MATHEMATICAL MODEL OF ATMOSPHERE POLLUTION IN YEREVAN CAUSED BY INDUSTRIAL EMISSIONS

Dr. Hamlet Melkonyan[1], Ani Melkonyan[2]
Scientific Applied Centre of Hydrometeorology and Ecology, Armstatehydromet
Yerevan, Armenia

For the solution of the task, the equation for distribution of admixture is as follows:

$$\frac{\partial\varphi}{\partial t}+u\frac{\partial\varphi}{\partial x}+V\frac{\partial\varphi}{\partial z}+w\frac{\partial\varphi}{\partial z}+p\varphi-\frac{\partial}{\partial x}k_x\frac{\partial\varphi}{\partial x}-\frac{\partial}{\partial y}k_y\frac{\partial\varphi}{\partial y}-\frac{\partial}{\partial z}k_z\frac{\partial\varphi}{\partial\varphi}=F(x,y,z,t)$$
(1)

Where**:** φ - concentration of admixture in the air; t - time; x,y,z - decartian coordinates; the axes Ox and Oy are located in a horizontal plane, the axis Oz is directed vertically upwards; u,v,w - wind velocity according to these axes; k_x,k_y,k_z - coefficient of horizontal and vertical components exchange., p - parameter describing changes of admixture concentration during transformations, connected with the life time of substation.

$F(x,y,z,t)$ - of pollution sources,

The area Ω Is set in the following kind:

$$\Omega=\{(x,y,z):0\le x\le L_x, 0\le y\le L_y, z_0(x,y)\le z\le z_0(x,y)+H\},$$

Where $z=z_0(x,y)$ (spreading surface) and $z=z_0(x,y)+H$ - equation of the bottom and top borders of the area Ω, and L_x,L_y - its horizontal scales.

The border conditions on a vertical enter is recorded in the following way:

$$k_z\,\partial\varphi/\partial z-\beta\varphi=0,\quad \text{at } z=z_0(x,y), \qquad (2)$$
$$\varphi=0,\quad \text{at } z=z_0(x,y)+H.$$

β characterizes interaction of admixture with a spreading surface.

Considering the horizontal sizes of area Ω as rather large, on the other L_x, L_y borders of the Ω area are accepted as zero boundary conditions:

$$\varphi\big|_{L_x,L_y}=0. \qquad (3)$$

primary condition is presented as:

$$\varphi\big|_{t=0}=\varphi(x,y,z). \qquad (4)$$

The primary condition (4) together with the border conditions (2) and (3) allows to set forth the only solution (1), if the function $F(x,y,z,t)$ is known.

The task (1) - (4) is solved numerically. For making an algorithm the curved area of integration is brought to rectangular means of replacement of variables. As a different scheme the obvious scheme of Djufor-Frankel was taken [1].

This scheme was used for dispersion of harmful admixture, thrown by industrial enterprises and energy power stations in Yerevan. Let's describe some details of application of the given scheme. The considered area is a horizontal section on axis Oy -17,5 kms, and on axis Ox - 16 kms. It is broken on a square net with a step 500 m, on axis Ox -32, on axis Oy - 35 of calculated units. By each unit of a net the relief height is determined which is the entrance parameter of the model. These data are taken from the relief card in scale 1:10000. The following entrance data are the fields of wind velocity, of which the accuracy of spreading and distribution of polluters depends. The estimations were carried out on the climatic data of wind on the ground, and by height at the second level, which was accepted by Dicon's law at the following three levels; the velocity is taken from the data of Yerevan radiosonde with 10-year's period in average. Other parameters and coefficients of considered scheme are described in [1]. The step for time was accepted as Δt = 2 minutes, based on conditions of stability of the scheme of estimation.

<u>The choice of mixing turbulent coefficient</u> For finding the turbulence vertical component for the territory of Armenia a number of methods were used and their amounts were verified by forwarding observations. According to M. Budiko k_z in a near-earth layer of air is decided in the following ratio;

$$k_z = k_1 \frac{z}{z_1}\sqrt{1-\overline{Ri}}$$

where k_1 is the value of k_2 in the height of z_1, R_i is Richardson's mean value in the limited layer;

$$R_i = \frac{g(\partial t|\partial z)}{t_\alpha(\partial u|\partial z)}, \qquad u = u_1 \frac{\ln\left[\dfrac{z+z_0}{z_0}\right]}{\ln\dfrac{z_1+z}{z_0}}$$

where t is temperature expressed by ^{0}C, t_a- temperature by absolute scale, g- the acceleration of gravity.

It is enough to have the projections of wind speed $\bar{u}$ (z) and turbulent exchange K (z) for calculating the concentration in a near-earth layer, for which during the calculation the following ratio were used;

$$K_z = \begin{cases} v + k_1 \dfrac{z}{z_1} & when \quad z \le h \\ v + k_1 \dfrac{h}{z_1} & when \quad z \succ h \end{cases}$$

where z_o-the parameter of roughness, h- the height of near-earth layer, u_1-wind speed on the height of z_1, v- the coefficient of molecular diffusion, k_1 and h amounts are taken from Berliand. For convective conditions k=0.1-0.2 m/sec. when z=1m and h=50-1000m. Using these ratios and data, in northern regions of Armenia the value of k_z is oscillating within 3-5cm^2/sec.

It is important to put this model for estimating the background of pollution in the cities of Armenia, proceeding from last 15 years change conditions of producing enterprises and transport.

This method is used for town-planning areas and standardization of emissions.

Model calculation For substantiation of a priority list of enterprises of Yerevan being the basic investors in pollution of air basin of the city, were used the data about mass emissions of pollutants in atmosphere for 1990, according to the data of Ministry of Nature Protection of Armenia. In result were analyzed and classified the data over 172 enterprises polluting the air basin of Yerevan.

By consideration of a general picture of air pollution of Yerevan the mass emissions of 43 enterprises were taken into account. It is necessary to mark, that the dispersion range of power of enterprise emissions of the city oscillates from ten thousand ton/year (for example, the annual emission of WEC makes about 15 thousand тon/year) up to several honeycombs kg/year for small- enterprises. Therefore, for calculations of distribution of pollution the sources were selected, the annual gross emission of which was higher than 10-20 т/years, which approximately makes 1-2 g/sec. It is necessary to mark, that the power of enterprises which are not taken into account makes less than 0,5-1 % of all emissions, i.e. they, naturally, can not have an essential influence on qualitative and quantitative structure of distribution of emissions over the city. These sources of emissions were clustered in 7 basic groups. They encompass all basic sources of emissions of Yerevan.

Let's pass to discussion of results of numerical calculations. Integration over time was made on separate groups of sources up to an output of the solution to a semipermanent mode. The purpose of the present concrete problem is the necessity of regularity research of distribution of pollution and their transformation under influence of a relief of territory in conditions of constant, climatic speed and wind direction. For research of temporary transformation of pollution with allowance of contribution of separate groups of sources, the calculations were conducted separate in each group, with the subsequent summation of concentration values of impurity in clusters of a computational grid over the all city as a whole.

At calculations of distribution of pollution, the fields of impurity concentrations were set to norms on maxima of values of concentrations on all computational area.

The maximum values of concentrations are also adduced.

As the calculations were conducted on climatic values of a wind, which in a ground layer does not exceed 2 m/sec (calm situation), the distribution of impurity descends basically at the expense of turbulence and effect of influencing of a relief and qualitatively describes a general picture of pollution at unfavorable meteorological conditions.

The lack of calculations is the rigid boundary conditions in horizontal direction. Therefore, in the prospect, it is necessary to decide illogical problems for large regions, for controlling the solutions on boarders of the region more correct. In future it is expedient to conduct calculations on separate ingredients of emissions for exposure of more polluted districts of the class of dangerous contaminant.

THE LITERATURE

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Filed of an atmosphere pollution of Yerevan is normalized on maximum.