1-D infiltration, analysis of unsaturated flow and increase in land subsidence

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Abstract Artificial groundwater recharge has several applications, including preventing the subsidence that takes place due to pumping. The investigations show that whenever the average of recharge in a year is more than pumping, we do not have any lowering of the groundwater level. But if recharge is less than the pumping and if the characteristics of the soil are suitable, land subsidence can occur. Investigations in the central regions of Kerman, a city in southern Iran, show that although we observe the groundwater level is rising, we unexpectedly have settlement. Ordinarily, the rise of groundwater level will increase the pore water pressure and decrease the effective stress, so subsidence will not occur. A possible explanation for the subsidence that occurs when groundwater levels are rising is the seepage forces generated by downward flowing water in the unsaturated zone. As we demonstrate, the vertical movement of water and the infiltration of water through unsaturated soil imparts forces to the soil, and when the flow direction is downward, the forces should add to effective stresses. Inclusion of unsaturated zone processes makes the problem more complicated, and taking them into account involves a coupled problem that is not amenable to analytical solutions. In this paper, with some simplifications, we show that the coupled problem should be considered in evaluating the effect of recharge on subsidence and that for artificial recharge, the rate of recharge should be considered. The resulting effective stresses can sometimes be greater than expected.

Key words unsaturated flow; effective stress; infiltration; groundwater level