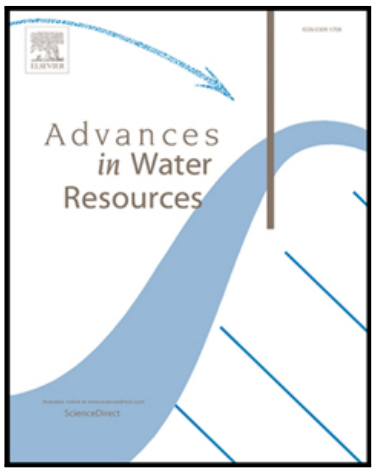

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Comparative analysis of the apparent saturation hysteresis approach and the domain theory of hysteresis in respect of prediction of scanning curves and air entrapment

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Abstract

This study theoretically analyzes the concept of apparent saturation hysteresis, combined with the Scott *et al.* (1983) scaling approach, as suggested by Parker & Lenhard (1987), to account for the effect of air entrapment and release on the soil water hysteresis. We found that the theory of Parker & Lenhard (1987) is comprised of some mutually canceling mathematical operations, and when cleared of the superfluous intermediate calculations, their model reduces to the original Scott *et al.*'s (1983) scaling method, supplemented with the requirement of closure of scanning loops. Our analysis reveals that actually there is no effect of their technique of accounting for the entrapped air on the final prediction of the effective saturation (or water content) scanning curves.

Our consideration indicates that the use of the Land (1968) formula for assessing the amount of entrapped air is in disaccord with the apparent saturation concept as introduced by Parker & Lenhard (1987).

In this paper, a proper routine is suggested for predicting hysteretic scanning curves of any order, given the two measured main curves, in the complete hysteretic domain and some verification tests are carried out versus measured results. Accordingly, explicit closed-form formulae for direct prediction (with no need of intermediate calculation) of scanning curves up to the third order are derived to sustain our analysis.

Keywords: soil water hysteresis; air entrapment; hysteretic scanning curves; scaling; domain theory.

Abbreviations:

FDC, MDC and MWC – first drying curve, main drying curve and main wetting curve, respectively.

1. Introduction

A general overview of the different theories and models of soil water hysteresis is given in our previous studies (Mualem & Beriozkin; 2008, 2009). These latter reviews are relevant to the present study as well, so as to avoid repetition the adduced review refers only to studies related to the present subject matter dealing with the apparent saturation model based on Scott *et al.*'s (1983) empirical scaling technique.

Using a simplified two-parametric form of the van Genuchten (1980) formula, Scott *et al.* (1983) suggested that two shape parameters of any primary drying curve be the same as those pertaining to the MDC. Similarly, two shape parameters of any primary wetting curve are the same as those pertaining to the MWC. Kool & Parker (1987) applied the Scott *et al.* (1983) model when using the three parameter form of the van Genuchten (1980) formula and assuming the exponent of the capillary head (ψ) to be the same for wetting and drying curves. However, their model suffered from an artifact of a 'pumping effect', producing unclosed scanning loops.

Parker & Lenhard (1987) followed by a series of publications (Lenhard, 1992; Lenhard & Parker, 1987; Lenhard *et al*., 1988; Kaluarachchi & Parker, 1992; Lenhard *et al*., 1989; Lenhard *et al*., 1991; Lenhard & Parker, 1992; Dane & Lenhard, 2004; etc.) introduced the concept of