retrieval and analysis
  - integrated data systems allowing real-time interactions between pollution monitoring, public information and pollution reduction measures.

Recommendations for the future

There are two main components to achieve this goal:

- *Integration of air quality data from diverse sources*

The main implied activities are: mobile and flexible installations, fixed sites, combination of local and regional air quality information, modelling and prediction of pollutants dispersion, remote sensing, including satellites.

The current focus of air quality monitoring in Europe needs to continue in the short to medium term on the basis of fixed monitoring sites. In the long term, should be explored the increased use of urban scale modelling linked to fewer fixed monitoring sites and a network of mobile, flexible monitors supplemented by remote monitoring. The validated results can provide more reliable data than the AEI fixed monitoring sites only. The substantial gains may be realized through the future systematic development and integration of these measurement and assessment techniques into a single homogeneous information network. Also minimizing the risks of pitfalls, and maximizing the benefits of each information source, to produce a high quality resolved data set in near real time is ne.

- *Integration of air quality monitoring and research through an overarching strategy*

Monitoring and research should be closely integrated through a strategy so that large investments are focused explicitly to address research questions effectively alongside conformity assessment and public exposure limit value.

It is necessary to create dedicated areas for research and monitoring of air quality facilitate research into such things as: new monitoring devices for fixed or mobile measurement locations, new data collection, analysis and visualisation tools, the development and testing of alternative air quality indicators for urban air quality and health.
Despite air quality monitoring being designed to protect human health, analysis of health impact does not form an integral part of current air quality assessments. Future monitoring strategies should therefore include the collection and assimilation of health effects data, along with air quality data. This data which should also include new pollutants and alternative metrics. The current review of the European air quality policy (launched in 2011), upcoming research under Horizon 2020 as well as the next revision of the European air quality directive foreseen for 2018 will be an excellent framework to further develop European air quality legislation and regulation, taking climate change issues into account, improve the environment, human health, and the quality of life.

<u>Activities:</u>

1.1 Estimating the scale of the phenomenon of emission of nanoparticles in the city of Timisoara.

Timisoara (45°46' N, 21°26' E) is a city located on the south-eastern edge of the Pannonia plain, and lies at an altitude of 85 m, being one of the largest Romanian cities, with a population of over 300 thousands inhabitants and more than 170 thousands automobiles. The air quality in urban areas is determined by the intensity of emissions (Popescu et al. 2011, Vetres et al. 2014). The principal sources of pollution come from transportation (emission from traffic), industrial and households. The main pollutants tend to be particulate matter suspensions (PM), sulphur dioxide, nitrogen dioxide, carbon monoxide, ozone and volatile organic compounds (VOCs) (Lungu et al. 2015). Health effects of air pollutants is an old issue in cities and urban areas around the world, but became evident during severe air pollution episodes in the first part of the 21-th century (Popescu et al. 2010, Zhinqiang et al. 2000). Once the association between the existence of fine particles suspended in atmosphere and their negative impact on the human health has been proved clearly, the problem of the control of the toxic emissions has become of great scientific interest. Recent health effects studies have shown an association between existing levels of fine particles (size, concentration) and health effects such as increased respiratory illness, cardiopulmonary morbidity, and premature mortality (Popescu et al. 2010, Brown and Woods, 2012).

Particulate matter dispersion maps for the city of Timisoara

To evaluate the spreading of pollutants in the atmosphere, the measurement points were chosen in the grid nodes and in the central points of the squares of a grid drawn on the city map, with an approximate resolution of 900mx900m. A number of 128 points was obtained. For each location, the GPS coordinates were collected together with the measurements. The coordinates were input in Google Maps in order to obtain the map of the measurement points. The measurements were performed with the Air particle counter P311, during September 2015. For each point on the map, three measurements were performed with an interval of one week between them, as cumulative values of the number of particles, for particulate matter suspensions in size ranges PM0.3, PM2.5 and PM5, as the counter's settings allow. In order to obtain the pollution map of Timisoara, the SURFER 11 software was used. A digital map of Timisoara was used as a base layer, over which a contour map obtained by interpolation of the measured data was superimposed for each type of particles. For each point on the map, three measurements were performed with an interval of one week between them, in size range of 300 nm, during month of September 2015. Figure 1 reveals the measurement points, function of local geographic coordinates, as described above.

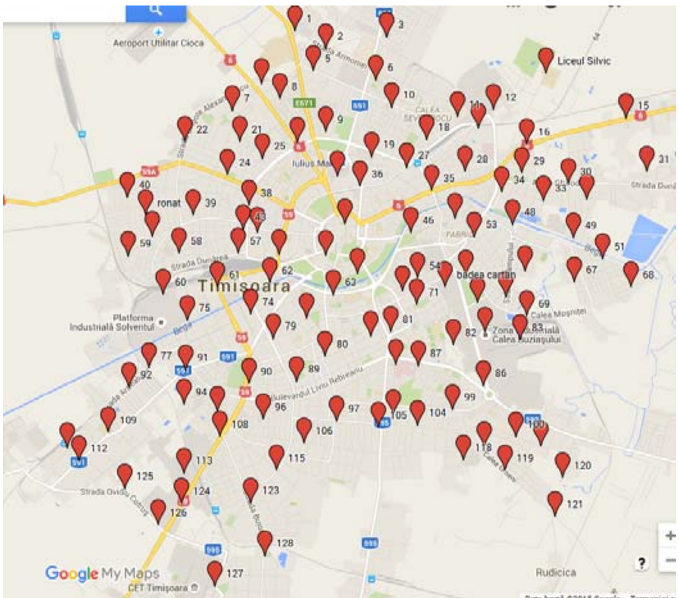

Figure 1 – Measurement points, function of local geographic coordinates.

Figure 2 shows the pollution map of Timisoara city during the month of September 2015, with airborne nanoparticle suspensions of 300 nm (PM0.3). On the axes are placed the local geographic coordinates.

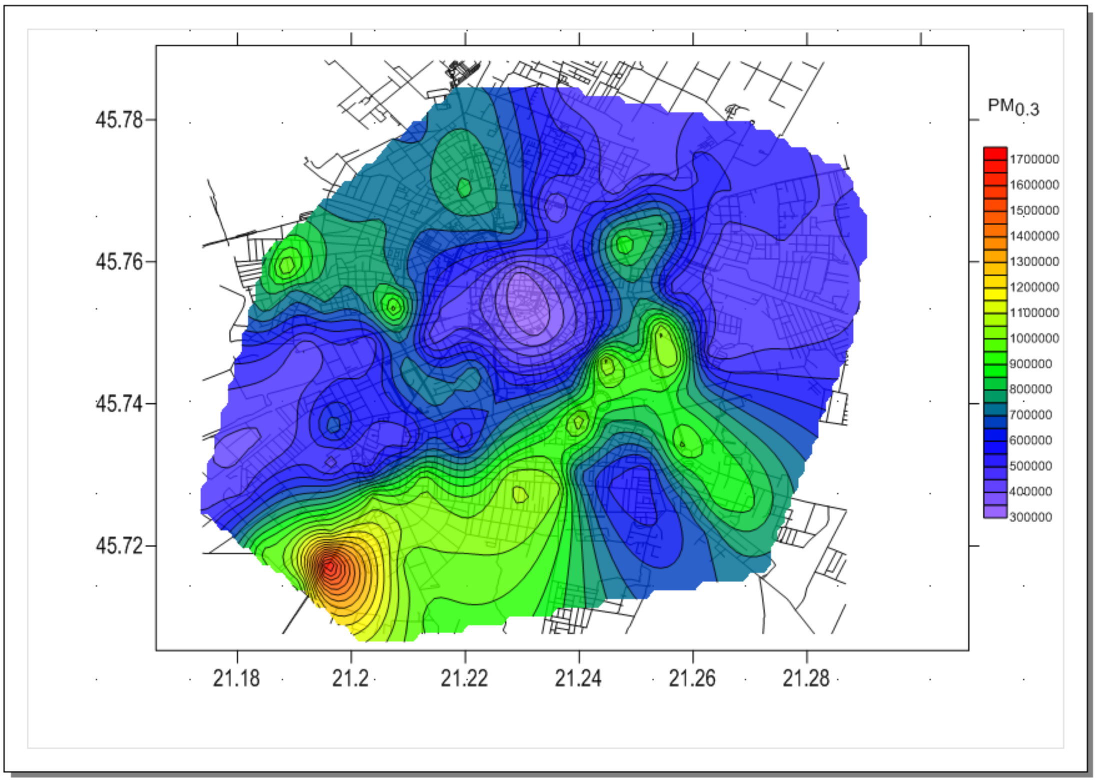

Figure 2 – Pollution map of Timisoara city for nanoparticle suspensions of 300 nm.

Figure 3 shows the pollution map of Timisoara city during the month of September 2015, for particulate matter suspensions of 2.5 μm (PM2.5).

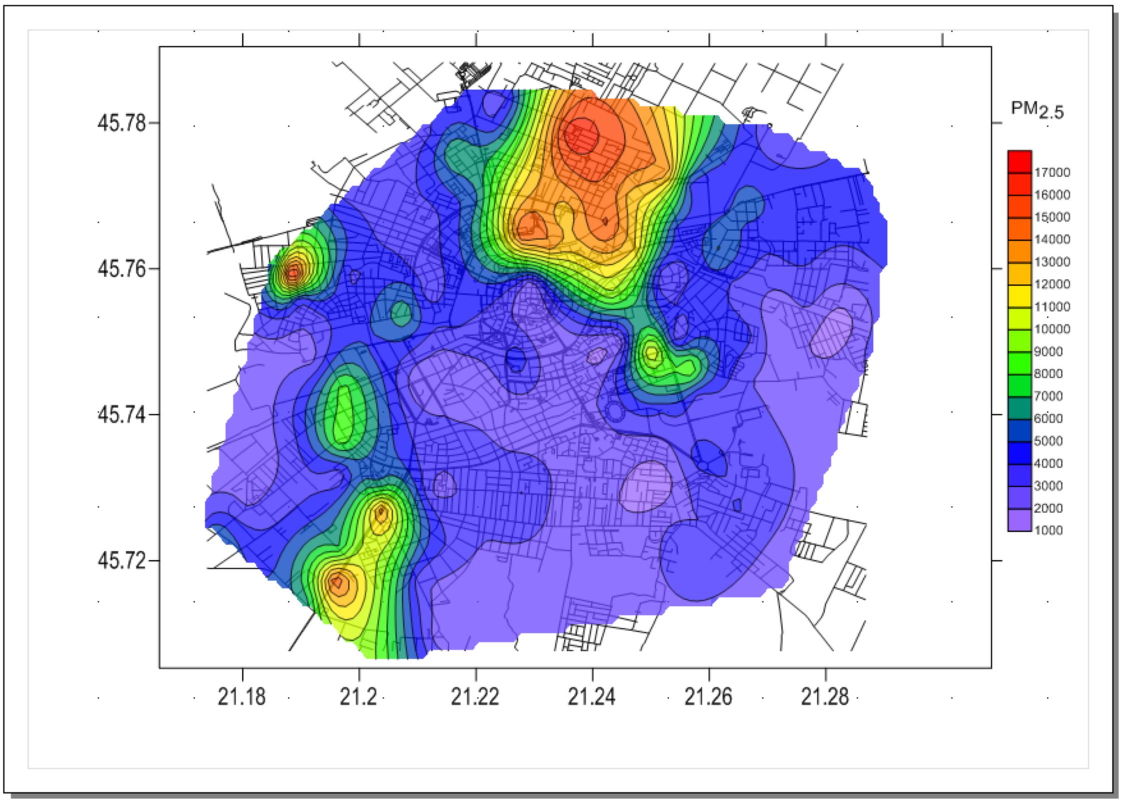

Figure 3 – Pollution map of Timisoara city for particulate matter suspensions of 2.5 μm.

Figure 4 shows the pollution map of Timisoara city during the month of September 2015, for particulate matter suspensions of 5 μm (PM5).

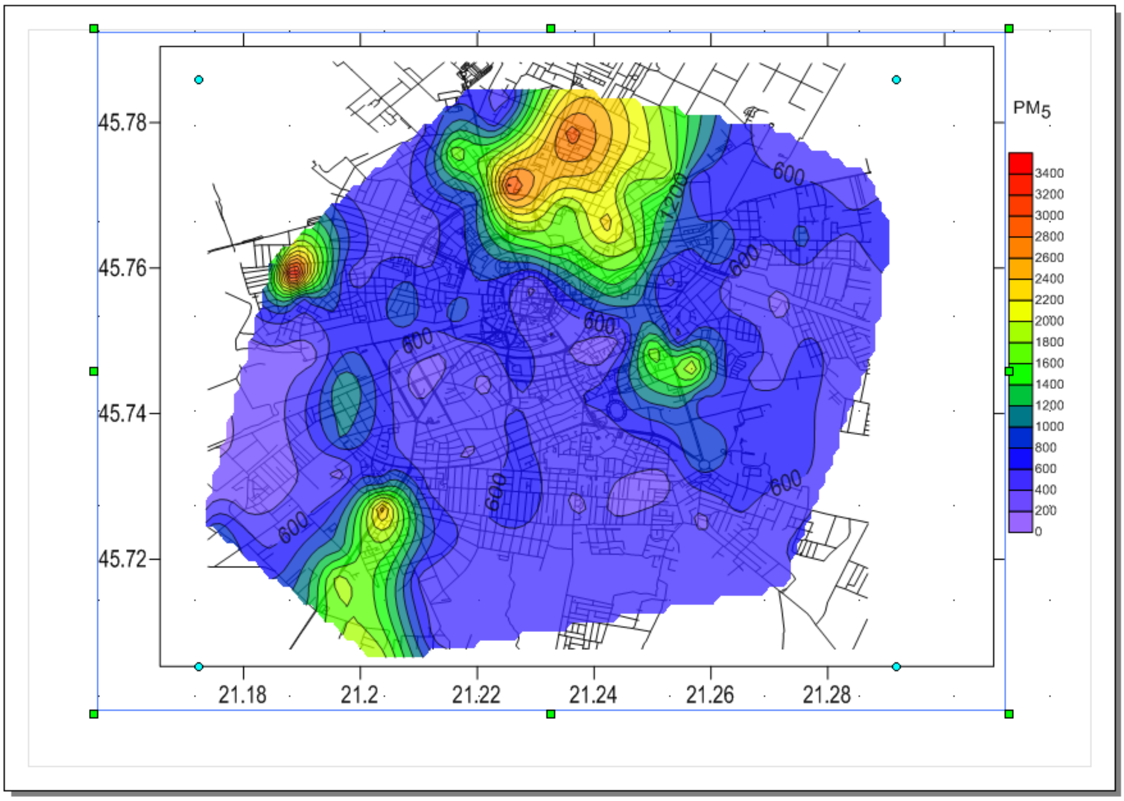

Figure 4 – Pollution map of Timisoara city for particulate matter suspensions of 5 μm.

1.2 Identification of economic agents, whose production processes leads to emission of nanoparticles.

Based on the obtained maps of pollution then we proceeded to identify economic agents whose production processes leads to emission of particulate matter suspensions in size ranges PM0.3, PM2.5 and PM5. Identifications were achieved by locating economic units on the map in Figure 1, specifying the points where measurements were made. The obtained results by groups of particle sizes are given below:

Pollution of Timisoara city with nanoparticle suspensions of 300 nm

As it can be seen in figure 2, this phenomenon occurs especially in the south side of Timisoara City:
Construction site for South shopping center Timisoara (triangle of points map 77-97-127),
POWER OIL COMPANY S.R.L.– powders from the dosing of raw materials (point map 123),
POWER OIL COMPANY S.R.L.– powders emissions from combustion gases (triangle of points map 77-97-127),
COLTERM S.A. – powders emissions from fuel deposits (point map 127),
COLTERM S.A.– powders emissions from combustion gases (triangle of points map 77-97-127),
COLTERM S.A. – powders emissions from ash deposits (point map 112),
PRO AIR CLEAN S.A.– powders emissions from combustion gases (point map 113).

Pollution of Timisoara city with PM2.5 and PM5

According to figures 3 and 4 this phenomenon occurs especially in the north side of Timisoara City:
AZUR S.A. – powders from the dosing of raw materials (point map 83),
The points south of the DN 6 route to Mosnitei route (triangle of points map 46-31-83).
CONTINENTAL AP S.R.L. – powders from the dosing of raw materials (point map 11),
The points south of the DN 6 route (triangle of points map 1-36-15).

Example:

Distribution of the pollutants emitted by a waste incinerator in Timisoara city urban area

Incinerator-related activities result in the emission of a host of air pollutants that adversely affect public health and the environment, including nitrogen oxides (NOx), hydrocarbons (HC), particulate (PM), carbon monoxide (CO), which causes lung irritation and aggravates diseases such as asthma, chronic bronchitis, and emphysema (Zhinqiang et al. 2000, Kulbush et al. 2015). In this context, the problem of obtaining information about the composition and dispersion of different resulted combustion residues is a first and fundamental step. This paper relates to the approaches achieved in the frame of collaboration between the Faculty of Physics of the West University of Timisoara and the waste incinerator plant Pro Air Clean Ecologic Timisoara, on the subject of the dispersion of different components from flue gas released during the waste incineration process. The main objective of the present study was to predict the dispersion of the pollutants emitted from an industrial source situated in Timisoara city, in the frame of Gaussian plume model. The transport process of the components is investigated numerically with the CloseView software (Lungu et al. 2015). The input programme data are the concentration and the chemical properties of the components detected experimentally in the combustion chimney. Our study takes into account the effects that the height of the combustion chimney, the velocity and the direction of the wind has on the dispersion process. The concentration profiles are calculated for a geometry specific to the city map of Timisoara. This analysis provides relevant information on the distribution of the pollutants and the most exposed zones of the city. We take a close view of pollutant dispersion in the environment, how the wind and atmospheric condition affects the dispersion for pointlike emission sources. Laying down the results on a graphical map we can picture how specific elements affect different areas in time. Also, based on the harvested data during time we can extrapolate results into forecast pollutants concentration levels.

To evaluate the spreading of pollutants in the atmosphere, there were used two methods: direct measurements of pollutants concentrations emitted at the incinerator chimney and numerical evaluation of dispersed emitted air pollutants based on mathematical equations. Many types of related software exist but only a few of them have global coverage and acceptance (Linkov et al. 2009, Vetres et al. 2014).

The first step for conducting an air quality study consists in producing an emissions inventory. In general terms, emissions inventories provide the total amount of pollutants generated from defined emission sources, for a selected period, month of September 2015 in our case. In this study, the emission factors were selected from a database including incinerator emissions, the wind speed and direction, and meteorological conditions as air temperature, relative humidity and atmospheric pressure. The chimney's height was considered also in the computations. The intensity of fine particulate matter (PM) emissions, together with meteorological measurements (wind speed and direction, temperature, pressure, humidity) was estimated by merging the information provided by direct measurement (hourly value). The pollutants, one identified, are subject to attributing emission factors. The way of presenting data is graphical, in a triangle of dispersion and the parameters used in computation (concentration, wind speed and direction). One also has the possibility of choosing types of data like cumulative concentration, averages or instantaneous data.

In figure 5 an overview of the schematic representation used in the problem is given, regarding the source of pollutants and the distance from source related to wind direction. Each wind direction has associated its own Cartesian coordinate system with the (x,y) axis.

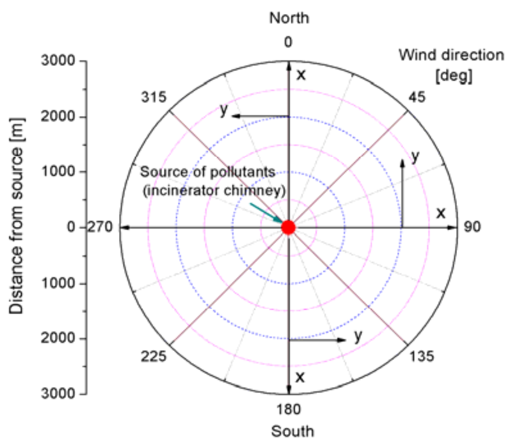

Figure 5 - Overview of the schematic of the problem, regarding the source of pollutants and distance from source related to wind direction. Each wind direction has associated its own Cartesian system with (x,y) axis of coordinates.

Computational base take in consideration a lot of elements important in dispersion: wind speed and direction, type of weather, time of day/night, type of sky like cloudy or clear. The effective height of the chimney is considered to be H=10 meters. Detailing the way of using is in the direction of wind, dispersion have a Gaussian concentration depending of the wind speed. On the other hand, the dispersion in the side direction of the main stream has different values depending of the type of the weather.

Gaussian plume model

Gaussian dispersion models have become a uniquely efficient tool of air quality management for the past decades, being successfully used for a wide range of studies of air quality in urban and industrial areas (Abdel-Rahman 2008, Wikipedia, 2015). It is the most widely used plume model and is the basis for most of the computer simulations. The concentration of an air pollutant at a given position is a function of a number of variables, including the emission rate, the distance of the receptor from the source, and the atmospheric conditions. The most important atmospheric conditions are wind speed, wind direction, and the vertical temperature structure of the local atmosphere. Atmospheric air quality dispersion models are usually used to estimate just how much reduction has occurred during the transport of pollutant from an industrial source, and consequently to project the pollution concentration at ground level.

The Gaussian plume dispersion model uses a realistic description of pollutants dispersion and represents an analytical solution to the diffusion equation for idealized circumstances, assuming that the atmospheric turbulence is both stationary and homogeneous. In this model the concentration of pollution downwind from a source is treated as spreading outward from the centreline of the plume following a normal statistical distribution. The plume spreads in both the horizontal and vertical directions, as presented in figure 6 that shows a definition sketch of its dispersion.

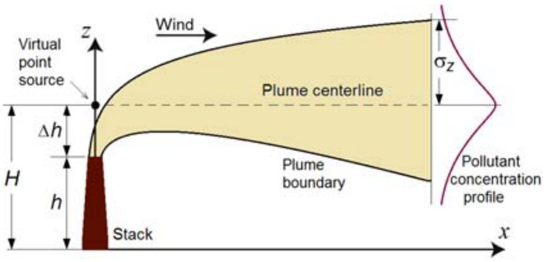

Figure 6 - Schematic figure of a Gaussian plume. The $H = h + \Delta h$ is the effective stack height and the crosswind and vertical deviation of the profile are the key parameters of the model.

In the Gaussian plume model, the determination of the pollutant concentrations at ground-level beneath an elevated plume involves two main steps: first is calculated the height to which the plume rises at a given downwind distance from the plume source. The calculated plume rise Δh is added to the height of the plume's source point h and obtain the effective stack height H. Second, the ground-level pollutant concentration beneath the plume at the given downwind distance is predicted using the Gaussian dispersion equation.

The model is based on formula (1) which results from the particular integration of Fick's second law of non-selective diffusion (Lungu et al. 2015), and the general form of the Gaussian dispersion equation can be written as (Abdel-Rahman 2008):

$$C(x,y,z,H) = \frac{Q}{2\pi u \sigma_y \sigma_z} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]\left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_y}\right)^2\right]\right\} \quad (1)$$

where:

C [kg/m^3] – the pollutant concentration,

Q [kg/s] – the source emission rate of the pollutant,

σ_y [m] – the horizontal diffusion coefficient (standard deviations of the concentration distribution in the crosswind),

σ_z [m] – the vertical diffusion coefficient (standard deviation of the concentration distribution in the vertical direction),

u [m/s] – average wind speed at stack heights in the dispersion layer,

x [m] – the distance downwind from the stack,

y [m] – the crosswind distance from the plume centreline (horizontal distance perpendicular to the wind direction),

z [m] – the vertical distance from the plume centreline,

H [m] – the effective stack height, which is the sum of stack height h and plume rise Δh (considering the additional height Δh to which the hot gases rise above the physical height of the source h).

One can observe that the x downwind distance from the source does not appear in equation (1), considering that, in fact, advection is more dominant compared to diffusion. Based on this theoretical background, an attempt has been made to develop dispersion model of atmospheric emissions of ultrafine particles at the stack of a special waste incineration plant. In our case the control measurements were taken at ground level at $z = 0$ and the effective stack height were considered H=10 m, equation (1) simplifies to:

$$C(x,y,0,10) = \frac{Q}{\pi u \sigma_y \sigma_z} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \exp\left[-\frac{1}{2}\left(\frac{10}{\sigma_z}\right)^2\right] \quad (2)$$

The dispersion coefficients σ, define the spread of the plume, having values determined by the magnitude of the turbulence in the atmosphere. The measurements of σ used in all the models are called as the *Pasquill-Gifford* coefficients (Turner 1970, Lungu et al. 2015), from data taken in open surroundings. In order to calculate average concentrations of coefficients σ for long-term (e.g. for a month, as in our case), it is necessary to take into account the wind speed, direction, and atmospheric stability over the entire period. The physical description of the Gaussian plume model is based on the traditional discrete stability categories (Pasquill-Turner stability classes). This kind of dispersion is called diffusion and is simplified presented in Table 1, which estimates the wind stability class:

Table 1: The estimation of wind stability class

Wind	I > 700 W/m^2	350 < I < 700	I < 350 W/m^2	Night Cloudy	Night Clear
< 2 m/s	A	A-B	B		
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

Weather stability classes are of six types (labelled from A to F) depending on wind speed and sky types (like clear or cloudy) to help choose the correct dispersion coefficient on specific distances from emission source. Classes A through C are unstable conditions, class D is neutral, and classes E and F are stable. The most frequently observed classes are C, D, and E.

The application of the Gaussian plume model to the specific conditions of Timisoara city and the analysis of the results obtained by numerical simulation are given in the following section.

Results and discussion

The main interest of the study is to evaluate the area affected by smoke plume or other sources and the way it is spread depending of concentration in the emission point. Measurement in the field correlated with measurement on chimney and prediction of spreading constructed a clear picture of how chemical compounds settle down on earth level. Due to the various physic-chemical characteristics of the pollutants, the pollution cannot be characterized globally, based on the weighted average of all the concentrations of the pollutants discharged into the atmosphere, but only of those belonging to specific groups of pollutants. Thus, attempts were made to develop a method accurate enough to characterize the dispersion of various pollutants, by determining the analytical value and graphical interpretation of the dispersion for several substances declared as harmful, such as particulate matter, in our case. By monitoring the emissions of these pollutants, their dispersal will be described based on sets of experimental values measured at different points on the path of the emission gases. The experimental measurements consist of the following parameters:

- The momentary concentration of particulate matter [mg/Nm^3];
- The momentary wind speed [m/s];
- Wind direction, relative to the cardinal points;
- The UV Index (in order to establish the UV conditions: sunny day, cloudy or night);
- The height of the point source of emission [m].

In this section we present a global evaluation of pollutants spreading in the atmosphere in the vicinity/around the incinerator for a period of a month (September 2015), as a function of their concentration at the exit of the incinerator chimney. The main data input were the wind speed and direction, chimney's height and meteorological conditions (air temperature, humidity and pressure). Figure 7 presents number of days of measurements for the considered period corresponding to wind default directions, where an angular range of 22.5 degrees was considered.

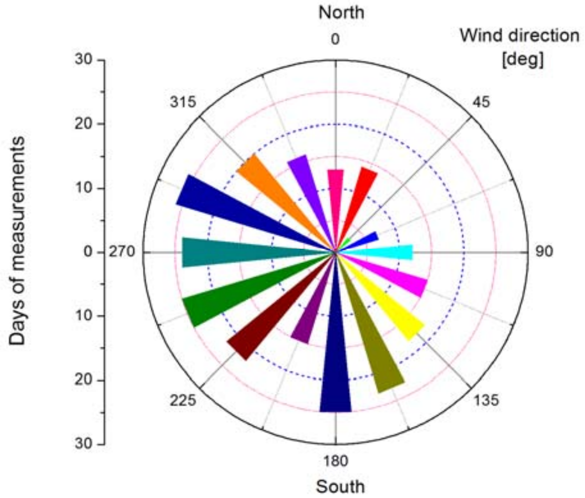

Figure 7 - Days of measurements during a month corresponding to the wind direction.

In figure 8 it is presented a wind rose, as resulted from applying the main measured data input: the mean values of wind speed and default wind direction for the considered period, with hourly and daily mean values.

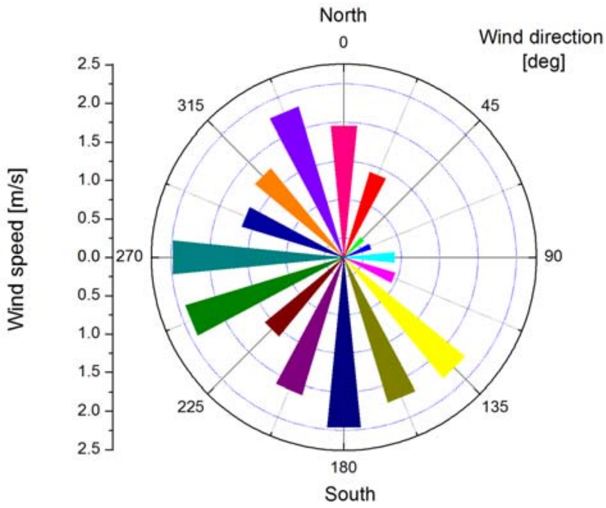

Figure 8 - Wind rose with mean values of the wind speed taken hourly and daily in a month depending on the wind default directions.

The transport process of the components were investigated numerically with the CloseView software (Lungu et al. 2015). First, the analytical values of the parameters collected from the acquisition devices are entered into a database. Then, CloseView software retrieves the data and generates a graphical representation shaped as a color cone, each dot having a color intensity depending on the pollutant concentration in that location. The results obtained with the measuring equipment are used as input data to simulate the dispersion of pollutants in the atmosphere. The simulation must replicate as closely as possible the pollutant distribution in the plume and its dynamics in time, based on the following framework:

- uniform turbulences in the atmosphere;
- measurements in the field and in the chimney are representative of the entire field of study;
- known densities of the pollutant;
- the vertical wind component is negligible;
- the regime is stationary (the smoke plume instantly reaches the steady state for the weather conditions used in the calculation of the dispersion).

The CloseView software analyzes and processes the data as follows:

- retrieves from the database the momentary values for the pollutant at the chimney (with a frequency of one value per minute) during the established time period;
- retrieves from the database the weather conditions with a frequency of one per minute during the established time period. These values are: pressure, temperature, air turbulence, wind speed, wind direction.

The equation for the dispersion is applied taking the *x* coordinate downwind and the *y* coordinate horizontally, as the distance from the wind axis on both sides.

Figure 9 presents the main window of the CloseView software. The window allows the choice of the desired average, of a pollutant on a specific period of time. It also shows the atmospheric conditions in current time with all relevant elements like wind speed, direction and weather conditions.

Figure 9 - The main window of CloseView software, from that can choose the pollutant on a specific period of time, and shows the atmospheric conditions in current time with all relevant elements like wind speed, direction and weather conditions.

Defining the input quantities requires placing the sample in time frame. The time period and the type of the averaging used on the values having the selected frequency (hourly, daily, monthly, or annually) have to be specified. For the current application, the concentration of particulate matter was chosen as examples, and prior to displaying the graphical representation of the dispersion, a way of presentation can be chosen:

- Present – the value of the pollutant dispersion at the time, regardless of the chosen time period;

• Instantaneous - the value of the pollutant dispersion based on the momentary measurements;
• Average - the value of the pollutant dispersion calculated as an average over the chosen time span;
• Cumulative – the cumulative mark of the pollutant over the chosen time span, obtained by successively overlapping the dispersions given by instantaneous values.

The atmospheric conditions during the investigated time period are also being displayed on the graph in order to characterize the climate in which the dispersion is evaluated. For the graphical representation, coordinates were taken on a representative triangle, point by point, and the concentration values were computed. Each point has been assigned a colour (in this case green) with its intensity (relative to the maximum allowable) decreasing with decreasing concentration value.In this way the dispersion of powders in atmosphere was generated as shown in Figures 6 for different values of wind direction. For a full understanding of the areas affected by pollutants, the graphical representation was superimposed on a map cantered on the point of emission of the exhaust plume. The dispersion of pollutants can be seen in green, and information about the atmospheric conditions that influenced that propagation is presented in the lower right side. The continuously tracking of emissions perfected in this way can be customized for any process of continuous evaluation of emissions into the atmosphere, which gives this program its utility in making a technological flux with gaseous emissions more efficient.

Figures 10 present dispersion maps of specific pollutants emerging from the source in the N-S, S-N and W-E directions of the wind. We can see how concentrated or faded are the footprints of pollutant depending of concentration on chimney and wind speed.

a) b) c)

Figure 10 - Dispersion map of pollutants emerging from the source in the N-S a), S-N b) and W-E c) directions of the wind.

These figures show very clearly that the wind direction make chemicals to lay strongly in the direction of wind. If a predominant wind blows more time in the same area, the mark of pollutants increases in that direction.

In the next figures, the calculated concentration curves of dispersed pollutant concentrations are presented, taking into account the hourly and daily mean values at incinerator chimney. In this dispersion study an area of 40 km^2 was considered, with the source situated in the center of the bidimensional coordination system.

Figures 11a and 11b present the concentration of pollutants at soil level versus distance from emission source, computed for North to South (N-S) and South to North (S-N) of wind direction, respectively.

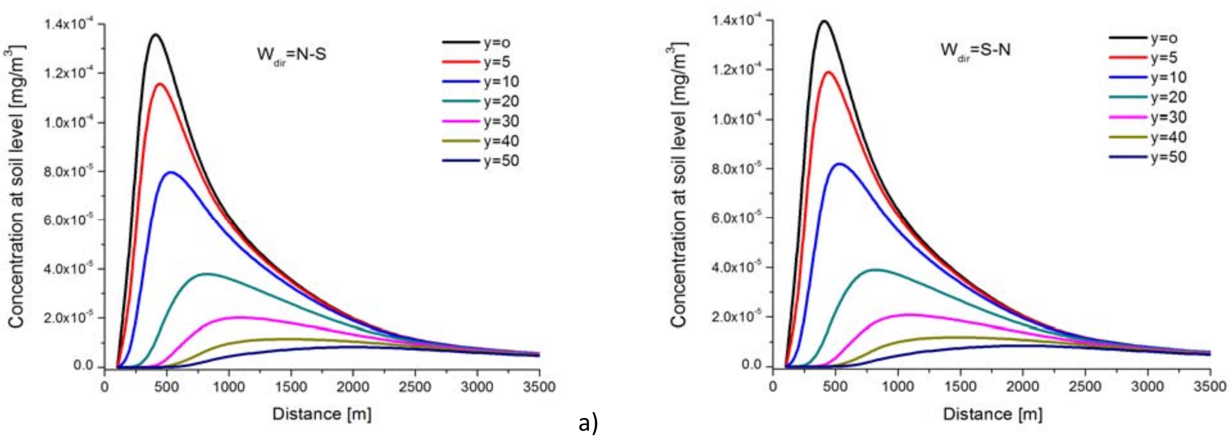

Figure 11 - Concentration of pollutants at soil level versus distance from emission source, computed for North to South of wind direction (180 degrees), a) and for South to North of wind direction (0 degrees), b).

Figures 12a and 12b present the concentration of pollutants at the soil level versus distance from emission source, computed for West to East (W-E) and East to West (E-W) of wind direction.

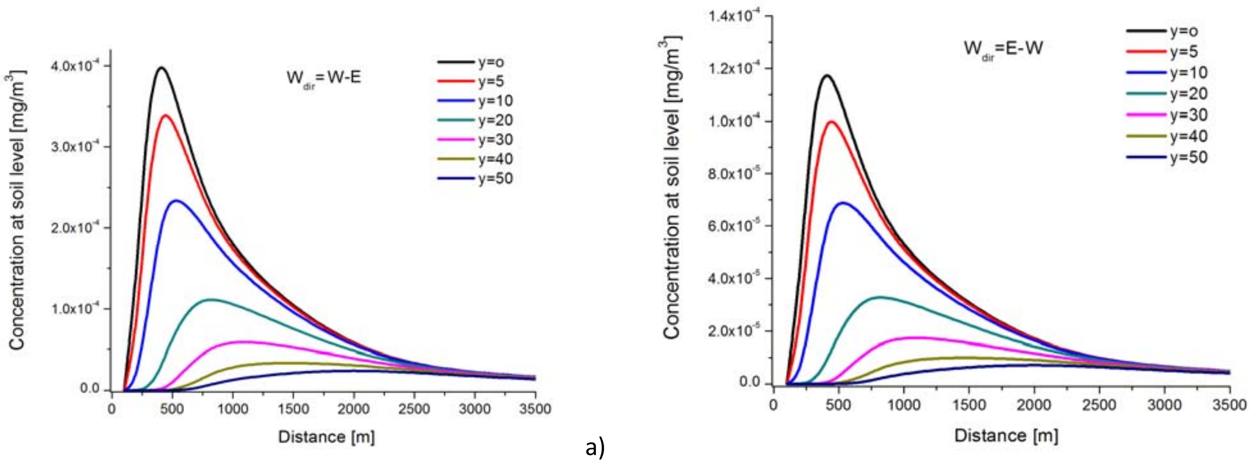

Figure 12 - Concentration of pollutants at soil level versus distance from emission source, computed for West to East of wind direction (90 degrees), a) and for East to West of wind direction (90 degrees), b).

Due to the similar behaviours that appear on the all directions, we considered that the examples presented so far are relevant enough in order to describe how the pollutants spread. It can be noticed that, in all cases, the concentration of pollutants at ground level initially increases quite sharply with distance up to a maximum value, then decreases slowly, and became insignificant after distance of 2500 m.

Figures 13a and 13b present concentration variation of pollutants at soil level as a function of the distance *y* from the wind axis, at different distances *x* from emission source, computed for North to South (N-S) and South to North (S-N) of wind direction.

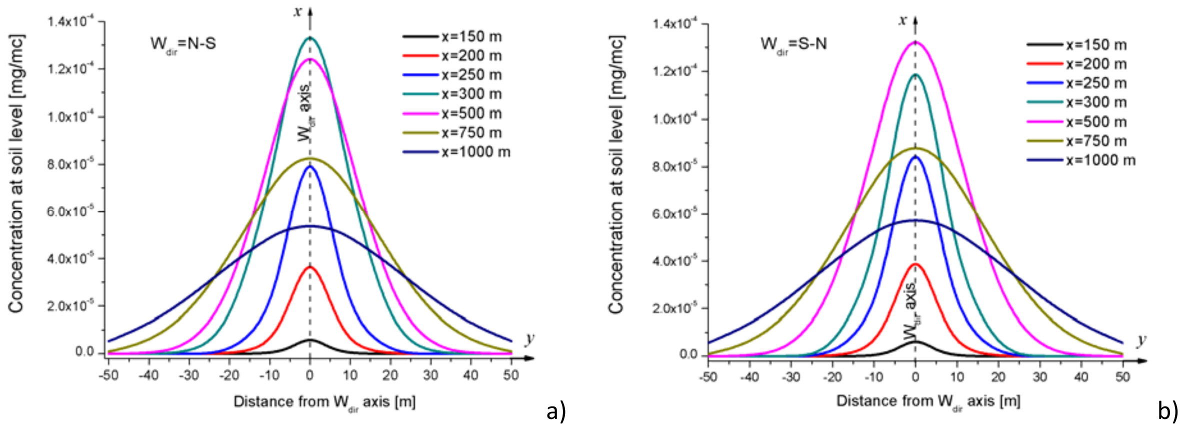

Figure 13 - Concentrations of pollutants at soil level function of distance *y* from wind axis, at different distances *x* from emission source, computed for North to South of wind direction, a) and for South to North of wind direction.

One observes that the pollutants concentration along *y* axis has a Gaussian behaviour. Its shows that the footprint is stronger in the vicinity of emission point and decreased along the wind direction. The decreasing is affected by the speed and other atmospheric condition, and, of course, the concentrations in the emission point have a great effect on footprint area. Anyway, it seems that all pollutants tending to lay down completely after a distance that is related with the chimney height. In the case of a chimney of 10 meters, the calculation predicts that after about 2500 m, the pollutants concentration is very small to none. Similar behaviours are observed for all the wind directions we considered in the study.

In summary, this work relates to approaches achieved in the frame of collaboration between Physics Faculty of the West University of Timisoara and the waste incinerator plant Pro Air Clean Ecologic Timisoara in the problem of the dispersion of different components from flue gas released during the waste incineration process. It have been performed a global evaluation of pollutants spreading in the atmosphere for an area of 40 km^2 in the around the incinerator for a period of a month (September 2014), as a function of their concentration at the exit of the incinerator chimney. The main data input were the wind speed and direction, chimney's height and meteorological conditions (air temperature, humidity and pressure), taking into account the hourly and daily mean values. The resulted concentration curves of dispersed pollutant concentrations at soil level are presented, versus distance from emission source, computed for different orientations of wind direction. In all cases, the concentration of pollutants at the ground level initially increases quite sharply with distance up to a maximum value, then decreases slowly, and became insignificant for distances longer then 2500 m.

Conclusions

The stage 2015 of the project has proposed to estimate the scale of the phenomenon of emission of nanoparticles in the city of Timisoara and to identify the economic agents, whose production processes leads to emission of nanoparticles.

The first part of the study presents the pollution maps with nanoparticles particulate matter suspensions in size ranges PM0.3, PM2.5 and PM5 of Timisoara city, obtained from measurements carried out with air particle counter P311. For the evaluation of the spreading of pollutants in the atmosphere, the measurement points were chosen in the grid nodes and in the central points of the squares of a grid drawn on the city map, with an approximate resolution of 900mx900m. A number of 128 points was obtained. For each location, the GPS coordinates were collected together with the measurements. The coordinates were introduced in Google Maps in order to obtain the map of the measurement points. A digital map of Timisoara was used as a base layer, over which a contour map obtained by interpolation of the measured data was superimposed for each type of particles. For each point on the map, three measurements were performed with an interval of one week between them, for particulate matter suspensions in size ranges PM0.3, PM2.5 and PM5, during month of September 2015.

In the second part, the study refers to Pollution of Timisoara city with nanoparticle suspensions of 300 nm, phenomenon whose emergence has been found mainly in the south of the city and, supplementary, pollution of Timisoara city with PM2.5 and PM5, with emergence mainly in the north of the city, for the identification of economic agents, whose production processes leads to emission of nanoparticles. The study finalizes with an example regarding distribution of the pollutants emitted by a waste incinerator in Timisoara city urban area.

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2. *Dissemination of the obtained results.*

The obtained results were disseminated in the frame of five international conferences, three papers in press and two submitted for publication in ISI journals. All publications contain acknowledgment of the project. During the stage the project website was constantly updated, at the address: www.nanodep.com.

Canference participations:

1. A. Neculae, A. Lungu, N. Strambeanu and M. Lungu: *Recovery of Nanoparticles from Flue Gas using Dielectrophoresis*, IMCET 2015, The 24th International Mining Congress and Exhibition of Turkey, Antalya, Turkey, April 14-17, 2015.
2. M. Lungu, A. Neculae, A. Lungu, M. Bunoiu, N. Strambeanu, D. Arghiriade, L. Demetrovici: *Prediction of the distribution of the pollutants emitted by a waste incinerator in an urban area using numerical simulations*, Conference Bucharest University Faculty of Physics 2015 Meeting, Section Atmosphere and Earth Science; Environment Protection, Bucharest, June 19-th, 2015.
3. M. Lungu, A. Neculae, A. Lungu, M. Bunoiu, N. Strambeanu, D. Arghiriade, L. Demetrovici: *Evaluation of the dispersion of the pollutants released by a waste incinerator using numerical simulations*, The 15-th International Balkan Workshop on Applied Physics, Constanta, July 2-4, 2015.
4. M. Lungu, D. Arghiriade, N. Strambeanu, A. Lungu, L. Demetrovici: *Numerical simulation of particulate matter emissions from the stack of a special waste incinerator as point source. Fractions of contained nanoparticles,* International Siposionum "The Environment and the Industry" SIMI 2015, Bucharest, October 29-30, 2015.
5. M. Lungu, A. Neculae, A. Lungu, N. Stefu: *Air pollution with nanoparticles and its prevention by filtering the flue gases using dielectrophoresis*, International Engineering Symposium at Banki - Efficiency, Safety and Security, IESB 2015, Obuda University, Budapest, November 19, 2015.

ISI Publications:

1. A. Neculae, M. Bunoiu, A. Lungu and M. Lungu: Filtration of flue gas in microfluidic devices using dielectrophoresis, *Romanian Journal of Physics, 2015* (accepted, in press).
2. A. Neculae, M. Bunoiu, A. Lungu and M. Lungu: Filtration of flue gas by retaining of nanoparticle in microfluidic devices using dielectrophoresis, *Romanian Reports in Physics*, 2015 (accepted, in press).
3. A. Neculae, N. Strambeanu, A. Lungu, M. Bunoiu and M. Lungu: Nanoparticle trapping from flue gas using dielectrophoresis, *AIP Conference Proceedings,* Melville, New York, 2015 (accepted, in press).
4. M. Lungu, A. Neculae and A. Lungu: Positive dielectrophoresis used for selective trapping of nanoparticles from flue gas in a gradient field electrodes device, sent to *Journal of Nanoparticle Research*, 2015 (under review).
5. M. Lungu, A. Neculae, A. Lungu, N. Strambeanu, D. Arghiriade, L. Demetrovici: Measurements and prediction of the dispersion of the pollutants emitted by a waste incinerator in Timisoara city urban area, sent to *Atmospheric Envirmnment* journal, 2015 (under review).

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