Water Science

ScienceDirect

Water Science 30 (2016) 1–9

journal homepage: www.elsevier.com/locate/wsj

Salt accumulation in irrigated loamy soil; Lower Euphrates Valley, Syria

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Received 29 March 2016; accepted 17 May 2016
Available online 16 July 2016

Abstract

In arid and semi-arid regions, soil salinity is a common problem threatening fertility of irrigated lands. The Lower Euphrates valley in Syria suffers from salt accumulation in soil because of the inappropriate climatic conditions, using the traditional methods in irrigation; flood irrigation. HYDRUS 1-D model was used to simulate water flow, salt transport and root water uptake processes in this area. Data from seventy soil profiles were acquired from the pedological reports obtained from the Ministry of Irrigation in Syria. Representative monthly evapotranspiration (ET_0) values in Deir Ez-Zor were taken from the FAO CLIMWAT database. The seventy soil profiles were grouped in fourteen zones distributed over the study area. For each zone, the monthly recharge and its salt concentration was estimated. The model was run for 24-month duration. The results showed increasing in soil salinity and, consequently, increasing in salts load transmitted into groundwater. Accordingly, mitigation measures have been suggested.

Keywords: Soil salinity; Hydrus 1-D; Salt transport; Root water uptake; Euphrates valley

1. Introduction

Syrian government depends on agriculture as a main part of its economy. The strategic crops like wheat and cotton represent major exported crops in Syria. Euphrates river existence and labor forces in the eastern north regions constitute the appropriate conditions to plant these strategic crops. Extensive applied irrigation water, inadequate soil drainage and climatic conditions lead to increasing in soil salinity. The saline areas increased to about 34% of total arable lands in the lower Euphrates basin. Salt accumulations, in soil, affect severely plants growth leading to reduction of crop yield.

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Peer review under responsibility of National Water Research Center.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.wsj.2016.05.002

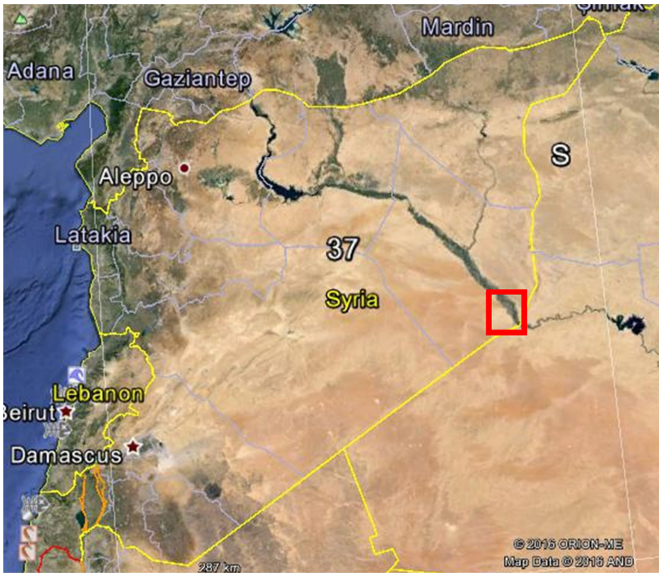

Fig. 1. Location of study area in the Syrian Arab Republic.

On the other hand, salts existence in the soil constitute a source of groundwater contamination. After irrigation, salts dissolve in water and finally reach and accumulate in the groundwater. In this regard, we should take into consideration the amount of salts adsorbed to the soil particles besides the dissolved salts. The partition coefficient controls the relationship between the dissolved and the adsorbed salts in linear or nonlinear relationship.

Extensive field data was conducted by the ministry of irrigation in the year 2005 under the land reclamation project of the Lower Euphrates Valley. In this paper, HYDRUS 1-D model was employed for one of these areas of interest (sector No. 7) in the Lower Euphrates Valley. Three processes were simulated; flow of water, salt transport and root water uptake. The developed model was used to assess the amount of water recharge and salts loads transmitted to the groundwater.

2. Study area

The study area lies in the east of Syria extending along the Euphrates River with approximate length of 38 km, covering an area of about 18,140 ha (Fig. 1). It lies between longitudes 40° 37.5′ and 41° 00.0′ East and latitudes 34° 22.5′ and 34° 45.0′ North. The area is bounded from the north-western direction by Deir Ez-Zor city, while Al-Bokamal city constitutes the south-eastern boundary on the border with Iraq.

3. HYDRUS 1-D simulation model

Flow process, solute transport and root water uptake were simulated using HYDRUS 1-D (Šimůnek et al., 2013).

3.1. Flow process

HYDRUS 1-D solves, numerically, Richard's equation. Richard's equation is the mathematical representation of downward flow in the one-dimensional isothermal uniform Darcian flow of water conditions:

$$\frac{\partial\theta}{\partial t} = \frac{\partial}{\partial z}\left[K(h)\left(\frac{\partial h}{\partial z}+1\right)\right] - S \quad (1)$$

where θ is the volumetric water content (L^3/L^3), h is the matric suction (L), $K(h)$ is the unsaturated hydraulic conductivity (L/T), z is the depth from the ground surface (L); t is the time (T), S is the sink term accounting for the root water uptake (T^{-1}).