Journal of Basic and Environmental Sciences 1 (2014) 156 – 166 **ISSN 2356-6388**

IMPACT OF COVERING CANALS ON QUALITY OF IRRIGATION WATER: *CASE STUDY 5th GANABIAT BAHR FAKUS, EGYPT*"

Sherien Abdel Aziz[1], Abdelazim Negm[2], Gamal Mustafa[3], Mohamed Nassar[3]

[1] Ministry of water resources and irrigation, West Sharkia Directorate, Egypt

[2] Environmental Engineering Dept. School of Energy and Environmental Engineering, Egypt-Japan University of Science and Technology, E-JUST, P.O.Box 179, New Borg Al-Arab City, Postal Code 21934, Alexandria (Seconded from Faculty of Engineering, Zagazig University), Email: negm@ejust.edu.eg, amnegm@zu.edu.eg

[3] Water and Water Structure Department , Faculty of engineering/ Zagazig University, Egypt

Article Information

Received; 2 May. 2014
In Revised form; 22 May 2014
Accepted; 22 May 2014

Keywords:
Environmental Impact
Water quality
R.C. Covering
Irrigation Canals
Physicochemical Tests,
water pollution, biological assessment.

Abstract

Parts of the irrigation canals networks passes through urbanized or rural areas. This may causes some diseases due to many reasons such as misuse of the residents in this area. The Ministry of Water Resources and Irrigation decided to cover these parts of the canals network by reinforced concrete (RC) as a part of the national policy to improve the public health of the residents of those areas. Once the canal is covered by RC, an important issue is raised concerning the interaction between the covering materials and the irrigation water. This present research investigates the interactive environmental impact of the reinforced concrete covering and the irrigation water compared to standards. Thus, the current assessment adopted the comparison between the measured values of the chemical, physical and biological characteristics and the standard values provided by FAO and WHO. The 5th Ganabiat Bahr Fakus, Sharkia Governorate, Egypt was selected as a case study for the collecting samples for laboratory investigations. Five locations along the irrigation canal near and at the covered part were chosen in order to collect water samples. The characterization of water samples was made at the Central Laboratory for Environmental Quality Monitoring (CLEQM), National Water Research Center, (NWRC). The laboratory investigation indicated that the values of physicochemical parameters such as CO3, HCO3, TA, PH, etc., were almost suitable within the permissible values for irrigation. However, these values exceed the acceptable limits for reinforced concrete itself and it may harm the concrete. In addition, the biological assessment showed that the amounts of sewage water pollutants in irrigation canals are about 10 and 100 times the average permissible limits for the total coliform and fecal coliform, respectively. Heavy metals assessment showed that, it has not negative impact on irrigation water.

1. INTRODUCTION

Covering irrigation canals has several advantages including saving water that evaporates, decreasing canals seepage to the groundwater aquifer and improve the water quality by preventing the bad behavior of the residents. Therefore, water quality parameters should be studied to assess the effect of covering irrigation canals on water quality and

vice versa. To the best knowledge of the paper authors, there is no scientific research papers on this topic in Egypt and hence this study comes on line to partially fill this gap. Recently, **Elkorashey (2012) [1]** investigated the quality of water of the Elsalam canal to recommend whether it is suitable for irrigation or not. She collected 64 samples and analyzed it in the CLEQM, NWRC, MWRI. The study area is 252.75 km of the canal. It begins at the intake of the canal at Km 219 on the right bank of Damietta Branch of the Nile and ends at 3 km upstream of the Faraskour Dam. The results of the laboratory investigations were compared to the Food and Agricultural Organization **(FAO) (1985) [2], Water Environment Federation (WEF) (1998) [3]** and the **World Health Organization (WHO) (1989) [4].** It was found that the water is capable to be used for irrigation purposes in the light of the pH, COD, BOD and heavy metals values but the values of EC, TDS, alkalinity, Na, Cl and fecal coliform might moderately restrict its implementation.

On the other hand, the regulation for ministerial Decree No. 402 issued in 2009, by virtue of Egyptian Law 48/1982 was updated for regarding the protection of the River Nile and water ways from pollution, **MWRI in Article (60) law 48,1982 [5]** (for water quality in Nile Branches (2009) provides that PH values ranged from 7 to 8.5, TDS value is 500 mg/l, Alkalinity values ranged from 20 mg/l to 150 mg/l, BOD value is less than 6 mg/l, COD value is less than 10 mg/l, Sulfate value is 200 mg/l and Nitrate value is 45 mg/l. **WHO (1989)[4],** provides the suitable values for irrigation water parameters. Such as PH values ranged from 6.5 to 8.5. TDS value is 1000 mg/l. Alkalinity value is 150 mg/l. **Ministry of Agriculture, Food and Air Fisheries(2003) [6]**, showed that standards for E. coli ranging from less than 77 cfu/100ml to less than 1000 cfu/100ml. Also the standards for Fecal Coliform ranging from less than 200 cfu/100 ml to less than 1000 cfu/100ml. **Pescod (1992)[7],** mentioned the maximum permissible values of heavy metals for irrigation water. Such as Al does not exceed 5.0 mg/l, As does not exceed 0.10 mg/l, Be does not exceed 0.10 mg/l. The present paper investigates the effect of covering irrigation canals on quality of irrigation water through collecting water samples from the 5th Ganabiat Bahr Facous (Sharkia Governorate, Egypt) at Km 0.2 where 4 km long was covered by reinforced concrete.

2. STUDY AREA

The study area is located at Abu Kebier, Sharkia Governorate. One canal where a reach of 4 km long of the canal was covered by reinforced concrete (R.C.). The canal is called 5th Ganabia left Bahr Facous at KM 16.4 on Bahr Fakus. The covered length was decided based on the MWRI policy and nature of the residential area where the canal passed. They all located near Bahr Fakus, as shown in Fig. (1) (blue color). The 5th Ganabia is a branch canal of Bahr Fakus canal. Figure (1) shows main canals in the irrigation network in the study area, The location of the study area is within Nile Delta Cities.

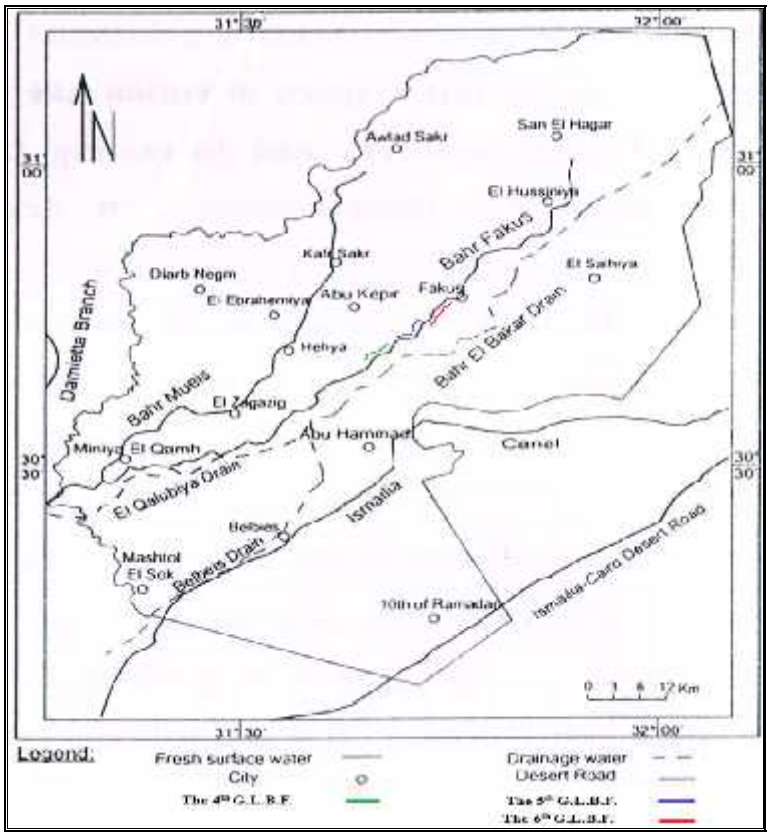


Figure (1) Location of the Study Area Among East Delta Cities, **[8].**

3. METHODOLOGY

The following methodology is adopted in this paper:

1- Five water samples collected from each canal, such that one sample at 100 m upstream of the covering length, one sample at 50 m downstream from the covering length. The other three sample are taken such that one at the inlet, one at the outlet and the third at manhole of the covered section.
2- The samples were collected according to the standards **[5]** followed by CLEQM of NWRC, MWRI. Fig. (3-a) shows the preservation of the collected sample. Fig. (3-a) shows a sample collection from a manhole.
3- All the collected water samples were analyzed by CLEQM to obtain the values of the following parameters: total dissolved solids (TDS), Sodium Hazard, total alkalinity (TA), biological oxygen demand (BOD), chemical oxygen demand (COD), electrical conductivity (EC), chloride, carbonate and bicarbonate, PH, sulfate, nitrite and nitrate and phosphates.
4- All samples were analyzed at the laboratory, CLEQM-NWRC. The temperature was about 25 ^{o}C, The parameters pH and Electrical Conductivity (EC) were measured in situ using the multi-probe system, model Hydralab-Surveyor. Total Dissolved Solids (TDS) were determined by the gravimetric method. Biochemical Oxygen Demand (BOD) was determined by using ORION BOD fast respirometry system model 890, Chemical Oxygen Demand (COD) was measured by COD spectrophotometer TR/2010 model 690 with COD reactor HACH. Major anions were determined using Ion Chromatography (IC) model DX-500, while carbonate and bicarbonate were determined by titration method using 0.02 N H2SO4. Major cations and trace metals were measured using the Inductively Coupled Plasma–Mass Spectrometry (ICP - MS), Perkin Elmer Sciex, ELAN 9000. These methods were also used by **[1]**
5- For bacteriological analysis, all collected samples were examined within 24 hours after collection. For counting total coliforms and fecal coliforms, the membrane filter technique was applied using a filtration system completed with stainless steel autoclavable manifold and oil-free "MILLIPORE" vacuum/pressure pump. Water samples were filtered through sterile, surface girded "SARTORIOUS" membrane of pore size 0.45 µm and diameter 47 mm, according to standard methods No. 9222B, 9222 D and 9230 C on M- Endo Agar LES, MFC agar, and M-Enterococcus agar medium, respectively. All media used were obtained in a dehydrated form, Difco USA. Results were recorded as Colony Forming Unit (CFU/100 ml) using the following formula:
6- Colonies / 100 ml = counted colonies x 100 / ml of sample filtered. This method was also used by **[1].**
7- The obtained values are compared with permissible values for irrigation water from the FAO guidelines **[2].**

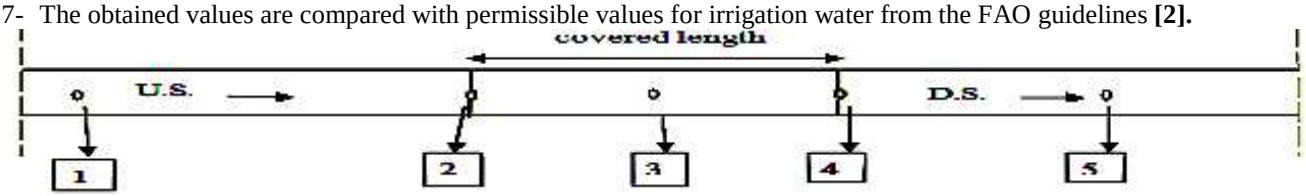


Figure (2) Points of Samples Collection for Each Canal.

Figure 3 (a) The Preservation of the collected samples (b) Collection of a sample from a manhole.

4. LABORATORY INVESTIGATION RESULTS

Table 1 presents the results of analyzing the collected samples. The results of the laboratory investigation are presented and at the last column of the table. Table 1 shows also the standard values from different sources. These results are analyzed in the next sections.

Table (1) The Results of Laboratory investigation for collected samples from the reach under investigation of 5th G.L.B.F

Serial		1	2	3	4	5	The Standard Value
Sample code		$RF.P._{US.1}$	$P._{I.1}$	$P._{M.1}$	$P._{O.1}$	$RF.P._{DS.}$	
Collection date/time		…../…./…../00:00					
Date of arrival/time		18/3/2012/00:00					
Physicochemical parameters							
PH	.....	7.58	7.9	7.86	7.8	7.69	6.5-8.5, **[5]**
Carbonate CO3	Mg/l	0	0	0	0	0	
Bicarbonate HCO3	Mg/l	185	195	180	180	185	
Total Alkalinity	Mg/l	185	195	180	180	185	
Electrical conductivity EC	Mmhos/cm	0.419	0.418	0.443	0.435	0.436	0.75(none)-1.13(some)-2.2-(moderate)-3(severe), **[9]**
Total Dissolved Solids	Mg/l	269	268	284	278	279	500, **[5]**
Biological Oxygen	Mg/l	1	4	4	2	1	6, **[5]**
Chemical Oxygen	Mg/l	18	26	17	16	18	10, **[5]**
Major Cations							
Calcium Ca	Mg/l	35.76	38.97	38.65	39.13	38.33	
Potassium K	Mg/l	7	8	8	7	7	
Magnesium Mg	Mg/l	11.76	12.92	13.41	10.01	11.08	
Sodium Na	Mg/l	34	33	34	34	34	46-460, **[10]**
Major Anions							
F	Mg/l	0.69	0.6	0.5	0.8	0.6	
Chloride Cl	Mg/l	30.5	30.8	38.8	34.2	34.4	70, **[10]**
Nitrite NO_2	Mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	
Nitrate NO_3	Mg/l	3.3	1.7	5.7	4.5	3	30, **[11]**
Phosphate PO_4	Mg/l	<0.2	<0.2	<0.2	<0.2	<0.2	0.01-0.03, **[12]**
Sulfate SO_4	Mg/l	40.6	40.2	49.7	44.8	44.0	200, **[5]**
Microbiological Parameters							
Total Caliform	Cfu/100ml	$25*10^2$	$88*10^2$	$80*10^2$	$19*10^3$	$90*10^2$	
Fecal Caliform	Cfu/100ml	$10*10^2$	$6*10^2$	$35*10^2$	$13*10^3$	$19*10^2$	<200crops eaten raw-<1000general crops, **[6]**
Heavy Metals Analysis							
Aluminum	Mg/l	<0.005	0.126	0.066	0.012	1.553	5, **[7]**
Antimony	Mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
Arsenic	Mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	1, **[7]**
Barium	Mg/l	0.074	0.106	0.087	0.086	0.107	
Beryllium	Mg/l	.....	.....	.....	.....	.....	1, **[7]**
Cadmium	Mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	0.01, **[7]**
Chromium	Mg/l	<0.001	<0.001	<0.001	<0.001	0.004	0.1, **[7]**
Cobalt	Mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	0.05, **[7]**
Copper	Mg/l	0.017	0.038	0.031	<0.001	0.094	0.2, **[7]**
Iron	Mg/l	0.009	0.053	0.010	<0.02	0.946	5, **[7]**
Lead	Mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	5, **[7]**
Manganese	Mg/l	0.013	<0.005	<0.005	<0.005	0.097	0.2, **[7]**
Molybdenum	Mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	0.01, **[7]**
Nickel	Mg/l	<0.001	<0.001	<0.001	<0.001	0.003	0.2, **[7]**
Selenium	Mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	0.02, **[7]**
Strontium	Mg/l	0.89	1.333	1.255	1.283	0.994	
Tin	Mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	
Vanadium	Mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	0.1, **[7]**
Zinc	Mg/l	<0.001	<0.001	<0.001	<0.001	0.063	2, **[7]**
Mercury	Mg/l	.....	.....	.....	.....	.....	

5. DISCUSSIONS OF RESULTS

5.1. Physicochemical Assessment

5.1.1. Carbonate, Bicarbonate, TA and PH

a clear indication that the media is alkaline. Generally, the HCO_3 values and PH values have direct relationship. The Results indicated that water samples contain zero carbonate. The values of bicarbonates for the five locations are shown in Fig. (4). The values at the inlet is the highest while the values at locations 1 and 5, the main stream are the same. The values at both the manhole and at the outlet are the smallest and equal. In darkness, when no photosynthesis occurs, respiration processes release carbon dioxide, and no new bicarbonate ions produced., **Covington(1985)[13]**. Consequently, as indicated in Figure 5 the trend of TA (mg/l) is exactly similar to that of HCO_3. Moreover, Figure (6) shows the values of PH. The figures give values of PH ranged from 7.58 to 7.96. The variation of the total alkalinity (TA) have similar trend to HCO_3 as TA is a function of HCO_3.

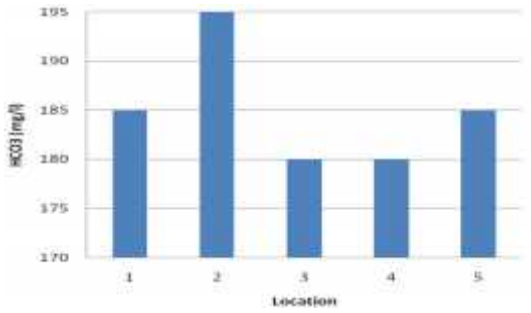


Figure (4) Measured values **of** HCO_3 at different locations

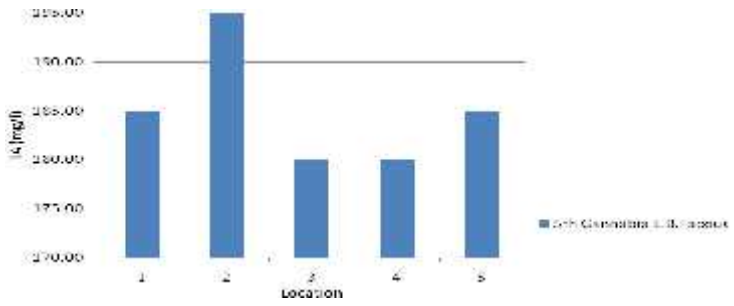


Figure (5) Measured values of TA (mg/l) at different locations

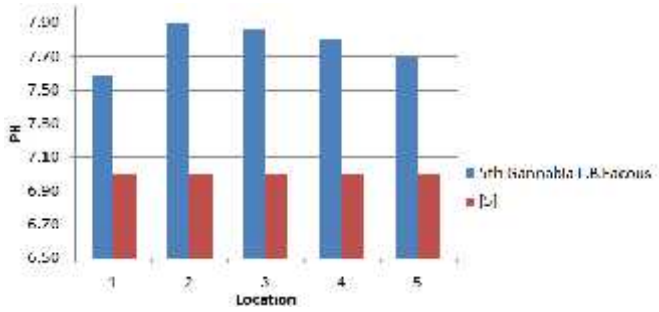
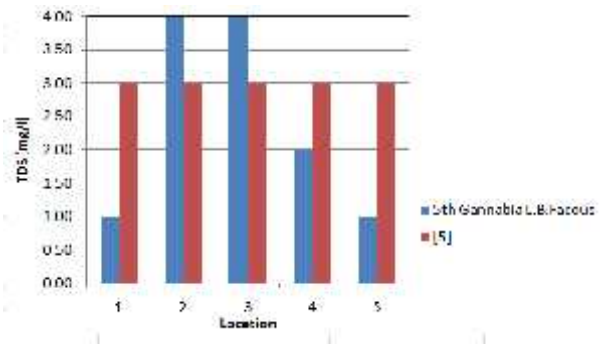


Figure (6) Measured Values of pH at different location compared to local standards **[5]**

5.1.2. Total Dissolved Solids (TSD)& Electrical Conductivity (EC)

Total dissolved solids, TDS, is used as an aggregate indicator of the presence of a broad array of chemical contaminants. Fig. (7) presents the variation of TDS for the five locations compared to those from reference **[5].** The values are almost the same at points 2 and 3 and are the highest at the same time. The values at 1 and 5 are similar and are the smallest. The value at the outlet is between that of the manhole and that the downstream side (main stream). This increase may be attributed to the presence of debris screen inlet section. This screen reserves pollutants on it and microorganisms may play a role in analyzing many of these pollutants to dissolved substances, Fig. (9). The values of EC ranged between 0.418 mmhos/cm to 0.459 mmhos/cm. Figure 8 shows the comparison of the present results with those from references **[9]** where the values of EC for no salts, some salts, moderate values of salts and severe salts are present in the water. **Ayers [9]** stated that salt-free water has EC ≤ 0.75 mmhos/cm (none), water has some salt if EC =0.76 : 1.5 mmhos/cm (some salts), water considered having moderate salts if EC = 1.51:3.00 mmhos/cm, and it considered having sever salts if EC ≤3.00. Figure (8) indicated that water samples had very low inorganic soluble ions. Conductivity in water affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (negative ions) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Organic compounds like oil, phenol, alcohol, and

sugar do not conduct electrical current very well and therefore have a low conductivity when in water, **Hach Company(1992)[14]**.



.**Figure (7)** Measured values of TDS (mg/l) at different locations compared to international standards **[5]**

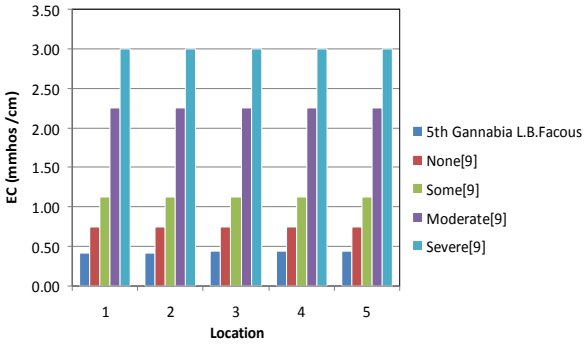


Figure (8) Measured values of EC (mmhos/cm) at different locations compared to international standards **[9]**

Figure (9) Collecting sample for the point of inlet (Just before the existing screen).

5.1.3. Sodium Hazard

The values of Na in the water samples ranged from 33 mg/l to 34 mg/l. It is observed that the values at the at the inlet is smaller than other values at all other locations. **Tanji (1990)[10],** concluded that susceptibility ranges for crops to avoid foliar injury were from 46 mg/l to 460 mg/l for Na concentration

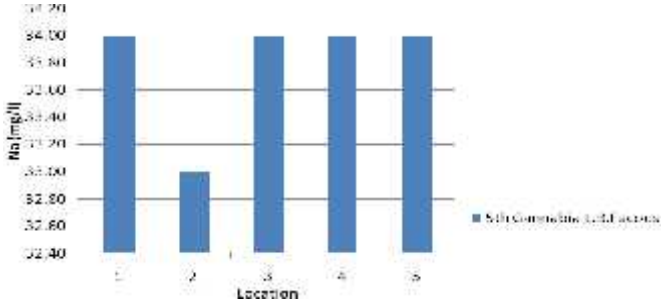


Figure (10) Measured values of Na (mg/l) at different locations

5.1.4. Chloride

The analysis of water samples for the five locations indicated that the values ranged from 30.5 mg/l to 38.8 mg/l which is blow the safe value (70 mg/l) for all types of plants, **Tanji (1990)[10].** Figure (11) shows the variation of chloride values at the five locations. The higher value at the manhole may be due to the interaction between the CL and the RC

concrete. The decrease in the values at locations 4 and 5 are lesser and support this assumption. This point needs more investigation at the location of the manhole to study the impact of the covering materials on the quality of irrigation water. Chlorides under the condition of pH less than 10 increased the risk of corrosion. All the study locations had pH less than 10. In most cases, however, excessive amounts of chloride in concrete originate from external, **CCAA(2009)[15].**

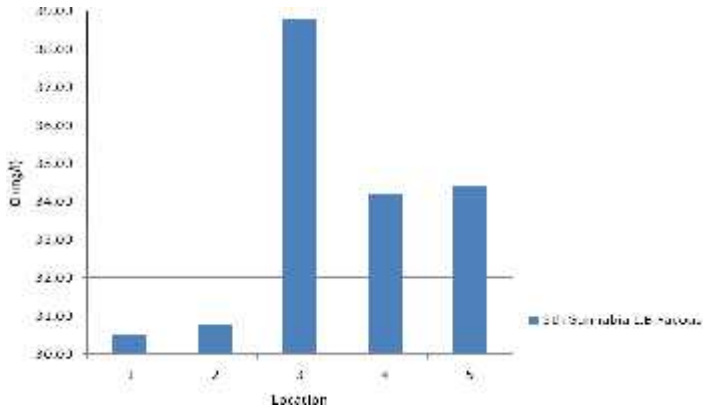


Figure (11) Measured values of Cl (mg/l) at different locations

5.1.5. Sulfate

Sulfate ion is a major contributor to salinity (TDS) in irrigation waters. Sulfate in irrigation water has fertility benefits. A few studies have reported sulfate toxicity to some aquatic organisms, including some fish and aquatic mosses at concentrations at or below 200 mg/l. The values of sulfate in irrigation water for the canal under consideration as shown in Fig. (12) is below the safe limit. However, the sulfate itself may has an adverse impact on the covering materials which should be studies to determine the extent of such impact. The construction material exposed to mild sulfate/salphate attack according to **The constructors civil engineering home (2012)[16].** Where all manholes points values were less than 150mg/l.

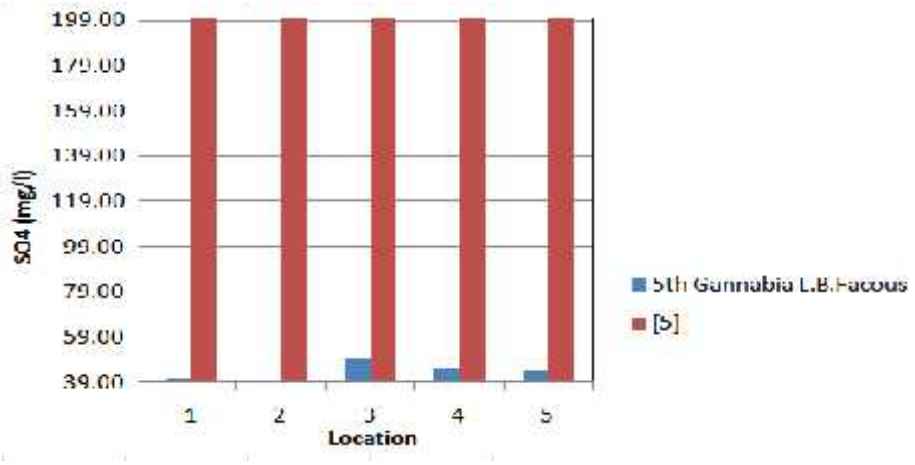


Figure (12) Measured values of SO_4 (mg/l) at different locations compared to local standards **[5]**

5.1.6. Nitrite and Nitrate

Figure (13) presents the variation of NO_2 and NO_3 for the three canal at the five locations. All the values were below the normal levels. Levels of nitrate over 30 ppm can inhibit plant growth. The decrease in values for NO_3 values at points of inlet is due to lack of Ammonia at these points. The values of NO_3 increased at the points of manholes may be due to the presence of source of Ammonia resulted from excess fertilizers in irrigation water which drained in covering length or the presence of the second group of bacteria which transforms nitrite ions to nitrate ions. **Könneke(2005)[17]** There was not clear link between concrete durability and Ammonia.

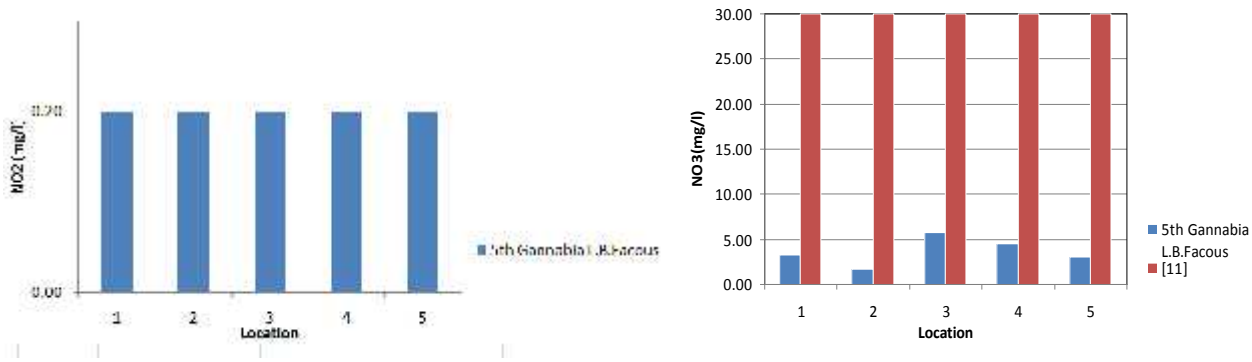


Figure (13) Measured values of NO_2(mg/l) & NO_3 (mg/l) at different locations compared to values from **[11]**

5.1.7. Phosphates

The analysis of Phosphates in the collected irrigation water sample indicates that the values are less than 0.2 mg/l and higher than 0.1 mg/l as indicated by Fig. (14). The values are similar at all locations for each canals which indicate that that there is no interaction between contaminated water and covering materials. Thus, Phosphates did not affect the covering material.

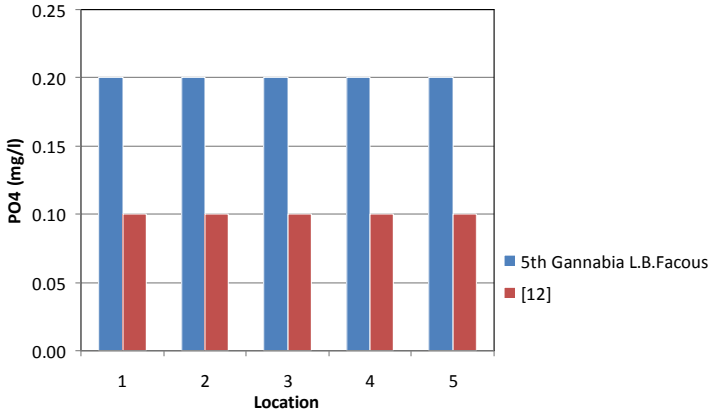


Figure (14) Measured values of PO4 (mg/l) at different locations compared to those of **[12]**

5.1.8. Biochemical oxygen demand (B.O.D.)

The second location (inlet of covering) and the 3rd one (manhole) locations had the greatest values and they are of the same value of about 4 mg/l as shown in Fig.(15). This is due to bacterial activity to disintegration waste and garbage at these points. The values ranged from 1mg/l to 4mg/l. The results indicate that the organic load between locations 2 and 3 are equal.

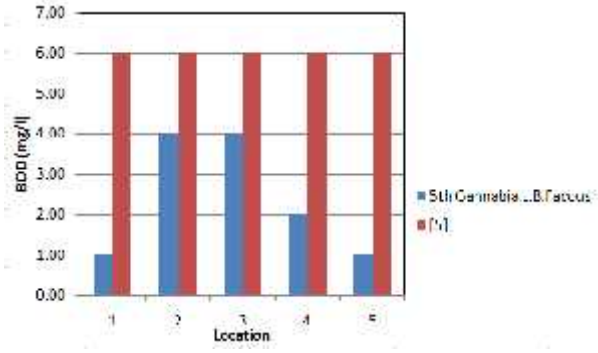


Figure (15) Measured values of BOD (mg/l) at different locations compared to local standards **[5]**

5.1. 9. Chemical oxygen demand C.O.D.

The location at the inlet has the highest value as shown in Fig.(16). These values reflect the amounts of organic pollutants at that location. The values ranged from 16mg/l to 26mg/l which exceeds the permissible values. The value at manhole is less than the inlet location and this due to the reduction in the organic pollutants.

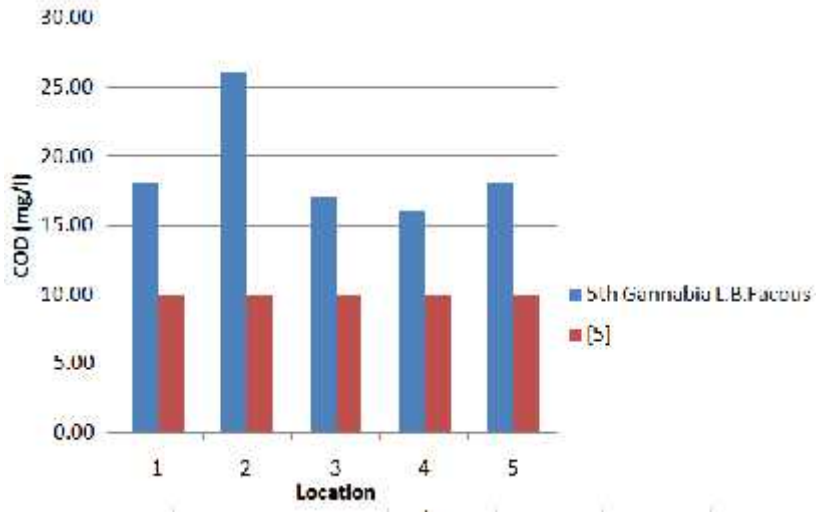


Figure (16) Measured values of COD (mg/l) at different locations compared to local standard values **[5]**

5.2. Microbiological assessment

The presented values in table 1 and in Fig. 16 indicated that all the values at all the five location are higher than permissible values **[6]**. This is due the sewage water which is drained in the canals as a result of the absence of sanitary networks. The values of FC increases gradually at the manhole location and attains the maximum value at the outlet of the covered part.

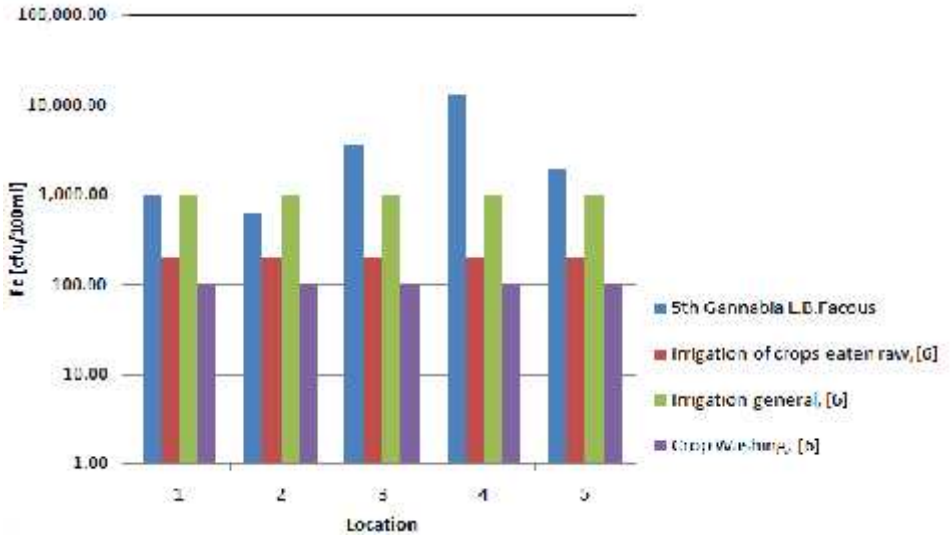


Figure (16) Measured values of FC (cfu/100ml) at different locations for the three sites

compared to international standards**[6]**

5.3. Heavy Metals:

All the values of heavy metals presented in Table 1 such as Pb, Al, As,....etc. are less than the permissible values **[7].**

6. CONCLUSION:

The analyzed results that presented in this paper revealed the following conclusion:

1- Presence of HCO3 and PH > 7 reflect the alkalinity of water. While PH values are not suitable for the construction material.

2- The inlet screen is considered as a point of high concentration of pollutants where the solid pollutants accumulate. Microorganisms play their role in the decomposition and converting the solid materials to dissolved or suspended materials.

3- The physicochemical assessment results showed good agreement with irrigation requirements but some of the elements has high concentration that are not suitable for covering material, such as Cl and SO_4. However, the values of PO_4 exceed the permissible limits.

4- The total Coliform and Fecal Coliform are found to be higher than the permissible values which are due to the presence of some sewage water mixed with irrigation water at the location of covering.

5- Results indicated that heavy metals were all within acceptable limits and thus water is suitable for agricultural irrigation purpose.

ACKNOWLEDGEMENT

The second author would like to thank the partial support of JSPS Core-to-Core Program, B.Asia-Africa Science Platforms.

REFERENCES

1. R.M. Elkorashey, Investigating the Water Quality of El-Salam Canal to Reconnoiter the Possibility of Implementing It for Irrigation Purposes, Nature and Science, 2012;10 (11), http://www.sciencepub.net/nature
2. FAO: Food and Agriculture Organization, Guidelines for irrigation water quality, 1985.
3. WEF (Water Environment Federation), 1998. Using reclaimed water to augment potable water resources. Alexandria, VA, USA.
4. WHO (World Health Organization), 1989. Health guidelines for the use of wastewater in agriculture and aquaculture. Report of a WHO scientific group. WHO technical report series 778, Geneva, Switzerland. Technical report series 778, Geneva, Switzerland.
5. MWRI, Article (60) for water quality in Nile Branches, The regulation for ministerial Decree No. 402 issued in 2009, by virtue of Egyptian Law 48/1982, 2009.
6. Ministry of Agriculture, Food and Air Fisheries, Treating Irrigation And Crop Wash Water For Pathogens, (Order No. 512.000-3, British Columbia, 2003).
7. M.B. Pescod, Wastewater treatment and use in agriculture, FAO irrigation and drainage J. paper 47, 1992.
8. A. M. A. Sharkawi, Theory and implementation of Groundwater Situation and aquifer Evaluation of some Localities in Sharkia Governorate, Egypt, M.Sc. diss., M. Sc., Geology Department, Faculty of Science, Zagazig University, 2008 .
9. R.S. Ayers, and D.W. Westcot, Water Quality for Agricultur, *Irrigation and Drainage , Paper 29, rev. 1,* 1994.
10. K.K. Tanji, (ed.), Mass Crop Salt Tolerance, Agricultural Salinity Assessment and Management Manual., (ASCE, New York. pp 262-304, 1990), Colorado State University Website.
11. Hach Company, Soil And Irrigation Water Interpretation Manual, in 7th (ed), Western Fertilizer Handbook, (Soil Improvement Committee, California Fertilizer Assoc., 1993).
12. Hach Company, Water, Water Everywhere, in 2nd (Ed), Western Fertilizer Handbook. (Soil Improvement Committee, California Fertilizer Assoc., 1983).
13. A. K. Covington, R. G. Bates, R. A. Durst, (1985)."Definitions of pH scales, standard reference values, measurement of pH, and related terminology". Pure Appl. Chem. 57 (3): 531–542.doi:10.1351/pac198557030531.
14. Hach Company, 1992. " Hach water analysis handbook. 2nd ed." Loveland, CO.
15. CCAA Organization, Cement Concrete & Aggregates Australia, June 2009. "Chloride Resistance of Concrete" WEBSITE: www.ccaa.com.au
16. Web: www. The constructors civil engineering home, 2012. " Sulphate Attack In Concrete And Its Prevention"
17. Könneke M, Bernhard AE, de la Torre JR,Walker CM, Waterbury JB, Stahl DA.,2005. "Isolation of a mesophilic autotrophic ammonia-oxidizing marine archaeon", Nature 437:543-546.

ABBREVIATION

FAO= Food and Agriculture Organization
R.P.US.= reference point upstream covering part.
P.I.= point of inlet.
P.M.= point of manhole.
P.O.= Point of outlet.
R.P.DS.= reference point downstream covering part.
CLEQM= Central Laboratory for Environmental Quality Monitoring.
The 5^{th} G.L.B.F.= Fifth Gannabia left Bahr Fakus
NWRC: National Water Research Center.
MWRI: Ministry of Water Resources & Irrigation