Air Quality – monitoring and modelling

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Abstract: *Air pollution is a major concern for all nations, regardless of their development. The rapid growth of the industrial sector and urban development have lead to significant quantities of substances and toxic materials, mostly discharged into the atmosphere and having adverse effects both on human health and environment in general. Human society has to recognize that environment has only a limited capacity to process all of its waste without major changes. Each of us is a pollutant but also a victim of pollution. If monitoring of air pollutants is particularly important for assessing the air quality at any moment, by modelling the monitoring data spectacular results are obtained both through the factor analysis and identification of potential pollution mitigation measures. Latest equipment and techniques come and support these problems giving medium and long term solutions.*

Key Words: *Air quality, Monitoring, Modelling, Equipments, Dispersion*

1. INTRODUCTION

A clean air supply is essential to our own health and to the environment. But since the industrial revolution, the quality of air we breathe has deteriorated considerably - mainly as a result of human activities [1], [2]. The concern for a clean environment and for human health in recent decades has led to a substantial improvement of the air quality. However, pollution exists, especially in and around large urban concentrations, people being constantly exposed to health hazards [3], [4], [5], [6], [7].

The air quality is determined by the air emissions from both stationary sources and mobile sources (mainly road traffic), and also by long distance transport of pollutants, very often exceeding of the limits imposed by legislation being registered [8], [9], [10].

Fig. 1 – Pollution sources and effects

2. TRANSPORT AND DISPERSION OF AIR POLLUTANTS – MONITORING – LEGISLATION

The air quality is determined by emissions from stationary sources (industry, agriculture, energy production or natural disasters) and mobile sources (road and air traffic). Once released, the pollutants are dispersed into the atmosphere, more or less rapidly, depending on the weather conditions (the state of the atmosphere at a given time and place) [11].

The wind (caused by pressure variation), temperature and atmospheric stability are the main factors that influence the transport and dispersion of the major pollutants, besides the climate, the geographical conditions, solar radiation, precipitation and humidity.

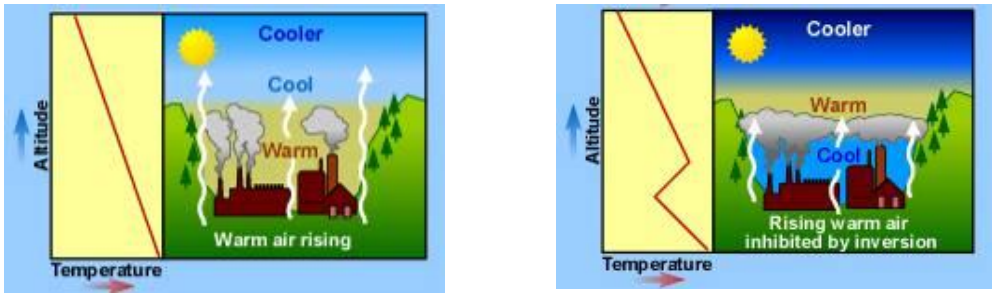

Fig. 2 – Atmospheric stability – Temperature inversions
Source: http://www.epa.gov/apti/course422/ce1.html

Many chemical reactions occur during this dispersion, forming more stable compounds that can be detected and analyzed in monitoring stations [12]. These are "immissions", pollutants we breathe or are deposited on the ground, epidemiological studies showing the link between the immissions and the health risks for the population exposed.

The Air quality assessment is usually based on the monitoring data. Periodic measurements are compulsory in most countries, in order to determine the ambient air quality (air quality monitoring networks) [13].

In Romania, in accordance to our legislation (Law no. 104/2011, transposition of European Directive 2008/50/CE), the responsibility of the air quality monitoring lies with the environmental protection authorities. The methods to measure the monitored pollutants, limit values, alert thresholds and criteria comply with the requirements of the European regulations. Currently, National Air Quality Monitoring Network (RNMCA) performs continuous measurements of sulphur dioxide (SO2), nitrogen oxides (Nox), carbon monoxide (CO), ozone (O3), particulate matter (PM10 and PM2,5), benzene (C6H6) and lead (Pb). Currently, 142 stations for monitoring the air quality (urban, industrial, traffic or regional), provided with automatic measurements equipments (based on IR non-dispersive spectroscopy, chemiluminescence, UV fluorescence, selective combustion and detection through flame ionization) [14] are located in Romania.

The monitoring system allows the local environmental protection authorities:

- to evaluate, to know and to keep the public and other authorities and institutions informed about the air quality;
- to take timely, prompt measures to reduce and / or eliminate the pollution episodes in case of emergency;
- to prevent accidental pollution;
- to warn and protect the public in case of emergency;

Fig. 3 – Air quality monitoring stations – Romanian network

3. AIR DISPERSION MODELLING

The measurements carried out to assess the air pollution degree provide important quantitative information about the concentrations of air pollutants and ground deposits. But they can only describe the air quality in specific places and moments in time, without giving clear guidance on identifying the causes of the air quality worsening. Instead, the air pollution 129modeling can provide a more complete description of the problem, including an analysis of the factors and causes (emission sources, meteorological conditions/processes, physical and chemical changes) and even some guidelines for implementation of measures for mitigation of pollution and harmful effects.

The dispersion 129 modeling of pollutants in the atmosphere is in fact, abstractly speaking, a computer simulation of the movement and dilution of the air pollutants from exhaust points (sources), to the ecologically sensitive objectives (receptors). Two common 129modeling systems used by EPA are the Industrial Source Complex model (ISC) and the Assessment System for Population Exposure Nationwide (ASPEN) [15], [16].

The IMMI software is a reference tool in the air pollution modeling research field. It integrates air dispersion modelling (gases, dust, odours), outdoors sound propagation (road, traffic, railway, industrial and recreational noise) and inter-faces to CAD and GIS packages. IMMI is used by professionals working with public authorities, consulting engineering companies and industry [17].

The dispersion models can predict concentrations at selected downwind receptor locations The dispersion model for estimation of plume contaminant concentration at a point in space is based on the Gaussian Dispersion Equation, according to the proven German TA-Luft, Annex C of 1986 [18].

The assumptions made in the development of the above mentioned equation are:

- ✓ The plume spread has a Gaussian (normal) distribution in both horizontal and vertical planes, with standard deviations of plume concentration distribution in the horizontal and vertical directions;
- ✓ Uniform emission rate of pollutants;
- ✓ Total reflection of the plume at ground;
- ✓ The plume moves downstream (horizontally in the x direction) with mean wind spread.
- ✓ The stack gases emitted from the mobile source (traffic) in the atmosphere are not reactive i.e. there is no form of reaction between the pollutants. [19], [20].

Fig. 4 – General idea of the IMMI air polluting software – Gaussian model
Source: http://www.woelfel.de/en/products/modelling-software/immi-air-pollution-mapping.html

4. CONCLUSION

The atmospheric dispersion modelling of a pollutant gas is, as a final act, the mathematical simulation of how pollutants from an emitted gas disperse in the ambient atmosphere. Currently, the simulation is performed with computer programs/specialized software that use mathematical equations and algorithms to simulate how pollutants disperse in the air and, in some cases, how they react in the atmosphere. The dispersion models are used in order to estimate or to predict the concentration of air pollutants downwind pollution from sources such as industrial plants, vehicles in road traffic or accidental chemical releases.
The air pollution software models play an important role in science because of their ability to assess the importance of relevant processes. The air pollution dispersion modelling is the only method that quantifies the deterministic relationship between emissions and concentrations/ depositions, including past and future scenarios consequences and determining the effectiveness of pollution reduction strategies. This makes that the air pollution models to be indispensable in regulatory research and even in forensic applications.

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REFERENCES

[1] *** European Commission – Environment – *Air*, available at: http://ec.europa.eu/environment/air/index_en.htm
[2] *** European Environment Agency. *Air Pollution*. Available at: http://www.eea.europa.eu/themes/air
[3] Jim Fitzpatrick, Roseanna Cunningham, Jane Davidson, Edwin Poots, *Air Pollution: Action in a Changing Climate*, March 2010, available at: http://www.defra.gov.uk/publications/files/pb13378-air-pollution.pdf
[4] *** *Environmental pollution, problems and control measures – Overview*, Posted by: safeeenvironment/September 1, 2009, available at: http://saferenvironment.wordpress.com/2009/09/01/environmental-pollution-problems-and-control-measures-%E2%80%93-overview/
[5] *** *Effects of Air Pollutants – Health Effects*, available at: http://www.epa.gov/apti/course422/ap7a.html
[6] Dr. Mashhood Ahmad Khan, Arsalan Mujahid Ghouri, *Environmental Pollution: its Effects on Life and its Remedies*, available at: http://www.researchersworld.com/vol2/issue2/Paper_23.pdf

[7] *** *Air Pollution - Health and Environmental Impacts*, available at: http://www.epa.gov/airtrends/2011/report/airpollution.pdf
[8] *** *Air Pollution, Sources and Characteristics*, available at: http://www.rrcap.unep.org/male/manual/national/02chapter2.pdf
[9] Roger Gorham, *Air Pollution from Ground Transportation – An Assessment of Causes, strategies and tactics, and Proposed Actions for International Community*, available at: http://www.un.org/esa/gite/csd/gorham.pdf
[10] *** CEQR Technical Manual, Chapter 17, May 2010, *Air Quality*, available at: http://www.nyc.gov/html/oec/downloads/pdf/2010_ceqr_tm/2010_ceqr_tm_ch17_air_quality.pdf
[11] *** U.S. Environmental Protection Agency. *Air Pollution Control Orientation Course, Control Emmissions Technologies – Transport & Dispersion of Air Pollutants*. available at: http://www.epa.gov/apti/course422/ce1.html
[12] *** XIV – Environment – A – Air Pollution – 1, *Air Pollution Monitoring* available at: http://nzic.org.nz/ChemProcesses/environment/14A.pdf
[13] ***EIONET-European Topic Centre on Air Pollutionj and Climate Change Mitigation, EuroAirnet, available at: http://acm.eionet.europa.eu/databases/EuroAirnet/index_html
[14] *** Ministerul Mediului si Padurilor. ANPM Calitate aer - *Reteaua Nationala de monitorizare*, available at http://www.calitateaer.ro/
[15] *** *User's Guide For the Assessment System for Population Exposure Nationwide* (Aspen, Version 1.1) Model, United States Office of Air Quality EPA-454/R-00-017 Environmental Protection Planning and Standards, April 2000 – Agency Research Triangle Park, NC 27711, available at: http://www.epa.gov/scram001/userg/other/aspenug.pdf
[16] Christian Seigneur, Kristen Lohman and Betty Pun, *Air Toxics Modeling*, available at: http://www.crcao.org/reports/recentstudies00-02/A-42-1%20Final%20Report.pdf
[17] *** *Wölfel - IMMI software for dispersion calculation of gaseous, odorous and dust pollutants*, available at: http://www.woelfel.de/en/products/modelling-software/immi-air-pollution-mapping.html
[18] *** *Excerpt of the Technical Instructions on Air Quality Control, Annex C : Model Calculation*, available at: http://www.soundplan.eu/fileadmin/user_upload/pdf/soundplan_luft/gauss/2009-08-13_en_---_ta_luft_86_annex_c.pdf
[19] Maudood N. Khan, William L. Crosson, and Maurice G. Estes, Jr. Universities Space Research Association (USRA), *Land Use and Land Cover Characterization within Air Quality Management Decision Support Systems: Limitations and Opportunities*, NASA Applications Program Lead Program Manager for Air Quality Applications NASA Headquarters Washington, DC 20546, February 23rd 2007.
[20] Mihaiella Cretu, Victoria Teleaba, Silviu Ionescu, Adina Ionescu, *Case study on pollution prediction through atmospheric dispersion modelling*, WSEAS Environment And Development, Issue 8, Volume **6**, August 2010, ISSN 1790-5079