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On-line Air Pollution Assessment in the Proximity of Coal Based Power Plants in Romania

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Abstract. This paper is presenting an on-line platform consisting in a measurement system and procedure used for air pollution assessment and warning, based on mobile and fixed sensor stations, located in the proximity of thermal coal power plants in western Romania, as well as the software interface used for data acquisition, visualization and interpretation. All the measurements were performed by the Politehnica University in Timisoara (mobile platform on vehicle) and by the Romanian Agency for Environmental Protection (fixed platforms, but located at a certain distance from these plants). The background acquisition devices and the dedicated user friendly software were developed by our team. Main polluting agents taken in account on this paper are SO₂, NO₂, O₃, CO and PM₁₀, as well as other polluting agents, by custom request of the site of the Romanian Environmental Agency and are used for environmental studies, alarms or didactic purpose, as well as for reports. This paper also provides some examples of real measurements performed on site and the interpretation of these results, as well some simple solutions and recommendations for air quality increase, customized for these power plants.

1. Introduction

Air is one of the main environmental factors extremely vital for life, and air quality is an important issue for the society, which has to be carefully supervised worldwide. In order to achieve this, it is necessary to make measurements of air quality in the proximity of all main polluting sources for:

- Repartition of the measuring points of interest on a certain area;
- Air quality monitoring program itself, consisting of all time parameters of air sampling (sampling periodicity, sampling duration and other specifications ensuring quality of data);
- Different external parameters influencing the measurements for the concentration of certain air pollution agents.

The purpose of any monitoring activity performed for air quality is [1]:

- Measurement of the maximal concentration of a pollutant in a rural or urban area, in order to determine whether or not they exceeded the maximum permissible concentration;
- Determination of the global parameters for national, regional or local air pollution;
- Issue of forecasts and, if necessary, even warnings, in order to adjust the emission of pollutants, correlated with the evolution of pollutants accumulation in the atmosphere, or the issue of protective



measures in case of an emergency;

- Risk assessment and management for potential injuries on sensitive receptors (humans, animals, plants or even agricultural and industrial objectives).

The main polluting agents, required by the European norms and regulations, taken in consideration are, in our case:

- SO₂ (Sulfur Dioxide);
- NO₂ (Nitrogen Dioxide);
- O₃ (Ozone)
- CO (Carbon Monoxide);
- PM10 (Particles in suspension, having less than 10 microns).

2. Location of measuring points

In order to establish the optimal location of air quality monitoring stations on a specific area, it is necessary to know from the start [2]:

- All polluting sources (industrial, traffic, etc.) in that area of interest;
- Main climate characteristics of that region (wind direction and speed, temperature, atmospheric pressure, weather stability, rainfall and relative humidity);
- Demographic and social characteristics and particularities of the considered area, including geographical distribution of the population by sub-areas, communities, density and repartition;
- Other local geographical features (relief, land, nature of soil cover, vegetation or fauna).

The establishment procedure for the geographical position of each air quality monitoring station involves the next steps [3]:

- Performing certain mathematical calculations. It is based on all given data, in risky points when higher concentrations are expected to occur in that area of interest;
- Hosting the required equipment. In order to make a proper establishment for a temporary surveillance station or group, if there is no representative meteorological station in the area, meteorological measurements have to be carried on temporary with a mobile meteorological station (wind speed and direction, rainfall and relative humidity and atmospheric stability);
- Optimizing the positions of points. A permanent surveillance network could be introduced when the temporary program of observations, meteorological and meteorological described above, becomes permanent, only with some minor changes in locations.

The locations belonging to air surveillance points and their service procedures are made in conjunction with any significant changes in the emission of pollutant in that area or for other temporarily or permanently surveillance purposes imposed by the authority in charge. In order to determine the maximum concentration of emissions in that area of possible polluted environment, the minimum number of points required for surveillance in case of gaseous pollutants and aerosols depends on the population of that urban area: from a single point, corresponding to a population fewer than 50,000 inhabitants, up to 16-20 measuring points corresponding to a population of over 2,000,000 inhabitants, according to EU regulations. For the high density particulate measurements inside urban areas, the stations (or mobile monitoring points) are placed one at each 10-20 km² of flat relief areas, or on every 5-10 km² in areas with rugged terrain, but, overall, at least three points on a normal urban area [4].

General guidelines applied by us when choosing mobile surveillance points are:

- Surveillance points will be installed in places with hard ground (asphalt or pitch), leaking, leaky building, trees or steep relief forms, avoiding deliberately dirty and dusty places;
- Installation of the suction devices is performed at the human breathing level, at least 1.5 m above the ground. When the suction port is installed near the wall of a building, we must select that side of the building which is mostly exposed to prevailing wind; suction port has to be installed at least 1 m, both horizontally and vertically, from the supporting structure.
- When measuring pollution due to car traffic, the placement of surveillance points will be made on roads having heavy traffic. Measurements shall be made at peak times and auto traffic

desirable dispersion in adverse weather conditions (temperature inversions, calm atmosphere, and fog). Absorption by plant air path should be as short and as straight as possible, with constant section and without unnecessary bends.

When establishing a procedure, in order to assess air quality, first of all, we must check if that atmospheric turbulence in concentration of the pollutant is a random event or not. Any statistical analyzed set of measurements is, by itself, a random procedure. The result of applying an air quality monitoring program has always a certain degree of uncertainty.

In case of determining the duration of the sampling procedure, a sort of mediation is mandatory, for accurate air quality surveillance purposes. These intervals between measurements are, typically as set in standards, 30 minutes or up to 24 hours. Of course, the measurements are set for 30 min when seeking to obtain information on high concentrations of pollutants in a short period of time. Whenever possible, it is recommended to make measurements with both sampling periods, because most of the maximum permissible concentrations are average values measured between these two period, because dust sediment sampling duration is even 30 days.

The timeshare of the measurement intervals, having measurements performed for less than one year, are not advisable, given that there is an annual cycle on meteorological parameters in our temperate climate region and thereby the parameters that characterize air quality are very dynamic.

The sampling frequency is specified by the following rules:

- Air quality measurements are as seamless as possible and in such a way as to cover all the possible variety of weather conditions;
- The establishment of air quality monitoring programs take into account the frequency of meteorological parameters, as well as the timing of human activities;
- Air quality data obtained in different parts of an area have to be comparable to each other, and, by consequent, it is necessary to be made simultaneously sampling and surveillance programs which are similar each other.

The average emission concentration over 30 min is obtained from a sample of air collected for 30 min continuously. In the case of using automated equipment (in many cases), the average concentration over 30 min. is the arithmetic mean of the values obtained within 30 min. The 24-hour average concentration is obtained from a sample of air collected continuously for 24 hours or as an average of the concentrations in shorter time intervals, distributed uniformly over the 24-hour period, insuring that the sum of the considered intervals has to be at least 12 hours. The monthly average concentration is the arithmetic mean of a 24 h concentration (or on shorter intervals) and equal to each data obtained during the considered month. If the calculation is well performed by using daily averages, they need to be carried out for at least 15 days on the month and have to be evenly distributed throughout the month. By principle, when the average calculating value is based on less than 24 h intervals, these values must uniformly cover the entire range of day. The annual average concentration is the arithmetic mean of the 24 h concentrations on smaller intervals equal to each obtained in the course of time. To calculate the annual average concentration of daily averages, they need to aggregate at least 100 days of the year and is evenly distributed throughout all the year. When using the average values on intervals of less than 24 hours, we must consider data provided as uniformly cover the entire duration of a day. The spatial average, over a certain area, at a certain moment, or for a given time, means the arithmetic average pollutant concentrations, resulting in various locations representatives of the area, at a certain time or characteristic for a given period. For spatial averages performed on those representative areas of interest, the calculation is done using statistical methods of interpolation (optimal mathematical interpolation).

For determining compliance or violation of air quality standards and regulations, we considered punctual values of the pollutant concentrations, which are not taken into account on spatial environments, because mediation is a smoothing procedure, leading to loss of information about the possible emergence of critical situations in some areas of lesser extent, for a brief period.

3. On-line platform for air quality surveillance

This assessment method is based on a mobile station (transported by a truck in a small container and

placed on the measurement point), belonging to the POLITEHNICA University of Timisoara, Romania and a simple expert system which allows real-time data measurements and transmission throughout GPRS. All received data could be easily accessed, on the Internet, throughout a partnership with the Agency for Environmental Protection [4], [5], the manager of the National Air Surveillance Network.

It could work also integrated as a part of the National Air Surveillance/Environmental Protection Network, as a standard measuring point, located for a certain time, near the polluting source, when demanded. The proposed measurement system consists on a mobile station which could be placed where it is needed, a local center (type EdaC 2000, placed inside a vehicle) and a national (regional) fixed center (LNRCA). Some statistic calculations are made manually (using a simple dedicated Matlab procedure) in order to obtain an average value as a reference. All data are saved on the National Center for future analysis. The final results could be used for certifications, reports, studies, monitoring as well as for public information, on-line student laboratories or internet display. All data are transmitted throughout GPRS modems in order to be useful in remote areas where simple 3G, 4G or other data protocols are not available. The mobile station is an AQM 65 made by Aeroqual, placed inside a container with a small electricity generator which can easily be loaded and unloaded on a small truck. The local center EdaC 2000 could be placed inside this mobile container, too [6].

The basic structure of the system is presented in Figure 1.

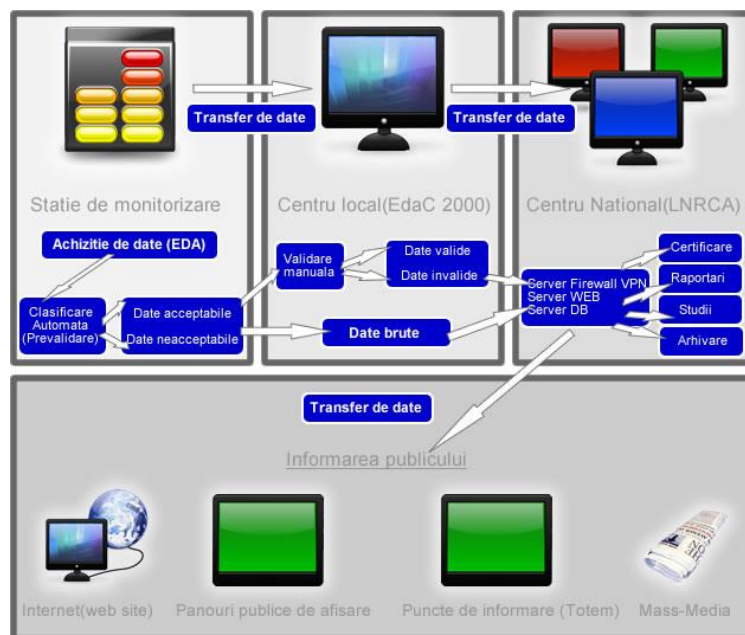


Figure 1. The architecture of the monitoring system

This system was conceived by our team from the POLITEHNICA University in Timisoara, Romania, mostly in order to be sent to the main power plants to verify all air quality parameters in that area. The main power plant taken in consideration for this study was Mintia – Deva (almost 1300 MW), a big unit located at 170 km from Timisoara, in the West Region of Romania [7].

As could be noticed from Figure 1, another important issue for our team was to develop an efficient Human-Machine Interface (HMI), capable to provide on-line data for each logged user, in order to insure transparency and diffusion of all measurements. It could be part of the fixed national network and it could also use and manage these resources too, depending on the selected point of measurements [8].

The Human-machine interface is based on the following sequences:

First of all, each user must log on to the site <http://www.calitateaer.ro>, which is the portal resulted from our partnership with the Romanian Agency for Environmental Protection.

Figure 2 shows us the main page of the on-line system.

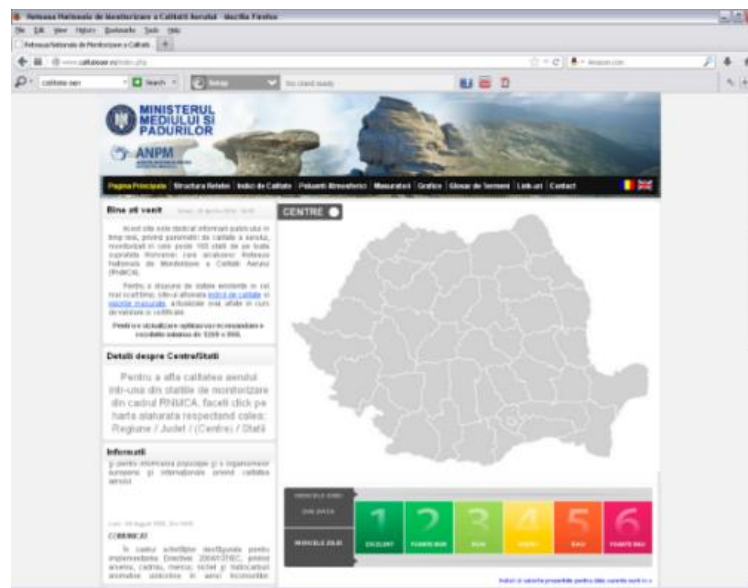


Figure 2. Main page of the air quality site

The user must choose, by using the provided information on air quality (gross measurements - validated - on-line, etc.) available on the website <http://www.calitateaer.ro>, certain air quality monitoring station located closest to its permanent address or to his certain area of interest, like a thermal power plant, for example. This is possible via the map located on the “Home” page, successively selecting Region - County - stations. In this example, we selected the Hunedoara County of our Region [6], where a few polluting power stations are located (Figure 3). This is close to the Mintia Power Plant, in case we don’t use the mobile equipment, sent to that location.

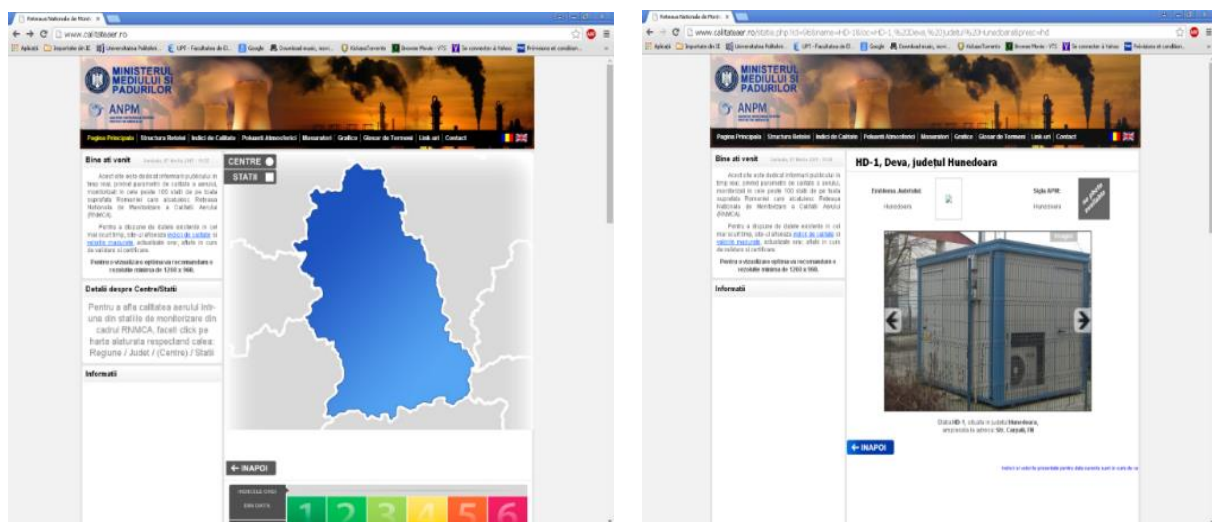


Figure 3. Selection of a permanent air quality station in Deva, Hunedoara County, Romania, belonging to the National Agency for Environment Protection

For that certain selected station, by using the menu “Measurements”, we start considering all the parameters measured by that station for a certain day. Those parameters could be shown both in tabular form as well as graphically one. This option will be detailed in Figure 4 as well as in Figure 5. Inside “Network structure” and “Links” menus, the users can extract and print all possible information about the selected area. The navigation inside the data base is possible due to our interface made basically under MatLab, for a cheaper software structure.

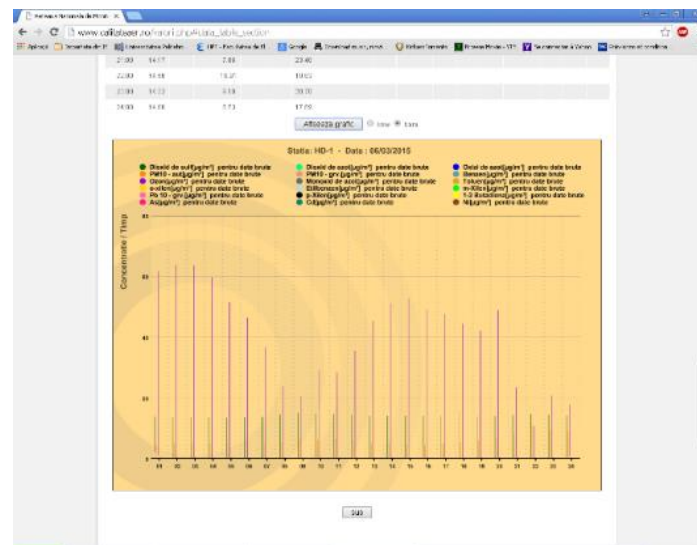


Figure 4. Air quality parameters on 24h for HD-1 Deva station

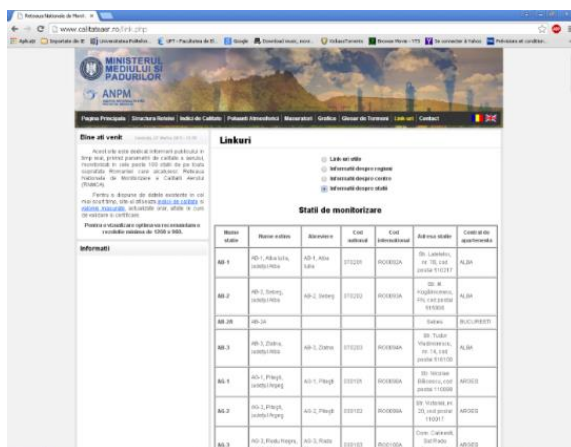


Figure 5. Operating with other stations on the network inside the selected area

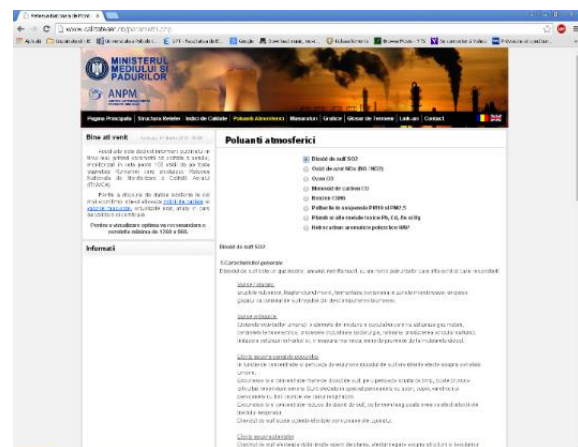


Figure 6. Selection of atmospheric pollution agents

From the “air pollutants” menus the users can extract and print all possible information about each pollutant measured in the station on the chosen day. Figure 6 shows us this possibility for selection.

4. Conclusions

This on-line system (including the Human-Machine Interface) was performed by our team from the Power Systems Department at the POLITEHNICA University in Timisoara in order to take measurements together with the National Environment Agency both for surveillance as well as for didactic purpose, mostly nearby Power Plants.

The methodology for using this system includes three stages:

- making measurements using the expert system for air quality monitoring;
- processing and analysis of the results provided by the expert system for air quality monitoring;
- taking some conclusions about air quality around the industrial objective.

Using the methodology described herein, for the teaching process, we noticed that it has been particularly effective for didactic purposes too.

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