RESULTS

1. Physico-Chemical assessment of water samples

Variations of physico-chemical characteristics of Ismailia Canal water during four seasons are shown in **Tables (4–9) and Figures (3-10)**.

1.1. Water temperature (T):

Water temperature ranged from 27.1-37, 23.2-31, 21-29 and 21.7-29.9^{o}C during summer, autumn, spring and winter seasons respectively. The maximum permissible limit of water temperature values for effluents discharged in canals, according to the Egyptian law 48 for the year 1982, is 35^{o}C. The outlet of north Cairo power plant and the outlet of petroleum companies were the only two sites that had temperatures (37 and 36.6^{o}C respectively in summer) above that permissible limit. **Table (4)**, **Figure (3)**

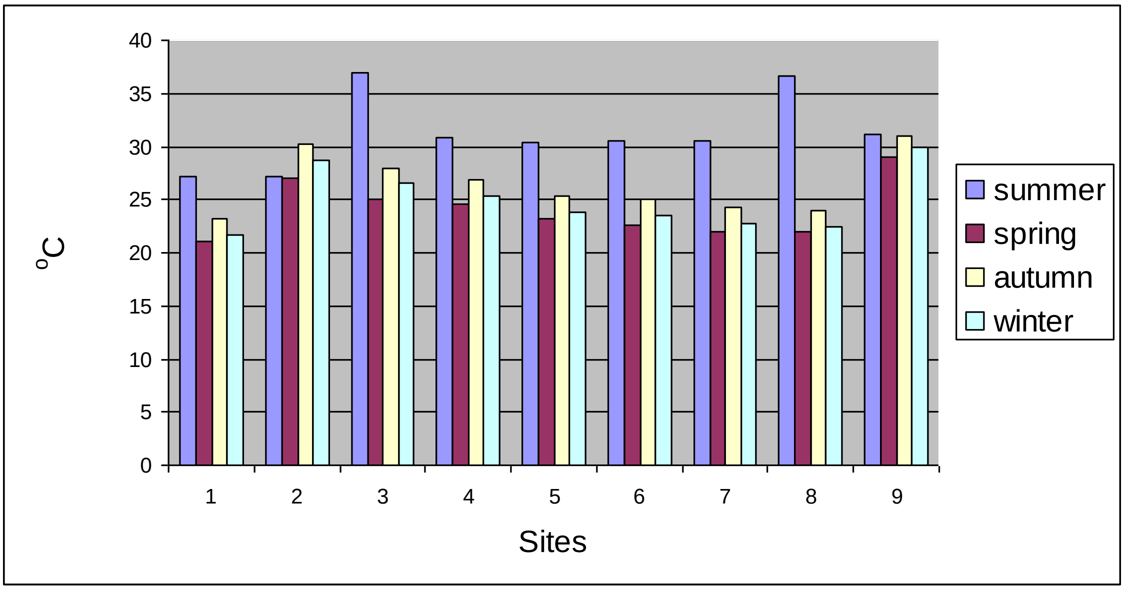


Figure (3): Seasonal variations of temperature values (^{o}C) of water samples of the area under investigation of Ismailia Canal.

1= The canal mouth (reference point)

2= The inlet (1500 m after the canal mouth) of north Cairo power plant

3= The outlet of north Cairo power plant

4= The inlet (100 m from outlet of north Cairo electrical company) of Amyeria water purification plant

5= The outlet of Amyeria water purification plant

6= 500 m after outlet of Amyeria water purification plant

7= inlet (8500 m from the canal mouth) of petroleum companies

8= The outlet of petroleum companies

9= 500 m after the outlet of petroleum companies

1.2. Electric conductivity (EC):

Electric conductivity ranged from 0.4-0.5, 0.37-0.48, 0.326-0.690 and 0.328-0.48 ms/cm during summer, autumn, spring and winter seasons respectively. The highest value was recorded at the outlet of petroleum companies in spring (0.69 ms/cm), while the lowest value at the canal mouth in spring (0.326 ms/cm). **Table (4)**, **Figure (4)**

Figure (4): Seasonal variations of EC values (ms/cm) of water samples of the area under investigation of Ismailia Canal.

<u>1.3. Total dissolved solids (TDS):</u>

Total dissolved solids ranged from 237.4-327.0, 238-310, 225-441 and 210-307.46 mg/L during summer, autumn, spring and winter seasons respectively. The maximum permissible limit of TDS values for effluents discharged in canals, according to the Egyptian law 48 for the year 1982, is 700 mg/L. **Table (4)**, **Figure (5)**

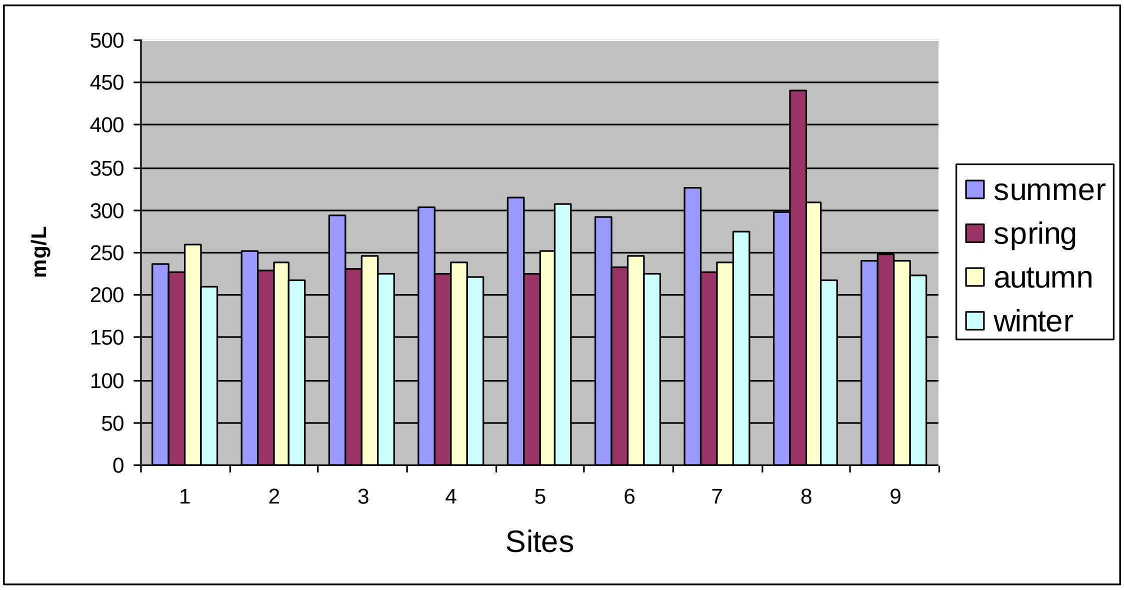


Figure (5): Seasonal variations of TDS values (mg/L) of water samples of the area under investigation of Ismailia Canal.

1.4. Dissolved oxygen (DO):

The DO ranged from 4.24-8.83, 4.32-9.10, 4.79-9.59 and 4.12-9.10 mg/L during summer, autumn, spring and winter seasons respectively. Both maximum DO values were in spring (9.10 mg/L) and winter (9.59 mg/L). **Table (5)**, **Figure (6**)

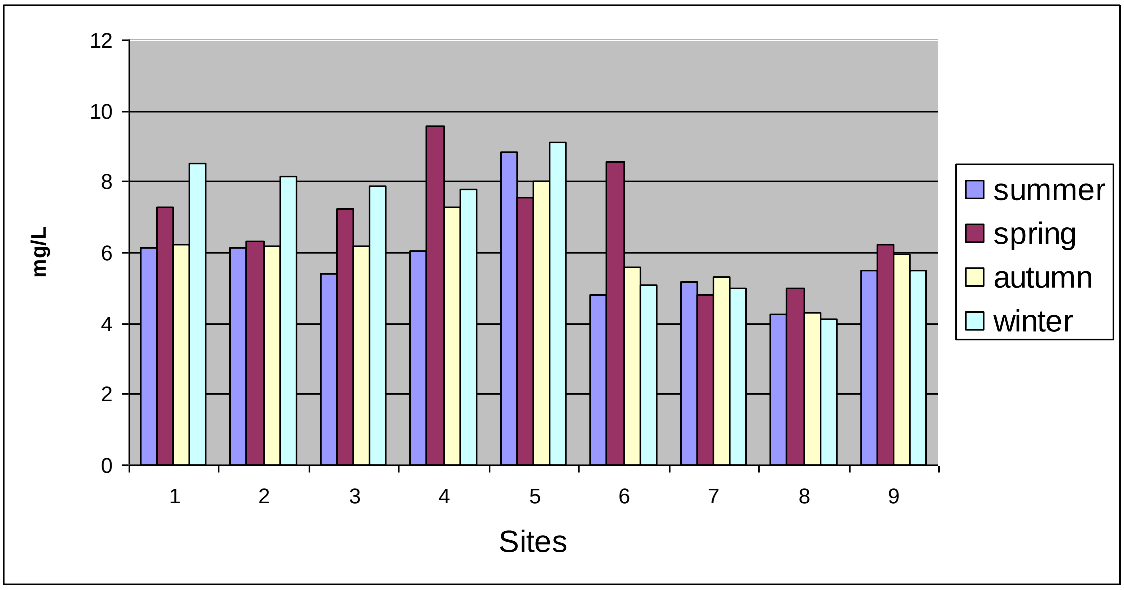


Figure (6): Seasonal variations of DO values (mg/L) of water samples of the area under investigation of Ismailia Canal.

1.5. Biochemical oxygen demand (BOD):

The BOD ranged from 3-40, 2-14, 2-15 and 1-11 mg/L during summer, autumn, spring and winter seasons respectively. The maximum permissible limit of BOD values for effluents discharged in canals, according to the Egyptian law 48 for the year 1982, is 20 mg/L. The outlet of Amyeria purification water plant is the only site that had BOD value (40 mg/L) in summer exceeded that permissible limit. **Table (5)**, **Figure (7**)

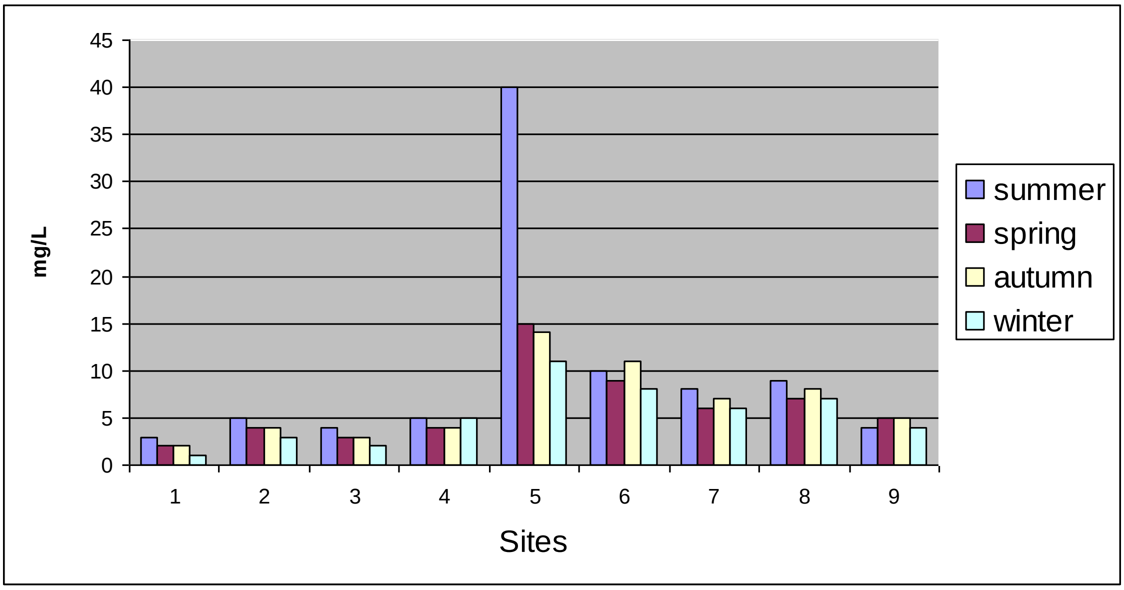


Figure (7): Seasonal variations of BOD values (mg/L) of water samples of the area under investigation of Ismailia Canal.

1.6. Chemical oxygen demand (COD):

The COD ranged from 5-84, 4-30, 5-32 and 3-21 mg/L during summer, autumn, spring and winter seasons respectively. The maximum permissible limit of COD values for effluents discharged in canals, according to the Egyptian law 48 for the year 1982, is 30 mg/L. The outlet of Amyeria purification water plant is only site that had BOD value exceeded that permissible limit in summer, autumn and spring. **Table (5)**, **Figure (8**)

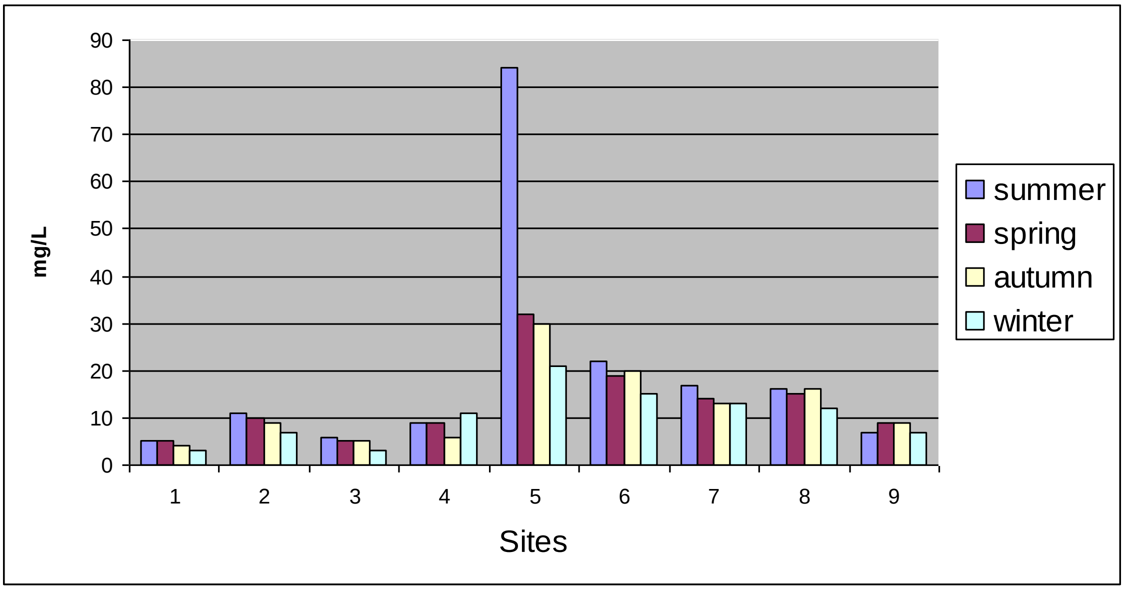


Figure (8): Seasonal variations of COD values (mg/L) of water samples of the area under investigation of Ismailia Canal.

1.7. The pH values:

The pH ranges ranged from 7.90-8.15, 7.80-8.02, 7.95-8.13 and 7.9-8.3 during summer, autumn, spring and winter seasons respectively. The permissible range of pH values for effluents discharged in canals, according to the Egyptian law 48 for the year 1982, is 6-9. **Table (6)**, **Figure (9)**

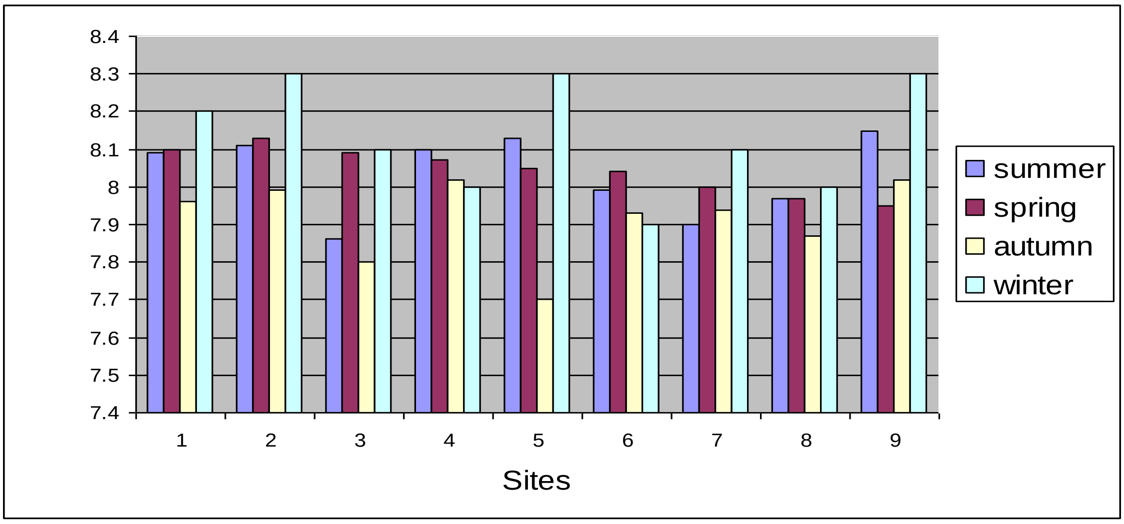


Figure (9): Seasonal variations of pH values of water samples of the area under investigation of Ismailia Canal.

1.8. Ammonia (NH_3):

The NH_3 concentration ranged from 0.08-2.50, 3.08-5.5, 0.88-3.3 and 0.2-2.9 mg/L during summer, autumn, spring and winter seasons respectively. The highest ammonia concentration was at the outlet of petroleum companies in autumn (5.5 mg/L).**Table (6)**, **Figure (10**)

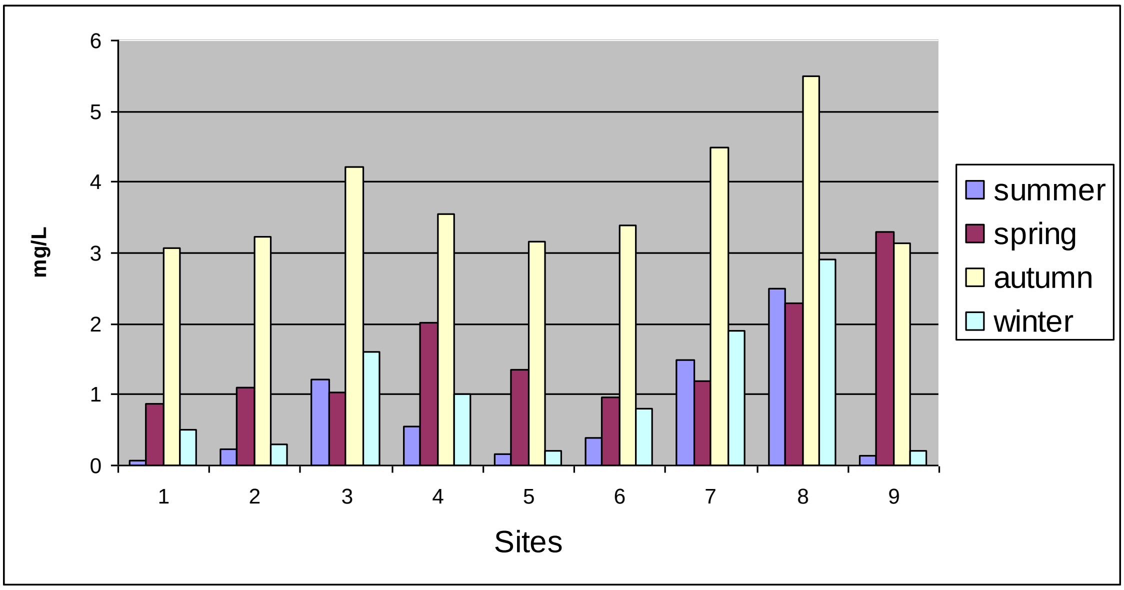


Figure (10): Seasonal variations of NH_3 values of water samples of the area under investigation of Ismailia Canal.

Table (6): Seasonal variation of ammonia concentrations (mg/L) and pH values

Season / Sites	Summer		Autumn		Spring		Winter	
	NH_3	**pH**	**NH_3**	**pH**	**NH_3**	**pH**	**NH_3**	**pH**
1	0.08	8.09	3.08	7.96	0.88	8.10	0.5	8.2
2	0.24	8.11	3.24	7.99	1.11	8.13	0.3	8.3
3	1.21	7.86	4.21	7.80	1.04	8.09	1.6	8.1
4	0.56	8.10	3.56	8.02	2.01	8.07	1.0	8.0
5	0.16	8.13	3.16	7.70	1.36	8.05	0.2	8.3
6	0.38	7.99	3.38	7.93	0.96	8.04	0.8	7.9
7	1.50	7.90	4.5	7.94	1.18	8.00	1.9	8.1
8	2.50	7.97	5.5	7.87	2.3	7.97	2.9	8.0
9	0.14	8.15	3.14	8.02	3.3	7.95	0.2	8.3

<u>1.9. Major anions and total alkalinity:</u>

The major anions included in that study were chloride (Cl^-), sulfate (SO_4^{-2}), nitrite (NO_2^-), nitrate (NO_3^-), phosphate (PO_4^{-3}), Carbonate (CO_3^-) and bicarbonate (HCO_3^-) as well as total alkalinity. Nitrite, phosphate and carbonate of water samples from different sites at different seasons were not detected.

The chloride concentration ranged from 28.00-53.00, 21.00-72.60, 19.00-150.00 and 18.00-69.60 mg/L during summer, autumn, spring and winter seasons respectively.

The nitrate concentration ranged from ND-3.70, 3.04-5.80, ND-9.00 and 0.04-2.80 mg/L during summer, autumn, spring and winter seasons respectively.

The sulphate concentration ranged from 15.00-44.00, 18.40-46.00, 26.00-40.00 and 15.40-43.00 mg/L during summer, autumn, spring and winter seasons respectively.

The bicarbonate concentration ranged from 141.00-168.00, 155.8-195.80, 168.00-193.0 and 160.00-185.60 mg/L during summer, autumn, spring and winter seasons respectively. As total alkalinity calculated by the summation of carbonate and bicarbonate and the carbonate concentration of water samples from different sites at different seasons was zero, total alkalinity will equal the bicarbonate concentration in value. **Table (7)**

Table (7): Seasonal variation of anions concentrations (mg/L)

Sites	**Seasons**			
	Summer			
	Cl^-	**SO_4^-**	**NO_3^-**	**HCO^-**
1	28.00	15.00	ND	170.00
2	33.00	20.00	2.20	178.00
3	45.00	35.00	2.50	175.00
4	44.00	44.00	3.40	165.00
5	53.00	25.00	2.62	185.60
6	46.00	38.00	3.70	185.60
7	52.00	42.00	3.00	165.00
8	45.00	42.00	2.50	160.00
9	28.00	22.00	1.66	180.00
Autumn				
1	25.40	18.40	3.04	170.00
2	31.20	28.00	5.00	185.00
3	30.00	33.00	5.80	190.00
4	33.00	32.00	5.50	186.00
5	72.60	46.00	5.28	168.00

6	30.00	28.00	5.30	193.00
7	21.00	27.00	5.20	180.00
8	31.00	30.00	4.90	185.00
9	59.20	44.40	4.22	183.00
Spring				
1	20.00	26.00	5.90	146.00
2	40.00	30.00	5.00	141.00
3	50.00	31.00	9.00	153.00
4	20.00	26.00	2.00	151.00
5	22.00	31.00	5.00	165.00
6	20.00	30.00	4.00	158.00
7	19.00	29.00	ND	168.00
8	150.00	40.00	3.00	165.00
9	30.00	30.00	3.50	165.00
Winter				
1	22.40	15.40	0.04	155.8
2	28.20	25.00	2.00	173.40
3	27.00	30.00	2.80	195.00
4	30.00	29.00	2.50	190.00
5	69.60	43.00	2.28	177.20
6	27.00	25.00	2.30	165.00
7	18.00	24.00	2.20	160.00
8	28.00	27.00	1.90	170.00
9	56.20	41.40	1.22	195.80

1.10. Major cations:

The major cations included in that study were calcium (Ca^{+2}), potassium (K^{+}), magnesium (Mg^{+2}) and sodium (Na^{+}).

The calcium concentration ranged from 25.00-38.00, 16.00-39.75, 30.46-40.10 and 18.00-41.75 mg/L during summer, autumn, spring and winter seasons respectively.

The potassium concentration ranged from 5.00-10.00, 5.00-8.00, 7.00-7.00 and 3.80-14.30 mg/L during summer, autumn, spring and winter seasons respectively.

The magnesium concentration ranged from 15.00-22.20, 10.82-25.10, 9.60-15.26 and 12.82-27.10 mg/L during summer, autumn, spring and winter seasons respectively.

The sodium concentration ranged from 22.00-47.00, 30.00-37.00, 27.00-76.00 and 13.00-63.30 mg/L during summer, autumn, spring and winter seasons respectively. **Table (8)**

Table (8): Seasonal variation of cations concentrations (mg/L)

Sites	**Seasons**			
	Summer			
	Ca^{2+}	**K^{+}**	**Mg^{2+}**	**Na^{+}**
1	25.00	5.00	15.00	22.00
2	32.00	8.00	18.00	30.00
3	31.00	6.00	17.00	41.00
4	37.00	7.00	19.00	41.00
5	37.00	10.00	22.20	35.00
6	34.00	7.00	15.00	41.00
7	36.00	7.00	16.00	47.00
8	38.00	7.00	19.00	41.00
9	30.20	6.20	15.00	32.00
Autumn				
1	21.76	8.00	10.82	33.00
2	28.40	7.00	13.20	31.00
3	27.00	7.00	12.00	31.00
4	22.00	7.00	19.00	31.00
5	35.20	6.00	20.00	35.00
6	18.00	7.00	17.00	37.00

7	16.00	5.00	19.00	30.00
8	19.00	7.00	14.00	35.00
9	39.75	5.00	25.10	32.00
Spring				
1	35.28	7.00	11.27	27.00
2	32.08	7.00	11.17	27.00
3	32.56	7.00	12.34	27.00
4	31.75	7.00	12.53	27.00
5	33.68	7.00	9.60	27.00
6	30.46	7.00	13.02	27.00
7	31.75	7.00	12.83	27.00
8	40.10	7.00	14.58	76.00
9	32.08	7.00	15.26	30.00
Winter				
1	23.76	3.80	12.82	19.80
2	30.40	6.60	15.20	24.40
3	29.00	6.00	14.00	22.00
4	24.00	5.00	21.00	25.00
5	37.20	7.40	22.00	37.20
6	20.00	6.00	19.00	23.00
7	18.00	7.00	21.00	13.00
8	21.00	5.00	16.00	22.00
9	41.75	14.30	27.10	63.30

1.11. Trace metals:

The trace metals included in that study were aluminum (Al), arsenic (As), barium (Ba), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb), antimony (Sb), selenium (Se), tin (Sn), strontium (Sr), vanadium (V) and zinc (Zn). Arsenic, cobalt, manganese, nickel, lead, antimony, selenium, tin, strontium and vanadium of water samples from different sites at different seasons were not detected.

The aluminum concentration ranged from ND-0.45, 0.15-1.74, 0.007-1.537 and 0.0066-1.6162 mg/L during summer, autumn, spring and winter seasons respectively.

The barium concentration ranged from ND-0.14, 0.20-4.36, ND-4.162 and ND-4.162 mg/L during summer, autumn, spring and winter seasons respectively.

The cadmium concentration ranged from ND-0.01, 0.20-0.22, 0.004-0.018 and 0.0036-0.018 mg/L during summer, autumn, spring and winter seasons respectively. The maximum permissible limit of Cd concentration for effluents discharged in canals, according to the Egyptian law 48 for the year 1982, is 0.01 mg/L.

The chromium concentration ranges ranged from ND-0.02, 0.20-0.40, ND-0.20 and ND-0.2 mg/L during summer, autumn, spring and winter seasons respectively. The maximum permissible limit of Cr concentration for effluents discharged in canals, according to the Egyptian law 48 for the year 1982, is 0.05 mg/L.

The copper concentration ranged from ND-0.22, 0.20-0.29, ND-0.0904 and ND-0.76 mg/L during summer, autumn, spring and winter seasons respectively. The maximum permissible limit of Cu concentration for effluents discharged in canals, according to the Egyptian law 48 for the year 1982, is 1 mg/L.

The iron concentration ranges ranged from ND-0.05, 0.20-0.86, ND-0.663 and ND-0.6632 mg/L during summer, autumn, spring and winter seasons respectively. The maximum permissible limit of Fe concentration for effluents discharged in canals, according to the Egyptian law 48 for the year 1982, is 1 mg/L.

The zinc concentration ranges ranged from ND-0.04, 0.115-0.35, 0.105-0.340 and 0.015-0.25 mg/L during summer, autumn, spring and winter seasons respectively. The maximum permissible limit of Zn concentration for effluents discharged in canals, according to the Egyptian law 48 for the year 1982, is 1 mg/L. **Table (9)**

Table (9): Seasonal variation of heavy metals concentrations (mg/L)

Sites	Seasons						
	Summer						
	Al	**Ba**	**Cd**	**Cr**	**Cu**	**Fe**	**Zn**
1	0.01	ND	ND	ND	ND	ND	0.01
2	0.04	0.06	0.01	0.02	0.04	0.02	0.01
3	ND	0.06	0.01	ND	0.12	ND	0.02
4	0.03	0.06	0.01	ND	0.08	ND	0.01
5	0.02	0.02	0.01	0.02	0.03	0.03	0.02
6	0.45	0.05	0.01	ND	ND	ND	ND
7	0.04	0.14	0.01	ND	0.22	ND	0.01
8	0.26	0.06	0.01	ND	0.14	ND	ND
9	0.19	0.02	0.01	0.02	0.03	0.05	0.04
Autumn							
1	0.21	0.20	0.20	0.20	0.20	0.20	0.115
2	0.62	1.53	0.21	0.21	0.29	0.86	0.35
3	0.52	4.06	0.22	0.40	0.27	0.65	0.321
4	0.44	4.22	0.22	0.22	0.26	0.69	0.285
5	1.59	4.36	0.21	0.25	0.27	0.50	0.198
6	1.74	3.78	0.21	0.21	0.28	0.45	0.225
7	0.92	1.74	0.21	0.22	0.27	0.53	0.314
8	0.15	2.08	0.21	0.22	0.27	0.55	0.19
9	0.82	3.94	0.21	0.22	0.28	0.44	0.156
Spring							
1	0.0954	ND	0.004	ND	ND	ND	0.105
2	0.052	1.880	0.010	0.015	0.0904	0.354	0.180

3	0.424	0.050	0.009	ND	0.072	0.352	0.273
4	0.321	1.146	0.009	0.012	0.06	0.663	0.340
5	0.237	3.857	0.015	0.200	0.066	0.452	0.311
6	1.389	4.021	0.018	0.015	0.076	0.490	0.275
7	1.537	4.162	0.014	0.053	0.065	0.298	0.188
8	0.720	3.578	0.009	0.014	0.067	0.065	0.215
9	0.007	1.540	0.013	0.016	0.0772	0.330	0.304
Winter							
1	0.0066	ND	0.0036	ND	ND	ND	0.015
2	0.4244	1.146	0.0094	0.0124	0.067	0.6632	0.25
3	0.321	3.857	0.015	0.2	0.042	0.452	0.221
4	0.237	4.021	0.018	0.015	0.090	0.49	0.185
5	1.3894	4.162	0.0136	0.0526	0.072	0.298	0.098
6	1.537	3.578	0.009	0.014	0.060	0.245	0.125
7	0.72	1.54	0.013	0.016	0.066	0.33	0.214
8	0.954	1.88	0.01	0.015	0.76	0.354	0.09
9	1.6162	3.7408	0.0078	0.015	0.245	0.2368	0.056

2. Microbiological assessment of water samples

Variations of microbiological characteristics of Ismailia Canal water during four seasons are shown in **Tables (10-16) and Figures (11-21)**.

2.1. Total viable bacterial count (TVBC) and total spore-forming bacteria (TSFB):

Total viable bacterial count ranges at 22^{o}C were found to be 1.79x10^{4}-166x10^{4}, 1.2x10^{4}-80x10^{4}, 0.4x10^{4}-8.5x10^{4} and 21.7x10^{4}-99.26x10^{4} CFU/mL during summer, autumn, winter and spring seasons respectively. **Table (10)**, **Figure (11)**

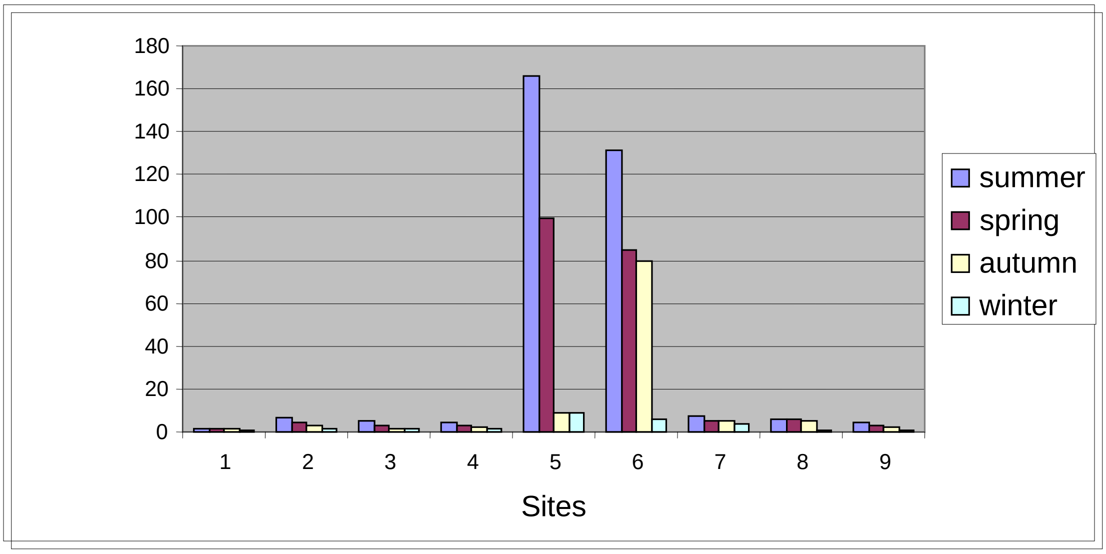


Figure (11): Seasonal variations of bacterial count x10^{4} cfu/mL in water of the area under investigation of Ismailia Canal at 22^{0}C.

Total viable bacterial count ranges at 37^{o}C were found to be 0.9 x10^{4}-90x10^{4}, 0.56x10^{4}-19.1x10^{4}, 0.28x10^{4}-4.3x10^{4} and 0.69x10^{4}-16.7x10^{4} CFU/mL during summer, autumn, winter and spring seasons respectively. **Table (10)**, **Figure (12)**

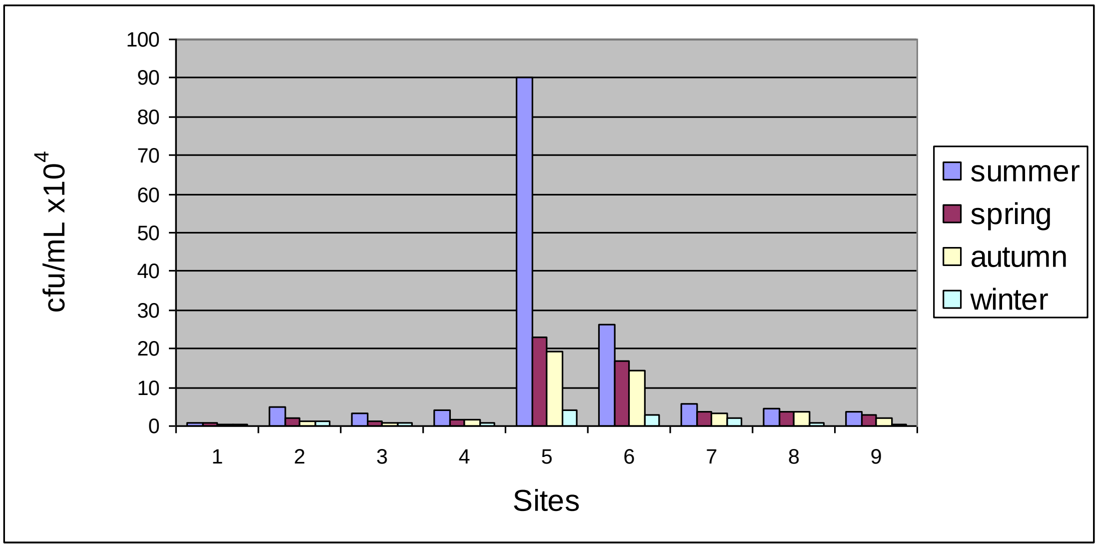


Figure (12): Seasonal variations of bacterial count x10^4 cfu/mL in water of the area under investigation of Ismailia Canal at 37°C

Total spore-forming bacteria ranges at 37°C were found to be 0.12x10^4-0.9x10^4, 0.09x10^4-0.49x10^4, 0.006x10^4-0.3x10^4 and 0.1x10^4-0.9x10^4 CFU/mL during summer, autumn, winter and spring seasons respectively. **Table (10)**, **Figure (13)**

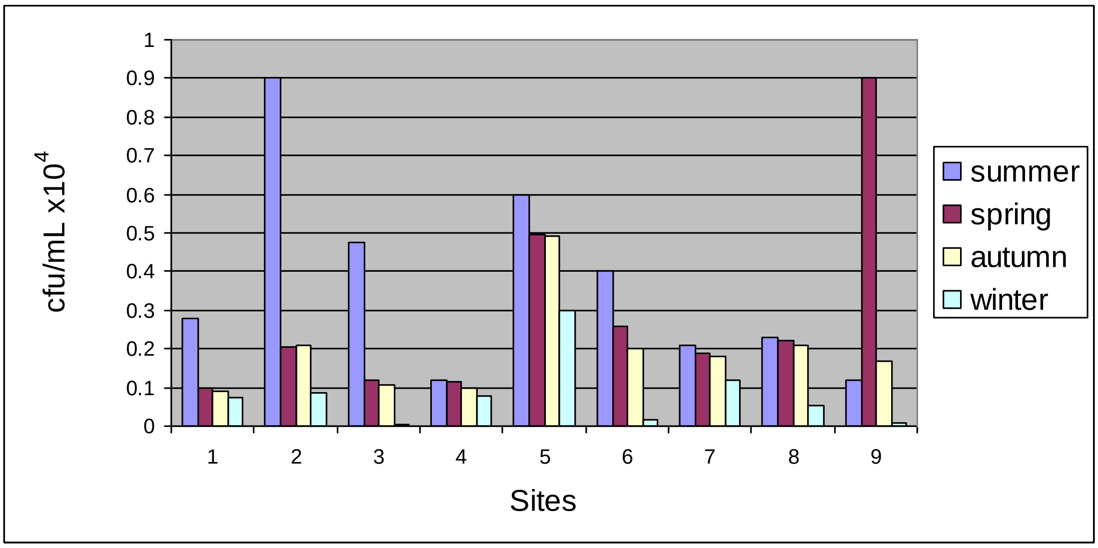


Figure (13): Seasonal variations of total spore forming bacteria x10^4 cfu/mL in water of the area under investigation of Ismailia Canal at 37°C

Total viable bacterial counts at 22°C and at 37°C and TSFB increases at sites 5 and 8 and decreases at site 3 during the four seasons with respect to their preceding sites.

2.2. Total coliform (TC), fecal coliform (FC), fecal streptococci (FS):

Total coliform count ranges were found to be 1180-7500, 900-4300, 410-3500 and 960-4400 CFU/ 100mL during summer, autumn, winter and spring seasons respectively. The maximum permissible limit of TC count for effluents discharged in canals, according to the Egyptian law 48 for the year 1982, is 2500 CFU/ 100mL. The outlets of North Cairo power plant, Amyeria water purification plant and petroleum companies exceed that maximum permissible limit especially in summer and autumn. The total coliforms count in this study was found to be higher than fecal coliform and fecal streptococci in all collected water samples from different sites during all seasons. **Table (11)**, **Figure (14)**

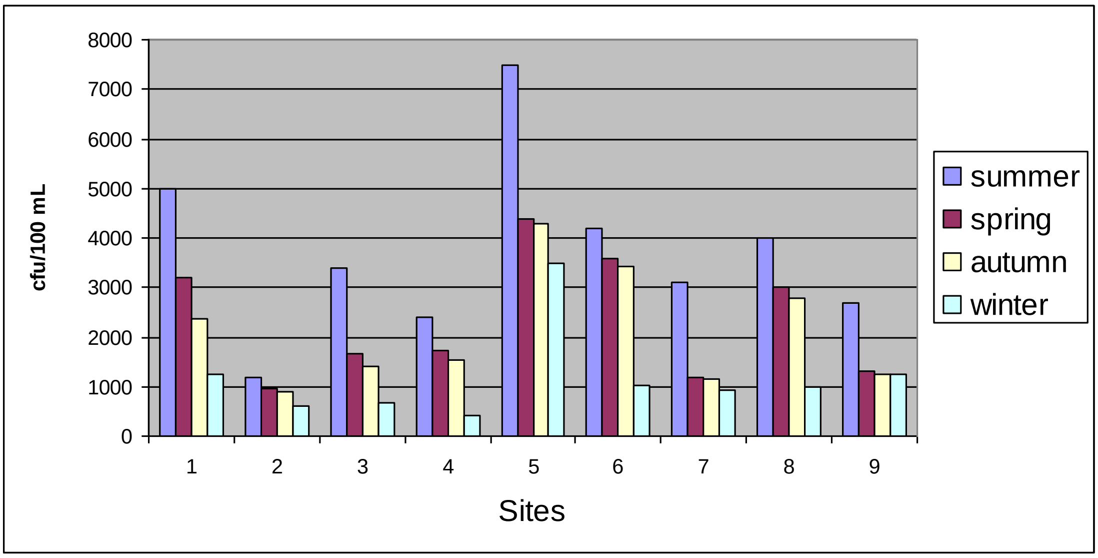


Figure (14): Seasonal variations of total coliform cfu/100 mL in water of the area under investigation of Ismailia Canal at 37°C

Fecal coliform count ranges were found to be **400-**3600, 220-2550, 30-2500 and 260-2700 CFU/ 100mL during summer, autumn, winter and spring seasons respectively. **Table (11)**, **Figure (15)**

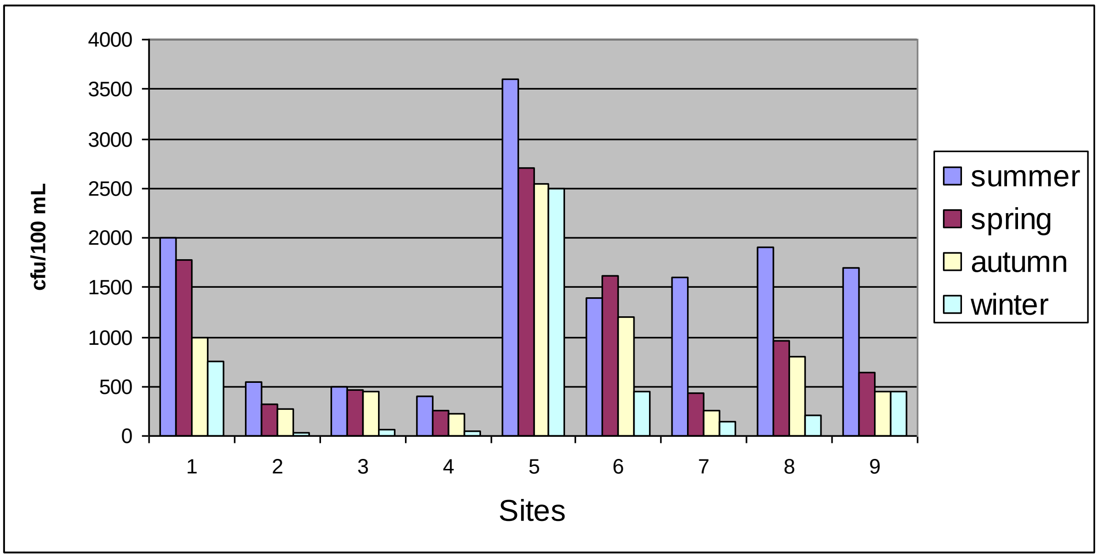


Figure (15): Seasonal variations of fecal coliform cfu/100 mL in water of the area under investigation of Ismailia Canal at 44^{o}C

Fecal streptococci count ranges were found to be 30-79, 15-50, 0-16 and 18-59 CFU/ 100mL during summer, autumn, winter and spring seasons respectively. The highest counts of fecal streptococci in each season were observed in water samples collected from the outlet of petroleum companies and the sites following it or preceding it. Fecal streptococci count in water samples collected during the period of study was generally lower than the fecal coliforms. **Table (11)**, **Figure (16)**

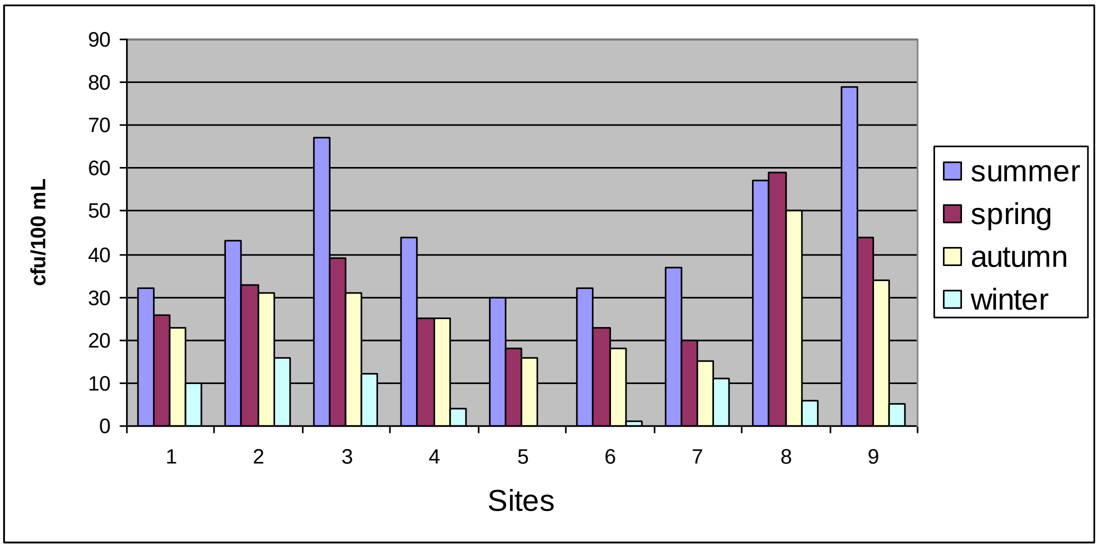


Figure (16): Seasonal variations of fecal streptococci cfu/100 mL in water of the area under investigation of Ismailia Canal at 37^{o}C

2.3. *Aeromonas hydrophila* Counts:

Aeromonas hydrophila count ranges were found to be 300-4400, 0-2400, 0-1500 and 0-2500 CFU/ 100mL during summer, autumn, winter and spring seasons respectively. **Table (12)**, **Figure (17)**

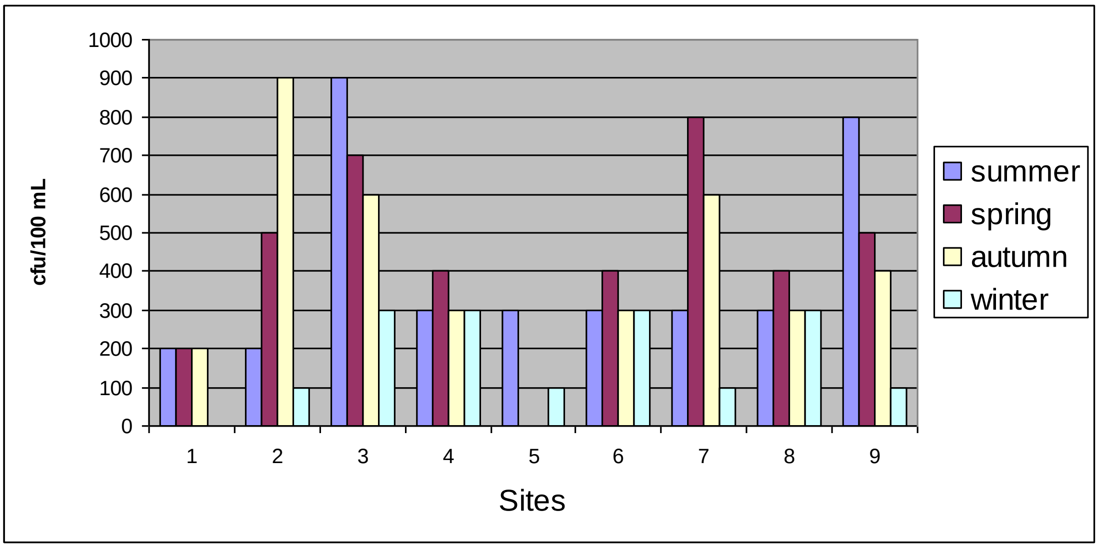


Figure (17): Seasonal variations of Total fungal count cfu/100 mL in water of the area under investigation of Ismailia Canal at 28^{o}C

Table (12): Seasonal variation of Total Fungal Count (TFC) and *Aeromonas hydrophila* counts (A.H) in CFU/ 100mL of water samples

Season / Sites	Summer		Autumn		Spring		Winter	
	TFC	**AH**	**TFC**	**AH**	**TFC**	**AH**	**TFC**	**AH**
1	200	4400	200	2400	0	1500	200	2600
2	200	2700	900	1000	100	100	500	1300
3	900	800	600	100	300	0	700	300
4	300	1900	300	500	300	200	400	600
5	300	1200	0	300	100	0	0	500
6	300	1500	300	300	300	0	400	300
7	300	300	600	0	100	0	800	0
8	300	3200	300	1200	300	600	400	1500
9	800	300	400	0	100	0	500	0

2.4. Isolation, purification and identification of bacteria:

In the present study, different selective media were used as mentioned in (3.1.) to isolate most indicator bacteria. These isolates were subjected to cultural and microscopic examinations according to **(Collins and Lyne, 1984)** and also physiological examinations according to **(Cheesbrough 1984; Sneath *et al.*, 1986; Krieg and Holt, 1986 and APHA, 2005).**

The bacterial isolates were found to belong to five species, which included to six genera. These species were *E.coli*, *Pseudomonas aeruginosa*, *Enterococcus fecalis*, *Aeromonas hydrophila* and *Proteus* *vulgaris*. *Salmonella* and *Shigella* were not detected during the four seasons at different sites.

2.5. Distribution of bacteria:

Table (24) shows the distribution of bacterial species at different sites during the four seasons. If the species was detected, it took the sign (+) and if it was not detected, it took the sign (-). The table shows that 166 bacterial isolates were obtained during the four seasons from the study area. They are divided into 36 *E.coli*, 33 *Pseudomonas aeruginosa*, 33 *Enterococcus fecalis*, 28 *Aeromonas hydrophila*, 36 *Proteus vulgaris*, 0 *Salmonella*, 0 *Shigella*.

2.6. Counting of fungi:

Fungi count ranges were found to be 200-900, 0-900, 0-300 and 0-800 CFU/ 100mL during summer, autumn, winter and spring seasons respectively. **Table (12)**, **Figure (18**)

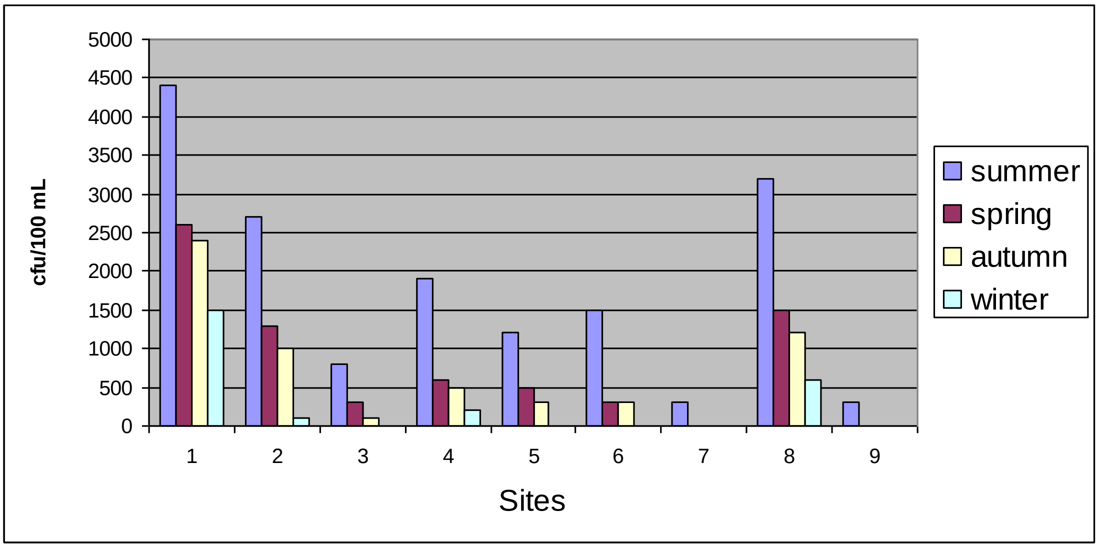


Figure (18): Seasonal variations of *Aeromonas hydrophila* count cfu/100 mL in water of the area under investigation of Ismailia Canal at 37^{o}C

Seasons Sites	Summer					Autumn					Spring					Winter				
Species	*E. coli*	*Ps. aeruginosa*	*E. fecalis*	*A. hydrophila*	*Proteus vulgaris*	*E. coli*	*Ps. aeruginosa*	*E. fecalis*	*A. hydrophila*	*Proteus vulgaris*	*E. coli*	*Ps. aeruginosa*	*E. fecalis*	*A. hydrophila*	*Proteus vulgaris*	*E. coli*	*Ps. aeruginosa*	*E. fecalis*	*A. hydrophila*	*Proteus vulgaris*
1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
2	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
3	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+
4	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+
5	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	-	+
6	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	-	+
7	+	+	+	+	+	+	+	+	-	+	+	+	+	-	+	+	+	+	-	+
8	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
9	+	+	+	+	+	+	+	+	-	+	+	+	+	-	+	+	+	+	-	+

Table (13): Different bacterial isolates at different sites during the four seasons

2.7. Isolation of bacteriophages:

The bacteriophages infecting *E.coli*, *Enterococcus fecalis*, *Aeromonas hydrophila* and *Proteus vulgaris* were not detected. The only isolated bacteriophages were that infecting *Ps. aeruginosa*. These bacteriophages were detected using spot test technique in all water samples under study (9 water samples collected from Ismailia Canal water plus the water sample collected from El-Rahway drain. Presence of that bacteriophage was confirmed by plaque assay test as shown in **Figure (19)**. The plaque assay showed morphologically differentiated plaques.

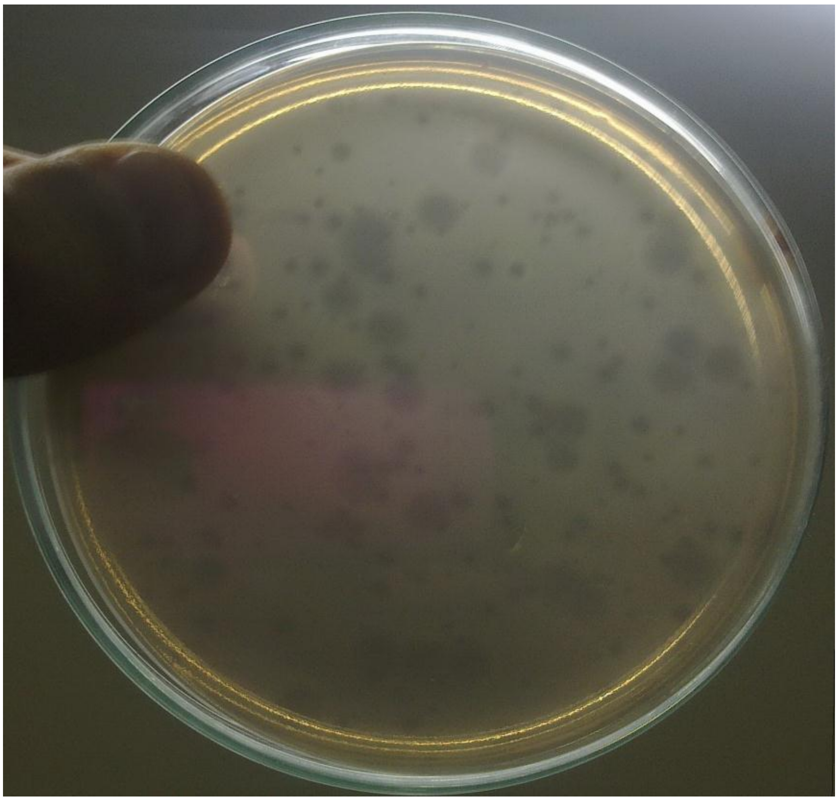


Figure (19): Plaque assay technique of bacteriophages infecting *Ps. aeruginosa*

2.8. Electron Microscopy:

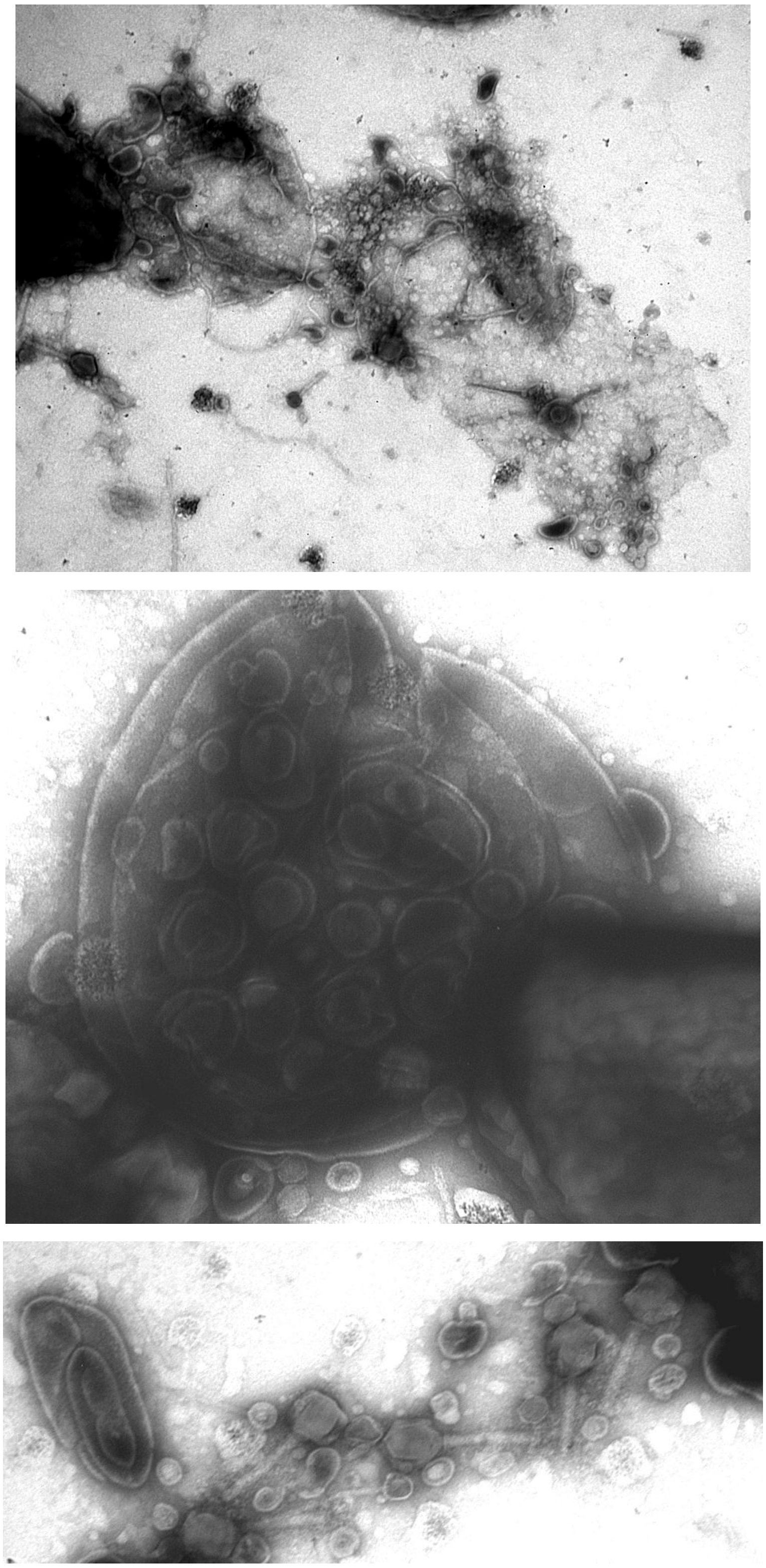
Electron microscope examination of partial purified bacteriophages showed three different bacteriophage particles. The first of them showed to have full hexagonal head with along-contractile tail. The second showed to have a big isometric head with along-contractile tail. The third showed to have a small isometric head with along-contractile tail. The examination also showed the contact of some bacteriophage particles on the bacterial cells, the replication of them inside the cells and the release of new bacteriophage particles from ruptured cell. **Figure (20).**

2.9. Fungi isolate:

Four fungal species were isolated and identified morphorologically and these species were *Aspergillus niger*, *Aspergillus tamurii*, *Aspergillus fumigatus*, and *Pacilomyces* sp.

3. Sanitation of *Pseudomonas aeruginosa* using phage

The treatment using the phage at room temperature and at 35^{o}C decreased the counts of *Ps. aeruginosa* by 50% and 80 %, respectively of their counts in the two controls. The treatment using the phage at 35^{o}C decreased the counts of *Ps. aeruginosa* more than that at room temperatures. The control at room temperature showed count less than before treatment (70 CFU/ 100 mL). The control at 35^{o}C showed count more than before treatment. The treatment using nanocomposite slightly decreased the counts of *Ps. Aeruginosa* in both; when treated lonely or with phage and at room temperature or at 35^{o}C. These results are shown in **Table (14)**.



TEM Mag= 80000x

Figure (20): Electron micrograph of *Ps. aeruginosa* phages negatively stained with uranyl acetate

Table (14): Sanitation of *Ps. aeruginosa* using bacteriophages

Treatments	**Room Temperature**		**Incubation (35^{o}c)**	
	Count (CFU)/100 mL	% reduction	Count (CFU)/100 mL	% reduction
10% w/v nanocomposite+ 100 mL sample	45	10	68	9.3
10 mL phage suspension + 100 mL sample	25	50	15	80
10 mL phage suspension +10%w/v nanocomposite+ 100 mL sample	20	60	12	84
100 mL sample (control)	50	-	75	-

Count /100 means the count of *Ps. aeruginosa* after treatment

% reduction means the percentage of the reduction in *Ps. aeruginosa* count after treatment

4. **Sanitation of trace metals using nanocomposite**

Table (15) shows that studied heavy metal concentrations decreased gradually with the time of exposure to used nanocomposite and finally reach to a concentration below the detection limits of Inductively Coupled Plasma-Optical Emission Spectroscopy.

Table (15): Sanitation of trace metals using nanocomposite

Time	Heavy metal concentrations (mg/L)						
	Ba	**Cd**	**Co**	**Cu**	**Ni**	**Pb**	**Zn**
0	0.092	0.04	0.023	0.039	0.049	0.024	0.029
30	0.073	0.01	0.02	0.038	0.04	0.01	0.025
60	0.065	0.007	0.015	0.031	0.032	0.005>	0.023
90	0.02	0.005>	0.01	0.027	0.01		0.01
120	0.009		0.007	0.02>	0.007		0.008
150	0.007		0.005>		0.006		0.005>
180	0.005>				0.005>		

Figure (21) shows that the studied heavy metal concentrations decreases exponentially with time and that obeys Arhenous relation,

$$C=C_o \exp(-t/\tau)$$

Where (τ) is the rate constant of treatment and (C_o) is the heavy metal concentration at t= 0. The values of τ, C_o have been extracted and given in **Table (16).** Studied heavy metals showed two trends in reply to the treatments. The first trend in which the metal concentration decreases slowly till 60 minutes then decreases rapidly with increasing time. This trend was shown by barium, nickel and zinc. The second trend in which the concentration decreases with increasing time rapidly. This trend was shown by cadmium, cobalt, copper and lead.

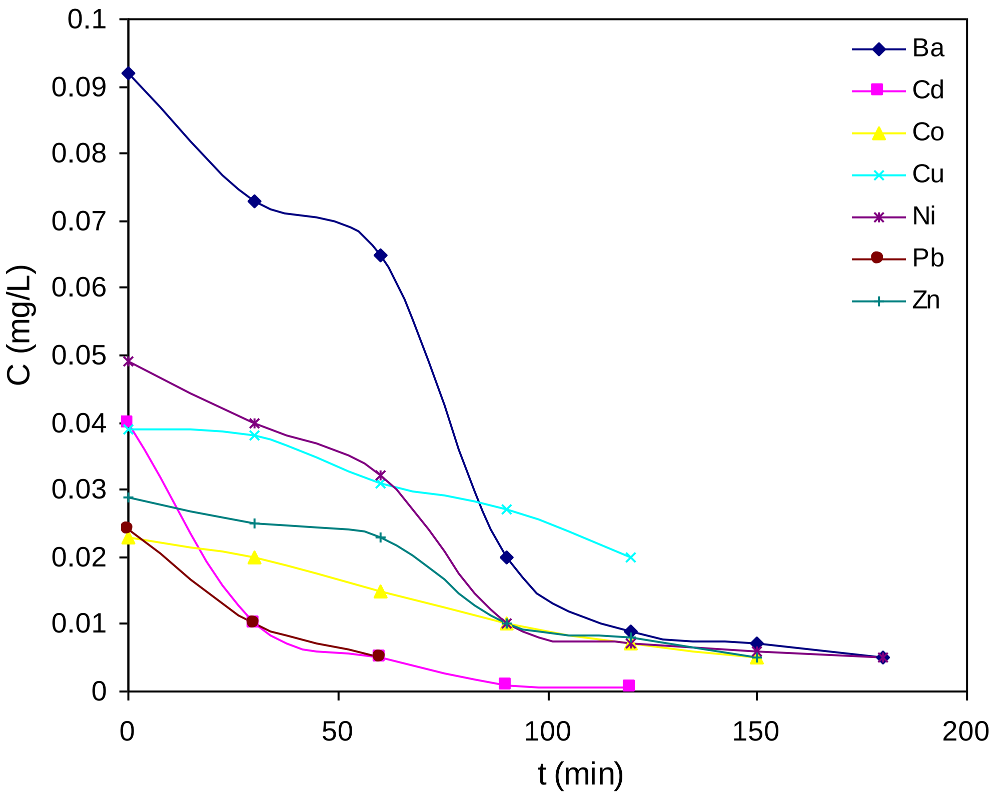


Figure (21): Sanitation of trace metals using nanocomposite

Table (16): The values of **τ, C_o** of studied heavy metals

Heavy metal	C_o (mg/L)	τ (min$^-$)
Ba	0.0456	48.54
Cd	0.036	27.1
Co	0.026	93.46
Cu	0.042	178.57
Ni	0.02	70.92
Pb	0.02	38.31
Zn	0.02	62.5

5. Statistical analysis:

Water temperatures showed positive correlation with total coliform, fecal streptococci and total fungal count .This positive correlation is ascertained by values of correlation coefficient (r) which were 0.3, 0.6 and

0.4 respectively. EC values were positively correlated with different studied ions e.g. chloride, sulphate, calcium and sodium. As well as with Total viable bacterial counts at 37^0C, total coliform, fecal streptococci and *Aeromonas hydrophila* counts. With them, EC have the following (r) values; 0.74, 0.44, 0.35, 0.7, 0.3, 0.47, 0.54 and 0.3, respectively. TDS values were positively correlated with EC values and different ions such as chloride, sulphate, calcium and sodium as (r) values indicate (0.98, 0.76, 0.44, 0.34 and 0.71, respectively). BOD is positively correlated to total viable bacterial counts at 22^oC and 37^oC, total spore-forming bacteria, total coliform and fecal coliform as (r) values indicates (0.76, 0.93, 0.37, 0.7 and 0.69). COD is positively correlated to total viable bacterial counts at 22^oC and 37^oC, total spore-forming bacteria, total coliform, fecal coliform and BOD as (r) values indicates (0.75, 0.92, 0.36, 0.66, 0.67 and 0.99, respectively). Total viable bacterial counts at 22^oC are positively correlated with TVB at 37^oC, TC, FC and TSB (r= 0.87, 0.72, 0.67 and 0.41, respectively). TVB at 37^oC is positively correlated with TSB, TC and FC (r= 0.42, 0.73 and 0.67, respectively). TSB is positively correlated with TC and FC (r= 0.39 and 0.31, respectively). TC is positively correlated with FC (r=0.91). FC is positively correlated with counts of *Aeromonas hydrophila* (r= 0.3).