Flow and concentration Transport through saturated porous layers

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ABSTRACT :

This paper describes the flow and concentration transport through heterogeneous porous media to simulate the riverbank phenomena**.**

The medium is three saturated porous layers with different physical properties, stratified in the horizontal direction.

The concentration was introduced at the top of the first layer and a free outflow occurred at the bottom of the opposite side. Two ratio aspects (large by depth) 5 and 10 where taken in order to apply the two-dimensional simulation.

The flow is described by the Navier-Stokes and concentration equations, including the Darcy-Brinkmen-Forchheimer terms in the streamline and vorticity formulation. The set of coupling equations were solved using finite difference scheme and ADI (Alterning Direction Implicit) technique.

In a first step and in order to well understand the fundamental mechanism of the transfer, simulations were investigated at Reynolds number=50, Prandtl number=5 and Lewis number=78.55. The porosity values of the three layers are respectively (from top to bottom) equal to .8, .4 and .1.

It was found that:

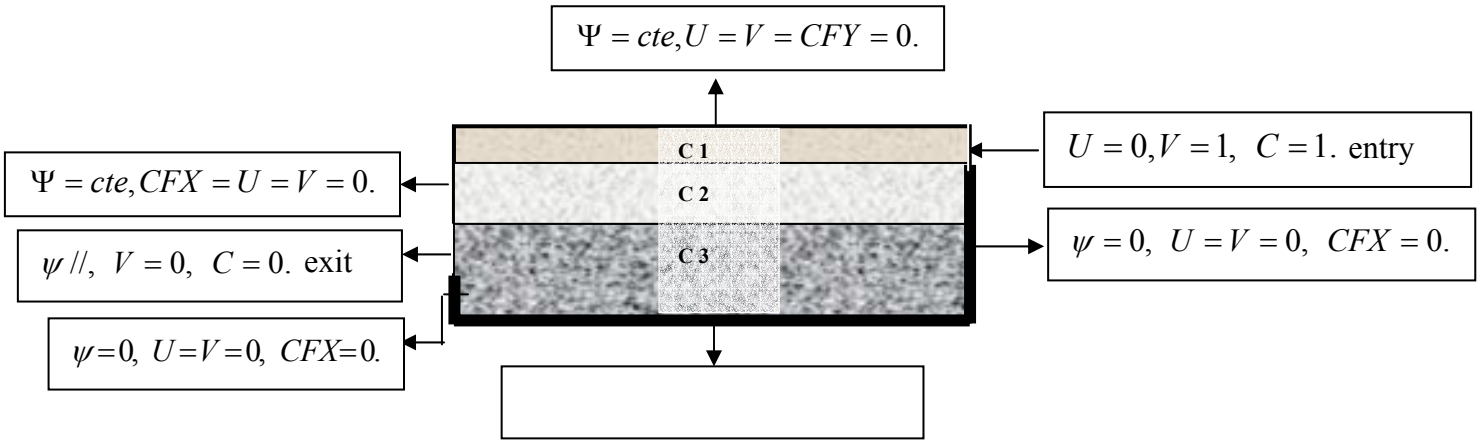
1) In the beginning, small vortices in the entrance and the exit appear, the most area of the system is of laminar flow with parallel streamlines. The concentration is located in the vicinity of the inlet.
2) After some time, the vortex near the entry extended in the horizontal direction and a recirculation zone took place inducing the acceleration of the diffusion of concentration. At the same time the vortices at the exit grew and form a single vortex moving in the opposite direction of the main flow.
3) As far as time increases, the recirculation zone extend towards the exit and hence, due to the presence of the backward movement, a chain of vortices took place increasing the dissipation of concentration.

At the end of the physical process, a single cell occupied the whole system with a small outflow rate. Consequently concentration was spread over the whole surface.

4) For a ratio aspect equal to 10, the flow behavior remained the same with less vortices and so less velocity propagation of the concentration front.

Keywords:
Riverbank, Porous Media, Darcy-Brinkmen-Forchheimer, Numerical Simulation

Physical Model with boundary conditions

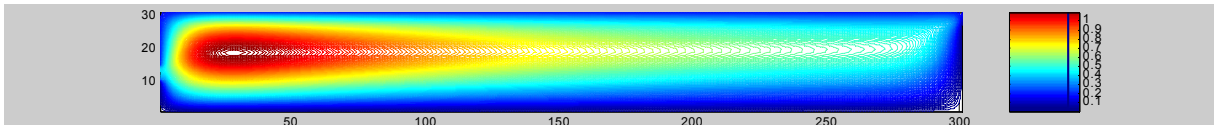


Results:

Ratio Aspect =10

At t=33.33

Streamlines



Iso-Concentration: