AGRICULTURAL DRAINAGE WATER QUALITY ANALYSIS AND ITS SUITABILITY FOR DIRECT REUSE IN IRRIGATION: CASE STUDY: KAFR EL-SHEIKH GOVERNORATE, EGYPT

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ABSTRACT

In Egypt, the major challenge facing the sustainable requirements for agricultural development is limited water resources. Water supply shortage at the end of irrigation network is a common problem in the north of the Nile delta, Egypt. Consequently, the use of agricultural drainage waters provides one of the national feasible solutions for the problem. Nowadays the local irrigation districts depend on feeding some canals, which have water supply shortage, by direct pumping from the nearby drains. The aim of the present study is to discuss the suitability of drainage water reuse in irrigation by backflow from drains at the end of the irrigation canals in the north of the Nile Delta. Moreover, to assess the drainage water quality and its suitability for direct reuse in irrigation in this area. The analysis of the collected data on drainage water quality of the study area compared to the Egyptian standards for the drainage water reuse indicated that the drainage water quality does not meet the local standards for the direct reuse of drainage water in irrigation. It is recommended to apply in-stream treatment system or mixing the drainage water with fresh irrigation water for improving the drainage water quality to avoid the excessive deterioration of drainage water, soil and plant productivity.

Keywords: Irrigation Water Shortage, Drainage Water Direct Reuse, Irrigation Water Quality, Irrigation Network, Kafr El-Sheikh Governorate, Egypt

1 INTRODUCTION

The Egyptian agricultural sector is the highest freshwater consumer, utilizing about 85% of the available supplies. By 2050, the Ministry of Water Resources and Irrigation (MWRI) of Egypt expects total water demand to increase to 81.7 billion m^3 (BCM)/yr (MWRI, 1998). The projected total water demand cannot be met by developing new water resources. Besides increasing water use efficiency, drainage water reuse is the most promising immediate and economically attractive option to make more water available for agriculture and (Fleifle et. al, 2013).

In the 1980s, the reuse of agricultural drainage water became a policy to increase Egypt's fixed freshwater resources and to close the gap between supply and demand. Reuse is centrally organized with the pumping of water from the main drains into the main canals. At present, drainage water reuse is widely practiced in Delta region through 23 locations defined as central drainage reuse system. The total amount of official drainage reuse increased from 6.0 BCM in 2008 to 6.5 BCM in 2013. This amount is expected to increase up to 9.0 BCM/year by the year 2017 (Shaban et. al, 2010) (El-Bably, 2002).

Irrigation water supply shortage at the end of irrigation networks is one of the common problems in the north of the Nile Delta region especially in Kafr El Sheikh Governorate. To overcome this problem, the farmers who receive inadequate fresh irrigation water pump the drainage water directly - sometimes without "permit"- to irrigate their fields. Moreover, the local irrigation districts of Kafr El-

Sheikh governorate constructed a number of emergency feeders to feed the end of the irrigation canals which have water supply shortage from the nearby drains. The main objective of this study is to assess the drainage water quality and its suitability for direct reuse in irrigation practices accompanying to the shortage of irrigation water supply, in Kafr El Sheikh Governorate, North of the Nile Delta, Egypt.

2 REUSE PRACTICES OF DRAINAGE WATER IN EGYPT

Drainage water reuse projects in the Nile Delta started as early as the 1980s alongside construction of the drainage projects. Drainage water reuse in the Delta is practiced in three ways (Abdel-Azim & Allam, 2005):

- Official reuse: by capturing drainage flows in main drains and mixing them with main canal water at centralized mixing pump stations. The volume of this type of reuse is planned and managed by the MWRI (El-Gammal & Ali, 2008).
- Intermediate reuse: water in branch drains can be captured when the water quality is appropriate. It can help avoid unnecessary losses of branch drain water by using it before it enters a more polluted main drain.
- Unofficial reuse: is defined as farmer's direct reuse of drainage water without pre-permission from (MWRI). It exists wherever canal water shortage is recorded, mainly at canal end. This drainage reuse practice was recorded in the latest decade as the water demand increased versus the constant supply. Two types of unofficial reuse are practiced in Egyptian irrigation system (Abu-Zeid & Abdel-Dayem, 1991), (El-Gamal et al., 2005):

1 - Direct pumping from drain to the field; and

2- In-field reuse by holding the water in the field by blocking the tile drainage system.

It is clear that both types of the unofficial reuse have negative impacts on irrigation system although they solve the problem of irrigation water deficit (El-Sayed, 2006). The unofficial reuse of drainage water is taken place in many locations in the north of the Nile Delta. It is impossible to measure this type of reuse because of its spontaneous nature. It is believed that a quantity of 2.7 BCM/year for the Nile Delta (MWRI, 1998).

3 STUDY AREA AND DATA COLLECTION

The study area is located in Kafr El Sheikh Governorate at the north of the Nile Delta area of Egypt. It covers 3,437 km^2 and is predominately agricultural area with some light industries related to the processing of agricultural products. Main agricultural products in this region are cotton, rice, and maize. A water supply shortage for El-Wasat area (75,000 feddan) in Kafr El-Sheikh Governorate is reported (El-Ganzori et. al, 2000). The study area receives its irrigation water from Bhr Shebeen Canal which is fed by Meet Yazeed Canal. The water is distributed to the area through 29 secondary canals (210 km length), Drainage water from the area is pumped at pumping stations No. 7 and 8 and conveyed through drains No. 7 and 8 into Lake Burulus (El-Ganzori et. al, 2000).

The farmers who receive inadequate irrigation water in the study area use the drainage water unofficially for irrigation by direct pumping to their fields. Moreover, the irrigation districts constructed several feeders to deliver drainage water from the nearby drains to satisfy the shortage of irrigation water at the end of the canals in the study area. The local irrigation districts operate these feeders officially. These feeders are connected with small pump stations for pumping the drainage water. While, sometimes the water level in the drain allows flowing of drainage water by gravity through a connecting pipe to the end of the irrigation canal.

The drainage water in the study area from Nashart drain is used to feed the end of Saafan, Eliwa, El-Masharqa, and Sidi Salem irrigation canals at the shortage time in irrigation water quantities, as shown in Fig.1. In order to assess the drainage water quality in the study area one monitoring location (MN01) on Nashart drain was proposed. The monitoring location located at the upper pump station

no.8 before the intake of the feeders in the study area, as shown in Fig. 1. Samples of Nashart drain water were collected monthly over one year, started at August 2010 to July 2011 by the Drainage Research Institute (DRI).

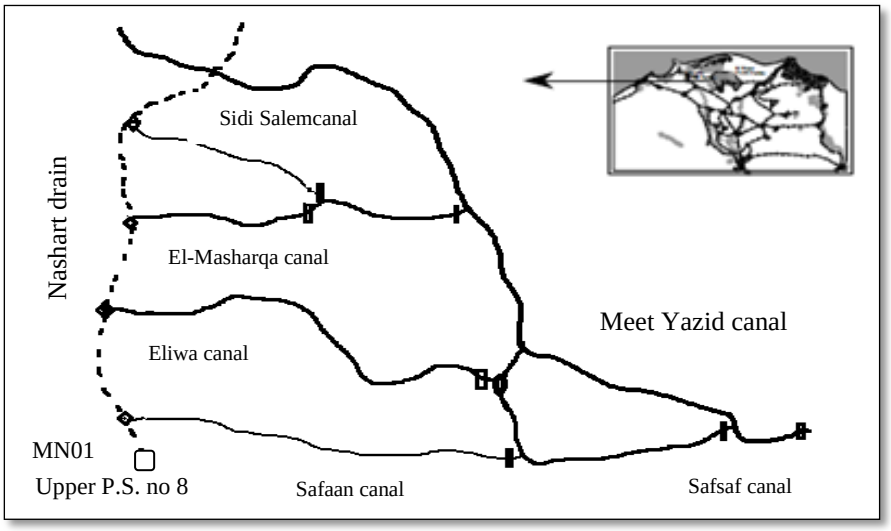

Figure 1. El-Wasat area, Kafr El Sheikh Governorate, Nile Delta, Egypt.

4 ASSESSMENT OF AGRICULTURE DRAINAGE WATER QUALITY IN THE STUDY AREA

To evaluate the drainage water status some parameters were selected, from the collected data, according to the American Standards Methods for the Examination of Water and Wastewater, 1995. These parameters include: Bio-chemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), total suspended solids (TSS), total dissolved solids (TDS), Nitrate (No_3), Ammonia (NH_4), Total Phosphorous (TP), pH, and the salinity (EC). These values were compared with the values of the local Egyptian standards for the drainage water reuse (Law 48/ 1982). As shown in Table 1.

The BOD values of the drainage water ranges between 8 and 36 mg/l which is higher than the local standards of fresh water (6mg/l). While, the COD values varies from 10 to 43 mg/l which is higher than the Egyptian local standards for fresh irrigation water (15mg/l) except for two months (June and July), as shown in Fig.2. It is clear from the results that the summer season experiencing improvement of the drainage water as these months are the rice cultivation season as the rice crop require large amounts of water the drainage water also will increase producing good quality for the drainage water. Also, the same occurs in October month due to the heavy rains at the north of the delta in this time of the year.

The TDS of the drainage water collected form Nashart drain varies between 808 and 1039 mg/l, which is 1.6-2.8 times the value of the water to be mixed as presented by the local standards. Moreover, it is clear that all values of the NO3, TSS, pH, TP over the year are within the limits of the Egyptian local standards for direct reuse. The results showed that the ammonia (NH4) values of the drainage water varies from 0.2 to 1.3 mg/l. while, the Egyptian local standards is 0.5 mg/l. It is should noticed that most of time the value is higher than the standards except for June. Finally, according to the Egyptian standards the drainage water of Nashart drain cannot be used directly without mixing with fresh water as the values of the salinity over the year are greater than 1 dS/m.

Table 1. The results of the analysis of the drainage water quality parameters

Month	BOD	COD	TSS	TDS	NO_3	NH_4	TP	pH	EC
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		dS/m
August	35	43	7	830	3.00	0.90	0.62	7.55	1.23
September	18	23	42	1,039	4.00	1.20	0.97	7.60	1.55
October	14	16	17	946	3.00	0.90	0.65	7.11	1.36
November	24	26	18	918	3.00	0.63	0.81	7.78	1.36
December	20	23	18	950	3.00	0.90	0.60	7.20	1.36
January	22	25	18	914	3.00	0.90	0.60	7.24	1.36
February	23	27	17	914	3.00	0.90	0.60	7.25	1.36
March	23	26	18	918	3.00	0.90	0.65	7.33	1.36
April	36	43	11	976	3.00	0.90	1.03	7.18	1.40
May	25	30	13	917	3.00	0.90	1.02	7.61	1.31
June	9	11	11	853	3.80	0.20	0.28	7.60	1.20
July	8	10	11	808	4.60	1.30	0.11	7.65	1.20
local standards(law 48/1982)	1o	15.00	50.00	less than 500	10.00	0.50	1.00	7.00	Less than 1 for direct reuse

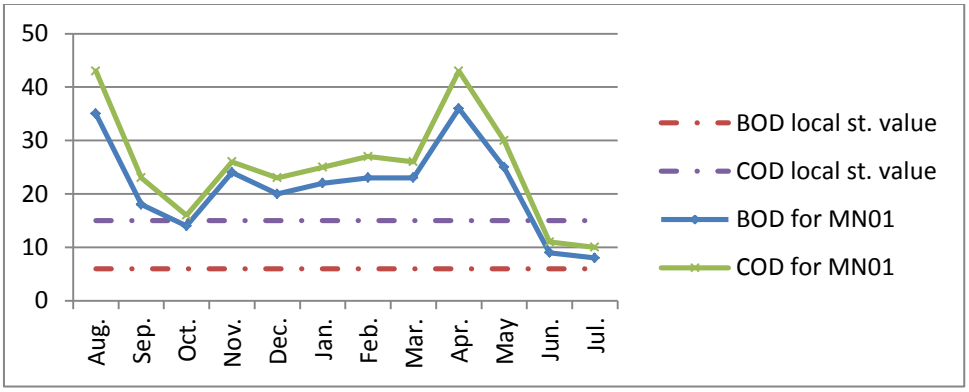

Figure 2. The monthly variation of BOD and COD of the drainage water in Nashart drain

5 CONCLUSIONS

Based on the drainage water quality analysis of Nashart drain and the Egyptian standards for the drainage water reuse it is shown that the water quality in Nashart drain does not meet the standards for the direct reuse of drainage water in the study area in irrigation. More specifically, the water quality of the drainage water experienced an improvement through the rice cultivating months (June, July) in the study area.

6 RECOMMENDATION

To avoid the future deterioration in the drainage water quality a detailed study is urgently required to identify the pollution sources for the drainage water and to define the appropriate pollution control measures. It is recommended to apply an in-stream treatment system at the end of the canals which feeds by drainage water by back flow from the nearby drains. Moreover, an integrated reuse plan that includes the recommended mixing locations and ratios should be identified for the study area to overcome the shortage in the irrigation water at the end of irrigation canals.

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REFERENCES

[1]. Abu-Zeid M. & Abdel-Dayem S., "Variation and Trends in Agricultural Drainage Water Reuse in Egypt", Water International Volume 16, Issue 4, 1991, pages 247-253.

[2]. Abdel-Azim R., Allam M.N., 2005, "Agricultural Drainage Water Reuse in Egypt: Strategic Issues and Mitigation Measures" CIHEAM / EU DG Research, pages 105- 117, 2005.

[3]. El-Bably A.Z., 2002, "Advanced and Integrated Approaches for Crop Tolerance to Poor Quality irrigation water in Egypt".CIHEAM, 2002. p. 363-378.

[4]. El-Sayed M. A. Rassoul, 2006, "Prospects of Water Reuse in Egypt" Tenth International Water Technology Conference, IWTC10 2006, Alexandria, Egypt.

[5]. El-Gammal A. H., Ali M. H., 2008, "Commissioning of Abandoned Drainage Water Reuse Systems in Egypt: A Case Study of Upgrading the Umoum Project, Nile Delta", The 3rd International Conference on Water Resources and Arid Environments and the 1st Arab Water Forum.

[6]. El-Gamal F., Mostafa H., Shalby A., "Reuse of low quality water in Egypt".CIHEAM / EU DG Research, 2005. p. 93-103. Available on http://om.cih eam.org/article.ph p?ID PD F=8007 54

[7]. El-Ganzori A., Abdel Gawad T., A.El-Sayed, Adel Hashim "Assessment of The Drainage Water Reuse In The Irrigation Improvement Areas, Kafr El Sheikh Governorate of Egypt", ICEHM 2000, Cairo University, Egypt, September, 2000, page 333- 344.

[8]. Fleifle E. A, O. C. SaavedraValeriano, Nagy H., Elfetiany F., Tawfik A., Elzeir M., (2013) "Simulation-Optimization Model for Intermediate Reuse of Agriculture Drainage Water in Egypt" Journal of Environmental Engineering, 139 (3) (2013), pp.391–401

[9]. MWRI, 1998, "National Policy for Drainage Water Reuse", Report no. 8, June 1998, EPIQ Water Policy Reform Program.

[10]. Shaban M., UrbanB., El-SaadiA., FaisalM., 2010,"Detection and Mapping of Water Pollution Variation in the Nile Delta Using Multivariate Clustering and GIS Techniques", Journal of Environmental Management 91(2010) 1785-1793

[11]. The American Standards Methods for the Examination of Water and Wastewater, 2005