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Monitoring of Fecal Pollution in Fresh Water and Soil of Abbis Area, East of Alexandria, Egypt

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Abstract: Great concern is currently assigned to monitor the environmental conditions at Abbis and its satellite villages, east of Alexandria City, Egypt that suffer severe fecal pollution arising from the lack of sanitary sewerage system. The main objective of the present study was to evaluate the bacteriological quality of water and soil at Abbis area (Villages no. 7 and 8) and some physicochemical characteristics of the water bodies. Results revealed that pH, salinity, dissolved oxygen, biodegradable organic matter and chemical oxygen demand exceeded their permissible limits. The total viable bacterial count ranged between 1.0 $x10^4$ and 6.2 $x10^5$ CFU/ml in water samples and from $7.1x10^6$ to 8.0 $x10^9$ CFU/g in soil samples. Total coliforms in the water of the less polluted sites recorded <300 cell/100 ml and in the highly polluted sites recorded >1800 cell/100 ml. However, all soil samples were heavily contaminated with total coliforms (>1800 cell/100 g). Fecal coliforms in the water samples ranged from 5 to 350 cell/100 ml. For soil, half of soil samples showed very high density of fecal coliforms (>1800 cell/100 g) and the rest showed fecal coliforms in the range of 35-1600 cell/100 g. Some correlations were detected among the tested water parameters at the study area and most of the sampling sites were similar. According to the European and Egyptian current standards, the bacteriological analyses confirmed the results of the physicochemical characterization where most of the selected sites were highly polluted.

Keywords: Abbis-Alexandria; Coliform bacteria; Fecal pollution; Physicochemical characteristics; Water; Soil.

INTRODUCTION

The most challenging problem facing the world now and in the near future may be the availability of clean and safe fresh water. It was reported that over two billion people in the world did not have access to safe water supply and sanitation services.(1) Water in sufficient quantity and of adequate quality is necessary for the well-being of all living organisms. The importance and intensive use of fresh

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water makes it a vulnerable and increasingly limited resource. A wide range of human activities may lead to environmental deterioration of surface water, either directly or indirectly.[2]

The way domestic pollution affects water quality heavily depends on the way of disposal of this pollution. Approximately, 65% of Egypt's population is connected to drinking water supply, and only 24% to sewage services and most drains are heavily polluted with sewage.[3] Rural areas sewerage and sewage systems are virtually non-existent in rural areas. There is a clear need for arrangements to reduce the ongoing discharge of completely untreated sanitary waste water into the river.[3]

Although high numbers of water–borne diseases are reported, it is believed that many more people suffer from diseases related to other forms of water pollution.[3] Protection of the public and environmental health requires safe, clean water, which means that it must be free of pathogenic bacteria.[4] Heterotrophic bacteria play an important role in the structure and function of the microbial food web in relation to environmental conditions.[5,6]

Among the pathogens disseminated in water sources, enteric pathogens are the most frequently encountered ones. As a consequence, sources of fecal pollution in waters devoted to human activity must be strictly controlled. [4] Most coliform bacteria are present in large numbers among the normal intestinal flora of humans and other warm-blooded animals, and are thus found in fecal wastes. As a consequence, coliform bacteria, detected in higher concentrations than other pathogenic bacteria, are used as indicators of potential fecal pollution in water environments.[4,7] It is established that these indicators are associated with disease-causing genera of concern to public health.[8] They are also used to measure the sanitary quality of water for recreation, industry, agriculture and water supply purposes[8,9]. Moreover fecal indicator bacteria such as total coliform, fecal coliform and streptococci are utilized worldwide to measure health hazards.[10] They must be identified in water resources in order to adequately address water problems and protect public health. Therefore, density of such indicators is considered as critical parameter that drives management decision.[11,12] Fecal indicator bacteria in rivers (freshwater supply) were investigated with special attention to the impact of the treatment of waste water effluents on microbiological quality of the receiving waters. A strong negative impact was observed in different areas of the watershed.[13]

Survival rates of fecal bacteria can vary from a few minutes to many days depending upon the environmental conditions.[14,15] or Physical factors including solar radiation.[16,17], temperature,[15,18] salinity,[15,19] and dissolved oxygen.[15]

Abbis villages no. 7 and 8 and their satellite villages are important from the environmental point of view since they are suffering a non-sanitary sewerage conditions that does not affect water and soil only, but also the whole community. The lack of a sanitary drainage system means that residents dispose of their sewage in the nearby watercourses. Unfortunately, at Abbis area such watercourses contaminated with wastewater are used for irrigation. Undesirable constituents in wastewater pose real threat on public health as well as the environmental compartments. Irrigation using contaminated water is an issue of concern to public agencies responsible for maintaining public health and environmental quality. The importance of revealing levels of pollution resulting from improper sanitation that is clear in the study area is a prime factor for reasoning putting the provision of proper sanitary sewerage system as a priority. The

Community Resources Development in Villages 7 & 8 Abbis, Alexandria Governorate Project has been designed to focus on the provision of proper sanitary drainage system as a major development and environmental improvement pre-request. Although there have been several studies on public health records indicating poor health conditions prevailing in the study area,[20] the present study presents the actual environmental circumstance that the inhabitants of Abbis live in. The present study concentrated on demonstrating bacteriological pollution in the water and soil of Abbis area as a part of the integrated monitoring project concerned with the evaluation of the current environmental conditions of the area. Moreover, some physicochemical l characteristics of the water in the study area were examined.

2. MATERIALS AND METHODS

2.1. Sampling Sites and Sampling

Fresh water and soil samples were collected from Abbis agricultural villages no. 7 and 8 located in Beheira Governorate. The area at the south of Lake Mariut was selected to include villages located within Alexandria Governorate Administrative Boundaries, Egypt. The study area is shown in Figure 1 (executed using IDRISI, ARCVIEW, SURFER and AUTOCAD software) housing five main canals as well as four water paths running around the investigated area. Several canals and drains exist in the study area similar to those existing in the traditional agricultural areas in Egypt.

Thirty stations were selected at specific distances from known and localized pollution sources. Samples were collected during April and May 2007. Fresh water and soil samples were collected according

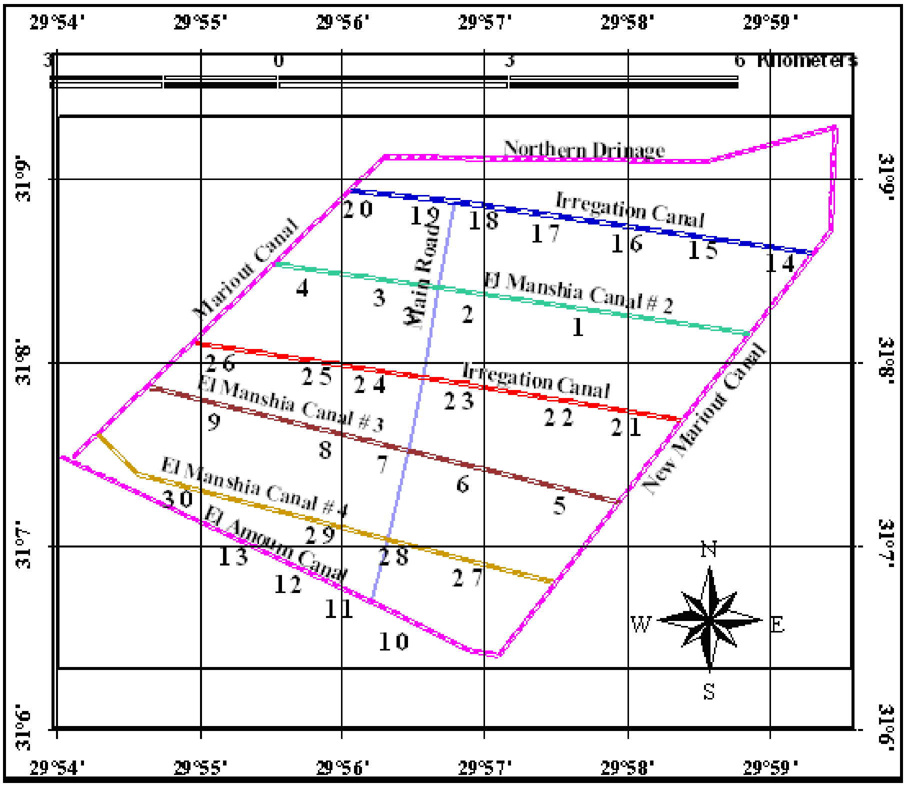

Figure 1: Sampling sites at Abbis area

to the standard methods described by Clesceri et al. (1999) in the Standard Methods for the Examination of Water and Waste water. (21) "GARMIN-GPS" was used to define the position (latitude and longitude) of each sampling station.

2.2. Physicochemical Characteristics of Water Samples

Salinity, pH, electrical conductivity and dissolved oxygen were measured using Auto analyzer (ALPKEM, 0-1-Analytical, ER Detector, RA Sampler, P/N: A001639, S/N: 709: 1639:40, Made in USA).

Biochemical oxygen demand (BOD) was determined using 5 day standard BOD test while chemical oxygen demand (COD) was determined using closed reflux colorimetric method.[21]

2.3. Bacteriological Examination

The freshly aseptically collected 30 soil samples (100 g each) were shaken in 100 ml aliquot sterile distilled water. Bacteria attached to soil particles were thus released and suspended in the distilled water, then serial dilutions were made and used for inoculation. Total viable bacterial counts (TVC) for water and soil samples were determined using pour plate method on nutrient agar medium (Oxoid LTD, Hampshire- England), three replicates were incubated at 37°C for 24 h. [21] The final counts were calculated as colony forming units (CFU/g soil and CFU/ml water)

The most probable number (MPN) of total and fecal Coliform bacteria was estimated using MacConkey broth medium (Oxoid LTD, Hampshire- England). Five tubes were used for each of the three concentrations (10.0, 1.0, 0.1 ml) of the sample. The inoculated tubes were incubated at 37 °C for 48 h for the determination of total Coliform bacteria (TC). Another set of tubes were incubated at 44.5°C for 24 h for the determination of fecal Coliform bacteria (FC). Positive reactions were indicated by the production of acid and gas. Positive tubes were streaked on Eosin Methylene blue (EMB) agar plates and incubated at 37°C for 24 h. Microscopic examination was carried out to ensure gram-negative, non-spore forming rods. The MPN-index per 100 ml was determined using the statistical tables. [21, 22].

2.4. Statistical Analysis

Pair-wise correlation coefficients between various physical, chemical and bacteriological parameters were calculated. Positive and negative associations were tested for their significance. The similarity between different sampling sites was performed depending on physical, chemical and bacteriological parameters of water samples. The percentages of similarities were plotted into cluster analysis to identify the percentages of closeness of the different sampling sites. The analysis was performed using Minitab version14.

3. RESULTS

3.1. Physicochemical Characteristics

The values of physicochemical characteristics in Table (1) for water quality of the samples collected from the canals in the study area revealed the following points

1. The pH values at the different sites of the studied canals were slightly alkaline, it ranged from 7.14 to 8.44.
2. Salinity varied at most sites with significant differences among them. It ranged from a minimum of 0.18 g/l to a maximum of 5.82 g/l.
3. Electrical conductivity recorded a range of 384 to 10280 milliSimens/m.
4. Dissolved oxygen content of water samples was between 7.0 and 9.0 mg/l.
5. The spatial variation of biodegradable organic matter in term of BOD_5 recorded a range of 72 to 318 mg/l.
6. Similarly COD represents very high levels at all sites (476-9520 mg/l) indicating very high organic loads prevailing in the water of these drains and that intensive treatment is required

3.2. Bacteriological Status of Water Courses at Abbis

Results in Table (2) and Figures (2,3) revealed the following points for the bacteriological quality of water canals in the study area:

1. Bacteriological examination of the water samples at the selected sites showed that they were highly polluted. This is clearly shown by the numbers of the TVC obtained in the water samples from the selected canals, which ranged between $1.0x10^4$ and $6.2x10^5$ CFU/ml.
2. TC (Table 2 and Figure 2) showed significant variations among sites. For total coliform (TC), the selected sites were divided into 2 categories; less polluted with TC content <300 cell/100 ml and highly polluted with TC content (>1800 cell/100 ml) at sites 1, 2, 3, 6,

10, 15, 16, 17, 19, 20, 23 and 24.

3. FC in the water samples ranged between a minimum of 5 and a maximum of 350 cell/100 ml (Table 2 and Figure 3).

Table 1: Physicochemical characteristics of water samples collected from the Seventh and Eighth Villages, Abbis-Alexandria.

Sampling Sites	pH	Salinity (g/l)	E. C. (milliSimens/m)	DO (mg/l)	BOD (mg/l)	COD (mg/l)
1	7.81	0.30	609	7.95	318	1251
2	7.70	2.99	5509	7.90	246	6188
3	7.60	5.46	9750	8.30	300	3332
4	7.67	4.84	8742	8.35	204	9520
5	7.73	3.07	5700	7.20	198	1111
6	7.55	2.09	3947	7.80	120	1019
7	7.70	2.00	3747	8.10	102	998
8	7.60	3.22	5909	7.00	138	6188
9	7.95	1.77	3377	8.20	120	1019
10	8.42	0.60	1178	8.00	186	1097
11	7.80	0.78	1566	8.15	84	8092
12	7.14	2.12	3940	7.39	78	970
13	8.28	0.26	531	8.40	180	1090
14	8.31	0.44	868	8.26	204	1118
15	8.11	0.32	653	8.35	120	476
16	7.90	0.28	583	8.45	246	2166
17	8.30	0.29	593	9.00	192	1104
18	8.40	0.49	992	8.20	306	1237
19	8.12	0.30	613	7.06	228	1146
20	7.50	5.82	10280	8.20	240	7616
21	8.10	0.65	1214	8.22	246	1428
22	8.23	0.28	568	8.90	120	3332
23	7.95	0.28	574	8.80	168	2856
24	8.44	0.44	890	7.70	240	1160
25	7.90	0.18	384	7.50	96	991
26	8.15	0.44	897	8.70	162	1069
27	7.40	3.50	6401	7.70	204	3118
28	7.80	0.30	615	8.40	72	476
29	7.75	2.77	5126	7.60	78	3332
30	7.99	0.31	640	8.10	210	1948

Table 2: Bacteriological examination of water samples collected from the Seventh and Eighth Villages, Abbis-Alexandria.

Sampling Sites	TVC (CFU/ml)	TC (MPN/100 ml)	FC (MPN/100 ml)
1	$4.8x10^4$	1800+	80
2	$3.9x10^5$	1800+	11
3	$5.5x10^4$	1800+	35
4	$1.2x10^5$	225	95
5	$2.9x10^4$	35	13
6	$2.0x10^5$	1800+	80
7	$5.0x10^4$	110	20
8	$1.2x10^5$	7	5
9	$3.4x10^4$	110	35
10	$5.3x10^4$	1800+	50
11	$3.8x10^5$	250	25
12	$2.5x10^4$	45	40
13	$5.2x10^4$	1600	350
14	$2.8x10^4$	900	65
15	$4.1x10^4$	1800+	80
16	$5.5x10^4$	95	50
17	$4.8x10^4$	1800+	30
18	$2.0x10^4$	50	35
19	$1.1x10^5$	1800+	50
20	$2.8x10^4$	1800+	350
21	$9.2x10^4$	250	45
22	$3.5x10^5$	275	110
23	$7.0x10^4$	1800+	80
24	$4.0x10^4$	1800+	175
25	$2.6x10^4$	40	17
26	$2.3x10^4$	900	14
27	$1.2x10^4$	65	25
28	$1.0x10^4$	900	55
29	$7.4x10^4$	110	80
30	$6.2x10^5$	275	275

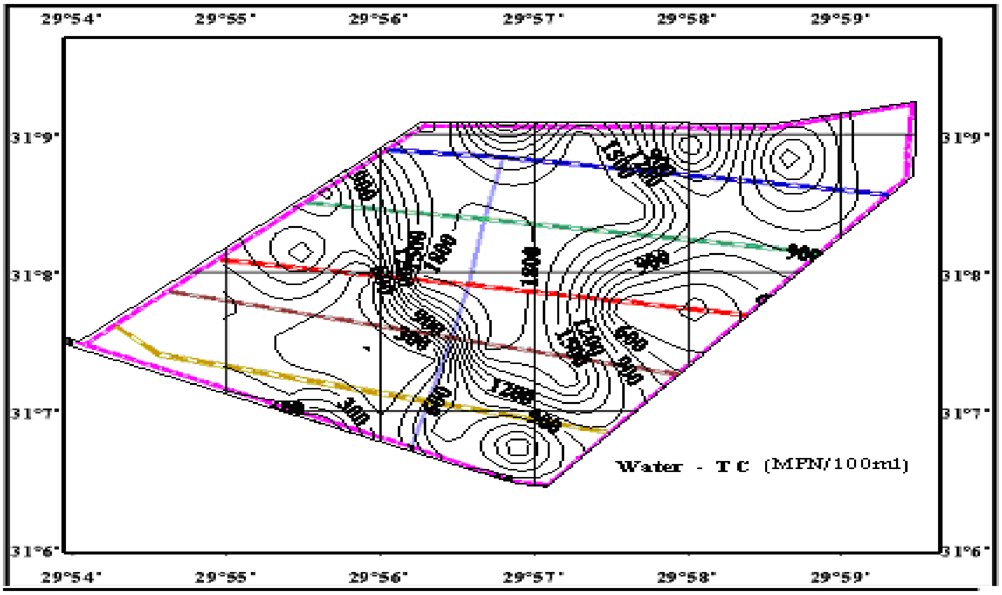

Figure 2: Horizontal distribution of total coliform bacteria (TC) in water at the selected sites in the study area.

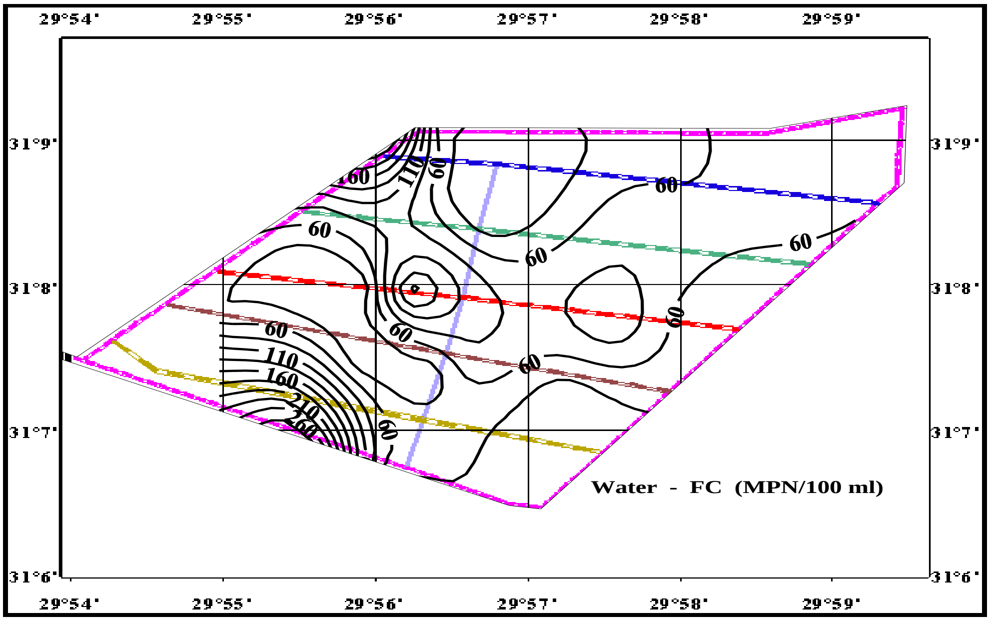

Figure 3: Horizontal distribution of fecal coliform bacteria (FC) in water at the selected sites in the study area.

3.3. Bacteriological Status of Soil at Abbis

According to the results given in Table 3, soil at the selected sites showed huge number of bacterial populations with TVC density that ranged between 7.1x 10^6 and 8.0 x 10^9 CFU/g. Except for site 30, all sites were heavily contaminated with total coliform bacteria (>1800 cell/100g), as shown in Figure 4. This was confirmed by the results of fecal coliform , where 15 sites out of the 30 showed very high density of FC (>1800 cell/100g) indicating recent fecal pollution while other sites recorded FC that ranged between 35-1600 cell/100g (Figure 5).

Table 3: Bacteriological examination of soil samples collected from the Seventh and Eighth Villages, Abbis-Alexandria.

Sampling Sites	TVC (CFU/g)	TC (MPN/100 g)	FC (MPN /100 g)
1	8.4x10^6	1800+	900
2	1.2x10^9	1800+	1800+
3	7.1x10^6	1800+	1800+
4	1.4x10^7	1800+	1800+
5	1.2x10^8	1800+	1800+
6	5.2x10^7	1800+	1600
7	2.5x10^8	1800+	275
8	6.3x10^8	1800+	1800+
9	1.9x10^8	1800+	275
10	1.8x10^8	1800+	1800+
11	1.7x10^8	1800+	1800+
12	6.3x10^7	1800+	1800+
13	2.0x10^8	1800+	1800+
14	1.5x10^9	1800+	1800+
15	2.3x10^8	1800+	80
16	4.0x10^8	1800+	425
17	1.3x10^9	1800+	900
18	1.6x10^9	1800+	175
19	2.0x10^8	1800+	1800+
20	6.0x10^8	1800+	1800+
21	6.6x10^8	1800+	550
22	1.3x10^9	1800+	1800+
23	1.5x10^8	1800+	1800+
24	2.3x10^9	1800+	175
25	7.9x10^7	1800+	900
26	8.0x10^9	1800+	1800+
27	4.6x10^8	1800+	35
28	5.9x10^8	1800+	35
29	2.0x10^8	1800+	45
30	2.0x10^7	250	170

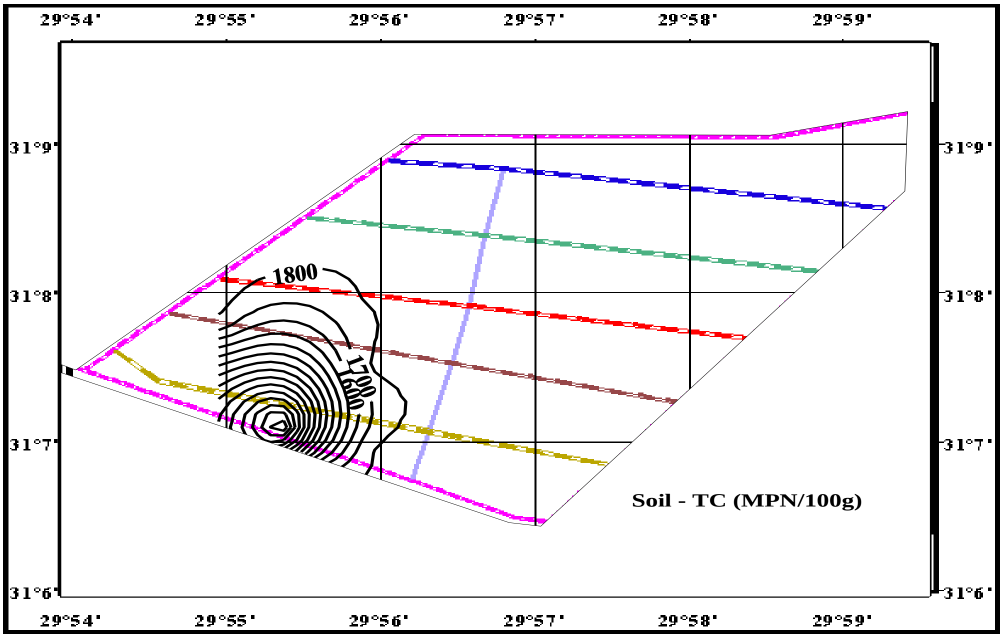

Figure 4: Horizontal distribution of total coliform bacteria (TC) of the soil in the study area.

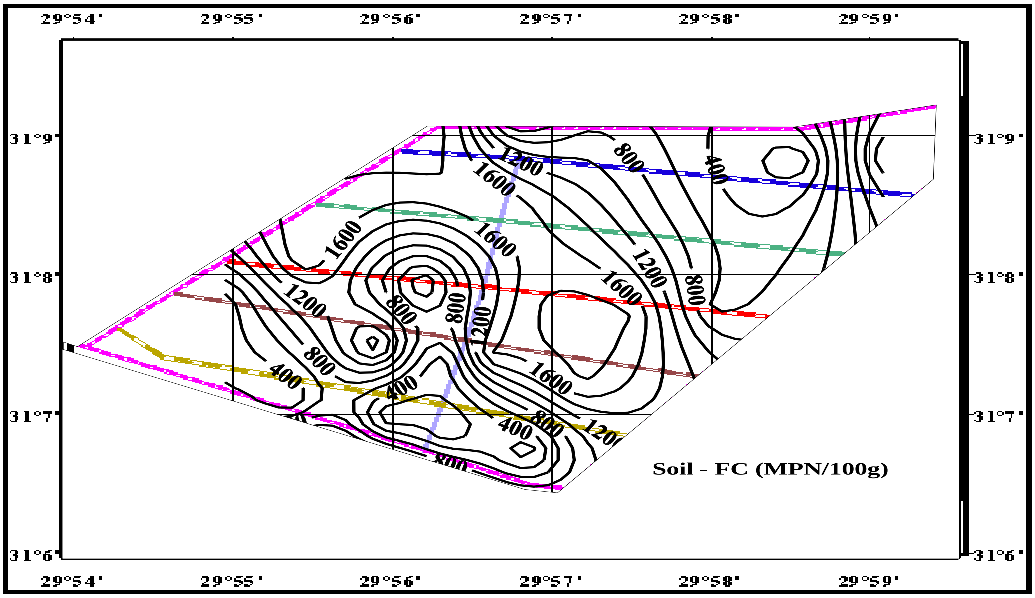

Figure 5: Horizontal distribution of fecal coliform bacteria (FC) of the soil in the study area.

Statistically, some correlations were detected among the tested water parameters in the study area. For example, significant negative correlation at $p<0.001$ and confidence limit 99.9% was detected between the pH and each of water salinity and EC (r= -0.667 and -0.672 respectively), also positive correlation was found between COD levels and each of water salinity and EC (r= 0.619 and 0.617 respectively). Significant negative correlation at $p<0.05$ and confidence limit 95.0% was detected between pH and COD levels (r=-0.373) while positive correlation was found between BOD and TC levels (r=0.355).

Analysis for the data of the 30 sampling sites using the similarity coefficient test is shown in the dendogram (Figure 6). The dendogram revealed that all sampling sites at study area were similar at similarity level 62.28 %. Sampling sites number 30 and 6 were singly separated at similarity level 62.28% and 87.43%, respectively. Sampling sites number 2, 11 and 22 were grouped with 74.85% similarity. The others sites (21, 19, 8, 4, 29, 23, 28, 27, 3, 20, 24, 15, 9, 26, 18, 25, 14, 12, 5, 7, 16, 13, 10, 17, and 1) were highly similar at similarity level that exceeded 97%.

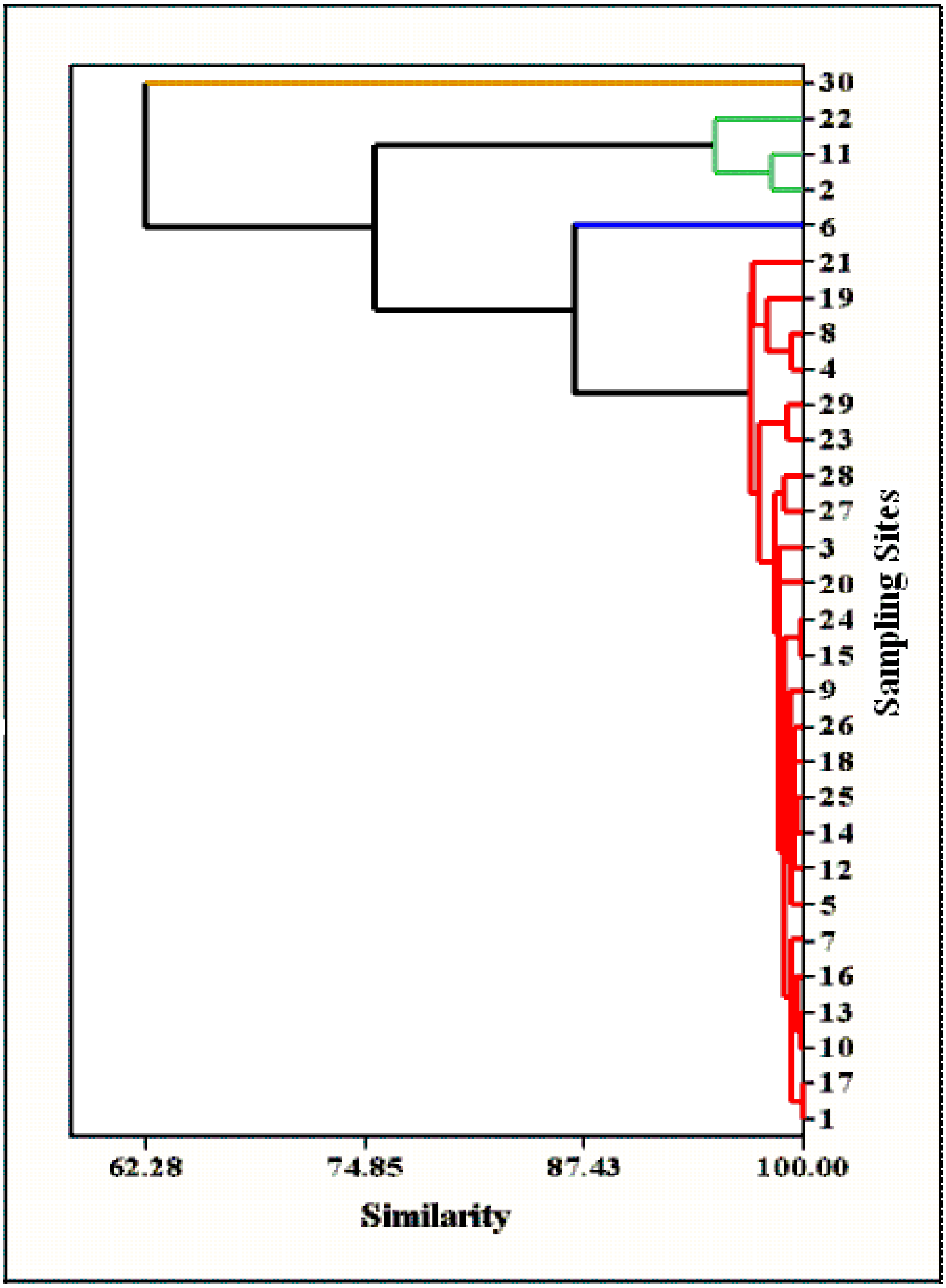

Figure 6: Dendogram, similarity among the sampling sites using similarity coefficient test.

DISCUSSION

Egypt shares in most of the environmental problems of developing countries. One of the most important health and environmental problems is water pollution resulting from, the deficiency of efficient sanitation services and the breaking down of old and consumed water networks, resulting in the appearance and prevalence of communicable and non-communicable diseases. [23] Recently, water quality issues have received high attention in the overall water resources planning and polices in Egypt. A water quality management program, with a national perspective was developed and implemented, based on an integrated approach to water quality data collection, analysis, interpretation, management and coordination.[2]

Contamination of national waters by microorganisms directly affects the public health. [1,6,24] Abbis area suffers from discharge of domestic sewage directly to surface water courses, hence, was considered as a heavily polluted area and referred as a hot spot. The physicochemical and bacteriological characteristics of water and soil collected from the canals of this area clearly reflect the deterioration of the water quality.

The physicochemical characteristics represent the important and critical parameters that determine the behavior and fate of different pollutants in any environment as well as its capacity for the self-purification. The comparison of the present results with the maximum permissible limit (MPL) of Egyptian Environmental Affair Agency, (1994), [25] revealed the degree of pollution in the study area. The hydrographical parameters indicated that pH values were slightly toward the alkaline side and lie at the optimum level for most microorganisms. [26] They were also within the normal and suitable range of irrigation water (MPL 6.5-8.4) at the different sites. Salinity exceeded the maximum permissible limit (MPL<0.36 g/l) at most sites with differences among them. Water salinity is considered as a sensitive parameter for measuring the rate of outfall discharge and subsequently it reflects the degree of pollution in aquatic environments. Salinity can affect viability of the fecal bacteria and their survival. [15,19] Dissolved oxygen contents of water samples were above the MPL (5 mg/l) at all sites (Table 1). Dissolved oxygen is an important parameter for the identification of different water mass and assessing the degree of pollution in a certain aquatic ecosystem. [27] The high concentrations of dissolved oxygen in water bodies could lead to enhanced microbial inactivation by solar UV radiation. [15] Organic matter is a good parameter for measuring the degree of pollution by sewage effluents, organic industrial and agricultural wastes. Biodegradable organic matter (BOD) in the study area recorded a range exceeding the MPL (60 mg/l) at all sites. Similarly, COD were at very high levels at all sites (Table 1) indicating very high organic loads prevailing in the water of these drains and that these waters required intensive treatment. This agrees with Abdel-Wahaab and Badawy, (2004) [3], who mentioned that, the water in the drains is currently of poor quality due to pollution from municipal and agriculture sources.

One of the most important impacts of water pollution is the microbial pollution, especially with pathogenic organisms. This is usually caused by the discharge of human fecal wastes into the aquatic environment. [6,28] The bacteriological examination confirmed the results of the physicochemical characterization of the water at the selected sites being highly polluted and needing an immediate solution. This is clearly shown by the high load of the TVC of bacteria obtained in the water samples from the selected canals (Table 2).

According to the Egyptian and

European Guide Standards, and law No. 48, 1982, regarding the protection of the Nile River and its water ways from pollution, [29, 30,31] the values of 500 cell/100 ml and 100 cell/100 ml are stated as the maximum permissible limits for water TC and FC values, respectively. Consequently, in the present study eleven sites (1, 2, 3, 6, 10, 15, 17, 19, 20, 23 and 24) were highly polluted with TC bacteria. Concerning FC counts, five sites (13, 20, 22, 24 and 30) exceeded the MPL of FC (100 cell/100 ml) and were considered fecally polluted. This requires an immediate action

For total coliform in water, the selected sites were divided into 2 categories; the first category, sites which were highly polluted (TC content more than 1800 cell/100 ml) and other sites which were less and moderately polluted with TC (less than 300 cell/ 100 ml). FC in the water samples ranged between a minimum of 5 and a maximum of 350 cell/100 ml (Table 2). These low densities of FC in the water doesn't mean that water is safe, but it could be attributed to the detrimental effect of the sunlight in these canals that can lead to significant loss in their numbers in addition to the possible inhibitory effects of the toxic organics that may be available in the water. Sinton *et al*., (2002) [32] mentioned that sunlight inactivation of fecal coliforms in fresh water (river) appears to be the most important mechanism inactivating sewage microorganisms in shallow water, although it has been reported to exert different rates of inactivation on various fecal bacteria and bacteriophages. The surviving cells exhibit greater sunlight resistance in natural waters than those from raw sewage

Bacteriological assessments of soil in the study area indicated the flourishing of the bacterial populations with high densities of bacterial TVC and heavy contamination with total coliforms derived from domestic sewage that find their way into these canals and drains. This was confirmed by the results of fecal coliforms where, 15 sites out of the 30 showed very high density of FC indicating recent fecal pollution, and remarkable pollution of the soil in the study area (Table 3). Generally, soil showed higher bacterial contamination compared to water samples.

Generally, all the investigated sites exhibited variation in both soil and water content of fecal coliforms. However, when comparing the ratio of soil/water fecal content, it would be clear that the ratio is below two in locations of low pollution (sites 15, 24, 27, 28, 29 and 30), while it is high (ranging from 5 to 360) in locations with high pollution levels (the rest 24 sites). This is attributed to the adsorption of bacterial cells on the soil particles and the availability of organic matter in the soil which provide rich environment for these bacteria. [(33)] These results agreed with a previous study, [(34)] where sediments have been shown to harbor fecal coliforms at concentrations higher than those observed in the overlying water column. It was stated that sediments may contain 100 to 1,000 times the number of fecal indicator bacteria contained in the overlying water. Also Crabill *et al*., (1999) [(35)] reported that sediment samples could have up to 2-200 times the FC counts of the water column. There is an evidence that fecal indicators and pathogenic bacteria don't survive in sediments longer than in the overlying water and it has been proposed that sediments serve as sinks for fecal bacteria with the potential to pollute the overlying bathing waters. [(33)]

The similarity between sampling sites were highly considered as unique environment from the microbiological and physicochemical point of view. In conclusion, Results of the present study clearly indicated remarkable levels of pollution, these high pollution levels are mainly attributed to the unsanitary disposal of domestic sewage and its mixing with the irrigation water in the different canals which ends up in the irrigated soil and crops. Pollution levels detected in the study area during the present study represent a serious environmental problem that would pose a potential health risk and requires the implementation of a good domestic sewerage system and application of correct agricultural practices.

REFERENCES

1. Haddad M, Al-Delaimy Kh. Bacteriological quality of selected pollution indices of Wadi El-Arab water reservoir in Jordan. International Journal of Lakes and Rivers. 2006; 1(1): 17-33.
2. Abdel-Gawad ST. Water Quality Challenges Facing Egypt. In: linkoy I. and Ramadan A. B., NATO Science Series, : IV: Earth and Environmental Sciences ,Comparative Risk Assessment and Environmental Decision Making, Springer Netherlands Publisher. 2006; 335-47.
3. Abdel-Wahaab R, Badawy M I. Water quality assessment of the River Nile System: An overview. Biomedical and environmental sciences. 2004; 17:87-100.
4. Rompre A, Servais P, Baudart J, Roubin M, Laurent P. Detection and enumeration of coliforms in drinking water: current methods and emerging approaches. Journal of Microbiological Methods. 2002; 49: 31–54.
5. Hahn MW, Hofle MG. Grazing of protozoa and its effect on population of aquatic bacteria. FEMS Microbial Ecology. 2001; 35: 113-21.
6. Shawky ZS, Abdel-Rahman SH. Bacteria as indicator of sewage pollution and as a trophic level in some selected Khors of Lake Naser, Egypt. Egyptian Journal of Aquatic Research. 2008; 34(2): 206-16.
7. Wutor VC, Togo CA, Pletschke BI. Suitability of total coliform beta-D-galactosidase activity and CFU counts in monitoring faecal contamination of environmental water samples. Water SA. 2009; 35 (1): 85-8.
8. Abdallah HH, Ibrahim H, El-Shenawy A. Fecal indicator bacteria and sanitary water quality along the Egyptian coast of Aqaba Gulf, Suez Gulf and Red Sea. Egyptian Journal of Aquatic Research.2008; 34(3):187-97.
9. El-shenway MA, Farag AE, Zaky M. Sanitary and aesthetic quality of Egyptian coastal waters of Aqaba Gulf, Suez Gulf and Red Sea. Egyptian Journal of Aquatic Research. 2006; 32(1):1687-90.
10. Sanders BF, Arega F, Sutula M. Modeling of the dry weather tidal cycling of faecal indicator bacteria in surface waters of an intertidal wetland. Water Research. 2005; 39: 3394-408.
11. Carson CA, Shear B L, Elleriek MR., Asfaw A. Identification of fecal *Escherichia coli* from human and animals by ribotyping. Applied Environmental Microbiology 2001; 67(3): 1503-07.
12. Mclellan SL, Daniels A D, Salmore AK. Genetic characterization of *Escherichia coli* population from host sources of faecal pollution by using DNA finger-printing. Applied Environmental Microbiology, 2003; 97(9): 2587-94.
13. Servais P, Garcia-Armison T, George I. Billen G. Fecal bacteria in the rivers of the Seine drainage network (France): Sources fate and modeling. Science of the Total Environments, 2007; 375: 167.
14. Statham JA, McMeekin TA. Survival of

fecal bacteria in Antarctic coastal waters. Antarctic Sciences. 1994; 6: 333-8.
15. Hughes KA. Influence of Seasonal Environmental Variables on the Distribution of Presumptive Fecal Coliforms around an Antarctic Research Station. Applied Environmental Microbiology, 2003; 69(8): 4884–91.
16. Solic M, Krstulovic N. Separate and combined effects of solar radiation, temperature, salinity and pH on the survival of fecal coliforms in seawater. Marine Pollution Bulletin, 1992; 24: 411-16.
17. Sinton LW, Davies-Colley RJ, Bell RG. Inactivation of enterococci and fecal coliforms from sewage and meatworks effluent in seawater chambers. Applied Environmental Microbiology, 1994; 60: 2040-48.
18. Rhodes MW, Kator HI. Seasonal variation in survival of *Escherichia coli* exposed *in situ* in membrane diffusion chambers containing filtered and non-filtered estuarine water. Applied Environmental Microbiology, 1983; 45: 1877-83.
19. Anderson IC, McMeekin MW, Kator HI. Sublethal stress in *Escherichia coli*: a function of salinity. Applied Environmental Microbiology, 1979; 38: 1147-52.
20. Ibrahim HZ. Environmental survey prior to the implementation of the sanitation component at Abbis, Villages 7&8, Alexandria, Final report for Egyptian Swiss Development Fund (ESDF). 2007.
21. Clesceri LS, Greenberg AE, Eaton AD. Standard methods for the examination of water and wastewater. 20th (ed.), American Public Health Association, USA. 1999.
22. Collins CH, Lyne PM, Grange JM. Microbiological Methods, 7th edition, Butterworth Heinemann, Oxford. 1999.
23. Anwar W.A. Environmental Health in Egypt. International Journal of Hygiene and Environmental Health. 2003; 206 (4-5): 339-50.
24. Francy DS, Hesel DR, Nelly RA. Occurrence and distribution of microbiological indicators in ground water and stream water. Water Environmental Research. 2000; 72: 152-61.
25. Egyptian Environmental Affair Agency (EEAA). Maximum limits of pollutants according to the Egyptian Environmental Protection Law. University of Mansoura. 1994; 39pp.
26. Rabeh SA. Bacteria as indication of both sewage pollution and trophic level in Abu Zabaal Lakes, Great Cairo, Egypt. Journal of Egyptian Academic Society For Environmental Development (D-Environmental Studies). 2006; 6(1): 27-48.
27. Hussein NR. Ecological and physiological studies on phytoplankton in some coastal areas around Alexandria. Ph.D. Thesis, Faculty of Science, Alexandria University, Egypt. 2000.
28. Karaboze I, Ucar F, Eltem R, Ozdmir G, Ates M. Determination of existence and count of pathogenic microorganisms in Izmir Bay. Journal of Equine Science. 2003; 26: 1-18.
29. Abo-Elela GM, Elsersy NA, El-shenawy M, and Abdel-Mawly E. Microbial assessment of El-Max fish farm, Egyptian Journal of Aquatic Research. 2005; 31(1):171-84.
30. European Commission Guide Standard. Quality of Bathing Water Document EUr18166, Brussels. 1998.
31. Law No. 48. Law regarding the protection of the Nile River and its water ways from pollution. Irrigation and Drainage Law, Ministry of Water Resources and Irrigation, Egypt. 1982.
32. Sinton LW, Hall CH, Lynch PA, Davies-Colley RJ. Sunlight

Inactivation of Fecal Indicator Bacteria and Bacteriophages from Waste Stabilization Pond Effluent in Fresh and Saline Waters. Applied Environmental Microbiology 2002; 68(3): 1122–31.

33. Abdallah SA, Elmanama AA, Fahd MI, Afifi S. Microbiological Beach S and Quality in the Gaza Strip in Comparison to Sea water. Polish Journal of Environmental Studies. 2005; 14(6): 841-850.

34. Shbolt N, Grohmann G, Kueh C. Significance of specific bacterial pathogens in the assessment of polluted receiving waters of Sydney. Water Science and Technology. 1993; 27: 449-58.

35. Crabill C, Donald R, Snelling J, Foust R, Southam G. Impact of sediment fecal coliform reservoirs on seasonal water quality in Oak Creek, Arizona. Water Research. 1999; 33(9): 2163.