APPROACH FOR REUSING THE FLOW OF EL RAHAWY DRAIN AT THE QATTARA DEPRESSION

Ahmed M. Nada [1]

[1] Researcher, Hydraulics Research Institute, National Water Research Centre, Egypt

Email: ahmedmostafanada@hotmail.com

Phone number: (+2012) 22642428

ABSTRACT

Egypt is facing a water scarcity problem; it is a must to reuse drainage water to substitute this deficit between supply and demand. Also the drainage water is polluted and needs to be purified before reusing it. Therefore an approach is proposed herein to reuse the flow discharge of El Rahawy Drain that drains its water to Rosetta Branch (the second most polluted drain in Egypt) and convey its water to the Qattara Depression in the North West of Egypt. This proposed approach and its assessment presents basic background data about the Qattara Depression characteristics, El Rahawy Drain water quality, self purification mechanism of pollutants, digital elevation model (DEM) for the studied area and preliminary economic evaluation of the approach. Two alignment paths were selected and the existing levels were computed employing a digital elevation model (DEM). Proposed design of the canal bed levels, pump and turbine stations locations were determined for the two paths. The proposed path length that exceeds 250 km between El Rahawy Drain and the Qattara Depression will improve its water quality by self purification. This approach will add a new source to the Qattara Depression water resources which will accordingly develop various activities in the area, with the additional benefits of reducing the pollution at the Rosetta Branch that consequently improving the public health.

Keywords: Qattara; Rahawy; Self Purification; DEM; Reuse

1. INTRODUCTION

Water resources in Egypt are under stress due to the increasing of demands for the available water and the inadequate pollution management. The expansion of demands for water in agriculture, domestic industry … etc, is due to population growth result in an additional pressure on the limited resources. Pollution is a major problem because it reduces the chance towards a sustainable development and threatens Egypt's water quality, the environment and the health of its citizens. The Ministry of Water Resources and Irrigation in Egypt (MWRI) depends mainly in its National Plan on reusing the drainage water. Currently about 5.5 Milliard m^3 /year of drainage water are being reused, this amount is expected to increase up to 8.8 Milliard m^3 /year by the year 2017 [1]. The water quality of the agricultural drains gradually deteriorates due to the poorly treated wastewater discharges from both domestic and industrial activities. Therefore, it contains high levels of various pollutants. In Egypt, self purification is an advantage in helping improving the drains water quality which allows reusing its discharge in national project like El Salam Canal. The developed area of Egypt covers only about 6% its total area. Egypt has a very limited water resources and population is growing annually, so there is an urgent need to reuse drainage water in developing new lands.

2. APPROACH AND BENFITS

It is proposed to reuse the available flow discharges of El Rahawy Drain (the second most polluted drain in Egypt), that drains its water directly to Rosetta Branch at Giza governorate and convey water to the Qattara Depression in the North West of Egypt. The proposed path length that exceeds 250 km between El Rahawy Drain and the Qattara Depression will improve its water quality by self purification and add a new water resource to the Qattara Depression which will accordingly develop various activities with additional benefit that the proposed approach will reduce the Rosetta Branch pollution. A network diagram is a technique for illustrating how benefits are related and what the consequences are of the benefits. A network diagram was conducted to evaluate the benefits of the proposed approach as shown in Table 1. The main features are conveying water to the Qattara Depression, abstract polluted water from El Rahawy Drain, generation of electricity and constructing embankments for the canal. The benefits are presented for each feature.

Table 1 Network Diagram for the Proposed Approach Benefits

	Feature	**Primary Benefits**	**Secondary Benefits**	**Tertiary Benefits**	**Quaternary Benefits**
1	Conveying water to Qattara Depression	Encourage business activities as agriculture, tourism, fish farming, grazing, mining, …	Utilization of abundant available water resources (precipitation and ground water)	Protection of the Nubian Sandstone aquifer system in the Western Desert from sea salt intrusion	Charging ground water at west delta and Wadi Natrun
2	Abstract polluted water from El Rahawy Drain	Decreasing pollution in Rosetta Improving public health	Improving water quality for drinking water plants and agriculture	Saving water which is released from Nile River for diluting pollutants	Increasing fish production
3	Generation of electricity	Used in operation of pump stations	Clean energy from hydropower	Renewable energy	Low cost
4	Constructing embankments for the canal	Adding more than 250 km of secondary roads in right and left banks	Transportation facilitating		

3. METHODOLGY

This proposed approach and its assessment requires basic background data about the Qattara Depression characteristics, El Rahawy Drain water quality, self purification mechanism of pollutants, digital elevation model (DEM) for the studied area and preliminary economic evaluation of the approach.

4. BACKGROUND OF THE QATTARA DEPRESSION

The Qattara Depression is located at Matruh Governorate and is considered as a part of the Libyan Desert. The Qattara Depression has the second lowest level in Africa of (−133 m) MSL. The depression covers a size of 20000 km2 that is comparable to Lake Ontario or twice as big as Lebanon [2]. Figure 1 shows the location of the Qattara Depression. The dominant climate of the Qattara Depression is highly arid with an annual precipitation that varies between 100 mm on the northern rim to less than 25 mm in the south of the depression. The average daily temperature is about 20 °C [3]. The Qattara Depression contains numerous oil concessions and several operating fields. Figure 2 presents the location of the fresh / salt water boundary for the Nubian sand stone aquifer system [4]. The first layer of soil is described as sand stone for the Nubian Sandstone Aquifer which covers the area between the Qattara Depression and El Rahawy Drain [5]. The Qattara Depression Project proposals call for a large canal or tunnel being excavated from the Qattara Depression due north of 55 to 80 km depending on the route chosen to the Mediterranean Sea to bring sea water into the area to generate electricity. Figure 3 indicates earlier proposals to extend water to the depression by Ball, Bassler and Gohar to conduct water from Mediterranean Sea to Qattara Depression [6]. The main problem of the Qattara Depression Project is represented in the high initial cost because of the difficulties and expenses of excavation in high ground to the north of the Qattara Depression (more than + 200 m MSL) and soil nature.

Figure 1 Location of the Qattara Depression in Egypt

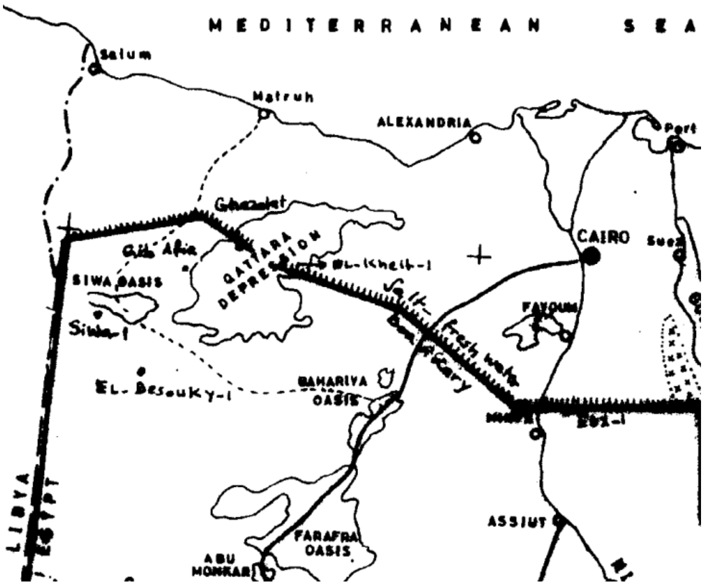

Figure 2 Nubian Sand Stone Aquifer System Fresh- Salt Water Boundaries

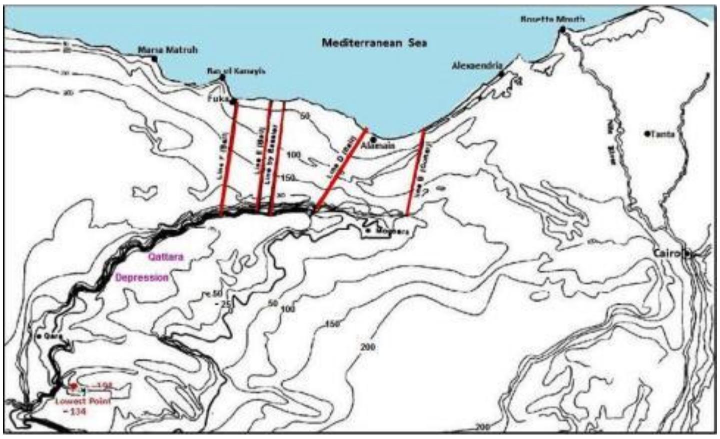

Figure 3 Proposals of Ball, Bassler and Gohar to Conduct Water from Mediterranean Sea to Qattara Depression

5. BACKGROUND OF EL RAHAWY DRAIN

El Mouheet Drain of length (70.2 km) in Giza Governorate is considered one of the most polluted main drains in Egypt. It serves about 140,000 feddans of agriculture land. Two main wastewater treatment plants are located within the drainage basin of El-Mouheet Drain namely Abu Rawash and Zenein plants with maximum effluents of 700,000 and 400,000 m^3 /day, respectively [7]. The whole system discharges its water into the Nile River (Rosetta Branch) through El Rahawy Drain with an average daily discharge of about 2 Million m^3 /day. Figure 4 shows the layout of El Rahawy Drain [8]. The El Rahawy Drain has serious harmful impacts on the water quality of the Rosetta Branch due to its high organic loads, which affect its availability as a source of drinking water supply for many cities located along this branch. This is due to the high concentrations of ammonia in the branch recorded during the low demand periods that cause a serious effect on the aquatic life in the branch especially for fish. Ammonia is extremely toxic and even relatively low levels pose a threat to fish life.

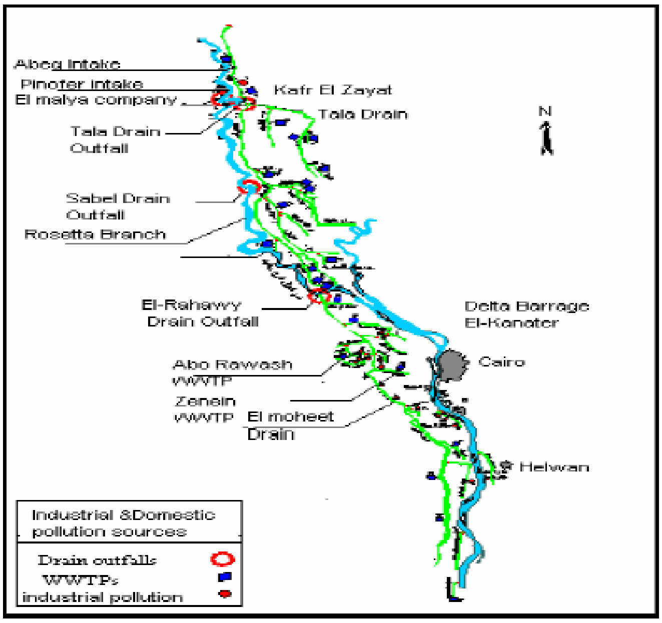

Figure 4 Layout of El Rahawy Drain

The Rosetta Branch is currently has a discharge of about 10 Million m^3 /day in during low demand period but it is recommend to release about 30 Million m^3 /day from Nile River water at the Delta Barrage for reducing the concentrations of ammonia and organic nitrogen below the limits of the local guidelines. This means that about 0.9 Milliard m^3 / month from Nile River fresh water can be saved in the low demands period by stopping pollution of El Rahawy Drain [8].

6. SELF PURIFICATION MECHANISM

Biological self-purification is the process in which organic wastes are broken down by the respiration of micro-organisms into stable end products. It is a biochemical oxidation process through which organic wastes are consumed leaving behind end products such as carbon dioxide, water, phosphates and nitrates. The water is purified in the sense that the concentration of waste material has been reduced. Organic materials which can be broken down (i.e. are biodegradable) include natural materials such as simple sugars, starch, fats, proteins as well as more complex natural or synthetic compounds which are found in sewage or other wastes. This type of respiration, in which biochemical oxidation takes place using the free dissolved oxygen in the water, is called aerobic respiration [8].

6.1 Self Purification of El Mahmoudia Canal

The intake of El Mahmoudia Canal is located at km 194.20 of Rosetta Branch. The majority of water quality problems are due to the receiving of low grade water of poor quality from the Rosetta Branch. The water used in agriculture, fisheries, public water supply, industry, hydroelectric power and recreation purposes. According to [9], natural self restoration of El Mahmoudia Canal water is observed and helping in improving water quality with the distance along El Mahmoudia Canal.

6.2 Self Purification of El Salam Canal

El Salam Canal is a potential project for reusing the drainage water for Sinai desert agriculture. El Salam Canal flow has a mixture of drainage water and fresh water by 1:1 ratio. El-Degwi et al [10] focused on the BOD parameter as a good measure for the organic load in the canal water, depending on water quality data during 1998–2001, along the first 89.4 km of the western part of the canal. They reported that the BOD values of the mixed water as 24–44 mg/l before crossing the siphon under the Suez Canal to North Sinai. The results on the eastern 55 km extension of the canal showed an average value of 0.01–9.88 mg /l [11]. Regarding the heavy metals, the highest concentration was reported for Fe as 9.97 mg/l. Fe is decreased significantly with distance, scoring about 2.24 mg/l further than the eastern 33 km [11].

6.3 Self Purification of El Rahawy Drain

According to [12], Table 2 shows the main measured water quality parameters at El Rahawy Drain at locations E4 and E5 which are chosen to calculate the average self purification ratio %. Where the distance between E4 and E5 is almost 3 km. E4 is far from El Rahawy Drain outfall with about 5.5 km. E5 is far from El Rahawy Drain outfall with about 2.5 km. According to linear calculation; the Ammonia (NH3) is on average decreased by 4.1% at three km. This means that the proposed canal will need about 73 km of length for full self purification.

Table 2 Main Measured Water Quality at El Rahawy Drain of Location E4 and E5

Character	Season	E4	E5	Average Self Purification ratio %
pH	Winter	7.15	7.2	
	Autumn	7.28	7.28	
	Spring	7.25	7.29	
	Summer	7.31	7.32	
TDS (mg/l)	Winter	1200	1020	
	Autumn	884	882	
	Spring	1085	1028	
	Summer	706	700	
NH_3 (mg/l)	Winter	23.85	22.32	4.1 %
	Autumn	20.61	20.27	
	Spring	18.56	17.28	
	Summer	20.2	19.97	
BOD (mg/l)	Winter	130	100	14.5%
	Autumn	110	100	
	Spring	80	70	
	Summer	75	65	

7. DIGITAL ELEVATION MODEL (DEM) FOR THE STUDIED AREA

From the previous background about the El Rahawy Drain, the Qattara Depression, and self purification, there is a need to find proposed paths between El Rahawy Drain and the Qattara Depression especially when the distance between them is in excess of 250 km that satisfies the self purification mechanism. To determine these paths, a DEM is used for the studied area.

7.1 Digital Elevation Model (DEM) Description

The National Aeronautics and Space Administration NASA Shuttle Radar Topographic Mission SRTM 3rd edition digital elevation data, produced by NASA originally, is a major breakthrough in digital mapping of the world, and provides a major advance in the accessibility of high quality elevation data for large portions of the tropics and other areas of the developing world. SRTM has provided DEMs for over 80% of the globe. This data is currently distributed free of charge by USGS and is available for download from the National Map Seamless Data Distribution System, or the USGS ftp site. The SRTM data is available as (approx. 90 m resolution) DEMs. The vertical error of the DEM's is reported to be less than 8 m. The data that is currently being distributed by NASA/USGS (finished product) contains holes ("no-data") where water or heavy shadow is preventing the quantification of elevation. These are generally small holes, which nevertheless render the data less useful, especially in fields of hydrological modeling [13].

7.2 Selection of Paths from El Rahawy Drain to the Qattara Depression

Two paths were selected from El Rahawy Drain to the Qattara Depression on the digital elevation model as shown in Figure 5. Figure 6 presents through the Google image the locations on of path 1 and path 2 for which the distances between the 2 points are 250 km and 290 km respectively. Therefore, path 1 was selected as the shortest path to avoid the high elevations. The potential bed level for path 1was computed as shown in Figure 7. Figure 8 presents the potential bed level for path 2.

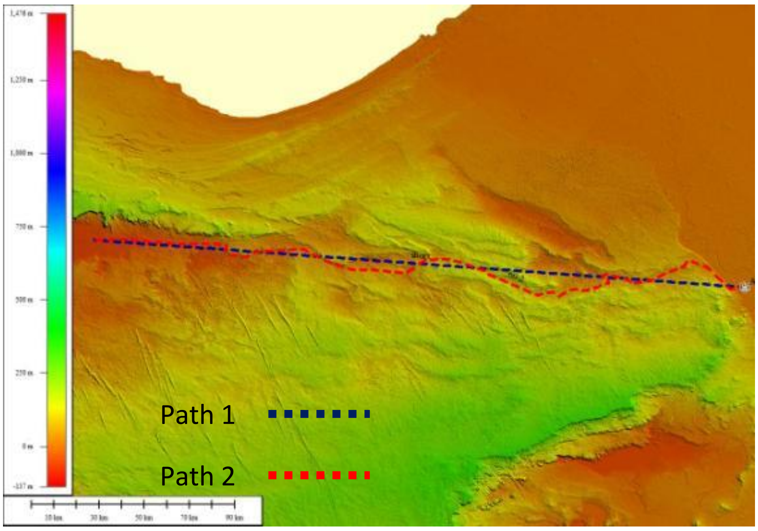

Figure 5 Locations of Path 1 and Path 2 on the Digital Elevation Model from El Rahawy Drain to the Qattara Depression

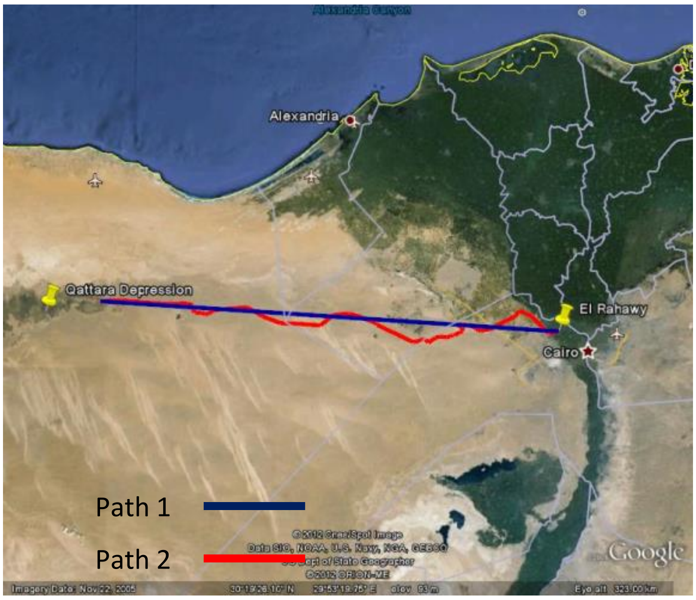

Figure 6 Locations of Path 1 and Path 2 on the Google Image from El Rahawy Drain to the Qattara Depression

Figure 7 Longitudinal Profile of the Existing Bed Level for Path 1

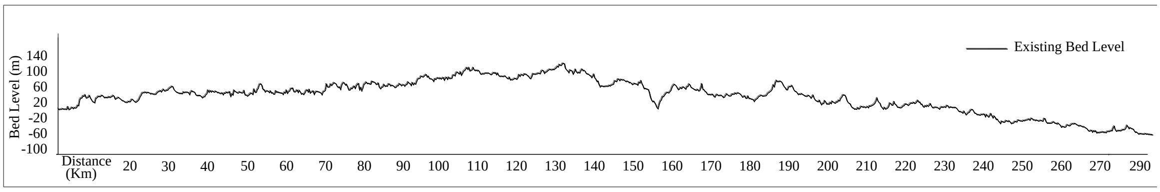

Figure 8 Longitudinal Profile of the Existing Bed Level for Path 2

8. DESIGN OF THE PROPOSED CANAL FROM EL RAHAWY DRAIN TO THE QATTARA DEPRESSION

The remodeling of the existing drain bed and the design of the proposed canal bed levels, pump and turbine stations locations was conducted for paths 1 and 2 as shown in figure 9 and 10 respectively. It is found that path 1 needs two large pump stations to elevate water head by 40 m. This static head needs special pumps as shown in Figure 9. Path 2 needs four pump stations with elevated the head just 20 m as shown in Figure 10. This path is however longer than path 1.

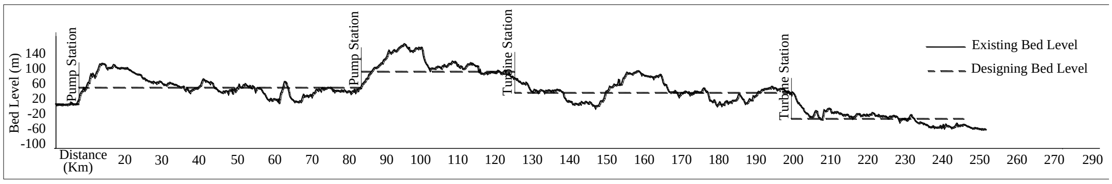

Figure 9 Longitudinal Profile of the Existing Bed Level for Path 1showing Designed Bed Levels, Pump and Turbine Stations Locations

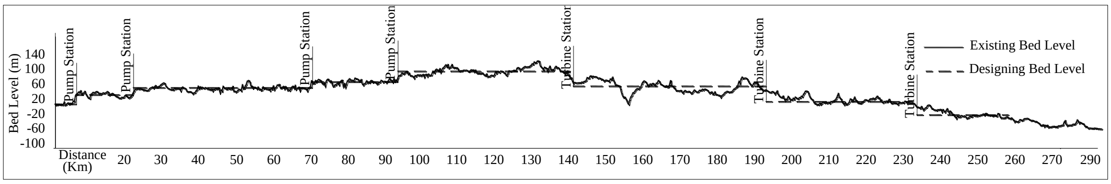

Figure 10 Longitudinal Profile of the Existing Bed Level for Path 2 showing Designed Bed Levels, Pump and Turbine Stations Locations

9. PRELIMNARY ECONOMIC EVALUATION

The construction cost of the proposed canal with a capacity two million m^3 / day is about one Milliard LE approximately. From [14] the proposed Gabal El-Asfar Wastewater Treatment Plant costs for additional treatment capacity of 0.5 Million m^3 / day is 2 Milliard LE. These works will be implemented within a period of 4 years, from 2010 to 2014. For the sake of the economic evaluation of the project, the construction of the wastewater treatment plants at Abu Rawash and Zenein plants are estimated about 4.4 Milliard LE for a treatment capacity of 1.1 million m^3 / day.

10. CONCLUSIONS AND RECOMENDATIONS

The approach proposed herein is prepared for conveying the drainage discharge of El Rahawy Drain and reuses it in the Qattara Depression. Self purification will improve the water quality safely as the proposed conveying canal length exceeds 250 km. The main features of this approach are conveying water to the Qattara Depression, abstract polluted water from El Rahawy Drain, generation of electricity and constructing embankments for the canal. The benefits of the approach were summarized in Table 1. Two paths were suggested from El Rahawy Drain to the Qattara Depression. The existing levels were computed from digital elevation model for the two paths. Outline designs and associated costs were prepared for the canal bed levels, pump and turbine stations locations for the two paths. From the preliminary evaluation of the approach, it is found that this approach is preferable to be implemented that it will add a new source to the Qattara Depression water resources which will accordingly develop various activities in the area with the additional benefits of reducing the pollution at the Rosetta Branch that consequently improving the public health.

It is recommended also to continue on further studies like:

1- Feasibility study including: survey study to fine tune the canal alignments to minimize pumping head and length for the selected path, geotechnical study to find out the soil structure, meteorological, structure, hydropower, hydraulic and ground water studies.
2- EIA study including: water quality, culture, socio-economic and health phases.

ACKNOLEDGEMENT

Great appreciation goes to Eng. Khaled Basset, Agronomist, for providing support for such this an important study.

REFERENCES

1- NWRP, "National Water Resources Plan: Water for Future, 2017" Planning Sector, Ministry of Water Resources and Irrigation, Egypt, 2005.
2- El Bassyony et al, "Introduction to the Geology of the Qattara Depression", International Conference on the Studies and Achievements of Geosciences in Egypt, 69 (85-eoa), 1995.
3- Mortensen N.G, Said U.S, Badger J., "Wind Atlas for Egypt: Measurements, Micro- and Mesoscale Modeling", New and Renewable Energy Authority, Cairo, Egypt, 2006.
4- Amer M. et al," A Finite Element Model of the Nubian Aquifer System in Egypt", proceeding of the international conference held in Cairo, 1981.
5- Ezzat M.A, "Impact of a Future Qattara Salt-Water Lake on the Nubian Sandstone Aquifer System in the Western Desert, Egypt", Improvements of Methods of Long Term Prediction of Variations in Groundwater Resources and Regimes Due to Human Activity Proceedings of the Exeter Symposium, IAHS Publ. no. 136, July 1982.
6- Martino, "The Qattara Depression", Hydraulics Institute, Naples, Italy & United Nations University Website: http://www.unu.edu/unupress/unupbooks/80858e/80858E0a.htm, 1973.
7- El Gammal H. A. and El Shazely, H. S.," Water Quality Management Scenarios in Rosetta Nile River Branch, EGYPT", Twelfth International Water Technology Conference, IWTC12, Alexandria, Egypt, 2008.
8- Whitehead P.G., "Dispersion and Self-purification of Pollutants in Surface Water Systems", ISBN 92-3-102049-8 © Unesco, 1982.
9- Abukila A. F, "Assessment of Natural Self Restoration of the Water of Al-Mahmoudia Canal, Western Part of Nile Delta, Egypt". Irrigate Drainage Sys Eng 1:104. doi:10.4172/2168-9768.1000104, 2012.
10- El-Degwi et al. "Estimating BOD Pollution Rates Along El-Salam Canal Using Monitored Water Quality Data (1998–2001). In: Proceedings of 9th international drainage workshop, Paper No 50. The Netherlands, Utrecht, September 10–13; 2003.
11- Othman A.A. et al." El-Salam Canal is a Potential Project Reusing the Nile Delta Drainage Water for Sinai Desert Agriculture: Microbial and Chemical Water Quality" Cairo University Journal of Advanced Research http://dx.doi.org/10.1016/j.jare.2011.04.003, 2011.
12- El Bouraie M. M., Eman A. M, Gehad G. M & Yehia M. M. "Water quality of Rosetta Branch in Nile delta, Egypt"© Suoseura — Finnish Peatland Society ISSN 0039-5471, Helsinki, 2011.
13- Amin A. M, Fahmy S. Abdelhaleem, Basset K. A. "Application of Data collection Technologies in River Catchments (Case study: Sue River, South Sudan)" Mansoura Engineering Journal, (MEJ), Vol. 37, No. 1, March 2012.
14- Assefaw M. et al "Gabal El-Asfar Wastewater Treatment Stage II Phase II Project" project Appraisal Report, http://www.afdb.org, 2009.