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ASSESSMENT OF ENVIRONMENTAL POLLUTION OF GASEOUS EMISSIONS OF CHEMICAL PLANTS BY MATHEMATICAL MODELING

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Abstract

Mathematical modeling of an environmental pollution by emissions of an industrial enterprise has been spent with using empiric model of Pasquille-Gifford. Spatial distribution of the aerosols in the near surface layer of the atmosphere was determined. Scattering of pollutants in the atmosphere with the indication of spray concentration were obtained..

Keywords: *mathematical modeling, pollution, aerosols, maximum permissible concentration, industrial emissions.*

1. Introduction

At present all labor processes cause anthropogenic change of nature. Notwithstanding the variety of anthropogenic processes in different countries and on different continents, differentiated man – induced flows integrate finally in the objects of geo- and biosphere causing global-scale ecological risks. Pollution and contamination of atmosphere, waters, soils, caused by industrial wastes and other substances and followed by changes of ecological balance present an enormous threat. Occasionally air pollution leads to disasters similar to large-scale natural ones. The total capacity of anthropogenic of real ecological situations on the basis of the data of control of the man-induced changes of the environment present one of the main tasks of engineering-ecological analysis of nature-technical geological systems [1-5].
There is no generally accepted method of evaluation of impact on the environment which allows characterization of an enterprise construction project as well as an enterprise activity in the period of operation. An unbiased evaluation of the system state rests on the group of indices, having a different physical nature and basing on different methods of measurements and control.

2. Materials and methods

Original statistical material for the mathematical modeling were data obtained during normal operation of industrial processing enterprise phosphorous rocks of Kazakhstan. In this study we used the model Paskuill-Gifford, as it is simple and has the official status (it is a working model of the International Atomic Energy Agency, IAEA). It is useful to realize, even if you plan to create more advanced models.

3. Results and discussion

Evaluation through mathematical modeling of an environmental pollution by aerosols caused by the industrial enterprise manufacture of thermal phosphoric acid is given in the present article.

In the present time in the Republic of Kazakhstan for calculation the air pollution are mainly use methods of numerical modeling devoted to the dispersion of contaminants in the atmospheric boundary layer [6-8]. In conditions of changing climatic indicators, of using of new laws and regulations environmental documents and fundamentally new approaches to the protection of the environment and, in particular, to the protection of the atmosphere, it is necessary to use in the Republic of Kazakhstan mathematical modeling that dominate in almost all developed countries and have official status.

With the aim of quantitative evaluation of atmosphere pollution by aerosols we have used Pasquille-Gifford empiric model based on the assumption of constant interference-free point source of a definite capacity having homogenous characteristics of atmospheric dispersion (equation number 1). This model is based upon the conception of concentration of admixture emitted by a constant point source into atmosphere as of a stream with vertical Gaussian distributions and transverse to wind:

$$q(x,y,z)=\frac{Q}{2\pi\sigma_y(x)\sigma_z(x)u}\times f_F f_W \times \exp(-\frac{y^2}{2\sigma_y{}^2(x)})\times(\exp(-\frac{(z-h)^2}{2\sigma_z{}^2(x)})+\exp(-\frac{(z-h)^2}{2\sigma_z{}^2(x)})) \quad (1)$$

where q – admixture concentration in the given point of space, mg/m^3; *x,v,z* – Cartesian coordinates, axis *z* – up -, axis *x* – downwind; Q - source of emission capacity, g/c; $\sigma_y(x)\sigma_z(x)$ - vertical and transverse dispersions of admixture cloud; *u* – wind velocity averaged for the layer of mixing, m/c; f_f and f_w – deduction for cloud depletion at the expense of dry deposition of admixture and its scavenging h - effective altitude of the source, m (i.e. altitude with consideration of the original rise of the overheated stream). Exponents sum in this formula corresponds to the ground surface not absorbing the admixture, in case of absolute absorption exponents the difference is observed. The main content of the model is presented by numerous summarizing experimental data, specific functions $\sigma_y(x)$ and $\sigma_z(x)$ and expressions for h, f_f and f_w.

Actually sources of emission are not exactly point sources, but for the purposes of simplification of mathematical description it is possible to assume they are. The nature of specification of the chosen model allows taking into consideration the peculiarities of local meteorological conditions and calculate the distribution of the pollutants concentration in current meteorological conditions at various values of emission capacity [9, 10].

In this work we have used the data on technical characteristics of the emission sources and averaged value of aerosols in the conditions of its actual operation. Calculations were made by means of universal integrated suite MATLAB [11].

As the emissions contain simultaneously several substances having their own corresponding maximum concentration limits values (MCL) with concentration C_i (*i=1,2,3…n*), it seems necessary to determine the distribution of the total concentration of aerosols of pollution agents emitted by the enterprise.

Total dimensionless spray concentration (*q*) is determined by the following formula ‘(equation number 2):

$$q=\frac{c_1}{MCL_1}+\frac{C_2}{MCL_2}+\frac{C_3}{MCL_3}+...+\frac{C_n}{MCL_n}, \quad (2)$$

where C_1, C_2, …, C_n are harmful substances concentrations in the atmospheric air in one and the same point of the area, mg/m^3 ; MCL_1, MCL_2, …, MCL_n are corresponding maximum concentration limits of harmful substances in the atmospheric air, mg/m^3 [12].

As the maximum environmental pollution takes place in the conditions of calm, we calculated for the wind velocity of 0.1 m/s, i.e. in conditions close to calm.

Fig. 1 demonstrates spatial dispersion of polluting agents in the atmosphere. Emission source point corresponds to the coordinates *x* = 0, *y* = 0. Wind direction is aligned with the direction of axis *x.* It is shown that the aerosols is distributed over the whole territory adjacent to the plant gradually decreasing with the distance from the source of emission down to 0,05-0,1 fractions of MCL at the range of 20 km.

The model allows prediction of the degree of atmospheric air pollution at different emission capacities and to obtain the data on the distribution of polluting aerosols and determine the zones of danger for human beings. Calculations for the emission capacity in the outlet of the conventional source equaling to 8,5 fractions of MCL demonstrated, that in the situation, close to calm, the aerosols concentration no exceeds MCL and in the residential area makes 0.16 fractions of MCL (Fig. 2).

Thus, the presented results of the calculation of the spray dispersion in the near-surface layer of the atmosphere using the empiric model of Pasquille- Gifford allows prediction the distribution of toxic substances concentration within the area, i.e. allows to single out the most dangerous sites of the contaminated area. The feasibility of singling out the areas most harmful for human health is realized.

4. Conclusions

1. Evaluation of the degree of the atmospheric pollution by emissions of aerosols caused by emissions of industrial enterprise in the near surface layer of the atmosphere was determined with using empiric model of Pasquille-Gifford

2. The opportunity to predict the pollution of surface air at various degrees of intensity of polluting agents emissions is shown.

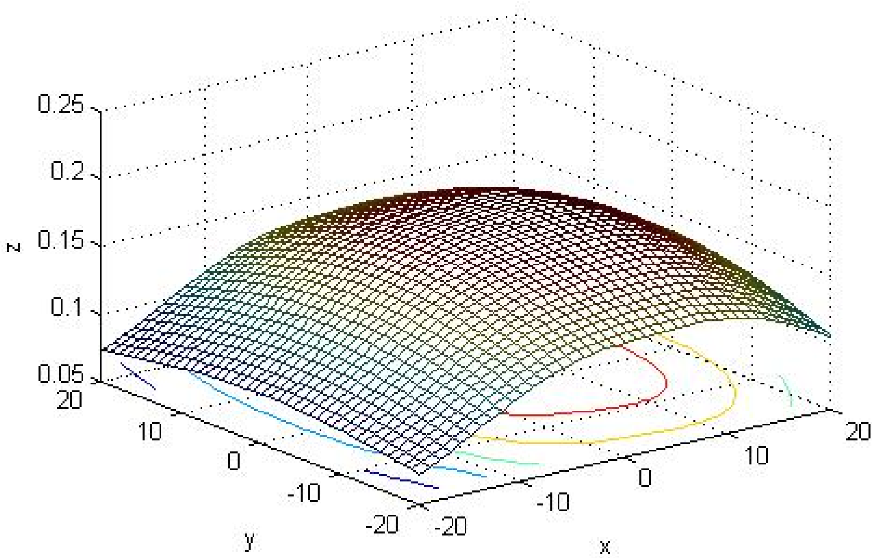

Fig.1. Spatial distribution of the aerosols in the near surface layer of the atmosphere. Axes *x* and y - distances, kms; axis z – concentration, fractions of MCL. Conventional point source of emission corresponds to coordinates x =0, y =0.

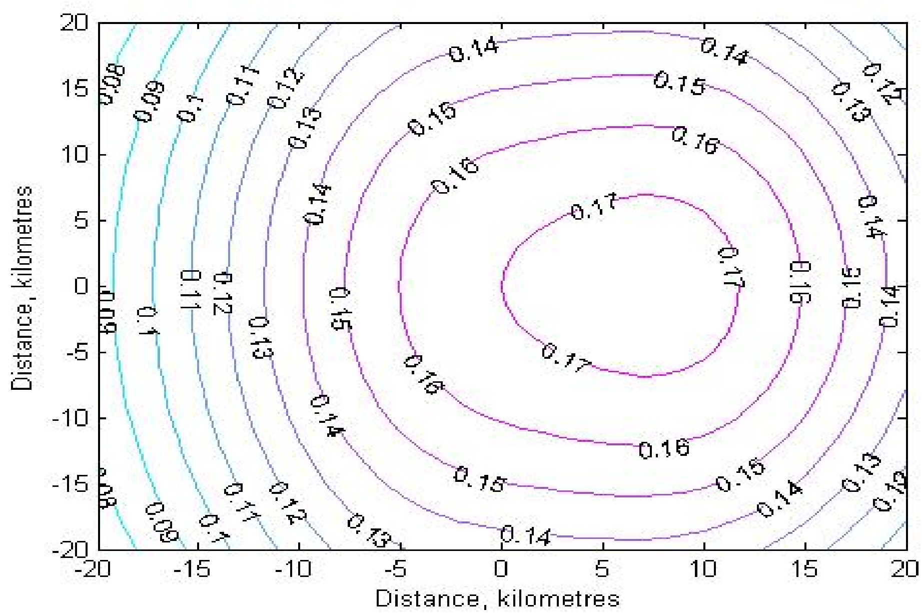

Fig.2. Aerosols distribution in the near-surface layer of the atmosphere with the indication of areas of danger. On the curves the values of dimensionless total concentration of spray in the fractions of MCL are shown.

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