Proposed Decision Support System for Reduction of Total Phosphorus in Lake Manzala

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Abstract

In Egypt, Lake Manzala has great economic importance as a major source of fish and salt. It is a natural resource and is considered highly important in terms of its socio-economic aspects. It has suffered from a high level of eutrophication, due to the heavy load of nutrients, especially phosphorus. Reduction of Total Phosphorous System (RTPS) has been conducted to solve the high level of eutrophication and pollution problems of Lake Manzala, which are unstructured and complex. The main component of RTPS is the inclusion of RTP model. Actually, this is a quantitative and dynamic model whose objective is to simulate the mass balance of TP in water and sediments in order to optimize the ecosystem of Lake Manzala. This model is considered as a useful water quality management tool in designing TP two reducing scenarios. The first scenario is the reduction of TP concentration in water drains, and the second scenario is the reduction of TP concentration in water drains and Lake Sediment. Furthermore, in each scenario there are multiple alternatives through ratios of reduced TP. It found that 30 % reduction of TP from each drain could act as an important solution for quick recovery of the lake condition to reach 560.56 $mg.m^{-3}$ of TP's initial concentration (1590 $mg.m^{-3}$ in spring season) after 10 days and a maximum 433.37 $mg.m^{-3}$ after 100 days.

Keyword:*DSS, Simulation, Modeling, Total Phosphorus, Ecosystem, Eutrophication, Lake Manzala*

1. Introduction

Decision Supports Systems (DSS) are computer-based information systems designed in such a way that help decision maker to select one of the many alternative solutions to a problem. It helps organization to increase production, reduce costs, increase profitability and enhance quality. It is an interactive system with an organized collection of models, people, procedures, software, databases, telecommunication, and devices, which helps decision makers to solve unstructured or semi-structured problems [1].

Lake Manzala is the largest lakes northern coastal lake of Nile Delta and is considered highly important in terms of geographical, social and economic aspects. where, the lake lies within the borders of five Egyptian governorates Damietta, Port Said, Ismailia and Sharkiya Dakahliya, and Its annual fish production represents about half of the total fish yield of the northern Delta lakes, and about one fifth the (non-marine) fish yield of Egypt [2]. In addition, it is the largest lake in terms of fish production in Egypt with an annual output of 60 thousand tons (35% of fish production of other lakes). Lake Manzala suffered from a high level of eutrophication, due to the heavy load of nutrients, especially phosphorus and nitrogen compounds due to agricultural run off, sewage and drains discharges [2].

Phosphorus is one of the major nutrients that lead to this phenomenon. Therefore, understanding its sources and transfers in catchments, as well as knowledge about its fate in aquatic system (interaction with bottom sediments) is needed in identifying and reducing this risk. Eutrophication of the Nile Delta Lakes Mariut, Edku, Brollus and Manzala constituted in the last four decades a considerable problem, causing cases of sudden mass mortality of fishes [3].

The present study aimed to solve eutrophication problem of Lake Manzala by using Reduction of Total Phosphorous System (RTPS). It is propose system use DSS which contain Reduction of Total Phosphorous model (RTP) model. RTP model aims to build simulation based model to optimize the ecosystem of Lake Manzala.

Donia and Hussein 2004 [4], were Studied the eutrophication assessment of Lake Manzala using geographical information system (GIS) techniques. GIS functions and operations have been analyzed to assess, monitor and model the environmental conditions of the lake Manzala. The eutrophic state index was calculated to describe the trophic state of the lake environment. A GIS overlay technique was applied to synthesize the information into a final map illustrating the spatial distribution of water quality conditions within the study area. Badr and Hussein M. 2010, developed an Input/ Output Flux Model of Total Phosphorous (TP) in Lake Edku, a Northern Eutrophic Nile Delta Lake. They reported that Lake Edku is suffering from a high level of eutrophication, due to the heavy load of nutrients, especially phosphorus. A water-sediment flux model for TP was implemented in this study to understand its geo-chemical behavior across water and sediments boundary and to calculate its concentration in the whole lake water volume as well as sediment volume as a result of discharging loads [4].

2. Problem and Proposed System

The present study will scan the environment to identify problem situation and its conditions through study area and proposed system to determine the ecosystem problem of Lake Manzala.

2.1. Study Area and Sample

Lake Manzalah is the largest natural Lake and economically the most important Delta Lake in Egypt. Lake El Manzala is situated at the eastern margin of the Nile Delta between 31° 00` - 31° 30` N latitude and 31° 45` - 32° 22`E longitude with an area of 120 km2 [5]. The morphmetrical and physical parameters of Lake Manzala is shown in Table 1.

Table 1: Morphmetrical and Physical Parameters of Lake Manzala

Maximum depth (m)	2.20 m	Present study
Mean depth (m)	1.50 m	Present study
Area (m^2)	120×10^6	Abdel Mageed, A. A. 2007
Water volume (m^3)	180×10^6	Present study
Sediment volume (m^3)	120×10^5	Present study
Porosity of upper 10 cm sediment layer	0.66	Ibrahim, M. K. H. (1994)
Density of solid phase in sediments ($kg.m^{-3}$)	2650	Zeigler and Lick (1988)

Lake Manzala is a highly dynamic aquatic system that has undergone considerable physical, chemical and biological changes during the past century. This was as a result of different aspects of human impacts of which closing and/or opening of straits, establishment of Aswan High Dam, silting of the lake, continuous drying processes for cultivation purpose and human settlement as well as pollution with different kinds of water discharge into the lake. Six main agricultural drains (Hadous Drain (D1), Bahr El Bakar Drain (D2), El-Serw Drain (D3), Ramsis Drain (D4), Faraskur Drain (D5), Matariya Drain (D6)) use to flow into Lake Manzala and affect its water quality. Drainage water contributes about 98% of the total annual inflow to Lake Manzala. There are six drains carrying the fresh and drainage water to the lake. The following are the main six drains with their relative contribution of the total flow in water (Donia, N. and Hussein, M. 2004) [4] as shown in Table 2.

Table 2: The main six drains with their relative contribution of the total flow in water

Drain	The total flow in water	Serving
D1	49%	790000 feddans
D2	25%	536000 feddans
D3	13%	68700 feddans
D4	4%	about 24 km long
D5	4%	20000 feddans
D6	2%	50000 feddans

The drains convey large amount of nutrients, especially from Bahr-El-Bakar, Ramsis and Hadous drains that are heavily contaminated by sewage and industrial waster. The northern part of the lake is affected by marine water invasion through El-Gamil outlet (Boughaz ElGamil). Sea water may be introduced into the lake during windy days; invading the area at the lake-sea connection such marine water and expelled from the lake by the normal flow of the drain water. Through these outlets, the exchange of water and biota between the lake and the adjoining Mediterranean Sea is possible as shown in Fig.1.

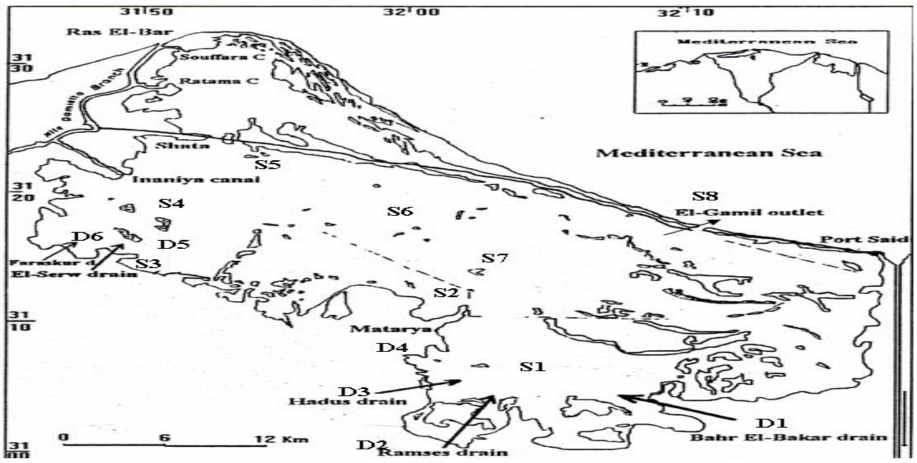

Fig. 1: Location of Lake Manzala with Selected Drains and Stations

2.1.1. TP Sampling

Water sampling was conducted seasonally in September, January, April and July (2010-2011), representing autumn, winter, spring and summer, respectively. One day in the middle of each season was select to represent the whole season. Surface water samples were collected in plastic bottles of one-liter capacity each at 10 cm below the surface water, at 8 stations as shown in Fig. 1 (El-Genka (S1) - Mataria (S2) - El-Serow (S3) - Faraskour and Inaniya (S4) - El Zarka (S5) - Lagan (Midle of Lake) (S6) - El-Bashteir (S7) - Boughaz El-

Gamil (S8)) representing the different ecological areas of Lake Manzala and at 8 stations in front of the outlets of the drains Table 3 shows the average TP content in water (mg/l) recorded in Lake Manzala and Table 4 show TP Concentrations (mg/L) in the Surface Water of Lake Manzala Drains during the Four Seasons. The TP Concentrations ($mg.g^{-1}$) in the Surface Sediments of Lake Manzala Drains during the Spring Seasons as shown in Table 5.

Table 3: Local and Seasonal variation as well as Seasonal Averages of TP in Water (mg/l) Recorded in Eight Stations of Lake Manzala

Seasons / Stations	Autumn	Winter	Spring	Summer
S_1	1.65	2.57	2.41	0.89
S_2	1.74	1.64	1.98	1.78
S_3	0.82	0.43	0.52	0.72
S_4	0.68	0.44	1.38	1.74
S_5	0.65	0.67	2.04	0.34
S_6	1.34	0.63	1.39	0.43
S_7	1.98	1.17	2.08	0.76
S_8	1.77	1.14	0.91	1.11
Average	1.33	1.09	1.59	0.97

Table 4: TP Concentrations (mg/L) in the Surface Water of Lake Manzala Drains during the Four Seasons

Seasons / Drains	Autumn 2010	Winter 2011	Spring 2011	Summer 2011
D1	1.97	2.98	3.77	2.86
D_2	1.76	2.21	1.82	1.28
D_3	1.88	2.91	1.73	1.35
D_4	1.79	1.96	1.98	1.98
D_5	0.95	0.69	0.64	0.79
D_6	0.766	0.73	1.68	1.79
Average	1.302	1.64	1.66	1.436
STDVE	0.745	1.173	1.182	0.909

Table 5: TP Concentrations ($mg.g^{-1}$) in the Surface Sediments of Lake Manzala Drains during the Spring Seasons

Drains	Spring 2011
D_1	18.20
D_2	8.69
D_3	9.17
D_4	4.032
D_5	25.05
D_6	14.68
D_7 (O/P)	37.15
Average	16.71

2.1.2. Water Balance for Lake Manzala

The water balance of a lake is usually evaluated by the basic hydrological equation in which the change in storage of the water volume in the given area per time is equal to the rate of water inflow from all sources minus the rate of water outflow, Table 6 shows seasonally water balance elements of Lake Manzala [6].

Table 6: Seasonally Water Balance Elements of El-Manzala Lake (x 10^6 m^3)

Seasons	Drainage Inflow	Rainfall	Evaporation	Out Flow
Autumn	1257.25	11.47	318.98	949.71
Winter	735.36	34.74	275.21	494.89
Spring	905.36	12.34	348.68	569.02
Summer	1232.53	0.34	334.71	898.16

The water balance for Lake Manzala can be written according to the equation developed by [7]:

$$S = \frac{dV}{dt} = Q_{in} - Q_{out} + G + PA_s - EA_s \qquad (1)$$

Where:

S = storage ($m^3.d^{-1}$)

V = volume (m^3)

T = time in days (d)

Q_{in} = total water inflow ($m^3.d^{-1}$)

Q_{out} = total water outflow ($m^3.d^{-1}$)

G = ground water flow ($m^3.d^{-1}$)

P = precipitation ($m^3.d^{-1}$)

E = evaporation ($m^3.d^{-1}$)

A_s = lake surface area (m^2)

There are six water sources to Lake Manzala, land runoff (Q_{in}) including Bahr El-Bagar, Ramsis, Hadous, Mataria, El-Serow and Faraskour Drains in addition to precipitation (P). These are opposed by water sinks; evaporation (E) and outflow water from the lake to Boughaz El-Gamil (Q_{out}). Precipitation directly on the surface area of Lake Manzala is restricted mainly to winter season with an average daily amount of 0.386 x10^6 m^3. The average amount of the evaporated water from the lake (restricted to the summer season) was estimated to be 3.719 ×10^6 $m^3.d^{-1}$. The ground water loads require an estimation of the average phosphorus concentration in the seepage area. As we did not include its effect in the model, this term was neglected. The seasonal amount of the water outflow from Lake Manzala ($m^3.d^{-1}$) was obtained from the direct measurements using a water current meter at Boughaz El-Gamil.

The water balance of Lake Manzala integrates in each season. It shows that the amounts of the outflow water to the sea ranged from 5.49×10^6 $m^3.d^{-1}$ in winter to 9.97×10^6 $m^3.d^{-1}$ in summer where the water input was primarily from the overland sources. Therefore, this lake can be classified as a “drainage lake” (Ibrahim, M. K. H. 1994). The calculations for water balance of Lake Manzala in the four seasons indicate that the total input values were equal to the total output values; which mean that there were no drastic changes in the lake volume throughout the year. The residence time (τ) of the lake water in each season, calculated from division of the lake volume by the lake outflow rate that changes from one season to another (are 10.5523, 5.4988, 6.3224 and 9.9796 $\times 10^6$ m^3 d^{-1}) for autumn, winter, spring and summer, respectively, with the annual average value of 8.0883 $\times 10^6$ m^3 d^{-1}. There for the water exchange time (τ); 32.7344 days in winter and 18.0368 days in summer [6].

2.2. Proposed System

This case will propose RTPS for reducing the source of TP in Lake Manzala. RTPS is an effectiveness DSS intended to support decision makers to solve high level of eutrophication problem of Lake Manzala. It consists of three interacting components: Environmental Database, RTP model and easy-to use interface.

2.2.1. Components of RTPS

RTPS components are the following and as shown in Fig. 2:

1- Environmental Database: Relevant environmental information of Lake Manzal was amalgamated and entered into a data base that is managed by a Database Management System (DBMS) to aid decision maker. Collected data are as follows:

- Morphmetrical parameters of Lake Manzala (Table 1).
- Initial concentration of TP for Lake Manzala (Average of each season) (Table 3).
- Input loads of TP for Lake Manzala.
- TP concentrations in water column and sediments of Lake Manzala Drains (Tables 4&5).
- Total suspended matter ($mg.m^{-3}$) for Spring season is 940 [8].

2- RTP Model: The objective of the model was to simulate the mass balance of TP in water and sediments of Lake Manzala. It utilizes algebraic and differential equation to optimize the ecosystem of Lake Manzala; hence, it a quantitative model. Also, it depends on time; hence, it is dynamic model. RTP gives decision makers a variety of choices, which assists their decision making process.

3- User interface: is used to communicate with and command the RTP. A user interacts with the RTP model to obtain output data.

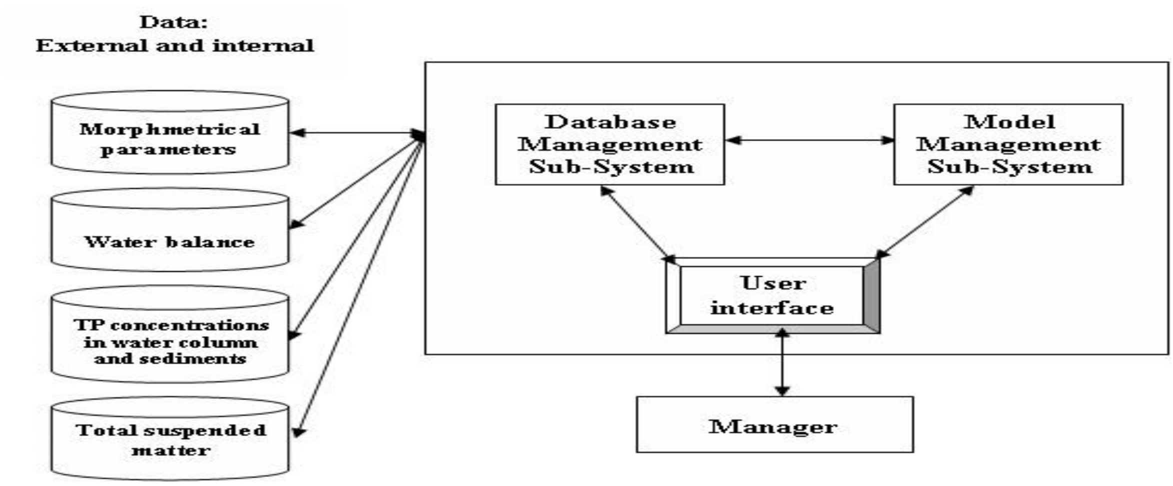

Fig. 2 Components of RTPS for Lake Manzala

2.2.2. Assumptions of RTPS

The major assumptions used in the RTPS include the following:

- The atmospheric input is considered as a minor source of phosphorus (P) to coastal waters, because Phosphorous is particularly not volatile [9]. Consequently, the model did not consider TP loads from rainfall and dry precipitation.
- In this case, ground water and shoreline erosion in the Lake Manzala were not considered owing to the lack of reliable data and the belief that these are small with respect to the other loads. According to [10], Groundwater flows can be particularly important in areas of porous limestone that is relevant to some tropical limestone islands.

3. RTP Model

In this model will address the Mass Balance Equations for TP in water Column and sediments, Parameterize of RTP and analytical solution for Model.

3.1. Mass Balance Equations for Total Phosphorus in Water Column and Sediments

As is common in shallow lakes, the movement of boats and moderate wave height in Lake Manzala are enough to induce re-suspension of the bottom sediments and can result in a large contribution to the total nutrient load in the lake water. Studies in a shallow, wind-exposed lake in Denmark [11] showed that the phosphorous loads induced by re-suspension could be 20-30 times greater than that released from undisturbed bed sediments. As such, sediments feedback could have a potential source of phosphorus to the overlying lake waters, which in turn have a significant impact on the recovery of such system especially in shallow lakes [4][12]. The following are the time dependent mass balance equations that govern the total phosphorus concentration in the water column and sediments layer [7]:

$$V_1 \frac{dp_1}{dt} = W_{in} - W_{out} - v_s A_s P_1 + v_r A_s P_2 \quad (2)$$

$$V_2 \frac{dp_2}{dt} = v_s A_s P_1 - v_r A_s P_2 - v_b A_s P_2 \quad (3)$$

Where:

V_1 & V_2 = volumes of lake water and sediments, respectively (m^3)

P_1 & P_2= TP concentrations in water column and sediments, respectively ($mg.m^{-3}$)

W_{in} = TP loads to the lake system

W_{out} = TP loads out of the lake system

v_s = settling velocity from water column to sediments ($m.d^{-1}$)

v_r = re-suspension velocity from sediments to water column ($m.d^{-1}$)

v_b = burial velocity from the enriched surface layer to the deep sediments ($m.d^{-1}$)

The first term in the water column mass balance equation describes the external loads, while the second one describes the outflow sink. The third and fourth terms give a net deposition of TP, including settling and re-suspension processes, respectively. For the sediments equation, the burial term is present in addition to other processes; settling and re-suspension.

3.2. Parameterize of RTP Model

RTP model parameters include: in/out Loads to the Lake system, settling, Re-suspension and Burial Process.

3.2.1. Loads to the Lake System

The total input load term (W_{in}) in the mass balance equation is listed in Table 7. It is the sum of the TP loadings (mg.d^{-1}) from Bahr El-Bakar Drain (W_1), Ramsis Drain (W_2), Hadous (W_3), Mataria (W_4), El-Serow (W_5) and Faraskour (W_6) (equation 4) [4]. The load from each drain was calculated by multiplication of the inflow concentration of TP by the volumetric flow rate of the water discharged. These loads included the leaching and drainage of fertilizers and other soil nutrients.

Table 7: Input loads of TP (x 10^{9}mg/m^{-3}/d^{-1}) for Lake Manzala in the four seasons.

Season	W_1	W_2	W_3	W_4	W_5	W_6	Input TP loads (10^{9}mg d^{-1})
Autumn	7.22	1.04	13.19	0.53	1.72	0.45	24.153
Winter	8.64	0.98	8.65	0.46	0.81	0.32	19.863
Spring	11.31	0.87	8.13	0.48	0.74	0.81	22.337
Summer	10.85	0.78	8.66	0.61	1.56	1.09	23.528

$$W_{in}=W_1+W_2+W_3+W_4+W_5+W_6 \quad (4)$$

Where:

W_{in}= TP loads from the six drains (mg. d^{-1})

W_1= TP load from Bahr El-Bakar Drain (mg. d^{-1})

W_2= TP load from Ramsis Drain (mg. d^{-1})

W_3= TP load from Hadous Drain (mg. d^{-1})

W_4= TP load from Mataria Drain (mg. d^{-1})

W_5= TP load from El-Serow Drain (mg. d^{-1})

W_6= TP load from Faraskour Drain (mg. d^{-1})

3.2.2. Loads out of the lake system

The TP load carried out from the lake to El-Gamil by the outflow stream can be represented by the following equation [7]:

$$W_{out} = Q_{out} P_1 \quad (5)$$

3.2.3. Settling Process

Settling represents uniform loss, which can be formulated as a flux of mass from the surface area of the lake to the sediments. Thus, a term for settling in the mass balance can be developed as following [7]:

$$V_s \; A_s P_1 \quad (6)$$

The settling velocity is called “apparent” because it represents the net effect of the various processes that act to deliver element to the lake’s sediments. According to [13][14], the settling velocity can be calculated by the following equation [7]:

$$\nu_s = \frac{H}{\sqrt{\tau_w}} \tag{7}$$

Where:

H = average depth of the lake (m)

τ_w = water residence time (day)

3.2.4. Re-suspension Process

To quantify the re-suspended sediments and the resulting contribution to TP load in the lake water, the re-suspension process can be estimated by the following equation (Chapra, S.C. 1997)[7]:

$$RP = \nu_r A_s P_2 \tag{8}$$

The P_2 value was modified from $mg.kg^{-1}$ to $kg.m^{-3}$ by multiplying P_2 concentration by the density of solid phase in the sediments Table 1.

The re-suspension velocity can be calculated from the following formula (Chapra, S.C. 1997)[7]:

$$\nu_r = \nu_s \frac{m_i}{(1-\phi)\rho} - \nu_b \tag{9}$$

Where:

m_i= average concentration of total suspended solids in each season ($mg.m^{-3}$)

φ= porosity of sediments layer (Table 1).

ρ= density of solid phase in sediments ($kg.m^{-3}$).

3.2.5. Burial Process

A burial mass transfer from the enriched surface sediment layer to the deep layer can be estimated by the following equation (Chapra, S.C. 1997)[7]:

$$BP = \nu_b A_s P_2 \tag{10}$$

and the burial velocity can be calculated from the following formula (Chapra, S.C. 1997)[7]:

$$\nu_b = \frac{w_{in} - w_{out}}{A(1-\phi)\rho} \tag{11}$$

3.3. Analytical Solution for RTP Model

In this study, RTP model is based on the analytical solution of a system of two linear non-homogenous differential equations (1 and 2), one for the water column and the other for the sediments. The following particular form of solution for the two differential equations will describe how the lake's TP concentrations (P_1 and P_2) change as a function of time following the change of TP loading (Badr, N.B. and Hussein, M. 2010)[3]:

$$P_1 = L_1 C_1 e^{\alpha t} + L_2 C_2 e^{\beta t} + L_3 \tag{12}$$

$$P_2 = C_1 e^{\alpha t} + C_2 e^{\beta t} + L_4 \tag{13}$$

Where:

$$L_1 = \frac{\alpha V_2 + S_4}{S_3} \quad (14)$$

$$L_2 = \frac{\beta V_2 + S_4}{S_3} \quad (15)$$

$$L_3 = \frac{S_4 W}{S_1 S_4 - S_2 S_3} \quad (16)$$

$$L_4 = \frac{S_3 W}{S_1 S_4 - S_2 S_3} \quad (17)$$

$$S_1 = Q + \upsilon_s A_s \quad (18)$$

$$S_2 = \upsilon_r A_s \quad (19)$$

$$S_3 = \upsilon_s A_s \quad (20)$$

$$S_4 = \upsilon_r A_s + \upsilon_b A_s \quad (21)$$

α and β = roots of the equations

To obtain the constant values (C_1 and C_2), the initial conditions for TP in the water column (P_s) and sediments (P_b) at t=0 were taken from the actual measured data (average concentration of six drains Tables 4 and 5):

$$P_s = L_1 C_1 + L_2 C_2 + L_3 \quad (22)$$

$$P_b = C_1 + C_2 + L_4 \quad (23)$$

From equations 22 and 23, C_1 and C_2 can be obtained

$$C_1 = \frac{P_s - L_1(P_s - L_4) - L_3}{(L_2 - L_1)} \quad (24)$$

$$C_2 = P_b - \left[\frac{P_s - L_1(P_s - L_4) - L_3}{(L_2 - L_1)}\right] - L_4 \quad (25)$$

By using equations 24 and 25 and substitute into equations 12 and 13, we can get the final solution of P_1 and P_2. The input-data for RTP model which appear the morphmetrical and physical parameters, total water inflow/ outflow TP concentrations in the surface water and in the surface sediments of Lake Manzala in the Spring season, as shown in Fig.3.

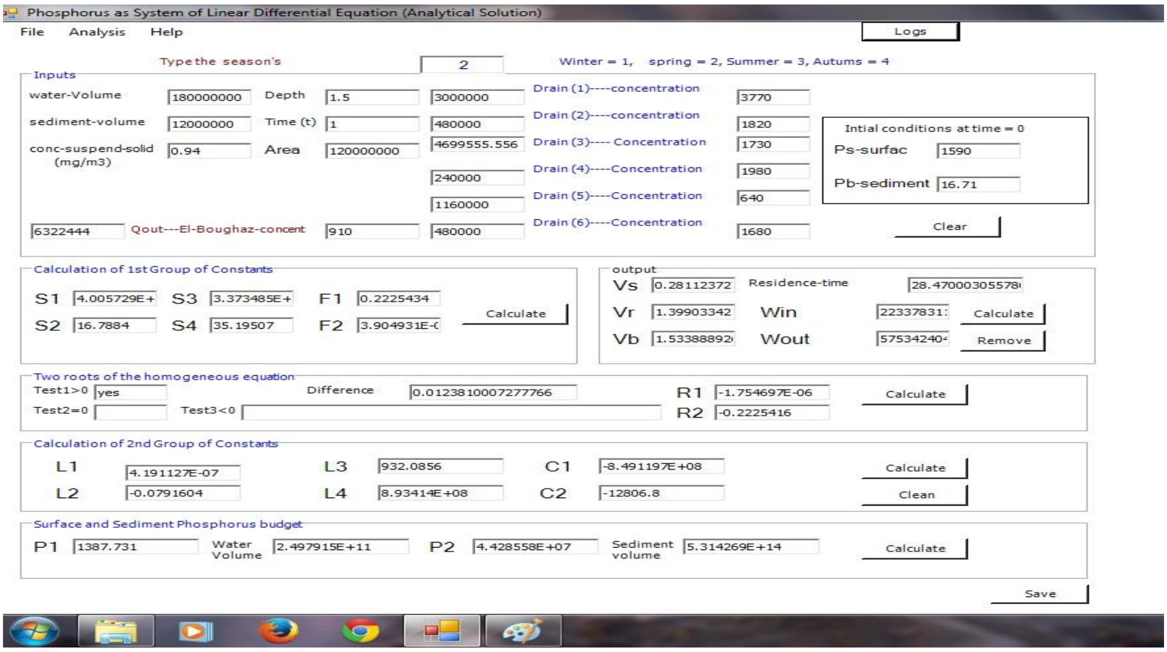

Fig. 3: RTP's Input Data Screen for Spring season.

4. Results and Discussions

For the need of better environmental protection in Egypt, its water resources and the health of Egyptian citizens are of high priority of the government. Egypt has stipulated the necessity for land and water management strategies. Regulation of fertilizers and pesticides and development of agricultural legislation in harmony with an effective environmental policy, especially for Nile Delta Lakes must be enforced. The present study indicates that Lake Manzala is considered as a highly eutrophic lake, due to the excessive phosphorus loading from agriculture drains, especially in spring season. Accordingly, a phosphorous reduction trial in the drains of the lake was implemented at the beginning of spring with the assumption of constant discharging rates. In order to identify the temporal response of the lake water to reduced TP loads, the model can be applied using two control options with the following scenarios:

4.1. First Scenario-Reduction of TP Concentration in Water Drains

In this case, there are also multiple alternatives through ratios of reduced in the water, whether this ratios constant or variable in each drains. In this study, TP concentration in spring season for each drain was reduced by 10%, 20% and 30% of its initial value 1590 $mg.m^{-3}$. The behavior of P1 is summarized in Table 8 and exemplified in Fig. 4.

Table 8: Percentages of TP Reduction in the Drains and the Calculated Concentrations of TP ($mg.m^{-3}$) at Different Time Intervals in Lake Manzala

% of TP reduction in all drains	TP concentrations ($mg.m^{-3}$)						
	Initial	After 10 days	After 100 days	After 250 days	After 500 Days	After 1000 days	After 3000 days
10%	1590	628.74	509.99	510.07	510.21	510.48	511.59
20%	1590	582.2	457.68	457.77	457.91	458.18	459.28
30%	1590	560.56	433.37	433.45	433.59	433.56	434.95

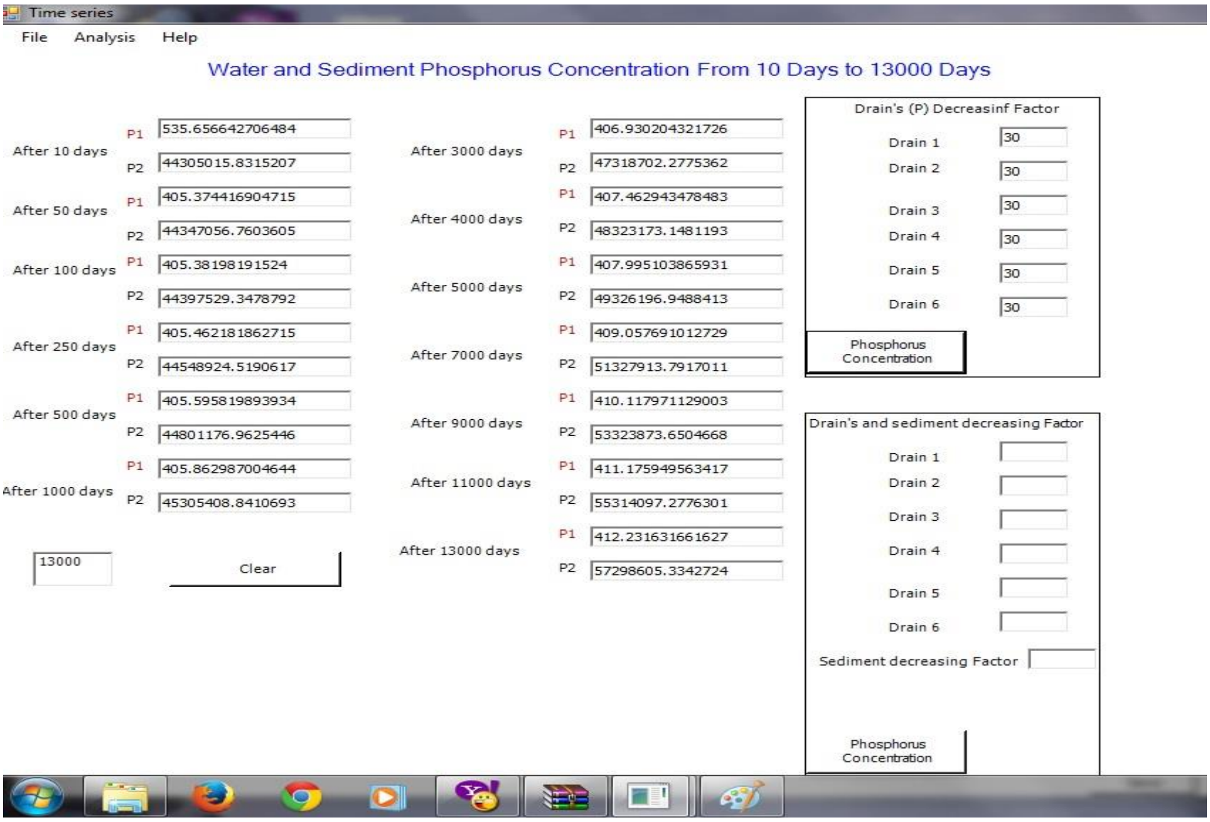

Fig. 4: RTP's Output Screen of Time Series Cotrol 30% of TP Concentrations (mg.m^{-3}) in Water Drains of Lake Manzala.

It was noticed that elimination of TP by 30% in water drains response time of Lake Manzala TP concentration was lowered to 560.56 mg.m^{-3} of its initial value 1590 mg.m^{-3} after 10 days in spring season; this is meaning that the reduction of TP will be 64.74% as shown in Table 9. After 100 days by 30% reduction in TP concentration in the six drains was reached 433.37 mg.m^{-3} of its initial value 1590 mg.m^{-3}, this is meaning that the reduction of TP will be 72.74% Table 9, so it is the optimization for treatment of pollution from TP.

Table 9: Percentages of TP Reduction in the Drains and the Calculated Percentage of TP Elimination at Different Time Intervals in Lake Manzala

% of TP reduction in all Drains	After 10 days	After 100days	After 250 days	After 500 days	After 1000 days	After 3000 days
10%	60.46	67.93	67.92	67.91	67.89	67.82
20%	63.38	71.22	71.21	71.20	71.18	71.11
30%	64.74	72.74	72.74	72.73	72.73	72.64

4.2. Second Scenario-Reduction of TP Concentration in Water Drains and Lake Sediment

In this case, there are also multiple alternatives through ratios of reduced in the water or sediment, whether this ratios constant or variable in each drains. In this study, TP concentration in spring season for each drain was reduced by 1%, 7% and 10% in the sediments and drains 10% in each drain of its initial value 1590 mg.m^{-3}. The behavior of P1 is summarized in Table 10 and exemplified in Fig.5.

Table 10: Percentage of TP Reduction in the Sediments With 10% Reduction in the Drains, as Well as the Calculated Concentrations of TP (mg.m^{-3}) at Different Time Intervals in Lake Manzala.

% of TP reduction in sediments	TP concentrations (mg.m^{-3})						
	Initial	After 10 days	After 100 days	After 250 days	After 500 days	After 1000 days	After 3000 days
1%	1590	627.63	498.42	492.84	491.39	491.26	491.26
7%	1590	622.27	491.23	491.21	491.21	491.21	491.21
10%	1590	620.26	491.22	491.21	491.21	491.21	491.21

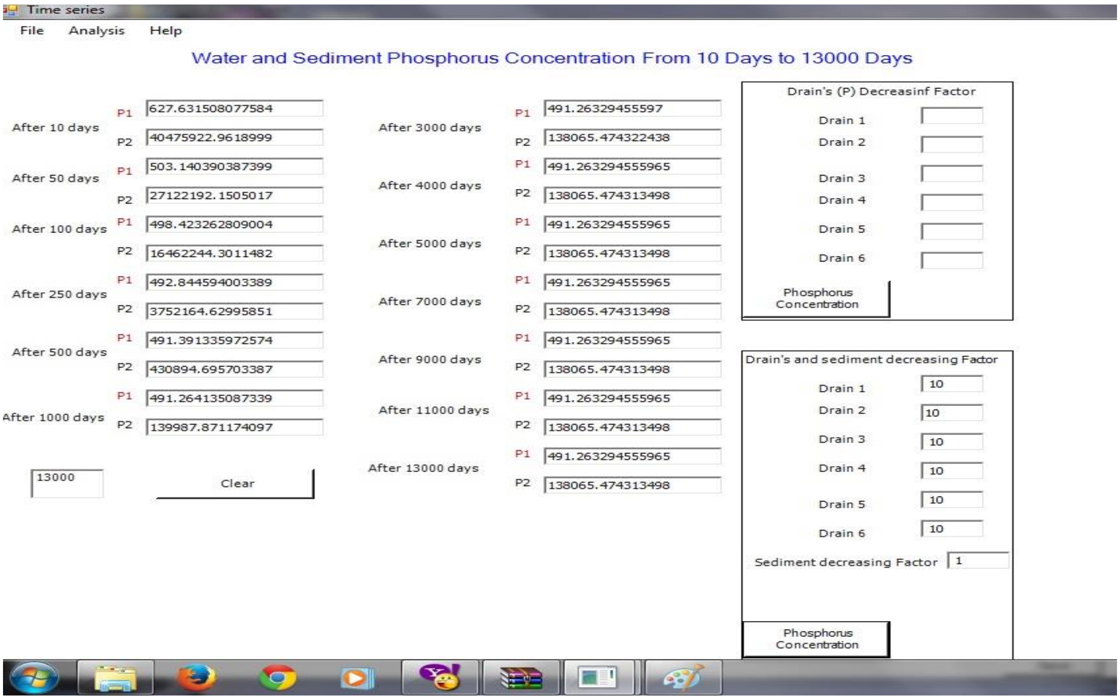

Fig. 5: RTP's Output Screen of Time Series Control 10% of TP Concentrations (mg.m^{-3}) in Water Drains and 1% Lake Manzala Sediment.

It was noticed that a 7% in the sediments response time of Lake Manzala TP concentration was lowered to 622.27 mg.m^{-3} of its initial value 1590 mg.m^{-3} after 10 days in spring season; this is meaning that the reduction of TP will be 60.86% Table11. After 100 days 491.23 mg.m^{-3} of its initial value 1590 mg.m^{-3}, this is meaning that the reduction of TP will be 69.11% as shown in Table 11 so it is the optimize for treatment of pollution.

Table 11: Percentage of TP Reduction in the Sediments With 10% Reduction in the Drains, as Well as the Calculated Percentage of TP Elimination at Different Time Intervals in Lake Manzala.

% of TP reduction in Sediment	After 10 days	After 100 days	After 250 days	After 500 days	After 1000 days	After 3000 days
1%	60.53	68.65	69	69.09	69.10	69.10
7%	60.86	69.11	69.11	69.11	69.11	69.11
10%	60.99	69.11	69.11	69.11	69.11	69.11

The study compare between optimize of two scenario then preferred the first choice (reduction of TP concentrations in water drains) because it is cost less; while the second choice (reduction of TP concentrations in water drains and sediment) need high technique and enormously costly. The results of the RTP model successfully eliminate the large amount of TP by 72.74% through 100 days (TP concentration 433.37 $mg.m^{-3}$); there for the result of RTP model optimize the Ecosystem of Lake Manzala in 100 days.

5. Conclusion

Lake Manzala has been subjected to huge inputs of terrigenous and anthropogenic nutrients (especially phosphorus and nitrogen compounds) from agricultural run off, sewage and drains discharges. These conditions have made the lake biologically productive. The major effort to control eutrophication problem of Lake Manzala and its pollution due to industrial and agricultural waste has been directed towards reducing the input of phosphorous.

RTPS is a proposed system which uses DSS tools to control eutrophication problem, a high concentration of phosphorous in the water column and sediments in Lake Manzala. RTPS's components are: Environmental Database, RTP model and user interface. RTP model is targeted towards simulating the mass balance of TP in water and sediments of Lake Manzala. It utilizes algebraic and differential equation to optimize the ecosystem of Lake Manzala; hence, it is a quantitative model. Also, it depends on time; therefore, it is a dynamic model. RTP model provides decision makers with a variety of choices, which assist their decision making process. RTP model is based on parameter estimation methods, using theoretical equations and the required input data are reduced to morphometric data of the lake. This is in addition to loads and a set of transport processes, as settling, resuspension and burial of the total phosphorous which are modeled as first-order processes. Our results indicated that the dynamics of total phosphorous concentrations is a result of the interplay between external load changes and major internal fluxes defined by sedimentation and re-suspension processes.

Accordingly, a phosphorous reduction trial in the drains of the lake was implemented with the assumption of constant discharging rates. In order to identify the temporal response of the lake water to reduced TP loads, the model can be applied using two control options with the following scenarios:

1- It was found that 30 % reduction of TP from each drain could act as an important solution for quick recovery of the lake condition to reach 560.56 mg.m-3 of TP's initial concentration (1590 mg.m-3 in spring season) after 10 days and a maximum 433.37 mg.m-3 after 100 days.

2- It was found that 7% reduction of TP concentration in the lake sediments and 10 % reduction of TP from each drain could act as an important solution for quick recovery of the lake condition to reach 622.27 $mg.m^{-3}$ of TP's initial concentration (1590 $mg.m^{-3}$ in spring season) after 10 days and a maximum 491.23 $mg.m^{-3}$ after 100 days, this alternative could be a solution to slow and too expensive.

To conclude, RTPS is an interactive decision support system to help decision maker to select one of the multiple alternative solutions to reduce TP concentration in Lake Manzala. RTP model can be applied using two control options of scenarios, each scenario have multiple alternatives through ratios of reduced. The first scenario is reduction of TP concentration in water drains and second scenario is reduction of TP concentration in water drains and Lake Sediment. The decision maker preferred the first scenario by choice 30 % reduction of TP from each drain because it is lower cost.

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