ENGINEERING RESEARCH JOURNAL (ERJ)
Vol. 1, No. 44 April 2020, pp.118-125.
Journal Homepage: erj.bu.edu.eg

Evaluation of Water Quality Index for Bahr Shebin Canal in Egypt

Neveen B. Abdel-Mageed[1], W.A. Fahmy, [2], H.A. Elgzzar [3]

[1]Associate Professor, Civil Engineering, Shoubra Faculty of Engineering, Benha University, Cairo, Egypt
[2]Researcher, Civil Engineering, Shoubra Faculty of Engineering, Benha University, Cairo, Egypt
[3]Research Assistant, Drainage Research Institute, National Water Research Center, Delta Barrages, Egypt

Abstract

Canadian Council of Ministers of the Environment Water Quality Index **CCME-WQI** is considered one of the most used global indices to evaluate water surfaces. Bahr Shebin Canal is an important canal in middle delta as it serves three big governorates Menofya, Gharbia and Kafr EL-sheikh. Therefore, the aim of this paper is to evaluate the water quality of Bahr Shebin Canal for irrigation use. The evaluation of the canal based on data collected monthly by drainage Research Institute **DRI** through National Water Quality Monitoring Network **NWQMN** project from August 2017 to July 2018. The index outputs are numbers between zero to 100 that reflect the water quality status of the canal. Evaluation results for the monitoring points along Bahr shebin canal were fair.

1 Introduction

Water is considered the most important resource from natural resources. In the past, the focus was at water quantity, for example calculating the amount of water required for irrigating lands. In the previous three decades, water quality has taken the concentration as water quantity required, but the problem was how to express the quality of water as the quality may be acceptable for specific use and refused for another.

Water quality index is a number that express the water quality for general or specific uses by converting large numbers of parameters to simple expression reflect the quality of the water. Water quality indices are proposed to provide simple number that can be understood easily to mangers, decision makers and public.

Canadian Council of Ministers of the Environment Water Quality Index **CCME-WQI** was used by several researchers to evaluate Egyptian streams.

(Khan et al., 2008) assess water quality of EL-Salam canal and Nile river for specific uses like aquatic life and drinking by using **CCME-WQI**

(Elshemy & Meon, 2010) used **CCME-WQI** to assess the water quality of lake Nubaria. The authors selected seven water quality parameters (Do, TDS, N-NO3, N-NH4, TP, FC, and PH) for the index and took the permissible values for the parameters from Egyptian water quality standards for surface waterways, law 48/1982-Article No. 60.

(Abukila et al., 2012) used **CCME-WQI** to evaluate water quality of EL-Salam canal.

(Donia & Farag, 2010) used **CCME-WQI** to evaluate Nubaria canal drinking water abstraction.

(Salah El, 2014) used **CCME-WQI** to evaluate water quality of Mahmoudia canal.

(Abdel-Satar et al., 2017) used **CCME-WQI** to assess the appropriateness of the Nile for drinking and aquatic life uses.

The main aim of this paper is to assess Bahr Shebin canal water for irrigation use.

2 Study Area

Bahr Shebin canal is considered one of the most important canals in middle delta. Although it is narrow and shallow canal in middle delta, it has 80 km long into the Nile delta passing through three big governorates Menofya, Gharbia and Kafr EL-sheikh. Bahr Shebin canal upstream is at (30.54266667 N, 31.01165 E) and its downstream is at (31.21415 N, 31.35111667 E). Figure (1) shows map for Bahr shebin canal and its monitoring points that are used to evaluate water quality of the canal.

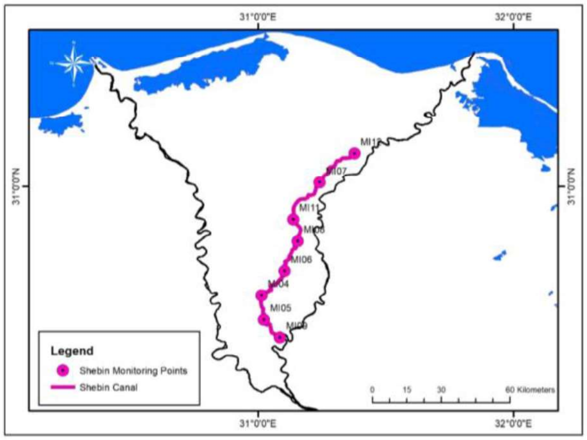

Figure 1: Bahr Shebin Canal and its monitoring points

3 Material and Methods

3.1 Data Collection

Evaluation of water quality of Bahr Shebin based on data collected monthly by Drainage Research Institute **DRI** through National water quality monitoring network **NWQMN** project from August 2017 to July 2018 in eight monitoring points. Table (1) shows Bahr Shebin Canal monitoring points and their descriptions.

Table 1: Bahr Shebin Canal monitoring points and their descriptions

MI04	Bahr Shebin Canal upstream of the Shebin drinking water intake.
MI05	Bahr Shebin Canal downstream shebin Al-kawm city
MI06	Bahr Shebin Canal downstream of reuse pumping station MG01
MI07	Bahr Shebin Canal downstream of reuse pumping station MG03
MI08	Bahr Shebin Canal downstream Mahalla City
MI09	Bahr Shebin Canal branch upstream of Tanta drinking water intake
MI11	Bahr Shebin Canal branch downstream Kafr Ash-Sheik city
MI12	Bahr Shebin Canal branch downstream Bilqas city

3.2 Canadian Council of Ministers of the Environment Water Quality Index CCME-WQI

The Canadian council of ministers of environment water quality index (CCME-WQI) is a development of British Columbia water quality index (BCWQI), CCME-WQI based on three factors F1, F2 and F3.

F_1 (the scope): is the ratio between number of failed parameters (parameters doesn't achieve standard guidelines) used in the index to total number of parameters used in the index.

$$F_1 = \left(\frac{number\ of\ failed\ variables}{total\ number\ of\ variables}\right) * 100 \quad \text{Eq 1}$$

F_2 (Frequency): it is the ratio between no. of failed measurements (measurements of the parameters that doesn't meet standards guidelines) to total number of measurements.

$$F2 = \left(\frac{Number\ of\ failed\ tests}{total\ number\ of\ tests}\right) *100 \quad \text{Eq 2}$$

F_3 (Amplitude): it is calculated in three steps:

1- Number of occasions that parameter value doesn't achieve guidelines standard, the objective is termed an "excursion" and is stated as follows:

- When the guidelines standard is maximum value, so the test value mustn't exceed it:

$$Excursion = \left(\frac{failed\ test\ value_i}{Objective_j}\right) - 1 \quad \text{Eq 3}$$

- When the guidelines standard is minimum value, so the test value mustn't be less than it:

$$Excursion_i = \left(\frac{Objective_j}{failed\ test\ value_i}\right) - 1 \quad \text{Eq 4}$$

2- (nse) term is calculated by the ratio between sum of extrusions of individual tests from their standard guidelines divided by total number of tests.

3- By using asymptotic function F_3 is calculated by:

$$nse = \sum_{i=1}^{n} \frac{excursion_i}{no.\ of\ tests} \quad \text{Eq 5}$$

$$F3 = \left(\frac{nse}{0.01\ nse + 0.01}\right) \quad \text{Eq 6}$$

$$CCME\text{-}WQI = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}\right) \quad \text{Eq 7}$$

Table (2) shows CCME-WQI categories

Table 2: CCME-WQI categories

CCME –WQI Value	**Rating**
95-100	Excellent
80-94	Good
65-79	Fair
45-64	Marginal
0.0-44	Poor

Bahr Shebin Canal was evaluated for irrigation use depending on eleven parameters: Total dissolved salts **TDS**, Dissolved Oxygen **DO**, Sulphate **So_4^{--}**, Sodium

Adsorption Ratio **SAR**, Biological Oxygen Demand **BOD**, Iron **Fe**, Total Nitrogen **TN**, Total Phosphates **TP,** Fecal Coliforms **FC,** Chloride **Cl^-,** Hydrogen ion concentration **PH**.

The parameters guidelines were according to Decree No. 49, Law/1982 amended in 2013 and FAO guidelines and standards. Table (3) shows (CCME-WQI) selected parameters and their guidelines.

Table 3: (CCME-WQI) selected parameters and their guidelines

No.	Parameter	unit	Guideline Decree No. 49, law 48/1982
1	TDS	mg/L	500
2	SO4	mg/L	200
3	Cl	mg/L	10 *
4	FC	MPN/100ml	1000
5	PH	--	6.5-8.5
6	Fe	mg/L	0.5
7	Do	mg/L	>6
8	BOD	mg/L	6
9	(SAR)	mg/L	9 *
10	TN	mg/l	3.5
11	TP	mg/l	2

* according to FAO guidelines

4 Results and Discussion

The final score indices for Bahr Shebin canal monitoring points were fair and this means that the water quality of Bahr Shebin canal are suitable for irrigation use. Table (4) illustrates the final score indices for monitoring points along Bahr Shebin canal. And the following figures show Average values for eleven parameters through water year (2017-2018) for Bahr Shebin Canal monitoring points.

Figure (2) shows that the max average value for (TDS) through water year (2017-2018) on Bahr Shebin Canal monitoring points was at (MI08) and min value was at (MI04) and the values compatible with Egyptian national standards (Law 48 issued in 1982 and its amendment 2013). (DO) concentrations through Bahr Shebin canal monitoring points were represented in figure (3) and the results show that the max average value was at (MI04) and min average value was at (MI07). And Figure (4) shows that the average values for (PH) on Bahr Shebin Canal monitoring points ranged from 7.5 to 7.7 which is considered under Egyptian guidelines and standards. Measurements of (Fe) values through water year (2017-2018) in figure (5) showed that the max average value was at (MI05) and min average value was at (MI06) and all values were under Egyptian guidelines and standards (Law 48 issued in 1982 and its amendment 2013).

In figure (6) the water quality parameter (SO4) in Bahr Shebin canal monitoring points were compatible with Egyptian guidelines and standards (Law 48 issued in 1982 and its amendment 2013). Total Nitrogen (TN) was represented in figure (7) and the max value was at (MI11) and min value at (MI12). Fecal Coliform parameter (FC) was illustrated in Figure (8) and the max average value through water year (2017-2018) for Bahr Shebin Canal monitoring points was at (MI12) and min value at (MI06). Total Phosphates (TP) was illustrated along Bahr Shebin canal monitoring points in figure (9) which were within the permissible limits according to Egyptian guidelines and standards (Law 48 issued in 1982 and its amendment 2013).

In the other hand, for the (BOD) concentrations in Bahr Shebin canal monitoring points, figure (10) shows that the max average value for (BOD) found at (MI08) and min value was at (MI07). Sodium Adsorption Ratio (SAR) values in figure (11) were compatible with FAO guidelines and standards along Bahr Shebin canal monitoring Points. And also figure (12) illustrated that the water quality parameter (Cl) values in Bahr Shebin canal monitoring points were within permissible limits according to FAO guidelines and standards.

Table 4: Water quality Indices for Bahr Shebin Canal calculated by CCME-WQI

Canal Name	Site Code	No. of Variables	failed Variables	No of Tests	failed Tests	F_1	F_2	Sum of Exc	nse	F_3	CWQI	Rank
Bahr Shebin	**MI04**	**11**	**4**	**132**	**17**	**36.36**	**12.88**	**7.92**	**0.06**	**5.27**	**77.52**	**Fair**
	MI05	**11**	**4**	**132**	**23**	**36.36**	**17.42**	**13.2**	**0.1**	**9.3**	**76.11**	**Fair**
	MI06	**11**	**5**	**132**	**24**	**45.45**	**18.18**	**7.92**	**0.06**	**5.58**	**71.55**	**Fair**
	MI07	**11**	**5**	**132**	**24**	**45.45**	**18.18**	**11.88**	**0.09**	**8.32**	**71.33**	**Fair**
	MI08	**11**	**4**	**132**	**23**	**36.36**	**17.42**	**19.8**	**0.15**	**12.98**	**71.54**	**Fair**
	MI09	**11**	**5**	**132**	**22**	**45.45**	**16.68**	**11.88**	**0.09**	**8.2**	**71.65**	**Fair**
	MI11	**11**	**4**	**132**	**28**	**36.36**	**21.21**	**15.84**	**0.12**	**10.91**	**74.89**	**Fair**
	MI12	**11**	**4**	**132**	**18**	**36.36**	**13.64**	**17.16**	**0.13**	**11.4**	**76.63**	**Fair**

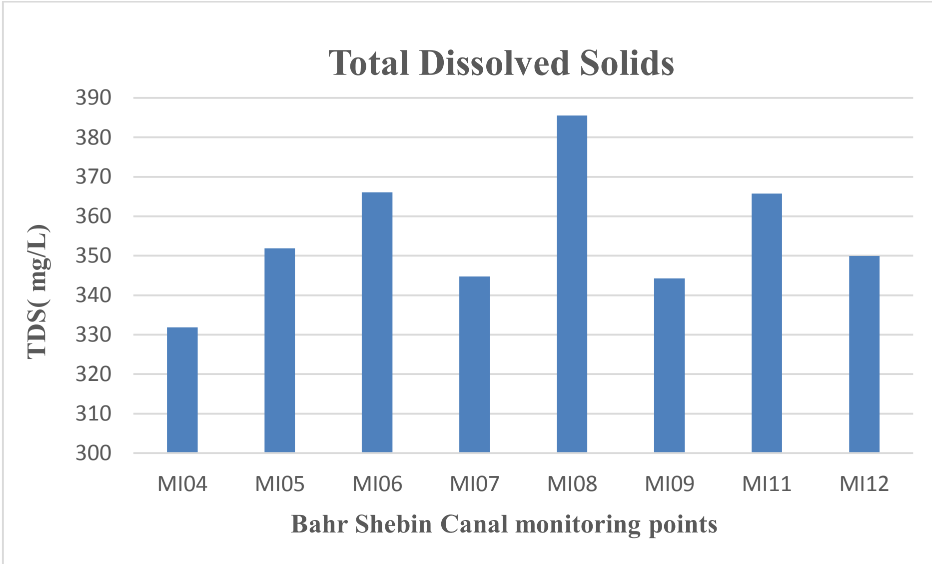

Figure 2: Average value for Total Dissolved Solids (TDS) through water year (2017-2018) for Bahr Shebin Canal monitoring points

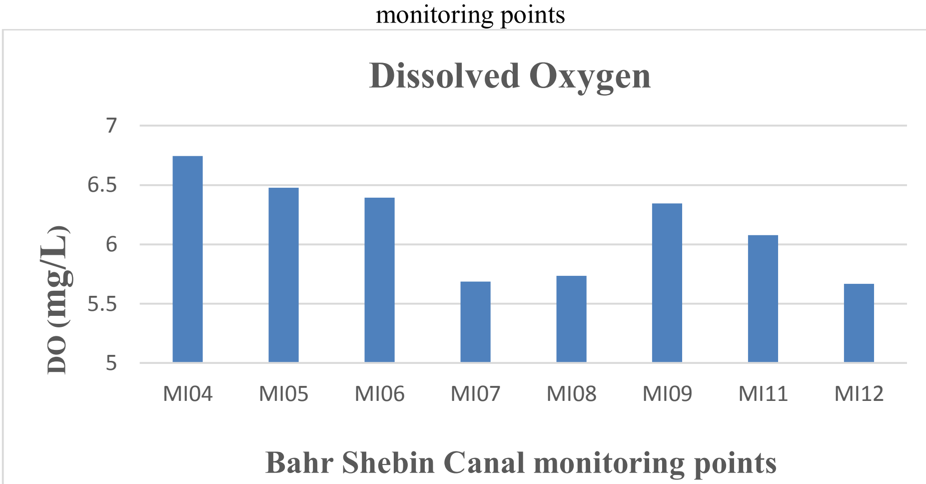

Figure 3: Average value for Dissolved Oxygen (DO) through water year (2017-2018) for Bahr Shebin Canal monitoring points

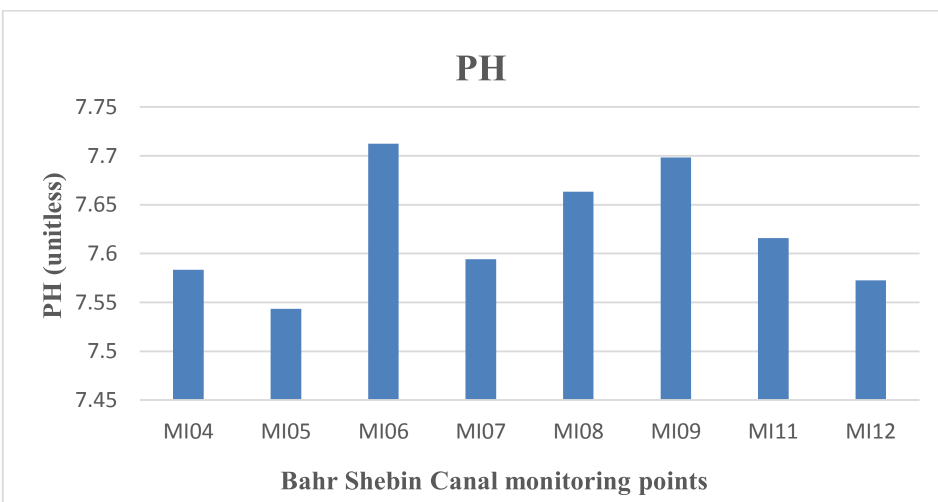

Figure 4: Average value for (PH) through water year (2017-2018) for Bahr Shebin Canal monitoring points

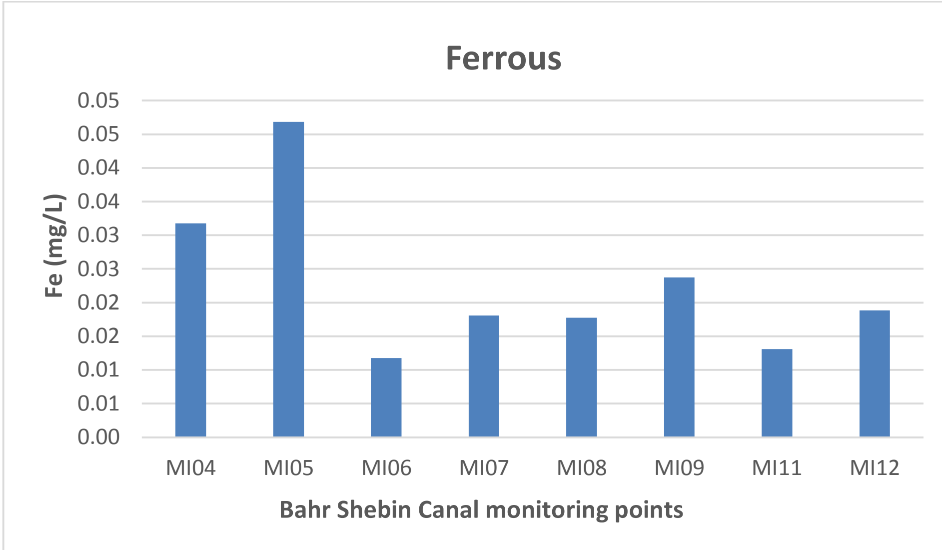

Figure 5: Average value for Ferrous Ion (Fe) through water year (2017-2018) for Bahr Shebin Canal monitoring points

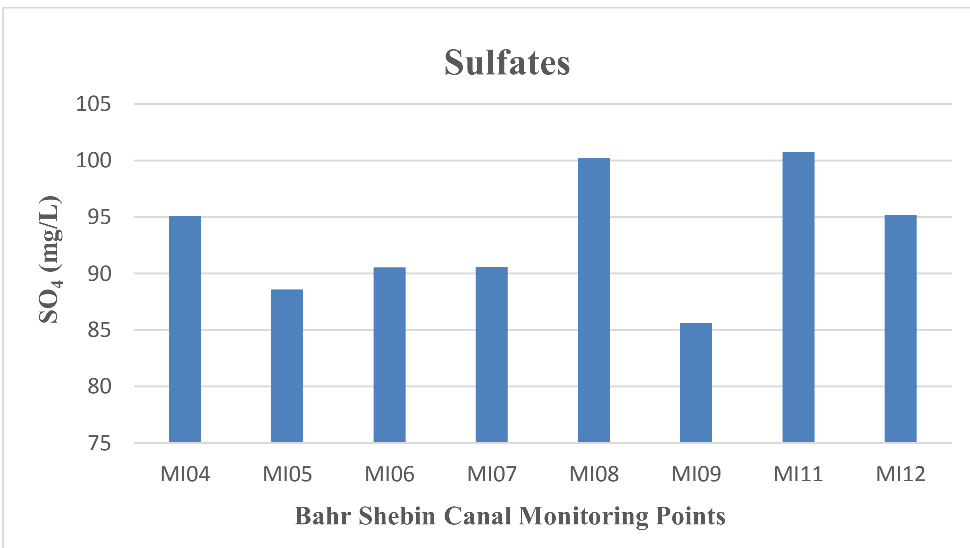

Figure 6: Average value for Sulfates (SO4) through water year (2017-2018) for Bahr Shebin Canal monitoring points

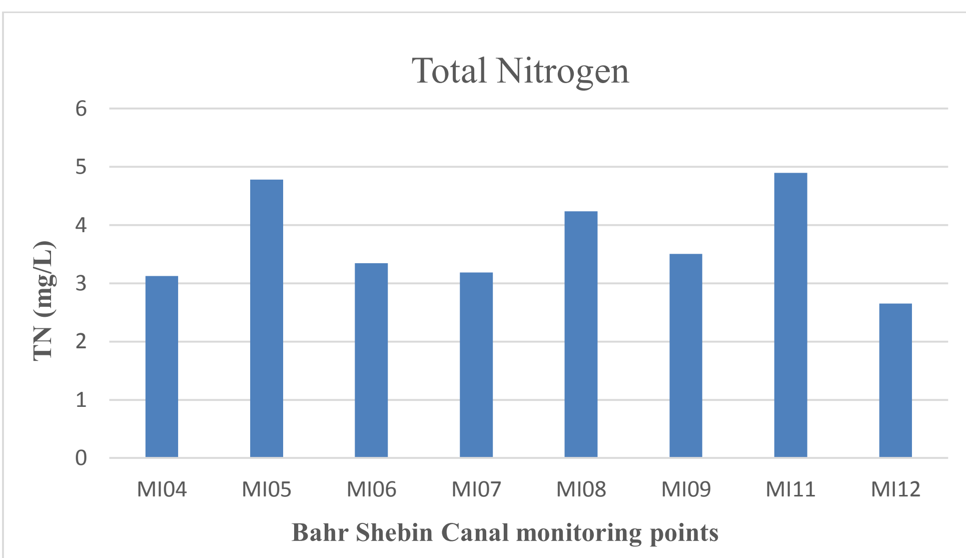

Figure 7: Average value for Total Nitrogen (TN) through water year (2017-2018) for Bahr Shebin Canal monitoring points

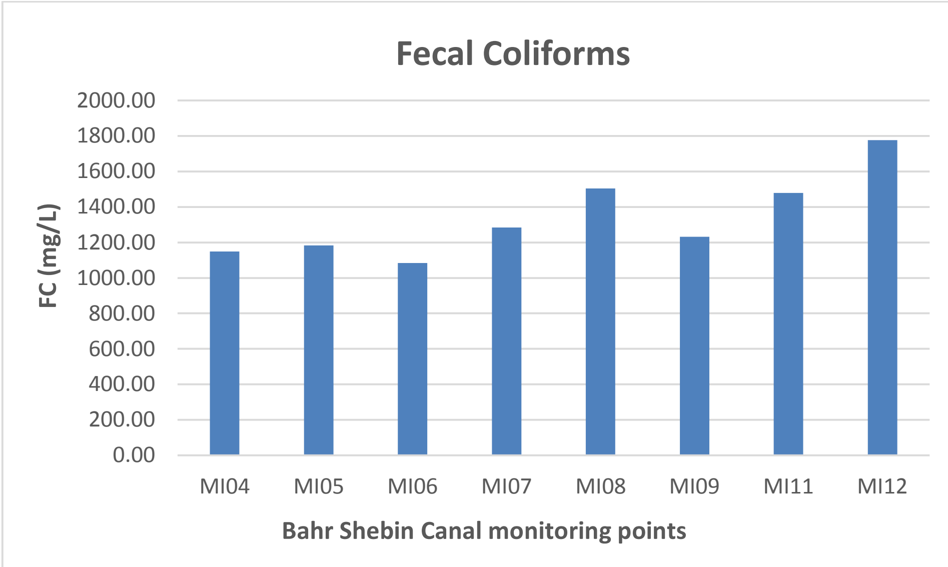

Figure 8: Average value for Fecal Coliform (FC) through water year (2017-2018) for Bahr Shebin Canal monitoring points

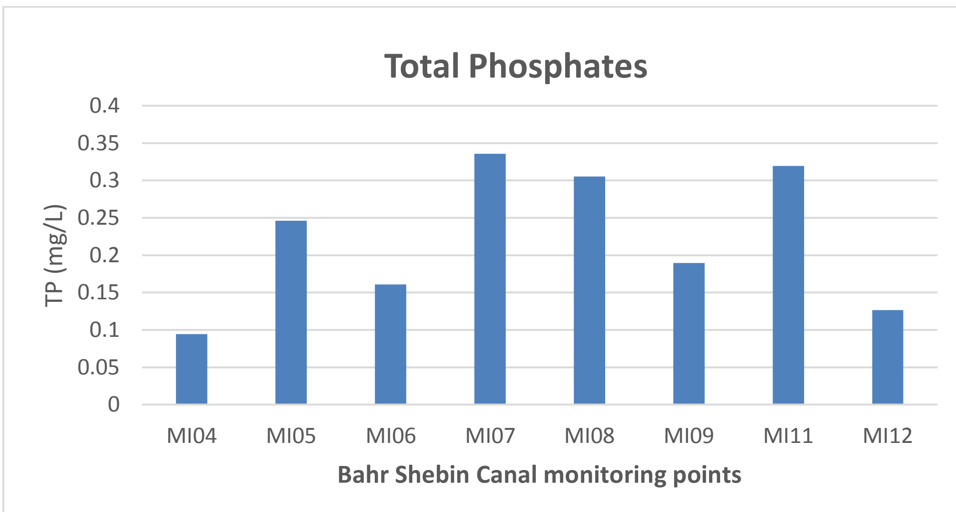

Figure 9: Average value for Total Phosphates (TP) through water year (2017-2018) for Bahr Shebin Canal monitoring points

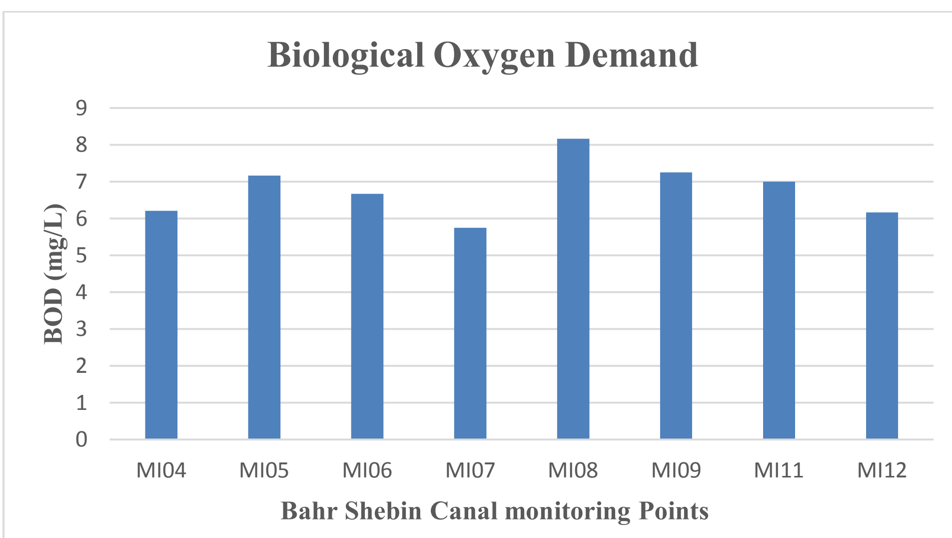

Figure 10: Average value for Biological Oxygen Demand (BOD) through water year (2017-2018) for Bahr Shebin Canal monitoring points

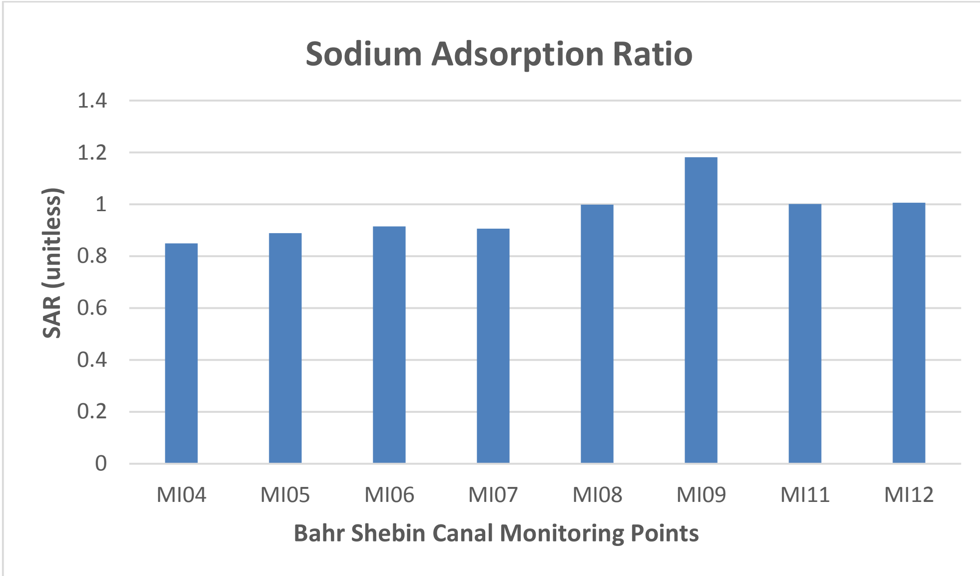

Figure 11: Average value for Sodium Adsorption Ratio (SAR) through water year (2017-2018) for Bahr Shebin Canal monitoring points

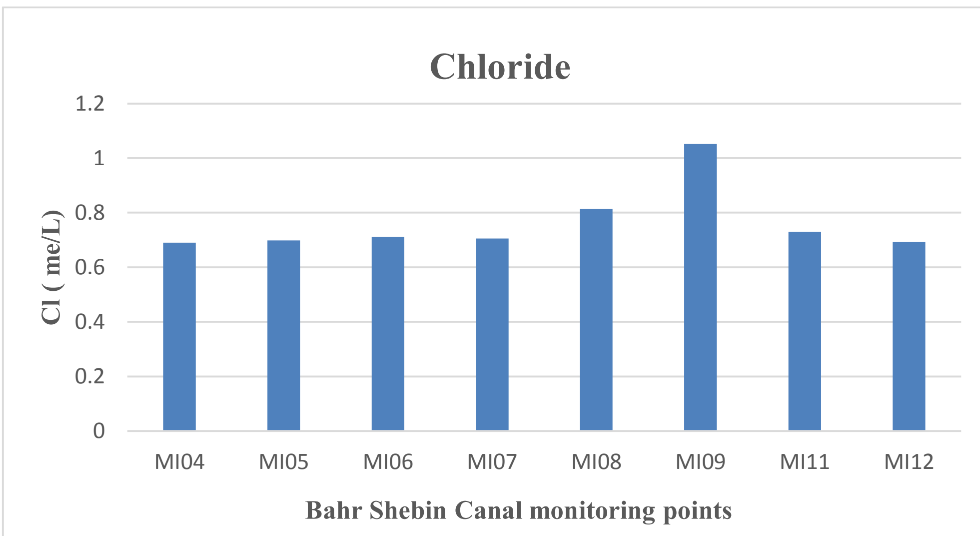

Figure 12: Average value for Chloride ion (Cl) through water year (2017-2018) for Bahr Shebin Canal monitoring points

5 Conclusion

Through the analysis of water year data (2017-2018) for Bahr Shebin canal monitoring points and depending on CCME-WQI and according to Decree No.49, Law/1982 amended in 2013 and FAO guidelines and standards. the following conclusions were found:

1. Bahr Shebin Canal water quality is appropriate for irrigation use.
2. Bahr Shebin canal water quality is fair.
3. Water quality Score for Bahr Shebin canal monitoring points ranged from 71.3 % to 77.5%.

6 References

[1]. Abdel-Satar, A. M., Ali, M. H., & Goher, M. E. 2017. Indices of water quality and metal pollution of Nile River, Egypt. Egyptian Journal of Aquatic Research, 43(1), 21–29. https://doi.org/10.1016/j.ejar.2016.12.006

[2]. .Abukila, A. F., Kholy, R. M. S. El, & Kandil, M. I. (2012). Assessment of water resources management and quality of El Salam Canal, Egypt. International Journal of Environmental Engineering, 4(1/2), 34. https://doi.org/10.1504/ijee.2012.048101

[3]. Canadian Council of Ministers of the Environment (CCME) 2001 'Canadian water quality guidelines for the protection of aquatic life: CCME water quality index 1.0, technical report', in Canadian Environmental Quality Guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

[4]. Donia, N. S., & Farag, H. A. (2010). A WASTE LOAD MODEL ANALYSIS FOR EL NOUBARIYA CANAL DRINKING WATER ABSTRACTION , EGYPT 2 . DESCRIPTION OF El-NOUBARIYA CANAL. Fourteenth International Water Technology Conference IWTC 14 2010 Cairo Egypt, 675–690. Retrieved from http://www.iwtc.info/2010_pdf/11-01.pdf

[5]. Elshemy, M., & Meon, G. (2010). Climate change impacts on the hydrodynamic characteristics of the southern part of Aswan High Dam reservoir, Lake Nubia. Environmental Hydraulics - Proceedings of the 6th International Symposium on Environmental Hydraulics, 2(October), 1145–1150. https://doi.org/10.1201/b10553-192

[6]. FAO 1985 'Water quality for agriculture', in R.S. Ayers and D.W. Westcot, FAO Irrigation and Drainage Paper 29, Rev. 1. FAO, Rome. 174p.

[7]. Government of Arab Republic of Egypt, Law No. 48 for the year 1982 Concerning the Protection of River Nile and Watercourses from Pollution.

[8]. Khan, A. Al, Abdel-Gawad, S., & Khan, H. (2008). A Real Time Water Quality Monitoring Network and Water Quality Indices for River Nile. 13th IWRA World Water Congress, 15.

[9]. Salah El, D. H. 2014. Water Quality Assessment of Mahmoudia Canal in Northern West of Egypt. Journal of Pollution Effects & Control, 02(02). https://doi.org/10.4172/2375-4397.1000121