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Environmental Impacts of Drainage Water Reuse on the Freshwater of El-Salam Canal (Egypt)

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KEYWORDS:
Water Quality; QUAL2K; Bahr Hadus Drain; Drainage Water Reuse; Environmental Impacts

***Abstract*—In Egypt, the Water Quality of fresh waterways, especially those receiving the wastewater from agricultural drainage such as El-Salam Canal is every, now, and then, precarious for some water use. Although, Egypt relies on this marginal water quality in order to cover the resulting gap between water needs and supply. The reuse of drainage water appears to be one of the most promising, practical, and economical means of increasing the Egyptian water budget in which the Government of Egypt has been looking for. The use of mathematical models for the quality assessments of waterways can be considered as one of the effective and practical assessment tools. This paper simulates the self-purification controlling of the water quality of Bahr Hadus Drain (BHD) using QUAL2K water quality model. The three-step approach, on Bahr Hadus Drain, was simulated with proposed hydraulic structures (I.e., weirs) at certain locations. Three different weir types were investigated with fixed height at the proposed locations. Then the best weir type from the first step was selected for simulation of the second step at a specified location and, investigated for the impact of the weir height on the water quality. It is concluded that there is a correlation between water depth and weir height on water velocity and improvement of dissolved oxygen. In the third step, logarithmic regression models have been developed describing this relationship.**

I. INTRODUCTION

Egypt as an arid country, in most of its regions, has a shortage of water resources. In fact, it is not the only country facing scarcity of water; other countries around the Mediterranean are facing the same problem such as France, Italy, Spain, Cyprus in Europe and Lebanon, Turkey in Asia and Morocco, Tunisia and Algeria in Africa [1]. The Egyptian water income from the River Nile is 55.5 BCM of water every year, a part of this water is stored in Lake Nasser, [2]. In addition to the high rate of increase in population and the continuous process of development of the country, Egypt faces highly risk concerns with some of Nile basin countries about the issue of redistribution of Nile water on these countries. The resulting increase in water demands places stress on Egypt's water authorities to provide the country's need for domestic, agricultural, industrial, and environmental water uses [3]. The actual water resources also include 1.3 BCM of water every year as an effective rainfall on the north of the Egyptian Delta, and 2.0 BCM of water every year as non-renewable groundwater in Sainai and the western desert. Not all these resources are sufficient for the annual water needed in Egypt, which is about 79.5 BCM of water per year [4].

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In highly developed and dense urban agglomerations, surface water is quite an exposure to pollution. Many sources cause pollution to surface water and rivers such as human activities, industry, agriculture, and society's development [5]. The balance contributions are irrigation and precipitation; the outlets are evapotranspiration, seepage, and discharge to the conventional sewerage system. The variation in the internal system is due to the local re-utilization of the volume of water and the variation in the water content of the soil [6].

In order to raise the amount of water income from the available resources in Egypt, the reuse of drainage wastewater acts as one of the most practical and economical solutions. In the last years, the Egyptian government begins to count drainage wastewater as a good and suitable resource for horizontal expansion in agriculture [7]. Since 1980, Egypt has established three major projects for land reclamation irrigated from drainage effluent.

The project of Salam Canal, Figure 1, is one of the important projects that have been designed based on the strategy of wastewater reuse to share with irrigation water in order to irrigate 620,000 feddans. The canal was planned to convey a discharge of 4.45 BCM of water annually. About 2.2 BCM annually would be freshwater supplied from the Nile from the Weirietta branch mixed with 1.905 BCM annually of the drainage wastewater from Bahr Hadus and 0.435 BCM annually of El Serw drainage water. It is crucial to investigate the quality of water throughout the canal on a regular basis along the years of cultivation and modify the mixing proportion according to the variation in properties of water and soil, as well as the kind of crops and growing stages of various crops [8].

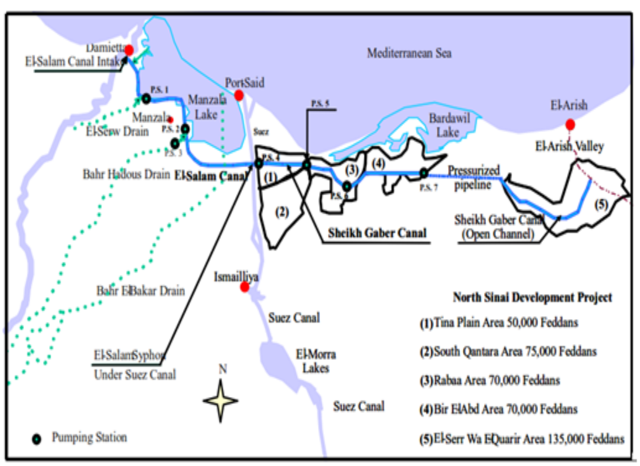


Fig. 1. The layout of Lake El-Salam Canal

However, the process of wastewater reuse has its limitations and imperfections. The largest load of contamination was received particularly by the sewage system. At the beginning of the third millennium, there was a high jump in drainage loads, for example, the Delta and Fayiom drain received about 13.5 BCM every year. Most of this load comes from agricultural sources, and some from minor sources like domestic and industrial sewage [9]. Nowadays Bahr El-Baqar drain started to receive the biggest amount of wastewater (about 3 BCM every year), while Bahr Hadus receives a wastewater load of about 1.75 BCM every year [10].

Using modeling tools to determine water quality can be an effective way to estimate pollution in a water environment. This could reflect in lowering the labor and materials costs needed to conduct the chemical testing of several water samples. It has been specified as an effective way to measure the degree of contamination of the water environment, and to be the ultimate attitude and behavior of water pollutants [11]. In this study, Bahr Hadus Drain water quality will be simulated by the quality model QUAL2K (or Q2K). This research model to identify water quality is a suitable model in its flexibility and accuracy that has been applied in the process of control of watershed contaminants and managing the water quality. The model is a one-dimensional type that is used to simulate the process of transportation and mixing in the mainstream. It provides specifying several kinetic variables or parameters until reaching a specific basis (QUAL2K user manual 2012). Therefore, QUAL2K was rated as one of the effective tools in developing Hadus Drain water quality model.

The overall objective of this research is to assess and enhance the water quality of Bahr Hadus drain (BHD) in Eastern Delta by the inclusive application of water quality modeling using QUAL2K model, In order to provide reliable drainage water quantity and quality for El-Salam Canal Project.

In order to achieve this objective, BHD was simulated for the water quality self-purification using QUAL2K water quality model. The three-step approach, on Bahr Hadus Drain, was simulated with proposed hydraulic structures (i.e., weirs) at certain locations. Three different weir types were investigated with fixed height at the proposed locations. Then the best weir type from the first step was selected for simulation of the second step at a specified location and, investigated for the impact of the weir height on the water quality. In the third step, logarithmic regression models have been developed describing the relation between weir height and its effect on (Dissolved Oxygen DO, Water Level, Velocity) and to point out if such relation exists.

II. MATERIALS AND METHODS

This research is focused on Bahr Hadus drainage system. The data needed to simulate BHD with the proposed model were carried out with the help of the Drainage Research Institute (DRI) staff. Afterward, the simulation case of BHD was calibrated and verified using the normal procedures for some of the water quality (WQ) variables, which are followed by a simulation of several WQ parameters. Also, assessing the adequacy of the selected model in simulating Hadus, a two-step approach is followed to enhance the water quality of Hadus Drain using hydraulic structures.

A. Study Area

As it comes in a report by DRI [12], BHD streams start at the east of Nile delta at the kilometer between The Gemeeza Bridge (EH14), and Hanut pumping station (EH02) (4 Kilometers far) covers an abundant part of its water discharge directed to Hanut irrigation canal. The end of the Drain is its outfall to Manzala Lake (EH17), with an approximate total length of 60 Kilometers. Seven main branches work as contamination sources, that affect the degree of water quality along the drain of Hadus. Those seven branches are respectively; Sadaqa pumping station (EH03), Nizaam branch Drain (EH04), Bani Ebied (EH06), The Additional of Qassabi (EH07), Qassabi the main (EH08) pumping stations, Erad pumping station (EH10), and Saft Drain (EH12), as shown in Figure 2.

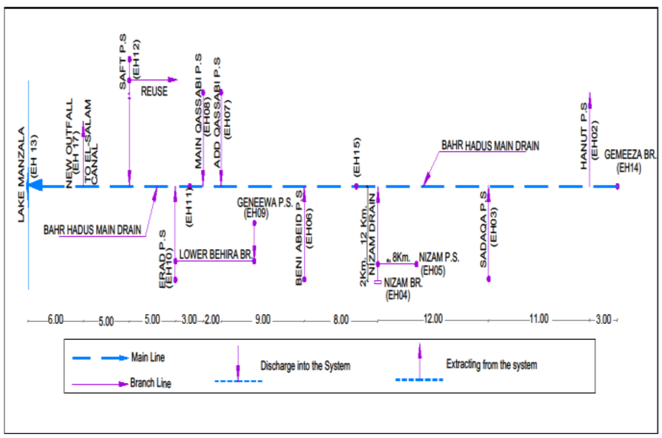


Fig. 2. Bahr Hadus Drainage system Layout

B. Water Sampling and Analysis

One of the important steps that needed for this research was the expansion of a field survey and collection of samples that cover all over the stream of Hadus Drain and all branches as illustrated in Figure 2. Water quality samples were collected from BHD at 12 sampling locations prepared by DRI staff during the summertime of the study period. The samples were analyzed for selective water quality parameters based on their significance for hygiene. In addition, hydraulic measurements including water depth were measured at selective locations on the mainstream of BHD. The concentration of dissolved oxygen DO was measured in field using an in-situ DO meter that has a membrane electrode. Optical electrodes are used to measure the dissolved oxygen in the water. This is done by emitting light from the device at a specific wavelength onto a dye in the sensing layer of the sensor that causes it to luminesce. At this moment the dissolved oxygen in the water samples diffuses into the electrode interferes with both the lifetime and intensity of luminescence of the chemical dye.

The water velocity was measured and the time of its measurements was recorded at each sampling location. The water samples were analyzed at the Laboratory based on water and wastewater standard methods of Examination and analysis [13]. These measurements were used in the process of calibration and validation for the research QUAL2K model to simulate their concentrations and the existing hydraulic conditions of the stream flow.

The data indicate that the quality of BHD is facing major water quality problems. The Drain suffers from a high level of organic matter, which prohibits the use of drainage water for irrigation purposes, and a low concentration of Dissolved Oxygen. The salinity of water may cause slight to moderate problems for sensitive crops. High levels of pathogens, which could cause health, risks for worker farmers, and crop consumers.

C. Self-Purification Intervention

Hydraulic structures (i.e., weirs) are proposed to increase the self-purification efficiency of BHD. The weirs produce hydraulic jumps enhancing the air entrainment to the drainage system, which improves the re-aeration processes and increases the dissolved oxygen concentration along with the system. The additional dissolved oxygen naturally recovers the water quality problems through improving the biological degradation of the organic matter and decrease the concentration of other major pollutants to meet the quality criteria for irrigation.

D. Model application

The process of data collection for the hydraulic characteristics of BHD was carried out which includes detailed data of the flows, velocities cross-sectional areas at different locations across the BHD. The collected values of velocity were differed based on the variation in the cross-sectional areas all over the stream. The simulation case that applied to the model has used collected data of the summer time during the study period for QUAL2K model. The total length of Hadus Drain is 64 km its bottom width starts at 20 m and ends at 70 m. The water depth on average varies between 1.5 and 2.0 m. QUAL2K model was set up for simulating main Hadus Drain dividing it into 33 reaches as Manning roughness coefficient of the natural drain and sections protected by grouted riprap lining is 0.04 with an equivalent time step of 0.01 hours.

The process of calibration for the research model is considered as the starting procedure done for testing and tuning the model by applying a group of collected data from the field that have been used during the construction of the original model [14]. The calibration of the research model was done manually using the method of fine-tuning the results until they become very close to the collected data from the field. This was accomplished by changing the kinetic parameters of the research model to meet the optimal convergence between the results of the model and the collected data from the field. It has been considered the suitable similarity between the equivalent boundary conditions used to calibrate the model and the real conditions in the site of Hadus.

After calibration comes to the validation process where QUAL2K model is verified for another period, at the winter season of the study period. After the end of Calibration and validation of QUAL2K, research model is used to simulate a two-step approach to enhance the degree of quality of water in Hadus Drain; each will provide hydraulic structures along the drain at certain locations.

First Step: Three different scenarios with three different weir types of broad crested weirs, Figure 3, were simulated along BHD at the upstream of the last four drain outfalls. The weirs were located in BHD as follows, Figure 4:

Upstream of Saft drain outfall at Km 11 of BHD where water depth is 2.07m and height of weir applied is 1.57m.

Upstream of Erad drain outfall at Km 16 of BHD where water depth is 1.83m and height of weir applied is 1.33m.

Upstream of Add. Qassabi outfall at Km 21 of BHD where water depth is 1.47m and height of weir applied is 0.97m.

Upstream of Bani Abeid outfall at Km 30 of BHD where water depth is 0.88m and height of weir applied is 0.38m.

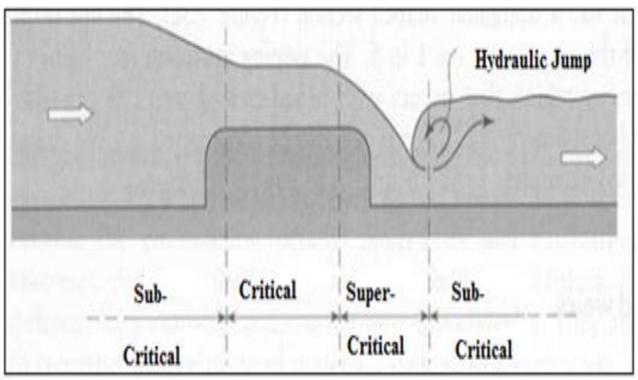


Fig. 3. Typical Flow Schematic across Rectangular Broad-Crested Weir

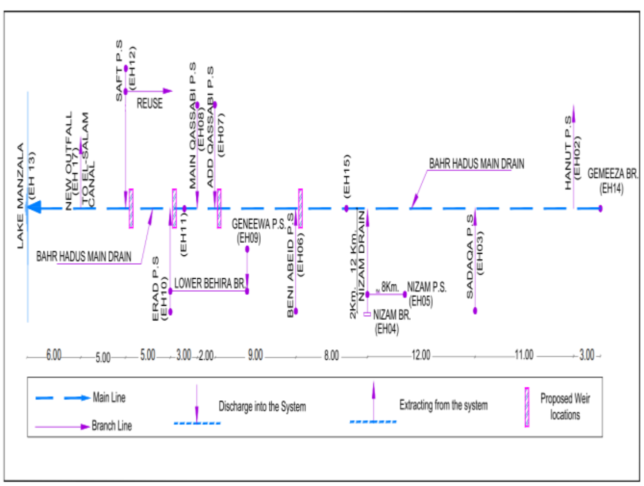


Fig. 4. Proposed Weir Locations along Main Hadus Drain

All weirs were applied 0.5m below water level at each weir location with heights of 1.57m, 1.33m, 0.97m, and 0.38m respectively. Such a drop was intended to increase the hydraulic jump and Froude number to enhance the re-aeration rate.

Each type of the weirs depends on different coefficients of (ad) and (bd) which the model uses for simulation where (ad) and (bd) represent the coefficients that correct the degree of water quality and the type of the weir respectively. Table 1 shows different coefficients of Weir-Type and Water Quality [15].

$$r_d = 1 + 0.38 a_d b_d H_d (1 - 0.11 H_d)(1 + 0.046T) \quad (1)$$

For the previous equation (1) that represents the deficit ratio above and below the weir (rd). the variables of the equation: difference in water elevation (Hd) in meters, water temperature (T) in Celsius, coefficient of water quality (ad), and coefficient of type of weir (bd). The values of (ad) and (bd) are shown in Table 1. The pollution state coefficient was selected for gross pollution ad=0.65. As in the following list and for this paper three weir flat broad types were simulated;

Flat broad –crested irregular step weir with Weir type coefficient (bd=0.8)

Flat broad –crested vertical face weir with Weir type coefficient (bd=0.6)

Flat broad –crested curved face weir with Weir type coefficient (bd=0.45)

TABLE I

WATER QUALITY AND WEIR-TYPE COEFFICIENTS USED BY QUAL2K MODEL

(a) Coefficient of water quality

Polluted degree	a_d
Gross	0.65
Moderate	1.0
Slight	1.6
Clean	1.8

(b) Coefficient of the type of weir

Weir Type	b_d
Flat broad –crested regular step	0.70
Flat broad –crested irregular step	0.80
Flat broad –crested vertical face	0.60
Flat broad –crested straight-slope face	0.75
Flat broad –crested curved face	0.45
Round broad –crested curved face	0.75
Sharp –crested straight-slope face	1.00
Sharp –crested vertical face	0.8
Sluice gates	0.05

Second Step: In this step, the best type of broad crested weir is chosen from the first step with the same locations as illustrated in Figure 4. The weirs are applied in this step as follows:

1. Upstream of Saft drain outfall at Km 11 of Bahr Hadus Drain where water depth is 2.07m and height of weir applied is 0.37m.
2. Upstream of Erad drain outfall at Km 16 of Bahr Hadus Drain where water depth is 1.83m and height of weir applied is 1.33m.
3. Upstream of Add. Qassabi outfall at Km 21 of Bahr Hadus Drain where water depth is 1.47m and height of weir applied is 0.97m.
4. Upstream of Bani Abeid outfall at Km 30 of Bahr Hadus Drain where water depth is 0.88m and height of weir applied is 0.38m.

In the second step, the weir located at Saft P.S is applied at a different height from the first step where it is 1.7m below water level, while the other three weirs at Erad, Add. Qassabi, Bani Abeid Drain outfalls are applied below water surface by 0.5 meters, the same as in the first scenario. Such change in height of weir at Saft drain outfall is to compare between results when using a different weir height and its effect on water quality parameters (DO, Water Level, Velocity) and to point out if such relation exists.

III. RESULTS AND DISCUSSION

A. First Step results:

1. Water Level along Hadus Drain after weirs installation:

The result of the simulation gave no significant change in water level after adding the three different types of broad crested weirs upstream of Beni Ebeid pump station P.S. The other weirs are located upstream of Add. Qassabi P.S, Erad P.S., and saft P.S. caused a noticeable increase in water level as shown in Figure 5 and Table 2.

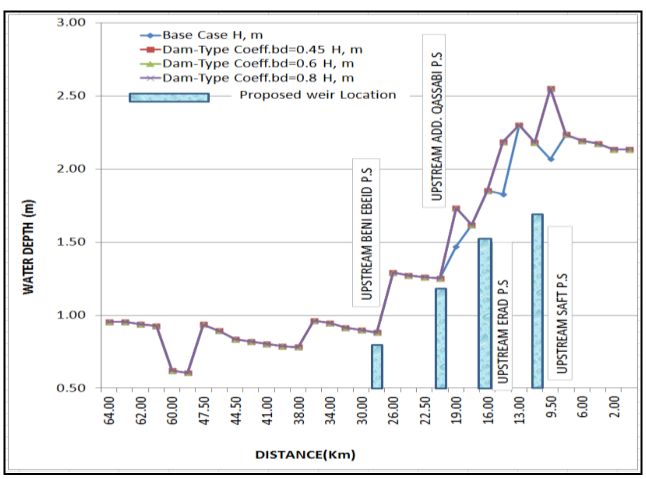


Fig. 5. Water Level along Hadus Drain with three different types of broad crested weir

TABLE 2
WATER LEVEL CHANGES IN PERCENT AFTER APPLYING THREE DIFFERENT TYPES OF BROAD CRESTED WEIRS

Location		Bani Ebeid weir	Add Qassabi weir	Erad weir	Saft weir
Water height (m)	Base Case	0.88	1.47	1.83	2.07
	bd=0.45		1.73	2.19	2.55
	bd=0.6		1.73	2.19	2.55
	bd=0.8		1.73	2.19	2.55
Change in water height (%)	bd=0.45	0	18	20	23
	bd=0.6				
	bd=0.8				

2. Velocity along Hadus Drain after Addition of weirs:

All three types of broad crested weirs with the proposed weir height located upstream of Beni Ebeid P.S increased the velocity along Hadus drain by 2%, while decreasing the velocity by 14%, 15%, and 18% at Add. Qassabi P.S, Beni Abeid P.S., and Saft P.S as shown in Figure 6 and Table 3. The negative results in velocity indicate that the weirs are acting as a Weir blocking water behind them instead of acting as a weir and producing hydraulic jumps enhancing the air entrainment to the drainage, hence improving water quality.

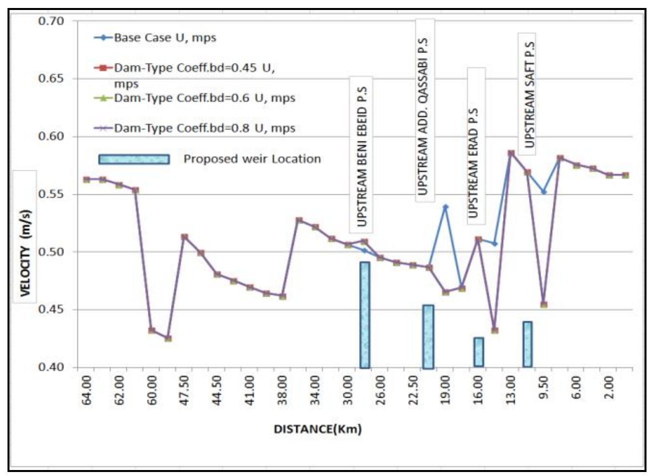


Fig. 6. Velocity along Hadus Drain with three different types of broad crested weir

TABLE 3
CHANGING IN VELOCITY OF WATER ALONG HADUS AFTER APPLYING THREE DIFFERENT TYPES OF BROAD CRESTED WEIRS

Location		Bani Ebeid weir	Add Qassabi weir	Erad weir	Saft weir
Water Velocity (m/s)	Base Case	0.50	0.54	0.51	0.55
	bd=0.45	0.51	0.47	0.43	0.46
	bd=0.6	0.51	0.47	0.43	0.46
	bd=0.8	0.51	0.47	0.43	0.46
Change in Velocity (%)	bd=0.45	2	-14	-15	-18
	bd=0.6				
	bd=0.8				

3. Dissolved Oxygen along Hadus Drain after Addition of weirs:

As a result of a decrease in velocity due to an improper weir height at the proposed location, no change in DO after weirs installation at the upstream of Beni Ebeid outfall, and a decrease in DO at the upstream of the last three-point source, however, the weirs led to an enhancement in dissolved oxygen concentration at the end of the drain before its discharge to El Salam canal as shown in Figure 7 and Table 4.

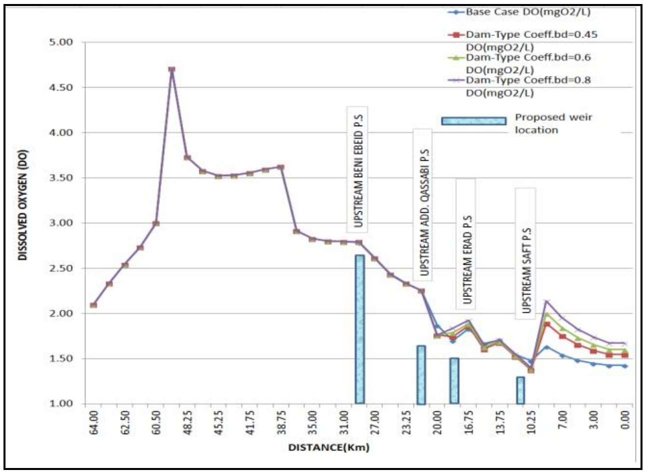


Fig. 7. Dissolved Oxygen concentration along Hadus Drain with three different types of broad crested weir

TABLE 4
DISSOLVED OXYGEN ALONG HADUS AFTER APPLYING THREE DIFFERENT TYPES OF BROAD CRESTED WEIRS

Location		Bani Ebeid weir	Add Qassabi weir	Erad weir	Saft weir
Dissolved Oxygen DO (mg/l)	Base Case	2.79	1.70	1.71	1.63
	bd=0.45		1.75	1.68	1.89
	bd=0.6		1.79	1.69	2.00
	bd=0.8		1.84	1.71	2.14
Change in DO (%)	bd=0.45	0.3	2.6	-1.7	15.9
	bd=0.6		5.0	-1.0	22.4
	bd=0.8		8.2	0	30.8

By comparing the three types of broad crested weirs, it is clear that from simulation results of dissolved oxygen of Flat broad–crested irregular step with a Weir-type coefficient (b) 0.8 and water-quality coefficient (a) 0.65, is the best broad crested of the other three broad crested weirs as it increased the percentage of dissolved oxygen by 17.2% at the last reach of the drain. Therefore, this type of weir will be chosen for the second step approach.

B. Second Step results:

1. Water Level along Hadus after changing weir height at Saft P.S:

The proposed weir height at Saft P.S has decreased water level by approximately 38% as shown in Figure 8 and Table 5.

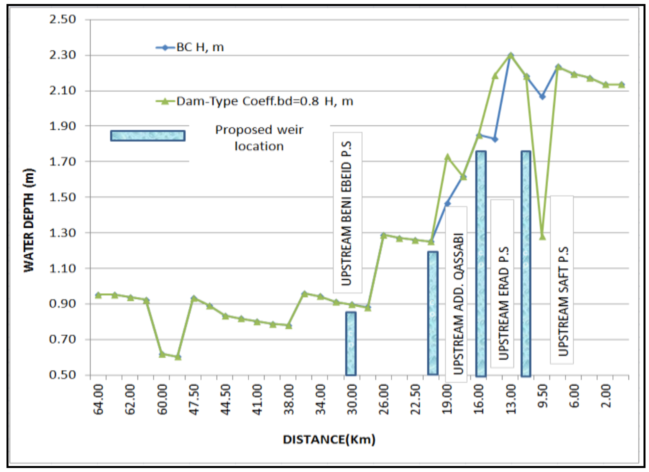


Fig. 8. Water level along Hadus drain after changing weir height at Saft P.S.

TABLE 5
CHANGE IN PERCENTAGE OF WATER LEVEL AFTER CHANGING WEIR HEIGHT AT SAFT P.S.

Water Height			
Distance Km	Base case (BC) H, m	Weir-Type Coeff. bd=0.8 H, m	Results in Percentage %
Bani Ebeid weir 28	0.88	0.88	-0.37
Add Qassabi weir 19	1.47	1.73	17.84
Erad weir 14.5	1.83	2.19	19.52
Saft weir 9.5	2.07	1.28	-38.02

2. Velocity along Hadus after changing weir height at Saft P.S:

From simulation results, it is clear that the proposed weir height upstream of Saft P.S produced a noticeably increase in velocity shown in Figure 9 and Table 6.

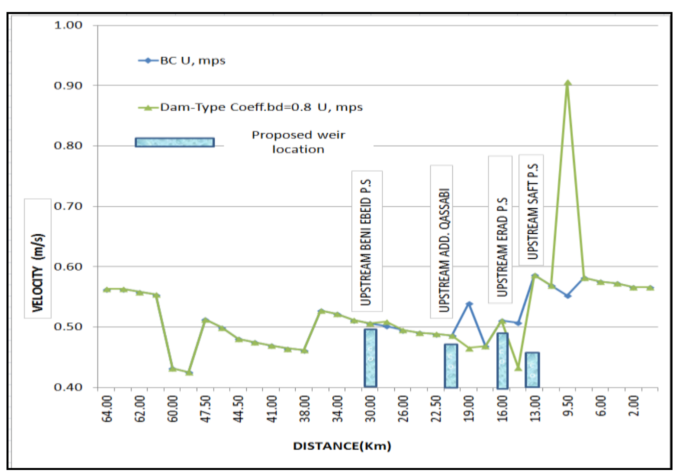


Fig. 9. Velocity along Hadus drain after changing weir height at Saft P.S

TABLE 6
PERCENTAGE CHANGE IN VELOCITY AFTER CHANGING WEIR HEIGHT AT SAFT P.S.

Water Velocity			
Distance Km	**Base Case (BC)**	**Weir-Type Coeff. bd=0.8**	**Results in Percentage %**
	U, mps	U, mps	
Bani Ebeid weir 28	0.50	0.51	1.51
Add Qassabi weir 19	0.54	0.47	-13.75
Erad weir 14.5	0.51	0.43	-14.81
Saft weir 9.5	0.55	0.91	64.12

3. Dissolved Oxygen along Hadus after changing weir height at Saft P.S:

As a result of the increase in velocity upstream of Saft P.S., dissolved oxygen has also increased by approximately 17% as illustrated in Figure 10 and Table 7.

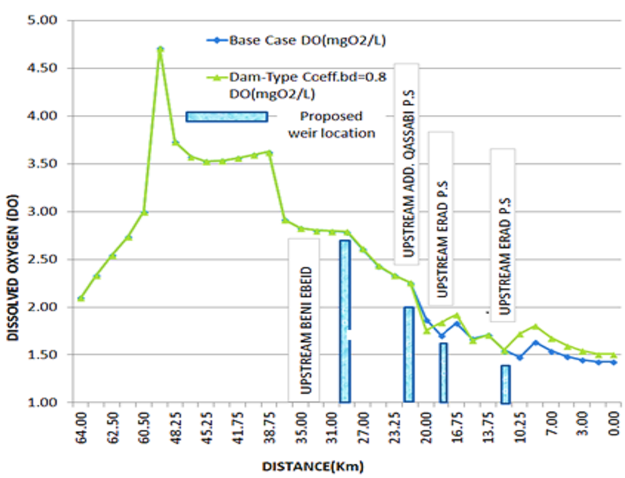


Fig. 10. Dissolved Oxygen along Hadus after changing weir height at Saft outfall

TABLE 7
DISSOLVED OXYGEN ALONG HADUS AFTER CHANGING WEIR HEIGHT AT SAFT

Dissolved oxygen			
Distance Km	Base Case	Weir-Type Coeff. bd=0.8	Results in Percentage %
	DO (mgO2/L)	DO (mgO2/L)	
Bani Ebeid weir 29	2.79	2.79	0.27%
Add Qassabi weir 20	1.87	1.76	-5.95%
Erad weir 15.25	1.67	1.66	-0.59%
Saft weir 10.25	1.47	1.73	17.02%
BHD outfall 0.00	1.43	1.51	5.68%

From the results of the first and second approach scenario, it is clear that the height of the weir can have a large effect on water quality.

The relationships between water depth (d), divided by the height of weir (h) (relative depth) with both dissolved oxygen and velocity are illustrated upstream of Saft P.S, Erad P.S, and Add. Qassabi P.S and Bani Abeid P.S. Six different heights of Flat broad–crested irregular step weir were chosen in the second scenario and their effect on water depth (d) dissolved oxygen, (DO), and the water velocity (V) is represented by the following two equations and the corresponding charts of the third approach step:

$$Velocity = a_1 \ln\left(\frac{d}{h}\right) + b_1 \qquad (2)$$

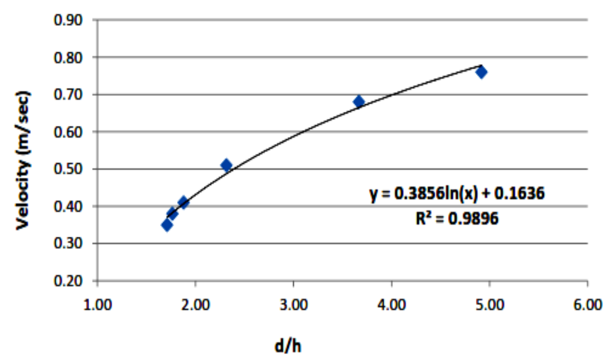
$$DO = a_2 \ln\left(\frac{d}{h}\right) + b_2 \qquad (3)$$

Where; a1, b1, a2, b2 are constants, d is the water depth and, h is the height of the weir.

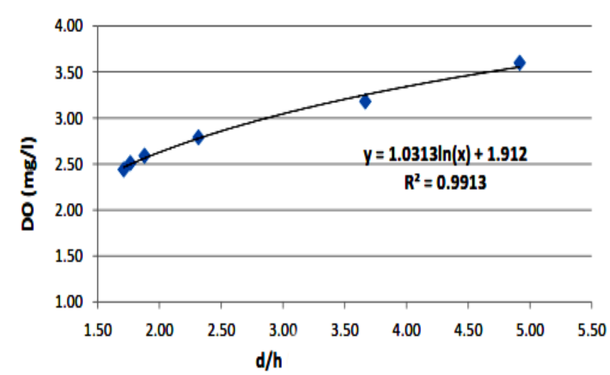
C. Third approach step:

1. The first relation illustrated for Beni Ebied P.S:

From Figure 11 it is noticed that both DO and Velocity increases with the increase of d/h ratio



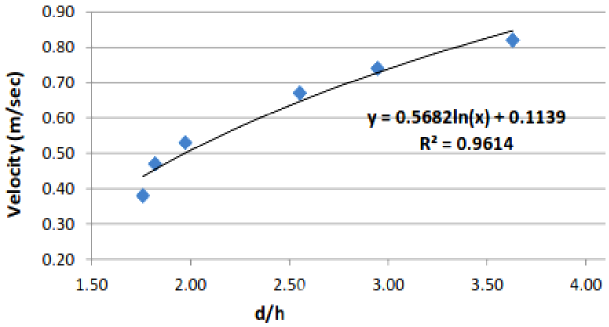
(a)



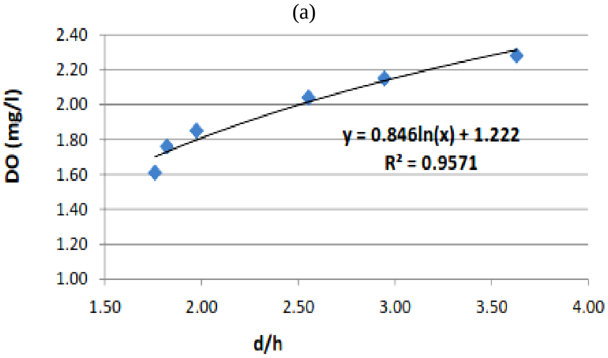
(b)

Fig. 11. Relationship between: (a) velocity of water (v) and relative depth d/h; (b) dissolved Oxygen (DO) and relative depth d/h for Beni Ebied P.S.

2. The second relation illustrated for Add Qassabi P.S:



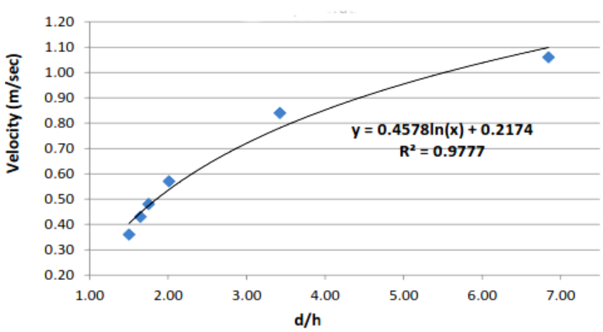
(a)



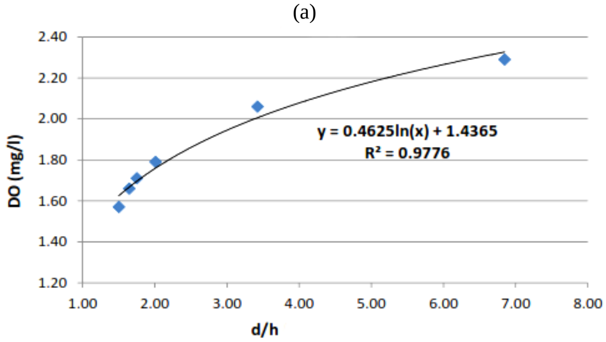
(b)

Fig. 12. Relationship between: (a) velocity of water (v) and relative depth d/h; (b) dissolved Oxygen (DO) and relative depth d/h for Add Qassabi P.S.

3. The third relation illustrated for Erad P.S:



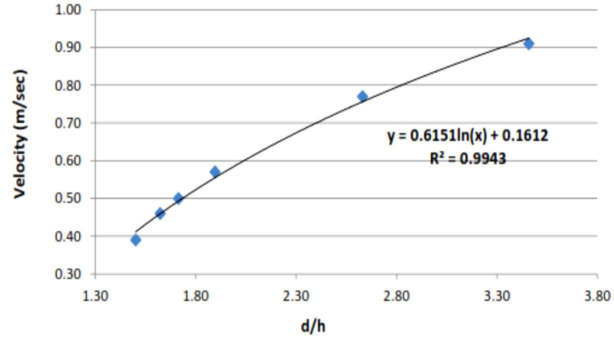
(a)



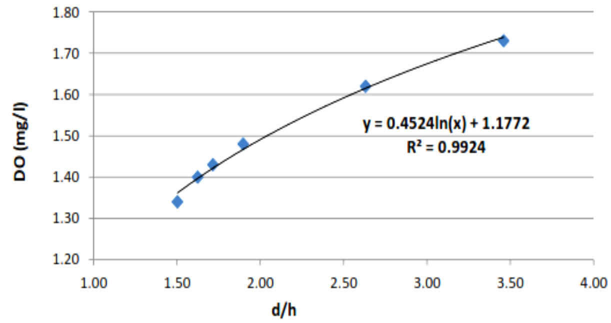
(b)

Fig. 13. Relationship between: (a) velocity of water (v) and relative depth d/h; (b) dissolved Oxygen (DO) and relative depth d/h for Erad P.S.

4. The fourth relation is illustrated for Saft P.S:



(a)



(b)

Fig. 14. Relationship between: (a) velocity of water (v) and relative depth d/h; (b) dissolved Oxygen (DO) and relative depth d/h for Saft P.S.

From Figure 14 it is noticed that both DO and Velocity increase with the increase of d/h ratio.

IV. CONCLUSIONS

In view of the developments and what the upstream countries of the Nile Basin are doing to establish projects for the purpose of development and generating electricity, the need for downstream countries such as Egypt and Sudan has become urgent to pay attention to managing their available water resources, as well as studying the environmental impact of reusing wastewater to compensate for the decline that will occur in their annual share from the Nile water.

Hydraulic structures such as weirs are proposed to enhance the quality of drainage water along Bahr Hadus main drain for the proposition of reuse of drainage water along with the drainage system as well as the quality of water diverted to El Salam Canal at the new outfall. Simulation on Bahr Hadus was done in three stages. At the first stage, we succeeded to identify the best types of weir that can be applied to construct in the following stages.

At the second stage of simulation after locating the best weir place, it is concluded that water depth and weir height have an effective impact on the dissolved oxygen concentration and water speed that may affect the quality of water. Finally, in the third simulation stage, we succeeded to develop the logarithmic regression models that describe the significant relations.

Water Quality Model QUAL2K can effectively simulate Bahr Hadus and other drainage canals of Egypt. The model can also be used for any other practical applications for water quality management and control.

AUTHORS CONTRIBUTION

M. Eizeldin, N. K. Abdelghani, A. Elsaadi: Conception or design of the work, Data collection and tools, Data analysis and interpretation, Methodology, software and Final approval of the version to be published

M. Ashmawy and M. H. Hegazy: Conception or design of the work, Methodology, Project administration, Supervision, Drafting the article, Critical revision of the article, and final approval of the version to be published.

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NOTATION AND ABBREVIATIONS

a_d	Coefficient of water quality;
b_d	Coefficient of weir type;
BCD	Billion per Cubic Meter;
BHD	Bahr Hadus Drain;
d	Simulated water depth;
d/h	Relative depth;
DO	Dissolved Oxygen;
DRI	Draining Research Institute;
EH	Sampling Location Code;
H_d	Difference in water elevation;
h	Height of Weir;
P.S.	Pump Station;
rd	Deficit ratio above and below the weir;
T	Temperature;
V	Water velocity; and
WQ	Water Quality.

ARABIC TITLE:

الآثار البيئية لإعادة استخدام مياه الصرف على المياه العذبة لترعة السلام (مصر)

ARABIC ABSTRACT:

في مصر، تعتبر جودة مياه المجاري المائية العذبة، خاصة تلك التي تتلقى مياه الصرف الصحي من الصرف الزراعي مثل ترعة السلام، محفوفة بالمخاطر بين الحين والآخر لبعض استخدامات المياه. على الرغم من أن مصر تعتمد على هذه النوعية الهامشية من المياه من أجل تغطية الفجوة الناتجة بين الاحتياجات المائية والإمدادات. مما لا شك فيه أن إعادة استخدام مياه الصرف من أكثر الوسائل الواعدة والعملية والاقتصادية لزيادة موارد المياه المصرية التي كانت الحكومة المصرية تبحث عنها. يمكن اعتبار استخدام النماذج الرياضية لتقييم جودة الممرات المائية كأحد أدوات التقييم الفعالة والعملية. تحاكي هذه الورقة التحكم في التنقية الذاتية لجودة مياه مصارف بحر حادوس (BHD) باستخدام نموذج جودة المياه QUAL2K. تمت محاكاة النهج المكون من ثلاث خطوات، في بحر حادوس، باستخدام الهياكل الهيدروليكية المقترحة (أي السدود) في مواقع معينة. تم فحص ثلاثة أنواع مختلفة من السدود بارتفاع ثابت في المواقع المقترحة. ثم تم اختيار أفضل نوع من السدود من الخطوة الأولى لمحاكاة الخطوة الثانية في موقع محدد، وتم التحقق من تأثير ارتفاع السد على جودة المياه. استنتجت علاقة لوغاريتمية بين سرعة المياه وعمق المياه النسبي (عمق الماء إلى ارتفاع الهدار) وجذلك علاقة لوغاريتمية بين الأكسيجين المذاب وعمق المياه النسبي مما يؤدي إلى اختيار الأبعاد المناسبة لزيادة الأكسيجين المذاب.