MIRZO ULUG‘BEK NOMIDAGI
O‘ZBEKISTON MILLIY UNIVERSITETI
JIZZAX FILIALI

KOMPYUTER ILMLARI VA MUHANDISLIK TEXNOLOGIYALARI

XALQARO ILMIY-TEXNIK ANJUMAN MATERIALLARI TO‘PLAMI

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O‘ZBEKISTON RESPUBLIKASI OLIY TA’LIM, FAN VA INNOVATSIYALAR VAZIRLIGI

MIRZO ULUG‘BEK NOMIDAGI O‘ZBEKISTON MILLIY UNIVERSITETINING JIZZAX FILIALI

KOMPYUTER ILMLARI VA MUHANDISLIK TEXNOLOGIYALARI

mavzusidagi Xalqaro ilmiy-texnik anjuman materiallari to‘plami

(2025-yil 26-27-sentabr)

1-QISM

JIZZAX-2025

Kompyuter ilmlari va muhandislik texnologiyalari. Xalqaro ilmiy-texnik anjuman materiallari to‘plami – Jizzax: O‘zMU Jizzax filiali, 2025-yil 26-27-sentabr. 355-bet.

Xalqaro miqyosidagi ilmiy-texnik anjuman materiallarida zamonaviy kompyuter ilmlari va muhandislik texnologiyalari sohasidagi innovatsion tadqiqotlar aks etgan.

Globallashuv sharoitida davlatimizni yanada barqaror va jadal sur’atlar bilan rivojlantirish bo‘yicha amalga oshirilayotgan islohotlar samarasini yaxshilash sohasidagi ilmiy-tadqiqot ishlariga alohida e’tibor qaratilgan. Zero iqtisodiyotning, ijtimoiy sohalarni qamrab olgan modernizatsiya jarayonlari, hayotning barcha sohalarini liberallashtirishni talab qilmoqda.

Ushbu ilmiy ma’ruza tezislari to‘plamida mamlakatimiz va xorijlik turli yo‘nalishlarda faoliyat olib borayotgan mutaxassislar, olimlar, professor-o‘qituvchilar, ilmiy tadqiqot institutlari va markazlarining ilmiy xodimlari, tadqiqotchilari, magistr va talabalarning ilmiy-tadqiqot ishlari natijalari mujassamlashgan.

Mas’ul muharrirlar: DSc.prof. Turakulov O.X., t.f.n., dots. Baboyev A.M.

Tahrir hay’ati a’zolari: p.f.d.(DSc), prof. Turakulov O.X., t.f.n., dots. Baboyev A.M., t.f.f.d.(PhD), prof. Abduraxmanov R.A., p.f.f.d.(PhD) Eshankulov B.S., p.f.n., dots. Alimov N.N., p.f.f.d.(PhD), dots. Alibayev S.X., т.f.f.d.(PhD), dots. Abdumalikov A.A, p.f.f.d.(PhD) Hafizov E.A., f.f.f.d.(PhD), dots. Sindorov L.K., t.f.f.d.(PhD), dots. Nasirov B.U., b.f.f.d. (PhD) O‘ralov A.I., p.f.n., dots. Aliqulov S.T., t.f.f.d.(PhD) Kuvandikov J.T., i.f.n., dots. Tsoy M.P., Sharipova S.F., Jo‘rayev M.M.

Mazkur to‘plamga kiritilgan ma’ruza tezislarining mazmuni, undagi statistik ma’lumotlar va me’yoriy hujjatlarning to‘g‘riligi hamda tanqidiy fikr-mulohazalar, keltirilgan takliflarga mualliflarning o‘zlari mas’uldirlar.

vizualizatsiya qilish, mashinani o‘rganish va boshqalarni o‘z ichiga olgan fanlararo sohadir.

Bu bizga ma'lumotni qayta ishlash, naqshlarni ko‘rish, katta hajmdagi ma'lumotlarni tushunish va qaror qabul qilish uchun ma'lumotlardan foydalanish imkonini beradi.

Foydalanilgan adabiyotlar:

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TWO-DIMENSIONAL MATHEMATICAL MODEL FOR MONITORING AND FORECASTING THE PROCESS OF IN-SITU LEACHING IN A POROUS MEDIUM

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Abstract: This research paper investigates the hydrodynamic processes of in-situ leaching, with a focus on the acid-based extraction of valuable metals from ore deposits. A mathematical model, grounded in filtration-convection and diffusion principles relevant to underground leaching, has been formulated to facilitate a thorough understanding, monitoring, and prediction of system dynamics. The model accounts for the influence of hydrodynamic parameters, including the filtration

coefficient and medium porosity, which are contingent on pressure conditions and process kinetics. The overarching goal of this study is to safeguard groundwater resources from potential contamination.

Keywords: In-situ leaching, mathematical modeling, minerals, filtration, diffusion, kinetics, useful component.

Physical statement of the two-dimensional problem

For studying the underground leaching process, it is necessary to determine the concentration function of the useful component of the $C_2(x,y,t)$ in a limited heterogeneous region

$G=\{(x,y,t),\ 0<x<L_x,\ 0<y<L_y,\ 0<t\le T\}.$

In this case, the propagation of the pressure field $H(x,y,t)$ is determined from the equations of the elastic filtration regime:

$$\frac{\partial}{\partial x}\left[k(x,y)h(x,y)\frac{\partial H(x,y,t)}{\partial x}\right]+\frac{\partial}{\partial y}\left[k(x,y)h(x,y)\frac{\partial H(x,y,t)}{\partial y}\right]=\beta m(x,y)h(x,y)\frac{\partial H(x,y,t)}{\partial t}+ \quad (1)$$
$$+f(x,y,t),\quad [x,y]\in G,$$

satisfying the initial

$$H(x,y,t)=H^0(x,y),\ t=0, \quad (2)$$

and boundary conditions

$$\left.k(x,y)\frac{\partial H(x,y,t)}{\partial x}\right|_{x=0}=-\alpha_1\xi(H-H_0),\ \left.k(x,y)\frac{\partial H(x,y,t)}{\partial x}\right|_{x=L_x}=\alpha_1\xi(H-H_0),$$
$$\left.k(x,y)\frac{\partial H(x,y,t)}{\partial y}\right|_{y=0}=-\alpha_2\xi(H-H_0),\ \left.k(x,y)\frac{\partial H(x,y,t)}{\partial y}\right|_{y=L_y}=\alpha_2\xi(H-H_0). \quad (3)$$

The filtration rates are determined by Darcy's law

$$V_x(x,y,t)=-k(x,y)\frac{\partial H(x,y,t)}{\partial x},$$
$$V_y(x,y,,t)=-k(x,y,)\frac{\partial H(x,y,t)}{\partial y}. \quad (4)$$

The propagation of the reactant field is determined by solving the convective diffusion equation

$$\frac{\partial}{\partial x}\left[D_{xx}(x,y)\frac{\partial C_1(x,y,t)}{\partial x}+D_{xy}(x,y)\frac{\partial C_1(x,y,t)}{\partial y}\right]+$$
$$+\frac{\partial}{\partial y}\left[D_{yy}(x,y)\frac{\partial C_1(x,y,t)}{\partial y}+D_{yx}(x,y)\frac{\partial C_1(x,y,t)}{\partial x}\right]- \quad (5)$$
$$-\frac{\partial(V_x(x,y,t)C_1(x,y,t))}{\partial x}-\frac{\partial(V_y(x,y,t)C_1(x,y,t))}{\partial y}=$$
$$=m_g\frac{\partial C_1(x,y,t)}{\partial t},\quad [x,y]\in G,$$

with initial

$$C_1(x,y,t)=0,\ t=0, \quad (6)$$

and boundary

$$C_1(x,y,t)=0\ ,\quad (x,y)\in G_k, \quad (7)$$

and also, internal conditions in wells

$$C_1(x,y,t)=C_{3i},\quad (x,y,)\in G_0,$$
$$\left(\frac{\partial C_1(x,y,t)}{\partial x}\right)^2+\left(\frac{\partial C_1(x,y,t)}{\partial y}\right)^2=0,\quad (x,y,)\in G_u, \tag{8}$$

The desired distribution of the concentration function of the useful component is determined by solving the following equation

$$\begin{aligned}&\frac{\partial}{\partial x}\left[D_{xx}(x,y)\frac{\partial C_2(x,y,t)}{\partial x}+D_{xy}(x,y)\frac{\partial C_2(x,y,t)}{\partial y}\right]+\\&+\frac{\partial}{\partial y}\left[D_{yy}(x,y,)\frac{\partial C_2(x,y,t)}{\partial y}+D_{yx}(x,y)\frac{\partial C_2(x,y,t)}{\partial x}\right]-\\&-\frac{\partial(V_x(x,y,t)C_2(x,y,t))}{\partial x}-\frac{\partial(V_y(x,y,t)C_2(x,y,t))}{\partial y}=\\&=m_c\frac{\partial C_2(x,y,t)}{\partial t}+\frac{\partial N}{\partial t},\quad [x,y,]\in G,\end{aligned} \tag{9}$$

with initial

$$C_2(x,y,t)=C_2^0,\qquad t=0, \tag{10}$$

and boundary

$$\begin{aligned}&\left.\frac{\partial C_2(x,y,t)}{\partial x}\right|_{x=0}=-\alpha(C_2-C_2^0),\qquad \left.\frac{\partial C_2(x,y,t)}{\partial x}\right|_{x=L_x}=\alpha(C_2-C_2^0),\\&\left.\frac{\partial C_2(x,y,t)}{\partial y}\right|_{y=0}=-\alpha(C_2-C_2^0),\qquad \left.\frac{\partial C_2(x,y,t)}{\partial y}\right|_{y=L_y}=\alpha(C_2-C_2^0).\end{aligned} \tag{11}$$

and also, internal conditions in wells

$$C_2(x,y,t)=C_{4i},\quad (x,y)\in G_0,$$
$$\left(\frac{\partial C_2(x,y,t)}{\partial x}\right)^2+\left(\frac{\partial C_2(x,y,t)}{\partial y}\right)^2=0,\quad (x,y,)\in G_u. \tag{12}$$

The equation of mass exchange kinetics, which determines the rate of transition of a substance from one phase to another, has the following form:

$$\frac{\partial N(x,y,t)}{\partial t}=\gamma(C_1)f(C_2,N,t),$$
$$N(x,y,t)=N^0(x,y),\ t=0,\quad [x,y]\in G. \tag{13}$$

Analysis of the problem statement reveals that variations in pressure within the ore deposit, induced by solution injection and extraction, directly impact the permeability and porosity coefficients of the stratum.

The rate of change in these hydrodynamic parameters is pressure-dependent; exhibiting exponential behavior under high pressure and linear behavior under low pressure conditions.

It should be noted that during the underground leaching process, due to the effect of the reagent on the ore deposits, a chemical reaction occurs and the substance passes from one phase to another, as a result of which the hydrodynamic parameters of the porous medium (filtration and porosity coefficients) and the pressure in the ore collector change.

As noted in [7], the change in porosity depending on the pressure can be expressed using the equation:

$$m=m_0+\beta_c\left(H-H_0\right),$$

and with significant changes in pressure, the change in porosity is described by the equation

$$m = m_0 e^{-\beta_c (H_0 - H)/m_0},$$

where m_0 is porosity coefficient at $H = H_0$.

The analysis of the experimental data showed that not only the porosity, but also the permeability of the ore reservoir significantly depends on the formation pressure and, with small changes in its value, this can be written as a linear dependence:

$$k = k_0 \left[1 - a_K \left(H_0 - H\right)\right],$$

and for large ones - exponential

$$k = k_0 \, \mathrm{e}^{-a_K (H - H_0)},$$

where: $H(x,y,t)$ is pressure value, (m); $H^0(x,y)$ is initial pressure value, (m); m is porosity coefficient value; γ is bulk density of solution, (kg/m^2); $k(x,y)$ is filtration coefficient, (m/day); t is time. $h(x,y)$ is thickness of the ore-bearing horizon (m); β is coefficient of elastic capacity, (cm^2/kg); α is a constant, taking values 0 or 1, (1/m); $\alpha_1, \alpha_2, \alpha_3$ are constants, taking values 0 or 1; ξ is coefficient for reducing equations to dimensions (1/day); $f(x,y,t) = \sum_{i=1}^{n} q_i(t) \delta(x - x_i, y - y_i),$; $q_i(t)$ is well flow rates; $\delta = \begin{cases} 1, x = x_i, y = y_i \\ 0, \textit{other all condation} \end{cases}$ is Dirac delta function.

Conclusion

The presented study offers a robust mathematical model designed to analyze the hydrodynamic processes inherent in in-situ leaching (ISL) within a two-dimensional porous medium. This model integrates filtration, diffusion, and kinetic factors, facilitating a more nuanced comprehension of the extraction process's sensitivity to pressure fluctuations, permeability characteristics, and porosity levels. The application of numerical methods to solve intricate quasilinear partial differential equations has demonstrated efficacy in simulating realistic ISL operational scenarios.

This research highlights the substantial impact of pressure fluctuations on hydrodynamic parameters, especially concerning solution injection and extraction processes. These variations directly influence mineral recovery efficiency and potential environmental risks, including groundwater contamination. The developed mathematical framework facilitates enhanced monitoring, forecasting, and optimization of ISL operations, thereby supporting economic viability and environmental protection.

Continued progress in computational algorithms is anticipated to improve the accuracy and utility of ISL simulations, thereby facilitating more sustainable and efficient mining operations.

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BAHOLASHGA OID MA'LUMOTLARNING KOGNITIV VA STATISTIK MODELLASHTIRILISHI

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Annotatsiya. Ushbu maqolada baholash jarayonida olinadigan ma'lumotlarning kognitiv va statistik modellashtirilishining nazariy va amaliy jihatlari tahlil qilinadi. Kognitiv modellar baholash sub'ektivligini aniqlash va tushunishga yordam beradi, statistik modellar esa ma'lumotlarni aniqlik va ishonchlilik nuqtai nazaridan qayta ishlashda muhim ahamiyat kasb etadi. Ushbu ikki yondashuv integratsiyasi baholash sifatini oshirish va ta'lim jarayonini optimallashtirish uchun samarali vosita bo'lib xizmat qiladi. Maqola metodologik asoslar, amaliy misollar va sohadagi yangi tendensiyalar bilan boyitilgan.

Kalit so'zlar: baholash, kognitiv modellashtirish, statistik modellashtirish, ta'lim, ma'lumotlarni tahlil qilish.

Kirish

Ta'lim tizimida o'quvchilar va talabalarni baholash jarayoni o'quv natijalarini aniqlash, pedagogik jarayonlarni boshqarish va sifat nazoratini ta'minlash uchun asosiy vosita hisoblanadi. Baholash natijasida olinadigan ma'lumotlar ko'pincha murakkab, ko'p qirrali va noaniq bo'lib, ularni to'g'ri talqin qilish uchun kognitiv va statistik modellarni qo'llash zarur. Kognitiv modellashtirish baholovchining qaror qabul qilish mexanizmlarini tushunishga yordam beradi, statistik modellashtirish esa ma'lumotlarning tasodifiyligi va noaniqligini kamaytirishga qaratilgan.

1. Baholash ma'lumotlarining kognitiv modellashtirilishi

Kognitiv modellashtirish — bu insonning baholash faoliyatidagi fikrlash jarayonlari, qaror qabul qilish mexanizmlari va bilim darajasini o'rganishga qaratilgan