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REVIEW

MODELLING AND SIMULATION OF DISPERSIONS OF POWDER EMISSIONS FROM MULTIPLE SOURCES WITH THE MATHEMATICAL MODEL *POL 15SM*

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Abstract. Over the last decades, air pollution has become one of the greatest challenges negatively affecting human health and the entire environment, including air, water, soil, vegetation, and urban areas. Lately, special attention has been given to mathematical modelling for diffusion of pollutants in the atmosphere as a particularly effective and efficient method that can be used to study, control and reduce air pollution. The diversity of models developed by different research groups imposed a rigorous understanding of model types in order to apply them correctly according to local or regional problems of air pollution phenomenon. Thus the authors have developed and improved two mathematical models for dispersion of air pollutants. This paper presents a case study of dispersion of powders in suspension originating from 14 point sources that correspond to 5 economic agents in the agroindustrial area of Vaslui city using a computer simulation based on the mathematical model *Pol 15sm,* for multiple point sources of pollution, designed by the authors.

Keywords: pollutant dispersion, dispersion models, air pollution, suspended powders, heavy metals, computer simulation.

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Introduction

Lately, a special attention has been given to studying the dispersion of pollutants emitted into the atmosphere by multiple or isolated pollution sources, operating continuously or accidentally, as it is increasingly evident that human activities have already produced a "disturbance" of the environmental balance (Carpentieri *et al.* 2011; Hanna 1981; Huang *et al.* 2011; Mezdrea-Cojocareanu-Pata *et al.* 2010; Miclaus *et al.* 2006).

Atmospheric emissions of heavy metals are deposited in the form of suspended powders on the ground at varying distances from the emission source, distances that depend on particle sizes and the intensity of air currents (Radulescu *et al.* 2010). Problems related to the presence in the environment of metallic elements in the environment are triggering a growing interest (Nisulescu *et al.* 2011; Stătescu, Cotiuşcă-Zauca 2006).

Areas with heavy metals contaminated soils around the industrial units differ in expansion due to intensity and duration of emissions, weather and geomorphologic aspects (Baldauf *et al.* 2009; Carpentieri *et al.* 2011; Gaba 2010; Miclaus *et al.* 2006).

In Romania, the calculation of pollutant emissions into the atmosphere is reflected in the methodology EEA/EMEP/CORINAIR and U.S. EPA/AP-42 for all business groups, including industrial point sources.

One way of knowing and subsequently taking action against air pollution is the mathematical modelling of pollutant dispersion into the atmosphere (Hanna 1981; Vătăşescu *et al.* 2011; Ani *et al.* 2012). This consists of

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estimating pollutants concentrations on soil and height accordingly with pollution sources characteristics, weather and geographic conditions, physical and chemical transformation processes that pollutants might have in the atmosphere and their interaction with the soil surface (Baldauf *et al.* 2009; Budianu, Macoveanu 2010; Carpentieri *et al.* 2011).

Insidious effects on medium and long term, regionally and even worldwide, can be caused by local polluting phenomena from a variety of "quasi-harmless" point sources. Considering them, especially in the last 30 years, scientific efforts have focused on detailed studying of transport and dispersion mechanisms of pollutants into the atmosphere and the consequences of these phenomena, without neglecting the measurement techniques of pollutants at source, adapted to various situations (Branquinho *et al.* 2008; Hanna 1981; Nisulescu *et al.* 2011; Stefan *et al.* 2013). The development and importance of mathematical models of pollutant dispersion are presented widely in specialized literature. Of the many models studied, four main types of models are distinguished: statistical/empirical, Gaussian (most used), Lagrangian and Eulerian (most complex) (Candelieri *et al.* 2012; Moreira *et al.* 2010; Pasquill 1961; Popescu *et al.* 2011; San Jose 1997; Smaranda, Gavrilescu 2008).

After analyzing these models, assessing the advantages, disadvantages, features, limitations and accessibility degree offered, computer simulations based on the mathematical models ECO95sp and *Pol 15sm* were used to calculate the pollutant dispersion in the atmosphere of Vaslui city (Nagacevschi, Macoveanu 1994, 1995, 1996, 2002; Nagacevschi *et al.* 1997).

The paper presents a case study on dispersion modelling of suspended powders emitted jointly by many point sources in the agroindustrial area of Vaslui, with calculating pollutant concentrations on immission for several set receptors, using *Pol 15sm* model.

1. Description of mathematical model *POL 15sm* and the accordingly simulation program

Using this Gaussian model for studying the dispersion of pollutants emitted by multiple sources is possible, continuing the study of pollutant dispersion originating from each individual point source, done using ECO95sp model. This is a logical follow-up of the fact that these 2 models have a complementary character; in addition, both use the same type of classification of atmospheric stability, the same division into 2 distinct types of terrain and, broadly, the same input requirements.

Like the mathematical model ECO95sp, *Pol 15sm* is a model for calculating dispersion of pollutants into the atmosphere, developed and tested as a computer simulation program in the Department of Chemical Engineering and Environmental Protection of Chemical Engineering and Environmental Protection Technical University "Gheorghe Asachi" of Iasi.

POL 15sm model is the base of a simulation program of concentration distribution for a pollutant emitted by several sources, well located, to a number of pollution receptors, also precisely located:

- maximum number of emitting point sources that the program can take into account – 15;
- maximum number of receptors that can be considered – 15.

Performances of the model can be best summarized by specifying the types of outputs; at each receiver point the following output are measured and played in the form of data:

- local concentration of pollutant due to emission of each source;
- total local concentration of pollutant, emitted by all sources considered;
- average local concentration, in the time interval of interest, due to each emission source;
- total average local concentration, in the time given.

Note that the first two categories of results are given periodically, with a period of maximum 15 hours, the modelling assumption formulated being that the average frequency weather changes is also periodically.

The stages of rolling are the classic ones, while the input required by *Pol 15sm* model needs:

- data describing the characteristics of each emission source in part (mass flow of pollutant emitted, total volumetric flow of exhaust gases, exhaust gas temperature, physical height of pollutant source, source coordinates to a fixed reference point);
- data describing the receptors considered (the number of receptors to pollutant immission concentration taken into account, the height of placement of every receptor considered, landmark coordinates to a fixed point, the nature of land);
- climatologically data (weather conditions, wind speed, air temperature).

To describe the model, it is said that both the input and the output are presented in tables in type ASCII text files: "POL.DAT" – for input data and "POL.REZ" – for output data. In term of input data required by the *Pol 15sm* model, these can be grouped in three categories:

a. "Sources" (valid for each emission source)

n_s = number of emission sources considered (n_s max. = 15);

Q = mass flow of pollutant emitted (mg/s);

Q_f = volumetric flow of "smoke" at emission (total gas flow emitted by each source), (m^3/s);

T_f = temperature of "smoke" at emission (exhaust gas temperature), (°C);

h = physical height of pollutant source, (m).

Sources coordinates set to a fixed reference point, were chosen accordingly:

- *cxs* = West-East coordinate, (m);
- *cys* = South-North coordinate, (m).

b. "Receptors" (valid for each receptor)

n_r = receptors number of pollutant concentration considered at emission (n_r max. = 15);

z = height of every receptor considered, (m).

Receptors coordinates, to the same fixed reference point chosen:

- *cxs* = West-East coordinate, (m);
- *cyr* = South-North coordinate, (m).

"Rural / Urban" = option regarding the terrain conditions for each source

c. "Hourly weather conditions"

n_o = number of considered hours (n_o max. = 15);

u = wind speed, (m/s);

θ = wind direction, from North, measured clockwise, (degrees);

(1–6) = class selected to define the atmospheric conditions (using all 6 Pasquill stability classes, as in the case of "ECO95sp" model);

T = atmospheric temperature, (°C).

To facilitate the use of the simulation program by people who do not have sufficient knowledge regarding the characterizing criteria stability/atmospheric turbulence state, within the program recommendations are stated regarding choosing classes for weather conditions, with values from "1" to "6". Thus, we considered I–VI cases, characterized below by the following conditions:

- case I – day, sun shining brightly, solar radiation within an angle wider than 60°;
- case II – day, sun shining moderately, solar radiation within an angle between 35° and 60° (so-called the "slightly covered" sky);
- case III – day, sun shining weakly, solar radiation within an angle slighter than 35° ("partially covered" sky);
- case IV – day/night (night/day) interval, cloudy sky
- case V – night, cloudy sky (cloudiness over 50%);
- case VI – night, partially cloudy sky (cloudiness below 50%).

Then, the appropriate class for characterization of certain atmospheric conditions is set, accordingly with the specifics of every situation of dispersion modelling considered, using Table 1.

Note that in the case of this model also, the value "1" (or "A") corresponds to the category "Highly unstable", and the value "6" (or "F") corresponds to the category "Highly stable", according to the classification made by Pasquill (1961).

In the input data for this program the main geographical characteristics (natural or anthropic) are not found. These can influence the dispersion of pollutants emitted in the atmosphere from a given source and they are:

- significant bumps of the terrain, located in the main propagation direction of the pollutant plume (geological formations of hill, mountains, deep and narrow valley, etc.);
- the existence in the area of significant water courses, lakes of important volume and surface, rich in vegetation areas (e.g. forests), whose presence somehow influence the micro-climate of areas more or less extensively;
- the presence, near the source, of constructions of important dimensions, especially in terms of height, which can induce local changes of direction and even speed of air flow with a role in training and dispersal of pollutants.

Unlike the U.S. AERMOD model, which is a model that applies to industrial sources and of the last generation, that already contains principles of planetary boundary layer, and *Pol 15sm* is a much simpler, easy to use software that requires no complex and expensive sites.

There are two input data processors that are regulatory components of the AERMOD modelling system: AERMET, a meteorological data preprocessor that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, and AERMAP, a terrain data preprocessor that incorporates complex terrain using USGS Digital Elevation Data. Other non-regulatory components of this system include: AERSCREEN, a screening version of AERMOD; AERSURFACE, a surface characteristics preprocessor, and BPIPPRIME, a multi-building dimensions program incorporating the GEP technical procedures for PRIME applications.

For *Pol 15sm* program selection in order to apply it with conclusive results for an industrial area (only for industrial point sources) a number of specific criteria were taken into account:

Criteria for the weather:

- the presence of atmospheric calm periods in over 24%;
- significant frequency of total and partial thermal inversions;
- the existence of periodic winds (NW and N wind);
- relatively high humidity conditions (favoring the occurrence of side effects for pollutants emitted).

Criteria for relief conditions:

- location in the Bârlad valley area – relatively flat surface;
- proximity to the relief of sub-Carpathians, with heights not exceeding 400 m and below 150 m altitude difference from the platform.

Criteria regarding emissions:

- the existence of emission sources with significantly different heights (between 12 m and 218 m);

- the existence of industrial buildings and constructions of moderate size, in the vicinity of emission sources of medium height, but at distances for which the existence of the building is not appreciated;
- different exhaust emissions, in favorable conditions, can lead to secondary reactions into the atmosphere, as the formation of another pollutant.

Other criteria:

- the importance of extending the assessment area within a radius of at least 40 km (to the border with Moldova);
- the opportunity to formulate conclusions based on modelling results, and consequences of historical pollution (e.g. damage quantification of buildings and civil engineering, possibly while assessing the impact on current health and the integrity of ecosystems potentially affected);
- the availability of models, both financially (since most of these models are only the demonstration, completing their purchase involves payment of substantial amounts) and in terms of logistics resources to be mobilized for their use.

The underlying mathematical model to the simulation program *Pol 15sm*, to calculate the dispersion of emitted pollutants into the atmosphere from multiple point sources, is described below:

1. Calculation of source – receptor distance in wind direction:

$$x_{rel} = cxr_j - cxs_i; \quad (1)$$

$$y_{rel} = cyr_j - cys_i; \quad (2)$$

$$x = x_{rel} \cdot \cos(\theta_k) + y_{rel} \cdot \sin(\theta_k); \quad (3)$$

$$y = \sqrt{\left(x_{rel}^2 + y_{rel}^2 - x^2\right)}, \quad (4)$$

cxr = West-East Cartesian coordinate, for receptors, (m);
cyr = South-North Cartesian coordinate, for receptors, (m);
cxs = West-East Cartesian coordinate, for point sources, (m);
cys = South-North Cartesian coordinate, for point sources, (m);
i = current point sources number;
j = current receptors number of pollutant concentration at imission considered;
θ = wind direction, from North, measured clockwise, (degree);
xrel, yrel = Cartesian projections of point source to receptor distance, (m);
x, y = projections of point source to receptor distance, on wind direction, (m).

2. Calculation of pollutant dispersion into the atmosphere:

$$\sigma_y = f_1(x, k); \quad (5)$$

$$\sigma_z = f_2(x, k), \quad (6)$$

σ_y, σ_z = pollutant dispersion on *y, z* directions, respectively.

3. Calculation of smoke plume height:

$$dh = f_3(x, k, i); \quad (7)$$

$$H_t = h_0 + dh, \quad (8)$$

H_t, h_0, dh = height of pollutant smoke plume (total, initial, increment), (m).

4. Calculation of concentration at receptor:

$$\psi_{i,j,k} = \frac{Q}{2\pi \cdot \bar{u} \cdot \sigma_y \cdot \sigma_z} e^{-0,5\left(\frac{y}{\sigma_y}\right)^2} \cdot \left[e^{-0,5\left(\frac{z-Ht}{\sigma_Z}\right)^2} + e^{-0,5\left(\frac{z+Ht}{\sigma_Z}\right)^2} \right], \quad (9)$$

– Q = mass flow of pollutant emitted (mg/s);
– u = wind speed, (m/s).

5. Calculation of averaged concentration:

$$\bar{\Psi}_{j,k} = \frac{1}{n_i} \sum_i^{n_i} c_{i,j,k}; \quad (10)$$

$$\bar{\Psi}_{i,j} = \frac{1}{n_k} \sum_k^{n_k} c_{i,j,k}, \quad (11)$$

– *i, j, k* = current index on x, y, z direction for receptor;
– $c_{i,j,k}$ = pollutant concentration in space at receptor, on wind direction, (mg/m^3);
– $c_{j,k}$, $c_{i,j}$ = averaged concentration on one direction, *x, k*, respectively.

Table 1. Weather condition classes assigning; correlation of weather conditions defined by cases I – VI, with wind speed

Case	Wind speed (m/s)				
	<2	between 2 and 3	between 3 and 5	between 5 and 6	>6
I	1	1;2	2	3	3
II	1;2	2	2;3	3;4	4
III	2	3	3	4	4
IV	4	4	4	4	4
V	5	5	4	4	4
VI	6	6	5	4	4

2. Method

2.1. The experimental part. Case study

Computer simulation of powders dispersion from multiple sources, using the *Pol 15sm* model, whose basic elements have been previously presented, was applied to 14 point sources, which belong to a number of 5 economical agents in the agroindustrial area of Vaslui city. It was necessary to correctly evaluate the total contribution of a specific pollutant, emitted by the group of sources with this characteristic and to establish the contribution of every source generating a certain type of pollutant, to "show" the total impact of that pollutants concentration at immission, determined in precisely set receiver points.

Encoding of the 14 point sources has been done as follows:

- S1–S3 for SC Stemar SRL Vaslui;
- S4–S9 for SC Termica SA Vaslui;
- S10 for Brick Factory SRL Vaslui;
- S11–S13 for SC Ulerom SA Vaslui; and
- S14 for SC Vascar SA Vaslui.

Six points were set – *initial receivers* in conjunction with existing fixed point for air quality monitoring from the network of Environmental Protection Agency Vaslui, so we can establish the territorial correspondence below:

- R1 – Point "APM headquarters";
- R2 – Point "Station Vaslui 1 – Public Finance Department Vaslui – urban background station";
- R3 – Point "Vaslui County Hospital";
- R4 – Point "Watewater Treatment Plant";
- R5 – Point "SC Termica SA Vaslui";
- R6 – Point "SC AMC Badotherm SA Vaslui".

As an additional element absolutely necessary for such a model, it is required to enter, in a certain form, the coordinates of emission sources, on West-East and South-North directions, that are ***cxs*** and ***cys***, set to a fixed reference point, chosen by user, as well as the coordinates for receptors on West-East and South-North directions, that are ***cxr*** and ***cyr***, set to the same reference point, called the "reference".

The input data entered in the modelling program in this particular case, to characterize the emissions of pollutants, the point sources and weather conditions are those presented in Table 2 and Table 3, specifying that the classification in stability classes was made considering the instructions in the presentation of *Pol 15sm* model, and the

Table 2. Input data – emission sources for *Pol 15sm* model

Emission sources	Geographical coordinates latitude/longitude	Q [mg/s]	Q [m^3/s]	T_f [°C]	h [m]	cxs [m]	cys [m]	Source encoding
SC Stemar SA Vaslui – chimney 1	46° 37' 8.352" 27° 43' 61.092"	0.3138	0.0707	110	12	0	0	S1
SC Stemar SA Vaslui – chimney 2	46° 37' 8.352" 27° 43' 61.092"	3.5357	0.2898	160	12	0	0	S2
SC Stemar SA Vaslui – chimney 3	46° 37' 8.352" 27° 43' 61.092"	3.3494	0.8588	100	25	0	0	S3
SC Termica SA Vaslui – chimney 1	46° 37' 35.4" 27° 43' 38.87	45.62	37.39	200	80	820	–495	S4
SC TermicaSA Vaslui – chimney 2	46° 37' 35.4" 27° 43' 38.87	4.82	4.15	160	60	820	–495	S5
SC Termica SA Vaslui – chimney 3	46° 37' 35.4" 27° 43' 38.87	199.3	4.91	95	16.5	820	–495	S6
SC Termica SA Vaslui – chimney 4	46° 37' 35.4" 27° 43' 38.87	164.4	4.91	95	16.5	820	–495	S7
SC Termica SA Vaslui – chimney 5	46° 37' 35.4" 27° 43' 38.87	118.4	1.76	95	16.5	820	–495	S8
SC Termica SA Vaslui – chimney 6	46° 37' 35.4" 27° 43' 38.87	328.9	4.91	95	16.5	820	–495	S9
SC Fabrica de caramizi SRL – chimney 1	46° 37' 46.25" 27° 43' 13.84"	156.0065	2.1488	95	12	1150	–1050	S10
Sc Ulerom SA Vaslui – chimney 1	46° 38' 41.52" 27° 43' 22.24"	0.5089	0.2827	174	25	1300	350	S11
Sc Ulerom SA Vaslui – chimney 2	46° 38' 41.52" 27° 43' 22.24"	0.5089	0.2827	174	25	1300	350	S12
Sc Ulerom SA Vaslui – chimney 3	46° 38' 41.52" 27° 43' 22.24"	43.1027	0.3848	160	218	1300	350	S13
Sc Vascar SA Vaslui – chimney 1	46° 37' 38.22" 27° 43' 65.59"	2.4504	0.6126	160	45	1200	100	S14

Table 3. Input data – receptors for ***Pol 15sm*** model

Receptors	Geographical coordinates latitude/longitude	h [m]	cxr [m]	cyr [m]	Terrain conditions regarding the source (rural/urban)	Receptor encoding
APM Vaslui	46° 38 '19.827" 27° 43'21.788"	1.5	2170	1000	urban	R1
Stația Vaslui 1	46° 37'55.777" 27° 43'51.307"	1.5	1450	800	urban	R2
Vaslui County Hospital	46° 38' 18" 27° 45' 61"	1.5	2250	2700	urban	R3
Statia de Epurare Vaslui	46° 37' 25" 27° 13' 65"	1.5	–515	–1050	urban	R4
SC TermicaA SA Vaslui	46° 37' 29.8 27° 43'61.092"	0	650	0	urban	R5
SC AMC Badotherm SA Vaslui	46° 38' 25.84" 27° 42' 51.404"	0	2450	–1500	urban	R6

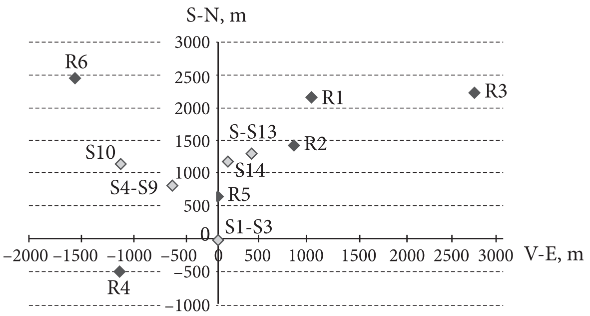
simulation was realized taking into account two categories of weather conditions: unstable and highly stable.

The geographical coordinates of the emission point sources considered (S1–S14), as well as the coordinates of receptors R1–R6 have been determined directly on field, using a GPS system. To facilitate calculation and subsequent graphic representations, the reference, (fixed or zero point) with the coordinates: 46° 37' 8,352" / 27° 43' 61,092", was established in the same place as the sources S1, S2, S3, the *Pol 15sm* model not introducing any interdiction or restriction in this regard.

Figure 1 shows the scheme for territorial arrangement of multiple sources and industrial receptors – points, by reporting to a fixed reference point, chosen by the user as input data for the program – reference point with the coordinates of SC Stemar SA Vaslui (S1–S3).

For every receptor, the output data provide by the model as strings of data that indicate:

- local concentration of pollutants due to every emission source;



S1-S3 – SC SETMAR SRL
S4-S9 – SC TERMICA SRL
S10– SC bricks factory SRL
S11-S13 – SC ULEROM SA
S14 – SC VASCAR SA

R1 – APM headquarter point
R2 – Vaslui 1 station – public finances direction point
R3 – Vaslui county hospital point
R4 – wastewater treatment plant point
R5 – SC TERMICA SA Vaslui point
R6 – SC AMC badotherm SA Vaslui point

Fig. 1. Scheme for territorial arrangement of multiple sources and industrial receptor – points, by reporting to a fixed reference point

- total local concentration of the pollutant due to emission of all sources considered.

Data were then selected and processed in table and graphic form, to become more relevant and accessible for analysis and to formulate correct and coherent conclusions.

3. Results and discussions

Using the processing facilities of this model tables and graphic representations for 10 different situations depending on weather conditions, have been made. Linking the data and information regarding the emission sources and the receptors with data and information regarding the direction and speed of air currents in Vaslui area, it is observed that:

- prevailing wind in the agroindustrial area of Vaslui is North-West, with an average of 18.5% out of total per an and a higher share (over 50% of the time) in the hot season;
- second prevailing wind – with a share of only 17.1% – is the wind from the North;
- in this evaluation of air currents characteristics in the agroindustrial area, a special place is occupied by the atmospheric calm with a share of over 24% a year's total.

In these conditions, returning to placement scheme of sources and receptors, some assessing guidelines to analyze the modelling results obtained using the simulation program for multiple sources *Pol 15sm* can be stated:

- with the prevailing wind direction from N-V. R5receptors are partially influenced by emissions of sources S4. S5. S6. S7. S8. S9 and S10 and not at all – influenced by emissions of sources S1. S2. S3. S11. S12 and S13;
- considering the next direction as a share, respectively the wind from N. In this case the receptors R5 and R4 are influenced by the emissions generated

by sources S4, S5, S6, S7, S8, S9, S10, S11, S12, S13 and S14;
- in situations of atmospheric calm, characterized by wind speeds under 1 m/s and without a definite prevalence of air currents direction (situations frequently accompanied by temperature inversion phenomena), an estimation of the influence shared of each source on the considered receptors cannot be a sufficiently exact. In this case, dispersion conditions must be taken into account, in approximately equal proportions. The direction of air currents in the studied area was also considered in connection with the effect of pollution source on each receptor, respectively – in the order to find the average frequency recorded in one year:
  - North-West wind – sources influence on receptors R5;
  - South-East wind – sources influence on receptors R6 ;
  - North-East wind – sources influence on receptors R4. R5;
  - North wind – sources influence on receptors R4. R5;
  - South-West wind – sources influence on receptors R1. R2. R3. R5.

Each of the four dominant wind directions has been considered for two atmospheric stability categories, selected as indicated by *Pol 15sm* model and according to weather characteristics of the investigated area, namely unstable and stable atmosphere.

Further, analyzing graphics and tables for modelling the dispersion of suspended powders from the multiple sources for ten of these cases, it is found that:

***A.** If atmosphere is unstable:*

For wind direction from W to E:
- in receptors R1. R2. R3 and R6 there is no contribution of any powders generating sources. reason for which the total concentration of powders at emission considered in these receiver-points is zero;
- at R4 receptor dust emissions arrive from sources S4. S6. S7. S8. S9. S10;
- at R5 receptor dust emissions arrive from sources S12. S13. S14.

For wind direction from N-W to S-E:
- in receptors R1. R2. R3. R4 and R6 there is no contribution of any powders generating sources. reason for which the total concentration of powders at emission considered in these receiver-points is zero;
- at R5 receptor dust emissions arrive from sources S4. S5. S6. S7. S8. S9. S10.

For wind direction from S-E to N-W:
- in receptors R1. R2. R3. R4 and R5 there is no contribution of any powders generating sources. Reason for which the total concentration of powders at emission considered in these receiver-points is zero;
- at R5 receptor dust emissions arrive from S4. S6. S7. S8. S9. S10 and S13.

For wind direction from N-E to S-W:
- at R1 receptor dust emissions arrive from sources S5. S6. S7. S8. S9. S10. S13 and S14;
- at R2 receptor dust emissions arrive from S4. S5. S6. S7. S8. S9. S10 and S14;
- at R3 receptor dust emissions arrive from S6. S7. S8. S9 and S14;
- in receptors R4, R5, R6 there is no contribution of any powders generating sources to the total concentration of powders at emissions, this being considered null.

Figure 2 is a data combination of Table and diagram and summarizes the distribution of powders emissions from the 14 sources in "less unstable" atmospheric conditions**.**

Reviewing all these observations and correlating them with the results of air quality monitoring, obtained by the surveillance network of the Environmental Protection Agency Vaslui, especially for period of 2000–2009, it is understandable why the annual frequency of powders exceedance registered in monitoring points is so small (not exceeding a maximum of 7% per year). Although, in this time, all said sources have almost continuously emitted powders with concentrations at emission that do not exceed with a lot the maximum allowed, though it happens.

Basically, the location of network points has partially captured the individual and cumulative influence of selected sources, on one wind direction, that is not the prevailing one (from N-E to S-W).

***B.** If stable atmosphere:*

For wind direction from S-W to N-E:
- in receptors R1. R2. R3. R5 and R6 there is no contribution of any powders generating sources to the total concentration of powders at emissions. this being considered null;
- at R4 receptor dust emissions arrive from S11.

For wind direction from S to N:
- in receptors R1. R2. R3. R4 R5. R6 there is no contribution of any powders generating sources to the total concentration of powders at emissions, this being considered null.

For wind direction from E to V:
- in receptors R1. R2. R3 and R4 there is no contribution of any powders generating sources to the total concentration of powders at emissions, this being considered null;
- at receptor R5 dust emissions arrive from S1. S2. S3;

Powders concentrations generated by the 14 sources to receptors R1–R6 in certain weather conditions											
Receptor No.	Weather conditions				Powders concentration [µg/m³]						
	Wind			T	Source	R1	R2	R3	R4	R5	R6
	Speed [m/s]	θ [degrees]	Pasquill stability classes	[°C]							
R1	5	45	1	10	S1	0.000	0.000	0.000	0.000	0.000	0.000
R2	5	45	1	10	S2	0.000	0.000	0.000	0.000	0.000	0.000
R3	5	45	1	10	S3	0.000	0.000	0.000	0.000	0.000	0.000
R4	5	45	1	10	S4	0.000	0.004	0.000	0.000	0.000	0.000
R5	5	45	1	10	S5	0.001	0.001	0.000	0.000	0.000	0.000
R6	5	45	1	10	S6	0.025	0.025	0.002	0.000	0.000	0.000
					S7	0.021	0.021	0.002	0.000	0.000	0.000
					S8	0.016	0.015	0.001	0.000	0.000	0.000
					S9	0.042	0.042	0.003	0.000	0.000	0.000
					S10	0.007	0.001	0.000	0.000	0.000	0.000
					S11	0.000	0.000	0.000	0.000	0.000	0.000
					S12	0.000	0.000	0.000	0.000	0.000	0.000
					S13	0.011	0.000	0.000	0.000	0.000	0.000
					S14	0.001	0.006	0.001	0.000	0.000	0.000
					Total concen-trations for receptor	**0.125**	**0.118**	**0.010**	**0.000**	**0.000**	**0.000**

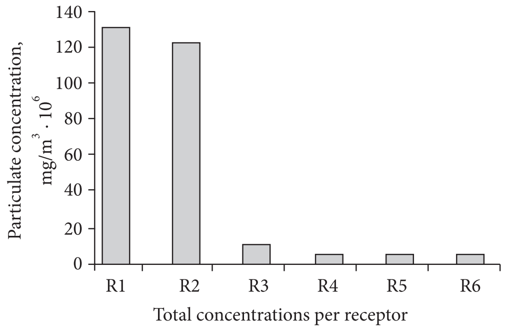


Fig. 2. Data and graphical representation for distribution of powders emissions from the 14 sources in “highly unstable” atmospheric conditions

Concentrations of powders generated by the 14 sources at receptors R1–R6 for certain atmospheric conditions											
Receptor No.	Weather conditions				Concentration of powders [µg/m³]						
	Wind			T	Source	R1	R2	R3	R4	R5	R6
	Speed [m/s]	E [degrees]	Pasquill stability class	[°C]							
R1	1	0	5	15	S1	0.000	0.000	0.000	0.000	0.000	0.000
R2	1	0	5	15	S2	0.000	0.000	0.000	0.000	0.000	0.000
R3	1	0	5	15	S3	0.000	0.000	0.000	0.000	0.000	0.000
R4	1	0	5	15	S4	0.000	0.000	0.000	0.000	0.000	0.000
R5	1	0	5	15	S5	0.000	0.000	0.000	0.000	0.000	0.000
R6	1	0	5	15	S6	0.000	0.000	0.000	0.000	0.014	0.000
					S7	0.000	0.000	0.000	0.000	0.000	0.000
					S8	0.000	0.000	0.000	0.000	0.000	0.000
					S9	0.000	0.001	0.000	0.000	0.000	0.000
					S10	0.000	0.324	0.000	0.000	0.000	0.000
					S11	0.000	0.000	0.000	0.000	0.000	0.000
					S12	0.000	0.000	0.000	0.000	0.000	0.000
					S13	0.000	0.000	0.000	0.000	0.000	0.000
					S14	0.000	0.000	0.000	0.000	0.000	0.000
					Total concen tration for receptor	**0.000**	**0.325**	**0.000**	**0.000**	**0.062**	**0.000**

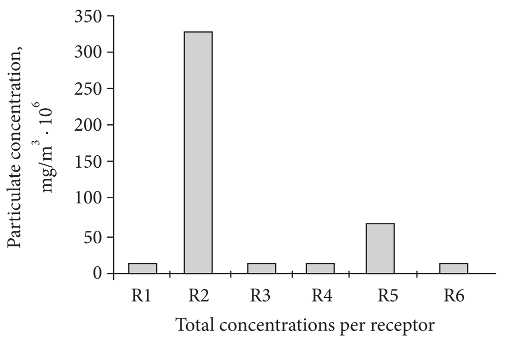


Fig. 3. Data and graphic representation for distribution of powders emissions from 14 sources in atmospheric condition “highly stable”

– at receptor R6 dust emissions arrive from S9. S10 and S11.

For wind direction from N to S (Fig. 3):

– in receptors R1. R3. R4. R6 there is no contribution of any powders generating sources to the total concentration of powders at emissions, this being considered null;

– at receptor R2 dust emissions arrive from S9 and S10;

– at receptor R5 dust emissions arrive from S6. S7. S8. S9.

Figure 3 is a combination of Table and diagram that summarizes the distribution of powders emissions from the 14 sources in "highly stable" atmospheric conditions.

In terms of influence areas and the intensity of impact made by every point source, it can be concluded that:

– total concentrations on receptors from all 14 sources, calculated with the simulation program *Pol 15sm* for multiple emission sources, are well below maximum admitted limit, and are between 0.004 and 0.076 micrograms/cubic meter;

– the calculations were done for the majority of weather conditions encountered in Vaslui city – from atmospheric calm to strong wind – for both models. In none of the situations maximum allowed concentrations have been reached;

– in any case, maximum concentrations at emission are, without exception, well below maximum allowed limits for suspended powders;

– results of dispersion of suspended powders that contain heavy metals using the simulation program *Pol 15sm* are consistent with those determined experimentally by the Environmental Protection Agency Vaslui over time and are a justification for reduction of monitoring points for air quality.

Conclusions

1. Dispersion modelling has been studied for 14 point sources of emission, from 5 economic agents: SC Stemar SRL Vaslui, SC Termica SA Vaslui, Fabrica de cărămizi SRL Vaslui, SC Ulerom SA Vaslui and SC Vascar SA Vaslui, with an original mathematical model of pollutants dispersion, which is the *Pol 15sm* model. Based on this model, a simulation program for a chosen pollutant's dispersion, emitted simultaneously by multiple sources has been made. As a result, pollutant concentrations at emission for many set receptors has been obtained.

2. The maximum number of usable sources in the same time (15) by the simulation program, as well as the maximum number of receptors that can be set (15) covers the needed investigations for industrial platforms. This, together with the fact that the model implies a plain input data, easy to introduce and accomplish, recommends the use of the model for very simple flat-land scenarios.

3. The POL15sm model application, as a tool for analyzing the problems of air pollution, provides a significant reduction in both cost and time than the application for other models (e.g. AERMOD) making possible the estimation of human activities' impact on the environment cheaper and faster.

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