NUMERICAL METHODS FOR SOLVING POLLUTION PROBLEMS IN AQUIFERS

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Abstract: *Groundwater pollution is a major environmental policies worldwide, show numerous international events devoted to the subject. Remedial and protective measures undertaken are limited in many cases failed efficiency expected due to excessive costs necessary to remedy, because the application of inappropriate methods and technologies as well as relatively long time necessary to remedy the aquifers. Currently we have a specialized unit able to develop and solve an aquifer pollution from its definition to the implementation of remedial solutions, recent reports show that after the pollution remediation, despite the progress made in the field, remains a major concern due to direct discharges, indirect discharges from spreading due to nitrogen fertilizers and pesticides, and leakage due to contaminated old industrial sites or landfills. Although point sources of pollution have caused most of the pollution identified so far, there are data showing that the diffuse sources have a growing impact on groundwater. For proper pollution problems exist in the aquifer analytical solutions and numerical solutions in this paper we present numerical methods used to solve the problems of polluted groundwater, and we pay special attention to finite differences method and the Random Walk method. These methods provide a representation in space and time pollutant concentrations. Market appeared many computer programs pollutant concentrations in the aquifer, but are very expensive and require a good knowledge of input parameters, an understanding of the phenomenon and field of use. We present an example of pollution of aquifers, using ASMWIN modeling program. In the process of transport of pollutants in the aquifer will keep it in mind the following aspects: physical and chemical properties of pollutants, the study environment in which transport pollutants found condition of pollutants into the underground: and the processes that control transport of contaminants in the environment Underground: The main objective in this paper is to develop mathematical models to study processes occurring in the aquifer pollution. The results obtained may contribute to an overall program evaluation, monitoring and remediation of aquifers to be consistent with the main trends and guidelines for the protection of groundwater resources on a European and global*

Key words**:** *aquifer, pollution, Difference finite method, Random Walk method*

INTRODUCTION

Problems encountered in porous media are important in many areas. These include infiltration and consolidation problems encountered in land reclamation, groundwater pollution problem encountered in Hydro, filtering proceed encountered in chemical engineering and bioengineering transport of liquid found in the human body.

Location and delimitation or groundwater contamination is often a difficult and costly. When considering a pollution problem, the first step consists in the study area. This involves investigating the history, geology and hydrogeology of the contaminated area. Often, only mathematical models are used to assess the current situation.

This paper shows the importance of understanding and knowing the phenomenon of pollution in the aquifer and illustrates how limited information can be used to describe a very complex real situation of pollution..

The paper is organized by cultures follows: the first part is given the current state of groundwater pollution in Romania in the second row are numerical methods to solve

environmental problems with emphasis on finite difference method and Random Walk method, and to give the third party is given an example of pollution in the aquifer

CURRENT STATUS OF POLLUTION IN ROMANIA AND SOLVING METHODS

Groundwater quality in Romania is still at an inappropriate level, due to slow self-purification, and over half of Romania's surface (58%) is vulnerable to nitrate pollution A report of the Romanian Waters National Administration, the most affected are rural areas where, because of lack of minimum facilities to municipal facilities, liquid waste reaching the ground.

According to report by ANAR for the European Commission about how to implement the directive on water protection against pollution by nitrates from agricultural sources in the years 2004-2007, the areas vulnerable to nitrate pollution of the perimeters represented 251 towns in 34 counties and 10 river basins.

Results in the period 2004-2007, and need zoning imposed extension zoning vulnerable areas declared as vulnerable, including potentially vulnerable areas, from 8.2% to 58% of the country. . In terms of nitrate concentrations, the report shows that 89.22% of monitoring points have averaged below 50 mg / l and 75.31% of them under the maximum limit.

High concentrations of nitrates are registered in the groundwater in the plains and plateaus less in area.

The two major sources of pollution by nitrates are permanent soil washing impregnated with nitrogen oxides from atmospheric rainfall and irrigation water, and surface water (rivers, lakes) where they evacuated loaded wastewater nitrogen.

These two sources using chemical fertilizers are added to some categories of farmland. Also, are exceeded, especially in the major platforms chemical compound.

Although nitrate concentrations in water do not exceed a value of 50 mg / l in terms of transitional waters, coastal and marine eutrophication can register (algal bloom), all monitoring sections, the Black Sea, especially in summer periods, mainly due to intake of nutrients and high temperature water, warns ANAR.

Besides agricultural activities, an important contribution to pollution by nitrates and nutrients, and have a human agglomerations that are not consistent in terms of sewerage systems and treatment stations.

Critical areas in Romania, the pollution is:

a. Surface Waters:

In 1999, over 81 percent of the amounts of waste water from the main sources of pollution have reached the natural receivers untreated or insufficiently treated. Under this criterion, the most affected river basins are: Prut (100%), and Arges Ialomita (99%), see (98%) and Cris (96%).

b. Groundwater:

Prahova-Teleajen-area polluted mainly by oil and phenolic compounds due to extraction activities. Industrial units generate frequencies exceeding the maximum admissible concentrations of water quality indicators: Dej-Integrated Pulp and Paper, Bathroom sup-mining, Baia de Aries-mining; Govora-Soda Works, Iasi and Comtom Penicillin Tomesti; Alum Tulcea, Turnu Severin, Turnu Severin, SC;-Azomures Targu Mures, Constanta harbor basin; Navodari-Petromidia.

Modeling as a method of analyzing numerous phenomena, is used in different areas of scientific research. After is development it was soon introduced to groundwater hydraulics and was quickly become an accepted method of exploring and predicting the behavior of a hydro

geological environment? Practically every model is in some way related to basic governing equations which describe the phenomenon studied.

Groundwater flow and transport in porous media is governed by the differential equation with boundary and initial condition. These equations can be solved by analytical and numerical methods as can be seen in figure 1.

Analytic solution of governing differential equation is possible only for the domain of a simple geometric shape or homogenous media. These were the first mathematical models, even though they were not called models at the time they were made. .Nowadays, since the development of numerical methods, they are not so important, but even now there are areas suitable for an analytic solution -

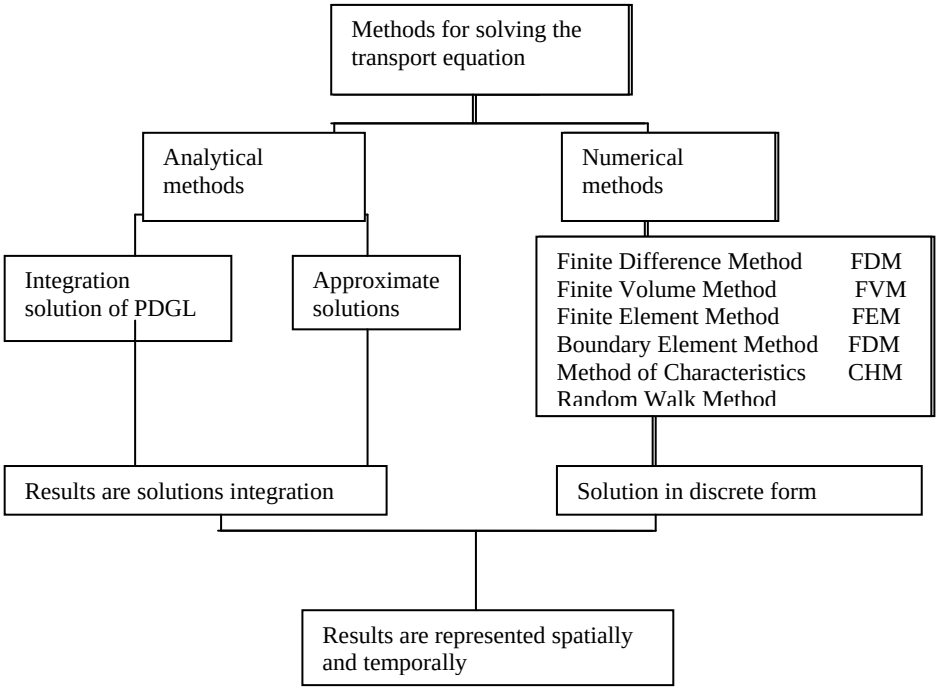

Fig. 1 Methods of solving problems of aquifer pollution

One of the most important method solving mathematical models of porous media is finite difference method.

Finite Differences Methods meant the first breakthrough in mathematical modeling in many areas, and is the oldest numerical method. Although its theoretical fundamentals were known long before, the method was fully applied only after the development of computers.

In this paper, case study is a dimensional pollution problem.

Equation describing the flow and transport in one-dimensional case is the following

$$\frac{\partial c}{\partial t} + \frac{v_a \partial c}{R \partial x} - \frac{D \partial^2}{R \partial x^2} + \lambda c = 0 \quad (1)$$

: For the Finite difference method initial and boundary condition are:

$c(x=0,t)= c_0 f(t)$ (2)

$$\left.\frac{\partial^2 c}{\partial x^2}\right|_{x=L} = 0 \quad (3)$$

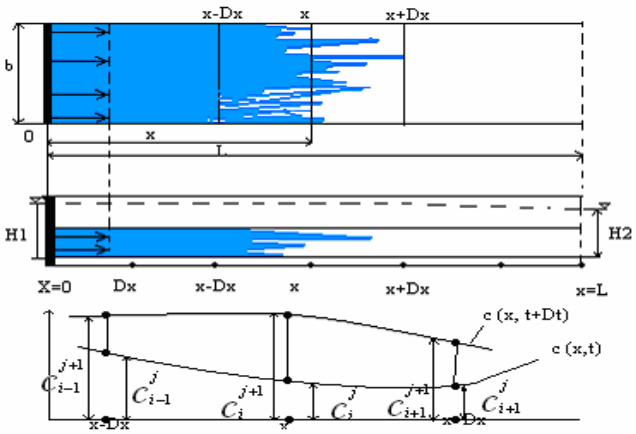

Fig. 2 Transport discretization process

Finite difference equations describing the method for one-dimensional case are:

- For x constant

$$c(x,t+Dt) = c(x,t) + \mathrm{Dt}\frac{\partial c}{\partial t_{x,t}} + \frac{Dt^2\partial^2 c}{2\partial t^2} + \frac{Dt^3}{3!}\frac{\partial^3 c}{\partial t^3} + \ldots\ldots\ldots\ldots (4)$$

$$c(x,t) = c(x,t+Dt) - \mathrm{Dt}\frac{\partial c}{\partial t_{x,t}} + \frac{Dt^2\partial^2 c}{2\partial t^2} - \frac{Dt^3}{3!}\frac{\partial^3 c}{\partial t^3} + \ldots\ldots\ldots\ldots (5)$$

For constant t

$$c(x+Dx,t) = c(x) + Dx\frac{\partial c}{\partial x_{x,t}} + \frac{Dx^2}{2}\frac{\partial^2 c}{\partial x^2} + \frac{Dx^3}{3!}\frac{\partial^3 c}{\partial x^3} + \ldots\ldots\ldots\ldots (6)$$

$$c(x-Dx,t) = c(x) - Dx\frac{\partial c}{\partial x_{x,t}} + \frac{Dx^2}{2}\frac{\partial^2 c}{\partial x^2} - \frac{Dx^3}{3!}\frac{\partial^3 c}{\partial x^3} + \ldots\ldots\ldots\ldots (7)$$

: Finite difference method and Random Walk method constituted a useful class of numerical method for solving transport problem.

The main advantages of the R.W. are the absence of numerical dispersion, the additively of the solutions and the shorter computing time required if a small number of particles is used. The disadvantages are coarse random fluctuations in the calculated concentration, concentration sometimes greater than the initial condition, and the necessity of using of large number of particles and cells to produce an acceptable and smooth representation of the solution.

For if one-dimensional equations describing RW method are:

$$x_p(t+Dt) = x_p(t) + v_a\frac{Dt}{R}Z\sqrt{2D_L\frac{Dt}{R}} \quad (8)$$

$$c_i\ (t) = \frac{Mn_i}{Nm_a}\ \frac{1}{n_e Dx} \quad (9)$$

M is total mass of pollutant
N is total number of particles used

APPLICATION TO A FIELD CASE, RESULTS AND DISCUSSION

Dimensional model is proposed to descry time evolution of water quality in the aquifer, when close to a source of pollution.

Groundwater is shallow, and is influenced by pollutants from the soil surface. Appropriate agricultural areas that have been applied fertilizers.

As a case study we determined the variation in time and space of a pollutant concentration, injected into a homogeneous layer horizontally. For calculation we used the program ASMWIN (Aquifer Simulation Modeling for Windows). Finite differences method we considered continuous injection type, and Random Walk method we considered continuous injection in the aquifer. Aquifer is constant speed. Field has been shaped in the figure

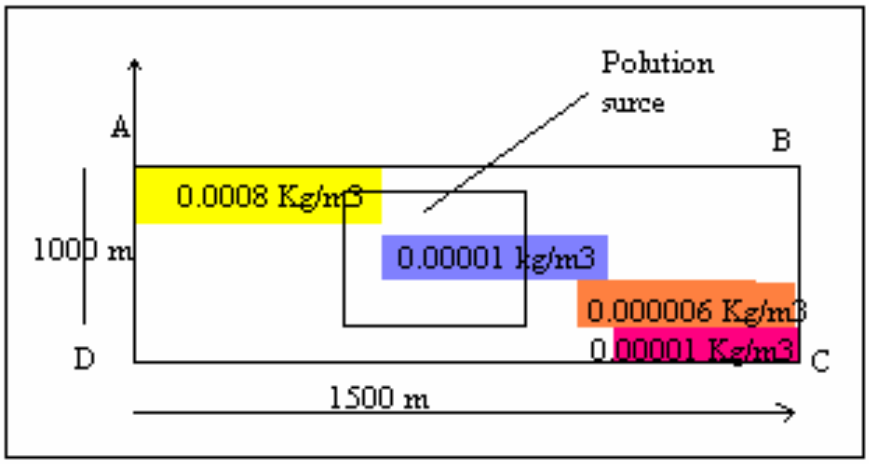

Fig. 3 Schematic of the field is modeled

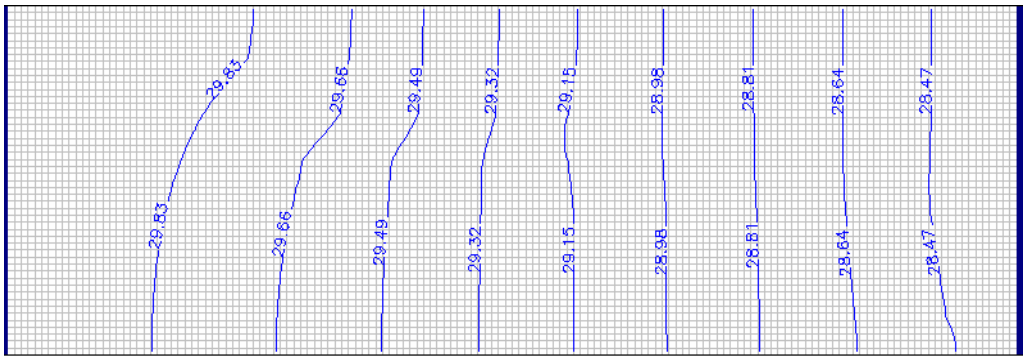

Fig. 4 Variation of water level

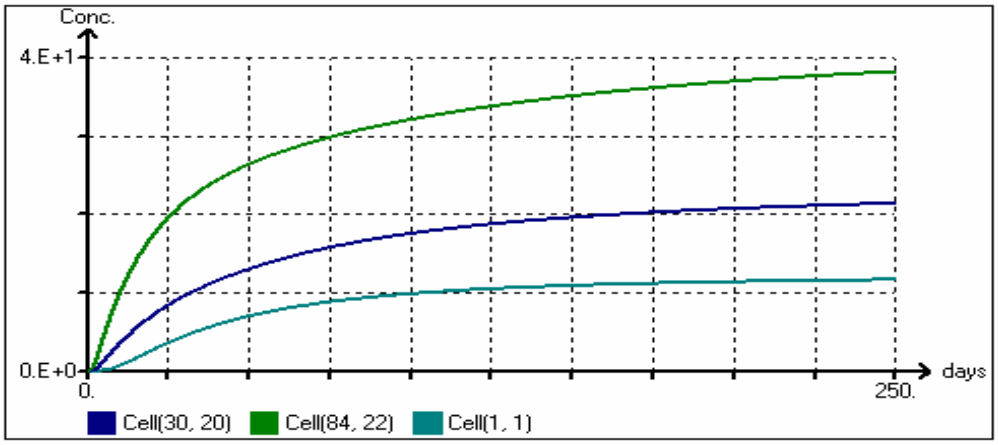

Fig. 5 Variation of concentration by finite difference method over a period of 250 days

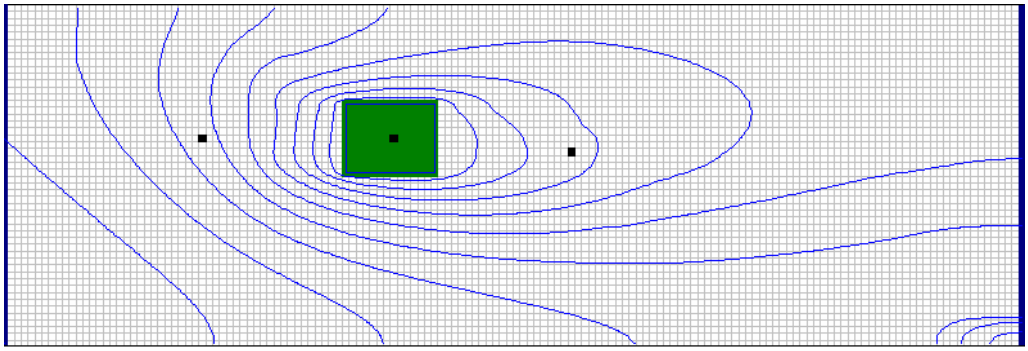

Fig. 6 Concentration distribution by finite difference method environment

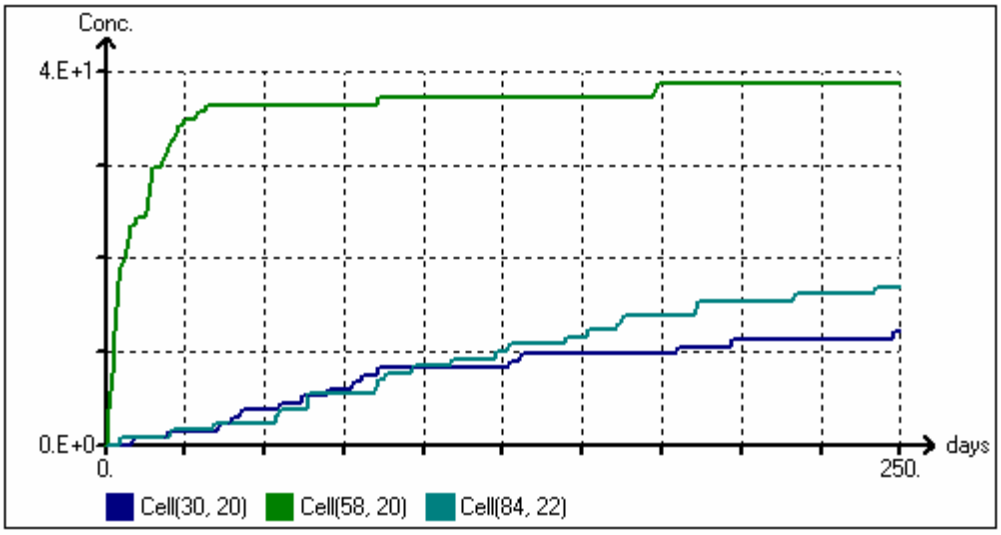

Fig. 7 Variation of concentration by Random walk method over a period of 250 days

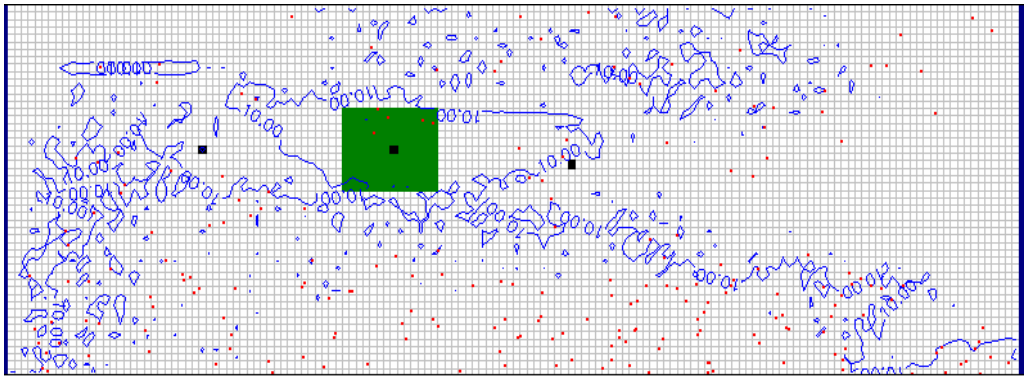

Fig.8 Concentration distribution by Random Walk method environment, continuous injection

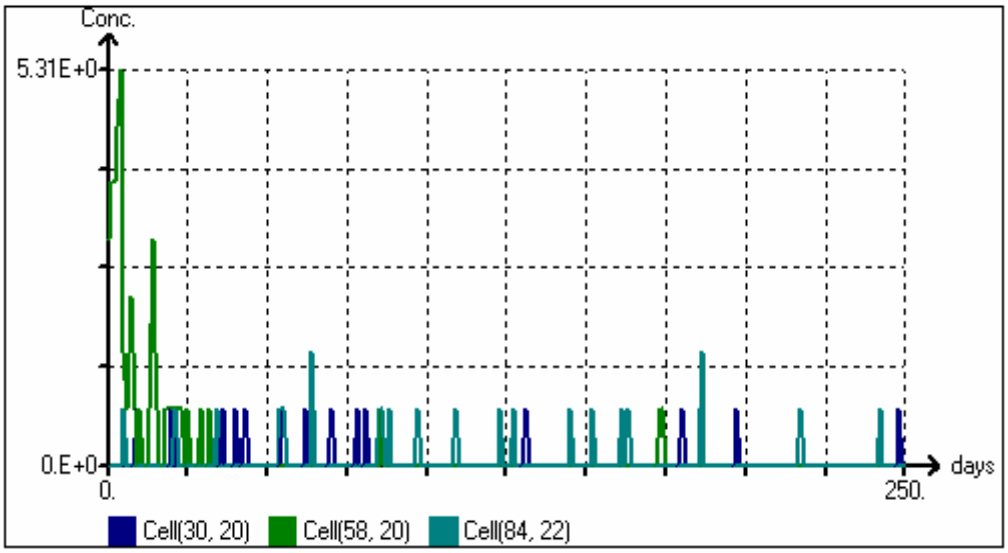

Fig.9 Variation of concentration by Random walk method over a period of 250 days, instantaneous injection

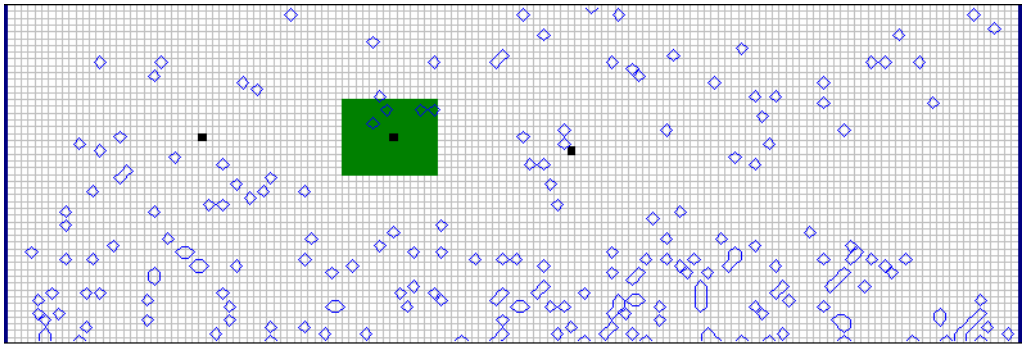

Fig. 10 Concentration distribution by Random Walk method environment, instant injection

RESULTS AND CONCLUSIONS

Pollution phenomena in porous media are very complex. In aquifer pollution forecasting requires prior determination of a number of hydro geological parameters. The case study presented was analyzed in the process of aquifer pollution by two methods: finite differences and Random Walk method. Dispersion equation is discredited into account differences finite used Aquifer Simulation Model for Windows soft, version 6.0. In Random Walk Method to simulated if pollution is instantaneous. Aquifer pollution is analyzed with a free level, the influence of the graphics field in homogeneity on evolution while the concentration in time and space pollutant. Evolution pollutant concentrations is presented in figure 5 .... 10.

The conclusion is that the pollutant is spread more vertical than horizontally, so you can use one-dimensional model for calculating the concentration.

Process of pollution resulting from overlapping of two phenomena: convection and dispersion mechanic.

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