

Effective Porosity Analysis in Low-Permeability Porous Media



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DOI: 10.2478/acmy-2019-0009

1.0. Introduction:

The transport through the porous medium leads the contaminant to spread into the other fluid medium. Low-permeability media (LPPM) is most commonly associated with fine-grained sedimentary deposits such as shales and clays. Groundwater flow in these environments appears to affect the development of geologic, hydrologic, and geochemical systems. Low-permeability clay layer interfaces are generally involved at waste disposal sites as the purpose of reducing the risk of groundwater contamination. For clay media have typically a hydraulic conductivity less than 10^{-7} cm s^{-1} [1]. Overall, low permeability media might play a significantly important role not only in the groundwater flow process but also for the solute transport process. This short review provides an insight into series of homogeneous medium transport experiments in one-dimensional columns (length 3cm to 10 cm) for transport and the leaching process conducted which NaCl was chosen as a Tracer [2]. The modeling approaches was used the Advection-Dispersion Equation (ADE), Fractional Advection-Dispersion Equation (FADE), Two-Region Model (TRM), and the Continuous Times Random Walk (CTRW) theory. The effective porosity can be calculated as $n_e = q/v$, in which q is the Darcian velocity, while v is the actual flow velocity. The velocities estimated from ADE during this process were used to calculate the effective porosity. For the leaching process, the velocities estimated from FADE were used as the FADE has a perfect agreement with the experimental data [2].

2.0. Results & Discussion:

The results are shown in Table 1, which indicated that the effective porosity (n_e) values for the transport process were close to the total porosity (n) values, suggesting that the immobile zone played a minor part in terms of transport [3]. From Table 1, one can also see that the estimated effective porosity (n_e) values for the leaching process were also close to the total porosity (n) values, suggesting that the effective porosity did not change too much when switching from transport process to leaching process. In the following, we would like to offer a few explanations on this point.

Firstly, the media used in our experiment conducted disturbed clay particles with nearly the same size with most of the pore spaces regarded as mobile [2]. This is quite different from native, non-disturbed clays which may have a great portion of the immobile zone. The relatively homogeneous nature of the disturbed clay particles may explain the fact that the effective porosity was found to be close to the total porosity. Secondly, switching from transport process to leaching process meant that the chemistry of water changed from Cl-rich water in the transport process to the Cl-poor water in the leaching process. Such a change of water chemistry would inevitably change the surface ionic interaction between clay particles, and flowing water and might lead to micro-adjustment of clay particles. Such micro-adjustment of clay particles would lead to a considerable change of media permeability which was very sensitive to the small changes of media structure. The change of media permeability was eventually manifested in the change of velocity profile [2]. Thirdly, even though the permeability of the media was altered when switching from a transport process to the leaching process, the micro-adjustment of clay particles did not lead to a considerable change of effective porosity.

Table 1: Summary of average actual velocity (v), average Darcian velocity (q) and estimated porosity (n_e) for the transport process and leaching process [2].

Soil column	Diameter	Average actual velocity for BTCs	Average actual velocity for leaching	Average Darcian velocity for BTCs	Average Darcian velocity for leaching	Effective porosity for BTCs	Effective porosity for leaching
		$v(\text{cmh}^{-1})$	$v(\text{cmh}^{-1})$	$q(\text{cmh}^{-1})$	$q(\text{cmh}^{-1})$	n_e	n_e
3 cm with smooth inner wall	14	0.406	0.110	0.2238	0.0604	0.5459	0.5491
5 cm with smooth inner wall	14	0.229	0.079	0.1603	0.0556	0.6970	0.6864
8 cm with smooth inner wall	14	0.031	0.036	0.0194	0.0223	0.6063	0.6027
5cm	7	0.111	0.093	0.0542	0.0455	0.4517	0.4740
5cm	9	0.113	0.054	0.0756	0.0362	0.6690	0.6351
5cm	10	0.167	0.046	0.1085	0.0302	0.6382	0.6292
3 cm with rough inner wall	14	0.338	0.125	0.2027	0.0750	0.5962	0.6048
5 cm with rough inner wall	14	0.113	0.097	0.0684	0.0590	0.6053	0.5673
8 cm with rough inner wall	14	0.053	0.048	0.0341	0.0308	0.5879	0.4646

3.0. Conclusion

The phenomenon of the possible change of media structure in low -permeability media when switching from the transport process to the leaching process. This phenomenon certainly deserved more scrutiny in further investigations, as this could be very important for studying transport in Low-Permeability Porous Media.

4.0. References

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