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MATHEMATICAL MODELING OF THE PROCESS OF DISTRIBUTION OF HARMFUL SUBSTANCES IN THE ATMOSPHERE, TAKING INTO ACCOUNT THE DIFFUSION COEFFICIENTS

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Annotation. In this study, mathematical modeling was carried out to calculate the diffusion process of harmful substances in the atmosphere, taking into account diffusion coefficients such as wind speed, particle size, and temperature.

Keywords: atmosphere, wind speed, particle size, temperature, advection-diffusion.

МАТЕМАТИЧЕСКОЕ МОДЕЛИРОВАНИЕ ПРОЦЕССА РАСПРОСТРАНЕНИЯ ВРЕДНЫХ ВЕЩЕСТВ В АТМОСФЕРЕ С УЧЕТОМ КОЭФФИЦИЕНТОВ ДИФФУЗИИ

Аннотация: В данном исследовании при расчете процесса диффузии вредных веществ в атмосфере было проведено математическое моделирование с учетом таких коэффициентов диффузии, как скорость ветра, размер частиц и температура.

Ключевые слова: атмосфера, скорость ветра, размер частицы, температура, адвекция-диффузия.

ATMOSFERADA ZARARLI MODDALARNING TARQALISH JARAYONINING DIFFUZIYA KOEFFITSIYENTLARINI INOBATGA OLIB MATEMATIK MODELLASHTIRISH

Annotatsiya: Ushbu tadqiqotda atmosferadagi zararli moddalarning tarqalishida, diffuziya jarayonini hisoblashda shamol tezligi, zarrachalar o‘lchami va harorat kabi diffuziya koeffitsentlarini hisobga olgan holda matematik modellashtirildi.

Kalit so‘zlar: atmosfera, shamol tezligi, zarracha o‘lchami, harorat, adveksiya-diffuziya.

Introduction. When modeling the process of transfer of harmful substances in the atmosphere the main aspects are considered [1, 448-2, 103-116]: source of pollution, its description, the presence of natural and artificial obstacles, terrain relief, taking into account the influence of chemical reactions and changes, physical and mechanical properties during the transfer of harmful substances into the atmosphere, meteorological conditions, washing away by precipitation, settling in the soil, on the water surface, etc., the existing base for comparing the impact of motor vehicles on the urban environment (for example, - per person in terms of compliance with sanitary and hygienic limits, permissible concentrations).

Mathematical modeling of the distribution of harmful substances in the atmosphere, taking into account the diffusion coefficients. The advection-diffusion equation is proposed for

monitoring and predicting the process of distribution of harmful substances in the atmosphere. The numerical method is represented by an explicit finite difference scheme. [3, 303-309, 4, 17-32, 5, 27-40].

$$\frac{\partial\theta}{\partial t}+u\frac{\partial\theta}{\partial x}+v\frac{\partial\theta}{\partial y}+\left(w-w_g\right)\frac{\partial\theta}{\partial z}+\theta(\sigma+\alpha)=$$

$$=D_x\left(T,|u|,d_p\right)\frac{\partial^2\theta}{\partial x^2}+D_y\left(T,|v|,d_p\right)\frac{\partial^2\theta}{\partial y^2}+D_z\left(T,\left|w-w_g\right|,d_p\right)\frac{\partial^2\theta}{\partial z^2}+Q, \tag{1}$$

initial and boundary conditions:

$$\theta\big|_{t=0}=\theta^0, \tag{2}$$

$$\left.\frac{\partial\theta}{\partial x}\right|_{x=0}=\frac{\theta_{Ex0}(t)-\theta\big|_{x=0}}{l_x},\quad \left.\frac{\partial\theta}{\partial x}\right|_{x=L_x}=\frac{\theta_{ExL}(t)-\theta\big|_{x=L_x}}{l_x},$$

$$\left.\frac{\partial\theta}{\partial y}\right|_{y=0}=\frac{\theta_{Ey0}(t)-\theta\big|_{y=0}}{l_y},\quad \left.\frac{\partial\theta}{\partial y}\right|_{y=L_y}=\frac{\theta_{EyL}(t)-\theta\big|_{y=L_y}}{l_y}, \tag{3}$$

$$\left.\frac{\partial\theta}{\partial z}\right|_{z=0}=\frac{\theta_{Ez0}(t)-\theta\big|_{z=0}}{l_z},\quad \left.\frac{\partial\theta}{\partial z}\right|_{z=L_z}=\frac{\theta_{EzL}(t)-\theta\big|_{z=L_z}}{l_z}.$$

Here, θ is the concentration of harmful substances in the atmosphere, t is time, $\theta_{Ex0}(t)$, $\theta_{ExL}(t)$, $\theta_{Ey0}(t)$, $\theta_{EyL}(t)$, $\theta_{Ez0}(t)$, $\theta_{EzL}(t)$ are the concentrations passing through the boundaries of the considered areas, x, y, z are coordinates of the system, u, v, w are the wind speeds in three directions, w_g is the settling velocity of the particles, σ is the coefficient of absorption of harmful substances in the atmosphere, α is the coefficient that organizes the retention of particles by plant elements, D_x, D_y, D_z are the diffusion coefficients, Q is the source power, δ is the Drak function, d_p is the particle diameter.

The results obtained in the software show that in the diffusion process, particle size, wind speed, and temperature play an important role in atmospheric dispersion. Small particles ($1*10^{-9}$ m) remain in the air longer and the concentration spreads rapidly, while large particles ($1*10^{-7}$ m) settle faster under the influence of gravity. Furthermore, particle mobility is observed to increase at high temperatures and decrease at low temperatures. Wind speed also affects the transport of pollutants; strong winds accelerate horizontal advection and ensure wider dispersion.

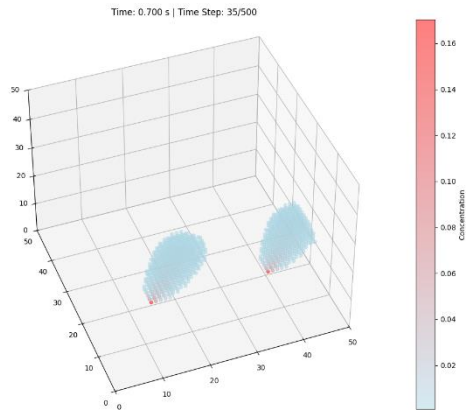

***Fig.1**. Changes in the concentration of harmful particles over time and particle size u = 1 m/s, v = 1 m/s, w = 0,2 m/s, T = 30° C, t = 0.7 h, d_p=1e^{-7} m*

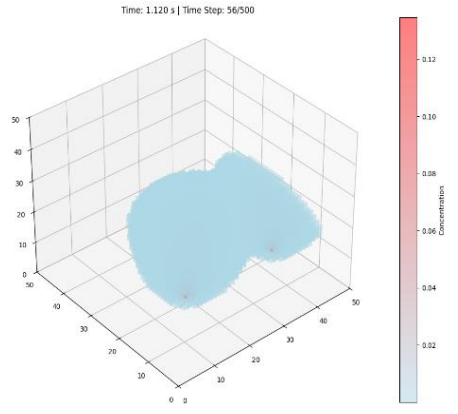

***Fig.2**. Changes in the concentration of harmful particles over time and particle size u = 1 m/s, v = 1 m/s, w = 0,2 m/s, T = 30° C, t = 1.3 h, d_p=1e^{-9} m*

Over time, pollutants are actively dispersed in the atmosphere, and their distribution area expands significantly. Wind speed influences the spread of pollutants. These observations make it important to take into account meteorological conditions when monitoring and forecasting the impact of industrial emissions on the atmosphere. The developed mathematical model and numerical algorithm are an effective tool for analyzing and predicting the distribution of pollutants in the atmosphere.

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SUST SHAKLLANGAN JARAYONLAR TUSHUNCHASI VA XUSUSIYATLARI

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Annotatsiya: Mazkur tadqiqot ishi sust shakllangan jarayonlarni asosiy tushunchalarini va xususiyatlarini tahlil qilishga bag‘ishlangan bo‘lib, unda tibbiy, ijtimoiy va texnologik tizimlarda uchraydigan jarayonlar, jumladan noaniqlik, ko‘p omillilik va formal modellashtirish murakkabligi kabilar bayon etilgan.

Kalit so‘zlar: sust shakllangan jarayonlar, yurak-qon bosimi kasalliklari, ob-havo omillari, noaniqlik, sun’iy intellekt, ansambl yondashuv.