MATHEMATICAL MODEL of AGRICULTURE DRAINAGE WATER POLLUTION and ITS EFFECT on El-NOBARIA CANAL

Submitted by

Sherif Ahmed Kamal Abd El-Aziz

B.Sc. of Civil Engineering, Faculty of Engineering,

Alexandria University, 1988

Master of (Irrigation & Hydraulics), Faculty of Engineering,

Alexandria University, 2004

A Thesis submitted in Partial Fulfillment

Of

The requirements for the Doctor of Philosophy Degree

In

Environmental Sciences

Department of Environmental Engineering Science

Institute of Environmental Studies and Researches

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Abstract

Water is life and the quality and adequacy of water is an essential measure of the quality of life or rather the existence of life. The management of water quality, or the protection of the aquatic ecosystem in a broader sense, means the control of pollution. El-Nobaria canal is largely used for constant disposal of untreated agriculture effluents. Consequently, water quality of the canal degrades particularly in the low flow months.

El-Nobaria canal irrigates $1.076X10^6$ feddans (451.535 ha). It is one of the most important drinking sources of Alexandria and El-Behera areas. Eight potable water intakes take their water from El-Nobaria canal and its branches, which suffer from pollution by agriculture drainage water at seven locations (point sources). A 59% of such drainage water is coming from El-Nasr-3 main drain. This tends to cause a deterioration of El-Nobaria canal water quality downstream El-Nasr-3 main drain outfall feeding all potable water intakes and several branches locating downstream km (52,960) on the canal.

In this study, four agricultural large catchments of El-Delengat Ext. drain, El-Bostan drain, El-Nasr-3 main drain and El-Nasr-1 drain are studied. DRAINMOD/ DRAINMOD-N/ DRAINMOD-S combined models have been tested at the field scale using the field data of 2006/07 & 2007/08 years to model the outflow discharge, salinity and nutrient load. Finally, the models' results from fields are integrated at each outlet of the four catchments. Graphical and Six Statistical measures comparisons are made between (Salinity, Nitrate and Total Nitrogen) concentrations measured by DRI and integrating results at each catchment level. Water quality models are water management tools used to diagnose

water quality problems and the impact of various environmental conditions. In this thesis, QUAL2K model inputs and characteristics of the model are explained. Then, QUAL2K model has been calibrated and validated on El-Nobaria canal using the field data during summer of 2007 and winter of 2008, respectively. The study concerned on salinity (TDS), NO_3-N, DO, TN and pH along El-Nobaria canal's length. The quality of El-Nobaria canal water has been investigated to estimate the impact of drain discharged on its quality. The results show that El-Nasr-3 main drain and El-Nasr-1 drain are highest pollution sources to El-Nobaria canal. The results show also that both combined models and QUAL2K represent the field measured data quite well.

A proposed drainage reuse scenario is presented in this study to improve the water quality of El-Nobaria canal. This thesis focuses on a proposal plan to manage the drainage water of El-Nasr-3 main drain and El-Nasr-1 drain by intermediate mixing of their water directly into El-Bostan canal at km (2.400) and El-Nasr canal at km (0.700), respectively, which serve agriculture uses only. The most suitable mixing locations are chosen according to the design values of discharges, levels, and measured salinities. The QUAL2K model is used to simulate water quality along El-Nobaria canal's length for the proposed scenario. The results show that TDS and NO_3-N values decrease from 850 mg/l to 370 mg/l and from 4.96 mg/l to 3.91 mg/l, respectively. The simulation shows that values of TDS and NO_3-N are lower than maximum permitted concentration of law 48 and drinking standards. This tends to cause an improvement of the canal water quality especially at points of the potable water intakes. This mixed water can be used as a safe drinking water abstraction source for the present water drinking plants and the planned ones. The proposed drainage reuse scenario is also found environmentally feasible.

LIST of ABBREVATIONS

BADP = Bostan Agriculture Development Project

BCM/y = Milliard Cubic Meter per year = 10^9 m^3 per year

BOD = Biological Oxygen Demand

Ca = Calcium

Cl = Chloride

CO_3 = Carbonate

COD = Chemical Oxygen Demand

DO = Dissolved Oxygen

DRI = Drainage Research Institute

DW = Drainage Water

DWIP = Drainage water irrigation project

DWR = Drainage Water Reuse

dS/m = Dece Siemens per meter = 640 ppm

EC = Electric Conductivity

EIA = Environmental Impact Assessment

EPADP = Egyptian Public Authority for Drainage Projects

ET = Volume of irrigation water to be consumed by crops

FAO = Food and Agriculture Organization of the United Nations

FW = Fresh Water

FW-DW = Mixed Water = Fresh water-Drainage water

GWT = Ground Water Table

Ha = Hectare

HAD = High Aswan Dam

HCO_3 = Bicarbonate

IAS = Irrigation advisory service

IDR = Intermediate drainage reuse

IIP = Irrigation Improvement Project

K = Potassium

Km = Kilometer

L_r = Leaching requirements

m^3/sec = Cubic meter per second

MAR = Monthly Average Rainfall

MCM/day = Million Cubic Meter per day = 10^6 m^3 per day

meq/L = milli equivalent per liter = 10 dS/m

Mg = Magnesium

mg/L = Milligram per liter

MPN = Most Probable Number of bacteria

MSL = Mean Sea Level

MWRI = Ministry of Water resources and Irrigation

Na = Sodium

NARS = Nobaria Agriculture Research Station

NDGD = El-Nasr Drainage General Directorate

NIGD = El-Nasr Irrigation General Directorate

NO_3 = Nitrate

NWRC = National Water Research Center

OW = Observation Well

Pathogens = Bacteria

PCM = Portable Conductivity Meter

pH = Negative Logarithm of hydrogen ion concentration.

PO_4 = Phosphate

ppm = part per million = mg/L = milligram per liter

PS = Pumping Station

PVB = Present Value of Benefit

PVC = Present Value of Cost

PVNB = Present Value of Net Benefits

PW = Potable Water Intake

Q2K = QUAL2K

Q_{Design} = Discharge of the drain at the proposed reuse location.

SAR = Sodium Adsorption Ratio

SO_4 = Sulphate

SRLQC = Soil Research Laboratory and Quality Control

SRP = Strategy Research Project

SDW = Saline drainage water

TDS = Total Dissolved Salts

UTM = Universal Transfers Merkator

WUAs = Water Users Association

Zn = Zinc

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