Modeling the Effects of Different Management Strategies of Drainage Water Effluent for Improving the Water Quality of Lake Qarun

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Introduction

Lake Qarun is located in Egypt about 80 km south west of Cairo as shown in figure 1. Although Lake Qarun was designated as protected area back in 1989, the lake has hardly been protected from various polluting elements. It suffers from a serious pollution problem due to uncontrolled solid/liquid domestic and industrial waste disposal practices[1]. Lake Qarun receives about 700 million m3of waste water per year from drains [3]. The main sources of water for the lake are El Batts drain (41%), El Wadi drain (36%) and other minor drains (23%) as shown in figure 3. These drains contain waste water from municipalities and agriculture that is responsible for large input of pesticides and fertilizers into the lake[2]. Furthermore the waste water coming from each drain contains salts with concentration2g/l and heavy metals with average concentration 1.5 mg/l. Due to the evaporation the salinity of the lake increases up to 36g/l[2]. The increasing of salinity is likely to convert the lake into a dead lake.

There is a company work for extracting salts from the lake called EMISAL company which attempt to stop the increasing of lake salinity and produce salt products as a profitable project. Although the lake salinity still increase every year. This requires improving the drainage water Quality as a source of contaminants. This project discusses different management strategies for improving El Batts drain water quality, which are mainly focusing on source control and treatment of drainage water that is feeding Lake Qarun. The tool to compare different management options is water quality modeling for El Batts drain. The outcome of this is identifying sources of pollution and places for implementing effective treatment plants. The water quality modeling is done by using the SOBEK software (Deltares). Modeling results show an impression on loads of salts and heavy metals and give an overview on the effect of possible treatment and management strategies. A comparison of three different strategies in terms of efficiency and effectivity result in recommendations for further activities.

Fig. 1: Satellite image : Fayoum location (Google maps)

Fig. 2: Picture of El Batts drain

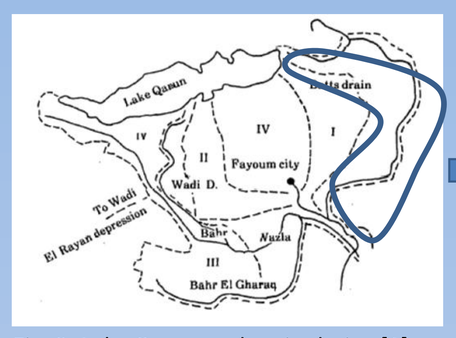

Fig. 3: Lake Qarun and main drains [1]

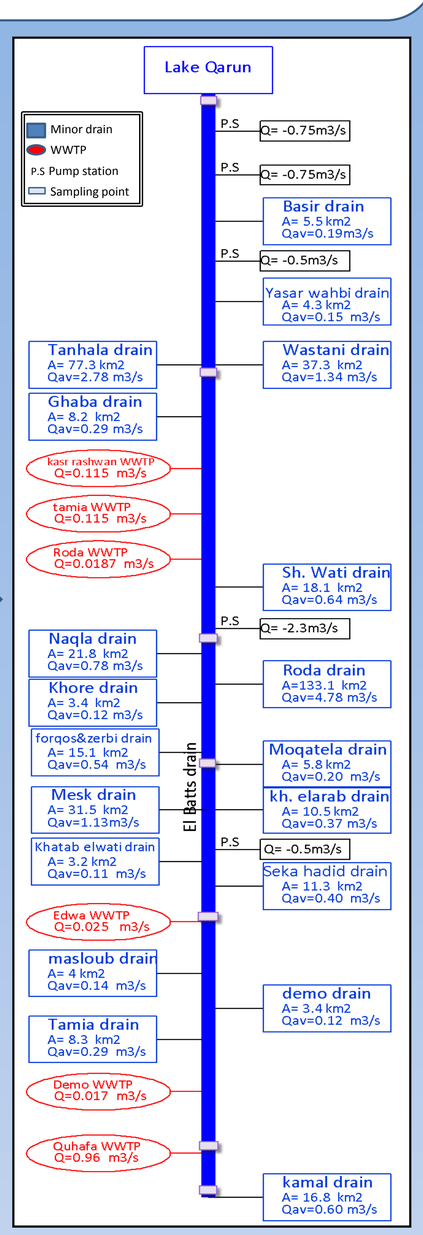

Fig. 4: Scheme of El Batts drain

Methods

The method to analyze the situation of drainage water is to model the water quality of main drain El Batts. The water quality modeling can be used as a tool to identify sources of high contaminants in order to improve the water quality of drains that feed lake Qarun. The studying area as shown in figure 3 corresponds to El Batts drain and minor drains. The length of El Batts drain is 57 km. It gets the waste water from 19 minor drains and six waste water treatment plant (WWTP). The minor drains get the waste water from agriculture and untreated municipal waste water. By studying all parameter of contaminants that feed the lake it is found that the parameters that have big effect on the aquatic life in the lake are heavy metals and salts.

This study is done by using results of sampling points of water along El Batts drain within the year 2011. This sampling is done by the Drainage and Public work management in Fayoum, Ministry of Irrigation and the places of sampling points are shown on the layout of El Batts drain with minor drains and WWTP that feed El Batts drain (figure 4). The water quality is modeled by SOBEK software (Deltares). The modeling is divided into two steps. First step is making hydrodynamic modeling to measure the discharge along the main drain. Second step is making water quality modeling to get the water quality along El Batts drain.

Management strategies for improving El Batts drain Water Quality

The management strategies for improving El Batts drain water quality depend on the treatment of minor drains which delivers high load of salt and heavy metals into El Batts drain. By modeling the discharge and the concentration of salts and heavy metals it is clear to indicate the source of high load to remove and obtain the effect on the lake. By studying the increase of salinity along El Batts drain as shown in figure 5 it show that the high loads are coming from two points. To decrease the concentration there are three options to do treatment for minor drains that are feeding this points. First option is making removal for salts and heavy metals from minor drain that feed point A with discharge 4.78 m3/sec. Second option is making treatment for point B with discharge 4.12 m3/sec. And the third option is making treatment for 50% of water comes from A and B.

Results and Discussion

Modeling results

The water quality model shows the variation in concentrations of salts and heavy metals. As shown in figure 5 the concentration of salts increase along El Batts drain because of the high load of salts comes from each minor drains. Heavy metals concentration for the minor drains have also high concentration along El Batts drain as shown in figure 6. These high concentrations combined with high discharges result in high loads of salts and heavy metals from El Batts drain to the lake.

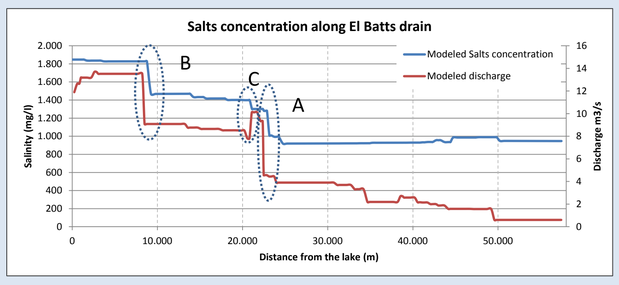

Fig. 5: The modeled discharge and salts concentration along El Batts drain

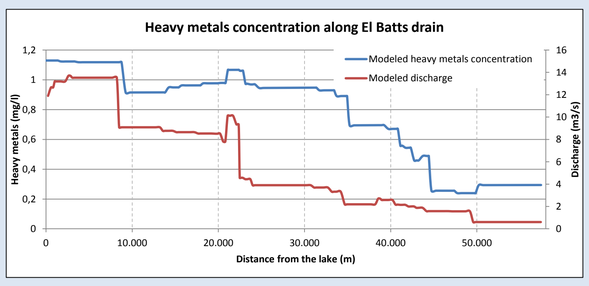

Fig. 6: The modeled discharge and heavy metals concentration along El Batts drain

Results of management strategies

The management strategies were modeled by SOBEK to get the effect of treatment at the end of el Batts drain before reaching the lake. The results of salinity at the last point of El Batts drain within the year 2011 for the recent case before treatment and for the three treatment options are shown in figure 7. The salt loads which are removed by option 1, 2 and 3 are 769,757 and 763 ton/ day . Although the second option gets the lowest load into the drain it gives the best results for the lake. For option one after removing the load there is a pump station (figure 5 point c) which takes water out from the drain to mix with irrigation water. This pump station decrease the loads in the main drain and also decrease the effect of treatment for option 1. For the same reason option 3 does not get the best effect on salts concentration at the end of El Batts drain as shown in figure 7. Although it also improve the condition of water quality along the drain.

The same strategies that modeled for salts are modeled for heavy metals to obtain the effect of treatment at the last point of el Batts drain before reaching the lake as shown in figure 8. By applying these strategies to remove cobalt as it have a high concentration in drainage water and adsorbed by fish in the lake it is found that the average loads of cobalt that are removed by option 1,2and 3 are 274, 332 and 303 kg/day. Therefore the heavy metals load which enter the lake by El Batts drain are decreased by 40%.

Effect of treatment strategies on salt balance for the lake

The salt balance is calculated by using the chemical analysis done by **EMISAL company** on all drains that feed the lake and compared with the amounts of salts that extracted by EMISAL company every month. Lake Qarun receives every year 1,460,242 ton of salts and EMISAL company extracts 410,000 ton/year[4]. By applying option3 as the best results for salts removal it was found that it decrease salts loads from El Batts by 40% and decrease total load of salts enter the lake by 15% as shown in figure 9.

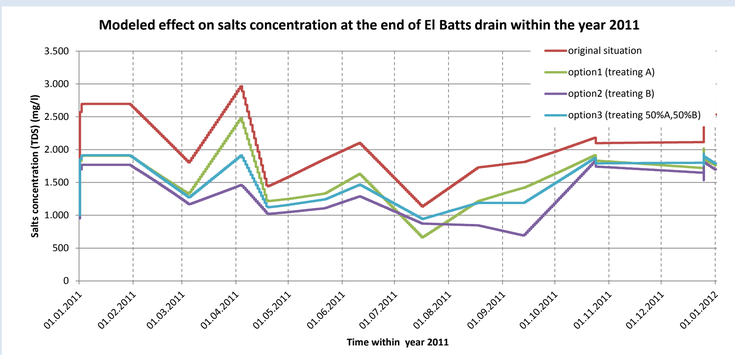

Fig.7: Effect of the management options on the salt concentration at the end of El Batts drain before reaching the lake

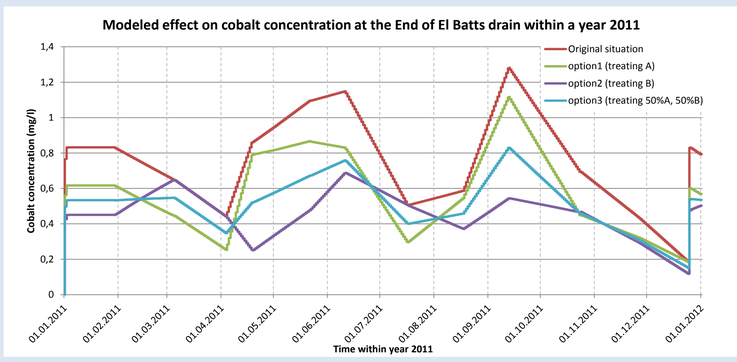

Fig. 8: Effect of the management options on cobalt concentration at the end of El Batts drain before reaching the lake

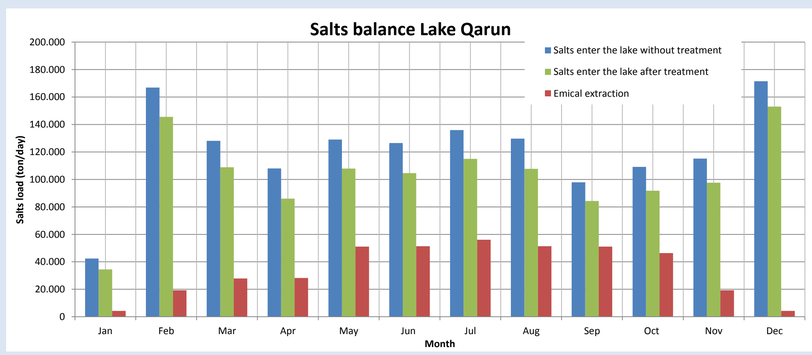

Fig. 9: Effect of the management options on salts balance on Lake Qarun

Conclusions and Outlook

This study analyzes the drainage water quality in Fayoum by using the example of El Batts drain as a main drain with a big effect on lake Qarun water quality . By comparing all contaminants in the drainage water it was found that almost all drainage water comes from agricultural work. The irrigation water contains high concentration of salts with average total dissolved salts (TDS) of 850 mg/l[2]. The irrigation common method in Egypt is surface irrigation. Therefore almost of irrigation water is evaporated within the irrigation process which increase drainage water salinity. Heavy metals come from the use of fertilizers and pesticides that used in agriculture. Fertilizers and pesticides also have some salt ions in its component which are responsible for increasing salinity. To keep Lake Qarun salt balance it is important to make a balance between loads of salts feed the lake and loads of salts extracted by EMISAL company. The benefit of applying different treatment options on minor drains that get high loads of contaminants into El Batts drain is decreasing the loads which enter the lake and use the treated water for irrigation to keep the water balance in the lake.

The considered treatment for drainage water is not enough for keeping salts balance in the lake. There is a need to improve the source of contaminants by improving the irrigation water quality and making studies for using pesticides and fertilizers without heavy metals. Controlling the source of contaminants and treatment could be useful to improve lake Qarun water quality and reuse part of drainage water to improve the irrigation system in Fayoum.

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2: Sedki, M. (1999). Academy of Scientific Research and Technology: national research center, Egypt.
3: management of public work, Fayoum.
4: EMISAL company

Acknowledgements

I wish to express my thanks to Eng. Ragaa Abdel Aziz (the director of drainage and public work management in fayoum, Ministry of irrigation), Dr. Abdel latif Elkordy (EMISAL company), Dr. Adel Abdel ELtawab (EMISAL company) and Dr. Sanaa Ahmed(HCWW) for their help to collect data about the study area. I would like also to express my thanks to Timo Wortberg and Rodolfo Alvarado Montero (University of Duisburg Essen) due to their support in my work.

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Funded by: