Hydrol. Earth Syst. Sci. Discuss., 2, S447–S449, 2005
www.copernicus.org/EGU/hess/hessd/2/S447/
European Geosciences Union

Hydrology and Earth System Sciences Discussions

HESSD

2, S447–S449, 2005

Interactive Comment

Interactive comment on "Experimental and rheoretical memory diffusion of water in sand" *by* G. Iaffaldano et al.

K. Roth (Referee)

kurt.roth@iup.uni-heidelberg.de

Received and published: 2 August 2005

This paper touches on a fundamental question of our current understanding of water movement through porous media: Is the flux law local in time or does it possess a memory? The authors postulate that there is indeed a memory and that it leads to very pronounced effects. They present supporting experimental evidence and a theoretical analysis. However, the case, as it is put forward here, is not convincing to me.

First, I take the experimental and data analysis perspective. The quality of the data could and should be improved in order to reduce the noise. An automated balance for measuring the outflow would do the job. Even with the current noisy data set, it appears that the fitted model is not correct: it does not correctly describe the tail. Plotting the residuals (measurement minus model) would show a positive bias at short times and a negative one at long times (figures 3...6). Is this because the model is forced through the first data point?

Second, I take the more fundamental perspective. Eq (3) introduces a time-dependent "memory" term. I believe that its current formulation is un-physical because flux does not change because time passes but because the packing settles under the action of the flowing water. Replacing flux by time is a simple matter in a rigid medium since the two are linearly related as long as the boundary conditions remain constant. This is not the case here, however, since the flux is not constant even for constant boundary conditions. A simple stop and go experiment would settle this issue experimentally.

I should mention that most experimentalists working with artifical packings, like the ones used here, either equilibrate them before the actual experiment – the experiments you describe would be such an equilibration run – or they stabilize the porous structure in some other way. Convolving an initial rearrangement of the porous structure into an effective flux law may be useful in some highly dynamic systems, e.g., debris flow or even swelling clays, but it is in my view not appropriate for the type of porous media considered in this work, coarse textured sandy soils and aquifers. Here the time scales of the two processes – structure dynamics and water flow – differ by many orders of magnitude and it is save to consider the processes as decoupled.

I should add some further, minor points.

(1) "Diffusion" implies a sqrt(t)-process. However, flowing water is a t-process as is apparent when a tracer is considered. I am well aware that there is a pressure diffusion equation in groundwater (not applicable for the current experiments) and that water movement in the unsaturated zone may be cast into a "diffusion-type form". Again not applicable here and a quick look reveals that this would be an advection-diffusion process.

(2) As I understood the setup of the cell from figure 2, flow is horizontal. Hence, compaction of the sand would occur perpendicular to the flow and effective conductivity would increase because (i) permeability is proportional to r^2 (nonlinear!), where r is a

HESSD

2, S447–S449, 2005

Interactive Comment

characteristic pore radius, and (ii) local permeabilities add up linearly (flow parallel to structuring) to the global value.

(3) Whether Fick studied porous media, I do not know, but eq (2) is typically referred to Darcy.

(4) Eq (5) implies that you are considering density changes of the water phase. Presuming some reasonable values for the pressure range in your experiment, I cannot see a justification for this additional complication. In any case, ρ would be the density, not its variation.

(5) Fractional calculus does in my view not require any justification anymore: it has been around for some time now. Whether or not it has been mentioned in a motivation for a Nobel prize (pg 11 in original paper) is immaterial. All that counts is if it has a sound conceptual basis in our understanding of the physical system at hand or if it can at least provide a convincing heuristic description of observed phenomena. With respect to the current work, both appear to be open to debate.

(6) Language needs to be improved.

Interactive comment on Hydrology and Earth System Sciences Discussions, 2, 1329, 2005.