Alexandria Engineering Journal (2015) 54, 1305–1313

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Alexandria Engineering Journal

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ORIGINAL ARTICLE

Assessment of the DRAINMOD-N II model for simulating nitrogen losses in newly reclaimed lands of Egypt

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Received 13 May 2014; revised 17 March 2015; accepted 25 May 2015
Available online 26 June 2015

KEYWORDS

Nitrogen losses;
Drainage rate;
DRAINMOD-N II;
Model calibration;
Subsurface drainage

Abstract The DRAINMOD-N II, which is a based field scale model for predicting Nitrogen, was successfully calibrated and validated using data sets from two experimental plots located at the North-East of Egypt over a period of one year (2009–2010). Lateral drains were installed at 12 m spacing in the first plot and at 18 m in the second plot. Both plots were cultivated with cotton during the summer of 2009 followed by wheat during the winter of 2009/2010. The quantity and quality of irrigation and drainage water were monitored for both sites over the two cropping seasons. DRAINMOD-N II was calibrated using data from the first plot, while data set from the second plot was used for model validation over the two cropping seasons. The model simulation results were evaluated statistically by comparing the simulated and measured drain flows and nitrate–nitrogen (NO_3–N) losses in the subsurface drains.

The study results showed good agreement between the observed and simulated results for both plots. The mean absolute error (MAE) of the drainage rate was less than 0.08 cm for the calibration plot over the two cropping seasons. The MAE results for the prediction of NO_3–N drainage losses were 0.028 and 0.035 kg NO_3–N/Feddan during cotton season and wheat season, respectively for the calibration plot. During the same period, MAE of the drainage rate was less than 0.04 cm for the validation plot. The MAE of NO_3–N drainage losses was 0.024 and 0.013 kg NO_3–N/Feddan during cotton season and wheat season, respectively for the validation plot. These results prove the DRAINMOD-N II capability to simulate nitrogen losses from the newly reclaimed agricultural lands under the Egyptian conditions.

1. Introduction

The Government of Egypt, as part of its horizontal land expansion program, embarked on an initiative to reclaim and irrigate an area covering 620,000 Feddan (260,400 Hectares) in the northern Delta and northern Sinai Peninsula (North Sinai

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Peer review under responsibility of Faculty of Engineering, Alexandria University.

http://dx.doi.org/10.1016/j.aej.2015.05.020
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Development Project). Due to deficit of fresh water supply, the area is irrigated using mixed (fresh and drainage water) water delivered by El-Salam Canal which takes the fresh water from Damietta branch of the Nile Delta and drainage water from the main open drains in Eastern Delta.

North Sinai Development Project is one of the mega irrigation projects in Egypt. South El Husseinia Plain is within the project area and comprises about 64,000 Feddan (26,700 Hectares). The plain is located in a former marshland which comprised the bed of Lake Manzala many years ago and its soil is highly saline. In the context of the project, a field experiment was set up to study the feasibility of installing subsurface drainage system in these newly reclaimed lands. The project concluded that the use of subsurface drainage has sharply decreased soil salinity, lowered the water table, and substantially improved crop productivity. The project, however, did not consider the effect of subsurface drainage on nitrogen dynamics in the soil–water–plant system and its impact on Nitrogen loss to surface water [1].

The newly reclaimed land in South El Husseinia Plain is close to Lake Manzala that is an environmentally sensitive surface water body. Leaching losses of Nitrogen from agricultural lands to surface waters are expected to increase after the installation of subsurface drainage. Nitrogen loads from the newly reclaimed land, could increase nutrient levels in Lake Manzala triggering phytoplankton growth, depleting the dissolved oxygen, and creating hypoxic zones within the lake. The ecological system of the lake could eventually be disturbed because of the continuous delivery of nutrients from drained lands.

DRAINMOD-N II was developed as a field-scale model to simulate the hydrology of poorly or artificially drained lands. The size of the area selected for calibration should be a field scale size, with drain spacing and depths representative field conditions. For agricultural catchments, the calibration area should generally consist of at least three lateral drains, instrumented to continuously measure flow rates and water table depths midway between the laterals [11]. In addition, the modeled area should be representing normal drainage boundary conditions.

The objective of this paper is to assess the validation of the DRAINMOD-N II model under the Egyptian conditions of the newly reclaimed lands in order to facilitate the design of the subsurface drainage systems that satisfy crop production needs, and correspondingly minimize the offsite delivery of nitrogen to surface waters in the newly reclaimed lands.

2. Methodology

2.1. Site description

For calibration and validation of DRAINMOD-N II model, an experimental site was established within South El-Husseinia Plain, 30 km South of Port Said, Egypt. The total cultivated area of the site is 6 Feddan (2.52 Hectares), divided into two plots: (i) plot A (2.5 Feddan (1.05 Hectares)), and (ii) plot B (3.5 Feddan (1.47 Hectares)). Soil texture of the site is loamy clay to clay extending to about 2 m below the ground surface (bgs). The soil is saline with Electrical Conductivity (EC) exceeding 16 dS/m and a hydraulic conductivity of 0.44 cm/day [3]. Shallow groundwater is highly saline and its average depth is 1 m bgs. The source of irrigation is mixed water (fresh water mixed with agricultural drainage water) from El-Salam Canal with Total Dissolved Solids (TDS) range between 700 and 800 ppm. The average concentration of NO_3–N in the irrigation water is 3 mg/l [2].

The subsurface drainage system was installed at different drain spacing. Lateral and collector drains were installed in the two neighboring plots at 1.2 m bgs using a 12 m spacing at plot A and an 18 m spacing at plot B. Each plot has a number of laterals and only one collector. The layout of the experimental field is shown in Fig. 1. Both plots were cultivated with cotton during the summer season of 2009 followed by wheat crop during the winter season of 2009/2010.

Similar agricultural management practices were applied at both plots during both cropping seasons. The same irrigation

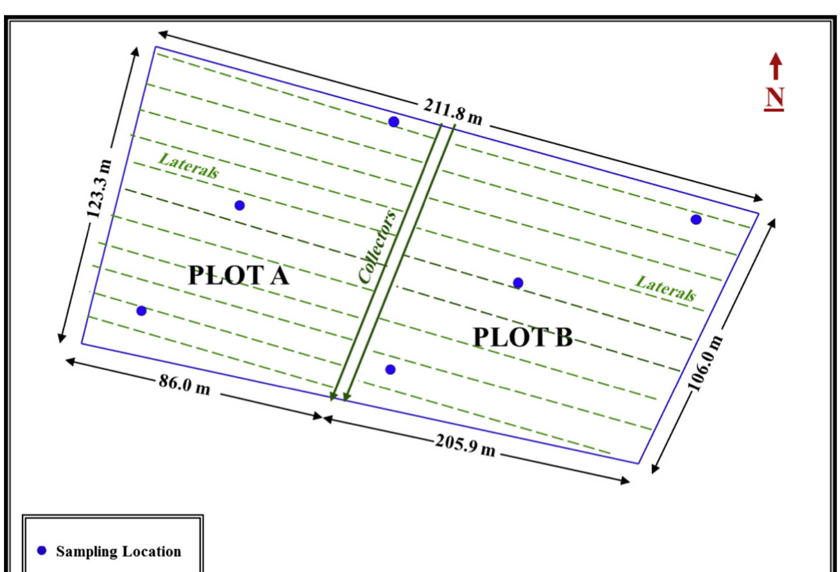

Figure 1 Sampling layout for both experimental plots.