Arab Univ. J. Agric. Sci., Ain Shams Univ., Cairo, Egypt
29(2), 801-811, 2021
Website: http://ajs.journals.ekb.eg
DOI: 10.21608/ajs.2021.55062.1320

Assessment of Water and Sediments Quality of Kitchener Drain Nile Delta - Egypt

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Received 13 January, 2021 Accepted 19 June, 2021

Abstract

Kitchener drain is considered one of the largest drains in the Nile delta. The current study aimed to assess water quality and level of some chemical and biological pollutants in both the water and sediments of Kitchener drain. The studied water quality parameters included nitrate (NO_3^-), phosphate (PO_4^{3-}), total solids (TS), total suspended solids (TSS) and total dissolved solids (TDS), in addition, water and sediment samples were exposed to bacteriological analysis which included, total coliform (TC) bacteria, faecal coliform (FC) bacteria and *Salmonella* & *Shigella* (SS). The results showed that nitrate (NO_3^-) and phosphate (PO_4^{3-}) concentrations in most sampling sides were within the permitted Food and Agriculture Organization (FAO) limits for irrigation water. In addition, all the values of total suspended solids (TSS) and total dissolved solids concentrations (TDS) in El-Gharbia governorate were higher than the World Health Organization (WHO) permitted limits. Bacteriological results revealed that most sampling sites were contaminated with both TC and FC bacteria where, the counts of them in the water samples exceeded the 1,000 CFU/100 ml which is higher than the WHO limits. In addition, the counts of studied organisms in all examined sediment samples were higher compared to water samples. Based on these results the water in Kitchener drain is considered unsuitable for domestic and agricultural purposes.

Keywords: Water quality, Kitchener drain, Total coliform (TC), Faecal coliform (FC).

1 Introduction

Kitchener drain streams from south into north direction reaching the Mediterranean Sea and releases about 1.9 billion cubic meter per year. According to Abdel Rashid, (2002), the water is mixture of 75% agricultural drainage water, 23% domestic water, and 2% industrial water, respectively. It receives pollutants from various effluents discharged from industries and domestic sewage. The aquatic environment is considered the major source controlling the state of health and disease. The main problem addressed during this study is in the low quality of surface water in Kitchener drain. Water quality is important for every type of cultivation. When used for irrigation, low water quality may lead to reduced crop yield, therefore, irrigation water quality should be known in order to preserve long-term productivity.

Faecal coliforms are the most commonly bacteria used in discussions of wastewater reuse (Blumenthal et al 2000). Kitchener drain is in Middle part of Nile Delta and has a total catchments area of about 1,800 km^2. It originates in El-Gharbia north of Tanta City and extends pass Kafr El-Sheikh in the north direction till it reaches the Mediterranean Sea at Baltim city (El-Alfy et al 2017). Industrial effluents released into the water bodies is one of main sources of environmental Pollution (Kaur et al 2010). Estimation of the number of various bacteriological pathogen in treated sewer water samples can lead to operative evaluation of the treatment procedure. According to Toze, (2005), reverse changes in treated effluent effluents must be considered when used to irrigate edible crops. Worldwide, wastewater is the main factor in water pollution due to human release of waste into water bodies, which affects the quality of the environmental water, making large quantities of water unsuitable for various uses. (Ganoulis, 2009, Yehia and Sabae, 2011). The rapid industrial expansion during the past era has preceded to increase in the complication of toxic discharges (Sewvandi and Adikary, 2011). Numerous sewage releases of raw water from of Elgharbia and Kafr Elsheikh Governorates as well as other cities and towns along the drain are problematic (El-Amier et al 2017). The objectives of the present work were to (1) evaluate the water quality of Kitchener drain at El-Gharbia and Kafr El-Sheikh Governorate, Egypt via the estimation of chemical and biological characteristics. (2) examined the biological characteristics in sediments of Kitchener drain.

2 Materials and Methods

2.1 Water and sediments sampling

Twenty-six samples of irrigation water and Twenty-six samples of sediments were collected, seven from Kitchener drain at El-Gharbia Governorate and nineteen from Kitchener drain at Kafr El-Sheikh Governorate (**Fig 1**). Water samples were examined for both chemical and biological analysis. Whereas sediment samples were examined for biological analysis only. The sediments were collected from the top layer of the drain and all samples were collected at the same sampling sites of water samples **(Table 1)**.

2.2 Laboratory analysis

Nitrate (NO_3^-) was determined using the Kjeldahl process described by (Chapman and Pratt, 1961). Phosphate (PO_4^{3-}) was measured using colorimetric methodology according to (AOAC, 2012) using spectrophotometer (model JENWAY 6705 UV/Vis).

Total solids (TS), total suspended solids (TSS) and total dissolved solids (TDS) were determined gravimetrically according to the method described by (Clesceri et al 1998).

Total coliform (TC) bacteria were counted on Endo Agar medium using the serial dilution poured plate method. The inoculated plates were incubated at 37° C for 24 hours colonies with metallic - green sheen were counted (APHA, 1989).

Faecal coliform (FC) bacteria were counted using the same previously mentioned medium but inoculated plats were incubated at 44.5° C for 48 hours, Colonies with metallic – green sheen were counted (APHA, 1989).

Salmonella and *Shigella* (*SS*) bacteria were counted using SS Agar medium by the serial dilution poured plate method. The inoculated plates were incubated at 35 – 37° C for 24 hours. Black – centered or mirror colonies were counted as *Salmonella* and *Shigella* microorganisms (Difco Manual, 1977).

3 Results and Discussion

3.1 Chemical parameters in water samples

3.1.1 Nitrate and Phosphate Concentrations in water samples

Nitrate (NO_3^-) may reach water via excess of mineral nitrate fertilizers It may also, formed inside water in drains and water networks by oxidation of other N-reduced forms (ammonia and nitrite) or organic N-substances like amino acids (Kidd, 2011).

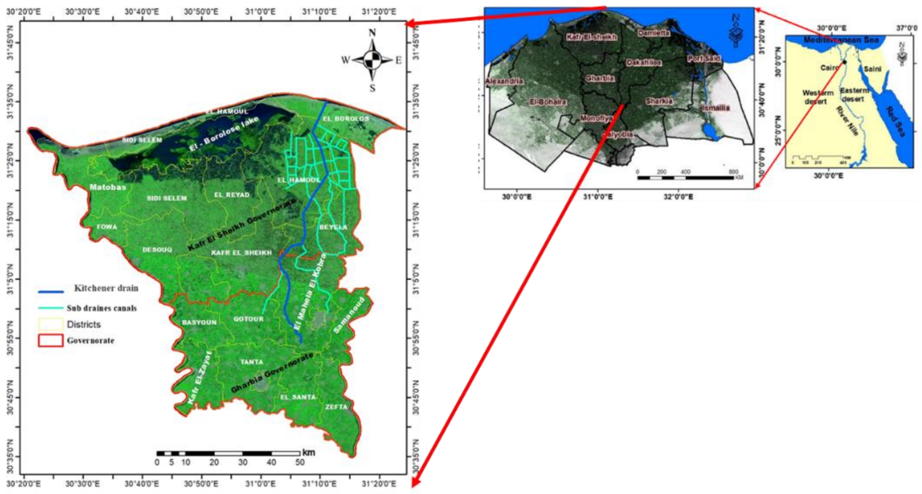

Figure 1. Location map of Kitchener drain

Table 1. Sampling sites for Kitchener drain at El-Gharbia and Kafr El-Sheikh Governorate

Sampling site No.	Latitude (N)	Longitude (E)
1	30° 58' 42.96"	30° 29' 28.68"
2	30° 58' 53.04"	31° 1' 3"
3	30° 58' 50.8836"	31° 4' 58.8"
4	30° 58' 43.3236"	31° 8' 20.04"
5	31° 4' 9.8436"	31° 13' 5.5236"
6	31° 4' 22.08"	31° 9' 32.0364"
7	31° 4' 17.4"	31° 56' 38.4"
8	31° 4' 21.7236"	31° 1' 59.88"
9	31° 4' 28.1964"	30° 57' 43.5564"
10	31° 10' 19.56"	30° 57' 39.6"
11	31° 10' 18.84"	31° 0' 55.0836"
12	31° 10' 17.76"	31° 5' 24"
13	31° 10' 16.6836"	31° 10' 29.2836"
14	31° 10' 15.24"	31° 15' 6.4836"
15	31° 16' 2.64"	31° 16' 48.036"
16	31° 16' 6.24"	31° 12' 40.68"
17	31° 16' 9.84"	31° 7' 59.1636"
18	31° 16' 12"	31° 5' 3.84"
19	31° 16' 4.8"	31° 2' 8.52"
20	31° 16' 16.6764"	30° 47' 36.24"
21	31° 16' 17.4"	30° 55' 22.8"
22	31° 26' 22.9164"	31° 14' 50.2764"
23	31° 26' 24"	31° 11' 35.16"
24	31° 26' 24.7236"	31° 8' 40.56"
25	31° 26' 25.08"	31° 5' 41.2836"
26	31° 26' 27.2436"	31° 1' 46.9164"

The present study illustrate that all nitrate (NO_3^-) concentrations were within permissible limit of 10 mgL^{-1} according to FAO (1994) limits except site 2 and 6. Whereas that, all phosphate (PO_4^{3-}) concentrations were within permissible limit of 2 mgL^{-1} except site 3 and 4 **(Table 2 & Fig 2)** in El-Gharbia. On the other hand, in Kafr El-Sheikh nitrate concentrations were above the permissible limit of FAO (1994) in site 10, 11, 12, 14, 18, 24, 25, 26**.** On the other hand, phosphate was above permissible limit in site 8 and 24 according to **(Table 2 & Fig 3).** The high values of phosphate are largely responsible for eutrophic conditions in a water (Addo et al 2011). These results are in agreement with those of Singh et al (2004) and Malik and Nadeem, (2011), who stated that the high concentrations of nitrate and phosphate in the drain water might be due to domestic, municipal waste and agricultural discharge.

3.1.2 TS, TSS and TDS Concentration

Total Solids (TS) are the total of TSS and TDS. The present study showed that all total solids concentration were within permissible limit of 1500 mgL^{-1} (FME, 2011) except site 4. Site 4 showed high concentration of TS could be due to receiving agricultural runoff containing fertilizer and suspended soil particles (Mezgebe et al 2015).

Total Suspended Solids (TSS) is a measure of particulate maters suspended in water. All total suspended solids concentration were above permissible limit of 60 mgL^{-1} (WHO, 2006). The highest TSS was observed (637 mgL^{-1}) in site 3. The recorded value of TSS might be due to poor management system of water sources in the governorate (Mezgebe et al 2015).

Total Dissolved Solids (TDS) represents for the dissolved elements in water (Uwidia, 2013). All TDS concentrations in El-Gharbia Governorate **(Table 2 & Fig 4)** were within permissible limit (1500 mgL^{-1}) stated by WHO, (2006). The high value of TDS recorded in the drain water might be due to discharge of wastes from the towns (Sonja, 2010).

On the other hand, in Kafr El-Sheikh Governorate, total solids were above permissible limit in site 8, 14, 21, 24 according to (FME, 2011). Moreover, According to WHO (2006) the concentration of TSS excessed the permissible limit, but some sites are below that level i.e. sites 9, 11, 16, 19 and 20. Total dissolved solids was above permissible limit in site 14 and 24 according to WHO (2006) **(Table 2 & Fig 5)**. Kaur et al (2010) reported that people subjected to water with such high concentrations of TSS and TDS are at threat of having cancer.

3.2 Biological parameters in water samples

One of important indicator to assess the biological quality of water is the incidence of faecal coliform (Chigor et al 2012). In El-Gharbia Governorate, all total and faecal coliform counts were above permissible limit of 10 CFU/ml, $\leq$ 10 CFU/ml respectively (WHO, 1989). Total and faecal coliforms recorded highest values in site 3 (180 x 10^2 CFU /ml, 79 x 10^2 CFU/ml respectively). The difference in the faecal coliform counts in the drain water samples could be due to the difference in the point source of pollution to the sites (Abakpa et al 2013). All sampling sites were contaminated with *Salmonella* & *Shigella* except site 7 shows negative results. The guidelines of WHO does not allow the existence of any colony of *Salmonella* and *shigella* in irrigation water because they are pathogen bacteria for human (El-Tohamy et al 2015). *Salmonella* and *Shigella* recorded highest values in site 4 (53 x 10^2 CFU/ml) **(Table 3 & Fig 6)**. On the other hand, in Kafr El-Sheikh Governorate, according to (WHO, 1989) all the sites were contaminated with total coliforms except sites 16, 22, 23 that show opposite results**.** The highest Total coliforms value was recorded in site 19 (2000 x 10^2 CFU/ml). All the sites were contaminated with faecal coliforms except sites 16, 22, 23, 24 that show contrary results according to (WHO, 1989). The highest faecal coliforms values were recorded in site 19 and 26 (1200 x 10^2 CFU/ml). Furthermore, *Salmonella* and *Shigella* recorded the highest values in site 19 (50 x 10^2 CFU/ml) **(Table 3 & Fig 7)**.

Table 2. Chemical parameters in water samples at El-Gharbia and Kafr El-Sheikh Governorate

Site No.	NO_3^- (mgL^{-1})	PO_4^{3-} (mgL^{-1})	TS (mgL^{-1})	TSS (mgL^{-1})	TDS (mgL^{-1})
El-Gharbia (1)	9.1	0.06	1100	352	748
El-Gharbia (2)	13.3	1.06	1200	298	902
El-Gharbia (3)	7.7	6.99	1100	637	463
El-Gharbia (4)	7	3.66	1600	577	1023
El-Gharbia (5)	7.7	1.38	1300	317	983
El-Gharbia (6)	15.4	0.88	800	447	353
El-Gharbia (7)	7.7	0.36	900	502	398
Kafr El-Sheikh (8)	6.3	3.07	3300	3119	187
Kafr El-Sheikh (9)	9.8	000	nd	nd	nd
Kafr El-Sheikh (10)	10.5	0.34	1100	552	548
Kafr El-Sheikh (11)	11.2	000	nd	nd	nd
Kafr El-Sheikh (12)	14.7	0.42	1300	328	972
Kafr El-Sheikh (13)	4.9	0.66	1000	181	819
Kafr El-Sheikh (14)	11.9	0.39	283300	775	282525
Kafr El-Sheikh (15)	7.00	0.33	1500	318	1182
Kafr El-Sheikh (16)	4.2	0.09	nd	nd	nd
Kafr El-Sheikh (17)	6.3	0.03	600	324	276
Kafr El-Sheikh (18)	10.5	000	400	352	48
Kafr El-Sheikh (19)	5.6	0.16	nd	nd	nd
Kafr El-Sheikh (20)	7.7	1.91	nd	nd	nd
Kafr El Sheikh (21)	9.8	0.45	1800	1297	503
Kafr El-Sheikh (22)	9.8	0.36	800	406	394
Kafr El-Sheikh (23)	6.3	0.28	300	294	6
Kafr El-Sheikh (24)	15.4	5.22	3600	2022	1578
Kafr El-Sheikh (25)	11.2	0.58	900	266	634
Kafr El-Sheikh (26)	19.6	1.22	1000	249	757

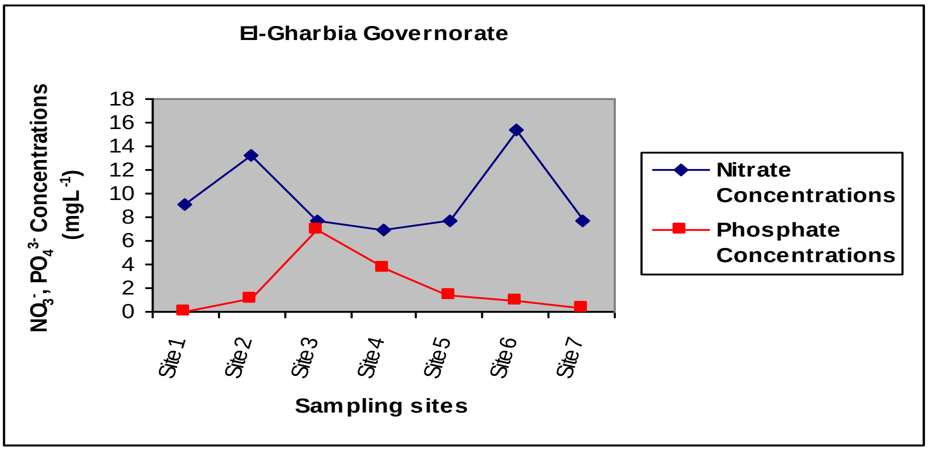

Figure 2. Nitrate and phosphate concentrations in water samples at El-Gharbia Governorate

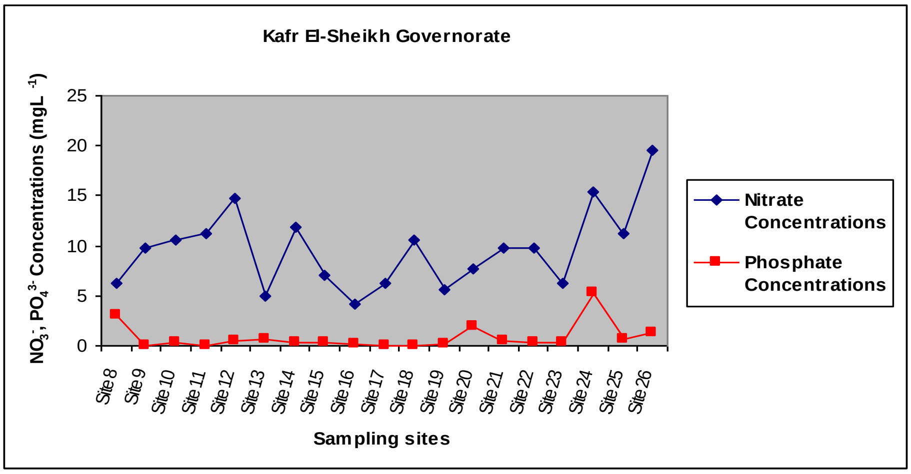

Figure 3. Nitrate and phosphate concentrations in water samples at Kafr El-Sheikh Governorate

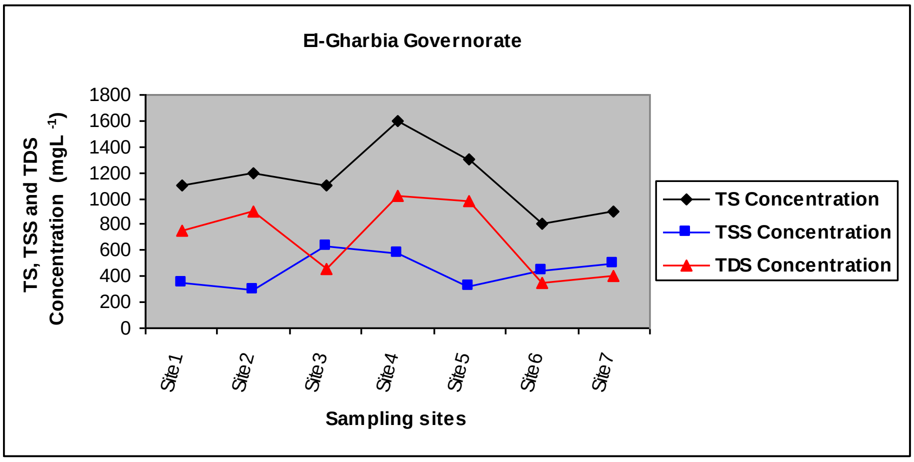

Figure 4. TS, TSS and TDS Concentration in water samples at El-Gharbia Governorate

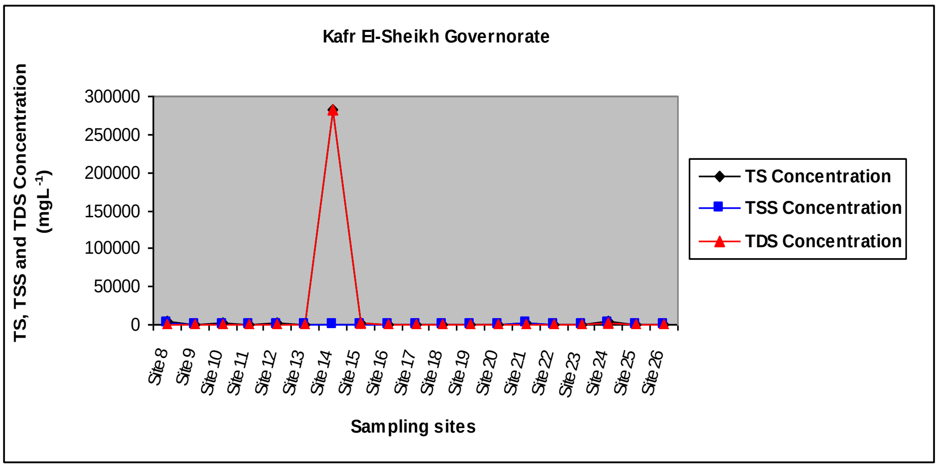

Figure 5. TS, TSS and TDS Concentration in water samples at Kafr El-Sheikh Governorate

Table 3. Biological parameters in water samples at El-Gharbia and Kafr El-Sheikh Governorate

Site No.	TC (CFU/ ml X 10^2)	FC (CFU/ ml X 10^2)	SS (CFU/ ml X 10^2)
El-Gharbia (1)	10	7	1
El-Gharbia (2)	22	11	6
El-Gharbia (3)	180	79	33
El-Gharbia (4)	164	64	53
El-Gharbia (5)	24	20	4
El-Gharbia (6)	28	11	8
El-Gharbia (7)	6	2	nd
Kafr El-Sheikh (8)	3	3	nd
Kafr El-Sheikh (9)	5	2	nd
Kafr El-Sheikh (10)	3	3	nd
Kafr El-Sheikh (11)	5	1	1
Kafr El-Sheikh (12)	4	1	nd
Kafr El-Sheikh (13)	2	2	nd
Kafr El-Sheikh (14)	11	2	nd
Kafr El-Sheikh (15)	960	600	15
Kafr El-Sheikh (16)	nd	nd	nd
Kafr El-Sheikh (17)	1200	700	16
Kafr El-Sheikh (18)	1160	570	30
Kafr El-Sheikh (19)	2000	1200	50
Kafr El-Sheikh (20)	300	210	5
Kafr El-Sheikh (21)	350	190	2
Kafr El-Sheikh (22)	nd	nd	nd
Kafr El-Sheikh (23)	nd	nd	nd
Kafr El-Sheikh (24)	20	nd	nd
Kafr El-Sheikh (25)	500	200	nd
Kafr El-Sheikh (26)	1500	1200	4

TC : Total Coliforms, FC: Faecal Coliforms, SS: *Salmonella and shigella*

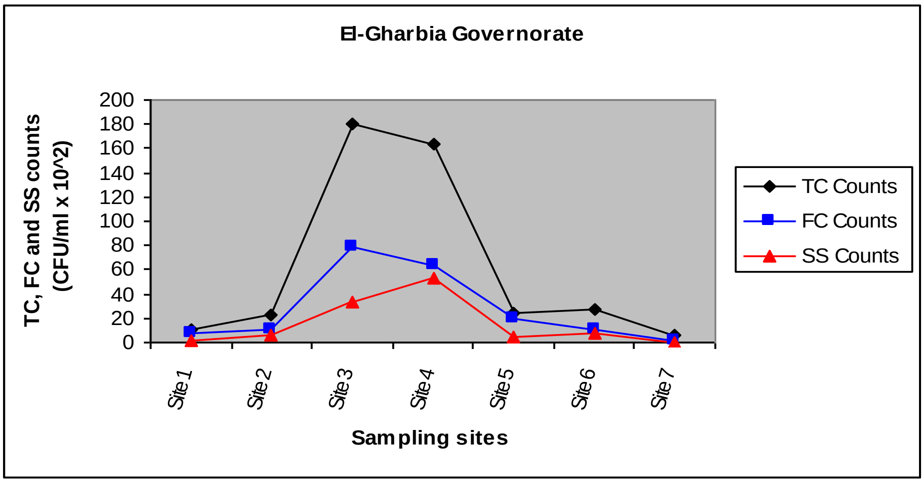

Figure 6. Biological parameters in water samples at El-Gharbia Governorate

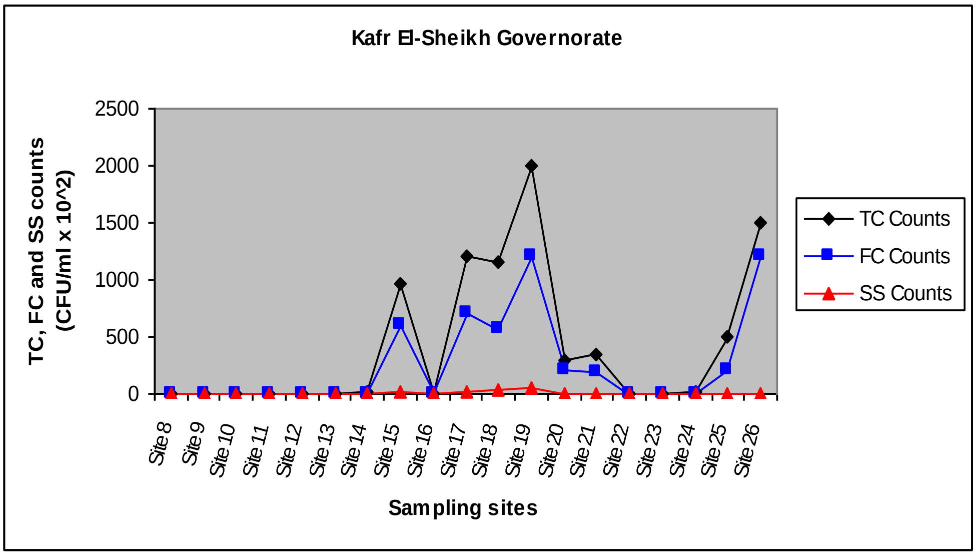

Figure 7. Biological parameters in water samples at Kafr El-Sheikh Governorate

Table 4. Biological parameters in sediment samples at El Gharbia and Kafr El Sheikh Governorate

Site No.	TC (CFU / ml X 10^2)	FC (CFU / ml X 10^2)	SS (CFU / ml X 10^2)
El-Gharbia (1)	40	10	1
El-Gharbia (2)	38	15	11
El-Gharbia (3)	192	100	43
El-Gharbia (4)	183	82	63
El-Gharbia (5)	30	25	11
El-Gharbia (6)	41	13	16
El-Gharbia (7)	12	5	nd
Kafr El-Sheikh (8)	9	6	nd
Kafr El-Sheikh (9)	11	9	nd
Kafr El-Sheikh (10)	5	3	nd
Kafr El-Sheikh (11)	11	2	4
Kafr El-Sheikh (12)	8	2	nd
Kafr El-Sheikh (13)	5	2	nd
Kafr El-Sheikh (14)	16	5	nd
Kafr El-Sheikh (15)	1030	800	25
Kafr El-Sheikh (16)	30	20	nd
Kafr El-Sheikh (17)	1500	820	23
Kafr El-Sheikh (18)	1200	620	40
Kafr El-Sheikh (19)	2100	1500	85
Kafr El-Sheikh (20)	350	280	13
Kafr El-Sheikh (21)	410	260	6
Kafr El-Sheikh (22)	50	20	nd
Kafr El-Sheikh (23)	nd	nd	nd
Kafr El-Sheikh (24)	80	40	nd
Kafr El-Sheikh (25)	620	310	nd
Kafr El-Sheikh (26)	1700	1300	15

TC : Total Coliforms, FC: Faecal Coliforms, SS: *Salmonella and shigella*

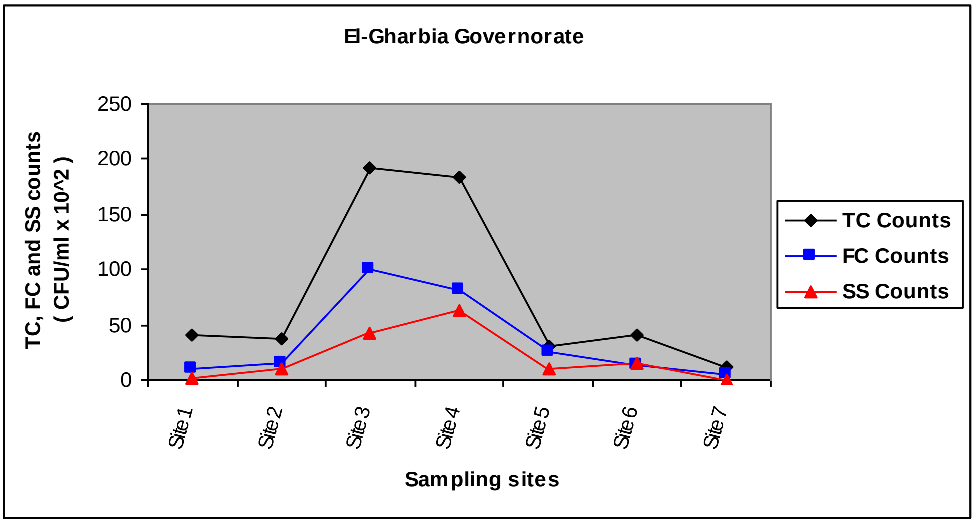

Figure 8. Biological parameters in sediment samples at El-Gharbia Governorate

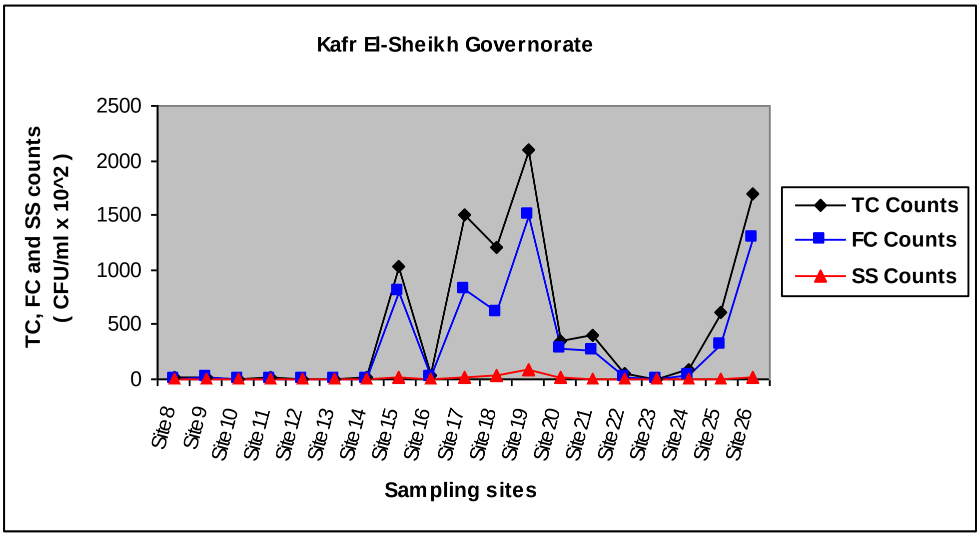

Figure 9. Biological parameters in sediment samples at Kafr El-Sheikh Governorate

3.3 Biological parameters in sediment samples

In El-Gharbia, total and faecal coliforms recorded highest values in the sediments collected from site 3 (192 x 10^2 CFU/ ml, 100 x 10^2 CFU/ ml, respectively). While, *Salmonella* and *shigella* recorded the highest value in site 4 (63 x 10^2 CFU/ ml) **(Table 4 & Fig 8)**. On the other hand, in Kafr El-Sheikh total coliforms, faecal coliforms, *salmonella* and *shigella* recorded the highest values in site 19 (2100 x 10^2 CFU/ ml, 1500 x 10^2 CFU/ ml and 85 x 10^2 CFU/ ml, respectively) **(Table 4 & Fig 9)**. The counts of bacterial indicator in the sediment samples were higher compared with water samples for each of the sampling sites. This could be attributed to that sediments mostly provide a proper natural environment for microbial existence and living (Jamieson et al 2005).

4 Conclusion

The results of the present investigation revealed that in Kitchener drain study area there is an obvious water contamination trend for all studied biological parameters. All studied parameters have exceeded the permitted limits for irrigation water at most sampling sites. Moreover, the biological analysis for sediment samples showed that most sampling sites were contaminated with total faecal coliform bacteria and *salmonella* & *shigella* that could be considered as an unfavorable source on water quality.

References

Abakpa GO, Umoh VJ, Ameh JB, Yakubu SE (2013) Microbial quality of irrigation water and irrigated vegetables in Kano State, Nigeria. *International Food Research Journal* 20, 2933-2938.

Abdel Rashid A (2002) Water quality control in open drains and its effect on soil properties. PhD. Thesis, Faculty of Agriculture, Ain Shams University, Egypt.

Addo MA, Okley GM, Affum HA, Acquah S, Gbadago JK, Senu JK, Botwe BO (2011) Water Quality and Level Some Heavy Metals in Water and Sediments of Kpeshie Lagoon, La-Accra, Ghana. *Research Journal of Environmental and Earth Sciences* 3, 487 – 497.

APHA (1989) Standard Methods for the Examination of Water and Wastewater. 17th edition, American public Health Association, Washington D.C 1, pp 268.

Ayers RS, Westcot DW (1994) Food, Agriculture Organization of the United Nations (FAO), Water Quality for Agriculture, Irrigation and Drainage, Rome, Paper No. 29. Rev. 1, M-56. ISBN 92-5- 102263-1.

Blumenthal U, Peasey A, Ruiz-Palacios G, Mara D (2000) Guidelines for waste water reuse in agriculture and aquaculture: recommended revisions based on new research evidence. WEDC, Loughborough University, UK, pp 42.

Chapman HD, Pratt RE (1961) Methods of Analysis for Soil, Plants and Water. Dept. of Soil, Plant Nutrition, Univ. of California, USA.

Chigor VN, Umoh VJ, Okuofu CA, Ameh JB, Igbinosa EO, Okoh AI (2012) Water quality assessment: Surface water sources used for drinking and irrigation in Zaria, Nigeria are a public health hazard. *Environmental Monitoring Assessment* 184, 3389-3400.

Clesceri LS, Greenberg AE, Eaton AD (1998) Standard Methods for the Examination of Water and Wastewater, *20th Edition. American Public Health Association, Washington DC* 2, 55 – 59.

Difco Manual and Dehydrated Culture Media and Readents 8th Edition. (1977) Difco Laboratories Detroit Michigan, pp 39.

El-Tohamy SA, Mahmoud YI, Afifi MMI, Hafez WA (2015) Environmental impact of using low quality water in irrigation. *J. Soil Sci and Agric Eng, Mansoura Univ* 6, 1029 - 1052.

El-Alfy MA, El-Amier YA, Abd El-Hamid HT (2017) Soil quality and health risk assessment of heavy metals in agricultural areas irrigated with wastewater from Kitchener Drain, Nile Delta, Egypt. *Journal of Scientific Agriculture* 1, 158-170.

El-Amier YA, Zahran MA, Gebreil AS, Abd El-Salam EH (2017) Anthropogenic activities and their impact on the environmental status of Kitchener drain, Nile Delta, Egypt. *Journal of Environmental Sciences* 46, 251-262.

Federal Ministry of Environment (FME) (2011) Federal Republic of Nigeria Official Gazette for National Environmental Surface and Groundwater Quality Control. Regulations, The Federal Government Printer: Lagos, Nigeria 98, 693–728, FGP 71/72011/400 (OL 46).

Ganoulis J (2009) Risk Analysis of Water Pollution, 2nd ed., WILEY-VCH Verlag GmbH & Co. KGaA:Weinheim, Germany, pp 1–311.

Jamieson RC, Joy DM, Lee H, Kostaschuk R, Gordon R (2005) Transport and deposition of sediment-associated Escherichia coli in natural streams. *Water Res* 39, 2665–2675.

Kaur A, Vats S, Rekhi S, Bhardwaj A, Goel J, Tanwar RS, Gaur KK (2010) Physico-chemical Analysis of the Industrial Effluents and Their Impact on the Soil Microflora. *Procedia Environ Sci* 2, 595–599.

Kidd S (2011) Summary of standard parameter ranges for salmonid habitat and general stream water quality." Water Quality Monitoring Grant Report, Oregon Watershed Enhancement Board, Salem, Oregon. Published July 2011.

Malik RN, Nadeem M (2011) Spatial and temporal characterization of trace elements and nutrients in the Rawal Lake Reservoir, Pakistan using multivariate analysis techniques. *Environmental Geochemistry and Health* 33, 525–541.

Mezgebe K, Gebrekidan A, Hadera A, Weldegebriel Y (2015) Assessment of physico-chemical parameters of tsaeda agam river in mekelle city, tigray, ethiopia. *Bull Chem Soc Ethiop* 29, 377-385.

O.A.C. (2012) Official Methods of Analysis, AOAC-Int., Arlington, VA.

Sewvandi GA, Adikary SU (2011) Removal of heavy metals from wastewater using chitosan. Soc. Soc. *Manag Syst Int J* 7, 1–8.

Singh KP, Malik A, Mohan D, Sinha S (2004) Multivariate statistical techniques for the evaluation of spatial and temporal variations in water quality of Gomti River (India) a case study. *Water Research* 38, 3980- 3992.

Sonja CJ (2010) River water quality assessment in selected yangtze tributaries: background and method development. *J Earth Sci* 21, 876-881.

Toze S (2005) Reuse of effluent water-benefits and risks. *Agric. Water Manag* 80, 147–159.

Uwidia IE, Ukulu HS (2013) Studies on Electrical Conductivity and Total Dissolved Solids. Concentration in Raw Domestic Wastewater Obtained from an Estate in Warri, Nigeria. Greener. *J Phys Sci* 3, 110–114.

World Health Organisation (WHO) (2006) A Compendium of Standards for Wastewater Reuse in the Eastern Mediterranean Region, Regional Office for the Eastern Mediterranean Regional Centre for Environmental Health Activities CEHA: Los Angeles, CA, USA, pp 1-19.

World Health Organisation (WHO) (1989) Health guidelines for the use of wastewater in agriculture and aquaculture. Report of a WHO Scientific Group. Geneva, Technical Report Series, No. 778.

Yehia HM, Sabae SZ (2011) Microbial pollution of water in El-Salam canal, Egypt. Am Eurasian *J Agric Environ Sci* 11, 305–309.