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MATHEMATICAL MODELING OF LIQUID CARRY IN POROUS SUBSTANCE

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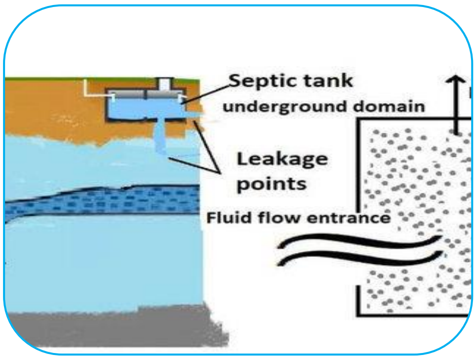
ABSTRACT

We summarise the analysis and demonstrate how the results can be directly used in practical estimations of the permeability co efficients of particulate porous media at low saturation levels with the macroscopic description of the low saturation regime of spreading in fibrous porous materials using a mesoscopic network model.the mathematical description of liquid dispersion in particulate porous media.the surface transport and laplace Beltrami problem over a set of coupled elements. We apple the developed technique and its finite element realisation to consider a representative ensemble of randomly packed interconnected particles.



KEY WORDS –: *analysis and demonstrate , mesoscopic network model , developed technique.*

INTRODUCTION

Most materials we encounter in everyday life, ranging from ordinary rocks, soils and clothing to sophisticated household products have porous structure. The structure of the porous materials has direct implications on their mechanical and transport properties. such as rigidity,plasticity, thermal conductivity, gas diffusivity and the coeffcients of liquid dispersion, which are in turn associated with the relavant process, such as deformation, gas diffusion and liquid dispersion. The phenomenon of liquid dispersion is of particular impotance due to its role in modern technological application(For Example, filtering,medical diagnosing and cleaning)and geaphysical and agricultural process,(for example land sliding and flooding) Understanding of the liquid transport in porou media is crucial in the desgn and assessment of building facilities, for example in construction of dams and artificial reservoirs, and in the environmental analysis of dissemination processes.

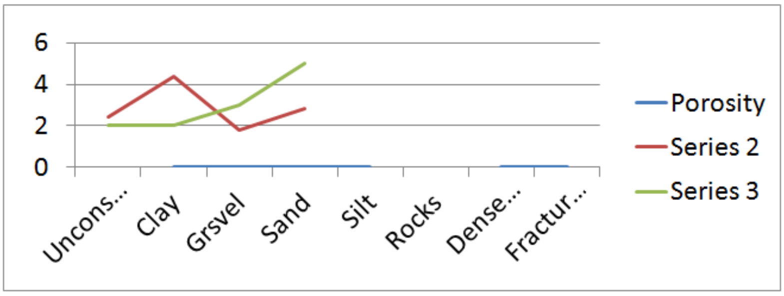
Structure and properties os porous media:

Porosity and saturation:

one of the main parameters used in the description of porous materials is porosity, commonly

Range of typical porosity Values

Material type	**Porosity**
Unconsolidated deposits	
Clay	0.40 - 0.70
Grsvel	0.25 -0.40
Sand	0.25 – 0.50
Silt	0.35 –0.50
Rocks	
Dense crystalline rock	0.00-0.05
Fractured basalt	0.05-0.50
Fractured crystalline rack	0.00-0.10
Granite	0.00-0.01
Karst limestone	0.05-0.50
Limestone dolomite	0.00-0.20
Paper	
Mechanical pulp	0.50-0.60
Filter paper	0.10-0.87

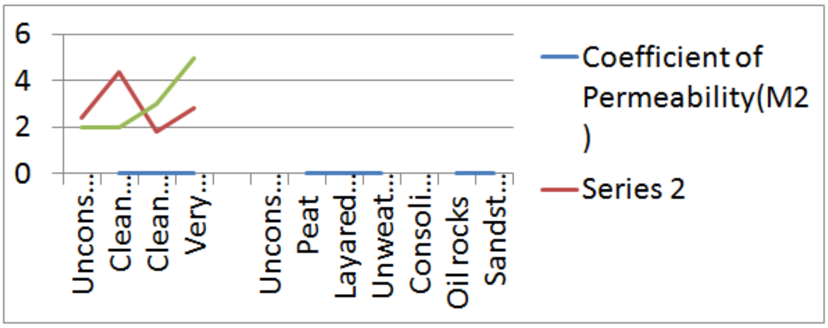


Darcy's Law and Permeability:

To understand the notion of permeability in porous materials,We consider the macroscopic models used to describe macroscopic liquid fluxes in porous media.As one can imagine as we have already brifly discussed, the structure of porous materials is very complex. If we dig a small hole in the ground one would see that even an ordinary soil consists of different granular particles mixed with complex organic material.

Range of the Typical coefficients of permeability in saturated regime of spreading.

Material type	**Coefficient of Permeability(M^2)**
Unconsolidated sand and Gravel	
Clean gravel	10^{-7} - 10^{-8}
Clean sand or sand and gravel	10^{-9} - 10^{-11}
Very fine sand,silt,loess,Loan	10^{-12} - 10^{-15}
Unconsolidated clay and organic	
Peat	10^{-11} - 10^{-12}
Layared clay	10^{-13} - 10^{-15}
Unweathered clay	10^{-16} - 10^{-19}
Consolidated rocks	
Oil rocks	10^{-11} - 10^{-13}
Sandstone	10^{-14} - 10^{-15}
Fresh Limestone,Dolomite	10^{-16} - 10^{-17}
Granite	10^{-18} - 10^{-19}



Unsaturated Regime of Liquid Dispersion:

Lateron the empirical Darcy,s law has been derived using averaging techniques and Generalised to the case of Unsaturated regimes of liquid spreading.

Linear and Non –Linear Diffusion:

To understand main Differences in herent in non – linear diffusin problems, consider a particular Example of the so called porous medium equation (PME) in a one Dimensional case.

Macroscopic Models of Liquid Dispersion in Soils:

In relation to mathematical simulations of unsaturated transport in soils, the permeablity coeffient demonstration very large variation as a function of saturation.-by five-six orders of magnitude.

Retention Curves and Capillary pressure:

Surface Tension:

Capillary pressure in liquids is generated due to the surface tension effect.in Macroscopic approximation, surface tension manifests itself through the work done to change surface area without varying other thermodynamic parameters such as volume and temperature.

Surface tension and Contact Angle:

In another way the wetting phenomena are described by the contact angle between the free surface of the liquid and the solid –liquid interface at the point of contact –the contact line.which is a function of surface tensions. The contact angle and the surfase tensions are related by the young equations.

Surface tension and Capillary pressure:

If the liquid gas interface is curved the interface cuvature creates a pressure difference known as the laplace pressure.

Macroscopic model of liquid dispersion at low saturation:

The mathematical models developed in soil science and hydrology to describe liquid transport in Unsaturated porous media are usually bounded from below by relatively high lower bounds, Just $S=S_c=10\%$ or so the lower limits of applicability of the models were partially dictated by the practical need and on the other hand by the strong reduction of permeability at low saturation levels making direct experimental observation of the spreading phenomena difficult unless very presistent liquids were used.

Morphology of Liquid distributions at Low Saturation Levels and Capillary Pressure:

Liquid Distribution in Surface Roughness Grooves:

The high negative capillary pressure generated by the surface irregularities of the Smallest Length Scale = 250 nm can be only observed at the moving front, basically within the layer of one practicle diameter thick. In the Bulk of the wet area the capillary pressure is distributed.

Liquid Distribution in the pendular Rings:

We have estmate that liquid content due to the surface roughness in partic ulate porous media can be considered to be constant and contributes about S_0=0.35% in terms of saturation. The pendular rings, on the other hand , due to much larger lengh scale involved should demonstate variations in the liquid content as pressure vries in the system.

Surface Diffusion and Microscopic model:

Consider now the local transport on the surface of particles, which is described by the average surface flux density **q** the quntity is defined by averaging the volumetric flux over a sample cross section area of width containing many grooves and including areas of both solid and liquid. According to a study of liquid spreading on rough surfaces made of microscopic grooves of various shapes and dimensions.

Super – Fast Non Linear Diffusion:

The non linear diffusion equation (1.2) is known to belong to the super fast non linear diffusion class

Super fast non linear diffusion and self similarity:

The moving boudary value problem to (1.29) has compact support, so that it is tempting to determine self similar solutions to that problem. But this is not the case here. The super fast diffusion model does not demonstrate this universal behaviour.

Super fast non linear diffusion and surface permeability:

Another essential element of the model which has to be determined in practical application of the model is the coefficient of permeability K=K (s) which is expected to be some function of saturation.

CONCLUTION:

The abundance and variety of liquid transport phenomena in porous media, And their importance have been stimulating research in this direction providing us with practical and reliable mathematical model, which can be further used in the analysis and simulations. Until recently the least studied area of liquid transport was at low and very low concentrations of transporting liquid in porous matrices.the mathematical aspects of modelling of this kind of processes is the main subject of this doctoral study.which are relevant to the mathematical modelling in porous materials.

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